

## CHEMISTRY PAPER 1

8:30 am – 11:00 am (2 hours 30 minutes)

This paper must be answered in English

### GENERAL INSTRUCTIONS

1. There are **TWO** sections, A and B, in this Paper. You are advised to finish Section A in about 45 minutes.
2. Section A consists of multiple-choice questions in this question paper, while Section B contains conventional questions printed separately in Question-Answer Book B.
3. Answers to Section A should be marked on the Multiple-choice Answer Sheet while answers to Section B should be written in the spaces provided in Question-Answer Book B. **The Answer Sheet for Section A and the Question-Answer Book for Section B will be collected separately at the end of the examination.**
4. A Periodic Table is printed on page 20 of Question-Answer Book B. Atomic numbers and relative atomic masses of elements can be obtained from the Periodic Table.

---

### INSTRUCTIONS FOR SECTION A (MULTIPLE-CHOICE QUESTIONS)

1. Read carefully the instructions on the Answer Sheet. After the announcement of the start of the examination, you should first stick a barcode label and insert the information required in the spaces provided. No extra time will be given for sticking on the barcode label after the 'Time is up' announcement.
2. When told to open this book, you should check that all the questions are there. Look for the words '**END OF SECTION A**' after the last question.
3. All questions carry equal marks.
4. **ANSWER ALL QUESTIONS.** You are advised to use an HB pencil to mark all the answers on the Answer Sheet, so that wrong marks can be completely erased with a clean rubber. You must mark the answers clearly; otherwise you will lose marks if the answers cannot be captured.
5. You should mark only **ONE** answer for each question. If you mark more than one answer, you will receive **NO MARKS** for that question.
6. No marks will be deducted for wrong answers.

This section consists of two parts. There are 24 questions in PART I and 12 questions in PART II.

Choose the best answer for each question.

Candidates may refer to the Periodic Table printed on page 20 of Question-Answer Book B.

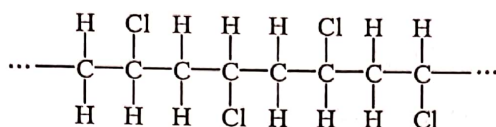
### PART I

1. Which of the following statements concerning  $\text{CO}_2(\text{g})$  is INCORRECT ?
- A. It can turn limewater milky.
  - B. It can be used to make dry ice.
  - C. It can be produced by adding marble to water.
  - D. It generally has a higher percentage in the air in urban areas than that in rural areas.
2. How many neutrons and electrons are there in a  ${}_{23}^{51}\text{X}^{3+}$  ion ?
- |    | Number of neutrons | Number of electrons |
|----|--------------------|---------------------|
| A. | 23                 | 20                  |
| B. | 28                 | 23                  |
| C. | 28                 | 20                  |
| D. | 51                 | 23                  |
3. Which of the following substances is an electrolyte ?
- A. sodium chloride
  - B. silicon dioxide
  - C. methanol
  - D. mercury
4. Which of the following is an INCORRECT procedure in titration ?
- A. Rinse the pipette with the solution to be delivered before titration.
  - B. Rinse the conical flask with the solution to be held before titration.
  - C. Take the burette readings with eyes on the same level as the meniscus.
  - D. Make sure that there are no air bubbles in the burette filled with the titrant.
5. Element X is one of the first twenty elements in the Periodic Table. X forms a stable  $\text{XH}_4^+(\text{aq})$  ion. Which group of the Periodic Table does X most likely belong to ?
- A. Group III
  - B. Group IV
  - C. Group V
  - D. Group VI
6. Copper(II) phosphate is insoluble in water. What is the number of moles of  $\text{Cu}^{2+}(\text{aq})$  ions remaining in the solution of the resulting mixture when 0.04 mol of  $\text{CuCl}_2(\text{aq})$  is mixed with 0.02 mol of  $\text{Na}_3\text{PO}_4(\text{aq})$  ?
- A. 0.00
  - B. 0.01
  - C. 0.02
  - D. 0.03

7. A white solid does NOT dissolve in both water and excess aqueous ammonia. Which of the following may this solid be ?

- A.  $\text{Pb}(\text{NO}_3)_2$
- B.  $\text{Zn}(\text{OH})_2$
- C.  $\text{MgSO}_4$
- D.  $\text{CaCO}_3$

8. The structure of a portion of a polymer is shown below :



Which of the following statements concerning the polymer is correct ?

- A. It can be used as a substitute for glass.
- B. Its repeating unit is  $\left[ \begin{array}{cccc} \text{H} & \text{Cl} & \text{H} & \text{H} \\ | & | & | & | \\ - \text{C} - & \text{C} - & \text{C} - & \text{C} - \\ | & | & | & | \\ \text{H} & \text{H} & \text{H} & \text{Cl} \end{array} \right]$ .
- C. It can be made from its monomer through addition polymerisation.
- D. It can decolourise bromine dissolved in an organic solvent quickly.

9. Consider the following three compounds :



Which of the following shows the decreasing order of their solubilities in water ?

- A.  $\text{X} > \text{Y} > \text{Z}$
- B.  $\text{Z} > \text{Y} > \text{X}$
- C.  $\text{Y} > \text{Z} > \text{X}$
- D.  $\text{Y} > \text{X} > \text{Z}$

10. 6.54 g of zinc granules are added to 100.0 cm<sup>3</sup> of 1.0 M  $\text{AgNO}_3(\text{aq})$ . After the reaction has completed, which of the following statements is correct ?

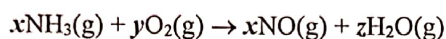
(Relative atomic masses :  $\text{Zn} = 65.4$ ,  $\text{Ag} = 107.9$ )

- A. Some zinc granules have reacted and no silver ions remain in the solution.
- B. All the zinc granules have reacted and no silver ions remain in the solution.
- C. All the zinc granules have reacted and some silver ions remain in the solution.
- D. The mass of the zinc granules reacted is equal to the mass of the solid product formed.

11. In the electrolysis of 1.0 M  $\text{CuSO}_4(\text{aq})$ , copper cathode and carbon anode are used. Which of the following combinations is correct ?

	Cathode	Anode
A.	Copper dissolves	Oxygen is formed
B.	Copper dissolves	Sulphur dioxide is formed
C.	Copper is deposited	Oxygen is formed
D.	Copper is deposited	Sulphur dioxide is formed

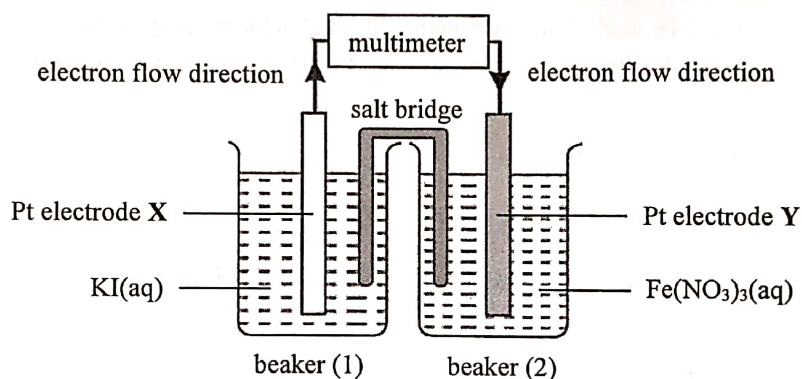
12. Consider the following chemical equation :



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 :

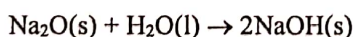


Which of the following statements is correct ?

- 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.  $\text{Fe}(\text{NO}_3)_3(\text{aq})$  acts as a reducing agent.
14. The enthalpy changes of formation of some substances under certain conditions are shown below :

Substance	Enthalpy change of formation / $\text{kJ mol}^{-1}$
$\text{H}_2\text{O}(\text{l})$	-286
$\text{Na}_2\text{O}(\text{s})$	-414
$\text{NaOH}(\text{s})$	-425

What is the enthalpy change of the following reaction under the same conditions ?

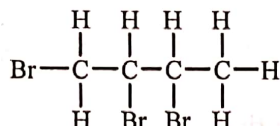


- A. +275  $\text{kJ mol}^{-1}$   
 B. -150  $\text{kJ mol}^{-1}$   
 C. -722  $\text{kJ mol}^{-1}$   
 D. -1125  $\text{kJ mol}^{-1}$

15. P, Q and R are three different metals. When dilute HCl(aq) is added to these metals separately, only Q and R give a colourless gas. When zinc is added to aqueous solutions of their chlorides separately, only the chloride of R shows no observable change. Which of the following shows the increasing order of the reducing power of the metals ?

- A.  $R < Q < P$   
 B.  $Q < P < R$   
 C.  $P < Q < R$   
 D.  $P < R < Q$

16. The molecular formula of compound X is  $C_4H_7Br$  and it has one carbon-carbon double bond. It can react with  $Br_2$  (dissolved in an organic solvent) to give the following organic product :

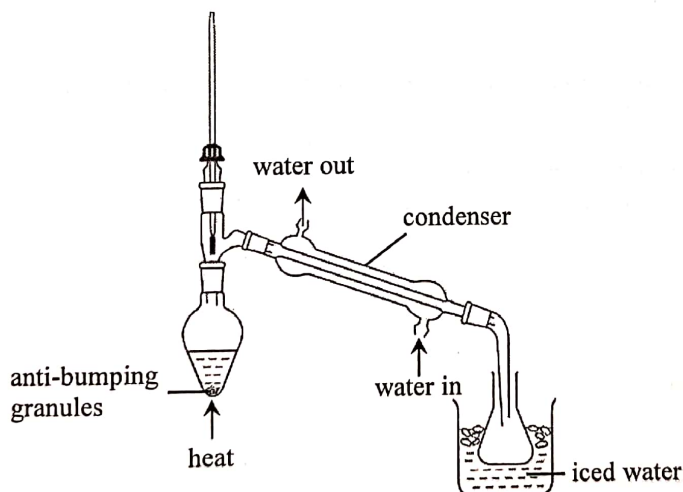


Which of the following is / are the possible structure(s) of X ?

- (1)  $CH_2BrCH_2CH=CH_2$   
 (2)  $H_2C=CHCHBrCH_3$   
 (3)  $CH_3CH=CHCH_2Br$

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

17. Refer to the following set-up :



Which of the following processes can be performed by using the above set-up ?

- (1) obtaining pure water from sea water  
 (2) obtaining propane from diesel oil  
 (3) obtaining oxygen from liquefied air

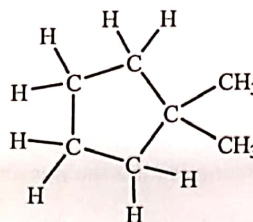
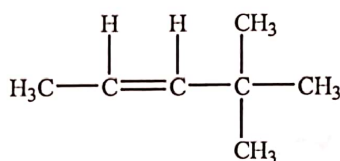
- A. (1) only  
 B. (2) only  
 C. (1) and (3) only  
 D. (2) and (3) only

18. Which of the following pairs of substances, when mixed, would release hydrogen gas ?

- (1) copper and concentrated HCl(aq)
- (2) iron and H<sub>2</sub>SO<sub>4</sub>(aq)
- (3) calcium and NaOH(aq)

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

19. Consider the following two compounds :



Which of the following statements is / are correct ?

- (1) They belong to the same homologous series.
- (2) They have the same molecular formula.
- (3) They are insoluble in water.

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

20. A small piece of sodium is added to water containing a few drops of universal indicator. Which of the following statements is / are correct ?

- (1) Sodium moves quickly on the water surface.
- (2) The resulting solution shows a red colour.
- (3) This reaction is exothermic.

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

21. Which of the following statements are correct ?

- (1) The standard enthalpy change of formation of graphite is zero.
- (2) The standard enthalpy change of combustion of carbon monoxide is a negative value.
- (3) The standard enthalpy change of formation of carbon monoxide is equal to the standard enthalpy change of combustion of graphite.

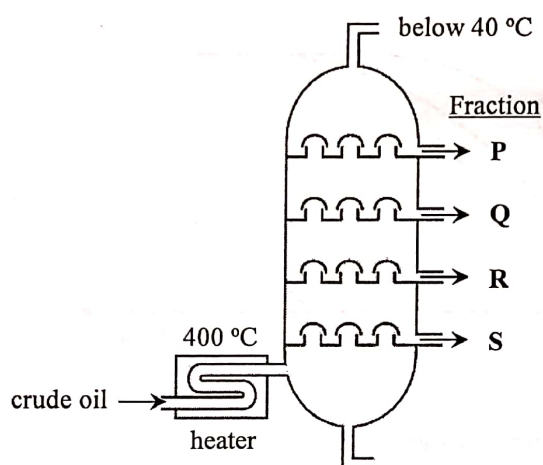
- A. (1) and (2) only
- B. (1) and (3) only
- C. (2) and (3) only
- D. (1), (2) and (3)

22. Both **A** and **B** are monobasic acids. The pH of 0.10 M **A**(aq) is 1.0 and the pH of 0.10 M **B**(aq) is 3.0. Which of the following statements are correct ?

- (1) **A** is a stronger acid than **B**.
- (2) Some **B** molecules are present in **B**(aq).
- (3) Complete neutralisation of 25.0 cm<sup>3</sup> of 0.10 M **A**(aq) and complete neutralisation of 25.0 cm<sup>3</sup> of 0.10 M **B**(aq) require the same number of moles of NaOH(aq).

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

23. The simplified diagram below shows how different petroleum fractions can be obtained from a fractionating tower.



Which of the following statements are correct ?

- (1) Fraction **S** has a darker colour than fraction **Q**.
- (2) Fraction **R** has a higher viscosity than fraction **P**.
- (3) Fraction **Q** is more flammable than fraction **P**.

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

24. Consider the following statements and choose the best answer :

**1st statement**

Ethene and but-1-ene have the same standard enthalpy change of combustion.

**2nd statement**

Ethene and but-1-ene have the same empirical formula.

- A. Both statements are true and the 2nd statement is a correct explanation of the 1st statement.
- B. Both statements are true but the 2nd statement is NOT a correct explanation of the 1st statement.
- C. The 1st statement is false but the 2nd statement is true.
- D. Both statements are false.

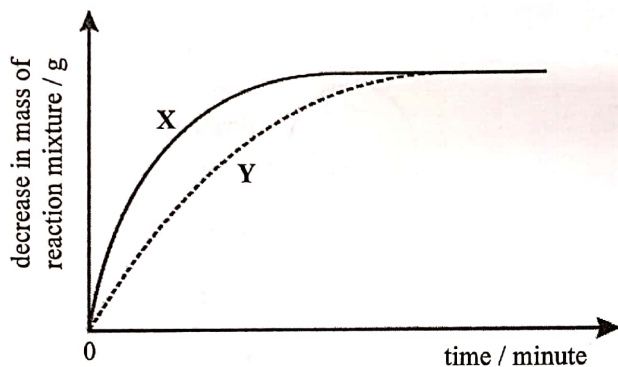
**PART II**

25. A mixture consists of methane and ethane.  $50 \text{ cm}^3$  of this mixture completely burns in oxygen to form  $80 \text{ cm}^3$  of carbon dioxide at room conditions. What is the volume of methane in this mixture at room conditions ?

(Molar volume of gas at room conditions =  $24 \text{ dm}^3$ )

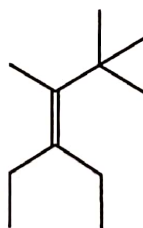
- A.  $10 \text{ cm}^3$
- B.  $20 \text{ cm}^3$
- C.  $30 \text{ cm}^3$
- D.  $40 \text{ cm}^3$

26.  $50 \text{ cm}^3$  of  $0.10 \text{ M HCl(aq)}$  reacts with excess calcium carbonate powder in an open conical flask giving curve X in the graph below.



Which of the following changes may give curve Y ?

- A. Increase the temperature by  $10 \text{ }^\circ\text{C}$ .
  - B. Use  $25 \text{ cm}^3$  of  $0.10 \text{ M HCl(aq)}$  instead of  $50 \text{ cm}^3$  of  $0.10 \text{ M HCl(aq)}$ .
  - C. Use  $50 \text{ cm}^3$  of  $0.05 \text{ M HCl(aq)}$  instead of  $50 \text{ cm}^3$  of  $0.10 \text{ M HCl(aq)}$ .
  - D. Use the same mass of calcium carbonate granules instead of calcium carbonate powder.
27. The structure of an organic compound is shown below :

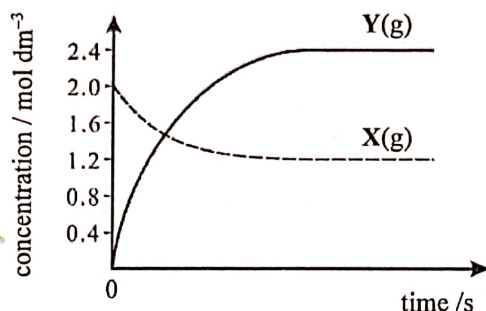


Which of the following combinations concerning whether *cis-trans* isomerism and enantiomerism can occur in the compound is correct ?

- |    | <i>cis-trans</i> isomerism | enantiomerism |
|----|----------------------------|---------------|
| A. | No                         | No            |
| B. | Yes                        | Yes           |
| C. | Yes                        | No            |
| D. | No                         | Yes           |



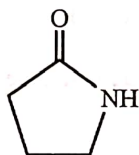
28. When chemical equilibrium is attained in a certain reversible reaction, only X(g) and Y(g) are present in a closed container of fixed volume. The following graph shows the variation in concentrations of X(g) and Y(g) with time :



Which of the following equations can represent the reversible reaction ?

- A.  $X(g) \rightleftharpoons 2Y(g)$   
 B.  $X(g) \rightleftharpoons 3Y(g)$   
 C.  $2X(g) \rightleftharpoons Y(g)$   
 D.  $2X(g) \rightleftharpoons 3Y(g)$

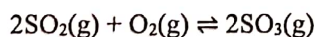
29. The structure of an organic compound is shown below :



When it is heated with excess NaOH(aq), followed by the addition of excess HCl(aq), a major organic product Z is formed. Which of the following is Z ?

- A.
- B.
- C.
- D.

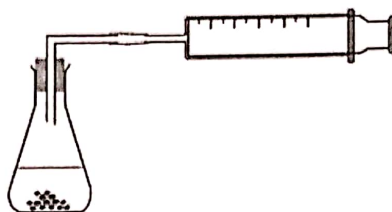
30. When 0.40 mol of SO<sub>2</sub>(g) and 0.60 mol of O<sub>2</sub>(g) are placed in a 1.0 dm<sup>3</sup> evacuated flask, the following reaction occurs.



When chemical equilibrium is attained at a certain temperature, the flask is found to contain 0.30 mol of SO<sub>3</sub>(g). What is the equilibrium constant  $K_c$  for the reaction at this temperature ?

- A. 20 mol<sup>-1</sup> dm<sup>3</sup>  
 B. 6.7 mol<sup>-1</sup> dm<sup>3</sup>  
 C. 2.0 mol<sup>-1</sup> dm<sup>3</sup>  
 D. 0.050 mol<sup>-1</sup> dm<sup>3</sup>

31. Consider the experimental set-up shown below :

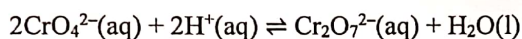


Under room conditions, which of the following pairs of reactants can the progress of their reaction be followed by the above set-up ?

- (1)  $\text{Zn(OH)}_2(\text{s})$  and  $\text{HNO}_3(\text{aq})$
- (2)  $\text{Mg}(\text{s})$  and  $\text{HCl}(\text{aq})$
- (3)  $\text{KBr}(\text{s})$  and  $\text{Cl}_2(\text{aq})$

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

32. Consider the following equilibrium system :

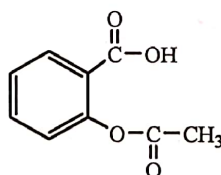


Which of the following statements can demonstrate that chromium exhibits the characteristic(s) of transition metals ?

- (1)  $\text{Cr}_2\text{O}_7^{2-}(\text{aq})$  ions are orange in colour.
- (2) Adding  $\text{HCl}(\text{aq})$  would shift the equilibrium position to the right.
- (3) The oxidation states of chromium in  $\text{CrO}_4^{2-}$  and  $\text{Cr}_2\text{O}_7^{2-}$  are the same.

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

33. The structure of aspirin is shown below :



Which of the following statements about aspirin are correct ?

- (1) It has an ester group.
- (2) It can reduce inflammation.
- (3) It has a higher solubility in  $\text{Na}_2\text{CO}_3(\text{aq})$  than in pure water.

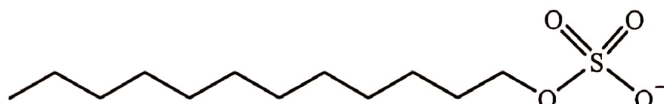
- A. (1) and (2) only
- B. (1) and (3) only
- C. (2) and (3) only
- D. (1), (2) and (3)

34. Which of the following compounds can be used as a monomer for condensation polymerisation ?

- (1)  $\text{H}_2\text{C}=\text{CHCH}_2\text{CH}_2\text{CH}=\text{CH}_2$
- (2)  $\text{HOOCCH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{COOH}$
- (3)  $\text{HOCH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$

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

35. The structure of a detergent is shown below :



Which of the following statements concerning this detergent are correct ?

- (1) It is a soapless detergent.
- (2) It can act as an emulsifying agent.
- (3) It can increase the surface tension of water.

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

36. Consider the following statements and choose the best answer :

**1st statement**

At chemical equilibrium, the concentration of reactants must be equal to the concentration of products.

**2nd statement**

At chemical equilibrium, both forward reaction rate and backward reaction rate are equal to zero.

- A. Both statements are true and the 2nd statement is a correct explanation of the 1st statement.
- B. Both statements are true but the 2nd statement is NOT a correct explanation of the 1st statement.
- C. The 1st statement is false but the 2nd statement is true.
- D. Both statements are false.

**END OF SECTION A**

**CHEMISTRY PAPER 1**  
**SECTION B : Question-Answer Book B**

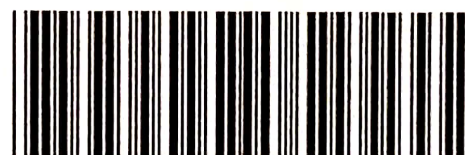
This paper must be answered in English

**INSTRUCTIONS FOR SECTION B**

- (1) After the announcement of the start of the examination, you should first write your Candidate Number in the space provided on Page 1 and stick barcode labels in the spaces provided on Pages 1, 3, 5, 7 and 9.
- (2) Refer to the general instructions on the cover of the Question Paper for Section A.
- (3) This section consists of **TWO** parts, Parts I and II.
- (4) Answer **ALL** questions in both Parts I and II. Write your answers in the spaces provided in this Question-Answer Book. Do not write in the margins. Answers written in the margins will not be marked.
- (5) An asterisk (\*) has been put next to the questions where one mark will be awarded for effective communication.
- (6) Supplementary answer sheets will be provided on request. Write your candidate number, mark the question number box and stick a barcode label on each sheet, and fasten them with string **INSIDE** this Question-Answer Book.
- (7) No extra time will be given to candidates for sticking on the barcode labels or filling in the question number boxes after the 'Time is up' announcement.

Please stick the barcode label here.

Candidate Number



\* A 1 4 0 E 0 1 B \*

## PART I

Answer ALL questions. Write your answers in the spaces provided.

1. Iodine is a halogen. It can form potassium iodide and hydrogen iodide.

(a) Name the relationship between  $^{127}_{53}\text{I}$  and  $^{129}_{53}\text{I}$ .

(1 mark)

(b) The electronic arrangement of an iodine atom is 2, 8,  $x$ , 18,  $y$ . What is  $x$ ?

(1 mark)

(c) Draw the electron diagram for potassium iodide, showing ELECTRONS IN THE OUTERMOST SHELLS only.

(1 mark)

(d) Suggest why an aqueous solution of hydrogen iodide can conduct electricity.

(1 mark)

(e) In terms of bonding and structure, explain whether potassium iodide or hydrogen iodide would have a higher melting point.

(2 marks)

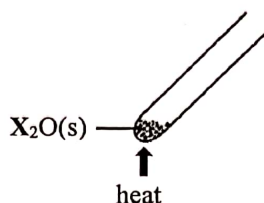
Answers written in the margins will not be marked.

Answers written in the margins will not be marked.

Answers written in the margins will not be marked.

Please stick the barcode label here.

2. The diagram below shows an experimental set-up in which a metal oxide  $X_2O(s)$  is decomposed upon strong heating. A silvery metal  $X$  and a colourless gas  $Z$  are formed.



- (a) State what  $Z$  is and suggest a test for it.

(2 marks)

- (b) When 3.028 g of  $X_2O(s)$  is completely decomposed, 2.819 g of metal  $X$  can be obtained.

- (i) Calculate the relative atomic mass of  $X$ .  
(Relative atomic mass :  $O = 16.0$ )

- (ii) Suggest what  $X$  is.

(3 marks)

- (c) Explain whether the decomposition of  $X_2O(s)$  is a redox reaction.

(1 mark)

Answers written in the margins will not be marked.

Answers written in the margins will not be marked.

Answers written in the margins will not be marked.

3. Antacid is a drug for neutralising stomach acid. A sample of an antacid contains  $\text{NaHCO}_3(\text{s})$  and other soluble inert substances. 1.52 g of the antacid sample was completely dissolved in deionised water to give a weakly alkaline solution. The solution was then titrated with 0.644 M  $\text{HCl}(\text{aq})$  using a suitable indicator. 25.20  $\text{cm}^3$  of the  $\text{HCl}(\text{aq})$  was required to reach the end point.

(a) Write the chemical equation for the reaction between  $\text{NaHCO}_3(\text{s})$  and  $\text{HCl}(\text{aq})$ .

(1 mark)

(b) Calculate the percentage by mass of  $\text{NaHCO}_3(\text{s})$  in the antacid sample.  
(Relative atomic masses : H = 1.0, C = 12.0, O = 16.0, Na = 23.0)

(2 marks)

Answers written in the margins will not be marked.

Answers written in the margins will not be marked.

Answers written in the margins will not be marked.

Please stick the barcode label here.

3. (c) The pH of the solution at the end point of the titration was found to be between 3 and 4.
- (i) Suggest a suitable indicator for this titration and state the colour change at the end point.

- (ii) Suggest an instrument to measure the pH of the solution accurately.

(3 marks)

- (d) State one advantage of taking antacids containing  $\text{Mg}(\text{OH})_2(\text{s})$  over those containing  $\text{NaHCO}_3(\text{s})$ .

(1 mark)

Answers written in the margins will not be marked.

Answers written in the margins will not be marked.

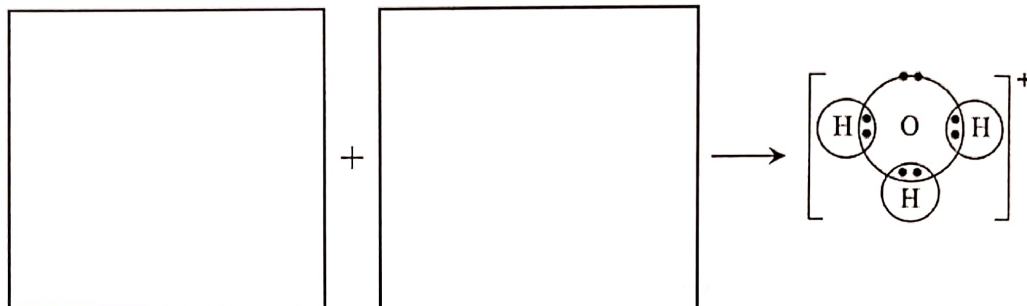
Answers written in the margins will not be marked.



4. Consider the molecules  $\text{H}_2\text{O}$ ,  $\text{BF}_3$  and  $\text{SF}_6$ .

(a)  $\text{H}_2\text{O}$  molecules can form  $\text{H}_3\text{O}^+$  ions.

(i) In each of the following boxes, draw the electron diagram (showing ELECTRONS IN THE OUTERMOST SHELLS only) for a suitable chemical species to show the formation of a  $\text{H}_3\text{O}^+$  ion.



(ii) Describe the formation of dative covalent bond using  $\text{H}_3\text{O}^+$  as an example.

(3 marks)

(b) Explain whether the boron atom in a  $\text{BF}_3$  molecule has an octet structure.

(1 mark)

(c) (i) Draw the three-dimensional structure of a  $\text{SF}_6$  molecule.

Answers written in the margins will not be marked.

Answers written in the margins will not be marked.

Answers written in the margins will not be marked.

Please stick the barcode label here.

4. (c) (ii) Explain whether SF<sub>6</sub> is a polar molecule.

(2 marks)

(d) Explain the following increasing order of the boiling points of the three compounds :



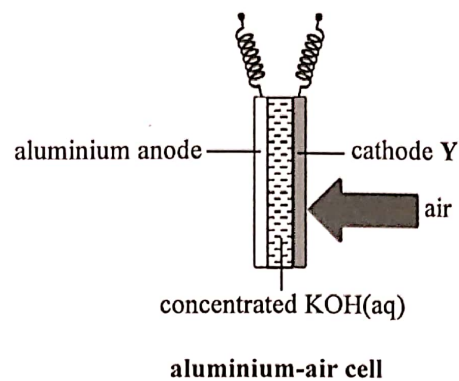
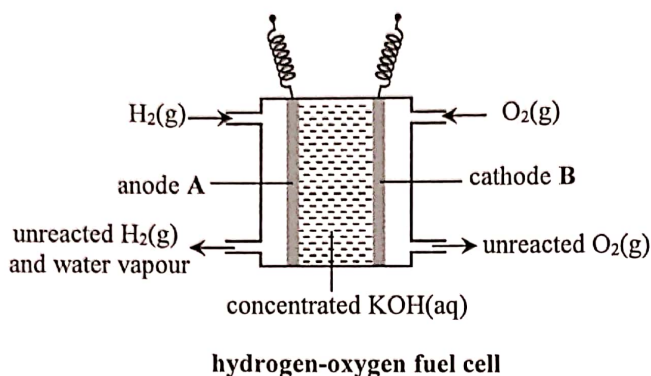
(3 marks)

Answers written in the margins will not be marked.

Answers written in the margins will not be marked.

Answers written in the margins will not be marked.

5. The following hydrogen-oxygen fuel cell and aluminium-air cell are primary cells. Their simplified structures are shown below :



- (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 :
- $$\text{Al(s)} + 3\text{OH}^{\text{(aq)}} \rightarrow \text{Al(OH)}_3\text{(s)} + 3\text{e}^-$$
- 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)

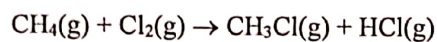
Answers written in the margins will not be marked.

Answers written in the margins will not be marked.

Answers written in the margins will not be marked.

Please stick the barcode label here.

6. Consider the following chemical equation for the formation of  $\text{CH}_3\text{Cl}$  from methane and chlorine :



(a) Name the type of reaction involved.

(1 mark)

(b) State the condition needed for the reaction to occur at room temperature.

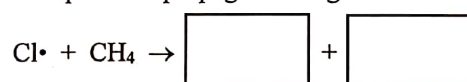
(1 mark)

(c) The reaction involves three stages: initiation, propagation and termination. In the initiation stage, chlorine free radicals ( $\text{Cl}\cdot$ ) are formed from chlorine molecules.

(i) With reference to the electronic structure, explain why a chlorine free radical ( $\text{Cl}\cdot$ ) is a reactive chemical species.

(ii) Complete the chemical equations below by filling in a suitable chemical species in each of the following boxes :

One of the steps in the propagation stage :



One of the steps in the termination stage :

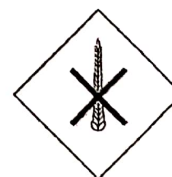


(3 marks)

(d) Explain why  $\text{CH}_3\text{Cl}$  is not the only organic product formed in the reaction between methane and chlorine.

(1 mark)

(e) From the hazard warning labels shown below, circle a label that should be displayed on a gas cylinder containing methane.



(1 mark)

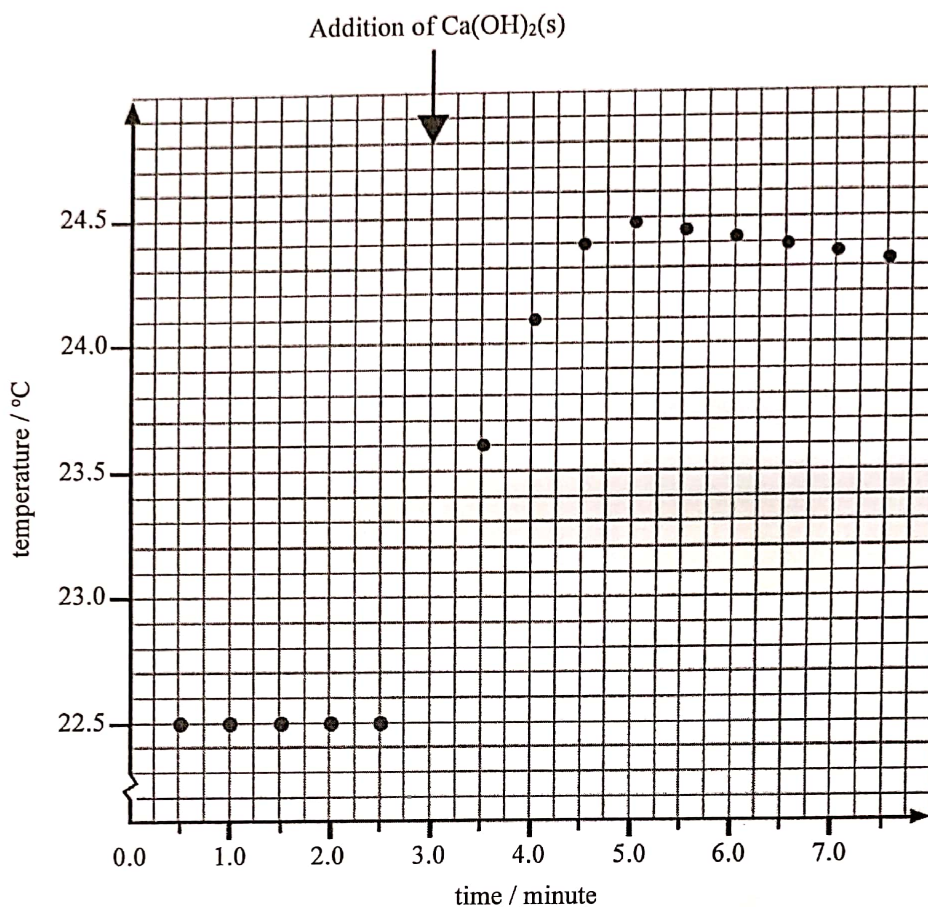
Answers written in the margins will not be marked.

Answers written in the margins will not be marked.

Answers written in the margins will not be marked.

7.

An experiment was performed to determine the enthalpy change of neutralisation between  $\text{Ca(OH)}_2(\text{s})$  and  $\text{HCl}(\text{aq})$ .  $100.0 \text{ cm}^3$  of  $1.0 \text{ M HCl}(\text{aq})$  was placed in an expanded polystyrene cup. The temperature of the contents in the cup was measured at half-minute intervals. Right at the third minute,  $0.502 \text{ g}$  of  $\text{Ca(OH)}_2(\text{s})$  was added to the cup with thorough stirring. The recordings of temperature are shown in the graph below :



- (a) Write a chemical equation for the reaction between  $\text{Ca(OH)}_2(\text{s})$  and  $\text{HCl}(\text{aq})$ .

(1 mark)

- (b) (i) By SKETCHING on the graph above, estimate the greatest temperature rise of the contents in the cup.

The greatest temperature rise = \_\_\_\_\_ °C

Answers written in the margins will not be marked.

7. (b) (ii) It is given that the enthalpy change of neutralisation is the enthalpy change when solutions of an acid and an alkali react together to produce one mole of water.

In the experiment, HCl(aq) is in excess. Calculate the enthalpy change of neutralisation between Ca(OH)<sub>2</sub>(s) and HCl(aq), in kJ mol<sup>-1</sup>, under the experimental conditions.

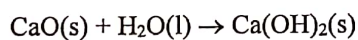
(Volume of the reaction mixture = 100.0 cm<sup>3</sup>;  
density of the reaction mixture = 1.00 g cm<sup>-3</sup>;  
specific heat capacity of the reaction mixture = 4.2 J g<sup>-1</sup> K<sup>-1</sup>;  
heat capacity of the expanded polystyrene cup : negligible)  
(Relative atomic masses : H = 1.0, O = 16.0, Cl = 35.5, Ca = 40.1)

(5 marks)

- (c) Standard enthalpy changes of neutralisation  $\Delta H_n^\circ$  for two reactions are given below :

	$\Delta H_n^\circ / \text{kJ mol}^{-1}$
Reaction between Ca(OH) <sub>2</sub> (s) and HCl(aq)	-58.6
Reaction between CaO(s) and HCl(aq)	-186.0

Calculate the standard enthalpy change of the following reaction.



(3 marks)

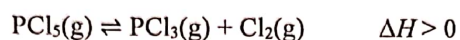
Answers written in the margins will not be marked.



**PART II**

Answer **ALL** questions. Write your answers in the spaces provided.

9. At a certain temperature, the equilibrium constant  $K_c$  for the following reaction is  $2.25 \times 10^{-2} \text{ mol dm}^{-3}$ .



In an experiment, 0.84 mol of  $\text{PCl}_5(\text{g})$ , 0.16 mol of  $\text{PCl}_3(\text{g})$  and 0.16 mol of  $\text{Cl}_2(\text{g})$  were initially introduced in a closed container of a fixed volume of  $4.0 \text{ dm}^3$ , and the system was allowed to attain equilibrium at that temperature.

- (a) (i) Calculate the reaction quotient  $Q_c$  for the system under the initial conditions.

- (ii) Explain whether the concentration of  $\text{PCl}_5(\text{g})$  would increase or decrease just after the reaction started.

(4 marks)

- (b) Explain whether  $K_c$  would increase, decrease or remain unchanged if the temperature of the equilibrium mixture is increased.

(2 marks)

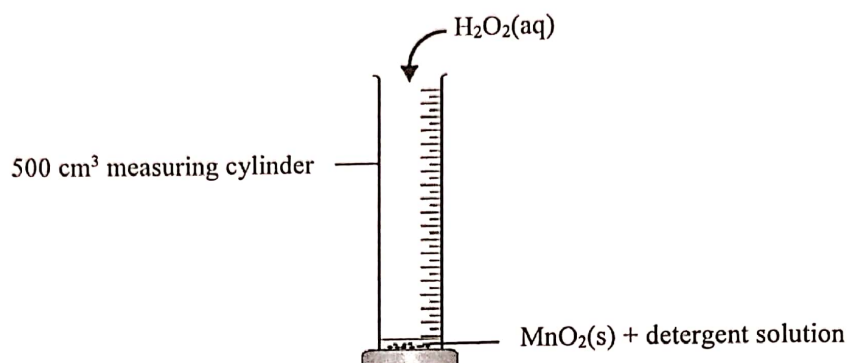
Answers written in the margins will not be marked.

Answers written in the margins will not be marked.

Answers written in the margins will not be marked.



10. At room conditions,  $\text{H}_2\text{O}_2(\text{aq})$  would decompose into  $\text{O}_2(\text{g})$  and  $\text{H}_2\text{O}(\text{l})$  very slowly in the absence of  $\text{MnO}_2(\text{s})$ . An experiment was performed as shown in the set-up below :



When  $10.0 \text{ cm}^3$  of  $3.00 \text{ M H}_2\text{O}_2(\text{aq})$  was mixed with a small amount of  $\text{MnO}_2(\text{s})$  and detergent solution at room conditions,  $\text{O}_2(\text{g})$  started to be released rapidly and foam was produced. The  $\text{MnO}_2(\text{s})$  remained chemically unchanged at the end of the reaction.

- (a) Write a chemical equation for the decomposition of  $\text{H}_2\text{O}_2(\text{aq})$ .

(1 mark)

- (b) Explain how manganese illustrates a characteristic of transition metals according to the results of this experiment.

(1 mark)

Answers written in the margins will not be marked.

Answers written in the margins will not be marked.

Answers written in the margins will not be marked.

Answers written in the margins will not be marked.

Answers written in the margins will not be marked.

10. (c) Upon completion of the reaction, all the  $\text{H}_2\text{O}_2(\text{aq})$  was used up. Calculate the theoretical volume of  $\text{O}_2(\text{g})$  released at room conditions.  
(Molar volume of gas at room conditions =  $24 \text{ dm}^3$ )

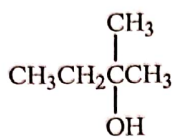
(2 marks)

- (d) In the experiment, the time taken for the foam to rise from the mark at  $100 \text{ cm}^3$  to the mark at  $200 \text{ cm}^3$  of the measuring cylinder was 18 seconds, while the time taken for the foam to rise from the mark at  $200 \text{ cm}^3$  to the mark at  $300 \text{ cm}^3$  was 63 seconds. Explain these results.

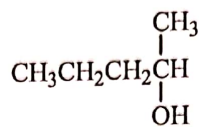
(2 marks)

Answers written in the margins will not be marked.

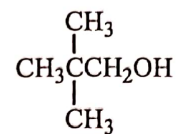
11. Compounds **P**, **Q** and **R** are structural isomers having the molecular formula of  $C_5H_{12}O$ . Their structures are shown below :



**P**



**Q**



**R**

- (a) Give the systematic name of **P**.

(1 mark)

- (b) Heating **Q** with acidified  $K_2Cr_2O_7(aq)$  under reflux will give an organic product.

- (i) Draw a labelled diagram to show the set-up for this reaction.

- (ii) State the expected observation for this reaction.

- (iii) Write the structural formula of the organic product.

(4 marks)

Answers written in the margins will not be marked.

Answers written in the margins will not be marked.

Answers written in the margins will not be marked.

Answers written in the margins will not be marked.

Answers written in the margins will not be marked.

11. (c) **W** is an organic compound containing five carbon atoms. Under suitable conditions, **R** can be prepared from the reduction of **W**.

(i) Suggest the structural formula of **W**.

(ii) Suggest a reducing agent required for the reaction.

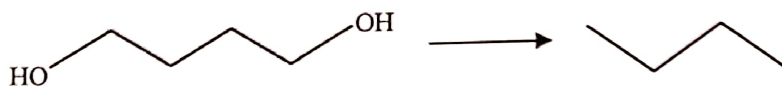
(2 marks)

(d) Compound **S** is an optically active secondary alcohol. It is also a structural isomer of compounds **P**, **Q** and **R**. Write the structural formula of **S**.

(1 mark)

Answers written in the margins will not be marked.

12. Outline a synthetic route, with NO MORE THAN THREE STEPS, to accomplish the following conversion. For each step, give the reagent(s), reaction conditions (as appropriate) and structure of the organic product.



Answers written in the margins will not be marked.

Answers written in the margins will not be marked.

(3 marks)

Answers written in the margins will not be marked.

