SECTION 7 Redox Reactions, Chemical Cells and Electrolysis

Multiple-Choice Questions

CE90_01

Which of the following elements in the third period of the Periodic Table is the strongest reducing agent?

A. sodium
B. sulphur
C. chlorine
D. aluminium

CE90_05

In going down the group VI elements of the Periodic Table, there is an increase in

(1) the size of the atoms.
(2) the melting point of the elements.
(3) the oxidizing power of the elements.

Which of the following combinations is correct?

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

CE90_13

A pupil, working with dilute acids in the laboratory, carelessly poured the unused acids into the sink. Later it was found that the copper pipe in the sink had begun to leak. Which of the following acids is/are most likely to have caused the damage?

(1) dilute nitric acid
(2) dilute sulphuric acid
(3) dilute hydrochloric acid

A. (1) only
B. (2) only
C. (1) and (2) only
D. (2) and (3) only

CE90_16

Sulphuric acid is NOT used to prepare carbon dioxide from limestone because

A. the reaction between sulphuric acid and limestone is reversible.
B. the reaction between sulphuric acid and limestone is too vigorous.
C. sulphuric acid is a strong oxidizing agent.
D. an insoluble product is formed which stops further reaction.

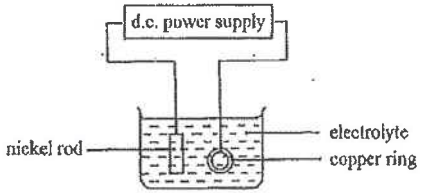
CE90_19

In which of the following pairs of substances is the oxidation number of the sulphur atom and the nitrogen atom the same?

A. H_2SO_4 and HNO_3
B. SO_2 and HNO_2
C. SCl_2 and NO
D. NaHS and NH_3

CE90_23

A student tries to plate a copper ring with nickel using the set-up below:



Which of the following combination is correct?

	Anode	Cathode	Electrolyte
A.	copper ring	nickel rod	$Ni^{2+}(aq)$
B.	nickel rod	copper ring	$Ni^{2+}(aq)$
C.	copper ring	nickel rod	$Cu^{2+}(aq)$
D.	nickel rod	copper ring	$Cu^{2+}(aq)$

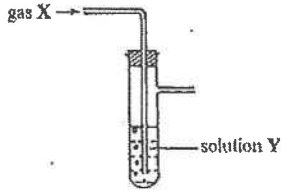
CE90_24

Which of the following pairs of metals would be expected to give the largest voltage when they are used as electrodes in a simple chemical cell using potassium nitrate solution as the electrolyte?

A. Zn and Pb
B. Mg and Ag
C. Pb and Cu
D. Fe and Mg

CE90_27

Gas X is bubbled steadily into solution Y as shown in the set-up below:

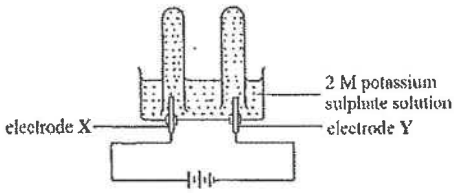


In which of the following cases will NO observable change occur in solution Y?

	gas X	solution Y
A.	sulphur dioxide	bromine water
B.	sulphur dioxide	calcium hydroxide
C.	carbon dioxide	bromine water
D.	carbon dioxide	calcium hydroxide

CE91_06

Direction: Questions 6 and 7 refer to the following electrolysis experiment.



The gases collected at electrodes X and Y respectively are in the volume ratio of

A. 1 : 1
B. 1 : 2
C. 1 : 4
D. 2 : 1

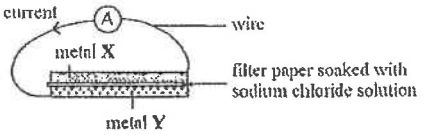
CE91_07

Which of the following statements concerning the experiment is/are correct?

(1) The pH value of the potassium sulphate solution remains unchanged at the end of the experiment.
(2) The concentration of the potassium sulphate solution remains unchanged at the end of the experiment.
(3) The products of electrolysis at electrodes X and Y would remain unchanged if 2M sulphuric acid were used instead of 2M potassium sulphate solution.

A. (1) only
B. (2) only
C. (1) and (3) only
D. (2) and (3) only

CE91_09

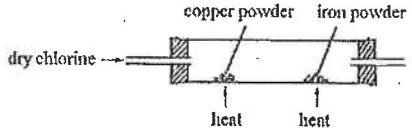


Which of the following combinations would produce the largest current flow from metal X to metal Y in the external circuit?

	metal X	metal Y
A.	Fe	Cu
B.	Mg	Ag
C.	Ag	Zn
D.	Cu	Pb

CE91_10

Dry chlorine is passed in excess over heated copper powder and iron powder as shown in the diagram below:



What is/are the product(s) at the end of the experiment?

A. copper(II) chloride only
B. iron(II) chloride only
C. copper(II) chloride and iron(II) chloride
D. copper(II) chloride and iron(III) chloride

CE91_12

Which of the following tests should be used to detect the presence of sulphite ions in a given solution **X**?

A. On adding barium chloride solution to **X**, a white precipitate is formed.
B. On adding lead(II) nitrate solution to **X**, a white precipitate is formed.
C. On adding dilute sulphuric acid to **X**, a colourless gas is evolved which can decolourize acidified potassium permanganate solution.
D. On adding dilute nitric acid to **X**, a reddish-brown gas is evolved.

CE91_14

Sulphur dioxide is passed into a test tube containing potassium dichromate solution acidified with dilute sulphuric acid. The colour of the solution gradually changes from orange to green.

Which of the following statements concerning the above experiment is correct?

A. Sulphur dioxide is oxidizing to sulphate.
B. The green colour is due to the presence of $Cr^{2+}(aq)$ ions.
C. The dilute sulphuric acid acts as a catalyst.
D. The oxidation number of chromium changes from +7 to +2 in the reaction.

CE91_17

When concentrated sulphuric acid is added to hydrated copper(II) sulphate crystals, which of the following would be observed?

A. The crystals dissolve to form a blue solution.
B. The crystals change to a white solid.
C. The crystals change to a black solid.
D. There is no visible change.

CE91_37

Which of the following oxidation numbers can nitrogen display in its compounds?

(1) −3
(2) +2
(3) +3
(4) +4

A. (1) and (4) only
B. (2) and (3) only
C. (1), (2) and (4) only
D. (1), (2), (3) and (4)

CE91_43

$Cl_2(aq) + 2I^-(aq) \longrightarrow I_2(aq) + 2Cl^-(aq)$

Which of the following statements concerning the above reaction are correct?

(1) $I^-(aq)$ acts as a reducing agent.
(2) Chlorine is a stronger oxidizing agent than iodine.
(3) The reaction is a displacement reaction.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

CE91_44

Which of the following gases can be dried by concentrated sulphuric acid?

(1) hydrogen chloride
(2) ammonia
(3) sulphur dioxide

A. (3) only
B. (1) and (2) only
C. (1) and (3) only
D. (2) and (3) only

CE92_08

The manufacture of sulphuric acid can be represented by the following flow diagram:

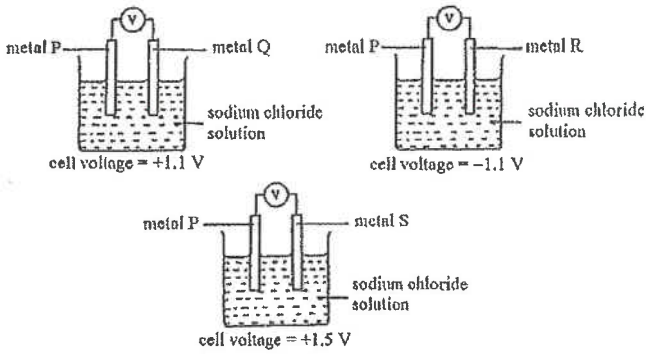
$$S \xrightarrow{\text{Stage I}} SO_2 \xrightarrow{\text{Stage II}} SO_3 \xrightarrow{\text{Stage III}} H_2S_2O_7 \xrightarrow{\text{Stage IV}} H_2SO_4$$

Which stage involves the greatest change in the oxidation number of sulphur?

A. Stage I
B. Stage II
C. Stage III
D. Stage IV

CE92_09

Directions: Q.9 and Q.10 refer to the following diagrams:



Which of the following represents the correct order of activity of the metals P, Q, R and S?

A. R, P, Q, S
B. Q, P, R, S
C. P, Q, S, R
D. P, R, S, Q

CE92_10

Which of the two metals used as electrodes would give the largest cell voltage?

A. Q and R
B. Q and S
C. S and R
D. S and P

CE92_11

Consider the following flow diagram:

$$CuO(s) \xrightarrow{\text{Reactant X}} Cu(s) \xrightarrow{\text{Reactant Y}} Cu^{2+}(aq)$$

Which of the following combinations is correct?

	Reactant X	Reactant Y
A.	$H_2(g)$	dilute H_2SO_4
B.	$CO(g)$	dilute HNO_3
C.	$NH_3(g)$	dilute HCl
D.	$C(s)$	concentrated HCl

CE92_12

Using 1 mole of reactant, which of the following chemical changes involves the highest number of electrons?

A. $CrO_4^{2-}(aq) \longrightarrow Cr^{3+}(aq)$
B. $Cr_2O_7^{2-}(aq) \longrightarrow Cr^{3+}(aq)$
C. $MnO_4^-(aq) \longrightarrow Mn^{2+}(aq)$
D. $MnO_4^-(aq) \longrightarrow MnO_2(aq)$

CE92_13

When 2 moles of oxygen gas are collected at the anode during the electrolysis of dilute sulphuric acid, the number of moles of electrons released at the anode is

A. 2.
B. 4.
C. 6.
D. 8.

CE92_15

Which of the following substances react with hot concentrated sulphuric acid?

(1) sulphur
(2) sodium nitrate
(3) hydrated copper(II) sulphate

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

CE92_16

When sulphur dioxide is bubbled into sodium hydroxide solution for a long time, the final product is

A. sodium sulphite.
B. sodium sulphate.
C. sodium hydrogensulphite.
D. sodium hydrogensulphate.

CE92_35

Which of the following reagents can be used to distinguish between $Fe^{2+}(aq)$ and $Fe^{3+}(aq)$ ions?

(1) ammonia solution
(2) concentrated nitric acid
(3) acidified potassium permanganate solution

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

CE92_37

Which of the following aqueous solutions, when electrolyzed using carbon electrodes, will liberate only gaseous products at both electrodes?

(1) KOH(aq)
(2) $AgNO_3(aq)$
(3) $MgCl_2(aq)$

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

CE92_38

Which of the following statements concerning the reaction between dry chlorine and hot iron wire is/are correct?

(1) Iron(II) chloride is formed.
(2) A solid product is obtained after cooling to room temperature.
(3) Chlorine is reduced.

A. (1) only
B. (3) only
C. (1) and (2) only
D. (2) and (3) only

CE92_40

Which of the following can be used to distinguish between dilute hydrochloric acid and dilute nitric acid?

(1) copper
(2) silver nitrate solution
(3) sodium hydrogencarbonate solution

A. (2) only
B. (1) and (2) only
C. (1) and (3) only
D. (2) and (3) only

CE92_50

1st statement	2nd statement
When concentrated sulphuric acid is poured onto a piece of cotton cloth, the piece of cloth becomes charred.	Concentrated sulphuric acid is a strong oxidizing agent.

CE93_05

Directions: Q.5 and Q.6 refer to the following experiment:

A silver coin, with a mass of 12.00 g, was dissolved completely in concentrated nitric acid. When excess potassium chloride solution was added to the resulting solution, 14.35 g of a white precipitate were obtained.

Which of the following equation correctly represents the reaction between silver and concentrated nitric acid?

A. $Ag + 2H^+ + NO_3^- \longrightarrow Ag^+ + NO_2 + H_2O$
B. $Ag + 4H^+ + NO_3^- \longrightarrow Ag^+ + 4NO_2 + O_2 + 2H_2O$
C. $3Ag + 4HNO_3 \longrightarrow 3AgNO_3 + NO + 2H_2$
D. $Ag + 4HNO_3 \longrightarrow AgNO_3 + 3NO_2 + 2H_2O$

CE93_06

What is the percentage by mass of silver in the coin?
(Relative atomic masses: Cl = 35.5, Ag = 108)

A. 45
B. 60
C. 75
D. 90

CE93_12

A mixture contains copper powder and zinc powder. In order to remove the zinc powder, the mixture is heated with an acid and filtered. Which of the following acids should be used?

A. Dilute nitric acid.
B. Concentrated nitric acid.
C. Dilute sulphuric acid.
D. Concentrated sulphuric acid.

CE93_15

The oxidation number of copper remains unchanged when

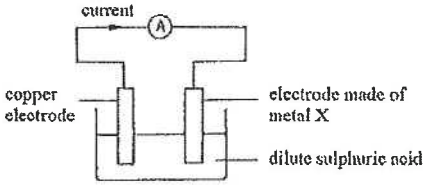
A. magnesium ribbon is added to copper(II) sulphate solution.
B. sodium carbonate solution is added to copper(II) sulphate solution.
C. carbon is heated with copper(II) oxide.
D. copper foil is burnt in chlorine.

CE93_16

In which of the following equations does the underlined substance undergo reduction?

A. $2H_2O + 2\underline{K} \longrightarrow 2KOH + H_2$
B. $Fe_2(SO_4)_3 + 2\underline{KI} \longrightarrow 2FeSO_4 + K_2SO_4 + I_2$
C. $2H_2S + \underline{SO_2} \longrightarrow 3S + 2H_2O$
D. $NaClO + \underline{SO_2} + H_2O \longrightarrow NaCl + H_2SO_4$

CE93_17



With reference to the above diagram, which of the following statements is correct?

A. The electrode made of metal X is the positive pole.
B. Copper is at a higher position in the electrochemical series than metal X.
C. The mass of the copper electrode decreases.
D. The mass of the electrode made of metal X decreases.

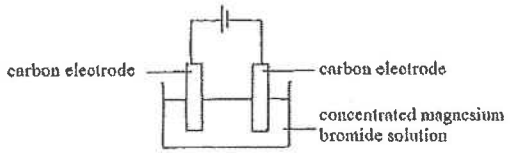
CE93_22

Which of the following reactions would produce a halogen?

(1) sodium chloride + concentrated sulphuric acid
(2) sodium bromide + concentrated sulphuric acid
(3) sodium iodide + concentrated sulphuric acid

A. (1) only
B. (3) only
C. (1) and (2) only
D. (2) and (3) only

CE93_19



In the above experiment, which of the following major products will be liberated at the electrode?

	cathode	anode
A.	magnesium	oxygen
B.	magnesium	bromine
C.	hydrogen	bromine
D.	hydrogen	oxygen

CE93_24

There is a gradual change in the properties of halogens from chlorine to iodine. Which of the following properties are in the order

chlorine < bromine < iodine?

(1) oxidizing power
(2) density
(3) boiling point

A. (1) and (2) only
B. (2) and (3) only
C. (1) and (3) only
D. (1), (2) and (3)

CE93_44

Which of the following statements is **INCORRECT**?

A. Tin is used for making food cans.
B. Sulphuric acid is used for making soap.
C. Ammonium chloride is used for making dry cells.
D. Chlorine is used for sterilizing drinking water.

CE93_45

1st statement	2nd statement
Concentrated sulphuric acid can be used to prepare nitric acid.	Sulphuric acid is more volatile than nitric acid.

CE94_04

Both rubidium (Rb) and sodium are elements in Group I of the Periodic Table, but rubidium is more reactive than sodium. When a rubidium hydroxide solution is electrolyzed using platinum electrodes, hydrogen gas is liberated at the cathode.

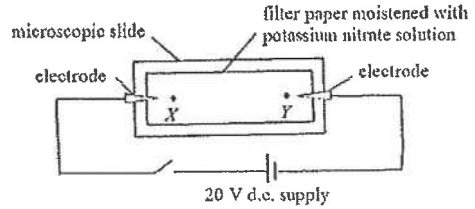
Which of the following statements is a correct explanation for the phenomenon described above?

A. The $H^+(aq)$ ion accepts an electron more readily than the $Rb^+(aq)$ ion.
B. The $H^+(aq)$ ion is more mobile than the $Rb^+(aq)$ ion and migrates faster to the cathode.
C. Rubidium is first liberated, but it reacts immediately with water to give hydrogen gas.
D. The concentration of $H^+(aq)$ ions is higher than that of $Rb^+(aq)$ ions in the rubidium hydroxide solution.

CE94_06

Directions: Q.6 and Q.7 refer to the following experiment:

A drop of silver nitrate solution and a drop of sodium iodine solution are placed respectively at *X* and *Y* as shown in the diagram below:



After the circuit has been closed for some time, a coloured patch is formed between *X* and *Y*.

What is the colour of the patch?

A. brown
B. purple
C. yellow
D. black

CE94_07

The main aim of this experiment is to show that

A. ions exist in silver nitrate solution and sodium iodine solution.
B. sodium ions can react with nitrate ions.
C. silver ions can react with iodine ions.
D. potassium nitrate is an electrolyte.

CE94_10

On strong heating, a solid X decomposes to give a solid residue and a brown gas. The solid residue can react with concentrated nitric acid with evolution of a brown gas. X is probably

A. $AgNO_3$.
B. $Cu(NO_3)_2$.
C. $NaNO_3$.
D. $Zn(NO_3)_2$.

CE94_12

In which of the following experiments will a redox reaction occur?

A. adding copper turnings to iron(II) nitrate solution.
B. adding bromine water to potassium chloride solution.
C. adding iron fillings to silver nitrate solution.
D. adding sodium chloride solution to silver nitrate solution.

CE94_13

When a substance X is electrolyzed using platinum electrodes, a gas is collected at each electrode. X may be

A. silver nitrate solution.
B. potassium chloride solution.
C. molten sodium chloride.
D. molten copper(II) chloride.

CE94_15

Which of the following is NOT a suitable method of preparation?

A. preparation of carbon dioxide from calcium carbonate and dilute sulphuric acid.
B. preparation of hydrogen from iron and dilute sulphuric acid.
C. preparation of sulphur dioxide from sodium sulphite and dilute hydrochloric acid.
D. preparation of nitrogen dioxide from zinc and concentrated nitric acid.

CE94_34

Which of the following reagents can be used to distinguish between sodium sulphite solution and sodium sulphate solution?

(1) barium chloride solution
(2) acidified potassium permanganate solution
(3) potassium iodide solution

A. (1) only
B. (2) only
C. (1) and (3) only
D. (2) and (3) only

CE94_38

Concentrated sulphuric acid turns blue litmus paper red and then black. On the basis of these colour changes, which of the following deductions concerning concentrated sulphuric acid are correct?

(1) It contains $H^+(aq)$ ions.
(2) It is an oxidizing agent.
(3) It is a dehydrating agent.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

CE94_49

1st statement	2nd statement
Iron reacts with chlorine to form iron(II) chloride.	Iron is a reducing agent in this reaction.

CE95_07

Which of the following substances, when mixed, would undergo a chemical reaction?

A. copper and zinc sulphate solution
B. calcium chloride solution and magnesium nitrate solution
C. lead(II) solution and sodium hydroxide solution
D. bromine water and sodium chloride solution

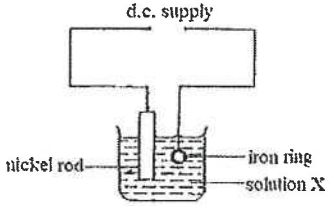
CE95_10

In which of the following equation does the underlined substance become reduced?

A. $\underline{CuSO_4} + Zn \longrightarrow ZnSO_4 + Cu$
B. $\underline{2FeCl_2} + Cl_2 \longrightarrow 2FeCl_3$
C. $\underline{Pb(OH)_2} + 2HNO_3 \longrightarrow Pb(NO_3)_2 + 2H_2O$
D. $\underline{MgCO_3} + 2HCl \longrightarrow MgCl_2 + CO_2 + H_2O$

CE95_11

A student tries to electroplate an iron ring with nickel using the set-up shown below.



Which of the following combinations is correct?

	Solution X	Anode	Cathode
A.	Iron(II) sulphate solution	Iron ring	Nickel rod
B.	Iron(II) sulphate solution	Nickel rod	Iron ring
C.	Nickel(II) sulphate solution	Iron ring	Nickel rod
D.	Nickel(II) sulphate solution	Nickel rod	Iron ring

CE95_13

The reaction of cane sugar and concentrated sulphuric acid may be represented by the following equation.

$$C_{12}H_{22}O_{11}(s) \xrightarrow{\text{conc. } H_2SO_4} 12C(s) + 11H_2O(l)$$

In this reaction, concentrated sulphuric acid acts as

A. a strong acid
B. an oxidizing agent
C. a drying agent
D. a dehydrating agent

CE95_30

$Fe_2O_3(s) + 3CO(g) \longrightarrow 2Fe(s) + 3CO_2(g)$

Which of the following statements is/are correct?

(1) Carbon monoxide is an oxidizing agent.

(2) The oxidation number of carbon changes from +2 to +4.

(3) The oxidation number of iron changes from +2 to 0.

A. (1) only B. (2) only

C. (1) and (3) only D. (2) and (3) only

CE95_33

Which of the following statements concerning a silver oxide cell is/are correct?

(1) The cell is rechargeable.

(2) The cell can maintain a steady voltage during discharge.

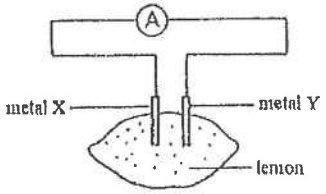
(3) The positive electrode of the cell is silver oxide.

A. (1) only B. (2) only

C. (1) and (3) only D. (2) and (3) only

CE95_37

In the set-up shown below metal X is more reactive than metal Y.



Which of the following statements concerning this set-up is/are correct?

(1) Electrolysis occurs inside the lemon.

(2) Chemical energy is changed into electrical energy.

(3) Electron flows from metal Y to metal X in the external circuit.

A. (1) only B. (2) only

C. (1) and (3) only D. (2) and (3) only

CE95_39

Which of the following substances can conduct electricity?

(1) molten zinc chloride

(2) an aqueous solution of magnesium sulphate

(3) a mixture of ethanol and water

A. (1) and (2) only B. (1) and (3) only

C. (2) and (3) only D. (1), (2) and (3)

CE95_40

Which of the following methods can produce hydrogen?

(1) adding zinc to water

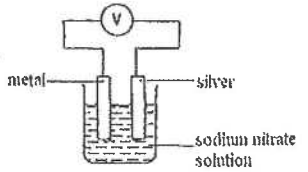
(2) electrolyzing dilute sulphuric acid

(3) adding magnesium to dilute hydrochloric acid

A. (1) and (2) only B. (1) and (3) only

C. (2) and (3) only D. (1), (2) and (3)

CE96_07



Which of the following metals would produce the smallest voltage in the above set-up?

A. iron B. aluminium

C. copper D. magnesium

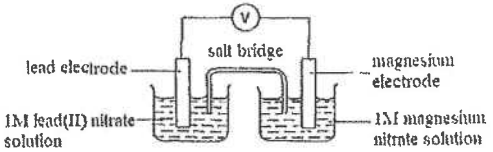
CE96_09

Which of the following experiments can be used to show that concentrated sulphuric acid is a dehydrating agent?

A. adding it to copper(II) oxide powder B. adding it to copper(II) sulphate crystals

C. adding it to calcium carbonate powder D. adding it to sodium chloride crystals

CE96_27



Which of the following statements concerning the above set-up is correct?

A. Electrons flow from the lead electrode to the magnesium electrode through the external circuit.

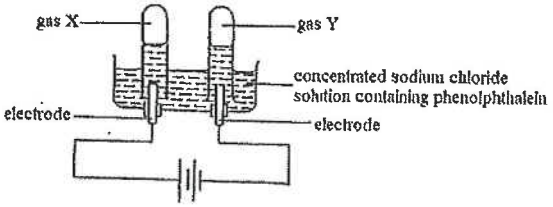
B. Electrons flow through the salt bridge.

C. The mass of the lead electrode remains unchanged.

D. Oxidation occurs at the magnesium electrode.

CE96_30

Directions: CE96_30 and CE96_31 refer to the following experiment.



Which of the following combinations is correct?

	Gas X	Gas Y
A.	chlorine	hydrogen
B.	chlorine	oxygen
C.	hydrogen	chlorine
D.	oxygen	hydrogen

CE96_31

Which of the following statements concerning the above experiment is/are correct?

(1) Platinum electrodes should be used.
(2) The concentration of $Na^+(aq)$ ions around the cathode increases.
(3) The solution changes from colourless to pink.

A. (1) only
B. (2) only
C. (1) and (3) only
D. (2) and (3) only

CE96_35

In which of the following processes will lead be produced?

(1) the electrolysis of lead(II) bromide.
(2) heating lead(II) oxide strongly.
(3) adding magnesium to lead(II) nitrate solution.

A. (1) only
B. (2) only
C. (1) and (3) only
D. (2) and (3) only

CE96_38

Which of the following substances are commonly found in the waste water produced by electroplating factories?

(1) acids
(2) alkalis
(3) cyanides

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

CE96_42

X is an element. It can form a cation X^{2+} which has an electronic arrangement 2, 8, 8. Which of the following statements concerning X are correct?

(1) X is a strong oxidizing agent.
(2) X is in Period 4 of the Periodic Table.
(3) X burns in oxygen with a brick red flame.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

CE96_46 [OUT]

1st statement	2nd statement
Zinc-carbon dry cells are rechargeable.	The electrolyte used in zinc-carbon dry cells is potassium hydroxide.

CE97_04

Which of the following statements concerning the elements in the third period of the Periodic Table is correct?

A. Both sulphur and chlorine can be reduced by aqueous sodium sulphite.
B. Magnesium is a stronger reducing agent than sodium.
C. Phosphorous and chlorine form a covalent compound.
D. Magnesium burns in oxygen to form an acidic oxide.

CE97_07

During the electrolysis of 1M copper(II) chloride solution using copper electrodes, which of the following changes would occur at the electrodes?

	Cathode	Anode
A.	hydrogen liberated	chlorine liberated
B.	copper deposited	chlorine liberated
C.	copper dissolved	copper deposited
D.	copper deposited	copper dissolved

CE97_08

Which of the following conversions involves the smallest change in oxidation number of the underlined element?

A. $\underline{C}(s) \longrightarrow \underline{C}O_2(g)$
B. $\underline{N}O_3^-(aq) \longrightarrow \underline{N}O_2(g)$
C. $\underline{S}O_3^{2-}(aq) \longrightarrow \underline{S}O_4^{2-}(aq)$
D. $\underline{Mn}O_4^-(aq) \longrightarrow \underline{Mn}^{2+}(aq)$

CE97_09

Metal X reacts with dilute nitric acid to give a colorless solution. When sodium hydroxide solution is added to the solution, a white precipitate which dissolves in excess sodium hydroxide solution is formed. X is probably

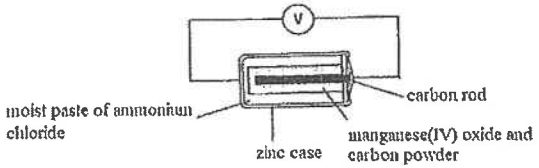
A. copper.
B. iron.
C. lead.
D. magnesium.

CE97_10

Which of the following combinations is **INCORRECT**?

	Chemical	Method of storage
A.	calcium	under water
B.	potassium	under paraffin oil
C.	ethanol	in a cool place
D.	potassium permanganate solution	in a brown bottle

CE97_11 [OUT]



A zinc-carbon cell is connected to a voltmeter as shown in the above diagram. Which of the following statements concerning the set-up is **INCORRECT**?

A. Electrons flow from the zinc case to the carbon rod in the external circuit.
B. The zinc case gradually becomes thinner as the cell discharges.
C. Manganese(IV) oxide acts as an oxidizing agent.
D. Ammonium chloride acts as a reducing agent.

CE97_29

An iron nail is heated with concentrated sulphuric acid. Which of the following combinations is correct?

	Gas given off	Color of solution formed
A.	hydrogen	pale green
B.	hydrogen	yellow
C.	sulphur dioxide	pale green
D.	sulphur dioxide	yellow

CE97_36

Which of the following substances can be used to distinguish between concentrated nitric acid and concentrated sulphuric acid?

(1) sodium carbonate powder
(2) copper turnings
(3) cane sugar

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

CE97_39

Concentrated sulphuric acid is corrosive to skin because

(1) it is a dehydrating agent.
(2) it is an oxidizing agent.
(3) each molecule of sulphuric acid has two ionizable hydrogen atoms.

Which of the above statements are correct?

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

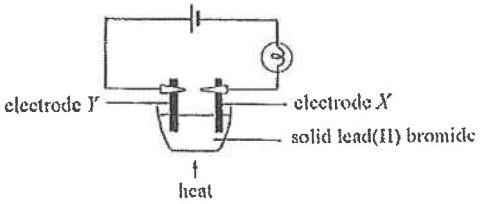
CE97_50

1st statement	2nd statement
Concentrated hydrochloric acid can react with silver.	Concentrated hydrochloric acid is a strong oxidizing agent.

CE98_04

Directions: Questions 4 and 5 refer to the following experiment:

The circuit shown below is set up and the solid lead(II) bromide is heated until it becomes molten.



Which of the following statements concerning the experiment is **INCORRECT**?

A. The bulb lights up.
B. A reddish brown gas is liberated at electrode X.
C. Electrodes X and Y can be made of nichrome.
D. Oxidation occurs at electrode Y.

CE98_05

Which of the following can be deduced from the experimental results?

A. Solid lead(II) bromide contains mobile ions.
B. Molten lead(II) bromide contains delocalized electrons.
C. Molten lead(II) bromide can be decomposed by electricity.
D. Solid lead(II) bromide is a covalent compound but molten lead(II) bromide is an ionic compound.

CE98_06

A part of the Periodic Table is shown below.

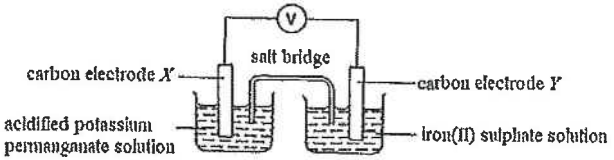
	Group I	II	III	IV	V	VI	VII	0
1								*a*
Period 2	*b*			*c*			*d*	
3							*e*	

Which of the following statements is correct?

A. The outermost electron shell of an atom of *a* is an octet structure.
B. The metallic character of the Period 2 elements increases from *b* to *d*.
C. *c* forms an ionic compound with *d*.
D. *e* is a strong oxidizing agent.

CE98_21

Consider the following experiment.



Which of the following statements concerning the above experiment is correct?

A. Permanganate ions migrate into the salt bridge.
B. Electrons flow from electrode *X* to electrode *Y* in the external circuit.
C. Carbon electrodes are used because they are chemically inert.
D. The half equation for the change occurring at electrode *Y* is $Fe^{2+} + 2e^- \longrightarrow Fe$.

CE98_22

In which of the following reactions does the underlined substance act as a reducing agent?

A. $\underline{SO_2} + 2H_2S \longrightarrow 2S + 2H_2O$
B. $\underline{Pb(NO_3)_2} + H_2SO_4 \longrightarrow PbSO_4 + 2HNO_3$
C. $2\underline{HCl} + MgO \longrightarrow MgCl_2 + H_2O$
D. $2\underline{KBr} + Cl_2 \longrightarrow 2KCl + Br_2$

CE98_38

Which of the following experiments would produce sulphur dioxide?

(1) heating iron pyrites in air
(2) heating a mixture of iron and dilute sulphuric acid
(3) heating a mixture of copper and concentrated acid

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

CE99_07

Substance X gives identical product(s) when treated with dilute sulphuric acid or concentrated sulphuric acid. X may be

A. zinc.
B. cane sugar.
C. ammonia.
D. hydrated copper(II) sulphate crystals.

CE99_09

In which of the following reactions is the underlined reactant reduced?

A. $\underline{Cu^{2+}} + 2OH^- \longrightarrow Cu(OH)_2$
B. $\underline{SO_2} + 2Mg \longrightarrow 2MgO + S$
C. $2\underline{NH_3} + 3CuO \longrightarrow 3Cu + N_2 + 3H_2O$
D. $\underline{Zn} + 2AgNO_3 \longrightarrow Zn(NO_3)_2 + 2Ag$

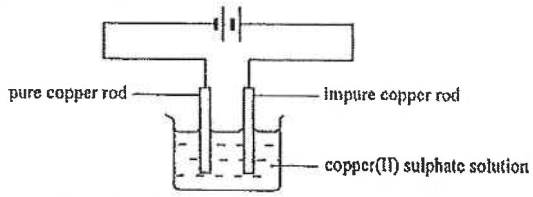
CE99_10

Which of the following statements concerning bromine and chlorine is INCORRECT?

A. They exist as diatomic molecules.
B. Their atoms have the same number of outermost shell electrons.
C. They form ions with a single negative charge.
D. Bromine is a stronger oxidizing agent than chlorine.

CE99_12

Consider the electrolysis experiment shown below:



Which of the following statements concerning this experiment is correct?

A. The mass of the impure copper rod decreases.
B. The blue colour of the copper(II) sulphate solution gradually fades off.
C. Oxidation takes place at the pure copper rod.
D. The electrolysis process can enhance the corrosion resistance of copper.

CE99_15

Potassium permanganate solution acidified with dilute sulphuric acid is a commonly-used oxidizing agent. Dilute nitric acid is not used to acidify potassium permanganate solution because

A. nitric acid is more expensive than sulphuric acid.
B. dilute nitric acid is an oxidizing agent and would react with the reducing agent.
C. nitric acid decomposes more readily than sulphuric acid.
D. dilute nitric acid would react with potassium permanganate solution.

CE99_18

Which of the following processes would NOT produce hydrogen gas?

A. adding calcium to water
B. adding magnesium to dilute hydrochloric acid
C. adding copper to dilute nitric acid
D. passing steam over red hot iron

CE99_24

In an experiment, sulphur dioxide is passed into an iodine solution which is prepared by dissolving some iodine in potassium iodide solution. Which of the following statements concerning this experiment is correct?

A. The colour of the iodine solution changes from purple to colourless.
B. A brown solid is formed.
C. A displacement reaction occurs.
D. Sulphur dioxide is oxidized to sulphate ions.

CE99_33

Which of the following reactions will occur when aluminium powder is added to silver nitrate solution?

(1) displacement
(2) anodization
(3) redox

A. (1) only
B. (2) only
C. (1) and (3) only
D. (2) and (3) only

CE99_36

The equation below represents the reaction of chlorine with hot concentrated potassium hydroxide solution:

$$3Cl_2(g) + 6KOH(aq) \longrightarrow 5KCl(aq) + KClO_3(aq) + 3H_2O(l)$$

Which of the following statements concerning this reaction is/are correct?

(1) Potassium hydroxide acts as a reducing agent.
(2) The oxidation number of chlorine changes from 0 to −1.
(3) The oxidation number of chlorine changes from 0 to +5.

A. (1) only
B. (2) only
C. (1) and (3) only
D. (2) and (3) only

CE99_38

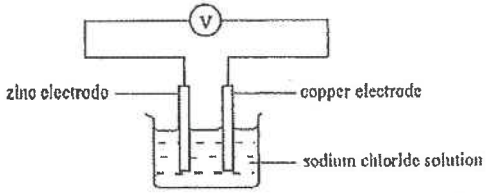
Which of the following reagents is/are commonly stored in brown bottles?

(1) potassium permanganate solution
(2) concentrated sulphuric acid
(3) concentrated nitric acid

A. (1) only
B. (2) only
C. (1) and (3) only
D. (2) and (3) only

CE99_40

Consider the following chemical cell:



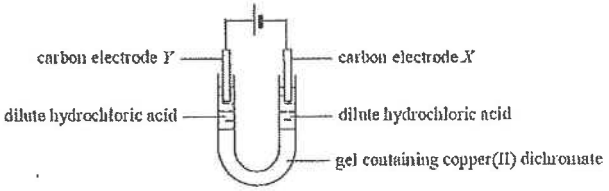
Which of the following changes would lead to an increase in the voltage of the cell?

(1) The zinc electrode is replaced with a magnesium electrode.
(2) The copper electrode is replaced with an iron electrode.
(3) The sodium chloride solution is replaced with a sugar solution.

A. (1) only
B. (2) only
C. (1) and (3) only
D. (2) and (3) only

CE99_42

Consider the following experiment:



Which of the following statements concerning the experiment are correct?

(1) Gas bubbles are evolved at electrode *X*.
(2) An orange colour gradually appears in the solution around electrode *Y*.
(3) The experiment can be used to show that ions migrate towards oppositely charged electrodes.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

CE00_05

Which of the following gases are the major products liberated in the electrolysis of concentrated sodium chloride solution using carbon electrodes?

	Cathode	Anode
A.	hydrogen	chlorine
B.	chlorine	hydrogen
C.	hydrogen	oxygen
D.	oxygen	hydrogen

CE00_16

Consider the following equation:

$3Zn(s) + 2NO_3^-(aq) + 8H^+(aq) \longrightarrow 3Zn^{2+}(x) + 2NO(y) + 4H_2O(z)$

Which of the following combinations is correct?

	x	y	z
A.	aq	g	aq
B.	aq	g	l
C.	aq	aq	l
D.	l	g	aq

CE00_28

Which of the following changes is NOT a redox reaction?

A. $Fe_2(SO_4)_3 + H_2S \longrightarrow 2FeSO_4 + S + H_2SO_4$

B. $2Al + 6HCl \longrightarrow 2AlCl_3 + 3H_2$

C. $CaCO_3 + CO_2 + H_2O \longrightarrow Ca(HCO_3)_2$

D. $2KClO_3 \longrightarrow 2KCl + 3O_2$

CE00_30

In which of the following substances does nitrogen has the smallest oxidation number?

A. NH_3 B. NO

C. N_2O D. N_2

CE00_31

Which of the following uses of sulphuric acid is/are correct?

(1) manufacture of soaps

(2) manufacture of paint additives

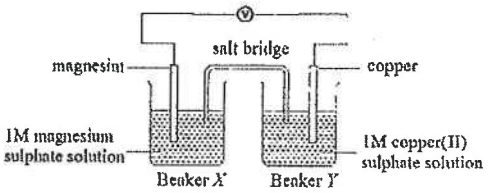
(3) manufacture of fertilizers

A. (1) only B. (2) only

C. (1) and (3) only D. (2) and (3) only

CE00_35

Consider the chemical cell shown below:



Which of the following statements concerning the cell is/are correct?

(1) Oxidation takes place at the copper electrode.

(2) The concentration of magnesium ions in beaker *X* increases.

(3) The salt bridge allows electrons to flow from one electrode to the other electrode.

A. (1) only B. (2) only

C. (1) and (3) only D. (2) and (3) only

CE00_43 [OUT]

Which of the following statements concerning a zinc-carbon cell are correct?

(1) The ammonium chloride in the cell acts as an electrolyte.

(2) The manganese(IV) oxide in the cell acts as an oxidizing agent.

(3) The zinc case of the cell acts as the positive terminal.

A. (1) and (2) only B. (1) and (3) only

C. (2) and (3) only D. (1), (2) and (3)

CE00_44

Which of the following statements concerning sulphur dioxide are correct?

(1) It can be prepared by heating copper turnings with concentrated sulphuric acid.

(2) It is denser than air.

(3) It can be absorbed by sodium hydroxide solution.

A. (1) and (2) only B. (1) and (3) only

C. (2) and (3) only D. (1), (2) and (3)

CE00_45

1st statement	2nd statement
Concentrated sulphuric acid can turn a piece of filter paper black.	Concentrated sulphuric acid is a strong oxidizing agent.

CE01_07

Which of the following statements concerning water is correct?

A. It reacts with calcium to give a colourless gas.

B. It is a strong electrolyte.

C. It turns anhydrous cobalt(II) chloride from pink to blue.

D. It is immiscible with methanol.

CE01_08

Which of the following statements concerning the formation of chloride ions from chlorine atoms is correct?

A. The number of shells occupied by electrons in a chlorine atom equals that in a chloride ion.
B. The atomic number of chlorine increases by 1.
C. The mass number of chlorine increases by 1.
D. The change is an oxidation.

CE01_11

Which of the following pairs of solutions, when mixed, would produce a precipitate?

A. lead(II) nitrate and sodium hydroxide
B. copper(II) sulphate and sodium nitrate
C. zinc chloride and potassium nitrate
D. iron(II) sulphate and acidified potassium permanganate

CE01_19

Consider the half equations of a redox reaction:

$$8H^+(aq) + MnO_4^-(aq) + 5e^- \longrightarrow Mn^{2+}(aq) + 4H_2O(l)$$
$$C_2O_4^{2-}(aq) \longrightarrow 2CO_2(g) + 2e^-$$

How many moles of $MnO_4^-(aq)$ ions will react completely with one mole of $C_2O_4^{2-}(aq)$ ions?

A. 0.4 B. 1.0
C. 2.5 D. 5.0

CE01_22

Which of the following equations represents a redox reaction?

A. $NH_4^+(aq) + OH^-(aq) \longrightarrow NH_3(g) + H_2O(l)$
B. $2CrO_4^{2-}(aq) + 2H^+(aq) \longrightarrow Cr_2O_7^{2-}(aq) + H_2O(l)$
C. $2FeSO_4(s) \longrightarrow Fe_2O_3(s) + SO_3(g) + SO_2(g)$
D. $2NaHCO_3(s) \longrightarrow Na_2CO_3(s) + H_2O(l) + CO_2(g)$

CE01_24

Consider the half equation:

$$IO_3^-(aq) + xH_2O(l) + ye^- \longrightarrow I^-(aq) + zOH^-(aq)$$

Which of the following combinations is correct?

	x	y	z
A.	1	2	2
B.	2	4	4
C.	3	6	6
D.	4	8	8

CE01_29

The oxidation number of lead in $[Pb(OH)_4]^{2-}$ is

A. –2. B. +2.
C. +4. D. +6.

CE01_35

Which of the following statements concerning the reaction of iron(II) carbonate with 1M sulphuric acid is/are correct?

(1) Sulphuric acid acts as an acid.
(2) Sulphuric acid acts as an oxidizing agent.
(3) Sulphuric acid acts as a dehydrating agent.

A. (1) only B. (2) only
C. (1) and (3) only D. (2) and (3) only

CE01_43

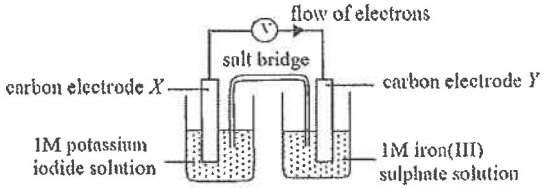
Which of the following are correct descriptions of the uses of sulphuric acid?

(1) treatment of metal surfaces in the electroplating industry
(2) manufacture of paint additives
(3) manufacture of fertilizers

A. (1) and (2) only B. (1) and (3) only
C. (2) and (3) only D. (1), (2) and (3)

CE01_44

Consider the set-up shown below:



Which of the following statements are correct?

(1) The solution around electrode *X* turns brown.
(2) The mass of electrode *X* remains unchanged.
(3) Reduction occurs at electrode *Y*.

A. (1) and (2) only B. (1) and (3) only
C. (2) and (3) only D. (1), (2) and (3)

CE02_06

Compound *X* dissolves in water to give a colourless solution. When chlorine gas is bubbled into the solution, the solution turns brown. *X* is probably

A. ammonium iodide. B. iron(II) sulphate.
C. sodium sulphite. D. potassium hydroxide.

CE02_07

Sodium chromate, Na_2CrO_4, dissolves in water to give a yellow solution. When dilute hydrochloric acid is added to the solution, the following reaction occurs:

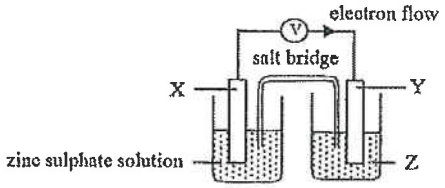
$$2CrO_4^{2-}(aq) + 2H^+(aq) \longrightarrow Cr_2O_7^{2-}(aq) + H_2O(l)$$

Which of the following statements concerning this reaction is correct?

A. The colour of the solution changes from yellow to green.
B. Chromate ions act as a reducing agent.
C. The oxidation number of oxygen remains unchanged during the reaction.
D. The reaction is a neutralization.

CE02_10

Consider the set-up below:



Electrons flow from *X* to *Y* in the external circuit. Which of the following combinations is correct?

	X	*Y*	*Z*
A.	carbon	silver	silver nitrate solution
B.	zinc	magnesium	magnesium sulphate solution
C.	carbon	carbon	copper(II) sulphate solution
D.	zinc	carbon	silver nitrate solution

CE02_13

Which of the following equations represents a redox reaction?

A. $Ca(HCO_3)_2 + 2HCl \longrightarrow CaCl_2 + 2CO_2 + 2H_2O$
B. $PCl_3 + Cl_2 \longrightarrow PCl_5$
C. $Fe^{3+} + 3OH^- \longrightarrow Fe(OH)_3$
D. $Al_2O_3 + 2NaOH \longrightarrow 2NaAlO_2 + H_2O$

CE02_18

The symbol of vanadium is V. What is the oxidation number of vanadium in NH_4VO_3?

A. −1
B. +3
C. +5
D. +6

CE02_19

Which of the following acids, when heated with copper, would produce a gas?

A. dilute nitric acid
B. dilute hydrochloric acid
C. dilute sulphuric acid
D. concentrated ethanoic acid

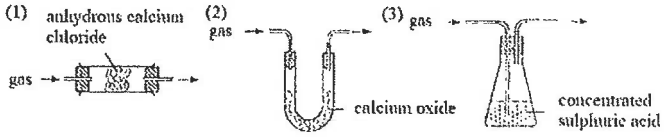
CE02_30

Starch, a natural polymer, is a carbohydrate. When concentrated sulphuric acid is added dropwise to some starch, a black substance is formed. The reaction involved is

A. dehydration.
B. depolymerisation.
C. redox reaction.
D. neutralization.

CE02_38

Which of the following set-ups can be used to dry moist sulphur dioxide gas?



A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

CE02_39

Which of the following statements concerning Group VII elements and their ions are correct?

(1) Chlorine has the highest oxidizing power among chlorine, bromine and iodine.
(2) Iodide ions have the highest reducing power among chloride, bromide and iodide ions.
(3) Bromine is a volatile liquid at room temperature and pressure.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

CE02_41

When sulphur dioxide is bubbled into water, a colourless solution is formed. Which of the following statements concerning the solution are correct?

(1) The solution conducts electricity better than water.
(2) The solution can change iron(III) sulphate solution from yellow to green.
(3) The solution can change potassium bromide solution from colourless to brown.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

CE02_47

1st statement	2nd statement
During electrolysis, oxidation takes place at the cathode.	Cations accept electrons and are discharged at the cathode.

CE03_03

When a small piece of calcium metal is put into a trough of water, a reaction occurs. Which of the following statements concerning this reaction is correct?

A. It is an endothermic reaction.
B. It is a redox reaction.
C. A slight explosion occurs.
D. The calcium metal burns spontaneously in water.

CE03_04

Which of the following statements concerning nitric acid is INCORRECT?

A. It is manufactured from ammonia.
B. It is used to make explosives.
C. It is used to make fertilizers.
D. It is a dehydrating agent.

CE03_07

Which of the following statements concerning halogens is INCORRECT?

A. Compounds of fluorine are added to tap water to help prevent tooth decay.
B. Chlorine is used as a sterilizing agent.
C. Bromine is a volatile liquid.
D. Iodine vapour is brown in colour.

CE03_13

Which of the following substances will NOT react with bromine water?

A. propene
B. sulphur dioxide
C. potassium iodide solution
D. ammonium chloride solution

CE03_15

In the electrolysis of a copper(II) sulphate solution, copper is used as the anode and carbon as the cathode. Which of the following statements concerning this electrolysis is correct?

A. The concentration of $Cu^{2+}(aq)$ ions in the solution remains unchanged.
B. The concentration of $H^{+}(aq)$ ions in the solution increases.
C. $O_2(g)$ is liberated at the anode.
D. $H_2(g)$ is liberated at the cathode.

CE03_16

Which of the following conversions is NOT a reduction?

A. $Fe_2O_3 \longrightarrow Fe$
B. $Cu(OH)_2 \longrightarrow CuO$
C. $CH_3CO_2H \longrightarrow CH_3CH_2OH$
D. $H_2SO_4 \longrightarrow SO_2$

CE03_18

Consider the following **information about three** elements, *X*, *Y* and *Z*.

Element	Atomic number
X	12
Y	16
Z	17

Which of the following statements concerning *X*, *Y* and *Z* is correct?

A. *X* reacts with *Z* to form an ionic compound.
B. *Y* is a stronger oxidizing agent than *Z*.
C. *X* has a simple molecular structure.
D. *Y* can conduct electricity in the molten state.

CE03_23

Consider the following equation:

$$5H_2S + 2KMnO_4(aq) + 3H_2SO_4(aq) \longrightarrow 5S(x) + 8H_2O(y) + 2MnSO_4(z) + K_2SO_4(aq)$$

Which of the following combinations is correct?

	X	Y	Z
A.	s	aq	aq
B.	s	l	aq
C.	aq	aq	s
D.	aq	l	s

CE03_35 [OUT]

Which of the following is/are advantage(s) of using alkaline cells over zinc-carbon cells in cassette players?

(1) Alkaline manganese cells have longer life time.
(2) Alkaline manganese cells are rechargeable.
(3) Alkaline manganese cells give a more steady voltage over discharge.

A. (1) only
B. (2) only
C. (1) and (3) only
D. (2) and (3) only

CE05SP_17

Consider the following equation:

$$O_2(g) + 4Fe(OH)_2(x) \longrightarrow 2Fe_2O_3(y) + 4H_2O(z)$$

Which of the following combinations is correct?

	X	Y	Z
A.	s	s	l
B.	s	aq	aq
C.	aq	s	aq
D.	aq	aq	l

CE05SP_31

Caesium (Cs) is a group I element in the Periodic Table and its relative atomic mass is greater than that of potassium. Which of the following statements concerning caesium is INCORRECT?

A. Caesium is a weaker reducing agent than potassium.
B. Caesium reacts violently with water.
C. Caesium is a soft metal.
D. Caesium reacts with oxygen to form an oxide with formula Cs_2O.

CE05SP_40

Which of the following statements concerning nitric acid is/are correct?

(1) Nitric acid is a stronger acid.
(2) Dilute nitric acid reacts with copper to give hydrogen.
(3) Concentrated nitric acid is a dehydrating agent.

A. (1) only
B. (2) only
C. (1) and (3) only
D. (2) and (3) only

CE04_05

Which of the following statements concerning nitric acid is correct?

A. Nitric acid can be used as a fertilizer.
B. Nitrogen monoxide is a raw material in the manufacture of nitric acid.
C. In the laboratory, concentrated nitric acid is commonly stored in brown bottles.
D. The following hazard warning label should be displayed on a bottle of concentrated nitric acid.

CE04_07

In which of the following compounds does sulphur exhibit the lowest oxidation number?

A. $Na_2S_2O_3$
B. $MgSO_4$
C. $KHSO_3$
D. $H_2S_2O_7$

CE04_13

Which of the following combinations concerning the uses of metals is correct?

	Metal	Use
A.	cadmium	making rechargeable cells
B.	copper	making fuse in electric plugs
C.	chromium	making duralumin
D.	zinc	making cans for canned food

CE04_14

Chlorine can be prepared from concentrated hydrochloric acid and potassium permanganate according to the following equation:

$$2KMnO_4 + xHCl \longrightarrow 2KCl + 2MnCl_2 + yH_2O + zCl_2$$

What is the value of z?

A. 4
B. 5
C. 8
D. 10

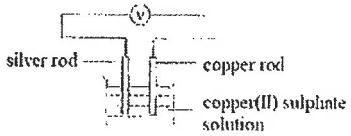
CE04_18

Which of the following reagents can be used to distinguish sodium bromide solution from sodium chloride solution?

A. bromine water
B. chlorine water
C. 1,1,1-trichloroethane
D. potassium fluoride solution

CE04_24

Which of the following combinations concerning the set-up shown below is correct after a current has flowed through the external circuit for some time?



	Mass of anode	Colour intensity of the copper(II) sulphate solution
A.	increases	no change
B.	decreases	no change
C.	increases	decreases
D.	decreases	decreases

CE04_32

Which of the following substances can decolourise acidified potassium permanganate solution?

(1) sodium nitrate solution
(2) sodium sulphite solution
(3) chlorine water

A. (1) only
B. (2) only
C. (1) and (3) only
D. (2) and (3) only

CE04_34

Which of the following substances, when dissolved in water, gives a solution with pH greater than 7?

(1) chlorine
(2) calcium oxide
(3) sulphur dioxide

A. (1) only
B. (2) only
C. (1) and (3) only
D. (2) and (3) only

CE04_38

A counterfeit gold coin is made from an alloy of copper and zinc. Which of the following methods can be used to show that the coin is NOT made of pure gold?

(1) determining its density
(2) treating it with dilute nitric acid
(3) treating it with dilute hydrochloric acid

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

CE04_39

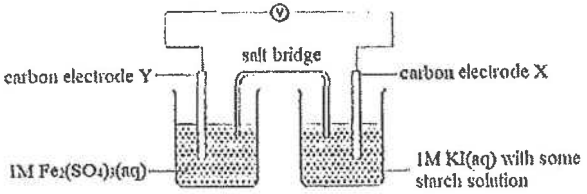
Which of the following gases can act as reducing agents?

(1) ammonia
(2) hydrogen
(3) fluorine

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

CE04_40

Consider the chemical cell shown below:



Which of the following statements concerning the cell are correct?

(1) Electrons flow from electrode X to electrode Y in the external circuit.
(2) Oxidation occurs at electrode Y.
(3) A blue colour appears in the KI(aq) after the cell has operated for some time.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

CE04_43

In which if the following processes would hydrogen be produced?

(1) electrolysis of an aqueous solution of potassium bromide
(2) passing steam over heated iron powder
(3) adding zinc granules to dilute ethanoic acid.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

CE05_08

Which of the following is NOT a redox reaction?

A. $NH_4NO_3 \longrightarrow N_2O + 2H_2O$
B. $NH_3 + HNO_3 \longrightarrow NH_4NO_3$
C. $N_2O_4 + H_2O \longrightarrow HNO_2 + HNO_3$
D. $4HNO_3 \longrightarrow 2H_2O + 4NO_2 + O_2$

CE05_15

$$ZnS \xrightarrow{\text{Stage 1}} SO_2 \xrightarrow{\text{Stage 2}} SO_3 \xrightarrow{\text{Stage 3}} H_2S_2O_7 \xrightarrow{\text{Stage 4}} H_2SO_4$$

Which of the following stages involves the largest change in oxidation number of sulphur?

A. Stage 1
B. Stage 2
C. Stage 3
D. Stage 4

CE05_25

Which of the following processes involve chemical changes?

(1) mixing sea water with silver nitrate solution
(2) evaporation of sea water
(3) electrolysis of sea water

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

CE05_26

An aqueous solution of a compound reacts with dilute hydrochloric acid to give a gas. This aqueous solution does not give a precipitate with sodium hydroxide solution. What could the compound be?

(1) potassium sulphite
(2) iron(II) sulphate
(3) ammonium carbonate

A. (1) only
B. (2) only
C. (1) and (3) only
D. (2) and (3) only

CE05_30

1st statement	2nd statement
Iodine can displace chlorine from potassium chloride solution.	Iodine is a stronger oxidizing agent than chlorine.

CE05_31

In which of the following combinations will oxygen be produced as the major product at the anode during electrolysis?

	electrolyte	cathode	anode
A.	0.1 M $CuCl_2$	platinum	platinum
B.	0.1 M $CuCl_2$	copper	copper
C.	5 M HCl	platinum	platinum
D.	5 M HCl	copper	copper

CE05_33

When a metal X is warmed with an acid Y, they react to form a colourless solution and a brown gas. Which of the following combinations is correct?

	X	Y
A.	zinc	concentrated nitric acid
B.	copper	concentrated sulphuric acid
C.	zinc	concentrated sulphuric acid
D.	copper	concentrated nitric acid

CE05_36

Which of the following properties of Group I elements decreases down the group?

A. melting point
B. reducing power
C. reactivity with water
D. tendency to form cations

CE05_48

1st statement	2nd statement
Anodization is a method used to enhance the corrosion resistance of aluminium.	By anodization, an oxide layer is formed to protect the aluminium.

CE06_03

What is the oxidation number of cobalt in $Co(NH_3)_4Cl_2$?

A. –2
B. 0
C. +2
D. +6

CE06_21

When substance X is treated with an aqueous solution of iron(II) sulphate, the iron(II) ions act as oxidizing agent. X may be

A. concentrated hydrochloric acid.
B. aqueous ammonia.
C. acidified potassium permanganate solution.
D. zinc granules.

CE06_27

Which of the following reactions involve oxidation and reduction?

(1) $2KClO_3(s) \longrightarrow 2KCl(s) + 3O_2(g)$
(2) $Pb(s) + PbO_2(s) + 2H_2SO_4(aq) \longrightarrow 2PbSO_4(s) + 2H_2O(l)$
(3) $H_2O_2(aq) + H_2SO_4(aq) + 2KI(aq) \longrightarrow K_2SO_4(aq) + I_2(aq) + 2H_2O(l)$

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

CE06_29

1st statement	2nd statement
Potassium is a stronger reducing agent than sodium.	Potassium atoms lose electrons more readily than sodium atoms.

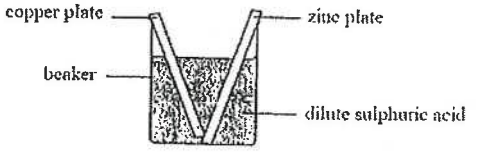
CE06_32

Which of the following combinations is correct for a zinc-carbon cell? [OUT]

	Anode	Cathode	Electrolyte
A.	zinc	graphite	manganese(IV) oxide
B.	zinc	graphite	ammonium chloride
C.	graphite	zinc	manganese(IV) oxide
D.	graphite	zinc	ammonium chloride

CE06_33

In an experiment, a copper plate and a zinc plate are placed in a beaker containing dilute sulphuric acid. The two metal plate are touching each other as shown in the diagram below:

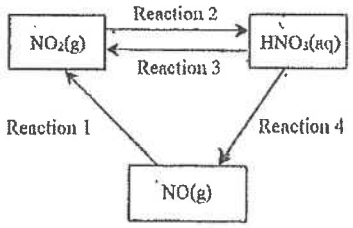


Which of the following statements correctly describes the observation in the experiment?

A. The solution in the beaker turns blue.
B. The mass of the zinc plate remains unchanged.
C. A white precipitate is formed in the beaker.
D. Gas bubbles are formed on the surface of the copper plate.

CE06_38

Consider the conversions between three nitrogen compounds shown in the flow diagram below:

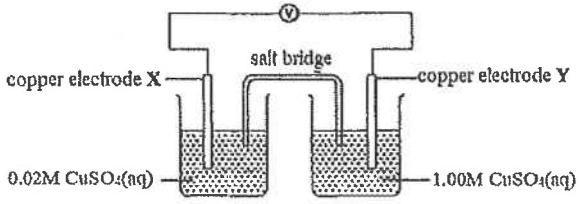


Which of the following statements is correct?

A. *Reaction 1* occurs spontaneously when nitrogen monoxide is exposed to air.
B. The oxidation number of nitrogen remains unchanged in *Reaction 2*.
C. *Reaction 3* can be brought about by adding very dilute nitric acid to magnesium.
D. *Reaction 4* can be brought about by adding concentrated nitric acid to copper.

CE06_40

The set-up below shows a chemical cell connected to a voltmeter:



In the set-up, electrons flow in such a direction that the concentration of $Cu^{2+}(aq)$ ions in each half cell becomes the same eventually.

Which of the following statements concerning the set-up is correct?

A. The salt bridge allows electrons to flow from one half cell to the other.
B. Oxidation occurs at Y.
C. Electrons flow from Y to X in the external circuit.
D. The mass of X will decrease but the mass of Y will increase.

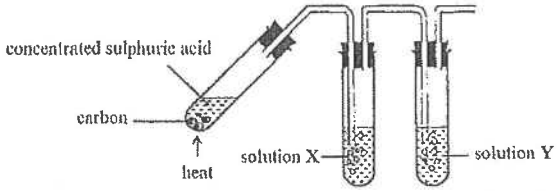
CE07_19

Chlorine is bubbled into an aqueous solution P for some time. The colour of P gradually changes to brown. P is NOT likely to be

A. calcium hydroxide solution.
B. potassium iodide solution.
C. iron(II) chloride solution.
D. zinc bromide solution.

CE07_20

Directions: Questions 20 and 21 refer to the following experiment.



Which of the following combinations of solution X and solution Y can be used to show that sulphur dioxide and carbon dioxide are produced?

	Solution X	Solution Y
A.	bromine water	calcium hydroxide solution
B.	iron(II) sulphate solution	calcium hydroxide solution
C.	acidified potassium dichromate solution	sodium hydroxide solution
D.	acidified potassium permanganate solution	sodium hydroxide solution

CE07_21

Which of the following statements concerning the reaction between carbon and concentrated sulphuric acid are correct?

(1) The oxidation number of carbon changes from 0 to +4.
(2) The oxidation number of hydrogen in sulphuric acid remains unchanged.
(3) Concentrated sulphuric acid acts both as a dehydrating agent and an oxidizing agent.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

CE07_22

Which of the following statements concerning chlorine, bromine and iodine is/are correct?

(1) They are all coloured substances.
(2) Their reactivity increases with relative atomic mass.
(3) They all react with sodium sulphite solution.

A. (1) only
B. (2) only
C. (1) and (3) only
D. (2) and (3) only

CE07_24

Consider the redox reaction represented by the equation below:

$2S_2O_3^{2-}(aq) + I_2(aq) \longrightarrow S_4O_6^{2-}(aq) + 2I^-(aq)$

Which of the following statements is/are correct?

(1) The oxidation number of sulphur in $S_2O_3^{2-}(aq)$ is +3.
(2) One of the half equations of this reaction is $2S_2O_3^{2-}(aq) \longrightarrow S_4O_6^{2-}(aq) + 2e^-$
(3) $I_2(aq)$ is oxidized by $S_2O_3^{2-}(aq)$ in the reaction.

A. (1) only
B. (2) only
C. (1) and (3) only
D. (2) and (3) only

CE07_25

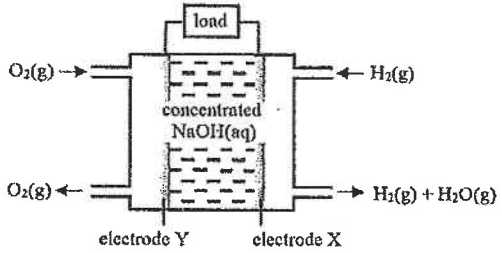
Which of the following processes would produce sulphur dioxide?

(1) roasting iron pyrite in air.
(2) heating zinc with concentrated sulphuric acid
(3) mixing dilute hydrochloric acid with sodium sulphite

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

CE07_36

The following diagram represents a chemical cell called fuel cell.



Hydrogen and oxygen are passed into the fuel cell. The half equations for the chemical changes occurring at electrode X and electrode Y are listed below:

at X: $H_2 + 2OH^- \longrightarrow 2H_2O + 2e^-$

at Y: $O_2 + 2H_2O + 4e^- \longrightarrow 4OH^-$

Which of the following statements concerning the fuel cell is correct?

A. Reduction occurs at X.
B. A current flows from X to Y through the external circuit.
C. Both $H_2(g)$ and $O_2(g)$ function as fuels in the cell.
D. The fuel cell is an environmentally-friendly chemical cell.

CE07_37

Which of the following mixtures can produce chlorine?

A. chlorine bleach and lemon juice
B. sodium chloride and vinegar
C. polyvinyl chloride and caustic soda
D. hydrochloric acid and limestone

CE07_41

Which of the following items does NOT require the use of the products obtained from electrolysis of brine?

A. manufacture of soaps
B. manufacture of polyethene
C. manufacture of bleaches
D. manufacture of hydrochloric acid

CE07_43

Which of the following bonds or attractive forces exist in ammonium nitrate?

(1) ionic bond
(2) covalent bond
(3) van der Waals' forces

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

CE07_44 [OUT]

Which of the following statements concerning a zinc-carbon cell are correct?

(1) Manganese(IV) oxide acts as the anode.
(2) Ammonium chloride acts as an electrolyte.
(3) Zinc acts as the negative electrode.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

CE07_45

Using carbon as electrodes, which of the following solutions would give hydrogen upon electrolysis?

(1) 1 M silver nitrate solution
(2) 2 M sodium hydroxide solution
(3) 3 M calcium chloride solution

A. (1) only
B. (2) only
C. (1) and (3) only
D. (2) and (3) only

CE07_46

Which of the following statements concerning the reaction of concentrated nitric acid with copper is/are correct?

(1) A colourless gas is evolved.
(2) One mole of $NO_3^-(aq)$ ions requires one mole of electrons for reduction.
(3) It involves a displacement reaction.

A. (1) only
B. (2) only
C. (1) and (3) only
D. (2) and (3) only

CE08_04

Consider the ionic equation below:

$$2MnO_4^- + x\ Sn^{2+} + y\ H^+ \longrightarrow 2Mn^{2+} + x\ Sn^{4+} + 8H_2O$$

What is the value of x?

A. 2
B. 4
C. 5
D. 7

CE08_05

In which of the following compounds is the oxidation number of nitrogen lowest?

A. NH_4Cl
B. $NaNO_2$
C. NH_2OH
D. $Pb(NO_3)_2$

CE08_11

In which of the following processes does sulphur dioxide act as a reducing agent?

A. passing sulphur dioxide into water
B. passing sulphur dioxide into iodine solution
C. passing sulphur dioxide into iron(II) sulphate solution
D. passing sulphur dioxide into sodium hydroxide solution

CE08_13

Which of the following statements concerning the reaction between acidified potassium permanganate solution and excess propene is INCORRECT?

A. The oxidation number of manganese changes from +7 to +2.
B. The reaction occurred is an addition reaction.
C. The acidified potassium permanganate solution decolourised.
D. The structure of the organic product is $CH_2(OH)CH_2CH_2OH$.

CE08_21

Which of the following substances, when mixed with bromine water, would form a colourless solution?

(1) sodium sulphite
(2) sodium chloride
(3) sodium iodide

A. (1) only
B. (2) only
C. (1) and (3) only
D. (2) and (3) only

CE08_23

Which of the following is/are related to the use of silver oxide cells in watches?

(1) Silver oxide cells are rechargeable.
(2) Silver oxide cells are small in size.
(3) Silver is an expensive metal.

A. (1) only
B. (2) only
C. (1) and (3) only
D. (2) and (3) only

CE08_24

When chlorine reacts with methane under sunlight, which of the following compounds can be formed?

(1) chloromethane
(2) dichloromethane
(3) hydrogen chloride

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

CE08_28

1st statement	2nd statement
The bleaching action of sodium sulphite lasts longer than that of sodium hypochlorite.	Sodium sulphite bleaches by oxidation while sodium hypochlorite bleaches by reduction.

CE08_34

From which of the following processes can lead be obtained in a school laboratory?

A. Lead(II) oxide is heated strongly.
B. Lead(II) oxide is mixed with carbon.
C. Dilute lead(II) nitrate solution is electrolyzed.
D. Zinc is added to dilute lead(II) nitrate solution.

CE08_36

Which of the following processes does NOT involve redox reaction(s)?

A. bromination of methane
B. electrolysis of sea water
C. thermal decomposition of limestone
D. removal of air pollutants in car exhaust by catalytic convertor

CE08_38

Which of the following statements concerning concentrated sulphuric acid is INCORRECT?

A. Concentrated sulphuric acid can be used as a drying agent for ammonia.
B. Adding concentrated sulphuric acid to sugar will give a steamy fume.
C. Blue litmus paper will finally turn black when dropper into concentrated sulphuric acid.
D. When a beaker of concentrated sulphuric acid is left in air, the volume of liquid inside the beaker increases gradually.

CE08_40

A compound is composed of element Z and hydrogen. Electrolysis of this compound under molten state produces the same number of Z atoms at the cathode as hydrogen molecules at the anode. The following half equation shows the change occurring at the anode:

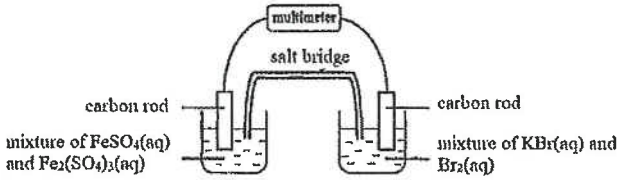
$2H^- \longrightarrow H_2 + 2e^-$

What is the oxidation number of Z in the compound?

A. −2
B. −1
C. +1
D. +2

CE08_44

The following diagram shows the set-up of a chemical cell.



Given that $Br_2(aq)$ is a stronger oxidizing agent than $Fe^{3+}(aq)$, which of the changes represented by the following half equations would occur if the cell is producing a current?

(1) $Fe^{3+}(aq) + e^- \longrightarrow Fe^{2+}(aq)$
(2) $Fe^{2+}(aq) \longrightarrow Fe^{3+}(aq) + e^-$
(3) $2Br^-(aq) \longrightarrow Br_2(aq) + 2e^-$

A. (1) only
B. (2) only
C. (1) and (3) only
D. (2) and (3) only

CE08_48

Upon electrolysis, which of the following solutions would give hydrogen at carbon cathode and oxygen at platinum anode?

(1) very dilute sodium chloride solution
(2) dilute copper(II) sulphate solution
(3) concentrated potassium sulphate solution

A. (1) only
B. (2) only
C. (1) and (3) only
D. (2) and (3) only

CE09_02

In which of the following reactions does nitrogen exhibit three different oxidation numbers in the species involved?

A. $NH_4NO_3 \longrightarrow N_2O + 2H_2O$
B. $8NH_3 + 3Cl_2 \longrightarrow 6NH_4Cl + N_2$
C. $Mg + 4HNO_3 \longrightarrow Mg(NO_3)_2 + 2NO_2 + 2H_2O$
D. $3Cu + 8HNO_3 \longrightarrow 3Cu(NO_3)_2 + 2NO + 4H_2O$

CE09_04

The table below shows whether displacement reaction occurs between metals W, X, Y and Z with their ions. '✓' represents that displacement reaction occurs, while 'X' represents that displacement reaction does not occur.

	W	X	Y	Z
$W^{2+}(aq)$		X	✓	✓
$X^+(aq)$	✓		✓	✓
$Y^{2+}(aq)$	X	X		✓
$Z^+(aq)$	X	X	X	

Which of the following is the strongest reducing agent?

A. X
B. X^+
C. Z
D. Z^+

CE09_13

A drunken driver breathes into a device containing dichromate ions. The oxidation number of chromium would change from

A. +6 to +3.
B. +3 to +6.
C. +3 to +2.
D. +2 to +3.

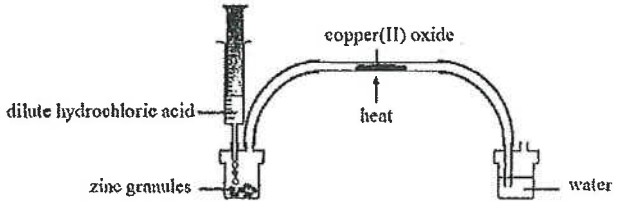
CE09_14

Which of the following is NOT an industrial product made from sulphuric acid?

A. fertilizer
B. paint additive
C. soapless detergent
D. sulphur dioxide preservative

CE09_17

This question refers to the following micro-scale experiment.



Which of the following types of reaction is/are involved in the experiment?

(1) redox reaction
(2) neutralization
(3) thermal decomposition

A. (1) only
B. (2) only
C. (1) and (3) only
D. (2) and (3) only

CE09_24

Which of the following substances can react with acidified potassium permanganate solution?

(1) propene
(2) potassium iodide solution
(3) sodium sulphite solution

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

CE09_30

1st statement	2nd statement
When sulphur dioxide is added to sodium bromide solution, the mixture obtained is colourless.	Sulphur dioxide can act as a bleaching agent.

CE09_31

Which of the following statements concerning ammonium iodide is correct?

A. Ammonium iodide solution is a weak alkali.
B. Ammonium iodide solution is brown in colour.
C. Reaction will occur when ammonium iodide is mixed with chlorine water.
D. No reaction will occur when ammonium iodide is heated with sodium hydroxide.

CE09_34 [OUT]

Which of the following would NOT occur when a zinc-carbon cell is supplying electricity?

A. Water is produced.
B. Zinc case becomes thinner.
C. Ammonium ions are consumed.
D. Manganese compound is oxidized.

CE09_38

In an experiment of electroplating nickel on a copper object, which of the following combinations is correct?

	Anode	Cathode	Electrolyte
A.	copper object	nickel	$CuSO_4(aq)$
B.	copper object	nickel	$NiSO_4(aq)$
C.	nickel	copper object	$CuSO_4(aq)$
D.	nickel	copper object	$NiSO_4(aq)$

CE09_39

Which of the following processes would NOT give an obvious colour change?

A. Bubble ethene into bromine water.
B. Add potassium chloride solution to bromine water.
C. Add concentrated nitric acid to iron(II) sulphate solution.
D. Electrolyze concentrated potassium iodide solution using platinum electrodes.

CE09_42

Which of the following acids can react with silver?

(1) dilute sulphuric acid
(2) concentrated nitric acid
(3) concentrated hydrochloric acid

A. (1) only
B. (2) only
C. (1) and (3) only
D. (2) and (3) only

CE09_44

In the electrolysis of a copper(II) sulphate solution using copper cathode and graphite anode, which of the following would change?

(1) pH of the solution
(2) colour of the solution
(3) mass of the graphite anode

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

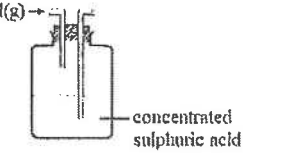
CE09_49

1st statement	2nd statement
Sulphates can be oxidized to sulphites.	Oxidation number of sulphur in sulphates is higher than the oxidation number of sulphur in sulphites.

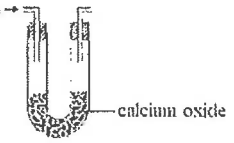
CE10_05

Which of the following set-ups can be used to dry hydrogen chloride gas?

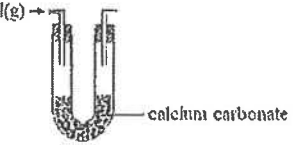
A. $HCl(g)$ → concentrated sulphuric acid



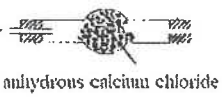
B. $HCl(g)$ → calcium oxide



C. $HCl(g)$ → calcium carbonate



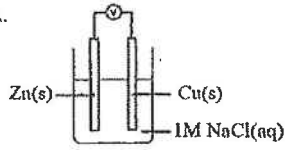
D. $HCl(g)$ → anhydrous calcium chloride



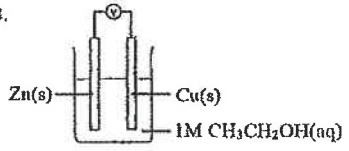
CE10_09

In which of the following set-ups would the voltmeter display the greatest magnitude of voltage reading?

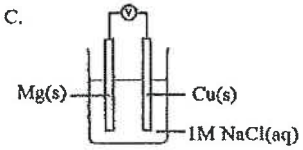
A.



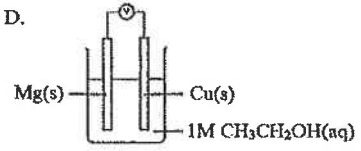
B.



C.



D.



CE10_11

In which of the following species does the underlined element have an oxidation number of +3?

A. $\underline{O}_3$
B. $H_3\underline{P}O_4$
C. $\underline{N}H_4^+$
D. $\underline{N}O_2^-$

CE10_24

Which of the following is/are redox reaction(s)?

(1) $CH_4 + Cl_2 \longrightarrow CH_3Cl + HCl$
(2) $2CrO_4^{2-} + 2H^+ \longrightarrow Cr_2O_7^{2-} + H_2O$
(3) $2KNO_3 \longrightarrow 2KNO_2 + O_2$

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

CE10_30

1st statement	2nd statement
Bromine water can react with NaI(aq).	The reducing power of I^-(aq) ion is stronger than that of Br^-(aq) ion.

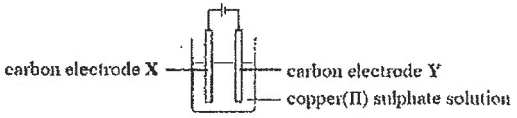
CE10_32

Which of the following processes gives hydrogen gas as the major product?

A. adding iron to dilute nitric acid.
B. adding copper to dilute sulphuric acid.
C. passing stem over heated zinc granules.
D. electrolysis of brine using mercury as the cathode.

CE10_34

In an experiment to study the electrolysis of copper(II) sulphate solution, the set-up used is shown below:



Which of the following statements concerning the above experiment is correct?

A. Reduction occurs at X.
B. Hydrogen gas is evolved at Y.
C. The pH of the solution increases gradually.
D. The colour of the solution remains unchanged.

CE10_36

Consider the experimental set-ups shown in the figures below:

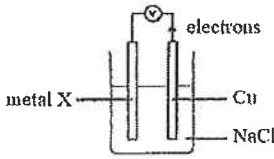


Figure 1

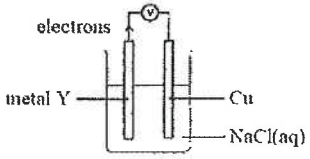


Figure 2

In Figure 1, if Cu is replaced by Y, which of the following statements is correct?

A. Chlorine gas will be evolved at Y.
B. A solid will be deposited on the surface of Y.
C. A greater magnitude of voltage will be recorded.
D. Electrons will flow from X to Y through the external circuit.

CE10_43

Solution Y is added dropwise to a solution of NaOH containing several drops of phenolphthalein. The mixture suddenly changes from pink to colourless. Which of the following substances may Y be?

(1) HCl(aq)
(2) KCl(aq)
(3) Cl_2(aq)

A. (1) only
B. (2) only
C. (1) and (3) only
D. (2) and (3) only

CE10_47

Which of the following reagents can convert iron(II) ions to iron(III) ions?

(1) chlorine water
(2) dilute nitric acid
(3) potassium bromide solution

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

CE10_48

Which of the following experiments would give a colour change?

(1) Sulphur dioxide is passed into a test tube containing bromine water.
(2) Sulphur dioxide is passed into a gas jar containing moist red flower petals.
(3) Sulphur dioxide is passed into a conical flask containing potassium iodide solution.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

CE10_49 [OUT]

	1st statement	2nd statement
	When using a zinc-carbon cell in electrolysis, the carbon electrode of the cell is connected to the cathode of the electrolytic cell.	In a circuit using zinc carbon cell to supply electricity, electrons in the external circuit flow to the carbon electrode of the zinc-carbon cell.

CE11_06

Which of the following processes does NOT involve redox reaction?

A. rusting of iron nails
B. thermal decomposition of calcium carbonate
C. adding zinc granules to concentrated hydrochloric acid
D. adding magnesium ribbons to copper(II) sulphate solution

CE11_07

Both D and E are metals. D reacts with ESO_4 solution according to the following equation:

$$D(s) + ESO_4(aq) \longrightarrow DSO_4(aq) + E(s)$$

If D and E are used as the electrodes in a lemon cell, which of the following statements concerning the lemon cell during discharge is correct?

A. Electrons flow from E to D in the external circuit.
B. $D^{2+}(aq)$ ions are found in the lemon juice.
C. E acts as the negative electrode.
D. D acts as the cathode.

CE11_09

Which of the following statements concerning the conversion of an iodine atom to an iodide ion is correct?

A. The conversion is a reduction.
B. The atomic number of iodine increases by 1.
C. The number of occupied electron shells in an iodine atom is less than that in an iodide ion.
D. The number of occupied electron shells in an iodine atom is greater than that in an iodide ion.

CE11_11

The following three chlorine-containing species are arranged according to the increasing order of oxidation number of chlorine:

HCl, J, $HClO_3$

Which of the following species may NOT be J?

A. Cl_2
B. ClO_2^-
C. Cl_2O_7
D. HOCl

CE11_14

Consider the following equation:

$$p\,ClO_3^- + q\,SO_2 + r\,H_2O \longrightarrow p\,Cl^- + q\,SO_4^{2-} + 2r\,H^+$$

Which of the following combinations is correct?

	p	q	r
A.	1	2	2
B.	1	3	3
C.	2	3	2
D.	1	2	3

CE11_20

Which of the following gases can be dried by using concentrated sulphuric acid?

(1) ammonia
(2) sulphur dioxide
(3) hydrogen chloride

A. (1) only
B. (2) only
C. (1) and (3) only
D. (2) and (3) only

CE11_21

Consider the redox reaction represented by the equation below:

$$PbO_2 + NO_2^- + 2H^+ \longrightarrow Pb^{2+} + NO_3^- + H_2O$$

Which of the following statements is/are correct?

(1) NO_2^- is reduced.
(2) PbO_2 is reduced.
(3) H^+ is neither oxidized nor reduced.

A. (1) only
B. (2) only
C. (1) and (3) only
D. (2) and (3) only

CE11_26

$SO_2(g)$ is passed into each of the following solutions. In which of the solutions will a colour change be observed?

(1) $Br_2(aq)$
(2) $FeSO_4(aq)$
(3) acidified $KMnO_4(aq)$

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

CE11_32 [OUT]

Which of the following statements concerning zinc-carbon cell is correct?

A. Zinc-carbon cell is rechargeable.
B. The positive electrode of zinc-carbon cell is carbon rod.
C. Zinc-carbon cell is a dry cell which does not contain water.
D. A zinc-carbon cell of larger size produces a higher voltage than a smaller one.

CE11_35

Which of the following statements concerning a working electrolytic cell is correct?

A. Water must be present in the electrolytic cell.
B. The electrolytic cell liberates electrical energy.
C. The electrodes in the electrolytic cell must be metal.
D. Redox reaction must be involved in the electrolytic cell.

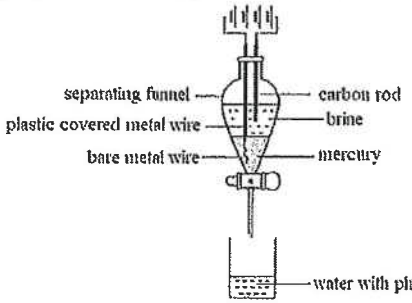
CE11_37

In the electrolysis of concentrated potassium chloride solution using carbon electrodes, gaseous products are liberated at both electrodes. After a short period of time, what is the theoretical volume ratio of *the gas collected at the cathode* to *the gas collected at the anode*?

A. 1 : 1
B. 1 : 2
C. 1 : 4
D. 2 : 1

CE11_44

The following diagram shows the set-up of an experiment.



After some time, the tap of the separating funnel is opened to run some mercury from the separating funnel into a beaker containing water with phenolphthalein. Which of the following statements concerning the experiment is/are correct?

(1) Mercury in the separating funnel can increase the electrical conductivity of the brine.
(2) The water with phenolphthalein turns red.
(3) The carbon rod acts as the cathode.

A. (1) only
B. (2) only
C. (1) and (3) only
D. (2) and (3) only

CE11_49

1st statement	2nd statement
2M nitric acid can react with copper but 2M ethanoic acid cannot.	2M nitric acid is a stronger acid than 2M ethanoic acid.

AL07(I)_03

The reaction shown below takes place in liquid ammonia:

$$NH_4Br + KNH_2 \longrightarrow KBr + 2NH_3$$

Which one of the following best describes the reaction?

A. Displacement
B. Neutralization
C. Redox
D. Substitution

ASL09(I)_03

Which one of the products listed below is NOT obtained industrially from the electrolysis of brine?

A. Hydrogen
B. Oxygen
C. Sodium chlorate(I)
D. Sodium hydroxide

ASL12(I)_03

In which of the following species does hydrogen have an oxidation of −1?

A. CaH_2
B. CH_4
C. H_2O
D. NH_3

ASL13(I)_03

Which of the following product(s) is/are obtained when chlorine gas is bubbled into a hot concentrated solution of sodium hydroxide?

A. NaClO only
B. NaCl and NaClO
C. $NaClO_3$ only
D. NaCl and $NaClO_3$

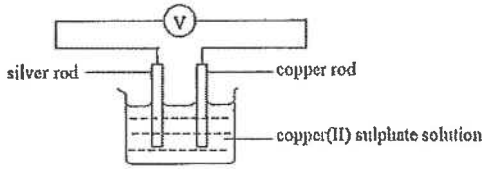
DSE11SP_02

In which of the following compounds does sulphur exhibit the lowest oxidation number?

A. $Na_2S_2O_3$
B. $MgSO_4$
C. $KHSO_3$
D. $H_2S_2O_7$

DSE11SP_12

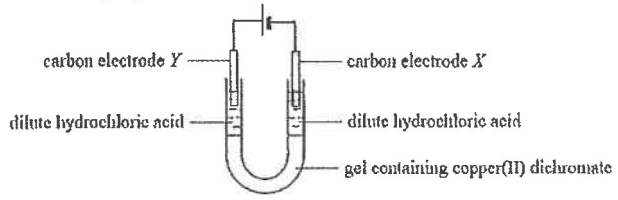
Which of the following combinations concerning the set-up shown below is correct after a current has flowed through the external circuit for some time?



	Mass of anode	Color of copper(II) sulphate solution
A.	Increases	No change
B.	Decreases	No change
C.	Increases	Becomes lighter
D.	Decreases	Becomes lighter

DSE11SP_21

Consider the following experiment:



Which of the following statements concerning the experiment are correct?

(1) Gas bubbles are evolved at electrode *X*.
(2) An orange color gradually appears in the solution around electrode *Y*.
(3) The experiment can be used to show that ions migrate towards oppositely charged electrodes.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

DSE11SP_23

1st statement	2nd statement
Bromine water can be used to distinguish between sodium sulphate and sodium sulphite solution.	Bromine can be reduced by sodium sulphite to colorless bromide, but not by sodium sulphate.

DSE12PP_14

Consider the following chemical equation:

$$p SO_2(aq) + q Ce^{4+}(aq) + r H_2O(l) \longrightarrow p SO_4^{2-}(aq) + q Ce^{3+}(aq) + 2r H^+(aq)$$

(Ce is the chemical symbol for cerium.)

Which of the following combinations is correct?

	p	*q*	*r*
A.	1	1	1
B.	1	1	2
C.	1	2	2
D.	2	1	2

DSE12PP_22

Consider the electrolysis experiments using the following combinations of electrolyte solution

	Electrolyte solution	Anode	Cathode
(1)	Copper(II) sulphate solution	Copper	Copper
(2)	Copper(II) chloride solution	Graphite	Graphite
(3)	Potassium sulphate solution	Platinum	platinum

In which of these experiments will the concentration of the electrolyte solution remain UNCHANGED?

A. (1) only
B. (2) only
C. (1) and (3) only
D. (2) and (3) only

DSE12PP_23

Which of the following statements about lithium-ion batteries is/are correct?

(1) In lithium-ion batteries, the electrolyte is a lithium salt in water.
(2) Lithium-ion batteries are rechargeable.
(3) The disposal of lithium-ion batteries causes less harm to the environment than that of nickel-cadmium batteries.

A. (1) only
B. (2) only
C. (1) and (3) only
D. (2) and (3) only

DSE12_06

What is the oxidation number of Cu in $Cu(NH_3)_4Cl_2$?

A. 0
B. +2

C. +4 D. +6

DSE12_13

The tendency of being reduced of six ionic species increase in the order as shown below:

$$Ba^{2+}(aq) < Na^{+}(aq) < Mg^{2+}(aq) < H^{+}(aq) < Cu^{2+}(aq) < Hg^{2+}(aq)$$

Which of the following statements is correct?

A. Ba(s) does NOT react with $H^{+}(aq)$
B. Na(s) has a stronger reducing power than Hg(l)
C. $Hg^{2+}(aq)$ is the weakest oxidizing agent among the six species.
D. Displacement reaction occurs when Cu(s) is immersed in $MgSO_4(aq)$

DSE12_18

Which of the following statements concerning a hydrogen-oxygen fuel cell is/are correct?

(1) It produces non-polluting product.
(2) The membrane in it selectively allows hydroxide ions to pass through.
(3) It can continuously produce electricity as long as hydrogen and oxygen are supplied under operating conditions.

A. (1) only B. (2) only
C. (1) and (3) only D. (2) and (3) only

DSE12_30

Which of the following ions can act as both an oxidizing agent and a reducing agent?

A. $Fe^{2+}(aq)$ B. $Cu^{2+}(aq)$
C. $Cr_2O_7^{2-}(aq)$ D. $MnO_4^{-}(aq)$

DSE13_16

$$2IO_3^{-}(aq) + wH_2O_2(aq) + xH^{+}(aq) \longrightarrow I_2(aq) + yO_2(g) + zH_2O(l)$$

Which of the following is the correct combination of the reaction coefficients y and z?

	y	z
A.	4	5
B.	5	4
C.	5	6
D.	6	5

DSE13_17

Potassium peroxodisulphate ($K_2S_2O_8$) can be obtained from the electrolysis of a saturated solution of potassium hydrogensulphate ($KHSO_4$).

Which of the following correctly describes the oxidation number of sulphur in $KHSO_4$, and the electrode at which $K_2S_2O_8$ is produced during the electrolysis?

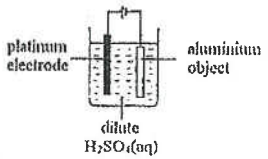
	Oxidation number of S	Electrode at which $K_2S_2O_8$ is produced
A.	+6	Anode
B.	+6	Cathode
C.	+4	Anode

D. +4 Cathode

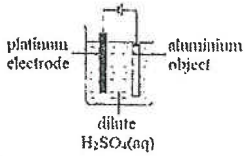
DSE13_06

Which of the set-ups shown below can best be used to anodize an aluminum object?

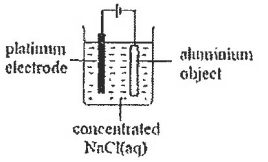
A.



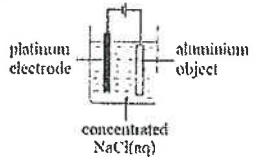
B.



C.



D.



DSE13_21

Which of the following is/are secondary cell(s)?

(1) Alkaline manganese cell
(2) Lithium ion cell
(3) Nickel metal hydride cell

A. (1) only B. (2) only
C. (1) and (3) only D. (2) and (3) only

DSE13_22

Which of the following reagents can be used to distinguish between sodium sulphite and sodium sulphate?

(1) Iron(II) chloride solution
(2) Acidified potassium permanganate solution
(3) Concentrated nitric acid

A. (1) only B. (2) only
C. (1) and (3) only D. (2) and (3) only

DSE14_15

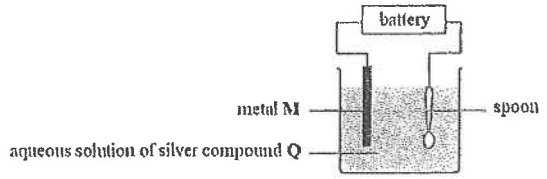
Which of the following hazard warning labels should be displayed on both the reagent bottle storing concentrated sulphuric acid and the reagent bottle storing concentrated hydrochloric acid?

(1) (2) (3)

A. (1) only B. (2) only
C. (1) and (3) only D. (2) and (3) only

DSE14_11

The diagram below shows a set-up in which silver is being plated on a spoon:



Which of the following statements concerning the above set-up is correct?

A. M must be silver.
B. Q can be silver chloride.
C. The spoon is connected to the negative pole of the battery.
D. Electrons flow from metal M to the spoon through the solution.

DSE14_16 [OUT]

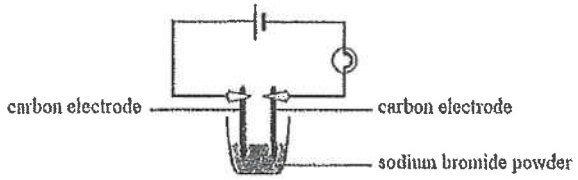
Which of the following statements concerning a zinc-carbon cell is / are correct?

(1) The zinc case would become thinner when being used.
(2) Its voltage remains unchanged when being used.
(3) It can be recharged after use

A. (1) only
B. (2) only
C. (1) and (3) only
D. (2) and (3) only

DSE14_20

The diagram below shows the set-up of an experiment:



Which of the following methods may light up the light bulb?

(1) heating the sodium bromide powder until molten
(2) adding deionized water to the sodium bromide powder
(3) replacing the sodium bromide powder with bromine liquid

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

DSE15_02

Which of the following processes would NOT give oxygen?

A. Heating mercury(II) oxide strongly
B. Electrolysis of dilute sulphuric acid
C. Fractional distillation of liquefied air
D. Passing steam over heated magnesium

DSE15_06

The conversion of nitrogen gas to nitric acid involves the following steps:

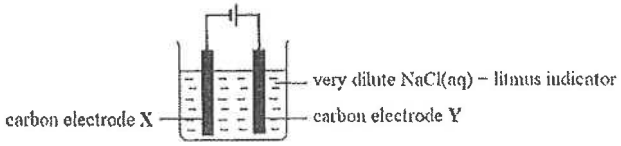
$$N_2 \xrightarrow{\text{Step 1}} NH_3 \xrightarrow{\text{Step 2}} NO \xrightarrow{\text{Step 3}} NO_2 \xrightarrow{\text{Step 4}} HNO_3$$

In which step is nitrogen reduced?

A. Step 1
B. Step 2
C. Step 3
D. Step 4

DSE15_13

An electrolysis experiment is conducted using the set-up shown below:

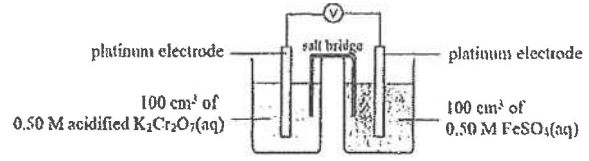


What are the expected colors around X and Y after the experiment has been conducted for some time?

	X	Y
A.	Yellow	Red
B.	Red	Blue
C.	Blue	Red
D.	Red	Yellow

DSE15_16

Consider the following set-up at the start of an experiment:



After a period of time, the concentration of $K_2Cr_2O_7(aq)$ drops to 0.47 M. What is the concentration of $FeSO_4(aq)$ at that time?

A. 0.53 M
B. 0.47 M

C. 0.41 M D. 0.32 M

DSE15_17

$$4KI(aq) + 2CO_2(g) + O_2(g) \longrightarrow 2K_2CO_3(aq) + 2I_2(aq)$$

Which of the following statements concerning the above reaction is / are correct?

(1) KI(aq) is oxidized by $O_2(g)$.
(2) KI(aq) is oxidized by $CO_2(g)$.
(3) The yellow color is due to the $K_2CO_3(aq)$ formed.

A. (1) only B. (2) only
C. (1) and (3) only D. (2) and (3) only

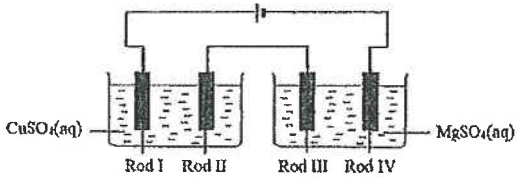
DSE16_11

In which of the following substances does nitrogen have the highest oxidation number?

A. NF_3 B. N_2H_4
C. $NaNH_2$ D. $HONH_2$

DSE16_12

The diagram below shows the set-up used in an electroplating experiment involving four iron rods:

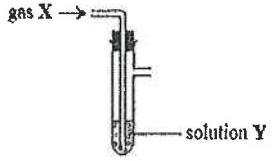


On which of the following iron rods would a metal be plated?

A. Rod I B. Rod II
C. Rod III D. Rod IV

DSE16_13

Gas X is bubbled steadily into solution Y as shown in the diagram below:



In which of the following combinations would NOT have a visible change in solution Y?

	Gas X	Solution Y
A.	$Cl_2(g)$	KI(aq)
B.	$O_2(g)$	$FeSO_4(aq)$
C.	$CO_2(g)$	acidified $KMnO_4(aq)$
D.	$SO_2(g)$	acidified $Na_2Cr_2O_7(aq)$

DSE16_14

Which of the following is NOT a redox reaction?

A. $2AgBr(s) \longrightarrow 2Ag(s) + Br_2(g)$
B. $SO_2(g) + 2H_2S(g) \longrightarrow 3S(s) + 2H_2O(l)$
C. $2KClO_3(s) \longrightarrow 2KCl(s) + 3O_2(g)$
D. $Ca(HCO_3)_2(aq) \longrightarrow CaCO_3(s) + H_2O(l) + CO_2(g)$

DSE16_15

The following equations shows the reaction when a secondary cell is discharging:

$$2NiO(OH)(s) + Cd(s) + 2H_2O(l) \longrightarrow 2Ni(OH)_2(s) + Cd(OH)_2(s)$$

Which of the following half equations shows the change at the negative electrode when the cell is being recharged?

A. $Cd(s) + 2OH^-(aq) \longrightarrow Cd(OH)_2(s) + 2e^-$
B. $Cd(OH)_2(s) + 2e^- \longrightarrow Cd(s) + 2OH^-(aq)$
C. $Ni(OH)_2(s) + OH^-(aq) \longrightarrow NiO(OH)(s) + H_2O(l) + e^-$
D. $NiO(OH)(s) + H_2O(l) + e^- \longrightarrow Ni(OH)_2(s) + OH^-(aq)$

DSE16_20

Pb is an element in Group IV of the Periodic Table and can form Pb^{2+} ion. Which of the following statements are correct?

(1) The change from Pb^{2+} ion to Pb atom is a reduction.
(2) Both Pb atom and Pb^{2+} ion have the same number of protons.
(3) Both Pb atom and Pb^{2+} ion have the same number of occupied electron shells.

A. (1) and (2) only B. (1) and (3) only
C. (2) and (3) only D. (1), (2) and (3)

DSE16_23

1st statement	2nd statement
During anodization, the aluminium oxide on the surface of aluminium is reduced to metal.	The corrosion resistance of aluminium can be enhanced by anodization.

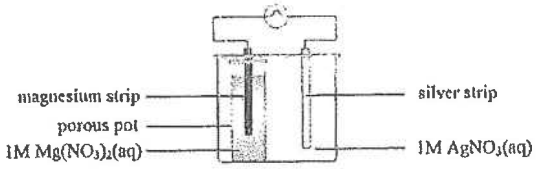
DSE17_08

Which of the following statements concerning hydrogen-oxygen fuel cell is INCORRECT?

A. It contains a catalyst.
B. Water is formed during discharge.
C. Oxygen gas is passed to the anode.
D. Hydrogen gas acts as the reducing agent.

DSE17_04

The diagram below shows a set-up with the bulb lights up:



Which of the following statements concerning the set-up is correct?

A. Silver ions migrate towards the porous pot.
B. The mass of he magnesium strip decreases.
C. Heat energy is converted into electrical energy.
D. Hydrogen ions are discharged on the silver strip.

DSE17_11

Which of the following statements concerning zinc is correct?

A. It forms a soluble oxide when placed in NH_3(aq).
B. It acts as a reducing agent when placed in HCl(aq).
C. It undergoes oxidation when placed in $MgCl_2$(aq).
D. It forms an acidic solution when placed in hot H_2O(l).

DSE17_15

Consider the following chemical equation:

$$3Ni(OH)_2(s) + xHCl(aq) + yAuCl_4^-(aq) \longrightarrow 3NiCl_4(aq) + yAu(s) + zCl^-(aq) + 6H_2O(l)$$

Which of the following combinations is correct?

	x	y	z
A.	4	2	2
B.	6	2	2
C.	4	3	3
D.	6	3	3

DSE17_23

What would be observed when a few drops of concentrated nitric acid is added to KI(aq)?

(1) A brown solution is formed.
(2) A brown precipitate is formed.
(3) A reddish brown gas is released.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

DSE18_12

Which of the following is NOT a redox reaction?

A. $2Mg + SO_2 \longrightarrow 2MgO + S$
B. $CaCO_3 + SiO_2 \longrightarrow CaSiO_3 + CO_2$
C. $Cu_2O + H_2SO_4 \longrightarrow CuSO_4 + Cu + H_2O$
D. $3CuS + 8HNO_3 \longrightarrow 3CuSO_4 + 8NO + 4H_2O$

DSE18_21 [OUT]

Which of the following statements concerning a zinc-carbon cell is/are INCORRECT?

(1) The graphite rod is inserted in a mixture of graphite powder and MnO_2.
(2) Potassium hydroxide acts as an electrolyte.
(3) Ammonia form around the cathode.

A. (1) only
B. (2) only
C. (1) and (3) only
D. (2) and (3) only

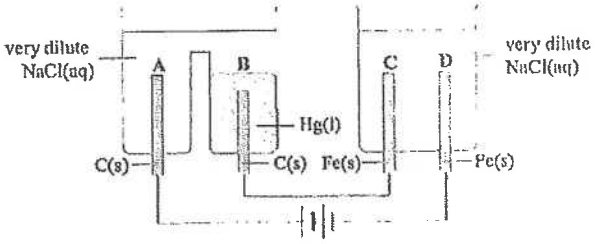
DSE19_03

Which of the following processes does NOT involve oxidation and reduction?

A. Red wine turning sour
B. Removing rust using white vinegar
C. Combusting natural gas in a power station
D. Removing nitrogen oxides in the catalytic converter of a car

DSE19_11

Consdier the following electrolytic cells:

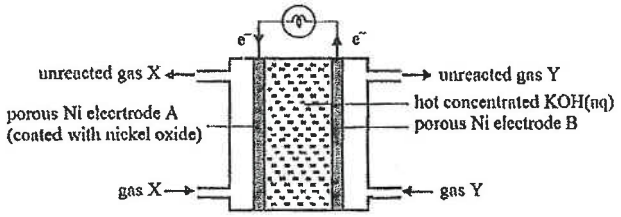


What would happen during electrolysis ?

A. Oxygen forms around A
B. Chlorine forms around B
C. Hydrogen forms around C
D. Iron(II) ions form around D.

DSE19_12

Which of the following statements concerning the fuel cell below that can form water is INCORRECT?



A. It is a primary cell.
B. Ni also acts as a catalyst.
C. X can be obtained from fractional distillation of liquid air.
D. The rquation for the change at electrode B is: $4OH^- \longrightarrow 2H_2O + O_2 + 4e^-$

DSE19_14

Consider the following reaction:

$$(NH_4)_2Cr_2O_7(s) \longrightarrow Cr_2O_3(s) + N_2(g) + 4H_2O(g)$$

Which of the following statements is /are correct?

(1) The oxidation number of chromium decreases.
(2) Only covalent bonds are broken and formed.
(3) Green solid turns to orange solid.

A. (1) only
B. (2) only
C. (1) and (3) only
D. (2) and (3) only

DSE19_19

In which of the following reactions does the underlined chemical acts as a reducing agent?

(1) $2\underline{C_4H_{10}} + 13O_2 \longrightarrow 8CO_2 + 10H_2O$
(2) $\underline{Ba(NO_3)_2} + Na_2SO_4 \longrightarrow BaSO_4 + 2NaNO_3$
(3) $\underline{Zn(OH)_2} + 2NaOH \longrightarrow Na_2Zn(OH)_4$

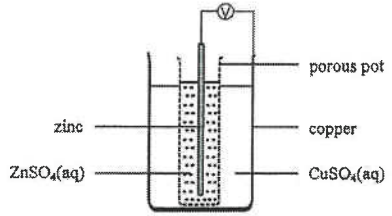
A. (1) only
B. (2) only
C. (1) and (3) only
D. (2) and (3) only

DSE20_5

5. Which of the following statements concerning francium (atomic number = 87) is correct ?

A. Francium has a higher melting point than potassium.
B. Francium forms cations more readily than potassium.
C. Francium is a weaker oxidising agent than potassium.
D. Francium has a fewer number of occupied electron shells than potassium.

9. Refer to the following chemical cell :



Which of the following statements is correct ?

A. Copper is the cathode of the cell.
B. Zinc ions act as the oxidising agent in the cell.
C. Only zinc ions can pass through the porous pot.
D. Electrons flow from copper to zinc through the external circuit.

DSE20_12

12. Refer to the following half equations :

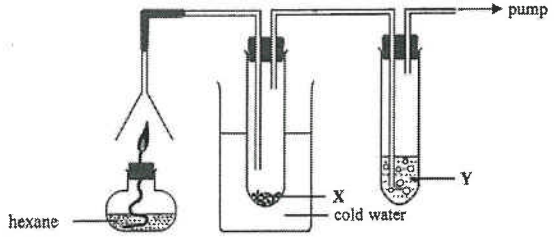
$$C_2O_4^{2-}(aq) \rightarrow 2CO_2(g) + 2e^-$$
$$MnO_4^-(aq) + 8H^+(aq) + 5e^- \rightarrow Mn^{2+}(aq) + 4H_2O(l)$$

What is the minimum volume of 0.010 M acidified $KMnO_4(aq)$ required to completely oxidise 15.00 cm^3 of 0.020 M $Na_2C_2O_4(aq)$?

A. 6.00 cm^3
B. 12.00 cm^3
C. 15.00 cm^3
D. 75.00 cm^3

DSE20_14

14. The set-up below is used to show that hexane (C_6H_{14}) contains carbon and hydrogen. What are X and Y ?



	X	Y
A.	$PbSO_4(s)$	limewater
B.	$NaOH(s)$	bromine water
C.	anhydrous $CoCl_2(s)$	limewater
D.	anhydrous $CuSO_4(s)$	bromine water

DSE20_19

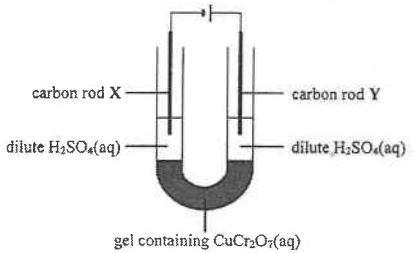
19. Which of the following processes can form a halogen ?

(1) Electrolyse concentrated KCl(aq).
(2) Add $Na_2SO_4(s)$ to concentrated HBr(aq).
(3) Add KI(s) to acidified $KMnO_4(aq)$.

A. (1) only
B. (2) only
C. (1) and (3) only
D. (2) and (3) only

DSE21_02

2. Consider the following experimental set-up :



Which of the following statements is correct when an electric current passes through the circuit ?

A. Blue colour is observed in the dilute $H_2SO_4(aq)$ around **Y**.
B. Gas bubbles are observed in the dilute $H_2SO_4(aq)$ around **Y**.
C. Orange colour is observed in the dilute $H_2SO_4(aq)$ around **X**.
D. Electrons flow from **X** to **Y** through the external circuit.

DSE21_07

7. The oxidation number of Pb in $Pb_{10}(VO_4)_6F_2$ is +2. What is the oxidation number of V ?

A. –3
B. +2
C. +4
D. +5

DSE21_09

9. Gases discharged from coal-fired power plants contain SO_2. SO_2 is also regarded as an air pollutant. What is the most suitable way to remove the SO_2 before discharging these gases into the atmosphere ?

A. Pass these gases through calcium oxide.
B. Pass these gases through concentrated sulphuric acid.
C. Cool these gases to liquefy SO_2 for subsequent removal.
D. Pass these gases through an organic solvent such as hexane.

DSE21_22

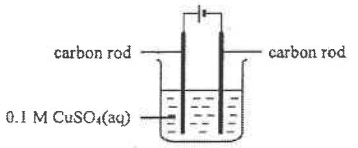
22. Which of the following statements concerning hydrogen-oxygen fuel cells are correct ?

(1) When used to power vehicles, they are more environmentally friendly than using petrol engine.
(2) When used in space stations, they can produce drinking water in addition to energy.
(3) When used as a back-up power source in hospitals, they do not produce noise pollution.

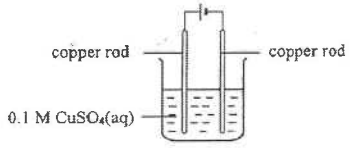
A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

DSE21_23

23. Consider the following two electrolytic cells :



Electrolytic cell 1



Electrolytic cell 2

During electrolysis, which of the following would occur in **Electrolytic cell 1** but not in **Electrolytic cell 2** ?

(1) Gas bubbles are given out.
(2) The blue solution becomes paler.
(3) A reddish brown solid is deposited.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

DSE21_27

27. Copper(II) oxide can catalyse the decomposition of hydrogen peroxide to form oxygen and water. In an experiment, hydrogen peroxide solution is shaken with copper(II) oxide in a test tube. What would be observed in the test tube after the completion of the reaction ?

A. a pale blue liquid
B. a blue solid and a colourless liquid
C. a black solid and a colourless liquid
D. a reddish brown solid and a colourless liquid

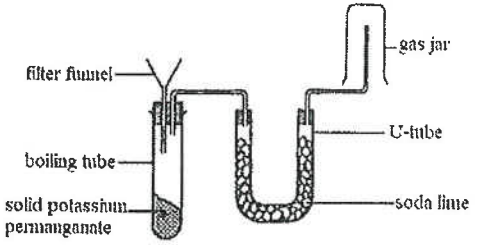
Structural Questions

CE90_02a(i)

A teacher asked a student to describe an experiment to illustrate a redox reaction using concentrated hydrochloric acid.

The following is the student's answer. There are three mistakes in this answer, two of which have been underlined by the teacher.

'Set up the apparatus in a fume cupboard as shown in the diagram below. Pour concentrated hydrochloric acid into a filter funnel. Pass the gas generated through a U-tube containing soda lime to dry the gas and to remove hydrochloric acid fumes. Collect the gas by downward displacement of air.'



(1) Write a balanced equation with state symbols for this redox reaction.

(2) Explain why this reaction is an example of a redox reaction in terms of changes in oxidation number of the reactants.

(4 marks)

CE90_04a

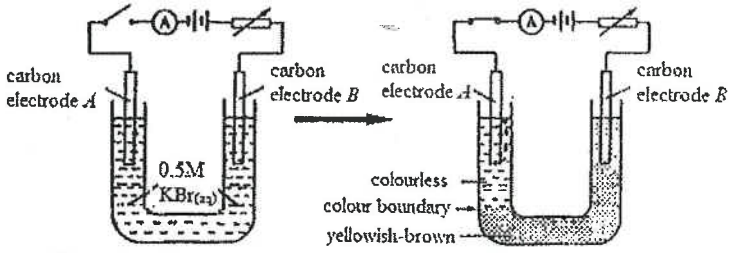


Diagram I: before electrolysis

Diagram II: after electrolysing for some time

Diagram I shows a set-up for the electrolysis of 0.5M potassium bromide solution. After passing electricity for some time, gas bubbles were observed at electrode A, while the solution around electrode B turned yellowish-brown. This colouration gradually extended to the bottom of the U-tube and a steady colour boundary was formed as shown in diagram II.

(i) Which of the electrodes was the cathode?

(ii) Name the gas produced at electrode A, and suggest a chemical test to identify this gas.

(iii) Write half equations for the reactions that occurred during electrolysis at electrodes A and B.

(v) Name the electrolysis product responsible for producing the yellowish-brown colour and explain why the colour extended to the bottom of the U-tube.

(vi) (1) What ions would migrate from the solution around electrode A towards electrode B during electrolysis?

(10 marks)

CE91_02c

Iron sheets can be tin-plated by electrolysis of either tin(II) or tin(IV) compounds before they are used to make food cans.

(i) In the above electrolysis, what material should be used as the anode?

(ii) Based on the quantity of electricity consumed, determine whether the use of a tin(II) or tin(IV) compound is more economical in the electrolysis process.

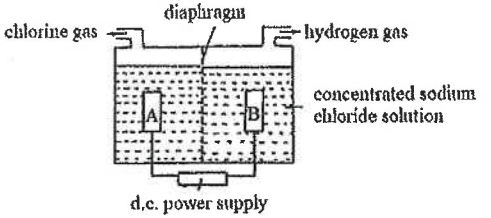
(iii) Give one reason to explain why iron is first tin-plated before food cans are made from it.

(iv) If the tin-plated iron sheet has been scratched to expose the iron, can it still be used to make a food can? Explain.

(6 marks)

CE92_05a

Sodium hydroxide can be manufactured by the electrolysis of concentrated sodium chloride solution in the following set-up, where A and B are inert electrodes.



(i) Explain which electrode, A or B, is the cathode.

(ii) Using the concept of preferential discharge of ions, explain the electrode reactions and why sodium hydroxide can be manufactured by the above electrolysis.

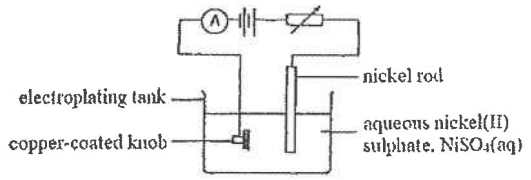
(6 marks)

CE03_02a

Turning knobs on radios are often made of plastics plated with metal coatings.

(ii) What is the purpose of plating the knobs with metals?

The plastic knobs are first coated with copper and then electroplated with nickel. The electroplating can be conducted using the following set-up:



(iii) Why is the plastic knob first coated with copper before electroplating?

(iv) Write an ionic equation for the reaction that occurs at the cathode during electroplating.

(3 marks)

CE94_01c

The table below lists some information about three metals X, Y and Z.

Metal	X	Y	Z
Atomic number	12	20	–
Action of cold water	No apparent change	A colourless gas slowly evolves	No apparent change
Action of 0.1M hydrochloric acid	A colourless gas evolves	–	No apparent change

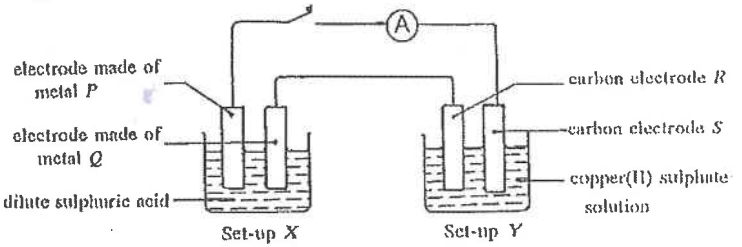
When Z is heated with concentrated sulphuric acid, a colourless gas evolves and the solution turns blue.

(i) What gas is evolved? Suggest a chemical test for the gas.

(ii) What would be observed if a piece of metal X is added to the blue solution?

(4 marks)

CE94_07a



In the above diagram, P and Q are two different metals. When the circuit is closed, a current flows in the external circuit. After some time, 0.36 g of copper is deposited on the carbon electrode R.

(i) (1) What is the direction of electron flow in the external circuit? Explain your answer.

(ii) After the circuit has been closed for some time, what would be observed

(1) at the carbon electrode S?

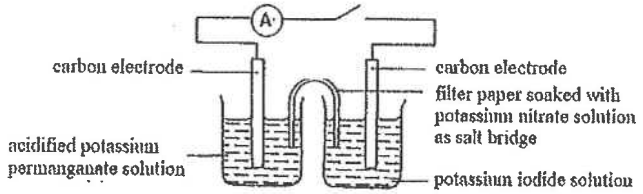
(2) in the copper(II) sulphate solution?

(iii) What is the function of set-up X in this experiment?

(iv) Which of the metals, P or Q, occupies a higher position in the electrochemical series? Explain you answer.

(7 marks)

CE95_09b



When the circuit in the set-up shown above is closed, the acidified potassium permanganate solution loses its colour gradually.

(i) Write a half equation for the reaction that occurs in the acidified potassium permanganate solution. Explain whether the permanganate ion is oxidized or reduced.

(ii) What would be observed in the potassium iodide solution after some time? Write a half equation for the reaction that would occur.

(iii) Identify the direction of electron flow in the external circuit.

(iv) Write an ionic equation for the reaction that occurs when an acidified potassium permanganate solution and a potassium iodide solution are mixed together.

(v) (1) What is the function of the salt bridge in the set-up?

(2) Explain whether a sodium sulphite solution can be used instead of a potassium nitrate in the salt bridge.

(8 marks)

CE96_06a

The table below lists the oxidation number of iron in two compounds:

Compound	Iron(II) sulphate	Iron(III) sulphate
Oxidation number	+2	+3

(i) (1) What would be observed when sodium hydroxide solution is added to iron(II) sulphate solution? Write an ionic equation for the reaction involved.

(2) Explain whether this reaction is a redox reaction.

(ii) When iron(II) sulphate solution is mixed with dilute sulphuric acid and a small amount of a purple solution, a reaction occurs and the oxidation number of iron changes from +2 to +3.

(1) Suggest what the purple solution may be.

(2) What would be observed in this reaction? Write an ionic equation for the reaction involved.

(iii) When iron(II) sulphate solution reacts with an element X, the oxidation number of iron changes from +2 to 0.

(1) Suggest what X may be.

(2) What would be observed in this reaction? Explain whether iron(II) sulphate solution acts as a reducing agent or an oxidizing agent in this reaction.

(10 marks)

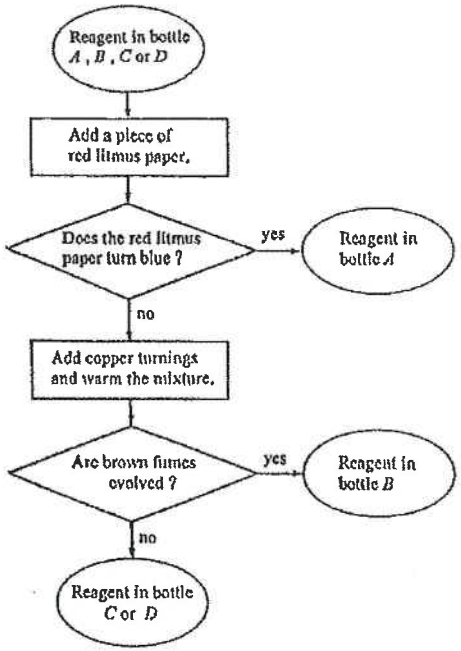
CE96_06b

A, B, C and D are four unlabeled bottles, each containing one of the following reagents:

2M ammonia solution, 2M ethanoic acid,

2M hydrochloric acid, 2M nitric acid

The following scheme is used to identify the four reagents:



(i) What is the reagent in bottle *A*? Explain why this reagent turns red litmus paper blue.

(ii) What is the reagent in bottle *B*? Write a chemical equation for the reaction between this reagent and copper turnings, and a chemical equation for the information of the brown fumes.

(iii) (1) Suggest a test to distinguish between the reagents in bottles *C* and *D*. (Smelling the reagents in NOT an acceptable answer.)

(2) State the observable change in this test and explain your answer.

(8 marks)

CE96_08b(iii)

The diagram below shows a ten dollar coin which is made of two alloys, *X* and *Y*.

When alloy *X* is heated with concentrated sulphuric acid, a bluish-green solution is formed and a colourless gas is evolved.

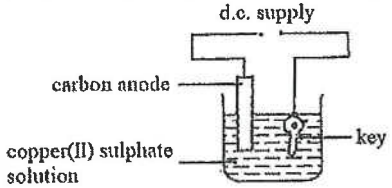
(1) Suggest ONE metal that may be present in *X*. Explain your answer.

(2) What is the colourless gas? Suggest a chemical test for the gas.

(4 marks)

CE96_09b

A student carried out a copper-plating experiment in the laboratory using the set-up shown below:



(i) Explain why copper(II) sulphate solution can conduct electricity.

(ii) What would be observed at the carbon anode during the experiment? Write a half equation for the reaction involved.

(iii) In the copper-plating industry, a metal is used as the anode instead of carbon. What is this metal? Explain your answer.

(iv) In a copper-plating factory, the waste water is treated with sodium hydroxide solution to remove the copper(II) ions present before discharge.

(1) Suggest TWO reasons why it is necessary to remove the copper(II) ions from the waste water before discharge.

(2) 20.0 dm^3 of a sample of waste water require 3.5 dm^3 of 8.0 M sodium hydroxide solution for complete removal of the copper(II) ions present.
Calculate the concentration, in mol dm^{-3}, of copper(II) ions in the sample.

(10 marks)

CE97_04

Briefly describe how you would conduct an experiment, using the materials and apparatus below, to nickel-plate a clean metal spoon. (Diagrams are NOT required). State the expected observation of the experiment.

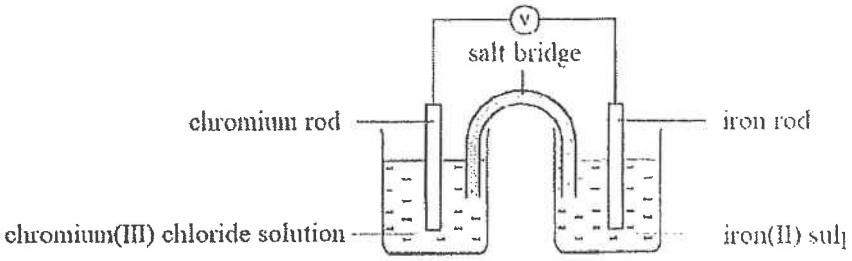
a clean metal spoon, a nickel plate, nickel(II) sulphate crystals,

a large beaker of distilled water, a d.c. power supply and connecting wires

(8 marks)

CE97_06a

A student used the following experimental set-up to study the migration of ions.



The student placed a drop of potassium dichromate solution at A and a drop of a deep blue solution at C. It is solutions do not react and the deep blue colour of the solution at C is due to the cation present.

(i) Write the formula of the ion responsible for the orange colour of potassium dichromate.

(ii) Why was the filter paper moistened with sodium sulphate solution?

(iii) An electric current was passed through the circuit for some time.

(1) What would be the colour change at A?

(2) What would be the colour change at B? Explain your answer.

(iv) Using the same apparatus and materials, suggest how you could show that the colour changes in diffusion.

CE97_08a

A class of students visited a chemical plant which manufactures chlorine by the electrolysis of brine. Some of the chlorine produced is used to make chlorine bleach. At the end of the visit, each student was given a bottle of chlorine bleach as a gift.

(i) Explain, in terms of preferential discharge of ions, how chlorine is produced in the electrochemical process.

(ii) The students found some metal cylinders containing chlorine in the chemical plant. The students were told that these cylinders would be used in water treatment plants.

(1) Which one of the following hazard warning labels should be displayed on the metal cylinders?

A B C D

(2) Explain why chlorine is used in water treatment plants.

(5 marks)

CE97_08b

Read the following paragraph concerning chromium and answer the questions that follow:

The Greek word "*chrōma*" means colour. Many chromium-containing compounds and chromium-containing gemstones are beautifully coloured. The oxidation number of chromium in its compounds can be +2, +3 and +6.

(ii) Potassium dichromate is an oxidizing agent. The oxidation number of chromium in potassium dichromate is +6.

(1) Name ONE compound which can be oxidized by potassium dichromate.

(2) State the condition(s) under which the compound reacts with potassium dichromate.

(3) What product is formed from the compound in the redox reaction?

(iii) In the presence of a dilute acid, chromium(II) ions react with atmospheric oxygen to form chromium(III) ions and water.

(1) Write the half equation for the formation of chromium ions.

(2) Write the half equation for the formation of water.

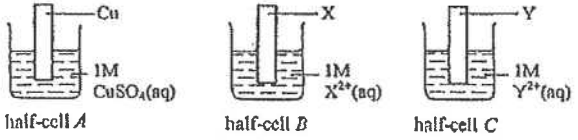
(3) Write the overall equation for the reaction.

(iv) Suggest TWO ways in which chromium can be used to prevent the corrosion of iron.

(8 marks)

CE97_09b

X and Y are different metals. A student studied the reactivity of X, Y and copper by setting up two electrochemical cells using the following materials and apparatus:



half-cell *A* half-cell *B* half-cell *C*

strips of filter paper

saturated solution of potassium nitrate

connecting wires with crocodile clips

The results of the experiment are tabulated below:

Electrochemical cell	Direction of electron flow in the external circuit
formed by connecting half-cells A and C	Y to Cu
formed by connecting half-cells B and C	X to Y

(i) What is the meaning of the term 'saturated solution'?

(ii) Explain the use of the strips of filter paper in the experiment.

(iii) The student had to use an additional instrument to determine the direction of electron flow in the external circuit.

(1) What instrument did the student use?

(2) Draw a labelled diagram to show the set-up for the experiment, using half-cells A and C.

(iv) Arrange X, Y and copper in the order of increasing reactivity. Explain your answer.

(v) What would be observed when a piece of copper foil is immersed in an aqueous solution containing 1 mol dm^{-3} of Y^{2+} ions? Explain your answer.

(9 marks)

CE98_02

For each of the following experiments, state the expected observation and write a relevant chemical equation.

(c) A sodium sulphate solution is added to an iodine solution (iodine dissolved in aqueous potassium iodide).

(2 marks)

CE98_06b

The table below includes some information about three types of dry cells. The voltage of each type of cell is 1.5V.

Type	Voltage over discharge	Price per cell / $	Shelf life / year	Life / minutes
Zinc-carbon cell (AA size)	falls quite rapidly	2.5	1.5	70
Alkaline manganese cell (AA size)	remains steady	5.0	3	90
Silver oxide cell (button type)	remains steady	8.0	2	30

(The life of a cell has been determined from its use in a test with a motorized toy.)

(i) Decide and explain which type of cell should be used in a small CD-player (Discman).

(ii) A package of 24 zinc-carbon cells is now being offered at a special price of $49.90. Assuming that your radio consumes one zinc-carbon cell per month, would you buy a package of these specially-priced cells for the use of your radio? Explain your answer.

(iii) The half-equations below show the changes at the two electrodes, A and B, of a silver oxide cell during discharge:

A : $Zn(s) + 2OH^-(aq) \longrightarrow ZnO(s) + H_2O(l) + 2e^-$

B : $Ag_2O(s) + H_2O(l) + 2e^- \longrightarrow 2Ag(s) + 2\,OH^-(aq)$

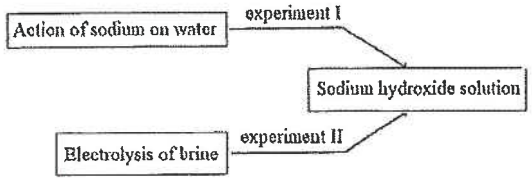
(1) Decide and explain which electrode, A or B, is the anode.

(2) Write the overall equation for the reaction that would occur in the cell during discharge.

(7 marks)

CE98_09b

Each of the following experiments produces a sodium hydroxide solution.



(i) What would be observed when a small piece of sodium is added to water?

(ii) Explain whether experiment I or experiment II is preferred for preparing a sodium hydroxide solution.

(iii) During the electrolysis of brine, chlorine and hydrogen are liberated at the anode and cathode respectively. A sodium hydroxide solution remains in the electrolytic cell after some time.

(1) Explain why hydrogen, instead of sodium is liberated at the cathode.

(2) Suppose that 50.0 cm^3 of hydrogen is liberated at the cathode at room temperature and pressure. Deduce the theoretical volume of chlorine liberated at the anode under the same conditions.

(3) Explain why a sodium hydroxide solution remains in the electrolytic cell.

(iv) Draw a labelled diagram to show the laboratory set-up for the electrolysis of brine and the collection of the gaseous products.

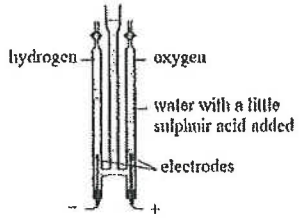
(10 marks)

CE99_06a

Water is a compound of hydrogen and oxygen. Under suitable conditions, 80.0 cm^3 of hydrogen and 60.0 cm^3 of oxygen (with one of the reactants in excess) react to give water. The volumes of both gases are measured at room temperature and pressure.

(i) Draw the electronic diagram of water, showing electrons in the *outermost shells* only.

(iii) Water can be decomposed by electrolysis with the following set-up to give hydrogen and oxygen.



(1) Explain why a little sulphuric acid has been added to the water used.

(2) Suggest a suitable material for the electrodes.

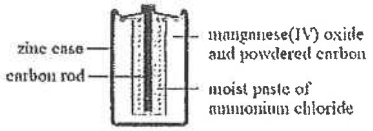
(3) Write the half-equation for the formation of oxygen.

(4) Suggest a chemical test for *each* product obtained in the electrolysis.

(8 marks)

CE99_08a [OUT, except (v)]

The diagram below shows the longitudinal section of a zinc-carbon cell.



(i) Write a half-equation for the reaction that occurs at the zinc case of the cell during discharge.

(ii) State the function of following substances in a zinc-carbon cell.

(1) carbon rod

(2) manganese(IV) oxide

(iii) Suggest a chemical test to show the presence of ammonium ions in the moist paste of ammonium chloride.

(iv) Explain whether you agree with the following statement.

'Zinc-carbon cells cause more environmental problems than nickel-cadmium cells do.'

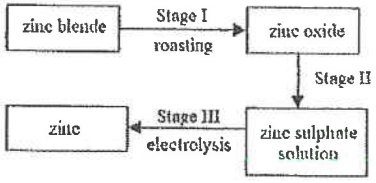
(v) Complete and balance the following half-equations for the reactions that occur at the electrodes of a nickel-cadmium cell.

$Cd + OH^- \longrightarrow Cd(OH)_2$

$NiO_2 + H_2O \longrightarrow Ni(OH)_2 + OH^-$ (10 marks)

CE00_06a

The flow diagram below shows the stages involved in the extraction of zinc from zinc blende, ZnS.



(i) The reaction in Stage I gives, apart from zinc oxide, a gaseous product.

(1) Write the chemical equation for the reaction.

(2) Give ONE industrial use of the gaseous product.

(ii) Suggest how zinc oxide can be converted to zinc sulphate solution in Stage II.

(iii) The zinc sulphate solution obtained contains ions of other metals. During the electrolysis in Stage III, zinc metal is liberated at one of the electrodes.

(1) Suggest ONE way to remove ions of metals which are less reactive than zinc from the zinc sulphate solution before electrolysis.

(2) Why is it not necessary to remove ions of metals which are more reactive than zinc from the solution?

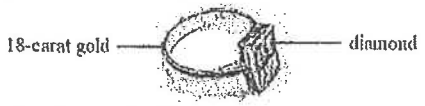
(3) Write half equations for the reactions occurring at the anode and cathode during the electrolysis.

(iv) Give ONE use of zinc in daily life.

(8 marks)

CE01_07c

The photograph below shows a diamond ring:



(i) Explain why gold and diamond each has a high melting point.

(ii) 18-carat gold is an alloy of gold. Suggest ONE reason why 18-carat gold instead of pure gold is used in making the ring.
(You are NOT required to consider the price of the materials.)

(iii) In an experiment, a piece of 18-carat gold was heated with concentrated nitric acid. A bluish green solution was formed.

(1) Suggest another metal that may be present in the 18-carat gold. Explain your answer with the help of a chemical equation.

(2) State another observation in the experiment.

(7 marks)

CE01_08a

A part of the Periodic Table is shown below:

		Group							
		I	II	III	IV	V	VI	VII	0
Period	2	Li	Be	B	C	N	O	F	Ne
	3	Na	Mg	Al	Si	P	S	Cl	Ar
	4	K	Ca					Br	Kr
	5								Xe

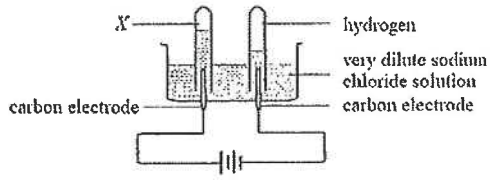
(ii) For each of the following pairs of elements, suggest ONE reaction in which both elements behave similarly. In each case, write a chemical equation for the reaction involving either one of the elements.

(2) chlorine and bromine

(2 marks)

CE01_09

(a) A student used the set-up shown below to prepare hydrogen and chlorine by electrolysis of a very dilute sodium chloride solution. Contrary to the student's expectation, a colourless gas X instead of chlorine was liberated at the anode.



(i) What is X?

(ii) Suggest a chemical test for X.

(2 marks)

(b) The experiment in (a) was then modified so that hydrogen and chlorine were produced at the cathode and anode respectively.

(i) Suggest how the experiment could be modified.

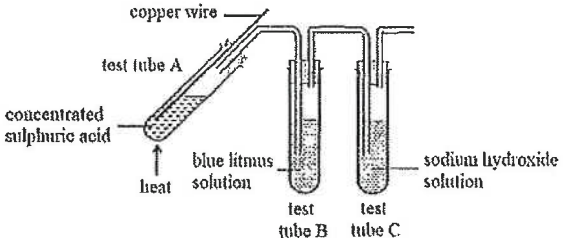
(ii) Deduce the ratio of the theoretical volumes of hydrogen and chlorine produced.

(iii) With the help of a chemical equation, explain why the volume of chlorine collected is significantly smaller than the theoretical volume.

(6 marks)

CE01_09c

The diagram below shows the set-up used in an experiment to study the reaction of copper with concentrated sulphuric acid.



(i) During the experiment, a black substance was formed on the surface of the copper wire. What is the black substance?

(ii) What other changes would be observed in test tube A? Write the chemical equation for the reaction that occurred.

(iii) State the observation in test tube B. Explain your answer.

(iv) What is the use of the sodium hydroxide solution in test tube C? State the potential hazard if sodium hydroxide solution is not used.

(8 marks)

CE02_02

For each of the following experiments, state an expected observation and write a chemical equation for the reaction involved.

(b) Excess iron(II) sulphate solution is added to an acidified potassium permanganate solution.

(c) Chlorine gas is bubbled into a sodium bromide solution.

(4 marks)

CE02_03 [OUT]

Consider the substances listed below:

ammonia, manganese(IV) oxide, potassium hydroxide,
sodium benzoate, sodium dichromate, sodium nitrite

(b) Which substance is used in zinc-carbon cells? State its function.

(2 marks)

CE02_04

Using the electrolysis of copper(II) chloride solution as an example, briefly discuss the factors affecting the discharge of ions in electrolysis.

(6 + 3 marks)

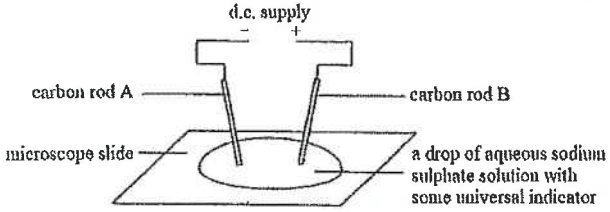
CE02_06a

(iii) Explain why molten magnesium chloride can conduct electricity.

(1 mark)

CE02_09c [Similar as DSE13_09]

A student used the set-up shown below to conduct a microscale experiment on electrolysis.



(i) (1) The initial colour of the drop shown above was green. State the colour change of the liquid around carbon rod A after a current was passed through the circuit for some time. Explain your answer with the help of a half equation.

(2) A gas was liberated at carbon rod B. What was the gas? Explain its formation.

(ii) Some objects readily available in daily life contain carbon rods which can be used in this experiment. Suggest ONE such object.

(iii) The use of microscale experiments in studying chemistry is becoming more popular nowadays. Suggest TWO advantages of carrying out experiments in microscale.

(8 marks)

CE03_04

Candidates are required to give paragraph-length answers. 3 of the marks for each of these two questions will be awarded for the effective communication of knowledge in Chemistry.

Discuss the similarities and differences in chemical properties of concentrated sulphuric acid and dilute sulphuric acid. Illustrate your answer using appropriate examples.

(6 + 3 marks)

CE03_06c

Ammonia reacts with copper(II) oxide upon heating. The products are nitrogen, copper and water.

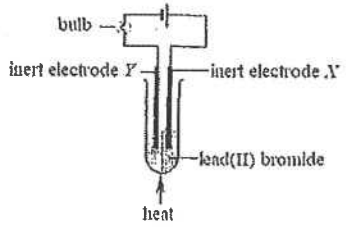
(i) State whether or not the reaction is a redox. Explain your answer in terms of oxidation number change.

(ii) Write the chemical equation for the reaction of ammonia with copper(II) oxide.

(3 marks)

CE03_07a [Similar to DSE16_08]

The set-up shown below is used to investigate the electrical conductivity of lead(II) bromide.



When the lead(II) bromide becomes molten, the bulb lights up.

(i) What would be observed at electrode X? Write the half equation for the reaction involved.

(ii) State ONE potential hazard when carrying out the experiment.

(iii) State what will happen to the bulb when heating is stopped and the molten lead(II) bromide is allowed to cool down gradually to room temperature. Explain your answer.

(6 marks)

CE04_06a

Water (H_2O) is an oxide of hydrogen. Electrolysis of water in the presence of sulphuric acid gives hydrogen and oxygen in a volume ratio of 2:1.

(i) Suggest suitable electrodes to be used in the electrolysis.

(ii) Write the half equation for the reaction at the cathode and that at the anode during the electrolysis.

(iii) What is the function of sulphuric acid in the electrolysis?

(iv) Is it possible to deduce the formula of water from the results of the electrolysis? Explain your answer.

(6 marks)

CE04_06b

Hydrogen peroxide (H_2O_2) is another oxide of hydrogen.

(i) What is the oxidation number of oxygen in hydrogen peroxide?

(ii) Draw the electronic diagram of a molecule of hydrogen peroxide, showing electrons in the *outermost shells* only.

(iii) In the presence of a dilute acid, hydrogen peroxide oxidizes iron(II) ions and it is reduced to water.

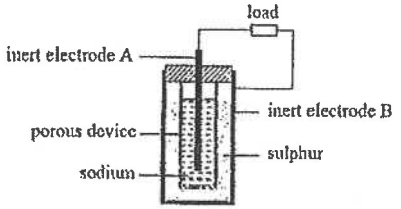
(1) Write the half equation for the reduction of hydrogen peroxide.

(2) State the expected observation and write a chemical equation for the reaction involved.

(5 marks)

CE03_09a

The diagram below shows a sodium-sulphur cell connected to an external circuit. This cell operates at a high temperature of about 370°C, which is above the melting point of sodium and sulphur.



(i) State and explain the direction of electron flow in the external circuit when the cell is discharged. Write half equations for the reactions at electrodes A and B.

(ii) Suggest TWO functions of the porous device.

(iii) Suggest why it is necessary for the cell to operate at a high temperature.

(iv) Sodium-sulphur cells are rechargeable and are used in power stations to reduce the wastage of electricity generated. Suggest why these cells can be used to reduce the wastage of electricity.

(8 marks)

CE04_02

For each of the following pairs of substances, suggest a chemical test to distinguish one substance from the other and state the expected observations.

(c) dilute sulphuric acid and dilute nitric acid

(2 marks)

CE04_07c

State what would be observed in each of the following experiments and explain your answer.

(i) A beaker containing some concentrated sulphuric acid was left in air for a long period of time.

(2 marks)

CE05_04

The wastewater generated from an electroplating factory contains dichromate ions. Before the wastewater is discharged, it is treated in two stages as described below to remove the chromium-containing substances.

Stage 1: Treat the wastewater with excess sodium sulphate solution in the presence of acid to reduce the dichromate ions to chromium ions.

Stage 2: Add a suitable chemical to the treated wastewater from *Stage 1* to precipitate the chromium(III) ions.

(a) Why is it necessary to remove chromium-containing substances from the wastewater?

(1 mark)

(b) In *Stage 1*, the sulphite ions are oxidized to sulphate ions by the dichromate ions.

(i) Write the half equation for the oxidation of sulphite ions.

(ii) Write the half equation for the reduction of dichromate ions.

(3 marks)

(c) Suggest a suitable chemical for the precipitation of chromium(III) ions in *Stage 2*.

(1 mark)

CE05_07

A chemical cell can be made from two metal strips and a lemon. Given the following materials and equipment, outline how you can set up a chemical cell with the *maximum* output voltage.

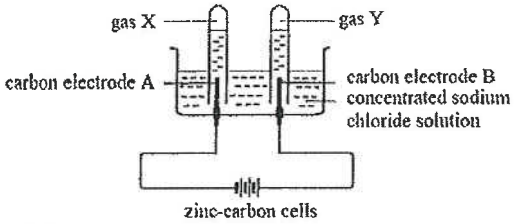
a lemon, a copper strip, a magnesium strip, a zinc strip, a multimeter and several connecting wires

(Your answer should include variables that need to be controlled.)

(6 + 3 marks)

CE05_09

An experiment was carried out to study the electrolysis of a concentrated sodium chloride solution using several zinc-carbon cells as a source of electricity. The following diagram shows the set-up used:



(a) (i) What is gas X?

(ii) Give ONE use of X in industry.

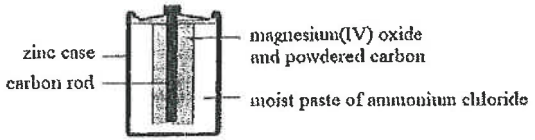
(2 marks)

(b) (i) What is gas Y?

(ii) If the electrolysis is repeated using a very dilute sodium chloride solution, another gas will be liberated at carbon electrode B. Suggest an explanation for this phenomenon.

(3 marks)

(c) With reference to the longitudinal section of a zinc-carbon cell shown below, suggest how chemical energy is converted to electrical energy when the cell is producing a current. [OUT]



(3 marks)

CE06_05

Silicon occurs in nature as silicon dioxide in sand and quartz. The extraction of silicon from silicon dioxide involves the following three stages:

Stage 1: $SiO_2(s) \xrightarrow[\text{heat}]{C(s)} Si(s)$

Stage 2: $Si(s) \xrightarrow[\text{heat}]{Cl_2(g)} SiCl_4(l)$

Stage 3: $SiCl_4(l) \xrightarrow[\text{heat}]{H_2(g)} Si(s)$

(a) What type of structure does quartz have?

(1 mark)

(b) The purpose of *Stage 1* is to convert silicon dioxide to silicon. The silicon obtained contains silicon carbide, SiC, as an impurity.

The structure of silicon carbide is similar to that of diamond. Draw the three-dimensional structure of silicon carbide.

(1 mark)

(c) The purpose of *Stage 2* and *Stage 3* is to purify the silicon obtained in *Stage 1*.

(i) Is silicon oxidized or reduced in the reaction in *Stage 2*? Explain your answer.

(ii) Draw the electronic diagram for $SiCl_4$, showing electrons in the *outermost shells* only.

(iii) The reaction in *Stage 3* produces silicon and hydrogen chloride. Suggest why the silicon obtained after *Stage 3* is of high purity.

(3 marks)

(d) Calculate the theoretical mass of silicon that can be obtained from 950 g of silicon dioxide.

(2 marks)

CE06_07

The following two methods can be used to convert copper metal into copper(II) nitrate solution:

Method 1: $Cu(s) \longrightarrow CuO(s) \xrightarrow{\text{dilute } HNO_3(aq)} Cu(NO_3)_2(aq)$

Method 2: $Cu(s) \xrightarrow{\text{dilute } HNO_3(aq)} Cu(NO_3)_2(aq)$

(a) Refer to *Method 1*.

(i) Suggest how copper metal can be converted into copper(II) oxide. Stage the expected observation in the reaction that you have suggested.

(ii) Name the type of reaction that occurs between copper(II) oxide and dilute nitric acid.

(3 marks)

(b) In *Method 2*, the reaction of copper metal with dilute nitric acid gives copper(II) nitrate, nitrogen monoxide and water. Write the chemical equation for this reaction.

(2 marks)

(c) Which of these methods would you recommend for the conversion of copper metal into copper(II) nitrate solution? Justify your answer with TWO reasons.

(2 marks)

CE06_08

'Elements in Group VII of the Periodic Table exhibit similar chemical properties. However, their reactivity decreases down the group.'

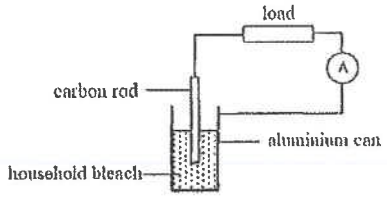
Elaborate the first statement above using two reactions of halogens. Also outline an experiment to illustrate the second statement.

(You are suggested to use chlorine and bromine as examples of halogens in answering this question.)

(6 + 3 marks)

CE06_10

A student used an aluminium can, a carbon rod and household bleach to make a chemical cell. The diagram below shows the set-up of the cell connected to a load and an ammeter.



(a) The materials used by the student to make the cell are readily available at home. Suggest ONE household item

(i) which contains a carbon rod.

(ii) which includes an aluminium can.

(2 marks)

(b) When the cell is producing a current, the aluminium can undergoes oxidation to give aluminate ions, $Al(OH)_4^-(aq)$, while at the carbon rod the hypochlorite ions undergo reduction in the presence of water to give chloride ions and hydroxide ions.

Given that household bleach is alkaline, write half equations for

(i) the oxidation of the aluminium metal, and

(ii) the reduction of the hypochlorite ions.

(2 marks)

(c) The student also used the above set-up to investigate the relation between the current produced by the cell and the concentration of hypochlorite ions in the bleach.

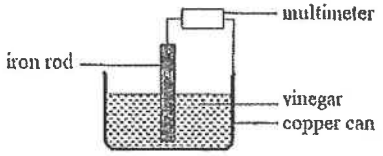
(i) Suggest TWO conditions which should be kept constant when conducting this investigation.

(ii) The student noticed that the current produced by the cell increases with the concentration of hypochlorite ions in the bleach. Suggest an explanation for the phenomenon.

(3 marks)

CE07_04

A student learnt from a book that an ancient chemical cell could be made by immersing an iron rod in a liquid placed inside a copper can. The liquid used was vinegar but not wine. The diagram below shows the set-up designed by him in simulating the cell.



(a) Explain, in terms of structure of property of particles, why the liquid inside the ancient chemical cell was vinegar but not wine.

(2 marks)

(b) The student found that the iron rod dissolved gradually, and colourless gas bubbles were given out on the inner wall of the copper can.

(i) Write a half equation, involving iron, for the reaction that occurred at the iron rod.

(ii) Write a half equation for the reaction that occurred on the inner wall of the copper can.

(2 marks)

(c) The student found that colourless gas bubbles were also given out at the surface of the iron rod that immersed in vinegar. Explain the observation.

(1 mark)

CE07_09

A certain brand of rust remover contains an acid of high concentration. The rust remover can be used for removing tough rust stains; while the rust remover, after dilution, can be used for removing comparatively light rust stains.

Write some instructions, with reasons, on how the rust remover can be used safely at home. Two sentences have been given below as an introduction.

The rust remover should be kept out of reach from children as it contains an acid of high concentration. The rust remover should not be swallowed because it is harmful.

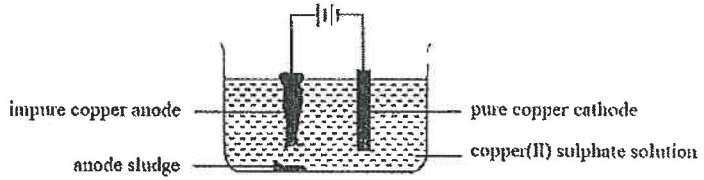
(6 + 3 marks)

CE07_11 [OUT, except (a)]

In a chemical plant, extraction of copper from its ores involves roasting copper(I) sulphide with air inside a high temperature furnace. Copper(I) sulphide reacts with oxygen in air according to the following equation:

$$Cu_2S + O_2 \longrightarrow 2Cu + SO_2$$

The copper so extracted contains impurities including metals such as silver, iron, zinc and gold. The impure copper is then purified by electrolysis as illustrated in the diagram below:



(a) With reference to the reaction between copper(I) sulphide and oxygen, identify the species undergoing oxidation and the species undergoing reduction. Explain your answers in terms of changes in oxidation numbers.

(2 marks)

(b) Explain briefly how impure copper can be purified by electrolysis as illustrated in the diagram above. [OUT]

(2 marks)

(c) Insoluble impurities deposit under the impure copper anode as 'anode sludge'. According to the information given, suggest what substances the anode sludge would contain. Explain your answer. [OUT]

(2 marks)

(d) 'The concentration of copper(II) ions in copper(II) sulphate solution remains UNCHANGED in the above electrolysis.' Is this statement correct? Explain your answer. [OUT]

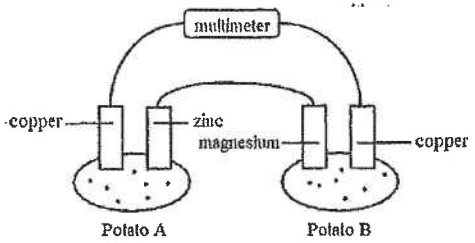
(2 marks)

(e) State TWO advantages of building a factory in which contact process is carried out near the chemical plant mentioned above.

(2 marks)

CE08_05

The diagram below shows a set-up with metal strips inserted in fresh potatoes. The multimeter reading in the set-up is +0.75V.



(a) State, with explanation, the direction of electron flow across the connecting wire between zinc strip and magnesium strip.

(1 mark)

(b) (i) Which metal strip in Potato B is anode? Why?

(ii) Write the half equation for the change occurred at the anode in Potato B.

(2 marks)

(c) Which two metal strips should be interchanged in order to increase the multimeter reading?

(1 mark)

(d) Explain why fresh potatoes should be used in the set-up.

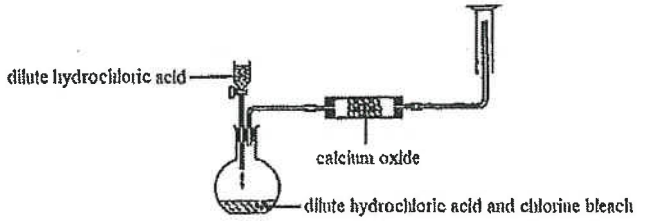
(1 mark)

(e) What will the multimeter reading be if the zinc strip in Potato A is replaced by another magnesium strip, while the other three metal strips remain unchanged?

(1 mark)

CE08_06

A student prepares dry chlorine gas by adding dilute hydrochloric acid to chlorine bleach using the following set-up:



(a) **There are two mistakes in the above** set-up. Complete the following table.

	Statet the mistake and explain why it is wrong	Suggest a method for correction
Mistake 1		
Mistake 2		

(4 marks)

(b) Suggest a safety precaution in performing the experiment other than wearing protective gloves and safety spectacles.

(1 mark)

(c) (i) Write an ionic equation for the reaction involved in the preparation of chlorine.

(ii) Explain, in terms of oxidation number, which species involved in the reaction in (i) is an oxidizing agent.

(3 marks)

CE09_06

Under suitable conditions, concentrated sulphuric acid can react with glucose and copper turnings respectively.

(a) State the observation and write a chemical equation for the reaction between concentrated sulphuric acid and glucose.

(2 marks)

(b) (i) State the observation and write a chemical equation for the reaction between hot concentrated sulphuric acid and copper turnings.

(ii) Hot concentrated sulphuric acid reacts with copper turnings inside a test tube. Describe how you should clean the test tube after the reaction.

(4 marks)

CE09_13

Electrolysis can be applied to enhance the corrosion resistance of iron. Describe the chemical principle involved in this application. Your description should include the chemical reactions involved, and the use of appropriate electrodes and electrolyte.
(Diagrams are NOT required.)

(6+3 marks)

CE10_03

A is an alkanol with three carbon atoms and one oxygen atom in its molecule. A reacts with acidified potassium dichromate solution to form compound B. In the presence of a small amount of concentrated sulphuric acid, A reacts with B to form compound C. C can be separated from the reaction mixture and has a pleasant smell.

(a) Write the structural formulae of A, B and C.

(3 marks)

(b) State the expected observation for the reaction of A with acidified potassium dichromate solution.

(1 mark)

(c) Suggest a method to separate C from the reaction mixture.

(1 mark)

(d) A compound has the same molecular formula as A but a different structure from A. Suggest a structural formula for this compound.

(1 mark)

CE10_05

The virus H1N1 can cause influenza. It has an oil-based coating.

(a) Washing hands with soapy detergent can help reduce influenza infection caused by the virus H1N1. Suggest why soapy detergent can destroy the virus.

(1 mark)

(b) Chlorine bleach can also help reduce influenza infection caused by the virus H1N1.

(i) What type of reaction is involved when chlorine bleach acts on the virus?

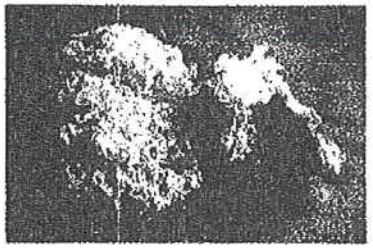
(ii) Explain why it is NOT appropriate to add acid to the chlorine bleach used in (i).

(iii) The concentration of sodium hypochlorite in a brand of chlorine bleach is 0.50 M. 1 volume of the bleach is diluted with 49 volumes of water. Calculate the molarity of sodium hypochlorite in the diluted bleach.

(4 marks)

CE10_07

Some people would use sulphur dioxide to treat food, such as the snow fungus shown below. They would make sulphur dioxide by burning sulphur in air.



(a) Suggest a purpose of treating snow fungus with sulphur dioxide.

(1 mark)

(b) Excessive intake of sulphur dioxide is hazardous to health. Suggest and explain how the sulphur dioxide in snow fungus can be removed before cooking.

(2 marks)

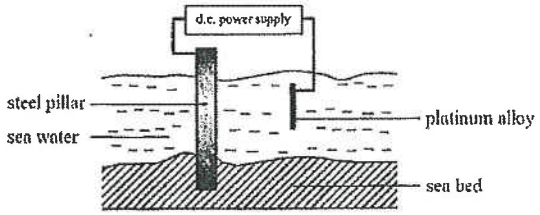
(c) Sulphur dioxide can also be obtained from the reaction of concentrated sulphuric acid with copper. Draw a labelled diagram to show the set-up in preparing and collecting sulphur dioxide from this reaction in a school laboratory.

(3 marks)

CE10_09

For question 9, candidates are required to give answers in paragraph form. For this question, 6 marks will be awarded for chemical knowledge and 3 marks for effective communication.

The following diagram shows a system used in some piers for slowing down the rusting of steel pillars.

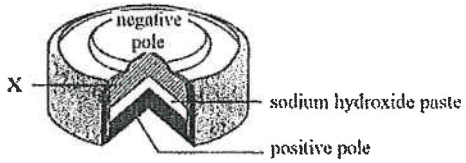


Design an experiment performed in a laboratory to show that such a system can slow down the rusting of steel in sea water. Labelled diagrams of the set-up, expected observation and the chemical principle involved should be included in your answer.

(6 + 3 marks)

CE10_11

The diagram below shows a kind of traditional 'button cell' making from mercury(II) oxide, zinc powder and sodium hydroxide paste:



When the cell is producing a current, the overall cell reaction can be represented by the following chemical equation:

$$Zn + HgO \longrightarrow ZnO + Hg$$

(a) Explain whether mercury(II) oxide or zinc powder should be at the region labelled X.

(1 mark)

(b) What is the function of the sodium hydroxide paste in the cell?

(1 mark)

(c) Why should this kind of button cell be banned in the market?

(1 mark)

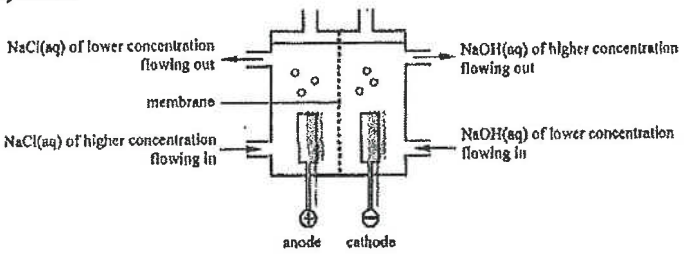
(d) Explain whether the cell can work if mercury(II) oxide is replaced by manganese oxide, while other materials remain unchanged.

(1 mark)

(e) Explain the change of the maximum voltage supplied by the cell if zinc powder is replaced by copper powder, while other materials remain unchanged.

(1 mark)

(f) The following diagram shows the electrolytic cell used in the manufacture of sodium hydroxide:



(i) Write a half equation for the anodic reaction.

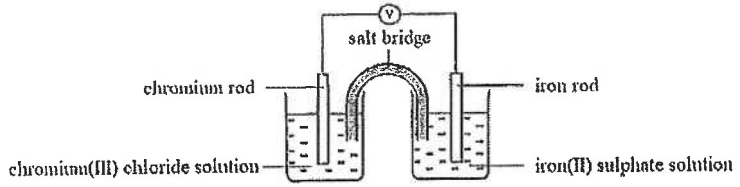
(ii) Write a half equation for the cathodic reaction.

(iii) It is known that only cations can pass through the membrane. Explain why sodium hydroxide solution of higher concentration is eventually obtained.

(4 marks)

CE11_04

The diagram below shows the set-up of a simple chemical cell. As time goes by, the colour of iron(II) sulphate solution in the beaker gradually fades out.



(a) State, with explanation, the direction of electron flow in the external circuit.

(2 marks)

(b) Write a half equation for the change occurring at the chromium rod.

(1 mark)

(c) (i) Chromium is one of the components of stainless steel. Suggest how chromium can prevent iron in stainless steel from rusting.

(ii) Coating chromium on iron-made objects can prevent the objects from rusting. Name this coating process and explain how this process can prevent rusting.

(3 marks)

CE11_05

(a) Sulphur dioxide reacts with sodium carbonate solution to form sodium hydrogensulphite ($NaHSO_3$). $NaHSO_3$ is commonly added to red wine for preventing the ethanol in the wine from turning to ethanoic acid.

(i) State the oxidation number of sulphur in $NaHSO_3$.

(ii) In terms of oxidation and reduction, explain how $NaHSO_3$ can prevent ethanol from turning to ethanoic acid.

(iii) 0.1 mole of sulphur dioxide is dissolved in excess sodium carbonate solution to form $NaHSO_3$ solution. Calculate the mass of $NaHSO_3$ formed. (Assume that sulphur dioxide is completely converted to $NaHSO_3$.)

(4 marks)

(b) Sodium hydrogensulphite ($NaHSO_3$) reacts with zinc to form sodium hydrosulphite ($Na_2S_2O_4$) and zinc hydroxide only. $Na_2S_2O_4$ is commonly used to bleach paper.

(i) Write a chemical equation for the reaction of $NaHSO_3$ with zinc.

(ii) What is the role of zinc in the reaction?

(2 marks)

CE11_10a

A very dilute sodium chloride solution is electrolyzed using inert electrodes for a long period of time.

(i) State the expected observation at the cathode. Explain your answer.

(ii) State ALL expected observations at the anode. Explain your answer.

(iii) Explain whether the resulting solution is acidic, alkaline or neutral.

(6 marks)

CE11_10b

A type of breathalyzer for investigating drink-driving consists of a chemical cell. The breath of the driver is allowed to get into contact with one of the electrodes of the cell. If the breath contains ethanol, the ethanol would be converted to ethanoic acid at this electrode and an electric current would be produced.

(i) Explain whether the above mentioned electrode acts as the anode or cathode of the chemical cell.

(ii) Write a half equation for the change occurring at this electrode.

(iii) Explain how this type of breathalyzer could estimate the amount of ethanol in the breath of the driver.

(3 marks)

AL95(II)_03 [OUT]

The electromotive force of a new zinc-carbon dry cell is 1.5 V. When it is producing an electric current, the following changes occur at the two electrodes:

Anode:	$Zn(s)$ reacts to give $Zn^{2+}(aq)$.
Cathode:	$MnO_2(s)$ and $NH_4Cl(aq)$ react to give $Mn_2O_3(s)$ and $NH_3(g)$.

(a) Write half equations for the reactions at the anode and at the cathode, and the equation for the overall reaction that occurs in the dry cell.

(3 marks)

(b) Explain why the electromotive force of the dry cell drops,

(1) after it has been used for some time;

(1.5 marks)

(2) after it has been stored for a long time without being used.

(1 mark)

ASL99(I)_07 (modified)

In a factory, steel handles are nickel-plated in an electroplating bath containing the following substances:

$NiSO_4$, Na_2SO_4 and H_3BO_3

(a) Write a half equation for the reaction occurring on the surface of a steel handle during the electroplating process.

(1 mark)

(b) State the function of each of the following substances in the electroplating bath:

(i) Na_2SO_4

(1 mark)

(ii) H_3BO_3

(1 mark)

(c) It is known that 4.50×10^{21} electrons have passed through the external circuit during the electroplating process. Assuming that the current efficiency is 100%, calculate the thickness of nickel deposited on the steel handle with a surface area of 20.0 cm^2.
(Relative atomic mass: Ni = 58.7; Density of nickel = 8.90 g cm^{-3};
Avogadro's constant = 6.02×10^{23} mol^{-1})

(3 marks)

(d) Suggest a method to remove nickel(II) ions from the waste electrolytic solution.

(1 mark)

ASL00(I)_02

In the laboratory, there are three bottles labelled A, B and C. Each bottle contains one of the following reagents:

$Cl_2(aq)$, NaI(aq) and KBr(aq)

Three tests were carried out using the reagents in the bottles. The results are summarized in the table below:

Test	Observation
Mixing reagent in bottle A with reagent in bottle B	No observable change
Mixing reagent in bottle A with reagent in bottle C	Mixture turned brown
Mixing reagent in bottle B with reagent in bottle C	Mixture turned brown

(a) Deduce which bottle contains $Cl_2(aq)$. Write the relevant chemical equations.

(3 marks)

(b) If hexane is also provided, suggest how you would carry out an experiment to identify the contents of the other two bottles.

(2 marks)

(c) State ONE safety precaution which should be taken when performing the experiment you have suggested in (b).

(1 mark)

ASL00(I)_03

The waste water from an electroplating factory contains chromium in the form of dichromate(VI) ions. In order to remove chromium from the waste water, green vitriol, $FeSO_4 \cdot 7H_2O$, was first added to reduce the dichromate(VI) ions to chromium(III) ions:

$$Cr_2O_7^{2-}(aq) + 6Fe^{2+}(aq) + 14H^+(aq) \longrightarrow 2Cr^{3+}(aq) + 6Fe^{3+}(aq) + 7H_2O(l)$$

The chromium(III) ions formed were then precipitated as hydroxide.

(a) Suggest ONE reason why it is necessary to remove chromium from the waste water.

(1 mark)

(b) A sample of the waste water of volume 1.0×10^5 dm^3 contains 1.2×10^{-4} mol dm^{-3} of dichromate(VI) ions. Calculate the minimum mass of green vitriol required in the waste water treatment process.

(3 marks)

(c) Suggest an appropriate reagent for the precipitation reaction.

(1 mark)

(d) Name TWO chemicals present in the precipitate formed.

(2 marks)

ASL00(I)_05

Car bumpers made of steel are usually plated with chromium. Prior to the chromium-plating process, the bumpers are first coated with a layer of nickel.

(a) Why are the car bumpers coated with a layer of nickel prior to the chromium-plating process?

(1 mark)

(b) Give TWO properties of chromium which make it suitable for plating car bumpers.

(2 marks)

(c) A chromium-plating bath consists of an aqueous solution of CrO_3 and H_2SO_4. What is the function of H_2SO_4 in this bath?

(1 mark)

(d) A car bumper with a total surface area of 3.0×10^3 cm^2 is chromium-plated using a current of 35 A.

(i) A car bumper with a total surface area of 3.0×10^3 cm^2 is chromium-plated using a current of 35 A.
It is known that 4.5×10^{23} electrons have passed through the external circuit during the electroplating process. Assuming that the current efficiency is 100%, calculate the thickness of chromium deposited on the car bumper.
(Relative atomic mass: Cr = 52.0; Density of chromium = 7.2 g cm^{-3};
Avogadro's constant = 6.02×10^{23} mol^{-1})

(3 marks)

(ii) If a current much larger than 35 A is used, what would be the effect on the quality of the chromium layer plated onto the bumper?

(1 mark)

ASL00(II)_10 (modified)

(a) Write the electron arrangement of an iron atom in its ground state.

(1 mark)

(b) With reference to the structure of iron, explain why iron is an electrical conductor.

(2 marks)

(c) When iron is heated with dry chlorine, a dark brown solid **X** is formed.

(i) What is **X**?

(1 mark)

(ii) Explain why the chlorine used should be dry.

(1 mark)

(d) When an acidified solution of **X** is heated with some iron filings, a pale green solution **Y** is formed. Write a chemical equation for the reaction involved.

(1 mark)

(e) State the expected observation when sodium hydroxide solution is added separately to

(i) an acidified solution of **X**, and

(1 mark)

(ii) the pale green solution **Y**.

(1 mark)

ASL00(II)_11

Suggest a chemical test to distinguish one solution from the other in each of the following pairs. Equations should be given where appropriate.

$Na_2SO_3(aq)$ and $Na_2SO_4(aq)$

(3 marks)

AL01(I)_04

The overall reaction occurring in a Leclanche cell when delivering a current can be represented by the equation:

$$2MnO_2(s) + 2NH_4Cl(aq) + Zn(s) \longrightarrow Mn_2O_3(s) + 2NH_3(aq) + H_2O(l) + ZnCl_2(aq)$$

(a) Write half equations for the anodic and cathodic reactions. [Same as DSE16_08c]

(2 marks)

(b) If the cell contains 25.0 g of $MnO_2(s)$, calculate the theoretical mass of Zn(s) that would be consumed for the $MnO_2(s)$ to undergo complete reaction.

(2 marks)

ASL01(I)_06 [Similar to DSE15_07(a)]

Steel objects are nickel-plated in an electroplating factory. Prior to the nickel-plating process, the steel objects are treated with an emulsion of kerosene and sodium hydroxide, then with dilute hydrochloric acid.

(a) Explain why the steel objects are treated with

(i) an emulsion of kerosene and sodium hydroxide,

(1 mark)

(ii) dilute hydrochloric acid.

(1 mark)

(b) A hollow cylindrical anode, which surrounds the steel object, is used in the nickel-plating process.

(i) Why is the anode in the shape of a hollow cylinder?

(1 mark)

(ii) Write the half equation for the anodic reaction.

(1 mark)

(c) Suggest one reason why the current efficiency of the nickel-plating process is not 100%.

(1 mark)

(d) State one environmental problem associated with the electroplating industry and suggest a possible solution.

(2 marks)

AL01(I)_07

Suggest a method to remove stains of colloidal sulphur in a conical flask. State the chemistry involved.

(2 marks)

AL02(II)_03

A hydrogen-oxygen fuel cell uses concentrated potassium hydroxide solution as electrolytes and nickel as electrodes.

(a) Draw a labeled diagram to show the design of the fuel cell.

(2 marks)

(b) Briefly describe how the cell works, giving the equations for the electrode half reactions.

(2 marks)

(c) State one advantage of using fuel cells over using batteries.

(1 mark)

ASL02(II)_11

Chlorine gas can be generated by the reaction of dilute hydrochloric acid with chlorine bleach.

(a) (i) Name the active ingredient in chlorine bleach.

(1 mark)

(ii) Write a chemical equation for the reaction of dilute hydrochloric acid with chlorine bleach.

(1 mark)

(b) The chlorine gas generated is bubbled into two test tubes, each containing one of the following solutions:

(i) iron(II) sulphate(VI) solution

(2 marks)

(ii) potassium bromide solution

(2 marks)

In each case, state an expected observation and write a chemical equation for the reaction involved.

ASL02(II)_12

In an electroplating factory, steel objects are plated with rhodium (Rh). Prior to the electroplating process, the steel objects are pretreated by immersing them firstly in a warm mixture of kerosene and sodium hydroxide solution, and subsequently in dilute hydrochloric acid. The steel objects are then plated with rhodium using an electrolytic bath containing an aqueous solution of a rhodium salt and dilute sulphuric(VI) acid.

(a) State the function of each of the following substances in the pretreatment process:

(i) Kerosene

(1 mark)

(ii) Sodium hydroxide solution

(1 mark)

(b) Why are the steel objects treated with dilute hydrochloric acid before they are electroplated?

(1 mark)

(c) Suggest TWO reasons why dilute sulphuric(VI) acid is used in the electrolytic bath.

(2 marks)

(d) It is known that 2.40×10^{23} electrons have passed through the external circuit during the electroplating process, causing 0.17 g of rhodium to be deposited on a steel object. If the current efficiency is 83%, calculate the oxidation state of rhodium in the rhodium salt. (Relative atomic mass: Rh = 102.9; Avogadro's constant = 6.02×10^{23} mol^{-1})

(3 marks)

(e) Suggest ONE reason why the current efficiency in the electroplating process is less than 100%.

(1 mark)

ASL03(I)_03

(a) (i) Arrange chlorine, bromine and iodine in order of increasing oxidizing power.

(1 mark)

(ii) Suggest how the above order can be established experimentally.

(2 marks)

(b) What is the meaning of the term 'disproportionation'? Illustrate your answer using a reaction involving chlorine.

(2 marks)

AL03(II)_04 (modified)

Carbon monoxide is a highly toxic gas and is also an indoor air pollutant. The level of indoor carbon monoxide can be monitored by the use of carbon monoxide detectors. One type of carbon monoxide detectors uses an electrochemical sensing method. The detector contains two inert electrodes coated with platinum which catalyzes the reaction of carbon monoxide with oxygen in the atmosphere. The anodic and cathodic reactions are as follows:

Anode:	$CO(g) + H_2O(l) \longrightarrow CO_2(g) + 2H^+(aq) + 2e^-$
Cathodic:	$\frac{1}{2}O_2(g) + 2H^+(aq) + 2e^- \longrightarrow H_2O(l)$

(a) Why is carbon monoxide toxic?

(2 marks)

(b) Outline how the carbon monoxide detector can detect the indoor carbon monoxide level.

(2 marks)

(c) Describe one situation in which the indoor carbon monoxide level would increase suddenly.

(1 mark)

ASL04(I)_02

For each of the following statements, state whether it is true or false. If you consider the statement to be false, then you have to give an example to support your answer.

Any halogen can exhibit more than one oxidation state in its compounds.

(1 mark)

AL04(II)_05

The active ingredient of household bleach is sodium chlorate(I) which is manufactured from chlorine.

(a) With the help of a chemical equation, suggest how sodium chlorate(I) can be obtained from chlorine.

(2 marks)

(b) Household bleach diluted by a volume ratio of 1 : 99 is widely used as an effective and inexpensive disinfectant during the recent SARS epidemic outbreak. A certain brand of household bleach contains 6.0 g of sodium chlorate(I) per 100 cm^3 of the bleach. Calculate the concentration of sodium chlorate(I), in mol dm^{-3}, in the diluted bleach.

(2 marks)

(c) Write the help of chemical equation(s), suggest why household bleach should not be used together with toilet cleans which contains sodium hydrogensulphate(V).

(2 marks)

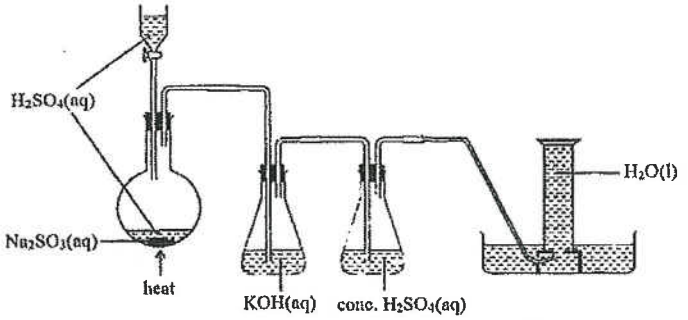
AL05(I)_07b

Sulphur dioxide can be prepared by reacting sodium sulphate(IV) solid with dilute sulphuric(VI) acid.

(i) Write the balanced equation for the reaction.

(1 mark)

(ii) A student suggested to use the set-up shown below to prepare a dry sample of sulphur dioxide from sodium sulphate(IV) solid.



Point out two mistakes in the above set-up, and suggest the corresponding rectifications.

(4 marks)

(iii) Suggest a chemical test for sulphur dioxide.

(2 marks)

ASL05(I)_07

An electroplating factory produces nickel-plated plastic handles for drawers. In the manufacturing process, the plastic handles are coated firstly with copper and then plated with nickel using an electrolytic bath containing nickel(II) sulphate(VI) and boric acid.

(a) (i) Why is it necessary to coat the handles with copper before they are nickel-plated?

(1 mark)

(ii) Suggest a reason for plating the handles with nickel.

(1 mark)

(b) Write the half equation for the cathodic reaction during nickel-plating process.

(1 mark)

(c) Boric acid is added to the electrolytic bath to maintain its pH within a range of 4 to 6.

(i) Why is it necessary to maintain the pH of the electrolytic bath within a small range?

(2 marks)

(ii) Suggest how boric acid functions in the bath.

(1 mark)

(d) Suggest why it is NOT recommended to use a high current density in the nickel-plating process. [Similar to DSE12_05]

(1 mark)

AL05(II)_02

The following three redox reactions take place at room temperature:

(1) $KMnO_4(s)$ reacts with concentrated HCl(aq) to give $Cl_2(g)$.

(2) $Fe^{2+}(aq)$ reacts with $Cl_2(g)$ to give $Fe^{3+}(aq)$.

(3) Acidified $KMnO_4(aq)$ is decolorized by $SO_2(g)$

(a) Write a balanced equation for each of the three reactions described above.

(3 marks)

(b) Is it possible to predict from the above information whether any reaction would occur in the following experiments? Explain your answer. If it is possible to predict a reaction, write the chemical equation for the reaction.

(i) Adding $FeSO_4(aq)$ to acidified $KMnO_4(aq)$.

(2 marks)

(ii) Passing $SO_2(g)$ into $Fe^{3+}(aq)$.

(2 marks)

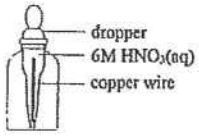
AL05(II)_04

The reaction of moderately concentrated nitric(V) acid (about 6 M) with copper gives nitrogen monoxide.

(a) Write the chemical equation for this reaction.

(1 mark)

(b) Instead of using a test tube, a teacher carried out a demonstration of the reaction using a reagent bottle as shown below. The dropper had a copper wire inside and was filled with 6 M $HNO_3(aq)$ as shown.



(i) Describe and explain the expected observations.

(3 marks)

(ii) Suggest one advantage of using this set-up in the demonstration.

(1 mark)

AL06(I)_03b

Write chemical equations for the following reactions.

(a) The reaction of S(s) with concentrated HNO_3 to give $SO_4^{2-}(aq)$ and $NO_2(g)$

(1 mark)

(b) The reaction of $Mn^{2+}(aq)$ with $O_2(g)$ under alkaline conditions to give $Mn(OH)_3(s)$

(1 mark)

(c) The disproportionation of $MnO_4^{2-}(aq)$ in water to give $MnO_4^-(aq)$ and $MnO_2(s)$

(1 mark)

ASL06(I)_03b

Account for each of the following statements.

(i) When concentrated sulphuric(VI) acid is added to sodium iodide solid, violet fumes are formed.

(2 marks)

(ii) Concentrated hydrochloric acid is used, not concentrated sulphuric(VI) acid, in flame tests.

(2 marks)

AL06(II)_04

The overall reaction for the discharging process of a lead-acid cell can be presented by the following equation:

$$PbO_2(s) + Pb(s) + 4H^+(aq) + 2SO_4^{2-}(aq) \longrightarrow 2PbSO_4(s) + 2H_2O(l)$$

(a) Write the half equation of the cathode reaction and that of the anodic reaction during discharge for a lead-acid cell.

(2 marks)

(b) Based on the above information, explain why a lead-acid cell is rechargeable.

(1 mark)

(c) A lead-acid accumulator used in automobiles consists of six-lead-acid cells connect in series. Suggest why

(i) the state of charge of a lead-acid accumulator can be estimated by measuring the density of the acid in the accumulator, and

(1 mark)

(ii) an excessively high voltage should not be used to charge a lead-acid accumulator.

(1 mark)

AL07(I)_02

Write the Lewis structures of SO_4^{2-} and $S_2O_3^{2-}$ ions, and give the oxidation states of all sulphur atoms in each of these ions.

(4 marks)

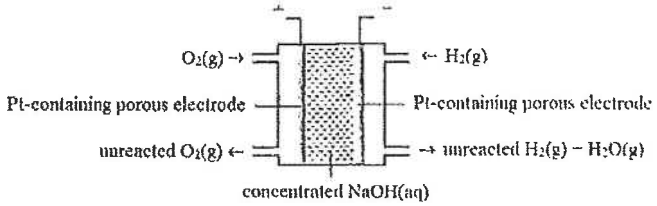
AL08(I)_01

Excess $NH_3(g)$ reacts with $Cl_2(g)$ in two steps to give $N_2(g)$ and $NH_4Cl(s)$. It is known that $NH_3(g)$ functions as reducing agent and as a base in the reaction. For each step, write the chemical equation and state the function of $NH_3(g)$.

(3 marks)

AL08(I)_02 [Similar to DSE13_10]

The diagram below shows the design of a hydrogen-oxygen fuel cell:



(a) Describe the working principle of the fuel cell.

(3 marks)

(b) One advantage of using hydrogen-oxygen fuel cells is that they do not emit air pollutants. Suggest ONE other advantage of using hydrogen-oxygen fuel cells.

(1 mark)

AL08(I)_02

Three reagent bottles each containing 0.5 M KI(aq), 14 M $HNO_3(aq)$ and 0.02 M $KMnO_4(aq)$ have been kept in the laboratory for a long time. The table below lists the observation for each of the bottles.

Solution	Observation
0.5 M KI(aq)	The liquid is pale yellow
14 M $HNO_3(aq)$	There are brown fumes above the yellow liquid.
0.02 M $KMnO_4(aq)$	There are brown stains on the interior wall of the bottle.

In each case, account for the observation and write the relevant chemical equation(s).

(6 marks)

ASL08(I)_02

Three reagent bottles each containing 0.5 M KI(aq), 14 M $HNO_3(aq)$ and 2 M NaOH(aq) have been kept in the laboratory for a long time. The table below lists the observation for each of the bottles.

Solution	Observation
0.5 M KI(aq)	The liquid is pale yellow
14 M $HNO_3(aq)$	There are brown fumes above the yellow liquid.
2 M NaOH(aq)	White powder is found around the stopper.

In each case, account for the observation and write the relevant chemical equation(s).

(6 marks)

AL09(I)_02

The compound $(CN)_2$ resembles the halogens in many ways and is often described as 'pseudohalogen'.

(a) Draw the Lewis structure of $(CN)_2$.

(1 mark)

(b) Deduce the physical state of $(CN)_2$ at room temperature.

(1 mark)

(c) Write the chemical equation for the reaction expected when $(CN)_2$ is added to dilute NaOH(aq) at room temperature.

(1 mark)

AL09(I)_07d

Suggest the most appropriate hazard warning label that should be displayed on a bottle of $NaClO_3(s)$.

(1 mark)

AL09(II)_03

Account for the following: "$FeSO_4(aq)$ gives a brown precipitate upon standing in air for a long time".

(2 marks)

AL10(I)_03

State the expected observation in the following experiments, and account for the observation with the aid of chemical equation(s).

Adding excess $H_2SO_4(aq)$ to $K_2CrO_4(aq)$, and then excess $FeSO_4(aq)$ to the resulting solution.

(3 marks)

AL10(I)_07b

State under what circumstances the following practice would be adopted and explain your answer.

"The use of concentrated H_3PO_4 instead of concentrated H_2SO_4 in the preparation of hydrogen halides from the corresponding sodium halides."

(2 marks)

AL12(I)_02

(b) (ii) What is the oxidation state of vanadium in $VOBr_2$?

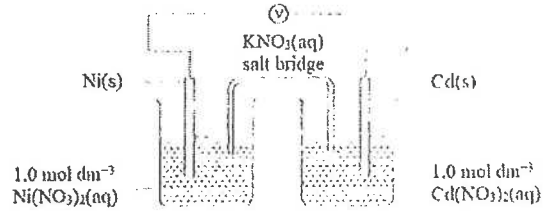
(1 mark)

(iii) Write a balanced equation for the reaction between $VO_2^+(aq)$ and Z(s) in an acidic medium to give $V^{2+}(aq)$ and $Zn^{2+}(aq)$.

(1 mark)

AL12(II)_07

(a) Consider the electrochemical cell shown below:



State and explain the direction of migration of $NO_3^-(aq)$ ions in the salt bridge.

(1 mark)

(b) Nickel-cadmium (NiCd) battery is a type of rechargeable battery. Its working principle is based on the following electrochemical reaction in an alkaline condition:

$$2NiO(OH)_2(s) + Cd(s) + 2H_2O(l) \longrightarrow 2Ni(OH)_2(s) + Cd(OH)_2(s)$$

(i) Write the half equation for the anodic reaction and that for the cathodic reaction when NiCd battery is producing current.

(2 marks)

(ii) NiCd battery maintains a steady voltage during discharge. Explain.

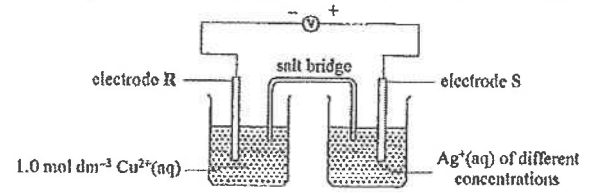
(1 mark)

(c) Nowadays, lithium-ion (Li-ion) batteries are more commonly used than NiCd batteries in portable electronic devices. Suggest ONE advantage of using Li-ion batteries over using NiCd batteries.

(1 mark)

AL13(I)_07

(a) The diagram below shows a set-up for investigating the effect on cell e.m.f. on the following system with changes in silver(I) ion concentration (from 10^{-4} to 10^{-1} mol dm^{-3}).



(i) Suggest suitable materials for use as electrodes R and S respectively.

(1 mark)

(ii) (I) State the function of the salt bridge.

(1 mark)

(II) Suggest why a freshly prepared salt bridge needs to be used when a new concentration of $Ag^+(aq)$ is used in the electrochemical cell.

(1 mark)

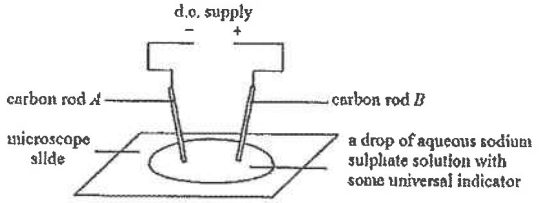
AL13(II)_02

(b) Purple $KMnO_4(aq)$ reacts with concentrated KOH(aq) to give green $K_2MnO_4(aq)$ and $O_2(g)$. Explain whether or not this reaction is a redox, and write the chemical equation for the reaction involved.

(2 marks)

DSE11SP_04

A student used the set-up shown below to conduct a microscale experiment on electrolysis.



(a) (i) The initial color of the drop shown above was green. State the color change of the liquid around carbon rod A after a current was passed through the circuit for some time. Explain your answer with the help of a half equation.

(3 marks)

(ii) A gas was liberated at carbon rod *B*. What was the gas? Explain its formation.

(2 marks)

(b) Some objects readily available in daily life contain carbon rods which can be used in this experiment. Suggest ONE such object.

(1 mark)

DSE11SP_09

There are four unlabelled reagent bottles each containing one of the white solids listed below:

ammonium chloride, ammonium nitrate, sodium hypochlorite and sodium sulphate

Suggest how you would carry out tests to distinguish the four solids from one another.

(6 marks + 1 mark)

DSE12PP_03

(a) Nitrogen reacts with magnesium to give magnesium nitride (Mg_3N_2).

(i) Draw the electron diagram of magnesium nitride, showing electrons in the outermost shells only.

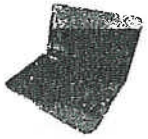
(1 mark)

(ii) Magnesium nitride reacts with water to give magnesium hydroxide and ammonia. Write the chemical equation for this reaction. Explain whether or not this reaction is a redox.

(2 marks)

DSE12PP_08

The photograph below shows a laptop computer which is powered by Direct Methanol Fuel Cell (DMFC).



The operation of DMFC is based on the following reaction under an acidic condition:

$$2CH_3OH(aq) + 3O_2(g) \longrightarrow 2CO_2(g) + 4H_2O(l)$$

(a) Write half-equations for the anodic and cathodic reactions when DMFC is producing a current.

anodic reaction

cathodic reaction

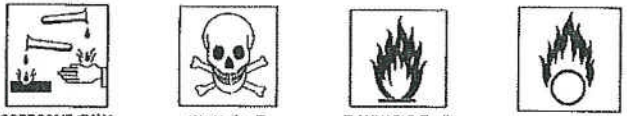
(2 marks)

(b) A concentrated aqueous methanol solution is used as the fuel in DMFC.

(i) Suggest why pure methanol is NOT used.

(1 mark)

(ii) Circle TWO of the following hazard warning labels that should be displayed on the container of a concentrated aqueous methanol solution.



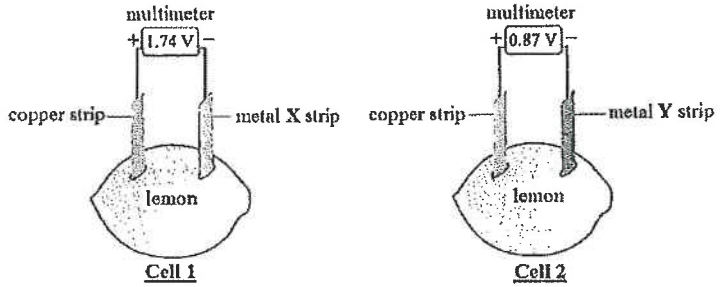
(1 mark)

(c) Would you expect DMFC to be widely used in powering laptop computers? Explain your answer.

(2 marks)

DSE12_03

Consider the information concerning the lemon cells shown in the diagrams below:



(a) What is the function of the lemons in these cells?

(1 mark)

(b) By completing the table below, arrange metal X, metal Y and copper in increasing order of reducing power.

Reducing power increasing →

(1 mark)

(c) For Cell 1, write the half equation for the change that occurs at:

(i) metal X strip (X is group II metal), and

(1 mark)

(ii) Copper strip.

(1 mark)

(d) For Cell 2, would the metal Y strip be the positive electrode if the copper strip is replaced with a silver strip? Explain your answer.

(1 mark)

DSE12_05

In order to prepare 50 dm^3 of 0.1 M $CuSO_4(aq)$, an inexperienced electroplating worker added the required exact amount of $CuSO_4 \cdot 5H_2O(s)$ to water in a plastic container. He then stirred the mixture with an iron rod until the $CuSO_4 \cdot 5H_2O(s)$ dissolved completely. Finally, he sent a sample of the solution to the Quality Control Laboratory for analysis, but found that the concentration of $CuSO_4(aq)$ was lower than 0.1 M.

(a) With the aid of a chemical equation, explain why the concentration of the $CuSO_4(aq)$ prepared was lower than 0.1 M.

(2 marks)

(b) The worker used the prepared $CuSO_4(aq)$ to coat a layer of copper on a metallic object by electrolysis. He uses the unreasonable high voltage, and found that some bubbles were formed on the object and the copper layer easily flaked off. [Similar to ASL05(I)_07d]

(i) Explain why copper can be coated on the metallic object by electrolysis.

(1 mark)

(ii) Suggest what the bubbles were, and explain why the copper layer easily flaked off.

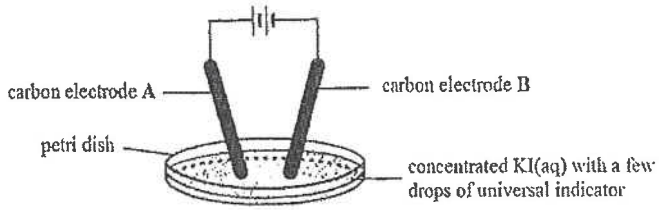
(2 marks)

(c) Draw a labelled diagram of the experimental set-up used in a laboratory for coating a layer of copper on a metallic object by electrolysis.

(3 marks)

DSE13_09 [Similar to CE02_09c, DSE11SP_04]

The diagram below shows the set-up used in an investigation on the electrolysis of concentrated potassium iodide solution:



(a) State and explain the expected observation around carbon electrode A during the electrolysis.

(2 marks)

(b) The solution near carbon electrode B gradually turned blue.

(i) Explain this observation.

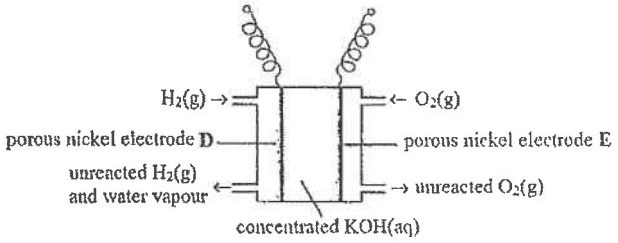
(2 marks)

(ii) Would there be any change in observation if carbon electrode B is replaced by a copper electrode in the investigation? Explain.

(1 mark)

DSE13_10 [Similar to AL08(I)_02]

The diagram below shows the structure of a hydrogen-oxygen fuel cell using concentrated potassium hydroxide solution as the electrolyte.



(a) An oxygen cylinder can be used to provided oxygen for the above fuel cell. From the hazard warning labels shown below, circle the label that should be displayed on the oxygen cylinder.

(1 mark)

(b) Write the half equation for the change occurring at each of the following electrodes when this fuel cell is producing a current.

Electrode D

Electrode E

(2 marks)

(c) Some people have the view that cars powered by hydrogen-oxygen fuel cells are more environmentally friendly than those powdered by petrol.

Comment on this view from each of the following aspects:

(i) Source of fuel

(1 mark)

(ii) The car emissions.

(1 mark)

DSE13_11

Safety airbags are important devices installed in vehicles. During a serious car crash, the chemicals in the airbag immediately react to release a large amount of gas. An airbag hence inflates instantly, protecting the passenger. The main chemicals in safety airbags are sodium azide (NaN_3) and potassium nitrate (KNO_3). The equations below show the reactions involved when an airbag is inflated.

$$2NaN_3(s) \longrightarrow 2Na(s) + 3N_2(g)$$

$$10Na(s) + 2KNO_3(s) \longrightarrow K_2O(s) + 5Na_2O(s) + N_2(g)$$

(c) The main function of $NaN_3(s)$ is to produce $N_2(g)$ for inflating the airbags. Suggest why it is necessary to include $KNO_3(s)$ in the airbags.

(1 mark)

DSE14_05

Concentrated acids are common reagents found in laboratories.

(a) State a safety measure in handing concentrated acids in laboratories.

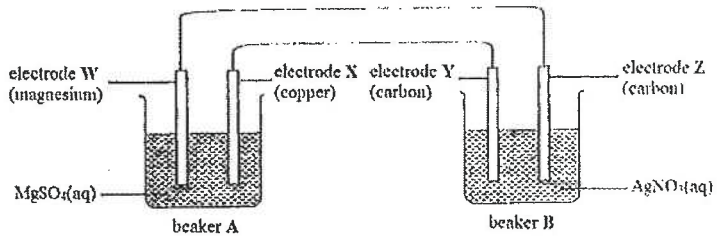
(1 mark)

(c) Explain how concentrated sulphuric acid, concentrated nitric acid and concentrated ethanoic acid can be distinguished by using copper granules.

(3 marks)

DSE14_08

The diagram below shows a set-up in which electrons are flowing through the electric wires. Moreover, one of the electrodes in beaker A is forming ions.



(a) State an expected observation at each of the following electrodes:

(i) Electrode W

(1 mark)

(ii) Electrode X

(1 mark)

(b) Write the half equation for the expected change at each of the following electrodes:

(i) Electrode Y

(1 mark)

(ii) Electrode Z

(1 mark)

(c) Complete the following table by filling in 'anode' or 'cathode' to describe the electrodes.

	Electrode W	Electrode Z
Anode / Cathode		

(1 mark)

(d) Predict, with reason, what would happen if the $MgSO_4(aq)$ in beaker A is replaced by ethanol.

(1 mark)

DSE14_09

Consider each of the experiments below and answer the questions that follow.

(b) Acidified potassium permanganate solution is added to sodium sulphite solution.

(i) State the expected color change.

(1 mark)

(ii) For the reaction leading to the color change,

(1) State the name of the type of reaction; and

(1 mark)

(2) Write the ionic equation for the reaction.

(1 mark)

DSE14_11

Vanadium is a transition metal, its chemical symbol is V. The formulae and the colors of three aqueous vanadium-containing ions are shown below:

Formula	$VO^{2+}(aq)$	$V^{3+}(aq)$	$V^{2+}(aq)$
Color	Blue	Green	violet

(a) Based on the given information, suggest TWO properties of vanadium to characterize it as a transition metal.

(1 mark)

(b) Vanadium also forms the ion $VO_2^+(aq)$. In the presence of acid, 1.0 mol of $VO_2^+(aq)$ ions and 1.0 mol of $SO_2(g)$ react completely to form $SO_4^{2-}(aq)$ ions and one of the above aqueous vanadium-containing ions.

(i) By considering the amount of electrons transferred, deduce the final color of the solution obtained.

(2 marks)

(ii) Write a chemical equation from the reaction in (i).

(1 mark)

DSE15_02

For each of the following experiments, state the expected observation, and write the chemical equation(s) for the reaction(s) involved.

(b) Adding sodium sulphite solution to acidified potassium dichromate solution until in excess.

(2 marks)

DSE15_04

Lead-acid accumulator is a secondary cell containing sulphuric acid. It is commonly used in starting up motor vehicle engines.

(a) What is meant by the term 'secondary cell'?

(1 mark)

(b) Suggest why a lead-acid accumulator is suitable for starting up motor vehicle engines.

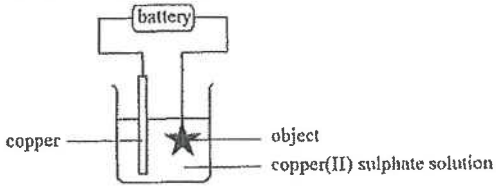
(1 mark)

(c) State one environmental impact that would be imposed from the disposal of lead-acid accumulators.

(1 mark)

DSE15_07 [Similar to ASL01(I)_06]

Refer to the set-up for electroplating an object shown in the diagram below:



(a) Explain why oily dirts on the object should be removed before electroplating.

(1 mark)

(b) Copper(II) sulphate is an electrolyte. What is meant by the term 'electrolyte'?

(1 mark)

(c) List ALL the ions existing in the solution

(1 mark)

(d) Explain why copper(II) ions are preferentially discharged during the electroplating process.

(1 mark)

(e) Write the half-equation of the change that occurs at the anode.

(1 mark)

(f) State the observable change, if any, in the solution during the electroplating process.

(1 mark)

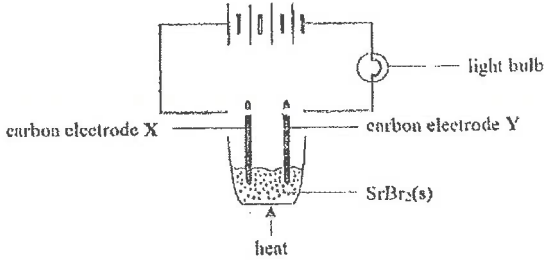
(g) It is known that 2.28×10^{22} electrons have passed through the external circuit during the electroplating process. Calculate the mass of copper that would theoretically be plated on the object. [Similar to ASL00(I)_05d]

(Relative atomic mass: Cu = 63.5; Avogadro's constant = 6.02×10^{23} mol^{-1})

(2 marks)

DSE16_08 [Similar to CE03_07a]

Consider the experimental set-up shown below:



(a) In the above experiment, the bulb lights up when the $SrBr_2(s)$ becomes molten.

(Atomic number of Sr = 38)

(i) State the observation at carbon electrode X.

(1 mark)

(ii) Write a half equation for the change that occurs at carbon electrode Y.

(1 mark)

(b) Explain why the experiment should be performed in a fume cupboard.

(1 mark)

(c) Zinc-carbon cells are used in the above experiment. The equation below shows the reaction that occurs in the zinc-carbon cells when the bulb lights up.

$$2MnO_2(s) + 2NH_4Cl(aq) + Zn(s) \longrightarrow Mn_2O_3(s) + 2NH_3(aq) + H_2O(l) + ZnCl_2(aq)$$

(i) Deduce, in terms of change in oxidation number, the oxidizing agent in a zinc-carbon cell.

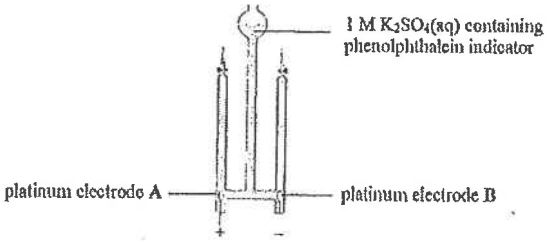
(2 marks)

(ii) Write a half equation for the change that occurs at the cathode in a zinc-carbon cell. [Same as AL01(I)_04a]

(1 mark)

DSE17_04

The diagram below shows a set-up for the electrolysis of a colorless solution of 1 M $K_2SO_4(aq)$ containing phenolphthalein indicator.



(a) State, with explanation, the expected observation around the following electrodes during the electrolysis:

(i) Electrode A

(ii) Electrode B

(3 marks)

(b) Write the equation of the overall reaction in the electrolysis.

(1 mark)

(c) Explain whether there are any changes in the expected observation around the following electrodes during the electrolysis if the 1 M $K_2SO_4(aq)$ is replaced with 1 M $H_2SO_4(aq)$.

(i) Electrode A

(ii) Electrode B

(3 marks)

DSE17_06

Concentrated sulphuric acid is a reagent commonly found in laboratories.

(a) Circle TWO hazard warning labels that should be displayed on a bottle of concentrated sulphuric acid:

(1 mark)

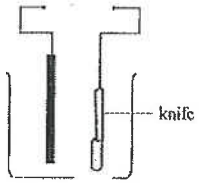
(c) With the help of a chemical equation, state the observation when hot concentrated sulphuric acid reacts with copper.

(2 marks)

DSE18_05

Electroplating and rust prevention are common applications of electrochemistry.

(a) The diagram below shows an incomplete set-up. Add suitable drawings and labels to the diagram for electroplating of silver onto the knife.



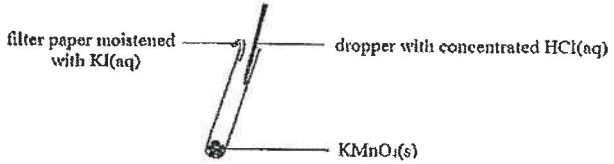
(2 marks)

(b) Suggest a method, besides painting or electroplating, that can prevent underground iron-made pipelines from rusting. Explain your answer.

(2 marks)

DSE18_08

Refer to the experimental set-up as shown below:



(a) HCl is a strong acid. What is meant by the term 'strong acid'?

(1 mark)

(b) When concentrated HCl(aq) is dropped into $KMnO_4(s)$, a yellowish green gas is formed.

(i) What is the yellowish green gas?

(1 mark)

(ii) Explain whether the reaction forming the yellowish green gas is a redox reaction.

(1 mark)

(c) With the aid of an ionic equation, state the expected observation when the yellowish green gas reaches the filter paper.

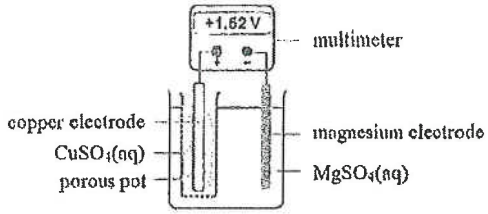
(2 marks)

(d) In consideration of laboratory safety, explain where the experiment should be performed.

(1 mark)

DSE19_07

Consider the chemical cell as shown below:



(a) (i) What is the function of the porous pot?

(1 mark)

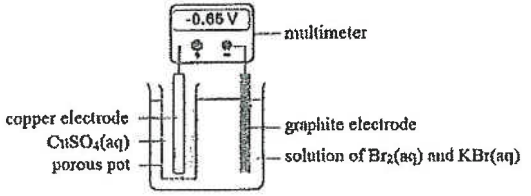
(ii) Deduce whether the electron flow through the external circuit from the magnesium electrode to the copper electrode.

(1 mark)

(iii) Write the hald equation for change that occurs at the cathode.

(1 mark)

Consider another chemical cell as shown below:



(b) (i) Write the half equation for the change that occurs at the graphite electrode.

(1 mark)

(ii) State the expected observation at the copper electrode.

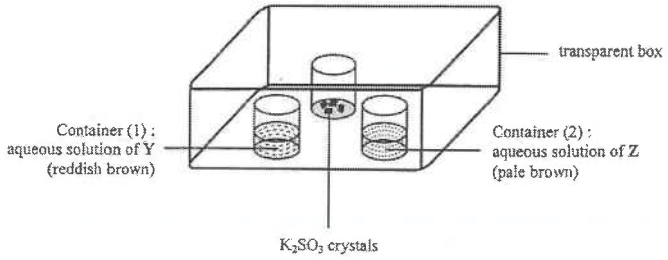
(1 mark)

(iii) Would the multimeter reading become more negative, less negative or remain unchanged if the solution of $Br_2(aq)$ and KBr(aq) is replaced by a solution of $I_2(aq)$ and KI(aq), while the other conditions remain unchanged? Explain your answer.

(1 mark)

DSE20_01cii

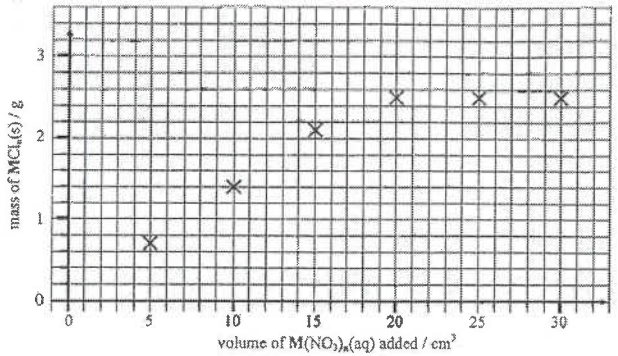
(c) An experiment for **Y** and **Z** is performed as shown in the set-up below. Dilute hydrochloric acid is added to the K_2SO_3 crystals, then the whole set-up is covered with a lid.



(ii) **State the expected observation in Container (1) and write an ionic equation for the reaction involved.**

DSE20_02

2. An experiment was performed to deduce the empirical formula of an insoluble chloride of a metal **M**. At room temperature, different volumes of a 0.50 mol dm^{-3} $M(NO_3)_n(aq)$ were added to six beakers each containing 50 cm^3 of 0.36 mol dm^{-3} HCl(aq). The $MCl_n(s)$ obtained in each beaker was filtered, washed, dried and weighed. The mass of $MCl_n(s)$ obtained and the corresponding volume of $M(NO_3)_n(aq)$ added were plotted on the graph below.



(a) Suggest why the masses of $MCl_n(s)$ for the last three points in the graph are the same.

(1 mark)

(b) (i) By **sketching** on the graph above, deduce the volume of the $M(NO_3)_n(aq)$ that can completely react with 50 cm^3 of 0.36 mol dm^{-3} HCl(aq).

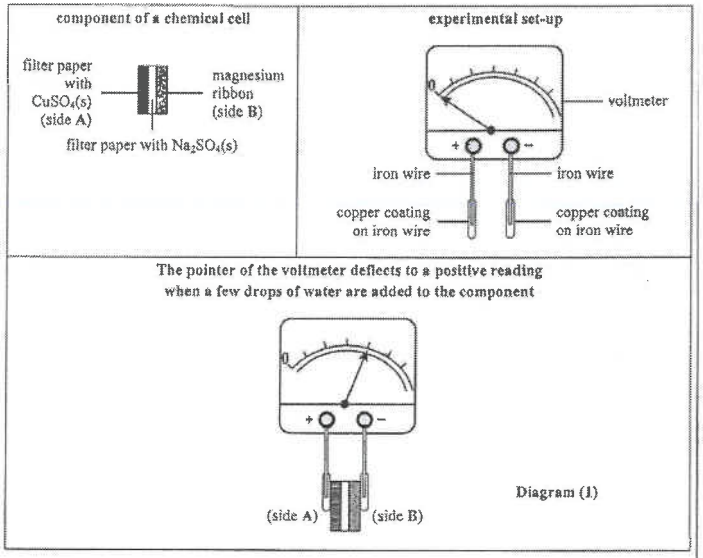
Volume of $M(NO_3)_n(aq)$ = _____ cm^3

(ii) Hence, calculate the number of moles of $M(NO_3)_n(aq)$ that can completely react with the HCl(aq).

2. (c) Determine, by calculation, the empirical formula of the chloride of **M**. Hence, deduce whether **M** would be silver or lead.

DSE20_06

6. The diagrams below show the component of a chemical cell, an experimental set-up and how the pointer of the voltmeter deflects when the set-up is connected to the component.



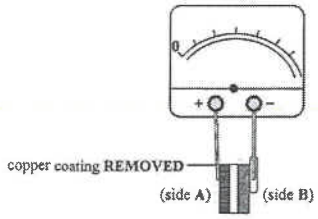
(a) Why does the pointer of the voltmeter deflect as shown when a few drops of water are added to the component ?

6. (b) Write the half equation for the change that occurs at each of the following electrodes when the pointer of the voltmeter deflects :

(i) anode

(ii) cathode

(c) Consider the following design modified from **Diagram (1)** by only removing the copper coating at side **A** :



Draw on **Diagram (2)** the expected position of the pointer of the voltmeter when water is added to the component.

(1 mark)

(d) In the design in part (c) above, a redox reaction occurs at side **A** when water is added to the component.

(i) Write a chemical equation for the reaction.

(ii) Name this type of reaction.

DSE21_02

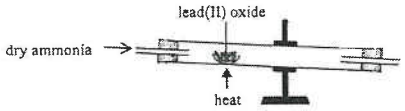
2. In the boxes (a) to (g) of the table below, fill in the information relating to the electrolysis of each electrolyte.

Electrolyte	Electrode	Observation at the electrode	Product at the electrode	Half equation OR Justification for the change occurred at the electrode
Molten $PbBr_2$	Graphite anode	(a) Observation:		
	Graphite cathode			(b) Half equation:
Very dilute $ZnCl_2$ solution	Platinum anode			(c) Half equation:
	Platinum cathode		(d) Product:	
Concentrated $CuSO_4$ solution	Copper anode		(e) Product:	
	Copper cathode	(f) Observation:		(g) Justification:

(7 marks)

DSE21_06(b),(c)

6. Lead can be obtained from lead(II) oxide using the experimental set-up shown below. Besides lead, nitrogen gas and steam are also formed.



(b) Write a chemical equation for the reaction. (1 mark)

(c) Explain which of the reagents is a reducing agent in the reaction. (1 mark)

DSE21_08

*8. You are provided with the following items :

lemon, multimeter, connecting wires, Zn strip, Cu strip, Ag strip

With the aid of a labelled diagram, suggest how you can perform an experiment to confirm (with explanation) the order of reducing power of metals as Zn > Cu > Ag.

(6 marks)

2022

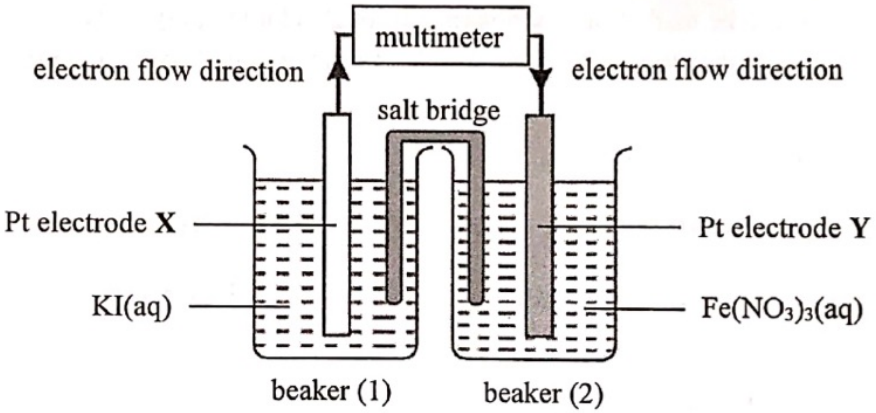
12. Consider the following chemical equation :

$$x\mathrm{NH_3(g)} + y\mathrm{O_2(g)} \rightarrow x\mathrm{NO(g)} + z\mathrm{H_2O(g)}$$

Which of the following combinations is correct ?

	x	y	z
A.	2	3	3
B.	2	3	6
C.	4	5	4
D.	4	5	6

13. Consider the following chemical cell :

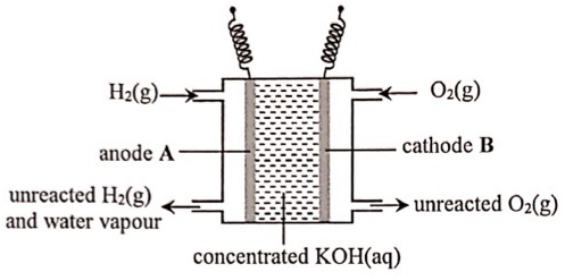


Which of the following statements is correct ?

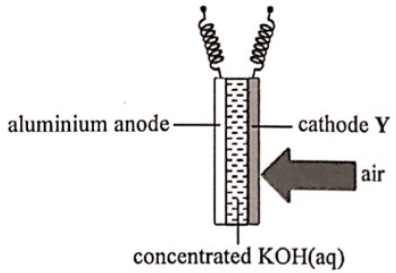
A. Electrode **X** is the cathode.
B. The solution in beaker (1) gradually turns brown.
C. The solution in beaker (2) gradually changes from pale green to yellow.
D. $Fe(NO_3)_3(aq)$ acts as a reducing agent.

2 (c) Explain whether the decomposition of $\mathbf{X_2O(s)}$ is a redox reaction.

5. The following hydrogen-oxygen fuel cell and aluminium-air cell are primary cells. Their simplified structures are shown below :



hydrogen-oxygen fuel cell



aluminium-air cell

(a) What is meant by the term 'primary cell' ?

(1 mark)

(b) For the above hydrogen-oxygen fuel cell,

(i) write the half equation for the change that occurs at anode **A**.

(ii) suggest one disadvantage of using this hydrogen-oxygen fuel cell.

(2 marks)

(c) In the above aluminium-air cell, oxygen in air reacts with water to form hydroxide ions at cathode **Y**.

(i) Write the half equation for the change that occurs at cathode **Y**.

(ii) The half equation for the change that occurs at the aluminium anode is as follows :

$$Al(s) + 3OH^-(aq) \rightarrow Al(OH)_3(s) + 3e^-$$

Write the chemical equation for the overall reaction in the aluminium-air cell.

(iii) Suggest how aluminium can be obtained from aluminium oxide.

(3 marks)

Section C Analytical Chemistry

Answer **ALL** parts of the question.

3. (a) Answer the following short questions :

(i) Suggest a chemical test to show how $SO_2(g)$ and $CO_2(g)$ can be distinguished.

(2 marks)

(ii) Illustrate how $CH_3CH_2CHO(l)$ and $CH_3COCH_3(l)$ can be distinguished from their respective mass spectra.

(2 marks)

(iii) Which one of the following chemicals is the most suitable for drying ethyl butanoate ?

concentrated sulphuric acid, solid sodium hydroxide, anhydrous sodium sulphate

(1 mark)

Marking Scheme

MCQ

CE90_01	A	CE90_05	A	CE90_13	A	CE90_16	D
CE90_19	C	CE90_23	B	CE90_24	B	CE90_27	C
CE91_06	B	CE91_07	C	CE91_09	C	CE91_10	D
CE91_12	C	CE91_14	A	CE91_17	B	CE91_37	D
CE91_43	D	CE91_44	C	CE92_08	A	CE92_09	A
CE92_10	C	CE92_11	B	CE92_12	B	CE92_13	D
CE92_15	D	CE92_16	C	CE92_35	D	CE92_37	B
CE92_38	D	CE92_40	B	CE92_50	B	CE93_05	A
CE93_06	D	CE93_12	C	CE93_15	B	CE93_16	C
CE93_17	D	CE93_22	D	CE93_19	C	CE93_24	B
CE93_44	B	CE93_45	C	CE94_04	A	CE94_06	C
CE94_07	A	CE94_10	A	CE94_12	C	CE94_13	B
CE94_15	A	CE94_34	B	CE94_38	B	CE94_49	C
CE95_07	C	CE95_10	A	CE95_11	D	CE95_13	D
CE95_30	B	CE95_33	D	CE95_37	B	CE95_39	A
CE95_40	C	CE96_07	C	CE96_09	B	CE96_27	D
CE96_30	A	CE96_31	D	CE96_35	C	CE96_38	D
CE96_42	C	CE96_46	D	CE97_04	C	CE97_07	D
CE97_08	B	CE97_09	C	CE97_10	A	CE97_11	D
CE97_29	D	CE97_36	C	CE97_39	A	CE97_50	D
CE98_04	B	CE98_05	C	CE98_06	D	CE98_21	C
CE98_22	D	CE98_38	B	CE99_07	C	CE99_09	B
CE99_10	D	CE99_12	A	CE99_15	B	CE99_18	C
CE99_24	D	CE99_33	C	CE99_36	D	CE99_38	C
CE99_40	A	CE99_42	D	CE00_05	A	CE00_16	B
CE00_28	C	CE00_30	A	CE00_31	D	CE00_35	B
CE00_43	A	CE00_44	D	CE00_45	B	CE01_07	A
CE01_08	A	CE01_11	A	CE01_19	A	CE01_22	C
CE01_24	C	CE01_29	B	CE01_35	A	CE01_43	D
CE01_44	D	CE02_06	A	CE02_07	C	CE02_10	D
CE02_13	B	CE02_18	C	CE02_19	A	CE02_30	A
CE02_38	B	CE02_39	D	CE02_41	A	CE02_47	C
CE03_03	B (55%)	CE03_04	D (69%)	CE03_07	D (38%)	CE03_13	D (43%)
CE03_15	A (41%)	CE03_16	B (64%)	CE03_18	A (76%)	CE03_23	B (84%)
CE03_35	C	CE05SP_17	A	CE05SP_31	A	CE05SP_40	A
CE04_05	C (60%)	CE04_07	A (73%)	CE04_13	A (58%)	CE04_14	B (66%)
CE04_18	B (37%)	CE04_24	B (41%)	CE04_32	B (42%)	CE04_34	B (67%)
CE04_38	D (43%)	CE04_39	A (49%)	CE04_40	B (50%)	CE04_43	D (43%)
CE05_08	B (49%)	CE05_15	A (63%)	CE05_25	B (84%)	CE05_26	C (62%)
CE05_30	D (61%)	CE05_31	A (60%)	CE05_33	A (61%)	CE05_36	A (39%)
CE05_48	A (80%)	CE06_03	C (53%)	CE06_21	D (53%)	CE06_27	D (43%)

CE06_29	A (71%)	CE06_32	B (47%)	CE06_33	D (44%)	CE06_38	A (67%)
CE06_40	D (43%)	CE07_19	A (69%)	CE07_20	A (54%)	CE07_21	A (38%)
CE07_22	C (59%)	CE07_24	B (64%)	CE07_25	D (36%)	CE07_36	D (44%)
CE07_37	A (75%)	CE07_41	D (68%)	CE07_43	A (24%)	CE07_44	C (68%)
CE07_45	D (49%)	CE07_46	B (52%)	CE08_04	C (65%)	CE08_05	A (68%)
CE08_11	B (55%)	CE08_13	D (54%)	CE08_21	A (45%)	CE08_23	B (68%)
CE08_24	D (58%)	CE08_28	D (67%)	CE08_34	D (56%)	CE08_36	C (54%)
CE08_38	A (51%)	CE08_40	D (45%)	CE08_44	B (49%)	CE08_48	C (44%)
CE09_02	A (51%)	CE09_04	C (56%)	CE09_13	A (76%)	CE09_14	D (37%)
CE09_17	A (35%)	CE09_24	D (57%)	CE09_30	B (39%)	CE09_31	C (65%)
CE09_34	D (46%)	CE09_38	D (61%)	CE09_39	B (51%)	CE09_42	B (56%)
CE09_44	A (55%)	CE09_49	C (64%)	CE10_05	D (54%)	CE10_09	C (83%)
CE10_11	D (81%)	CE10_24	B (60%)	CE10_30	A (39%)	CE10_32	C (52%)
CE10_34	D (44%)	CE10_36	C (78%)	CE10_43	C (48%)	CE10_47	A
CE10_48	A (51%)	CE10_49	C (31%)	CE11_06	B (71%)	CE11_07	B (61%)
CE11_09	A (71%)	CE11_11	C (74%)	CE11_14	B (70%)	CE11_20	D (48%)
CE11_21	D (53%)	CE11_26	B (56%)	CE11_32	B (65%)	CE11_35	D (74%)
CE11_37	A (58%)	CE11_44	B (35%)	CE11_49	B (39%)	AL07(I)_03	B
ASL09(I)_03	C	ASL12(I)_03	A	ASL13(I)_03	D	DSE11SP_02	A
DSE11SP_12	B	DSE11SP_21	D	DSE11SP_23	A	DSE12PP_14	C
DSE12PP_22	A	DSE12PP_23	D	DSE12_06	B (74%)	DSE12_13	B (60%)
DSE12_18	C (77%)	DSE12_30	A (71%)	DSE13_16	C (65%)	DSE13_17	A (59%)
DSE13_06	B (51%)	DSE13_21	D (72%)	DSE13_22	D (49%)	DSE14_15	B (70%)
DSE14_11	C (61%)	DSE14_16	A (88%)	DSE14_20	A (63%)	DSE15_02	D (77%)
DSE15_06	A (72%)	DSE15_13	C (58%)	DSE15_16	D (38%)	DSE15_17	A (73%)
DSE16_11	A (84%)	DSE16_12	B (50%)	DSE16_13	C (51%)	DSE16_14	D (75%)
DSE16_15	B (36%)	DSE16_20	D (38%)	DSE16_23	C (77%)	DSE17_08	C (52%)
DSE17_04	B (76%)	DSE17_11	B (64%)	DSE17_15	B (83%)	DSE17_23	B (70%)
DSE18_12	B (79%)	DSE18_21	B (41%)	DES19_03	B	DES19_11	A
DES19_12	D	DES19_14	A	DES19_19	A		

DSE20_5 B
DSE20_9 A
DSE20_12 B
DSE20_14 C
DSE20_19 C

Structural Questions

CE90_02a(i)

(1) Oxidation: $2Cl^-(aq) \longrightarrow Cl_2(g) + 2e^-$

Reduction: $5e^- + 8H^+(aq) + MnO_4^-(aq) \longrightarrow Mn^{2+}(aq) + 4H_2O(l)$

Overall: $2MnO_4^-(aq) + 16H^+(aq) + 10Cl^-(aq) \longrightarrow 2Mn^{2+}(aq) + 8H_2O(l) + 5Cl_2(g)$ [2]

OR, $2KMnO_4(aq) + 16HCl(aq) \longrightarrow 2KCl(aq) + 2MnCl_2(aq) + 8H_2O(l) + 5Cl_2(g)$

(2) $HCl \longrightarrow Cl_2$ (oxidation)

-1 0 [1]

$KMnO_4 \longrightarrow MnCl_2$ (reduction)

+7 +2 [1]

[The (+) and (-) sign for oxidation numbers is essential]

CE90_04a

(i) Electrode A. [1]

(ii) Hydrogen [1]

burns with a pop sound. [1]

(iii) At electrode A: $2H^+(aq) + 2e^- \longrightarrow H_2(g)$ [1]

At electrode B: $2Br^-(aq) \longrightarrow Br_2(aq) + 2e^-$ [1]

(v) Bromine [1]

Bromine is heavier (or denser) than the solution [1]

it sinks to the bottom [1]

(vi) (1) $OH^-(aq)$ and $Br^-(aq)$ [1]

OR, hydroxide ion and bromide ion

CE91_02c

(i) Tin metal [1]

(ii) The use of tin(II) is more economical because tin(II) gains two moles of electrons to become tin while tin(IV) gains four moles of electrons. [2]

(iii) Tin protects iron from rusting because tin prevents the contact of iron with water and air. [1]

(iv) No. Iron is more reactive than tin. [1]

Iron will lose electrons and corrode faster. [1]

CE92_05a

(i) B is the cathode because reduction occurs at B, $2H^+ + 2e^- \longrightarrow H_2$ [1]

(ii) Cathode (B) attracts Na^+ and H^+ ions. [1]

H^+ preferentially discharged because H is in a lower position than Na in the electrochemical series. [1]

Anode (A) attracts Cl^- and OH^- ions. [1]

Cl^- is preferentially discharged because the concentration of Cl^- is high.

Finally, as H^+ and Cl^- are preferentially discharged, [1]

Na^+ and OH^- are left. [1]

CE93_02a

(ii) To improve its appearance or to give it a shiny surface. [1]

(iii) To make the knob to conduct electricity. [1]

(iv) $Ni^{2+}(aq) + 2e^- \longrightarrow Ni(s)$ [1]

CE94_01e

(i) Sulphur dioxide [1]

SO_2 can turn acidified potassium permanganate solution from purple to colourless [1]

(ii) Any two: [2]

A brown solid is formed.

Metal X dissolves.

The blue solution fades.

CE94_07a

(i) (1) From Q to R, then S to P [1]

because reduction occurs at R ($Cu^{2+} + 2e^- \longrightarrow Cu$)

electrons must flow out from metal Q. [1]

(ii) (1) Colourless gas is formed at S. [1]

(2) The colour changes from blue to colourless. [1]

(iii) Set-up X is an electrochemical cell (to provide electricity). [1]

(iv) Q.

It is because electrons flow from Q to R. [1]

So Q loses electrons more readily than R. [1]

CE95_09b

(i) $MnO_4^- + 8H^+ + 5e^- \longrightarrow Mn^{2+} + 4H_2O$ [1]

MnO_4^- is reduced because it receives electrons / the oxidation number of Mn changes from +7 to +2 / the oxidation number of Mn decreases. [1]

(ii) The solution turns (pale) brown / yellow. [1]

$2I^- \longrightarrow I_2 + 2e^-$ [1]

(iii) From KI solution to $KMnO_4$ solution / from right to left. [1]

(iv)

Oxidation:	$2I^-(aq) \longrightarrow I_2(g) + 2e^-$
Reduction:	$MnO_4^-(aq) + 8H^+(aq) + 5e^- \longrightarrow Mn^{2+}(aq) + 4H_2O(l)$
Overall:	$2MnO_4^-(aq) + 16H^+(aq) + 10I^-(aq) \longrightarrow 2Mn^{2+}(aq) + 8H_2O(l) + 5I_2(g)$

[1]

OR, $2MnO_4^- + 16H^+ + 10I^- \longrightarrow 2Mn^{2+} + 8H_2O + 5I_2$

(v) (1) To allow migration (movement) of ions between the two beakers. [1]

(2) No. Sodium sulphite can be oxidized / react with permanganate ions. [1]

CE96_06a

(i) (1) (dirty) green precipitate / solid is formed [1]

$Fe^{2+}(aq) + OH^-(aq) \longrightarrow Fe(OH)_2(s)$ [1]

(2) No, because the reaction does not involve any change in oxidation number / there is no transfer of electron(s) [1]

(ii) (1) The purple solution is potassium permanganate / permanganate ions / manganese(VII) / $KMnO_4$ / $NaMnO_4$ / contains MnO_4^- ions [1]

(2) The solution changes colour from purple to yellow / brown.

Oxidation:	$Fe^{2+}(aq) \longrightarrow Fe^{3+}(aq) + e^-$
Reduction:	$MnO_4^-(aq) + 8H^+(aq) + 5e^- \longrightarrow Mn^{2+}(aq) + 4H_2O(l)$
Overall:	$MnO_4^-(aq) + 8H^+(aq) + 5Fe^{2+}(aq) \longrightarrow Mn^{2+}(aq) + 4H_2O(l) + 5Fe^{3+}(aq)$

[2]

(iii) (1) Magnesium (Mg) / Zinc (Zn) / Aluminium (Al) [1]

(2) Any TWO of the following: [2]

Mg/ Zn/ Al/ metal dissolves.

Silvery (grey) powder deposit /

Colour of solution becomes paler (colourless)

Iron(II) sulphate acts as an oxidizing agent because the oxidation number of iron changes from +2 to 0 / decreases / Fe^{2+} ions accept electrons. [1]

CE96_06b

(i) A is 2M ammonia / 2M NH_3 [1]

Ammonia solution is alkaline. When ammonia ionizes in water to give OH^- which turns red litmus paper blue. $NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$ [1]

(ii) B is 2M nitric acid / 2M HNO_3 [1]

Oxidation:	$Cu(s) \longrightarrow Cu^{2+}(aq) + 2e^-$
Reduction:	$3e^- + 4H^+(aq) + NO_3^-(aq) \longrightarrow NO(g) + 2H_2O(l)$
Overall:	$3Cu(s) + 8H^+(aq) + 2NO_3^-(aq) \longrightarrow 3Cu^{2+}(aq) + 2NO(g) + 4H_2O(l)$

[1]

$2NO(g) + O_2(g) \longrightarrow 2NO_2(g)$ [1]

Brown gas

(iii) (1) Add a piece of pH paper / a few drops of universal indicator to the reagent. [1]

(2) HCl will give a lower pH / a deeper red colour [1]

because HCl ionizes to a greater extent than CH_3COOH. HCl is a stronger acid / HCl has a higher concentration of H^+ [1]

OR (1) Add a piece of Mg ribbon / Zn granules / $CaCO_3(s)$ to the reagent.

(2) HCl will give gas bubbles at a faster rate

because HCl ionizes to a greater extent than CH_3COOH. HCl is a stronger acid / HCl has a higher concentration of H^+

OR (1) Measure the electrical conductivity of the solutions.

(2) HCl has a higher conductivity

because HCl ionizes to a greater extent than CH_3COOH. HCl is a stronger acid / HCl has a higher concentration of H^+

OR (1) Measure the pH of the solutions with a pH meter.

(2) HCl has a lower pH

because HCl ionizes to a greater extent than CH_3COOH. HCl is a stronger acid / HCl has a higher concentration of H^+

CE96_08b(iii)

(1) Copper (Cu) / nickel (Ni) [1]

Copper(II) / nickel(II) ions are bluish-green in colour. [1]

(2) Sulphur dioxide / SO_2 [1]

It can turn acidified (potassium) dichromate solution from orange to green. [1]

Oxidation:	$2H_2O(l) + SO_2(g) \longrightarrow SO_4^{2-}(aq) + 4H^+(aq) + 2e^-$
Reduction:	$6e^- + 14H^+(aq) + Cr_2O_7^{2-}(aq) \longrightarrow 2Cr^{3+}(aq) + 7H_2O(l)$
Overall:	$3SO_2(g) + 2H^+(aq) + Cr_2O_7^{2-}(aq) \longrightarrow 3SO_4^{2-}(aq) + 2Cr^{3+}(aq) + H_2O(l)$

OR, it can turn acidified (potassium) permanganate solution from purple to colourless.

Oxidation:	$2H_2O(l) + SO_2(g) \longrightarrow SO_4^{2-}(aq) + 4H^+(aq) + 2e^-$
Reduction:	$5e^- + 8H^+(aq) + MnO_4^-(aq) \longrightarrow Mn^{2+}(aq) + 4H_2O(l)$
Overall:	$2H_2O(l) + 5SO_2(g) + 2MnO_4^-(aq) \longrightarrow 5SO_4^{2-}(aq) + 4H^+(aq) + 2Mn^{2+}(aq)$

OR, it can turn bromine water from brown to colourless.

Oxidation:	$2H_2O(l) + SO_2(g) \longrightarrow SO_4^{2-}(aq) + 4H^+(aq) + 2e^-$
Reduction:	$2e^- + Br_2(aq) \longrightarrow 2Br^-(aq)$
Overall:	$2H_2O(l) + SO_2(g) + Br_2(aq) \longrightarrow SO_4^{2-}(aq) + 4H^+(aq) + 2Br^-(aq)$

CE96_09b

(i) The solution contains mobile ions. [1]

(ii) A colourless gas (bubbles) is evolved. [1]

$4OH^- \longrightarrow O_2 + 2H_2O + 4e^-$ [1]

(iii) Copper / Cu [1]

During the copper-plating process, the copper in the anode is oxidized to give Cu^{2+} ions. [1]

OR, $Cu \longrightarrow Cu^{2+} + 2e^-$ occurs at anode.

Concentration of Cu^{2+} ions in the electrolyte solution can be maintained. [1]

(iv) (1) To recover copper metal / To produce the loss of copper metal [1]

Cu^{2+} ions can cause water pollution / death of (harmful to) marine lives [1]

(2) 1 mole of Cu^{2+} ions react with 2 moles of NaOH [1]

OR, $Cu^{2+} + 2OH^- \longrightarrow Cu(OH)_2$

Concentration of Cu^{2+} ion

$$= \frac{3.5 \times 8}{20} \times \frac{1}{2} = 0.7\ M$$

[1]

CE97_04

Chemical knowledge

- Dissolve the nickel(II) sulphate crystals in the distilled water (in the beaker). [1]
- Connect the spoon and the nickel plate to the power supply with the spoon as the cathode and the nickel plate as the anode. [1]
- Immerse the spoon and the nickel plate in the nickel(II) sulphate solution. [1]

Observation (Any TWO of the following): [2]

- A layer of nickel (silvery / greyish metal) is deposited onto the spoon.
- The thickness of the nickel plate decreases.
- The colour of the nickel(II) sulphate solution remains unchanged.

Effective communication [3]

CE97_06a

(i) $Cr_2O_7^{2-}$ [1]

(ii) The sodium sulphate solution provides ions for the conduction of electricity / acts as an electrolyte to completes the circuit [1]

(iii) (1) The orange colour becomes paler / colourless / fades [1]

(2) Green / brown / purple colour was observed [1]

Explanation:

Under the influence of the electric field, cations in the deep blue solution are attracted to the negative pole (move to the left) and negative / $Cr_2O_7^{2-}$ ions are attracted to the positive pole (move to the right). [1]

OR, Under the influence of the electric field, the cations and anions are respectively attracted towards the negative and positive poles

The orange negative ions and the blue positive ions mix / meet at B to give the green colour. [1]

(iv) Reverse the polarity of the d.c. supply [1]

OR, connect the left hand electrode to the positive pole and the right hand electrode to the negative pole

Observation:

orange colour will appear at the left of A and blue colour will appear at the right of C. [1]

CE97_08a

(i) During electrolysis, both Cl^- and OH^- ions migrate towards the anode (positive electrode). [1]

Since a concentrated NaCl (brine) is used, the concentration of Cl^- ions is much higher than that of OH^-. [1]

Cl^- ions will be discharged at the anode to give chlorine. [1]

OR, $2Cl^- \longrightarrow Cl_2 + 2e^-$

(ii) (1) B / toxic [1]

(2) Chlorine can kill the bacteria / germs in water / sterilize water. [1]

CE97_08b

(ii) (1) Iron(II) sulphate (any iron(II) compound / sulphur dioxide / ethanol / potassium iodide / hydrogen sulphide) [1]

(2) Any one of the following:

For iron(II) sulphate (the iron(II) compound in (1))

Treat $Fe^{2+}(aq)$ with acidified potassium dichromate / in the presence of acid / H^+ ions. [1]

For SO_2

Bubble SO_2 into acidified potassium dichromate

(or place a piece of filter paper moistened with acidified potassium dichromate in SO_2 gas)

For ethanol

Heat/ reflux ethanol with acidified potassium dichromate

For KI

Treat KI(aq) with acidified potassium dichromate

For H_2S

Bubble $H_2S(g)$ into acidified potassium dichromate

(or place a piece of filter paper moistened with acidified potassium dichromate in H_2S gas)

(3) For Fe(II): Fe^{3+} / iron(III) ions [1]

For SO_2: $SO_4^{2-}(aq)$ / sulphate ions

For C_2H_5OH: CH_3COOH / ethanoic acid / CH_3CHO / ethanal

For KI: I_2 / iodine

For H_2S: S / sulphur

(iii) (1) $Cr^{2+} \longrightarrow Cr^{3+} + e^-$ [1]

(2) $O_2 + 4e^- + 4H^+ \longrightarrow 2H_2O$ [1]

(3) $O_2 + 4H^+ + 4Cr^{2+} \longrightarrow 4Cr^{3+} + 2H_2O$ [1]

(iv) making stainless steel [1]

chromium-plating [1]

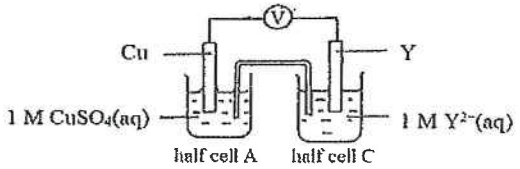
CE97_09b

(i) A solution containing the maximum amount of a solute (KNO_3) at a specified temperature. [1]

(ii) The strips of filter papers, after soaked with the saturated KNO_3 solution, is used as a salt bridge (to complete the circuit) [1]

(iii) (1) voltmeter / ammeter / multimeter / galvanometer [1]

(2) [2]



(1 mark for a correct diagram; 1 mark for labelling the half-cells and the voltmeter/ammeter/multimeter/galvanometer)

(iv) Reactivity: Cu < Y < X [1]

A more reactive metal loses electrons more readily than a less reactive metal. [1]

OR, electrons flow from a more reactive metal to a less reactive metal.

OR, electrons flow from X to Y and from Y to Cu.

(v) no observable change [1]

because Cu is less reactive than Y. [1]

CE98_02c

Brown colour of iodine fades / turns colourless [1]

Oxidation:	$H_2O(l) + SO_3^{2-}(g) \longrightarrow SO_4^{2-}(aq) + 2H^+(aq) + 2e^-$
Reduction:	$2e^- + I_2(aq) \longrightarrow 2I^-(aq)$
Overall:	$H_2O(l) + SO_3^{2-}(g) + I_2(aq) \longrightarrow SO_4^{2-}(aq) + 2H^+(aq) + 2I^-(aq)$

[1]

CE98_06b

(i) Alkaline-manganese cell. [1]

Silver oxide cell is not used because it is not of the right size. [1]

Zinc-carbon cell is not used because its voltage drops quite rapidly. [1]

(ii) No.

The shelf life of zinc-carbon cell is 1.5y and only 18 pieces can be consumed. 6 pieces will be wasted. [1]

The average price per cell used = \$49.9 / 18 = \$2.77

which is more expensive than the normal price of a zinc-carbon dry cell.

The price for 18 zinc-carbon cells = \$2.5 × 18 = \$45

which is cheaper than the price of the package. [1]

(iii) (1) **Electrode A** (zinc metal) because an oxidation occurs. [1]

(2)

Oxidation:	$Zn(s) + 2OH^-(aq) \longrightarrow ZnO(s) + H_2O(l) + 2e^-$
Reduction:	$Ag_2O(s) + H_2O(l) + 2e^- \longrightarrow 2Ag(s) + 2OH^-(aq)$
Overall:	$Zn(s) + Ag_2O(s) \longrightarrow ZnO(s) + 2Ag(s)$

[1]

CE98_09b

(i) Any TWO of the following: [2]

Sodium melts into a silvery ball / dashes around on the surface of water / floats on surface of water.

Sodium burns with a yellow flame.

Colourless gas evolved.

(ii) Open-ended question

Experiment II because sodium metal is highly reactive, it is dangerous to handle sodium metal. The reaction in experiment I is too violent and difficult to control. [1]

OR, Experiment I because a sodium hydroxide solution with high purity can be obtained.

(iii) (1) Na occupies a higher position than H in the electrochemical series / H^+ is more readily to receive electron than Na^+. [1]

(2) At anode: $2Cl^- \longrightarrow Cl_2 + 2e^-$

At cathode: $2H^+ + 2e^- \longrightarrow H_2$ [1]

Overall: $2Cl^- + 2H^+ \longrightarrow Cl_2 + H_2$

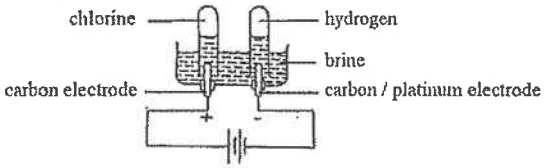
Equal number of moles of Cl_2 and H_2 will be liberated during electrolysis

Under the same temperature and pressure, equal no. of moles of gases occupy the same volume.

Theoretical volume of chlorine liberated = 50.0 cm^3 [1]

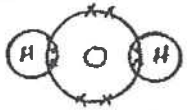
(3) After removal of Cl^- and H^+, only $Na^+(aq)$ and $OH^-(aq)$ ions remain in the solution. [1]

(iv) Labelled diagram of laboratory set-up [3]



(1 mark for labelling the two electrodes; 1 mark for showing the collection of gaseous products at the electrodes; 1 mark for labelling the correct products.)

CE99_06a

(i) 

[1]

(iii) (1) Provide mobile ions to increase the electrical conductivity of water. [1]

(2) Platinum / carbon (graphite) [1]

(3) $4OH^- \longrightarrow 2H_2O + O_2 + 4e^-$ [1]

(4) H_2 : burn with a 'pop' sound [1]

O_2 : relights a glowing splint [1]

CE99_08a

(i) $Zn \longrightarrow Zn^{2+} + 2e^-$ [1]

(ii) (1) Acts as a conductor of electricity / cathode / positive pole / electrode [1]

(2) Acts as an oxidizing agent to remove hydrogen produced. [1]

(iii) Warm the paste with NaOH(aq) in order to change NH_4^+ ion to NH_3. [1]

Evolution of a gas (ammonia) [1]

which turns moist pH paper (red litmus) from red to blue. [1]

OR, Gives white fumes with HCl(g) indicate the presence of NH_4^+.

(iv) Open-ended question:

Yes, zinc-carbon cells will produce more (solid) wastes [1]

because zinc-carbon cells are not rechargeable. [1]

OR, No, cadmium / cadmium compounds are toxic and disposal of Ni-Cd cells can cause pollution problems.

(v) $Cd + 2OH^- \longrightarrow Cd(OH)_2 + 2e^-$ [1]

$2e^- + NiO_2 + 2H_2O \longrightarrow Ni(OH)_2 + 2OH^-$ [1]

CE00_06a

(i) (1) $2ZnS + 3O_2 \longrightarrow 2ZnO + 2SO_2$ [1]

(2) manufacture of sulphuric acid / ammonium sulphate / fertilizers / bleach / food preservatives [1]

(ii) Dissolve ZnO in sulphuric acid. [1]

(iii) (1) Add zinc / magnesium / aluminium to displace ions of less reactive metals [1]

(2) Zn^{2+} ions will be preferentially discharged and ions of more reactive metals will remain in the solution [1]

(3) anode : $4OH^- \longrightarrow O_2 + 2H_2O + 4e^-$ [1]

cathode : $Zn^{2+} + 2e^- \longrightarrow Zn$ [1]

(iv) making electrodes (anode) in zinc-carbon cell / galvanized iron / brass [1]

CE01_07c

(i) Gold has strong metallic bond between atoms. [1]

Diamond has a covalent network structure and strong covalent bonds exist between carbon atoms. [1]

(ii) 18-carat gold is stronger / not easily deformed [1]

(iii) (1) Copper / Cu [1]

because Cu^{2+} ions are blue / green [1]

Oxidation:	$Cu(s) \longrightarrow Cu^{2+}(aq) + 2e^-$
Reduction:	$e^- + 2H^+(aq) + NO_3^-(aq) \longrightarrow NO_2(g) + H_2O(l)$
Overall:	$Cu(s) + 4H^+(aq) + 2NO_3^-(aq) \longrightarrow Cu^{2+}(aq) + 2NO_2(g) + 2H_2O(l)$ [1]

OR, $Cu + 4HNO_3 \longrightarrow Cu(NO_3)_2 + 2NO_2 + 2H_2O$

Alternative answer:

Nickel / Ni

because Ni^{2+} ions are green

Oxidation:	$Ni(s) \longrightarrow Ni^{2+}(aq) + 2e^-$
Reduction:	$e^- + 2H^+(aq) + NO_3^-(aq) \longrightarrow NO_2(g) + H_2O(l)$
Overall:	$Ni(s) + 4H^+(aq) + 2NO_3^-(aq) \longrightarrow Ni^{2+}(aq) + 2NO_2(g) + 2H_2O(l)$

OR, $Ni + 4HNO_3 \longrightarrow Ni(NO_3)_2 + 2NO_2 + 2H_2O$

(iii) (2) Brown gas evolves / The piece of gold is partially dissolved. [1]

CE01_08a

(ii) (2) **Both** Br_2 and Cl_2 can react with $SO_3^{2-}(aq)$ [1]

Oxidation:	$H_2O(l) + SO_3^{2-}(aq) \longrightarrow SO_4^{2-}(aq) + 2H^+(aq) + 2e^-$
Reduction:	$2e^- + Br_2(aq) \longrightarrow 2Br^-(aq)$
Overall:	$H_2O(l) + SO_3^{2-}(aq) + Br_2(aq) \longrightarrow SO_4^{2-}(aq) + 2H^+(aq) + 2Br^-(aq)$ [1]

OR,

Oxidation:	$H_2O(l) + SO_3^{2-}(aq) \longrightarrow SO_4^{2-}(aq) + 2H^+(aq) + 2e^-$
Reduction:	$2e^- + Cl_2(aq) \longrightarrow 2Cl^-(aq)$
Overall:	$H_2O(l) + SO_3^{2-}(aq) + Cl_2(aq) \longrightarrow SO_4^{2-}(aq) + 2H^+(aq) + 2Cl^-(aq)$

Alternative answers:

Both Br_2 and Cl_2 can react with KI(aq)

Oxidation:	$2I^-(aq) \longrightarrow I_2(aq) + 2e^-$
Reduction:	$2e^- + Br_2(aq) \longrightarrow 2Br^-(aq)$
Overall:	$2I^-(aq) + Br_2(aq) \longrightarrow I_2(aq) + 2Br^-(aq)$

OR,

Oxidation:	$2I^-(aq) \longrightarrow I_2(aq) + 2e^-$
Reduction:	$2e^- + Cl_2(aq) \longrightarrow 2Cl^-(aq)$
Overall:	$2I^-(aq) + Cl_2(aq) \longrightarrow I_2(aq) + 2Cl^-(aq)$

CE01_09

(a) (i) oxygen [1]

(ii) relights a glowing splint [1]

(b) (i) use a solution of sodium chloride with a higher concentration / increasing the concentration of Cl^- ions in the electrolyte. [1]

(ii) At cathode : $2H^+(aq) + 2e^- \longrightarrow H_2(g)$

A anode: $2Cl^-(aq) \longrightarrow Cl_2(g) + 2e^-$ [1]

Equal no. of moles of H_2 and Cl_2 will be liberated during the electrolysis

Under the same temperature and pressure, equal no. of moles of all gases occupy the same volume. [1]

So, ratio of theoretical volumes of $H_2 : Cl_2 = 1 : 1$ [1]

(iii) Chlorine dissolves in water [1]

$Cl_2 + H_2O \rightleftharpoons HOCl + HCl$ [1]

OR, Some of the chlorine produced reacts with the hydroxide ions formed during electrolysis.

$Cl_2 + 2OH^- \longrightarrow Cl^- + OCl^- + H_2O$

Volume of Cl_2 collected is smaller than the theoretical volume.

CE01_09c

(i) Copper(II) oxide / CuO [1]

(ii) Any TWO of the following: [2]

Effervescence / gas bubbles / misty fumes

Liquid in tube A turns blue / green

Copper wire dissolves.

Equation:

$Cu + 2H_2SO_4 \longrightarrow CuSO_4 + 2H_2O + SO_2$ [1]

Oxidation:	$Cu(s) \longrightarrow Cu^{2+}(aq) + 2e^-$
Reduction:	$2e^- + 4H^+(aq) + SO_4^{2-}(aq) \longrightarrow SO_2(g) + 2H_2O(l)$
Overall:	$Cu(s) + 4H^+(aq) + SO_4^{2-}(aq) \longrightarrow Cu^{2+}(aq) + SO_2(g) + 2H_2O(l)$

(iii) Blue litmus solution turns red [1]

because SO_2 dissolves in water to give an acidic solution [1]

(iv) To absorb excess SO_2 / prevent SO_2 to escape into air [1]

because SO_2 is toxic / harmful to the respiratory system [1]

CE02_02

(b) **The colour of the** potassium permanganate solution changes from purple to yellow. [1]

Oxidation:	$Fe^{2+}(aq) \longrightarrow Fe^{3+}(aq) + e^-$
Reduction:	$5e^- + 8H^+(aq) + MnO_4^-(aq) \longrightarrow Mn^{2+}(aq) + 4H_2O(l)$
Overall:	$5Fe^{2+}(aq) + 8H^+(aq) + MnO_4^-(aq) \longrightarrow 5Fe^{3+}(aq) + Mn^{2+}(aq) + 4H_2O(l)$ [1]

(c) The solution changes from colourless to brown / orange / yellow [1]

Oxidation:	$2Br^-(aq) \longrightarrow Br_2(aq) + 2e^-$
Reduction:	$2e^- + Cl_2(aq) \longrightarrow 2Cl^-(aq)$
Overall:	$2Br^-(aq) + Cl_2(aq) \longrightarrow Br_2(aq) + 2Cl^-(aq)$ [1]

CE02_03

(b) Manganese(IV) oxide [1]

It reacts with $H_2(g)$ which produced at the cathode / It acts as an oxidizing agent. [1]

CE02_04

Chemical knowledge

Position of ion in the electrochemical series [2]

If carbon / platinum / copper is used as the cathode, Cu^{2+} ions instead of H^+ ions will be discharged because Cu^{2+} occupies a lower position in the electrochemical series.

In the electrolysis of dilute $CuCl_2(aq)$ using carbon / platinum as anode, OH^- ions instead of Cl^- ions will be discharged because OH^- occupies a higher position in the electrochemical series.

Concentration of ion [2]

In the electrolysis of very dilute $CuCl_2(aq)$ using carbon / platinum as anode, OH^- ions will be discharged / O_2 is liberated at the anode. If concentrated $CuCl_2(aq)$ is used, Cl^- ions will be discharged / chlorine gas will be liberated instead.

Nature of electrode [2]

If carbon / platinum is used as the anode, Cl_2 / O_2 will be liberated at the anode

$4OH^-(aq) \longrightarrow O_2(g) + 2H_2O(l) + 4e^-$

If copper is used as the anode, the anode will dissolve.

$Cu(s) \longrightarrow Cu^{2+}(aq) + 2e^-$

Effective communication [3]

CE02_06a

(iii) It contains mobile ions (Mg(l) and Cl(l)). [1]

CE02_09c

(i) (1) violet / purple / blue [1]

H^+ is discharged at carbon rod A (cathode)

$2H^+ + 2e^- \longrightarrow H_2$ [1]

OH^- concentration increases around carbon rod A / concentration of $OH^-(aq)$ is higher than that of $H^+(aq)$ [1]

(2) oxygen [1]

OH^- is discharged at carbon rod B (anode) [1]

$4OH^- \longrightarrow O_2 + 2H_2O + 4e^-$

(ii) pencils / zinc-carbon cells [1]

(iii) Any TWO of the following: [2]

save chemicals / reduce the cost of chemicals (or laboratory equipment) used

reduce chance of chemicals hazards

reduce chemical wastes produced / environmental problems

shorten the time required for conducting an experiment

require less working space for carrying out an experiment

CE03_04

Chemical knowledge

<u>Similarities in chemical properties:</u>

- Sulphuric acid as an acid – H_2SO_4 ionizes in water to give $H_3O^+(aq)$ ions [1]

  Examples: reaction with alkali (base) to give salt and water only (neutralization) [1]

  $H_2SO_4 + 2NaOH \longrightarrow Na_2SO_4 + H_2O$

  Reaction with carbonate (hydrogencarbonate) to give carbon dioxide, action on acid-base indicator, etc.

  $H_2SO_4 + NaHCO_3 \longrightarrow Na_2CO_3 + H_2O + CO_2$

<u>Differences in chemical properties:</u>

- The oxidizing power of concentrated H_2SO_4 is much stronger than that of dilute H_2SO_4 [1]

  Example: conc. H_2SO_4 can oxidize metal/non-metal/compounds. It is commonly reduced to SO_2. [1]

  e.g. $Cu + H_2SO_4 \longrightarrow CuSO_4 + SO_2 + 2H_2O$

Oxidation:	$Cu(s) \longrightarrow Cu^{2+}(aq) + 2e^-$
Reduction:	$2e^- + 4H^+(aq) + SO_4^{2-}(aq) \longrightarrow SO_2(g) + 2H_2O(l)$
Overall:	$Cu(s) + 4H^+(aq) + SO_4^{2-}(aq) \longrightarrow Cu^{2+}(aq) + SO_2(g) + 2H_2O(l)$

- Conc. H_2SO_4 can act as a dehydrating agent but dilute H_2SO_4 cannot. [1]

  Examples: conc. H_2SO_4 can dehydrate $CuSO_4.5H_2O$/sugar [1]

  e.g. $CuSO_4.5H_2O(s) \xrightarrow{\text{conc. } H_2SO_4} CuSO_4(s) + 5H_2O(l)$

  blue white

  e.g. $C_{12}H_{22}O_{11} \xrightarrow{\text{conc. } H_2SO_4} 12C + 11H_2O$

- Conc. H_2SO_4 is a non-volatile acid but dil. H_2SO_4 is not.

  Examples: conc. H_2SO_4 is used in the preparation of hydrochloric acid and nitric acid.

  e.g. $H_2SO_4 + NaCl \longrightarrow NaHSO_4 + HCl$

  $H_2SO_4 + NaNO_3 \longrightarrow NaHSO_4 + HNO_3$

Effective communication [3]

CE03_06c

(i) Yes

Oxidation number of Cu decreases from +2 to 0 [1]

Oxidation number of N increases from –3 to 0 [1]

(ii) $3CuO + 2NH_3 \longrightarrow 3Cu + 3H_2O + N_2$ [1]

CE03_07a

(i) Brown / orange / red fumes evolved [1]

$2Br^- \longrightarrow Br_2 + 2e^-$ [1]

(ii) Bromine / lead(II) bromide / lead is toxic [1]

(Accept bromine vapour is corrosive.)

(iii) The light bulb gradually goes out / becomes dim. [1]
At lower temperatures, movement of ions slows down. Therefore, a smaller current flows through the external circuit. [1]
When molten lead(II) bromide becomes solid, there is no translational motion of ions / ions are no longer mobile. Thus no current flow through the external circuit. [1]

CE04_02c

Heat the acids with copper metal [1]
Only $HNO_3(aq)$ gives gas bubbles / brown fumes / a blue solution. [1]
OR, Add the acids to Zn(s) / Fe(s) / Mg(s)
$HNO_3(aq)$ gives a colourless gas which subsequently turns brown; $H_2SO_4(aq)$ gives a colourless gas only.
OR, Treat the acids with $BaCl_2(aq)$ / $Pb(NO_3)_2(aq)$ / $SrCl_2(aq)$ / $CaCl_2(aq)$.
Only $H_2SO_4(aq)$ gives a white precipitate.

CE04_06a

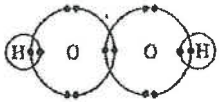
(i) platinum (Pt) / carbon (C) / graphite [1]
(ii) cathode: $2H^+ + 2e^- \longrightarrow H_2$ [1]
anode: $2H_2O \longrightarrow O_2 + 4H^+ + 4e^-$ / $4OH^- \longrightarrow O_2 + 2H_2O + 4e^-$ [1]
(iii) to increase electrical conductivity / to provide mobile ions [1]
(iv) Yes
volume of hydrogen collected : volume of oxygen collected = 2 : 1
∴ In water, hydrogen and oxygen combine in mole ratio of 2 : 1 [1]
As the atomicity of hydrogen and oxygen are both 2, [1]
∴ Formula of water is H_2O

CE03_09a

(i) From A to B
Sodium has a higher tendency to donate electrons than sulphur. [1]
At electrode A:
$Na \longrightarrow Na^+ + e^-$ [1]
At electrode B:
$S + 2e^- \longrightarrow S^{2-}$ [1]
(ii) To separate sodium from sulphur so as to prevent them from direct reaction. [1]
To allow the passage of ions between the two compartments to balance the charges. [1]
(iii) To keep sodium and sulphur in molten state / to keep mobility of particles inside the cell [1]
(iv) Sodium-sulphur cells can store up electricity produced in power station. [1]
When there is a surplus of electricity generated, the cell is charged up. [1]
When the consumption of electricity is greater than its production, the electricity that has been stored up in the cell will be used.

CE04_06b

(i) −1 [1]
(ii) [1]



(iii) (1) $H_2O_2(aq) + 2e^- + 2H^+(aq) \longrightarrow 2H_2O(l)$ [1]
(2) colour changes from pale green to yellow / brown [1]

Oxidation:	$Fe^{2+}(aq) \longrightarrow Fe^{3+}(aq) + e^-$
Reduction:	$H_2O_2(aq) + 2e^- + 2H^+(aq) \longrightarrow 2H_2O(l)$
Overall:	$H_2O_2(aq) + 2Fe^{2+}(aq) + 2H^+(aq) \longrightarrow 2Fe^{3+}(aq) + 2H_2O(l)$ [1]

CE04_07c

(i) The mass of the beaker and its contents increases. / The volume of liquid in the beaker increases. [1]
Conc. H_2SO_4 absorbs water from the atmosphere / has a high affinity for water / is hygroscopic. [1]

CE05_04

(a) Chromium-containing substances are harmful to marine life / toxic / poisonous. [1]
(b) (i) $SO_3^{2-} + H_2O \longrightarrow SO_4^{2-} + 2H^+ + 2e^-$ [1]
(ii) $Cr_2O_7^{2-} + 14H^+ + 6e^- \longrightarrow 2Cr^{3+} + 7H_2O$ [1]
(iii) $Cr_2O_7^{2-} + 8H^+ + 3SO_3^{2-} \longrightarrow 2Cr^{3+} + 4H_2O + 3SO_4^{2-}$ [1]
(c) $NaOH$ / Na_2CO_3 / NH_3 / $Ca(OH)_2$ [1]

CE05_07

Chemical knowledge [6]
Insert two of the metal strips into the lemon to form a chemical cell.
Measure the voltage of the cell using the multimeter.
Complete the electric circuit.
Control variables in the experiment such as:
– the size of the strips
– the separation / position between strips should be the same in each trial
– the temperature
The highest voltage can be obtained using a magnesium strip and a copper strip. (It is because among the three metals, Mg occupies the highest position in the electrochemical series and Cu the lowest position).
Adjust the distance / position between the two metal strips until the maximum output voltage is obtained.
Effective communication [3]

CE05_09

(a) (i) hydrogen [1]

(ii) manufacture of NH_3 / manufacture of CH_3OH / manufacture of hydrochloric acid / hardening of vegetable oils. [1]

(b) (i) Chlorine

(ii) At very low concentrations, O_2 will be formed / $OH^-(aq)$ discharged. [1]

Position of OH^- in ECS is higher than that of Cl^-. / OH^- is a stronger reducing agent than Cl^-. / OH^- loses electron more readily than Cl^-. [1]

(c) Zn is a reducing agent / Zn loses electrons [1]

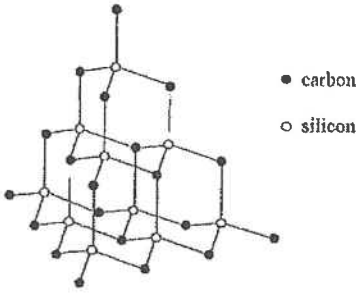
MnO_2 is an oxidizing agent / MnO_2 gains electrons [1]

When the cell is connected to an external circuit, electrons will flow through the external circuit. [1]

CE06_05

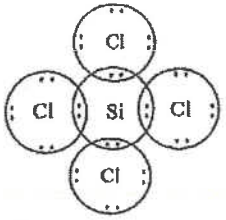
(a) covalent crystal [1]

(b) [1]



(c) (i) Oxidized. The oxidation number of Si increases from 0 to +4. [1]

(ii) [1]



(iii) Both H_2 and HCl are gases. They can easily be removed from the solid silicon produced. [1]

(d) mole of Si obtained = moles of $SiO_2 = \frac{950}{28.1 + 16 \times 2} = 15.8$ [1]

mass of Si = $15.8 \times 28.1 = 444$ g [1]

CE06_07

(a) (i) Heat the copper metal in air. [1]

Reddish brown copper changes into black copper(II) oxide. [1]

(ii) neutralization [1]

(b) $3Cu + 8HNO_3 \longrightarrow 3Cu(NO_3)_2 + 4H_2O + 2NO$ [2]

(c) Open-ended question

Method 1 [2]

- Less reactants / nitric acid is used. (For the production of 1 mol of $Cu(NO_3)_2$, 2 mol of HNO_3 is required in method 1, while 2.67 mol in method 2)
- Method 2 gives toxic product (NO) but Method 1 does not.

OR, Method 2

- The conversion involve only one step.
- In method 1, copper and oxygen do not easily undergo complete reaction / react slowly.

CE06_08

Chemical knowledge

Similarity in Chemical properties [4]

Both Cl_2 and Br_2 can oxidize SO_3^{2-} to SO_4^{2-}

$X_2 + SO_3^{2-} + H_2O \longrightarrow 2X^-(aq) + SO_4^{2-} + 2H^+$

Both Cl_2 and Br_2 can undergo addition with alkenes

$X_2 + CH_2{=}CH_2 \longrightarrow CH_2XCH_2X$

Both Cl_2 and Br_2 can undergo substitution with alkanes

$X_2 + CH_4 \longrightarrow CH_3Cl + HX$

Both Cl_2 and Br_2 can react with metals (e.g. Na) to give ionic halides

$X_2 + 2Na \longrightarrow 2NaX$

Both Cl_2 and Br_2 can react with Fe^{2+} to give Fe^{3+}

$X_2 + 2Fe^{2+} \longrightarrow 2X^- + 2Fe^{3+}$

Both Cl_2 and Br_2 can react with I^- to give I_2

$X_2 + 2I^- \longrightarrow 2X^- + I_2$

Both Cl_2 and Br_2 can undergo disproportionation in alkalis

$X_2(g) + 2OH^-(aq) \longrightarrow X^-(aq) + OX^-(aq) + H_2O(l)$

Trend in reactivity [2]

Chlorine is more reactive than bromine.

The addition $Cl_2(g)$ to KBr(aq) gives a brown solution. But the addition of $Br_2(aq)$ to KCl(aq) gives no observable change.

Effective communication [3]

CE06_10

(a) (i) zinc-carbon cells / pencil lead [1]

(ii) cans for soft drinks [1]

(b) (i) $Al + 4OH^- \longrightarrow Al(OH)_4^- + 3e^-$ [1]

(ii) $OCl^- + H_2O + 2e^- \longrightarrow Cl^- + 2OH^-$ [1]

(c) (i) Any TWO of the following: [2]

- the volume of bleach used / the depth of immersion of the carbon rod
- the distance between the carbon rod and the aluminium can
- temperature
- a carbon rod / aluminium can of the same size should be used

(ii) The electrical conductivity of the electrolyte increases with the concentration of NaOCl in the bleach. [1]

∴ The current produced by the cell increases.

CE07_04

(a) Both vinegar and wine contain molecules. [1]

Only vinegar (ethanoic acid) can ionize in water / contains (mobile) ions for conducting electricity. [1]

(b) (i) $Fe \longrightarrow Fe^{2+} + 2e^-$ [1]

(ii) $2H^+ + 2e^- \longrightarrow H_2$ [1]

(c) Iron reacts directly with vinegar / $H^+(aq)$ giving out hydrogen gas. [1]

CE07_09

Chemical knowledge [6]

<u>Corrosive property</u>

- safety glasses / goggles / rubber gloves / protective clothings / avoid contact with skin or eyes / wash with plenty of water if contacted with skin
- because acid of high concentration is corrosive

<u>Dilution process</u>

- add slowly small amount of rust remover into a large amount of water with stirring
- because large amount of heat given out in dilution of the rust remover (acid of high concentration) / avoid rust remover (acid) splashing out

<u>Other potential dangers</u>

- use plastic container instead of metal / do not use to clean marble / do not mix with chlorine bleach or caustic soda / do not put in warm place
- because will damage metal container / damage marble / toxic gas evolves if mix with chlorine bleach / large amount of heat releases if mix with caustic soda / acidic gas evolves if put in warm place

Effective communication [3]

CE07_11

(a) Species undergo oxidation is sulphide ion, O.N. of S changes from –2 to +4. [1]

Species undergo reduction are copper(I) ion and oxygen, O.N. of Cu changes from +1 to 0 and O.N. of O changes from 0 to –2. [1]

(b) The impure copper anode (+ve electrode) becomes copper(II) ions / $Cu \rightarrow Cu^{2+} + 2e^-$ [1]

Copper(II) ions in the solution discharge on the pure copper cathode (-ve electrode) / $Cu^{2+} + 2e^- \rightarrow Cu$ [1]

(c) Silver and gold [1]

They are less reactive than copper (less readily to dissolve as ions when compared with copper) [1]

(d) Not correct. Concentration of copper(II) ions drops gradually.

At anode, iron/zinc dissolve as ions because they become ions more readily than copper. [1]

However at cathode, copper(II) ions are always preferentially discharged. [1]

(e)
- SO_2 available as resource for contact process
- The cost of transportation of SO_2 is minimized
- Prevent air pollution induced by SO_2

[Any 2 points above. 1 mark for each point.] [2]

CE08_05

(a) Electrons flow from magnesium strip to zinc strip / from right to left because Mg is more reactive / easier to be oxidized / easier to lose electrons than Zn. [1]

(b) (i) Magnesium strip: oxidation / losing of electrons occurs at it. [1]

(ii) $Mg \longrightarrow Mg^{2+} + 2e^-$ [1]

(c) Interchange copper strip and zinc strip in Potato A. [1]

(d) Fresh potatoes contain water so that ions move more easily / ions are more mobile / more mobile ions. [1]

(e) The multimeter reading drops to zero / near zero. [1]

CE08_06

(a)

Chlorine should NOT be dried by calcium oxide because they will react.	Dry by concentrated sulphuric acid / silica gel / anhydrous calcium chloride
Chlorine should NOT be collected by upward delivery / downward displacement of air because it is denser than air	Chlorine should be collected by downward delivery / upward displacement of air / gas syringe.

[2] [2]

(b) The preparation should be carried out in a fume cupboard / well-ventilated area. [1]

(c) (i) $Cl^- + OCl^- + 2H^+ \longrightarrow Cl_2 + H_2O$ [1]

(ii) OCl^- / NaOCl / NaClO [1]

[wrong species = 0 mark for whole part (ii)]

The O.N. of Cl in OCl^- changes from +1 to 0. [1]

CE09_06

(a) chars / turns black / turns brown / swells up / steam / white fumes [1]

$C_6H_{12}O_6 \longrightarrow 6C + 6H_2O$ [1]

(b) (i) copper dissolves / blue solution / colourless gas / choking smell [1]

$Cu + 2H_2SO_4 \longrightarrow CuSO_4 + SO_2 + 2H_2O$ [1]

OR, $Cu + 2H^+ + H_2SO_4 \longrightarrow Cu^{2+} + SO_2 + 2H_2O$

OR, $Cu + 4H^+ + SO_4^{2-} \longrightarrow Cu^{2+} + SO_2 + 2H_2O$

(ii) Let the test tube cool down. [1]

Put the whole test tube in a tank of water with mouth of the tube point downward and then clean it. [1]

CE09_13

Chemical knowledge

A description of electroplating of iron: [6]

a. The protective layer plated on iron can be a metal such as nickel / chromium / copper / silver.

b. Electrolyte used is an aqueous salt solution of the metal. Example: nickel(II) sulphate (solution)

c. The metal (e.g. Ni) should be made anode (positive electrode / connected to positive pole of power supply).

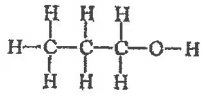
d. The iron object should be made cathode (negative electrode / connected to negative pole of power supply).

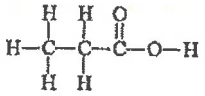
e. The metal (e.g. Ni) (anode) is oxidized / loses electrons to form ions.
(Accept half equation: $Ni \longrightarrow Ni^{2+} + 2e^-$)

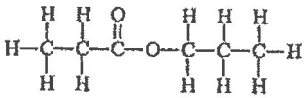
f. The metal ions (e.g. Ni^{2+}) are reduced/gain electrons on iron (cathode) surface to form metal (e.g. Ni)
(Accept half equation: $Ni^{2+} + 2e^- \longrightarrow Ni$)

Effective communication [3]

CE10_03

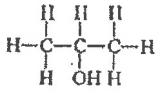
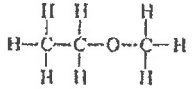
(a) A:  [1]

B:  [1]

C:  [1]

(b) from orange to green [1]

(c) fractional distillation / using separating funnel [1]

(d)  OR  [1]

CE10_05

(a) Emulsify / Dissolve the oil in the coating. [1]

(b) (i) Oxidation / redox [1]

(ii) Toxic / Poisonous chlorine gas is evolved. [1]

(iii) Molarity of sodium hypochlorite $= 0.5 \div (1 + 49)$ [1]

$= 0.01$ (mol dm^{-3}) [1]

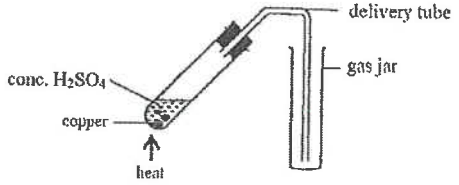
CE10_07

(a) bleaching [1]

OR, food preservation

(b) Immerse in water. / Rinse with water. [1]

Sulphur dioxide is soluble in water. [1]

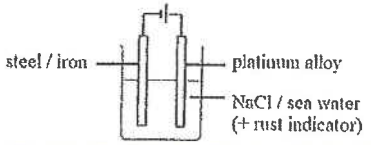
(c) 

[3]

CE10_09

Chemical knowledge [6]

(a) Set-up:



(b) Control experiment (steel / iron not connected to negative terminal)

(c) Observation:

Rust indicator does not turn blue (but turns blue in the control experiment).

OR, After some time there is no rusting (but rusting occurs in the control experiment).

(d) Principle:

Electrons flow to steel / iron, and thus steel / iron cannot be oxidized to iron(II) ions.

Effective communication [3]

CE10_11

(a) It should be zinc powder because zinc undergoes oxidation / releases electrons in the reaction. [1]

(b) providing medium for ions transfer [1]

(c) Mercury is toxic / poisonous. [1]

(d) No, Mg occupies a higher position in the electrochemical series than Zn. [1]
OR, Mg is a stronger reducing agent than Zn.
OR, Mg loses electrons more readily than Zn. Mg is more reactive than Zn.
OR, MgO is more stable than ZnO.

(e) Decrease. The difference in position of electrochemical series / reactivity series between Cu and Hg is smaller than that between Zn and Hg. [1]

(f) (i) $2Cl^- \longrightarrow Cl_2 + 2e^-$ [1]

(ii) $2H_2O + 2e^- \longrightarrow 2OH^- + H_2$ [1]
OR, $2H^+ + 2e^- \longrightarrow H_2$

(iii) Unreacted Na^+ ions in the anodic compartment can pass through the membrane to the cathodic compartment. [1]
OH^- ions are formed in the reduction of H_2O at the cathode. [1]
OR, As H^+ ions are discharged at the cathode, OH^- ions remain.

CE11_04

(a) Electrons flow from chromium rod to iron rod in the external circuit. [1]
Because iron(II) ions accept electrons making the ion colour fade out. [1]
$Fe^{2+} + 2e^- \longrightarrow Fe$

(b) $Cr \longrightarrow Cr^{3+} + 3e^-$ [1]

(c) (i) By sacrificial protection. / Chromium reacts with oxygen or water more readily than iron. / Chromium is oxidized more readily than iron. [1]

(ii) Electroplating [1]
Chromium covered on the object can prevent iron from contacting with oxygen and water. [1]

CE11_05

(a) (i) +4 [1]

(ii) Sodium hydrogensulphite ($NaHSO_3$) can react with oxygen in air, [1]
thus it can prevent the ethanol from oxidation to form ethanoic acid. [1]

(iii) $0.1 \times (23.0 + 1.0 + 32.1 + 16.0 \times 3) = 10.41$ g [1]

(b) (i) $2NaHSO_3 + Zn \longrightarrow Na_2S_2O_4 + Zn(OH)_2$ [1]

(ii) Reducing agent. [1]

CE11_10a

(i) Colourless bubbles / gas evolve. [1]
Because hydrogen ions are preferentially discharged. / $2H^+ + 2e^- \longrightarrow H_2$ [1]

(ii) At the beginning, colourless bubbles / gas evolve. [1]
After some time, a greenish-yellow gas / pale green gas / a gas with choking smell evolve. [1]
Because the hydroxide ion is higher than chloride ion in the electrochemical series, thus hydroxide ions are preferentially discharged at the beginning. After some time, the concentration of chloride ions is much higher than that of hydroxide ions, thus chloride ions are preferentially discharged. [1]

(iii) The resulting solution is alkaline.
Because $H^+(aq)$ ions are eventually discharged, but $OH^-(aq)$ ions are not discharged. [1]
OR, The resulting solution is sodium hydroxide.
OR, The concentration of $OH^-(aq)$ ions after electrolysis is higher than that of $H^+(aq)$ ions.

CE11_10b

(i) Anode. It is because the conversion of ethanol to ethanoic acid is an oxidation. [1]

(ii) $CH_3CH_2OH + H_2O \longrightarrow CH_3COOH + 4H^+ + 4e^-$ [1]

(iii) Higher concentration of ethanol produced larger current. [1]

AL95(II)_03

(a) At anode: [1]
$Zn(s) \longrightarrow Zn^{2+}(aq) + 2e^-$
At cathode:
$2MnO_2(s) + 2NH_4^+(aq) + 2e^- \longrightarrow Mn_2O_3(s) + 2NH_3(g) + H_2O(l)$ [1]
OR $2MnO_2(s) + NH_4^+(aq) + 2e^- \longrightarrow Mn_2O_3(s) + OH^-(aq) + NH_3(g)$
Overall equation
$Zn(s) + 2MnO_2(s) + 2NH_4^+(aq) \longrightarrow Zn^{2+}(aq) + Mn_2O_3(s) + 2NH_3(g) + H_2O(l)$ [1]
OR $Zn(s) + 2MnO_2(s) + NH_4^+(aq) \longrightarrow Zn^{2+}(aq) + Mn_2O_3(s) + NH_3(g) + OH^-(aq)$

(b) (i) If a current is drawn for some time, $NH_3(g)$ will accumulate at the cathode, [½]
and increase the internal resistance, leading to a drop in electrode potential. [1]

(ii) If the cell is allowed to stand for some time, $NH_4^+(aq)$ which is an acid will react with Zn. [½]
$Zn(s) + 2NH_4^+(aq) \longrightarrow Zn^{2+}(aq) + 2NH_3(aq) + H_2(g)$
With decrease in $[NH_4^+(aq)]$, the electrode potential will also drop. [½]

ASL99(I)_07 (modified)

(a) $Ni^{2+}(aq) + 2e^- \longrightarrow Ni(s)$ [1]

(b) (i) To increase the electrical conductivity of the electrolyte. [1]

(ii) Boric acid is added to the electrolytic bath to maintain a slightly acidic environment. [1]

(c) Mole of electron formed $= \frac{4.50 \times 10^{21}}{6.02 \times 10^{23}} = 7.46 \times 10^{-3}$ [1]

Mass of Ni(s)formd $= \frac{7.46 \times 10^{-3} \times 58.7}{2} = 0.219\ g$ [1]

Thickness of nickel $= \frac{0.219}{8.90 \times 20} = 1.23 \times 10^{-3} cm$ [1]

(d) By precipitation of $Ni^{2+}(aq)$ with NaOH(aq). [1]

ASL00(I)_02

(a) Bottle C [1]

Mixing reagent A and B does not have an observable change, which implies that there is no redox reaction between A and B. As both $I^-(aq)$ and $Br^-(aq)$ are reducing agent, [½]
and they do not react with each other. Hence, A or B can be a NaI or KBr. [½]

Mixtures turn to brown when A or B mix with C, where $I_2(aq)$ and $Br_2(aq)$ are brown.

$Cl_2(aq) + 2I^-(aq) \longrightarrow 2Cl^-(aq) + I_2(aq)$ [½]

$Cl_2(aq) + 2Br^-(aq) \longrightarrow 2Cl^-(aq) + Br_2(aq)$ [½]

(b) Add hexane into the mixture of A, C and B, C respectively. [1]

If the hexane layer turns from colorless to violet, the reagent contains NaI(aq). [½]

If the hexane layer turns from colorless to orange, the reagent contains KBr(aq). [½]

(c) Perform the experiment in the fumehood. [1]

ASL00(I)_03

(a) Because $Cr^{3+}(aq)$ is toxic, [1]

(b) Mole of $Cr_2O_7^{2-}(aq) = 1.0 \times 10^5 \times 1.2 \times 10^{-4} = 12$ [1]

Mole of $FeSO_4 \cdot 7H_2O$ required $= 12 \times 6 = 72$

Mass of $FeSO_4 \cdot 7H_2O$ required $= 72 \times (55.8 + 32.1 + 16 \times 4 + 7 \times 18)$ [1]

$= 20000\ g = 20\ kg$ [1]

(c) NaOH / sodim hydroxide [1]

(d) Chromium(III) hydroxide and iron(III) hydroxide [1]

ASL00(I)_05

(a) The nickel plating provides the smoothness / higher corrosion resistance. [1]

(b) Sivery shiny surface for decoration. [1]

Higher reactive than iron to provide sacrificial protection. [1]

(c) To provide acidic environment to convert water insoluble CrO_3 to water soluble CrO_4^{2-}. [1]

(d) (i) $CrO_4^{2-}(aq) + 8H^+(aq) + 6e^- \longrightarrow Cr(s) + 4H_2O(l)$ [1]

Mole of electron $= \frac{4.50 \times 10^{23}}{6.02 \times 10^{23}} = 0.748$ [½]

Mole of Cr(s) formed $= \frac{0.748}{6} = 0.125$ [½]

Thickness of chromium $= \frac{0.125 \times 52}{7.2 \times 3 \times 10^3} = 3.00 \times 10^{-4}\ cm$ [1]

(ii) H_2 gas bubbles formed will hinder the deposition of chromium metal layer. [1]

ASL00(II)_10 (modified)

(a) 2,8,14, 2 [1]

(b) Iron exists as giant metallic structure which the cations lattice soaked in the sea of [1]
delocalized electrons. These delocalized electrons have a translational motion [1]
along the electric field.

(c) (i) Iron(III) chloride / $FeCl_3$ [1]

(ii) Cl_2 can dissolve in water to give HCl(aq), and loss its oxidizing properties. [1]

(d) $Fe^{3+}(aq) + Fe(s) \longrightarrow 2Fe^{2+}(aq)$ [1]

(e) (i) A reddish brown $Fe(OH)_3$ solid forms [1]

(ii) A dirty green $Fe(OH)_2$ solid forms [1]

ASL00(II)_11

Add few drops of acidified $KMnO_4(aq)$ into two solutions respectively. [1]

Only $Na_2SO_3(aq)$ can decolorize the purple color of $KMnO_4(aq)$, while $Na_2SO_4(aq)$ cannot. [1]

$2MnO_4^-(aq) + 5SO_3^{2-}(aq) + 6H^+(aq) \longrightarrow 2Mn^{2+}(aq) + 5SO_4^{2-}(aq) + 3H_2O(l)$ [1]

AL01(I)_04

(a) Anode: $Zn(s) \longrightarrow Zn^{2+}(aq) + 2e^-$ [1]

Cathode: $2MnO_2(s) + 2NH_4^+(aq) + 2e^- \longrightarrow Mn_2O_3(s) + 2NH_3(aq) + H_2O(l)$ [1]

(b) No. of mole of $MnO_2 = 25.0 \div (54.94 + 16.00 \times 2) = 0.2876$ [1]

Mass of Zn(s) consumed $= 0.5 \times 0.2876 \times 65.38 = 9.40\ g$ [1]

ASL01(I)_06

(a) (i) Remove oil and grease [1]

(ii) Remove metal oxides [1]

(b) (i) To provide an even discharge of nickel to nickel cations for more even distribution of cations. [1]

(ii) $Ni(s) \longrightarrow Ni^{2+}(aq) + 2e^-$

(c) Part of electron is used to discharge another metal cation impurities present in the anode. [1]

(d) Discharge of strong acid or strong alkali as sewage can cause pollution. [1]

Neutralize acidic or alkaline sewage before discharge. [1]

OR, sewage contains high concentration of toxic metal cations.

Precipitate these toxic metal cations by NaOH before discharge

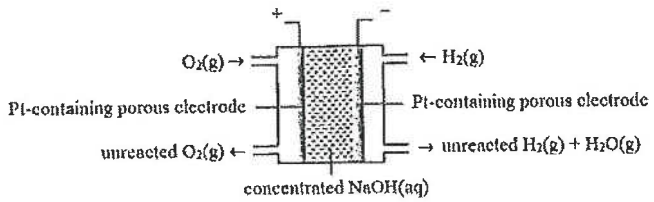
AL01(I)_07

Warm with concentrated HNO_3 / concentrated H_2SO_4 [1]

S is oxidized by HNO_3 / H_2SO_4 to SO_2 [1]

AL02(II)_03

(a)



[2]

(b) Half equation for cathodic reaction:

$O_2(g) + 2H_2O(l) + 4e^- \longrightarrow 4OH^-(aq)$ [½]

Half equation for anodic reaction:

$H_2(g) + 2OH^-(aq) \longrightarrow 2H_2O(l) + 2e^-$ [½]

Overall reaction:

$2H_2(g) + O_2(g) \longrightarrow 2H_2O(l)$

The enthalpy change of the reaction is liberated in the form of electrical energy. [1]

(c) Any one of the following: [1]

Fuel cells are more efficient than batteries in the conversion of chemical energy into electrical energy.

Fuel cells cause less environmental problems.

ASL02(II)_11

(a) (i) Sodium hypochlorite / sodium hypochlorite(I) [1]

(ii) $OCl^-(aq) + 2H^+(aq) + Cl^-(aq) \longrightarrow Cl_2(aq) + H_2O(l)$ [1]

(b) (i) Solution turns from green (Fe^{2+}) to orange (Fe^{3+}) [1]

$Cl_2(aq) + 2Fe^{2+}(aq) \longrightarrow 2Fe^{3+}(aq) + 2Cl^-(aq)$ [1]

(ii) Solution turns from colorless to orange (Br_2) [1]

$Cl_2(aq) + 2Br^-(aq) \longrightarrow Br_2(aq) + 2Cl^-(aq)$ [1]

ASL02(II)_12

(a) (i) To form a wetting agent / emulsion with sodium hydroxide to prevent spraying of alkaline solution. [1]

(ii) To remove oil and grease on the article to be electroplated. [1]

(b) To neutralize the alkaline residue and remove the oxides on the metal article. [1]

(c) To remove oxides on the metal article. [1]

To provide acidic condition for dissolving rhodium salt. [1]

(d) Mole of electron used for electroplating $= \dfrac{2.40 \times 10^{21} \times 80\%}{6.02 \times 10^{23}} = 3.19 \times 10^{-3}$ [½]

Mole of Rh formed $= \dfrac{0.17}{102.9} = 1.65 \times 10^{-3}$ [½]

Oxidation state of Rb $= \dfrac{3.19 \times 10^{-3}}{1.65 \times 10^{-3}} = 1.93$

∴ Oxidation state of Rb = +2 [1]

(c) Other cations, such as H^+, in the electrolyte may also be discharged on cathode. [1]

$2H^+(aq) + 2e^- \longrightarrow H_2(g)$

ASL03(I)_03

(a) (i) Oxidizing power: $I_2 < Br_2 < Cl_2$ [1]

(ii) Using displacemen reactions:

$Cl_2(g)$ can displace Br_2 from KBr(aq) and can displace I_2 from KI(aq). [1]

$Br_2(aq)$ can displace I_2 from KI(aq), but cannot displace Cl_2 from KCl(aq). [1]

∴ oxidizing power: $Cl_2 > Br_2 > I_2$

(b) A redox reaction in which a species is simultaneously oxidized and reduced. [1]

$H_2O_2 \longrightarrow H_2O + O_2$ [1]

$Cl_2 + 2OH^- \longrightarrow ClO^- + Cl^- + H_2O$

AL03(II)_04 (modified)

(a) It forms strong dative bond with Fe(II) in haemoglobin and inhibits Fe(II) from forming complex with O_2. Thus the oxygen carrying capacity of haemoglobin is decreased. [1] [1]

(b) When there is an increase (decrease) in indoor CO level, the electrochemical reaction will proceed at faster (slower) rate. [1]

A larger (smaller) current will flow through the CO detector. [1]

(c) Incomplete combustion of fossil fuels / leakage of town gas. [1]

ASL04(I)_02

False.

F, the most electronegative element, can exhibit only one O.S. of −1. [1]

AL04(II)_05

(a) Treating $Cl_2(g)$ with dilute NaOH(aq) at room temperature.

$Cl_2 + 2OH^- \longrightarrow Cl^- + OCl^- + H_2O$

(b) Formula mass of NaOCl = 23.0 + 16.0 + 35.5 = 74.5 [1]

$[NaOCl]$ in diluted bleach $= \dfrac{60}{74.5} \times 10 \times \dfrac{1}{100} = 8.05 \times 10^{-3}$ mol dm^{-3} [1]

(c) HSO_4^- hydrolyzes in water to give H^+ and SO_4^{2-} [½]

$HSO_4^- \rightleftharpoons H^+ + SO_4^{2-}$

OCl^- reacts with H_3O^+ to give $Cl_2(g)$ which is toxic [½]

$Cl^- + OCl^- + 2H^+ \rightleftharpoons H_2O + Cl_2$ [1]

AL05(I)_07b

(i) $Na_2SO_3(aq) + H_2SO_4(aq) \longrightarrow Na_2SO_4(aq) + H_2O(l) + SO_2(g)$ [1]

(ii) KOH(aq) should not used as $SO_2(g)$ reacts vigorously with KOH(aq). An empty conical flask (as a trap) should be used instead. [1]
It is not necessary to include the flask containing KOH(aq) in the set-up. [1]
$SO_2(g)$ should not be collected over water as it is very soluble. Collect the $SO_2(g)$ produced by downward delivery / upward displacement of air / using a syringe. [1]

(iii) Treat $SO_2(g)$ with $Cr_2O_7^{2-}/H^+(aq)$. [1]
The solution changes from orange to green. [1]
OR, Treat $SO_2(g)$ with $MnO_4^-/H^+(aq)$.
The solution changes from purple to colorless.

ASL05(I)_07

(a) (i) To make the knobs a conductor of electricity for the nickel-plating process. [1]

(ii) To make it more appealing [1]

(b) $Ni^{2+}(aq) + 2e^- \longrightarrow Ni(s)$ [1]

(c) (i) At low pH, $H^+(aq)$ instead of $Ni^{2+}(aq)$ will be discharged at the cathod. [1]
The current efficiency will decrease.
At high pH, $Ni^{2+}(aq)$ will be precipitated as $Ni(OH)_2(s)$ [1]
∴ It is necessary to maintain the pH in a range of about 4 to 6.

(ii) H_3BO_3 is a weak acid. The ionization of H_3BO_3 can replenish the $H^+(aq)$ ions lost by discharge at the cathode and maintains the pH of the electrolytic bath. [1]

(d) A high current density can result in a loose spongy metal deposit which may peel off from the knobs. [1]

AL05(II)_02

(a) $2MnO_4^-(aq) + 10Cl^-(aq) + 16H^+(aq) \longrightarrow 2Mn^{2+}(aq) + 5Cl_2(g) + 8H_2O(l)$ [1]
$Cl_2(aq) + 2Fe^{2+}(aq) \longrightarrow 2Cl^-(aq) + 2Fe^{3+}(aq)$ [1]
$2MnO_4^-(aq) + 5SO_2(g) + 2H_2O(l) \longrightarrow 2Mn^{2+}(aq) + 5SO_4^{2-}(aq) + 4H^+(aq)$ [1]
OR $2MnO_4^-(aq) + 5SO_3^{2-}(aq) + 6H^+(aq) \longrightarrow 2Mn^{2+}(aq) + 5SO_4^{2-}(aq) + 3H_2O(l)$

(b) (i) The reaction
$MnO_4^-(aq) + 5Fe^{2+}(aq) + 8H^+(aq) \longrightarrow Mn^{2+}(aq) + 5Fe^{3+}(aq) + 4H_2O(l)$ is feasible. [1]
As revealed in the given experimental results, oxidizing power is in the order: [1]
$MnO_4^-(aq) > Cl_2(g) > Fe^{3+}(aq)$
Acidified $KMnO_4(aq)$ can oxidize $Fe^{2+}(aq)$

(ii) Cannot be predicted from the given information [1]
The experimental results only reveal the following:
Oxidizing power: $MnO_4^-(aq) > SO_4^{2-}(aq)$, and $MnO_4^-(aq) > Fe^{3+}(aq)$ [1]
No comparsion of oxidizng power between $SO_4^{2-}(aq)$ and $Fe^{3+}(aq)$ can be obtained.

AL05(II)_04

(a) $3Cu(s) + 8HNO_3(aq) \longrightarrow 3Cu(NO_3)_2(aq) + 4H_2O(l) + 2NO(g)$ [1]

(b) (i) Colorless gas bubble (NO) are formed / The liquid level in the dropper becomes lower (owing to the gas pressure). [1]
The liquid turns blue owing to the formation of $Cu^{2+}(aq)$ ions. [1]
When all liquid has been driven out of the dropper, a brown gas is formed. [1]
This is due to the formation of $NO_2(g)$.
$2NO(g) + O_2(g) \longrightarrow 2NO_2(g)$

(ii) Any ONE of the following: [1]

- The product of the reaction between Cu and HNO_3 (NO) readily reacts with O_2 to give NO_2. The formation of colorless NO(g) cannot be seen if a test tube is used.
- Less toxic gas $NO_2(g)$ is released to the atmosphere.

AL06(I)_03

(a) $S(s) + 6HNO_3(aq) \longrightarrow H_2SO_4(aq) + 2H_2O(l) + 6NO_2(g)$ [1]

(b) $4Mn^{2+}(aq) + O_2(g) + 8OH^-(aq) + 2H_2O(l) \longrightarrow 4Mn(OH)_3(s)$ [1]

(c) $3MnO_4^{2-}(aq) + 2H_2O(l) \longrightarrow 2MnO_4^-(aq) + MnO_2(s) + 4OH^-(aq)$ [1]

ASL06(I)_03b

(i) Hydrogen iodide vapor is formed initially. [1]
Concentrated sulphuric acid oxidizes hydrogen iodide to iodine [1]
Iodine vapor is violet in color. [1]

(ii) Metal chloride is usually more volatile than the sulphate. [1]

AL06(II)_04

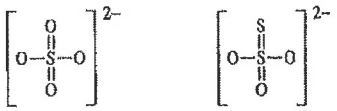
(a) Cathodic reaction:
$PbO_2(s) + 2e^- + 4H^+(aq) + SO_4^{2-}(aq) \rightleftharpoons PbSO_4(s) + 2H_2O(l)$ [1]
Anodic reaction:
$Pb(s) + SO_4^{2-}(aq) \rightleftharpoons PbSO_4(s) + 2e^-$ [1]

(b) There is no loss of materials from the cell during the charging and recharging process. [1]

(c) (i) During the charging process, $H_2SO_4(aq)$ is produced. The density of the battery acid increases. [½]
During the discharging process, $H_2SO_4(aq)$ is consumed. The density of the battery acid decreases. [½]

(ii) If the battery is charged with a high voltage, the $PbO_2(s)$ formed will not adhere strongly to the lead plate. The life of the battery will become shortened. [1]

AL07(I)_02



[2]

In SO_4^{2-}, O.S. of S = +6 [1]

In $S_2O_3^{2-}$, O.S. of central s atom = +4; O.S. of the other S atom = 0 [1]

AL08(I)_01

Step 1: $2NH_3(g) + 3Cl_2(g) \longrightarrow N_2(g) + 6HCl(g)$ [1]

$NH_3(g)$ acts as **reducing agent.** [½]

Step 2: $NH_3(g) + HCl((g) \longrightarrow NH_4Cl(s)$ [1]

$NH_3(g)$ acts as **base.** [½]

AL08(I)_02

(a) The principle of the fuel cell is based on the conversion of chemical energy released in the reaction [½]

$2H_2(g) + O_2(g) \longrightarrow 2H_2O(l)$ to electrical energy. [½]

In the $H_2(g)$ compartment, $H_2(g)$ is oxidized to $H_2O(l)$:

$H_2(g) + 2OH^-(aq) \longrightarrow 2H_2O(l) + 2e^-$ (the negative electrode) [½]

In the $O_2(g)$ compartment, $O_2(g)$ is reduced to $OH^-(aq)$:

$O_2(g) + 2H_2O(l) + 4e^- \longrightarrow 4OH^-(aq)$ (the positive electrode) [½]

The concentrated NaOH(aq) acts as an electrolyte and **provides $OH^-(aq)$ ions for the anodic reaction.** [½]

The porous electrodes allow the flow of $H_2(g)$ and $OH^-(aq)$ in and out of the compartments. [½]

The electrolytic reactions are catalyzed by the Pt in the electrodes.

(b) Any ONE of the followings: [1]

- $H_2 - O_2$ fuel cells have high efficiency of energy conversion.
- $H_2 - O_2$ fuel cells can operate continuously if the flow of $H_2(g)$ and $O_2(g)$ can be maintained.
- Water formation which can be drunk.

AL08(I)_02

0.5 M KI(aq):

Some $I^-(aq)$ ions have undergone air oxidation to give $I_2(s)$, which dissolve in $I^-(aq)$ to give brown $I_3^-(aq)$. [1]

$4I^-(aq) + O_2(g) + 4H^+(aq) \longrightarrow 2I_2(s) + 2H_2O(l)$ [½]

$I_2(s) + I^-(aq) \longrightarrow I_3^-(aq)$ [½]

(Accept equations showing other oxidizing agent, e.g. O_3)

14 M $HNO_3(aq)$:

$HNO_3(aq)$ undergoes **photodecomposition** to give $NO_2(g)$, which is brown both in gaseous state and in aqueous solution. [1]

$4HNO_3(aq) \longrightarrow 4NO_2(g) + 2H_2O(l) + O_2(g)$ [1]

0.02 M $KMnO_4(aq)$:

$MnO_4^-(aq)$ undergoes **slow decomposition** and the decomposition is catalyzed by sunlight. [1]

Brown $MnO_2(s)$ is formed.

$4MnO_4^-(aq) + 4H^+(aq) \longrightarrow 4MnO_2(s) + 3O_2(g) + 2H_2O(l)$ [1]

ASL08(I)_02

0.5 M KI(aq):

Some $I^-(aq)$ ions have undergone air oxidation to give $I_2(s)$, which dissolve in $I^-(aq)$ to give brown $I_3^-(aq)$. [1]

$4I^-(aq) + O_2(g) + 4H^+(aq) \longrightarrow 2I_2(s) + 2H_2O(l)$ [½]

$I_2(s) + I^-(aq) \longrightarrow I_3^-(aq)$ [½]

(Accept equations showing other oxidizing agent, e.g. O_3)

14 M $HNO_3(aq)$:

$HNO_3(aq)$ undergoes **photodecomposition** to give $NO_2(g)$, which is brown both in gaseous state and in aqueous solution. [1]

$4HNO_3(aq) \longrightarrow 4NO_2(g) + 2H_2O(l) + O_2(g)$ [1]

2M NaOH(aq)

NaOH(aq) reacts with $CO_2(g)$ in air to give $NaHCO_3(aq)$ which undergoes dehydration to give $Na_2CO_3(s)$. [1]

$NaOH(aq) + CO_2(g) \longrightarrow NaHCO_3(aq)$ [½]

$2NaHCO_3(aq) \longrightarrow Na_2CO_3(s) + H_2O(l)$ [½]

AL09(I)_02

(a) $:N{\equiv}C{-}C{\equiv}N:$ [1]

(b) $(CN)_2$ exists as simple molecules. Its relative molecular mass is smaller than that of Cl_2. [1]

$(CN)_2$ is a gas.

(c) $(CN)_2(g) + 2NaOH(aq) \longrightarrow NaOCN(aq) + NaCN(aq) + H_2O(l)$ [1]

AL09(I)_07d

Oxidizing [1]

AL09(II)_03

$Fe^{2+}(aq)$ is readily oxidized by $O_2(g)$ in air to $Fe^{3+}(aq)$. [1]

$Fe^{3+}(aq)$ undergoes hydrolysis to give brown $Fe(OH)_3(s)$. [1]

AL10(I)_03

Adding $H_2SO_4(aq)$ to $K_2CrO_4(aq)$: the yellow $CrO_4^{2-}(aq)$ solution turns orange $Cr_2O_7^{2-}(aq)$. [½]

$2CrO_4^{2-}(aq) + 2H^+(aq) \longrightarrow Cr_2O_7^{2-}(aq) + H_2O(l)$ [1]

Adding $FeSO_4(aq)$ to the orange solution: it turns green $Cr^{3+}(aq)$. [½]

$6Fe^{2+}(aq) + Cr_2O_7^{2-}(aq) + 14H^+(aq) \longrightarrow 6Fe^{3+}(aq) + 2Cr^{3+}(aq) + 7H_2O(l)$ [1]

AL10(I)_07b

HBr and HI and reducing agents. They react with concentrated H_2SO_4 to give the corresponding halogens (Br_2 or I_2). In such cases, the non-oxidizing and non-volatile acid H_3PO_4 should be used. [1] [1]

Concentrated H_2SO_4 can only be used to prepare HCl and HF.

AL12(I)_02

(b) (ii) +4 [1]

(iii) $2VO_2^+(aq) + 3Zn(s) + 8H^+(aq) \longrightarrow 2V^{2+}(aq) + 3Zn^{2+}(aq) + 4H_2O(l)$ [1]

AL12(II)_07

(a) When the cell is producing a current, $Cd^{2+}(aq)$ ions will be formed at the anode. [1]

$NO_3^-(aq)$ ions in the salt bridge will migrate to the anode compartment to neutralize the surplus $Cd^{2+}(aq)$ ions. [1]

(Accept explanations based on reduction of $Ni^{2+}(aq)$ ions at cathode.)

(b) (i) Anode reaction:

$Cd(s) + 2OH^-(aq) \longrightarrow Cd(OH)_2(s) + 2e^-$ [1]

Cathodic reaction:

$NiO(OH)_2(s) + H_2O(l) + e^- \longrightarrow Ni(OH)_2(s) + OH^-(aq)$ [1]

(ii) In the overall reaction, all species involved are either in solid state or in liquid state. As solid and liquids have constant concentration, depleting or formation of the reactant or product will have very little effect on the cell e.m.f. [1]

(c) Any ONE of the followings: [1]

- Li-ion batteries have higher current / energy density
- As compared with NiCd batteries of the same dimensions, Li-ion batteries are lighter.
- Li-ion batteries pose less harm to the environment when they are disposed of.
- Li-ion batteries have litte memory effect.

AL13(I)_07

(a) (i) R: Cu(s) [½]

S: Ag(s) [½]

(ii) (I) To complete the circuit by allowing movement of ions between the two half-cells but prevent mixing of the two solutions. [1]

(II) Some $Ag^+(aq)$ ions may have migrated to the salt bridge so that the concentration will be affected. [1]

AL13(II)_02

(b) Yes, the oxidation state of Mn changes from +7 to +6 / the oxidation state of O changes from 0 to −2. [1]

$4MnO_4^-(aq) + 4OH^-(aq) \longrightarrow 4MnO_4^{2-}(aq) + 2H_2O(l) + O_2(g)$ [1]

DSE11SP_04

(a) (i) Purple / blue [1]

H^+ is prefentially discharged at carbon rod A (cathode)

$2H^+(aq) + 2e^- \longrightarrow H_2(g)$ [1]

$\therefore$ OH^- concentration increase around carbon rod A / concentration of $OH^-(aq)$ is higher than that of $H^+(aq)$. [1]

(ii) oxygen [1]

$OH^-(aq)$ is more preferentially discharged at carbon rod B (anode) than $SO_4^{2-}(aq)$. [1]

$4OH^-(aq) \longrightarrow O_2(g) + 2H_2O(l) + 4e^-$

(b) Pencil / zinc-carbon cells [1]

DSE11SP_09

3 sets of tests needed each of which carries 2 marks: [6]

- Suitable test matches the intention to distinguish certain compounds
- Correct observation / result

Effective communication [1]

Conduct flame test using the samples.

Only two sodium compounds (NaOCl and Na_2SO_4) give a golden yellow flame.

Heat samples with NaOH(aq).

Only the two ammonium compounds (NH_4Cl and NH_4NO_3) give an alkaline gas / ammonia.

Add HCl(aq)

Only NaOCl(aq) gives greenish yellow gas / chlorine.

Touch with moist litmus paper / color flower petal.

Only NaOCl gives bleaching effect.

Added acidified $BaCl_2(aq)$ to aqueous solution of the two sodium compounds.

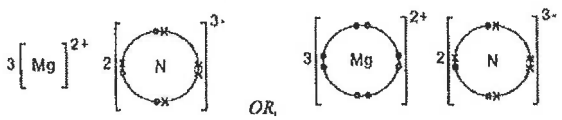
Only $Na_2SO_4(aq)$ gives a white precipitate.

Add acidified $AgNO_3(aq)$ to aqueous solutions of the two ammonium compounds.

Only $NH_4Cl(aq)$ gives a white precipitate.

DSE12PP_03

(a) (i)



OR,

[1]

(ii) $Mg_3N_2 + 6H_2O \longrightarrow 3Mg(OH)_2 + 2NH_3$ [1]

No. There is no change in oxidation number of any atom. [1]

DSE12PP_08

(a) Anode : $CH_3OH(aq) + H_2O(l) \longrightarrow CO_2(g) + 6H^+(aq) + 6e^-$ [1]

Cathode : $O_2(g) + 4H^+(aq) + 4e^- \longrightarrow 2H_2O(l)$ [1]

(b) (i) Methanol does not conduct electricity. It is not suitable to be used as the reaction medium for the electrochemical reaction. [1]

OR, H_2O is involved in the half-equations.

OR, Acid is involved in the electrochemical reaction.

(ii) Toxic and flammable [1]

(c) Accept both 'Yes' and 'No' answers. Marks will be awarded only to the explanation. [2]

For 'No' answer,

- Electrical sockets can be found in most places. DMFC laptop computers will only be used in places where electic sockets are not available.
- The cost for the manufacture of methanol is higher than that for the generation of electricity in most places.

For 'Yes' answers,

- The use of DMFC laptop computers will become prevalent when stringent environmental laws are enforced as the disposal of DMFCs causes less harm to the environment than other rechargeable cells / methanol is a greener fuel than hydrocarbons.
- DMFC laptop computers will be commonly be used in the field work where electric sockets are not available.

Accept other reasonable answers.

DSE12_03

(a) Provide H^+ / ions / electrolyte for the chemical cell. [1]

(b) Copper, Metal Y, Metal X / Cu, Y, X [1]

(c) (i) $X \longrightarrow X^{2+} + 2e^-$ [1]

(ii) $2H^+ + 2e^- \longrightarrow H_2$ [1]

(d) No, the metal Y strip would be the negative electrode. It is because silver is lower than copper in the electrochemical series / silver is less reactive than copper. So silver should be lower than Y in the electrochemical series / less reactive than Y. [1]

DSE12_05

(a) Displacement reaction occurred when the iron rod is dipped into the copper(II) sulphate solution. / Some copper(II) ions (Cu^{2+}) are reduced and deposited onto the surface of the iron rod as copper metal. [1]

$Cu^{2+}(aq) + Fe(s) \longrightarrow Cu(s) + Fe^{2+}(aq)$ [1]

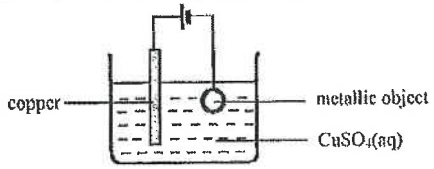
$CuSO_4(aq) + Fe(s) \longrightarrow Cu(s) + FeSO_4(aq)$

(b) (i) Copper is lower than hydrogen in the electrochemical series / Cu^{2+} is discharged preferentially than H^+ when a current is applied. [1]

(ii) Hydrogen gas / H_2 [1]

The hydrogen gas bubbles hinder the deposition of copper on the surface of the metallic object, hence causing the copper metal deposited easily flaked off. [1]

(c)



[3]

DSE13_09

(a) Brown color / yellow color is observed. [1]

Due to the high concentration of KI in the solution, I^- ions are preferentially discharged to give I_2 / discharged instead of OH^- to give I_2 which dissolves in KI(aq) to give brown I_3^- ions. [1]

(Note – minimum requirement: concentration effect + preferentially discharge of I^- / high concentration of KI + discharge of I^-)

(b) (i) H^+ is discharged / reduced to H_2 at electrode B. [1]

$2H^+(aq) + 2e^- \longrightarrow H_2(g)$

Depletion of H^+ ions makes $[OH^-(aq)] >> [H^+(aq)]$ / The amount of OH^- ions increases at electrode B as H^+ is being consumed. [1]

∴ Universal indicator turns blue under alkaline conditions.

(ii) Accept both 'yes' and 'no' answers. Award 1 mark for a reasonable explanation. [1]

'No': B is the negative electrode. Copper will not lose electrons to give Cu^{2+} at the negative electrode / Copper (Cu) cannot undergo reduction at the negative electrode / Copper will not take part in chemical changes and will act only as the electrode.

'Yes': Copper and carbon have different electrical conductivity. Therefore the solution near electrode B turns blue more quickly / The current in the external circuit changes.

DSE13_10

(a)  [1]

(b) Electrode D: $H_2(g) + 2OH^-(aq) \longrightarrow 2H_2O(l) + 2e^-$ [1]
Electrode E: $O_2(g) + 2H_2O(l) + 4e^- \longrightarrow 4OH^-(aq)$ [1]

(c) (i) Accept both 'agree' and 'disagree' answers. Award 1 mark for a sound argument. [1]

Agree: The hydrogen can be obtained from renewable source (with one proper example) (E.g. electrolysis of water using the electricity generated from hydropower / reforming of CH_4 obtained from animal manure.)

Disagree: The hydrogen gas used is produced from fossil fuel such as steam reforming of nature gas.
Disagree: (Electrical) energy is consumed in the production of hydrogen (from water).
(NOT Accept the answer is yes, because the hydrogen can be obtained from the electrolysis of water, and so the fuel cells do not consume fossil fuel.)

(ii) Agree: Only water is produced from the hydrogen-oxygen fuel cells [1]
OR, No CO_2 / SO_2 / NO_x / CO / unburnt hydrocarbon in the exhaust.

DSE13_11

(c) KNO_3 is added to react with sodium which is (highly) reactive / corrosive / flammable / strongly reducing. [1]

DSE14_05

(a) Wearing protective gloves or plastic gloves or gown or safety googles or any suitable PPE / adding concentrated acids into water when diluting the concentrated acids / use a fume cupboard. [1]
Not accepted : maintain a good ventilation.

(c) Concentrated sulphuric acid reacts with copper to liberate a colorless gas / irritating gas / gas with characteristic smell / black solid (copper(II) oxide). [1]
Concentrated nitric acid reacts with copper to liberate a brown gas / bluish-green or blue solution. [1]
When concentrated ethanoic acid is added to copper granules, no observable changes occur / no reaction. [1]
Not accepted: exothermic / bluish-green or blue solution in concentrated sulphuric acid.

DSE14_08

(a) (i) The electrode dissolves / becomes smaller / becomes thinner gradually. [1]
(ii) (Colorless) bubbles / gas are given out. [1]

(b) (i) $4OH^-(aq) \longrightarrow O_2(g) + 2H_2O(l) + 4e^-$ [1]
(ii) $Ag^+(aq) + e^- \longrightarrow Ag(s)$ [1]

(c) Electrode W Electrode Z [1]
Anode Cathode

(d) Electrons would not flow through the electric wires / no observable changes on all electrodes / no reaction occurs because ethanol is not an electrolyte / cannot conduct electricity. [1]

DSE14_09

(b) (i) Purple acidified potassium permanganate solution is decolorized / turns into colorless / turns into pale pink. [1]

(ii) (1) Redox / reduction (of acidified potassium permanganate) / oxidation-reduction [1]

(2) $2MnO_4^-(aq) + 5SO_3^{2-}(aq) + 6H^+(aq) \longrightarrow 2Mn^{2+}(aq) + 5SO_4^{2-}(aq) + 3H_2O(l)$ [1]
(State symbols are not required)

DSE14_11

(a) Vanadium exhibits variable oxidation numbers and its ions in aqueous solution carry colors. [1]

(b) (i) 1 (mol of) $VO_2^+(aq)$ ions gains 2 (mol of) electrons from 1 (mol) of $SO_2(g)$ to become 1 (mol of) $V^{3+}(aq)$. [1]
$V^{3+}(aq)$ is green in color. [1]

(ii) $SO_2(g) + VO_2^+(aq) \longrightarrow SO_4^{2-}(aq) + V^{3+}(aq)$ [1]

DSE15_02

(b) The solution changes from orange to green. (NOT accept "colorless gas bubbles / $SO_2(g)$") [1]
[1]
$Cr_2O_7^{2-}(aq) + 3SO_3^{2-}(aq) + 8H^+(aq) \longrightarrow 2Cr^{3+}(aq) + 3SO_4^{2-}(aq) + 4H_2O(l)$

DSE15_04

(a) A cell that can be recharged after use. [1]

(b) It can provide a high current / voltage / power to start up the engine. [1]
NOT accept "energy", "electrical energy".

(c) Lead / lead compounds are toxic / harmful. [1]
OR, Sulphuric acid is corrosive / irritant.
NOT accept answers like "lead compounds are pollutants / heavy metal"
NOT accept answers like 'acid cause harm the environment".

DSE15_07

(a) Oily dirts hinders the conduction of electricity / hinders the plating of copper on the object. [1]

OR, The copper surface will easily flake off / the electroplated surface will not be smooth.

(b) Electrolyte is a compound that conducts electricity when melted or dissolved in water. [1]

OR, Electrolyte is a substance that consist of mobile ions when melted or dissolved in water.

OR, Electrolyte is a substance that undergoes decomposition when electricity is passing through it.

(c) Cu^{2+}, SO_4^{2-}, H^+, OH^- [1]

(d) Copper(II) ion has higher oxidizing power than hydrogen ion. [1]

OR, Copper(II) ion undergoes reduction more readily than hydrogen ion.

OR, Copper(II) ion is lower than hydrogen the electrochemical series.

(e) $Cu \longrightarrow Cu^{2+} + 2e^-$ [1]

(f) No observable change [1]

(g) Mole of electrons involved $= \frac{2.20 \times 10^{22}}{6.02 \times 10^{23}} = 0.0379$ [1]

Mass of copper formed $= \frac{0.0379}{2} \times 63.5 = 1.20\ g$ (accept 1.20 – 1.21) [1]

DSE16_08

(a) (i) Reddish brown gas observed. (*NOT accept reddish brown liquid.*) [1]

(ii) $Sr^{2+} + 2e^- \longrightarrow Sr$ [1]

(b) Bromine gas formed is toxic / poisonous. / Bromine is toxic. / A toxic gas is formed. [1]

Do not accept answers like "irritant", "harmful".

(c) (i) Oxidation number of Mn decreases / changes from +4 to +3. [1]

Therefore $MnO_2(s)$ is the oxidizing agent. [1]

(ii) $2MnO_2(s) + 2NH_4^+(aq) + 2e^- \longrightarrow Mn_2O_3(s) + 2NH_3(aq) + H_2O(l)$ [1]

OR, $2NH_4^+(aq) + 2e^- \longrightarrow 2NH_3(aq) + H_2(g)$

DSE17_04

(a) (i) A: $OH^-(aq)$ ions are (preferentially) discharged to give a (colorless) gas (oxygen). [1]

(Accept oxygen is not mentioned. Not accept incorrect gas is mentioned.)

(Not accept: $OH^-(aq)$ ions are preferentially discharged to give oxygen.)

(ii) $H^+(aq)$ ions are (preferentially) discharged to give a (colorless) gas (hydrogen). [1]

(Accept hydrogen is not mentioned. Not accept incorrect gas is mentioned.)

(Not accept: $H^+(aq)$ ions are preferentially discharged to give hydrogen.)

The solution turns pink as $[OH^-(aq)] > [H^+(aq)]$ (when H^+ ions are consumed). [1]

(Accept only mentioned concentration of OH^- / amount of OH^- / no. of mole of OH^- increases / accumulate more OH^-, without mentioning H^+.)

(b) $2H_2O \longrightarrow 2H_2 + O_2$ [1]

(State symbols not required. Incorrect answer if wrong state symbols were given.)

(c) (i) A: No change. $OH^-(aq)$ ions are (still preferentially) discharged to give a colorless gas (oxygen). [1]

(ii) No change. $H^+(aq)$ ion, the only cations, discharged to give a colorless gas (hydrogen). [1]

(Accept: A faster rate of colorless gas bubble formation will be observed with increased concentration of H^+ in the solution.)

No color change in the solution / The solution will not turn into pink as it is still acidic, despite the decrease in $[H^+(aq)]$ / as $H^+(aq)$ is in excess. [1]

(Accept: The solution close to the surface of the electrode will turn pink due to the discharge of H^+, but the overall color change will become much less obvious / the solution remains colorless due to the presence of excess H^+ in the solution.)

DSE17_06

(a) Oxidizing and corrosive [1]

(c) Copper dissolves / The solution turns blue / A colorless / choking gas (bubbles) evolves. [1]

$Cu + H_2SO_4 \longrightarrow CuSO_4 + 2H_2O + SO_2$ [1]

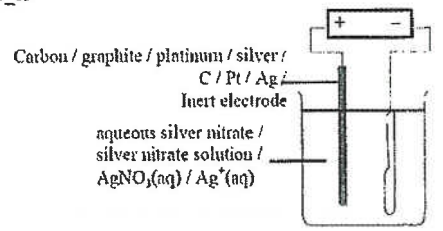
OR The liquid turns black / A black solid / precipitate is formed.

$Cu + H_2SO_4 \longrightarrow CuO + H_2O + SO_2$

State symbols not required.

DSE18_05

(a) [3]



All 3 labels correct: 2 marks, Any 1 label correct: 1 mark

(Accept drawing of battery with correct poles / only + and – signs at the correct positions / electron flow in the correct direction in the external circuit.

(b) Connect zinc / magnesium blocks (through connecting wires to the surface of the pipelines / scarification protection. [1]

Zinc / magnesium can release electrons more readily than iron. [1]

OR, Zinc and magnesium are more reactive than iron. / Zinc and magnesium has greater reducing power than iron. / Zinc and magnesium is higher than iron in the ECS.

OR, Connect the negative electrode of a D.C. source (through connecting wires)

to the surface of the pipelines (and the positive electrode to a platinum electrode) / Cathodic protection
The electrons provided by the D.C. source prevent iron from releasing electrons.
(Do not accept wrapping with plastics / alloying / use stainless steel pipelines)

DSE18_08

(a) An acid which can (almost) completely ionize / dissociate to H^+ ions in water. [1]

(b) (i) Chlorine / $Cl_2(g)$ [1]

(ii) Any ONE of the followings: [1]
It is a redox reaction:
- O.N. of Cl changes from -1 to 0 /
- O.N. of Mn changes from +7 to +2
- Cl^- transfer electrons to MnO_4^-
- O.N. of Mn and Cl change at the same time
- MnO_4^- is reduced and Cl^- is oxidized.

(c) The filter paper turns yellowish brown [1]
(Do not accept yellow / orange)
$2I^- + Cl_2 \longrightarrow 2Cl^- + I_2$ [1]

(d) The experiment should be performed in a fume cupboard as chlorine gas is toxic / toxic gas is released. [1]
(Do not accept well-ventilated benches, etc.)

DSE19_07

(a) (i) Separate the $CuSO_4(aq)$ and $MgSO_4(aq)$ / allow ions to pass through / to complete the circuit. [1]

(ii) Yes, the multimeter reading is positive showing electrons flow from Mg to Cu through the external circuit because
Mg loses electrons more readily than Cu. [1]
OR
- Mg is more reactive than Cu.
- Mg is a stronger reducing agent than Cu.
- Mg is higher than Cu in the reactivity series or ECS.
- Mg is the negative electrode and Cu is the positive electrode.

(iii) $Cu^{2+}(aq) + 2e^- \longrightarrow Cu(s)$ (Ignore state symbols) [1]

(b) (i) $Br_2(aq) + 2e^- \longrightarrow 2Br^-(aq)$ (Ignore state symbols) [1]

(ii) The size of the electrode decreases. [1]
OR
- The mass of the electrode decreases.
- The electrode dissolves.
- Colour around the electrode deepens.
- Colour around the electrode becomes darker blue.

(Do NOT accept "the colour around the electrode turns blue".)

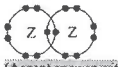
(iii) Less negative [1]

Iodine gains electrons less readily than bromine. [1]
OR
- Iodine is less reactive than bromine.
- Iodine is a weaker oxidising agent than bromine.
- Iodine is higher than bromine in the ECS.

(Accept "iodine is a weaker oxidising agent".)

DSE20_01

1. (a) 2, 8, 18, 7 1

(b) 

1
(Accept answer with correct inner shell electrons)
(Not accept answer with incorrect inner shell electrons, if inner shell electrons are drawn)

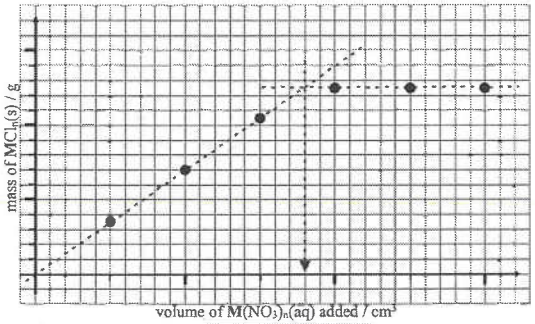
(c) (i) $K_2SO_3(s) + 2HCl(aq) \rightarrow 2KCl(aq) + H_2O(l) + SO_2(g)$ / 2
$K_2SO_3(s) + 2H^+(aq) \rightarrow 2K^+(aq) + H_2O(l) + SO_2(g)$
Correct states (1 mark)
Balanced equation (1 mark)
(No mark if the chemical species shown in the equation are incorrect)

(ii) (Reddish brown / brown) changes to colourless. / The solution changes to colourless. 1
(Not accept incorrect initial colour. Not accept pale brown)
$Br_2 + SO_2 + 2H_2O \rightarrow 2Br^- + SO_4^{2-} + 4H^+$ 1
(State symbols not required) (Ignore incorrect state symbols)
OR $Y_2 + SO_2 + 2H_2O \rightarrow 2Y^- + SO_4^{2-} + 4H^+$

(iii) Y and Z have the same number of electrons / seven electrons in the outermost shells, hence similar chemical properties (leading to similar observation). 1
(Not accept "Same chemical properties")

DSE20_02

2. (a) It is because for the last three points in the graph, the amount of $M(NO_3)_n$ / M^{n+} added is in excess. / 1
It is because for the last three points in the graph, all HCl / Cl^- has been used up.
(Not accept only "The reaction is completed" is written)

(b) (i) 1


volume of $M(NO_3)_n(aq)$ = 18 cm^3 (Accept 17.5 – 18.5 cm^3) 1
(Accept max. 1 decimal place)
(No mark if the answer is correct, but the answer was obtained with a wrong way.)

(ii) 18 / 1000 x 0.5 = 0.009 mol (Accept 0.00875 – 0.00925 mol) 1
(Accept answer with no unit) (Not accept answer with incorrect unit)

(c) no. of mole of Cl^-: 50 / 1000 x 0.36 = 0.018 mol 1
Ratio of metal ions : chloride ions = 0.009 : 0.018 = 1 : 2. The empirical formula of the metal chloride is MCl_2. 1
M would be lead because the ratio of Ag to Cl in its empirical formula is 1:1 while now is 1:2 applicable to Pb to Cl. 1

6. (a) • To provide an aqueous medium / dissolve $CuSO_4(s)$ and $Na_2SO_4(s)$ so as to produce mobile ions. 1
• Magnesium is higher than copper in the electrochemical series / ECS and release electrons. The electrons pass from the negative pole of the voltmeter to the positive pole, producing to a positive reading. 1

• Magnesium is more reactive than copper.
• Magnesium is a stronger reducing agent than copper.
• Magnesium losses electrons more readily than copper.
• Magnesium occupies a higher position than copper in the ECS.
• Electrons flow from side B to side A.
• Current flows from side A to side B.

(b) (i) $Mg(s) \rightarrow Mg^{2+}(aq) + 2e^-$ (Ignore state symbols) (Electron with a negative charge symbol) (Not accept: Mg^{+2}) 1

(ii) $Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$ (Ignore state symbols) 1

(c) The position of the pointer is higher than 0 and lower than the reading in Diagram (1). 1
(Candidates have to draw the pointer in Diagram (2))

(d) (i) $Fe(s) + CuSO_4(aq) \rightarrow FeSO_4(aq) + Cu(s)$ (Ignore state symbols) 1
/ $Fe(s) + Cu^{2+}(aq) \rightarrow Fe^{2+}(aq) + Cu(s)$ (Ignore state symbols)

(ii) † (Metal) Displacement (reaction) 1