SECTION 9 Rate of Reaction

Multiple-Choice Questions

CE90_08

Which of the following contains the largest number of ATOMS at room temperature and pressure?

(Relative atomic masses: H = 1.0, N = 14.0, Cl = 35.5; Molar volume of gas at room temperature and pressure = 24 dm^3)

A. 2 mol of ammonia gas
B. 3 mol of nitrogen gas
C. 7 g of hydrogen gas
D. 90 dm^3 of hydrogen chloride gas

CE90_11

What volume of 0.5 M sulphuric acid is required to liberate 4.8 dm^3 of carbon dioxide at room temperature and pressure from excess solid hydrogencarbonate?

(Molar volume of gas at room temperature and pressure = 24 dm^3)

A. 0.2 dm^3
B. 0.4 dm^3
C. 2.0 dm^3
D. 4.0 dm^3

CE91_03

Solid X undergoes complete thermal dissociation according to the following equation:

$$X(s) \longrightarrow Y(g) + Z(s)$$

On heating 4.90 g of solid X, 1.40 dm^3 of gas Y and 2.30 g od solid Z are obtained at room temperature and pressure. What is the relative molecular mass of Y?

(Molar volume of gas at room temperature and pressure = 24 dm^3)

A. 32.0
B. 39.4
C. 44.6
D. 84.0

CE91_32

Which of the following gases contain the same number of molecules as 300cm^3 of oxygen under the same temperature and pressure?

(1) 150 cm^3 of NH_3
(2) 200 cm^3 of O_3
(3) 300 cm^3 of He
(4) 300 cm^3 of HCl

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

CE93_09

0.21 g of a gaseous hydrocarbon occupies 0.12 dm^3 at room temperature and pressure. If this hydrocarbon has the empirical formula CH_2, what is its molecular formula?

(Relative atomic masses: H = 1.0, C = 12.0;

Molar volume of gas at room temperature and pressure = 24 dm^3)

A. C_2H_4
B. C_3H_6
C. C_4H_8
D. C_5H_{10}

CE94_47

1st statement	2nd statement
At room temperature and pressure, the molar volume of oxygen gas is greater than that of hydrogen gas.	The relative atomic mass of oxygen is greater than that of hydrogen.

CE95_31

Question 31 refers to the following chemical equation:

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

What volume of carbon dioxide, measured at room temperature and pressure, is produced if 224 g of iron are formed?

(Relative atomic mass: Fe = 56;

Molar volume of gas at room temperature and pressure = 24 dm^3)

A. 16 dm^3
B. 36 dm^3
C. 72 dm^3
D. 144 dm^3

CE96_11

In an experiment, 1.6 g of sulphur are burnt completely in air to form sulphur dioxide. What volume of sulphur dioxide, measured at room temperature and pressure, is formed?

(Relative atomic mass: S = 32.0;

Molar volume of gas at room temperature and pressure = 24 dm^3)

A. 0.6 dm^3
B. 1.2 dm^3
C. 2.4 dm^3
D. 12.0 dm^3

CE96_19

Under certain conditions, 60 cm^3 of a gaseous compound, N_xO_y, decompose completely to give 60cm^3 nitrogen gas and 30 cm^3 of oxygen gas. (All gas volumes are measured at room temperature and pressure.)

Which of the following combinations is correct?

	x	y
A.	1	1
B.	1	2
C.	2	1
D.	2	3

CE96_32

Which of the following statements concerning one mole of nitrogen gas is/are correct?

(1) It has a mass of 14.0 g.
(2) It occupies the same volume as 4.0 g of helium gas at room temperature and pressure.
(3) It contains 6.02×10^{23} atoms of nitrogen.

(Relative atomic masses: He = 4.0, N = 14.0; Avogadro's constant = 6.02×10^{23} mol^{-1})

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

CE97_17

Which of the following gases occupies the largest volume at room temperature and pressure?
(Relative atomic masses: H = 1.0, C =12.0, N = 14.0, O = 16.0; molar volume of gas at room temperature and pressure = 24 dm^3)

A. 1.0 g of ammonia
B. 2.0 g of nitrogen
C. 3.0 g of oxygen
D. 4.0 g of carbon dioxide

CE97_34

One mole of sulphur atoms has a mass twice that of one mole of oxygen atoms. Which of the following statements is/are correct?

(1) 2 g of sulphur and 1 g of oxygen each occupy the same volume at room temperature and pressure.
(2) 2 g of sulphur and 1 g of oxygen each contain the same number of atoms.
(3) The number of atoms contained in one mole of sulphur is twice that contained in one mole of oxygen.

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

CE98_28

7.5 g of calcium carbonate is added to 50.0 cm^3 of 2 M hydrochloric acid. What is the volume of carbon dioxide liberated at room temperature and pressure?
(Relative atomic masses: C =12.0, O = 16.0, Ca = 40.0; molar volume of gas at room temperature and pressure = 24.0 dm^3)

A. 0.9 dm^3
B. 1.2 dm^3
C. 1.8 dm^3
D. 2.4 dm^3

CE98_46

1st statement	2nd statement
One mole of water occupies the same volume as one mole of carbon dioxide at room temperature and pressure.	One mole of water contains the same number of atoms as one mole of carbon dioxide.

CE99_16

At room temperature and pressure, 8.0 g of oxygen and 20.0 g of gas X occupy the same volume. What is the molar mass of X?
(Relative atomic mass: O = 16.0; molar volume of gas at room temperature and pressure = 24 dm^3)

A. 20.0 g
B. 40.0 g
C. 60.0 g
D. 80.0 g

CE01_10

Consider the reaction:

$4H_2(g) + Fe_3O_4(s) \longrightarrow 3Fe(s) + 4H_2O(l)$

What mass of iron would be obtained if 96.0 cm^3 of hydrogen, measured at room temperature and pressure, is consumed in the reaction?
(Relative atomic mass: Fe = 56.0; molar volume of gas at room temperature and pressure = 24 dm^3)

A. 0.056 g
B. 0.084 g
C. 0.168 g
D. 0.224 g

CE01_27

Suppose that the Avogadro number is L. How many atoms does 600 cm^3 of oxygen at room temperature and pressure contain?
(Molar volume of gas at room temperature and pressure = 24 dm^3)

A. 1/40 L
B. 1/20 L
C. 25 L
D. 50 L

CE01_33

Consider the information below about the reaction of hydrogen with chlorine:

$H_2(g) + Cl_2(g) \longrightarrow 2HCl(g) \quad \Delta H < 0$

Which of the following statements can be deduced from the above information?

(1) Heat is liberated when hydrogen chloride is formed.
(2) Hydrogen and chlorine react at room temperature.
(3) When measured at room temperature and pressure, the total gas volume before the reaction equals that after the reaction.

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

CE02_16

Gases X and Y react to give a gaseous product Z. The reaction can be represented by the equation:

$X(g) + 3Y(g) \longrightarrow 2Z(g)$

In an experiment, 40 cm^3 of X and 60 cm^3 of Y are mixed and are allowed to react in a closed vessel. What is the volume of the resultant gaseous mixture?
(All volumes of are measured at room temperature and pressure.)

A. 40 cm^3
B. 60 cm^3
C. 80 cm^3
D. 100 cm^3

CE03_06

Sodium azide, NaN_3, is used in air bags in cars. When there is a serious collision, the azide will decompose to give nitrogen. The decomposition can be represented by the equation:

$$2NaN_3(s) \longrightarrow 2Na(s) + 3N_2(g)$$

What is the mass of sodium azide required to produce 72 dm^3 of nitrogen at room temperature and pressure?

(Relative atomic masses: N = 14.0, Na = 23.0;
molar volume of gas at room temperature and pressure = 24 dm^3)

A. 65.0 g
B. 130.0 g
C. 195.0 g
D. 292.5 g

CE03_20

A sample of zinc granules of mass 1.8 g was added to 100 cm^3 of 0.25 M hydrochloric acid. What is the theoretical volume of hydrogen produced at room temperature and pressure?

(Relative atomic mass: Zn = 65.4; molar volume of gas at room temperature and pressure = 24 dm^3)

A. 0.30 dm^3
B. 0.33 dm^3
C. 0.60 dm^3
D. 0.66 dm^3

CE05SP_38

In an experiment, 8.1 g of magnesium was treated with 250 cm^3 of 2.0 M hydrochloric acid. What volume of hydrogen was liberated at room temperature and pressure?

(Molar volume of gas at room temperature and pressure = 24 dm^3)

A. 4 dm^3
B. 6 dm^3
C. 8 dm^3
D. 12 dm^3

CE05SP_50

1st statement	2nd statement
The volume of 10.0 g of gaseous carbon dioxide is the same as the volume of 10.0 g of solid carbon dioxide.	10.0 g of gaseous carbon dioxide contains the same number of molecules as 10.0 g of solid carbon dioxide.

CE04_03

The relative atomic masses of hydrogen and oxygen are 1.0 and 16.0 respectively. Which of the following statements concerning 36.0 g of water is correct?

(Molar volume of gas at room temperature and pressure = 24 dm^3;
Avogadro constant = 6.02×10^{23} mol^{-1})

A. It contains 4 mol of hydrogen atoms.
B. It contains $3 \times 6.02 \times 10^{23}$ atoms.
C. It contains $6 \times 6.02 \times 10^{23}$ molecules.
D. It has a volume of 48 dm^3 at room temperature and pressure.

CE04_06

Decomposition of $KClO_3(s)$ at elevated temperatures gives KCl(s) and $O_2(g)$ as the only products. What is the volume of $O_2(g)$ produced, measured at room temperature and pressure, when 63.1 g of $KClO_3(s)$ undergoes complete decomposition?

(Relative atomic masses: O = 16.0, Cl = 35.5, K = 39.1;
molar volume of gas at room temperature and pressure = 24 dm^3)

A. 3 dm^3
B. 12 dm^3
C. 18 dm^3
D. 36 dm^3

CE05_35

$NaHCO_3$ decomposes upon heating to form Na_2CO_3, CO_2 and H_2O. What is the volume of CO_2 formed at room temperature and pressure if 336 g of $NaHCO_3$ undergoes complete decomposition?

(Relative atomic masses: H = 1.0, C = 12.0, O = 16.0, Na = 23.0;
molar volume of gas at room temperature and pressure = 24 dm^3)

A. 12 cm^3
B. 24 cm^3
C. 48 cm^3
D. 96 cm^3

CE05_44

Which of the following statements concerning 1 mole of aluminium is/are correct?

(Avogadro's constant = 6.02×10^{23};
molar volume of gas at room temperature and pressure = 24 dm^3)

(1) It can form 1 mole of Al^{3+} ions.
(2) It can form $3 \times 6.02 \times 10^{23}$ Al^{3+} ions.
(3) It occupies 24 cm^3 at room temperature and pressure.

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

CE06_41

Metal X forms an oxide with the formula X_2O. Upon strong heating, the oxide undergoes decomposition according to the following equation:

$$2X_2O(s) \longrightarrow 4X(s) + O_2(g)$$

Complete decomposition of 2.90 g of the oxide gives 150 cm^3 of oxygen, measured at room temperature and pressure. What is the relative atomic mass of X?

(Relative atomic mass: O =16.0; molar volume of gas at room temperature and pressure = 24dm^3)

A. 54.0
B. 108.0
C. 216.0
D. 232.0

CE06_50

1st statement	2nd statement
Under room temperature and pressure, 1 mol of $O_2(g)$ occupies a smaller volume than 1 mol of $O_3(g)$.	The number of atoms in 1 mol of $O_2(g)$ is less than that in 1 mol of $O_3(g)$.

CE07_39

$CO_2(g)$, $SO_3(g)$ and $O_2(g)$ are composed of atoms of different elements. At room temperature and pressure, what is the ratio of the number of atoms involved in 100 cm^3 of $CO_2(g)$, 100 cm^3 of $SO_3(g)$ and 200 cm^3 of $O_2(g)$?
(Molar volume of gas at room temperature and pressure = 24 dm^3)

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

CE07_40

When 10 g of PURE calcium carbonate (molar mass = 100.1 g) reacted with excess hydrochloric acid, 2.40 dm^3 carbon dioxide was obtained at room temperature and pressure. However, in a similar experiment using 10 g of IMPURE calcium carbonate, 2.50 dm^3 of carbon dioxide was obtained. Assuming that the impurity is a metallic carbonate, what would this impurity be?
(Molar masses: $MgCO_3$ = 84.3 g, $ZnCO_3$ = 125.4 g, $FeCO_3$ = 115.8 g, $CuCO_3$ = 123.5 g;
molar volume of gas at room temperature and pressure = 24dm^3)

A. $MgCO_3$
B. $ZnCO_3$
C. $FeCO_3$
D. $CuCO_3$

CE08_32

Nitroglycerin ($C_3H_5N_3O_9$) is an explosive and can explode according to the following equation:

$$4C_3H_5N_3O_9(l) \longrightarrow 12CO_2(g) + 12H_2O(g) + 6N_2(g) + O_2(g)$$

0.1 mole of nitroglycerin undergoes explosion and the products are allowed to cool to room temperature. What is the total volume of gases left behind at room temperature and pressure?
(Molar volume of gas at room temperature and pressure = 24 dm^3)

A. 11.4 dm^3
B. 17.4 dm^3
C. 45.6 dm^3
D. 69.6 dm^3

CE08_50

1st statement	2nd statement
When equal mass of Mg and Zn granules is added separately to excess dilute H_2SO_4, a greater amount of gas will be produced by Mg than Zn.	Mg is more reactive than Zn.

CE08_39

Consider the following information on two reactions involving magnesium ribbons of the same shape:

	Reaction mixture
Reaction 1	1.5 g Mg + 100 cm^3 of 1 M HCl
Reaction 2	1.5 g Mg + 100 cm^3 of 1 M H_2SO_4

Which of the following statements is correct?
(Relative atomic mass: Mg = 24.3)

A. The magnesium reacts completely in Reaction 1.
B. The sulphuric acid reacts completely in Reaction 2.
C. The initial rates of Reaction 1 and Reaction 2 are the same.
D. The initial rate of Reaction 1 is smaller than that of Reaction 2.

CE09_33

An oxide of metal M reacts completely with carbon to give 12.6 g of metal M and 2.38 dm^3 of carbon dioxide measured at room temperature and pressure. What is the chemical formula of the oxide?
(Relative atomic masses: M = 63.5, O =16.0;
molar volume of gas at room temperature and pressure = 24 dm^3)

A. MO
B. MO_2
C. M_2O
D. M_2O_3

CE09_40

Assuming that air contains 20% of oxygen by volume, how much air is required to burn completely 100 cm^3 of ethane? (All volumes are measured at the same temperature and pressure.)

A. 350 cm^3
B. 1000 cm^3
C. 1750 cm^3
D. 3500 cm^3

CE09_43

Beaker A contains 100 cm^3 of 1 M HCl(aq), while beaker B contains 50 cm^3 of 2 MHCl(aq). Equal mass of magnesium ribbons are added to the two beakers. Both magnesium ribbons disappear after reaction. Which of the following statements is/are correct?

(1) The reaction occurring in both beakers have the same initial rate.
(2) Same volume of gas, measured at the same temperature and pressure, is given out in both beakers.
(3) Magnesium chloride solutions of the same concentration are produced in both beakers.

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

CE10_37

What is the theoretical volume of carbon dioxide gas, measured at room temperature and pressure, that can be obtained by adding 100 cm^3 of 2.0 M HCl(aq) to 0.80 g of $Na_2CO_3(s)$?
(Relative atomic masses: H = 1.0, C = 12.0, O = 16.0, Na = 23.0, Cl = 35.5;
molar volume of gas at room temperature and pressure = 24 dm^3)

A. 90 dm^3
B. 180 dm^3
C. 240 dm^3
D. 480 dm^3

CE10_46

At room temperature and pressure, 1 mole of gas A and 2 moles of gas B react completely to form 1 mole of gas C and 1 mole of gas D. If the temperature and pressure remain unchanged, which of the following will decrease after the reaction?

(1) the mass of the gaseous mixture
(2) the volume of the gaseous mixture
(3) the total number of atoms making up the gases in the gaseous mixture

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

CE11_33

In an experiment, excess calcium granules are added to 100.0 cm^3 of 2.0M hydrochloric acid. What is the theoretical volume of hydrogen gas liberated at room temperature and pressure?
(Molar volume of gas at room temperature and pressure = 24 dm^3)

A. 0.6 dm^3
B. 1.2 dm^3
C. 2.4 dm^3
D. 4.8 dm^3

CE11_45

In an experiment to determine the initial rate of the reaction between dilute hydrochloric acid and magnesium carbonate powder, which of the following items may be measured at regular intervals as the reaction proceeds?

(1) the colour intensity of the reaction mixture
(2) the mass of the reaction mixture
(3) the volume of gas liberated

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

DSE11SP_25

Which of the following changes will NOT increase the initial rate of the reaction between 50 cm^3 of 1 M HCl(aq) and excess calcium carbonate granules?

A. Using 100 cm^3 of HCl(aq) instead of 50 cm^3 of HCl(aq).
B. Using 2 M HCl(aq) instead of 1 M HCl(aq).
C. Using 25 cm^3 of 2 M HCl(aq) instead of 50 cm^3 of 1 M HCl(aq)
D. Using calcium carbonate powder instead of calcium carbonate granules.

Directions: Questions DSE11SP_32 to DSE11SP_33 refer to the following information.

An experiment was performed on the study of the rate of reaction between hydrochloric acid and sodium thiosulphate solution. 10 cm^3 portions of 2.0 M hydrochloric acid were added to four separate conical flasks, W, X, Y and Z, each containing sodium thiosulphate solution which was prepared respectively as follows:

Conical flask	Sodium thiosulphate solution		Volume of water
	Concentration	Volume	
W	1.0 M	80 cm^3	10 cm^3
X	1.5 M	60 cm^3	30 cm^3
Y	2.5 M	30 cm^3	60 cm^3
Z	3.0 M	20 cm^3	70 cm^3

DSE11SP_32

In which of the above conical flasks does the reaction proceed at the fastest rate?

A. W
B. X
C. Y
D. Z

DSE11SP_33

Which of the following apparatus should be used when carrying out the above experiment in addition to the conical flasks?

(1) syringe
(2) stop watch
(3) measuring cylinder

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

DSE12PP_07

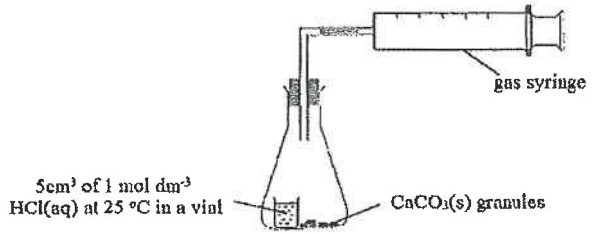
A scientist extracted a sample of 'nitrogen' from air by removing the oxygen and carbon dioxide. The scientist then compared the mass of a known volume of the 'nitrogen' sample (m_1) with that of the same volume of pure nitrogen (m_2) under the same set of conditions. The experiment was repeated a number of times. It was found that m_1 was consistently greater than m_2.
Which of the following gases is likely to be present in the 'nitrogen' obtained to account for the result that m_1 is greater than m_2?

A. Neon
B. Argon
C. Methane
D. Water vapor

DSE12PP_25

The set-up shown below is used in an experiment to study the rate of the reaction:

$$CaCO_3(s) + 2HCl(aq) \longrightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$$



The conical flask is shaken to overturn the vial in order to start the reaction. The initial rate of the reaction with respect to the gas liberated is determined. The experiment is then repeated with only one of the conditions changed while the others remain unchanged.

Under which of the following situations would the initial rate be the same as that in the original experiment.

A. using 10 cm^3 of 1 mol dm^{-3} HCl(aq)
B. using 5 cm^3 of 2 mol dm^{-3} HCl(aq)
C. using 5 cm^3 of 1 mol dm^{-3} HCl(aq) which is preheated to 50 °C
D. using powdered $CaCO_3(s)$ of the same mass

DSE12PP_29

0.40 g of an impure sample of zinc granules reacts with excess dilute sulphuric acid to give 100 cm^3 of hydrogen, measured at room temperature and pressure. Assuming that the impurities in the zinc granules do not react with sulphuric acid, what is the percentage by mass of zinc in the sample?

(Relative atomic masses: H = 1.0, Zn = 65.4;
molar volume of gas at room temperature and pressure = 24 dm^3)

A. 25 B. 34
C. 68 D. 73

DSE12PP_32

Some brands of washing powder contain enzymes. Which of the following statements about the action of the enzymes is/are correct?

(1) The activity of the enzymes increases with temperature.
(2) The enzymes facilitate the removal of specific kinds of dirt.
(3) The enzymes reduce the surface tension of water.

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

DSE12_25

What is the theoretical volume of carbon dioxide that can be obtained, at room temperature and pressure, when 1.2 g of $Na_2CO_3(s)$ reacts with 50 cm^3 of 1.0 M HNO_3?

(Molar volume of gas at room temperature and pressure = 24 dm^3;
Relative atomic masses: H = 1.0, C = 12.0, N = 14.0, O = 16.0, Na = 23.0)

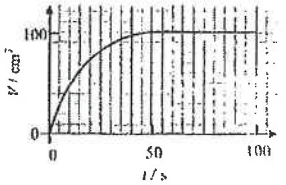
A. 272 cm^3 B. 544 cm^3
C. 600 cm^3 D. 1200 cm^3

DSE13_25

In an experiment to study the rate of the following reaction, a small amount of powdered calcium carbonate was added to excess hydrochloric acid and the volume of gas liberated was recorded.

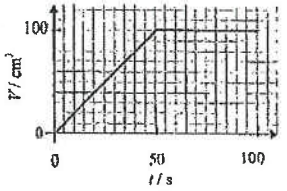
$$CaCO_3(s) + 2HCl(aq) \longrightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$$

The graph below shows the volumes of gas liberated (V) a different times (t) during the experiment:

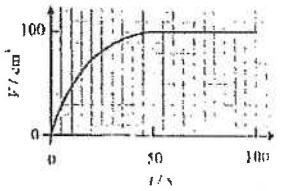


The experiment was repeated under the same conditions using the same mass of calcium carbonate granules instead of powdered calcium carbonate. Which of the following graphs would best represent the results obtained in the repeated experiment?

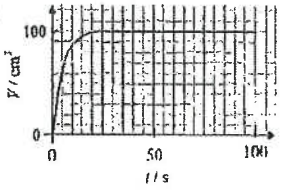
A.



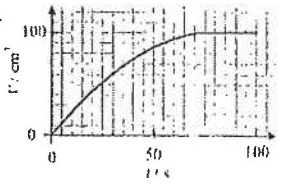
B.



C.



D.



DSE13_33

For which of the following can their progress of reaction be followed by colorimetry?

(1) $2MnO_4^-(aq) + 5C_2O_4^{2-}(aq) + 16H^+(aq) \longrightarrow 2Mn^{2+}(aq) + 10CO_2(g) + 8H_2O(l)$

(2) $SO_3^{2-}(aq) + 2H^+(aq) \longrightarrow SO_2(g) + H_2O(l)$

(3) $Br_2(aq) + HCO_2H(aq) \longrightarrow 2Br^-(aq) + CO_2(g) + 2H^+(aq)$

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

DSE14_25

$H_2O_2(aq)$ decomposes into $H_2O(l)$ and $O_2(g)$ in the presence of $MnO_2(s)$. Two experiments are performed to study this decomposition under the same conditions, except that 50 cm^3 of 2M $H_2O_2(aq)$ is used in Experiment (1), while 100 cm^3 of 1M $H_2O_2(aq)$ is used in Experiment (2). Which of the following combinations is correct?

	Rate of formation of $O_2(g)$ at the start	Total volume of $O_2(g)$ formed
A.	Experiment (1) > Experiment (2)	Experiment (1) = Experiment (2)
B.	Experiment (1) > Experiment (2)	Experiment (1) > Experiment (2)
C.	Experiment (1) = Experiment (2)	Experiment (1) = Experiment (2)
D.	Experiment (1) = Experiment (2)	Experiment (1) > Experiment (2)

DSE15_28

Which of the following pairs of chemicals, upon mixing under the same temperature, has the highest rate of gas formation?

A. 0.10 g of Zn powder and 100 cm^3 of 1.0 M HCl(aq)
B. 0.10 g of Zn granules and 200 cm^3 of 1.0 M HCl(aq)
C. 0.10 g of Zn granules and 200 cm^3 of 1.0 M $H_2SO_4(aq)$
D. 0.10 g of Zn powder and 100 cm^3 of 1.0 M $H_2SO_4(aq)$

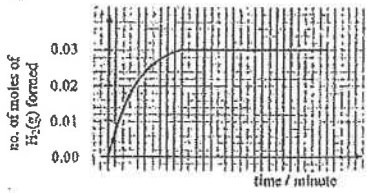
DSE15_36

1st statement	2nd statement
At room conditions, the volume of 1 mol of $SO_2(g)$ is larger than that of 1 mol of $N_2(g)$.	The number of atoms constituting 1 mol of $SO_2(g)$ is greater than that constituting 1 mol of $N_2(g)$

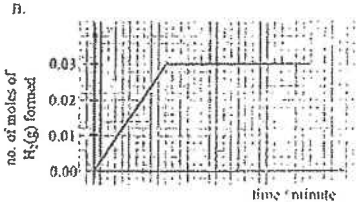
DSE16_25

In an experiment, 0.03 mol of Mg(s) is allowed to react with 20.0 cm^3 of 1.0 M HCl(aq). Which of the following graphs best represents the results of the experiment?

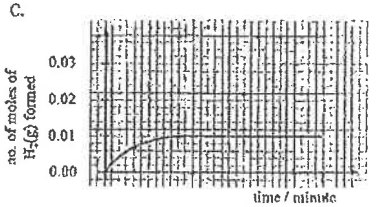
A.



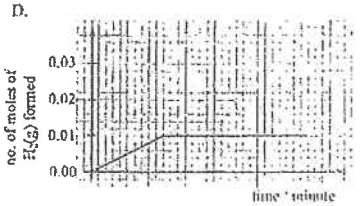
B.



C.



D.



DSE16_33

Which of the following statements are correct?

(1) Magnesium oxide dissolves faster in 1 M HCl(aq) than 1 M $CH_3CO_2H(aq)$.
(2) Powdered marble dissolves faster in 1 M HCl(aq) than granular marble does.
(3) $H_2O_2(aq)$ decomposes faster in the presence of $MnO_2(s)$ than without $MnO_2(s)$.

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

DSE16_34

Consider the following reaction:

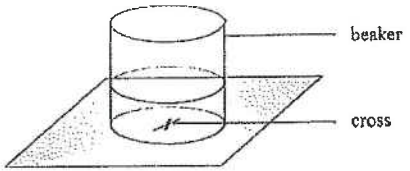
$$Br_2(aq) + HCOOH(aq) \longrightarrow CO_2(g) + 2HBr(aq)$$

Which of the following can be measured in order to follow the progress of the reaction?

(1) The volume of gas formed
(2) The turbidity of the reaction mixture
(3) The color intensity of the reaction mixture

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

Direction: Question DSE17_27 and DSE17_28 refer to the following set-up.



DSE17_27

A(aq) and B(aq) react to form a turbid mixture. Three trials of an experiment were performed to study the rate of the reaction. In each trial, A(aq) was mixed with $H_2O(l)$ in the beaker. After that, B(aq) was added to the mixture, and immediately started to measure the time needed for the cross to become invisible when viewed from above. The table below shows the relevant data.

Trial	Volume used / cm^3			Time / s
	A(aq)	$H_2O(l)$	B(aq)	
1	10.0	20.0	10.0	82
2	10.0	10.0	20.0	41
3	20.0	10.0	10.0	82

Which of the following statements concerning the rate of the reaction is correct?

A. It depends on [A(aq)], and also depends on [B(aq)].
B. It increases with [A(aq)], but does not increase with [B(aq)].
C. It increases with [B(aq)], but does not increase with [A(aq)].
D. It does not depend on [A(aq)], and also does not depend on [B(aq)].

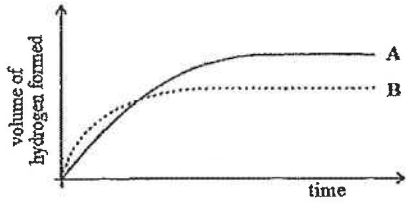
DSE17_28

Of which of the following reactions can the rate be studies by the above set-up?

A. $CaCl_2(aq) + H_2SO_4(aq) \longrightarrow CaSO_4(aq) + 2HCl(aq)$
B. $Na_2CO_3(aq) + 2HCl(aq) \longrightarrow 2NaCl(aq) + H_2O(l) + CO_2(g)$
C. $2FeSO_4(aq) + 2H_2SO_4(aq) \longrightarrow Fe_2(SO_4)_3(aq) + 2H_2O(l) + SO_2(g)$
D. $Na_2S_2O_3(aq) + 2HCl(aq) \longrightarrow S(s) + SO_2(aq) + H_2O(l) + 2NaCl(aq)$

DSE18_25

100 cm^3 of 1.0 M HCl(aq) reacts with excess zinc granules giving curve A in the graph below.



Which of the following changes may give curve B?

A. Increase the temperature by 5 °C.
B. Use the same mass of zinc powder instead of zinc granules.
C. Use 200 cm^3 of 0.8 M HCl instead of 100 cm^3 of 1.0 M HCl(aq).
D. Use 50 cm^3 of 1.50 M HCl(aq) instead of 100 cm^3 of 1.0 M HCl(aq).

DSE18_33

Consider the following two reactions:

Reaction	Reactants
(I)	1.0 g of $Na_2CO_3(s)$ + 100 cm^3 of 1.0 M HCl(aq)
(II)	1.0 g of $Na_2CO_3(s)$ + 100 cm^3 of 1.0 M $CH_3COOH(aq)$

Which of the following statements are correct if the two reactions are performed under the same experimental conditions?

(Relative atomic masses : C = 12.0, O = 16.0, Na = 23.0)

(1) The decrease in mass for the two reaction mixture is the same.
(2) The initial rate of Reaction (I) is higher than that of Reaction (II).
(3) The heat given out for the two reactions is the same.

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

DSE18_36

Consider the following statements and choose the best answer:

1st statement	2nd statement
The molar volume of bromine is larger than that of fluorine at room temperature and pressure.	The molecular size of bromine is larger than that of fluorine.

DSE19_34

Consider the following reaction :

$$2H_2O_2(aq) \xrightarrow{MnO_2(s)} 2H_2O(l) + O_2(g)$$

Which of the following statements is / are correct if the concentration of $H_2O_2(aq)$ changes from 2 M to 1 M, while the other conditions remain unchanged?

(1) The consumption of $MnO_2(s)$ will decrease.
(2) The rate of formation of $O_2(g)$ will decrease.
(3) The volume of $O_2(g)$ formed will decrease.

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

DSE19_35

Consider the following reaction :

$$5NaBr(aq) + NaBrO_3(aq) + 6HCl(aq) \longrightarrow 3Br_2(aq) + 6NaCl(aq) + 3H_2O(l)$$

(colourless)

Which of the following can be measured in order to follow the progress of the reaction ?

(1) pH of the reacting mixture
(2) pressure of the reaction system
(3) colour intensity of the reacting mixture

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

DSE20_25

25. Consider the following reaction :

$$4H_2(g) + Fe_3O_4(s) \rightarrow 3Fe(s) + 4H_2O(l)$$

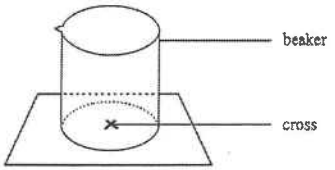
What is the minimum volume of $H_2(g)$ at room conditions required to form 0.168 g of Fe(s) ?

(Molar volume of gas at room conditions = 24 dm^3;
Relative atomic mass : Fe = 55.8)

A. 24 cm^3
B. 48 cm^3
C. 96 cm^3
D. 192 cm^3

DSE20_35

35. Refer to the following set-up :



Which of the following reactions can the effect of concentration on rate be studied by the above set-up ?

(1) $MgO(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2O(l)$
(2) $Na_2S_2O_3(aq) + 2HCl(aq) \rightarrow S(s) + SO_2(g) + H_2O(l) + 2NaCl(aq)$
(3) $Mg(s) + ZnSO_4(aq) \rightarrow MgSO_4(aq) + Zn(s)$

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

DSE21_25

Direction: Questions 25 and 26 refer to the following experiment on the study of the rate of reaction between $HCO_2H(aq)$ and $Br_2(aq)$ at a certain temperature. It is given that the rate depends on both the concentrations of $HCO_2H(aq)$ and $Br_2(aq)$:

$$HCO_2H(aq) + Br_2(aq) \rightarrow 2HBr(aq) + CO_2(g)$$

5.0 cm^3 of 0.05 M $HCO_2H(aq)$ are separately added to four conical flasks each containing $Br_2(aq)$ prepared by mixing different volumes of 0.05 M $Br_2(aq)$ and water as shown in the table below :

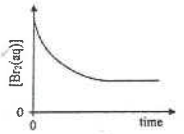
Conical flask	Volume of 0.05 M $Br_2(aq)$ / cm^3	Volume of water / cm^3
A	1.0	4.0
B	2.0	3.0
C	3.0	2.0
D	4.0	1.0

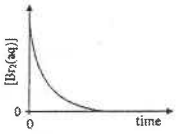
25. In which of the above conical flasks does the reaction have the fastest initial rate ?

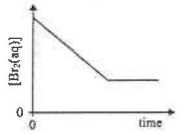
A. A
B. B
C. C
D. D

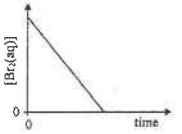
DSE21_26

26. Which of the following graphs best represents the variation of $[Br_2(aq)]$ in the reaction mixture of conical flask B with time ?

A.


B.


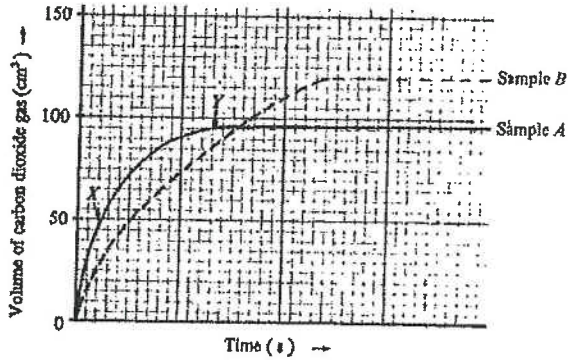
C.


D.


Structural Questions

CE90_02b

Two different samples of calcium carbonate (A and B), each weighing 0.8 g and containing inert impurities, were allowed to react with excess dilute hydrochloric acid under the same laboratory conditions. The volumes of carbon dioxide gas evolved with time are shown in the graph below:



(i) Draw a diagram to show how the above experiment can be performed in the laboratory.

(ii) Explain why the slope of the curve for sample A is steeper at X than at Y.

(iii) From the two curves, deduce TWO differences between sample A and sample B.

(iv) (1) What is the total volume of gas liberated from sample B?

(2) Hence, calculate the percentage of calcium carbonate in sample B.

(Relative atomic masses: C = 12.0, O = 16.0, Ca = 40.0;
Molar volume of gas under the laboratory conditions = 24 dm^3)

(10 marks)

CE92_02c

1.0 g of calcium carbonate is added to 50.0 cm^3 of 0.1 M nitric acid. At the end of the reaction, 55.0cm^3 of a certain gas are collected at room temperature and pressure.

(i) Draw a diagram of the set-up suitable for this experiment.

(ii) Calculate the theoretical volume of the gas which would be liberated at room temperature and pressure.

(iii) Explain any difference between the theoretical volume and the volume of the gas collected.

(Relative atomic masses: C = 12.0, O = 16.0, Ca = 40.0;
Molar volume of gas at room temperature and pressure = 24.0 dm^3)

(6 marks)

CE92_03b

Neon, a monatomic gas, occurs naturally as a mixture of three isotopes. The relative abundance of these isotopes is tabulated below:

Isotope	$^{20}_{10}Ne$	$^{21}_{10}Ne$	$^{22}_{10}Ne$
Abundance / %	90.52	0.31	9.17

(i) State the number of electrons in the outermost shell of a neon atom.

(ii) Explain why neon gas is monatomic.

(iii) What is meant by the term 'isotope'?

(iv) Calculate

(1) the relative atomic mass of neon.

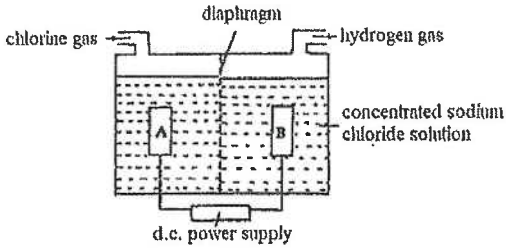
(2) the density (in g dm^{-3}) of neon gas at room temperature and pressure.

(Molar volume of gas at room temperature and pressure = 24.0 dm^3)

(7 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.

(iii) If 234 g of sodium chloride are used up during the electrolysis, calculate the volume of hydrogen liberated at room temperature and pressure.

(Relative atomic masses: Na = 23.0, Cl = 35.5;
Molar volume of gas at room temperature and pressure = 24.0 dm^3)

(9 marks)

CE93_04b

To determine the percentage by mass of calcium carbonate in egg shells, a student added 100 cm^3 of 2 M hydrochloric acid to 0.3 g of egg shells in a container. After 30 minutes, all the egg shells dissolved and 67 cm^3 of carbon dioxide were collected at room temperature and pressure.

(i) Write an equation for the reaction between calcium carbonate and hydrochloric acid.

(ii) Calculate the percentage by mass of calcium carbonate in the egg shells.

(iii) The rate of reaction between the egg shells and 2 M hydrochloric acid was slow. Suggest TWO method to increase the rate of this reaction without using other chemicals. Explain your answer in each case.

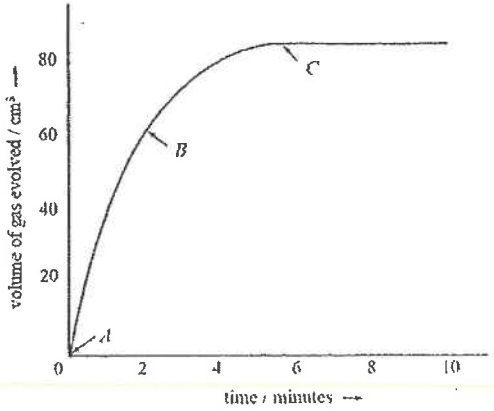
(Relative atomic masses: H = 1.0, C =12.0, O = 16.0, Ca = 40.0;
Molar volume of gas at room temperature and pressure = 24.0 dm^3)

(8 marks)

CE94_08a

The rate of decomposition of hydrogen peroxide solution in the presence of manganese(IV) oxide was studied by means of the following experiment.

50.0 cm^3 of a hydrogen peroxide solution was mixed with 0.5 g of powdered manganese(IV) oxide in a conical flask. The volumes of gas evolved at room temperature and pressure at different times are shown in the graph below.



(i) Write an equation for the decomposition of hydrogen peroxide.

(ii) Compare the rates of decomposition of the hydrogen peroxide solution at points A, B and C, and explain why these rates are different.

(iii) Calculate the original molarity of the hydrogen peroxide solution.

(iv) If the experiment is repeated with an equal volume of the hydrogen peroxide solution and 1.0 g of powdered manganese(IV) oxide, would the shape of the curve obtained be the same? Explain your answer.

(Molar volume of gas at room temperature and pressure = 24.0 dm^3)

(8 mraks)

CE95_07a

The label on a bottle of 'Effervescent Calcium' tablets is shown below.

Effervescent Calcium	
Each bottle contains 10 tablets.	
Each tablet contains:	
Calcium carbonate	625 mg
Vitamin C	1000 mg
Citric acid	1350 mg
Dosage: 1 tablet daily	
Administration : Dissolve one tablet in a glass of water.	
Warning : (1) Keep out of reach of children.	
(2) Keep	

(i) Effervescence occurs when a tablet of 'Effervescent Calcium' is added to water. Based on the information given on the label, explain why effervescence occurs.

(ii) Suppose that a student puts a tablet of 'Effervescent Calcium' into an excess amount of water and collects the gas liberated.

(1) Assuming that the tablet completely dissolves, calculate the theoretical volume of gas liberated.

(2) It is found that the volume of gas collected in the experiment is less than the theoretical volume calculated in (1). Give ONE reason to explain the difference, assuming that there is no leakage of gas in the experiment.

(8 marks)

CE96_07a

The boxes below show some information about two atoms.

Hydrogen (H) and deuterium (D):

Mass number → 1, Atomic number → 1, **H**

Mass number → 2, Atomic number → 1, **D**

(i) Suggest a term to indicate the relationship between a hydrogen atom and a deuterium atom.

(ii) State the number of neutrons in a deuterium atom.

(iii) Deuterium reacts with oxygen in the same way as hydrogen.

$2D_2(g) + O_2(g) \longrightarrow 2D_2O(l)$ ΔH is negative

The product of the reaction is known as 'heavy water'.

(1) Explain why deuterium reacts with oxygen in the same way as hydrogen.

(2) Draw the electronic structure of 'heavy water', showing the electrons in the outermost shells ONLY.

(3) What is meant by 'ΔH is negative'?

(4) What is the formula mass of 'heavy water'?

(5) 100 cm^3 of deuterium and 100 cm^3 of oxygen, both measured at room temperature and pressure, are allowed to react. Calculate the mass of 'heavy water' produced.

(9 marks)

CE00_09a

X, Y and Z are three different metals. The table below shows the result of two experiments carried out using the metals or their oxides.

Experiment	X	Y	Z
Adding the metal to water	Effervescence	No observable change	No observable change
Heating the metal oxide	No observable change	Metal produced	No observable change

(i) Based on the above information, arrange the three metals in order of increasing reactivity. Explain your answer.

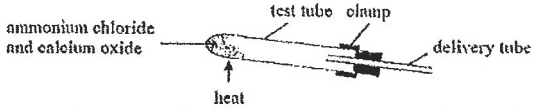
(ii) An oxide of Y has the formula YO. When 1.08 g of this oxide is heated strongly, it decomposes completely to give 60.0 cm^3 of oxygen, measured at room temperature and pressure. Calculate the relative atomic mass of Y.

(Relative atomic mass: O = 16.0;
molar volume of gas at room temperature and pressure = 24.0 dm^3)

(6 marks)

CE03_06a

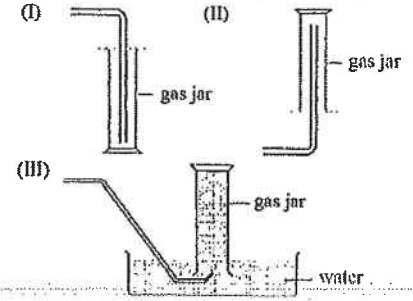
Ammonia gas can be prepared by heating a mixture of ammonium chloride and calcium oxide in the set-up shown below:



(i) The reaction of ammonium chloride with calcium oxide also gives calcium chloride as a product. Write the chemical equation for the reaction of ammonium chloride with calcium oxide.

(ii) Why is it necessary to clamp the test tube with its mouth pointing downwards as shown?

(iii) Decide which of the following set-ups, (I), (II) or (III), should be connected to the delivery tube to collect the ammonia gas produced. Explain your answer.



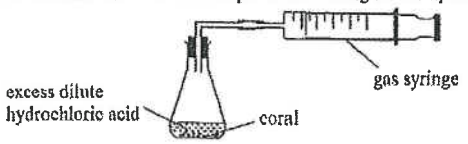
(iv) Calculate the theoretical volume of ammonia gas, measured at room temperature and pressure, which can be obtained from the reaction of 1.0 g of ammonium chloride with excess calcium oxide.

(Relative atomic masses: H = 1.0, N = 14.0, Cl = 35.5;
molar volume of gas at room temperature and pressure = 24.0 dm^3)

(9 marks)

CE04_08a

Coral consists mainly of calcium carbonate. An experiment was carried out to determine the percentage by mass of calcium carbonate in a sample of coral using the set-up shown below:



(i) Write a chemical equation for the reaction of calcium carbonate with dilute hydrochloric acid.

(ii) The mass of the sample used was 0.36 g. At the end of the experiment, 78 cm^3 of carbon dioxide was collected at room temperature and pressure.
Calculate
(1) the number of moles of carbon dioxide collected; and
(2) the percentage by mass of calcium carbonate in the sample.

(iii) Assuming that there was no leakage of gas in the set-up, suggest ONE source of error in the experiment.

(Molar volume of gas at room temperature and pressure = 24.0 dm^3;
relative atomic masses: C = 12.0, O = 16.0, Ca = 40.0)

(7 marks)

CE06_12

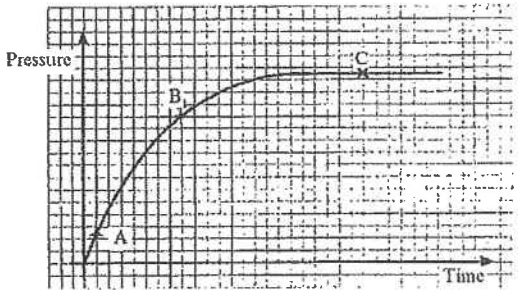
For question 12, candidates are required to give answers in paragraph form. For this question, 6 marks will be awarded for chemical knowledge and 3 marks for effective communication.

You are provided with the following materials:
magnesium ribbon and 2M hydrochloric acid
Design an experiment to determine the molar volume of hydrogen at room temperature and pressure.
(You may use apparatus commonly available in a school laboratory.)

(6 + 3 marks)

CE09_10

In an experiment, a data-logger with pressure sensor was used to study the rate of decomposition of hydrogen peroxide (H_2O_2) in the presence of manganese(IV) oxide. The relation between the pressure and time measured is shown in the curve below.



(a) The decomposition of hydrogen peroxide gives water and oxygen. After the experiment, it was found that the manganese(IV) oxide used did not undergo any chemical change.

(i) State the function of manganese(IV) oxide.

(ii) Explain why a pressure sensor could be used in this experiment.

(iii) Write a chemical equation for the decomposition of hydrogen peroxide. Hence discuss the changes, if any, in the oxidation numbers of hydrogen and oxygen in the reaction.

(5 marks)

(b) (i) Explain why the respective rates of decomposition of hydrogen peroxide differ at points A, B and C on the curve.

(ii) On the graph above, sketch a curve that should be obtained if the initial concentration of the hydrogen peroxide is *half* of its original value, while all other conditions remain unchanged.

(4 marks)

AL99(I)_07

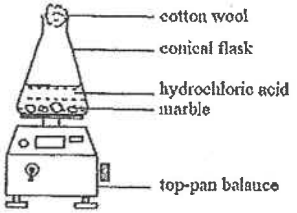
In a chemical kinetics experiment, samples of the reaction mixture are removed at regular time intervals for titrimetric analysis.

Suggest TWO methods by which the reaction in the samples removed can be stopped or slowed down.

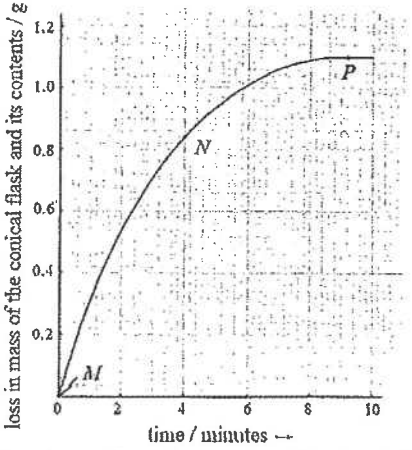
(2 marks)

ASL99(II)_11

In an experiment, 50.0 cm^3 of 1.0 M hydrochloric acid was allowed to react with 10.0 g of marble (in excess). The progress of the reaction was monitored using the set-up shown below.



The graph below shows the loss in mass of the conical flask and its contents against time.



(a) Write a balanced equation for the reaction of marble with hydrochloric acid.

(1 mark)

(b) What is the purpose of placing some cotton wool at the mouth of the flask?

(1 mark)

(c) Suggest how to determine the rate of loss in mass of the conical flask and its contents at point *N* from the graph.

(2 marks)

(d) Account for the change in shape of the curve from point *M* to point *P*.

(3 marks)

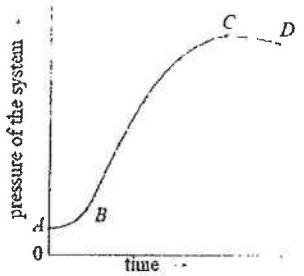
(e) The experiment was repeated using 50.0 cm^3 of 0.5 M hydrochloric acid and 10.0 g of marble.

Sketch a curve on the same graph to show the variation of the loss in mass of the conical flask and its contents against time.

(1 mark)

ASL00(II)_07

A chemical kinetics experiment was carried out using a roll of magnesium ribbon which had been exposed to air for some time. A piece of the magnesium ribbon of mass 0.12 g was placed in a flask containing 15.0 cm^3 of 1.0 M hydrochloric acid. The progress of the reaction was followed by measuring the pressure of the system at different times. The graph on below shows the results of the experiment.



(a) Show, by calculation, that magnesium was the limiting reactant.

(2 marks)

(b) Account for the variation of pressure of the system as shown in the graph

(i) from *A* to *B*,

(2 marks)

(ii) from *B* to *C*, and

(1 mark)

(iii) from *C* to *D*.

(2 marks)

(c) The experiment was repeated using the same mass of the magnesium ribbon and 15.0 cm^3 of 2.0 M hydrochloric acid. Sketch, on the same graph, the variation of pressure of the system in the repeated experiment. Explain your answer.

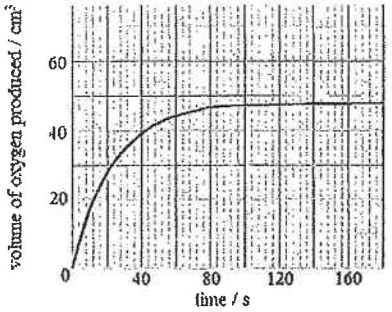
(4 marks)

ASL01(II)_07 [Similar to DSE17_10]

The decomposition of hydrogen peroxide can be catalysed by catalase which is an enzyme.

$$2H_2O_2(aq) \xrightarrow{\text{catalyst}} 2H_2O(l) + O_2(g)$$

In an experiment to study the rate of decomposition of hydrogen peroxide, 10.0 cm^3 of 0.40 M hydrogen peroxide solution and a small amount of catalase were used. The graph on below shows the results of the experiment.



(a) Draw a labelled diagram of the experimental set-up used.

(2 marks)

(b) Account for the change in the rate of decomposition of hydrogen peroxide as shown in the graph.

(3 marks)

(c) The experiment was repeated using 30.0 cm^3 of 0.20 M hydrogen peroxide solution while keeping other conditions unchanged. Sketch, on the same graph, the results of the repeated experiment.

(1 mark)

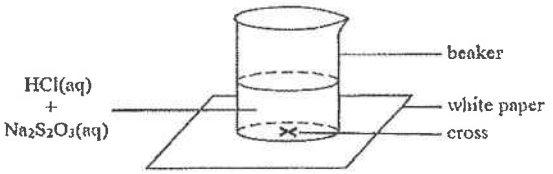
(d) Suggest another substance which can catalyse the decomposition of hydrogen peroxide.

(1 mark)

ASL02(II)_11

The set-up shown below was used to investigate how the concentration of $S_2O_3^{2-}(aq)$ affects the rate of the following reaction.

$$S_2O_3^{2-}(aq) + 2H^+(aq) \longrightarrow S(s) + SO_2(g) + H_2O(l)$$



10.0 cm^3 of 1.0 M HCl(aq) and 25.0 cm^3 of $H_2O(l)$ were mixed in a beaker. 5.0 cm^3 of 0.040 M $Na_2S_2O_3(aq)$ was then added to the mixture and simultaneously a stop-watch was started. The time, t, required for the cross to disappear when viewed from above was recorded. The experiment was repeated using the same volume of HCl(aq) but different volumes of $H_2O(l)$ and $Na_2S_2O_3(aq)$. The table below lists the results obtained.

Experiment	Volume used / cm^3			t / s
	1.0 M HCl(aq)	$H_2O(l)$	0.040 M $Na_2S_2O_3(aq)$	
1	10.0	25.0	5.0	170
2	10.0	20.0	10.0	83
3	10.0	15.0	15.0	56
4	10.0	10.0	20.0	42
5	10.0	5.0	25.0	33
6	10.0	0.0	30.0	y

(a) Explain why

(i) different volumes of water were used in this investigation, and

(1 mark)

(ii) the cross, when viewed from above, disappeared after time t.

(1 mark)

(b) Plot a graph of $\frac{1}{t}$ aginst the volume of 0.040 M $Na_2S_2O_3(aq)$used.

(3 marks)

(c) What conclusion can be drawn from this investigation? Explain.

(2 marks)

(d) From your graph, estimate the value of *y* in the table.

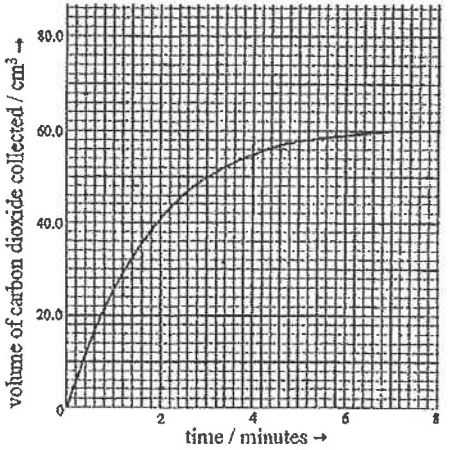
(1 mark)

ASL03(II)_10

An experiment was carried out to study the rate of the following reaction:

$$CaCO_3(s) + 2HCl(aq) \longrightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$$

A sample of marble chips was allowed to react wth 0.1 M hydrochloric acid, which had been saturated with carbon dioxide. The graph below shows the experimental results obtained.



(a) (i) Suggest how hydrochloric acid can be saturated with carbon dioxide.

(1 mark)

(ii) If the hydrochloric acid used has not been saturated with carbon dioxide, different experimental results would be obtained. Sketch the results that would be obtained on the graph.

(1 mark)

(b) (i) Suggest how the rate of the reaction at a particular time can be determined from the graph.

(2 marks)

(ii) Explain why the rate of the reaction decreases with time.

(1 mark)

(c) Keeping the other conditions unchanged, the experiment was repeated using

(i) the same mass of powdered calcium carbonate instead of marble chips, and

(1 mark)

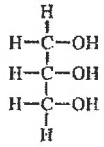
(ii) The same volume of 0.1 M ethanoic instead of 0.1 M hydrochloric acid.

(1 mark)

State and explain the respective changes in the reaction rate.

ASL04(I)_05 (modified)

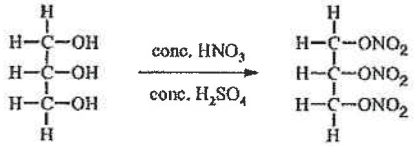
Glycerine has the following structure:



(a) Give the systematic name of glycerine.

(1 mark)

(b) When glycerine is treated with a mixture of concentrated nitric(V) acid and concentrated sulphuric(VI) acid, trinitroglycerine is formed.



trinitroglycerine

Trinitroglycerine is an explosive. Nitroglycerin can explode to give carbon dioxide, water, nitrogen and oxygen gas as following equation.

$$\_\_C_3H_5N_3O_9(l) \longrightarrow \_\_CO_2(g) + \_\_H_2O(g) + \_\_N_2(g) + \_\_O_2(g)$$

(i) Balance the above equation for the explosion of nitroglycerin.

(1 mark)

(ii) Calculate the theoretical volume in cm^3, measured at room temperature and pressure, of gas produced when 1 g of trinitroglycerine explodes completely.
(Formula masses: $C_3H_5N_3O_9 = 227$;
Molar volume of gas at room temperature and pressure = 24 dm^3)

(2 marks)

(iii) Calculate the enthalpy change of decomposition of trinitroglycerine, from the enthalpy terms given below.

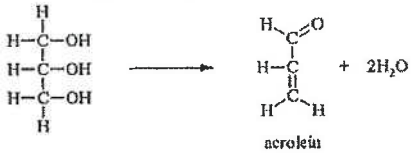
	$\Delta H^\circ_{f,298K}$ / kJ mol^{-1}
$C_3H_5N_3O_9(l)$	–364
$CO_2(g)$	–394
$H_2O(g)$	–242

(2 marks)

(iv) Besides forming a large volume of gases, give another TWO reasons why trinitroglycerine would undergo explosion upon ignition.

(2 marks)

(c) A sample of glycerine, after being stored for a long time, may contain acrolein. The formation of acrolein can be represented by the following equation:



acrolein

(i) Suggest a chemical test to show the possible presence of acrolein in a sample of glycerine.

(2 marks)

(ii) Acrolein readily undergoes addition polymerization. Draw the repeating unit of the polymer formed.

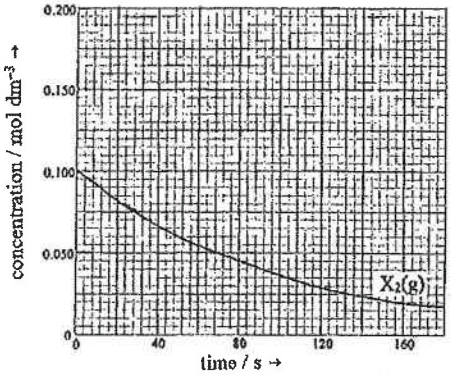
(1 mark)

ASL05(II)_08

$X_2(g)$ undergoes decomposition according to the following equation:

$$X_2(g) \longrightarrow 2X(g)$$

In an experiment to study the decomposition of $X_2(g)$, 0.100 mol of $X_2(g)$ was charged into a closed container of volume 1 dm^3 kept at a constant temperature. The graph below shows the variation of the concentration of $X_2(g)$ in the container with time.



(a) From the graph, calculate the average rate of decomposition of $X_2(g)$ in the time internal from the start of the experiment to the 40th seconard.

(2 marks)

(b) Sketch, on the same graph, the variation of the concentration of X(g) with time during the experiment.

(2 marks)

(c) Explain, in molecular terms, why the decomposition of $X_2(g)$ is faster at a higher temperature.

(2 marks)

ASL06(I)_07

A student performed an experiment to investigate the rate of reaction between zinc and and acid. 6 g of zinc granules was added to a conical flask containing 100 cm^3 of 2 M hydrochloric acid at 20 °C. Afterwards the experiment was repeated with the following changes. In each case, state and explain whether the expected reaction rate would increase or decrease.

(a) 6 g of zinc powder was used instead of zinc granules.

(1 mark)

(b) 100 cm^3 of 2 M ethanoic acid was used instead of hydrochloric acid.

(1 mark)

(c) The temperature was raised to 50 °C.

(1 mark)

ASL06(II)_10

Ammonia reacts with oxygen in the presence of platinum to give nitrogen monoxide.

$$4NH_3(g) + 5O_2(g) \xrightarrow{Pt} 4NO(g) + 6H_2O(g) \quad \Delta H < 0$$

(a) $NH_3(g)$ and $O_2(g)$ are allowed to react in a vessel of constant volume. Find the rate of consumption of $O_2(g)$ if the rate of formation of NO(g) is 1.24×10^{-4} mol dm^{-3} s^{-1}.

(2 marks)

(b) Platinum is a catalyst in the above reaction. What is meant by the term 'catalyst'?

(1 mark)

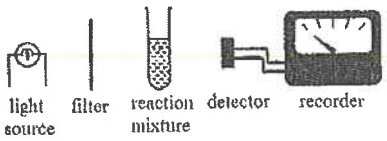
(c) State an important industrial product that can be obtained from NO(g).

(1 mark)

ASL08(I)_07

The diagram below shows the essential components of an instrument for studing the kinetics of the reaction:

$$Br_2(aq) + HCO_2H(aq) \xrightarrow{H^+} 2Br^-(aq) + 2H^+(aq) + CO_2(g)$$



(a) What is this instrument?

(1 mark)

(b) What physical parameter of the reaction mixture is measured by this instrument?

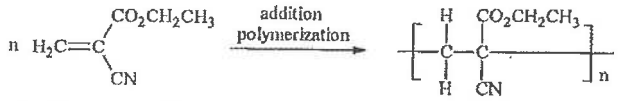
(1 mark)

(c) Sketch a graph to show the variation of the measured physical parameter with time.

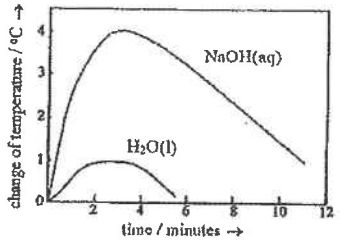
(1 mark)

AL08(I)_08a

Super glue works as an adhesive by addition polymerization as shown below:



Two experiments were carried out to study the effects of NaOH(aq) and $H_2O(l)$ on the polymerization. The conditions of the experiments were the same except that one was conducted in the presence of NaOH(aq) and the other in the presence of $H_2O(l)$, Figure shows the change of temperature of two reaction mixtures with time.



(i) Account for the increase and decrease in temperature of the reaction mixtures.

(2 marks)

(ii) Suggest a reason for the significant difference in the two curves.

(1 mark)

ASL10(I)_02

A student made the following remark:

'The rate of an elementary gaseous reaction increases with temperature because the average kinetic energy of the reactant molecules increases with temperature.'

Is the explanation provided by the student regarding the increase in reaction rate appropriate? Elaborate your answer.

(3 marks)

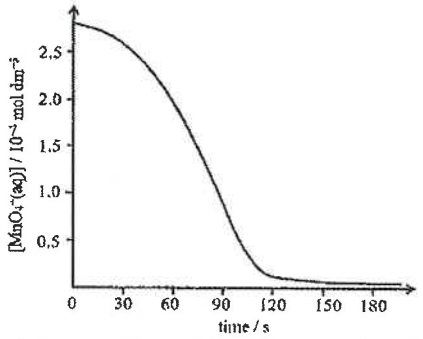
AL10(II)_02b [Similar to DSE12PP_10]

(i) Complete and balance the equation of the following reaction under an acidic condition:

$$MnO_4^-(aq) + C_2O_4^{2-}(aq) + \_\_\_\_\_ \longrightarrow Mn^{2+}(aq) + CO_2(g) + \_\_\_\_\_$$

(1 mark)

(ii) An experiment was performed to study the kinetics of the reaction in (i). The graph below shows the results obtained:



(I) Suggest a physical method for monitoring the concentration of $MnO_4^-(aq)$ ions in the reaction mixture.

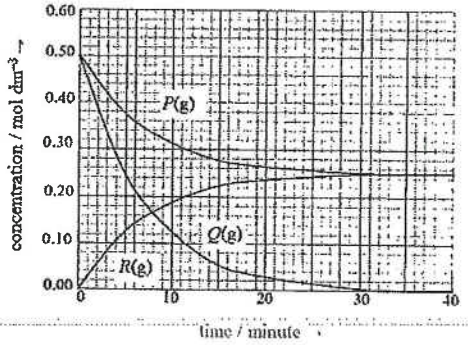
(1 mark)

(II) Suggest an explanation for the variation of the concentration of $MnO_4^-(aq)$ ions with time.

(3 marks)

DSE11SP_10

$P(g)$ reacts with $Q(g)$ irreversibly to give $R(g)$. A mixture of $P(g)$ and $Q(g)$ is allowed to react in a closed container of volume 1 dm^3 kept at a constant temperature. The graph below shows the changes in concentrations of $P(g)$, $Q(g)$ and $R(g)$ in the container with time.



(a) With reference to the above graph, deduce the chemical equation for the reaction in terms of $P(g)$, $Q(g)$ and $R(g)$.

(2 marks)

(b) If the mixture of $P(g)$ and $Q(g)$ is allowed to react at the same temperature but in a closed container of volume 2 dm^3 instead, will the time required for the reaction to complete remain the same? Explain.

(1 mark)

(c) Explain why the collisions between molecules of $P(g)$ and $Q(g)$ will not necessarily lead to a reaction.

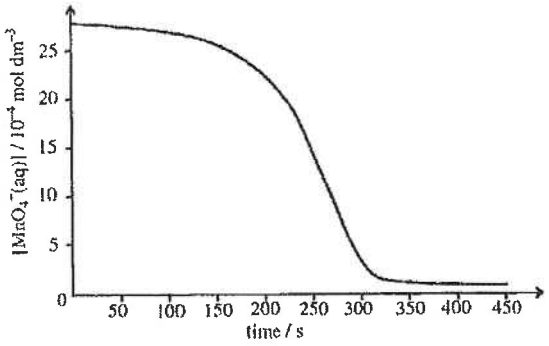
(2 marks)

DSE12PP_10 [Similar to AL10(II)_02b]

The equation below shows the reaction of potassium permanganate with sodium ethanedioate under acidic conditions:

$$2MnO_4^-(aq) + 5C_2O_4^{2-}(aq) + 16H^+(aq) \longrightarrow 2Mn^{2+}(aq) + 10CO_2(g) + 8H_2O(l)$$

A student conducted an experiment to study the rate of this reaction. The results are shown in the graph below:



(a) Suggest ONE physical method that can be used to monitor the concentration of $MnO_4^-(aq)$ ions in the reaction mixture.

(1 mark)

(b) Based on the experimental results, the student suggested that one of the products might have catalysed the reaction.

(i) What evidence from the above graph supports the student's suggestion? Explain your answer.

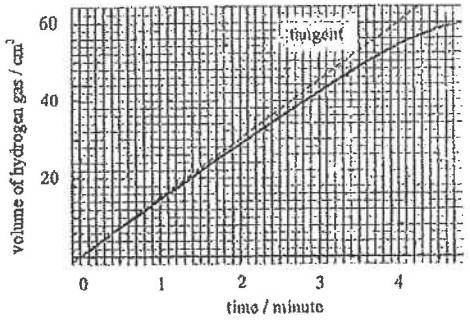
(2 marks)

(ii) Suggest how the student can show whether or not $Mn^{2+}(aq)$ is a catalyst for this reaction.

(2 marks)

DSE12_11

In an experiment, 50 cm^3 of 2.0 M HCl(aq) was added to a conical flask containing 2.0 g of zinc powder. The curve in the graph below shows the volume, measured at room temperature and pressure, of the hydrogen gas liberated in the first few minutes of the experiment. The dotted line in the graph is the tangent to the curve at the start of the reaction.



(a) The 'initial rate' of a reaction is defined as the instantaneous rate at the start of the reaction. With reference to the graph above, calculate the initial rate of the reaction with respect to the volume of hydrogen gas liberated.

(1 mark)

(b) Explain qualitatively the effect on the initial rate of the reaction of replacing the 2.0 M HCl(aq) with 2.0 M H_2SO_4(aq).

(1 mark)

(c) Upon completion of the reaction, all the zinc powder was used up. Calculate the theoretical volume of hydrogen gas liberated measured at room temperature and pressure.
(Molar volume of gas at room temperature and pressure = 24 dm^3; Relative atomic mass: Zn = 65.4)

(3 marks)

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.

$$2NaN_3(s) \longrightarrow 2Na(s) + 3N_2(g)$$
$$10Na(s) + 2KNO_3(s) \longrightarrow K_2O(s) + 5Na_2O(s) + N_2(g)$$

(a) Explain why the NaN_3(s) and KNO_3(s) used in the airbags are in the form of fine powder.

(1 mark)

(b) An airbag contains 100.0 g of NaN_3(s) and 200.0 g of KNO_3(s). Calculate the theoretical

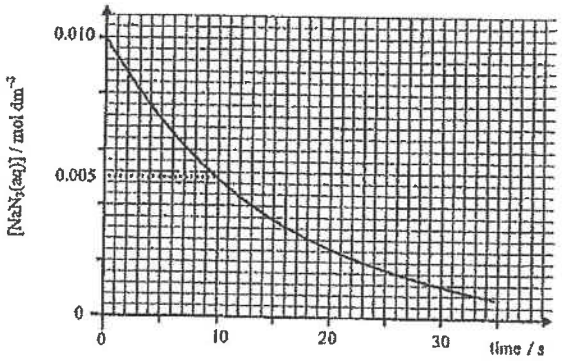
volume, measured at room temperature and pressure, of the gas produced when the bag is inflated.
(Formula masses: NaN_3 = 65.0, KNO_3 = 101.1;
Molar volume of gas at room temperature and pressure = 24 dm^3)

(3 marks)

(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)

(d) Sodium azide is a toxic chemical. Thus any NaN_3 waste remained during the manufacture of safety airbags needs special treatment before disposal. The treatment involves first dissolving NaN_3 in water, and then reacting the solution formed with excess nitrous, HNO_2(aq). The graph below shows the variation of the concentration of NaN_3(aq) in the reaction mixture with time in one such process:



(i) Calculate the average rate of consumption of NaN_3(aq) in the first 10 seconds.

(1 mark)

(ii) Suggest how the instantaneous rate of consumption of NaN_3(aq) at the 10th second can be determined from the graph.

(1 mark)

DSE14_10

You are provided with common laboratory apparatus, calcium carbonate and 1M hydrochloric acid. Outline how you would perform a fair comparison in studying the effect of different concentrations of acid on the rate of production of carbon dioxide from the following reaction:

$$CaCO_3(s) + 2HCl(aq) \longrightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$$

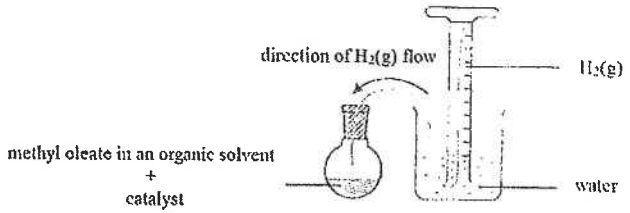
(4 marks + 1 mark)

DSE15_09

Consider the reaction below:

$$\underset{\text{methyl oleate}}{CH_3(CH_2)_7CH{=}CH(CH_2)_7CO_2CH_3(l)} + H_2(g) \xrightarrow{\text{catalyst}} CH_3(CH_2)_7CH_2CH_2(CH_2)_7CO_2CH_3(l)$$

At room temperature and pressure, a micro-scale experiment was performed using the set-up shown below in which 0.080 g of methyl oleate in an organic solvent was allowed to react with excess $H_2(g)$. The $H_2(g)$ flowed from the inverted measuring cylinder to the reacting flask through the tubing.



(a) State one advantage of conducting this reaction in a micro-scale experiment.

(1 mark)

(b) Explain why the right end of the tubing was placed at the uppermost position of the inverted measuring cylinder.

(1 mark)

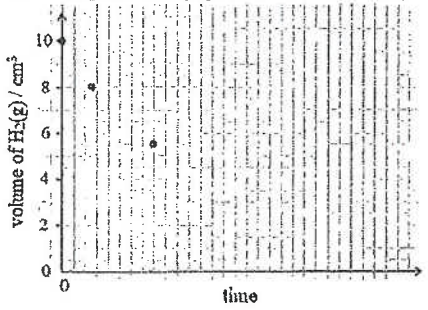
(c) State an expected observation in the inverted measuring cylinder during the reaction.

(1 mark)

(d) Calculate the theoretical volume of $H_2(g)$ needed for the reaction to complete at room temperature and pressure.
(Molar volume of gas at room temperature and pressure = 24 dm^3;
Relative molecular mass: methyl oleate = 296.0)

(3 marks)

(c) (i) Sketch, in the graph below, the variation of the volume of $H_2(g)$ in the measuring cylinder with time from start until the completion of the reaction. You should label this sketch as 'A'. (The measuring cylinder initially contained 10.0 cm^3 of $H_2(g)$. The first few points have been given in the graph to facilitate the sketch.)



(1 mark)

(ii) In the same graph above, give another sketch as required in (i) but only using 0.040 g of methyl oleate for the reaction while the other conditions remain unchanged. You should label this sketch as 'B'.

(1 mark)

DSE16_11

Under certain conditions, a pink compound X react with NaOH(aq) to give a colorless product. Three trials of an experiment were conducted to study the kinetics of the reaction. Firstly, three NaOH(aq) solutions were prepared by mixing different volume of 2.0 M NaOH(aq) and $H_2O(l)$ at 25 °C. after that, one drop of X was added top each of the them and the time needed for the pink color to disappear was recorded. The relevant data is shown below:

	Volume of 2.0 M NaOH(aq) used / cm^3	Volume of $H_2O(l)$ used / cm^3	Time needed for the pink color to disappear / s
Trial 1	5.0	0	61
Trial 2	4.0	1.0	76
Trial 3	3.0	2.0	101

(a) Why is it necessary to make the total volume of the reaction mixtures the same for the trials?

(1 mark)

(b) Given that at 25 °C, $[H^+(aq)][OH^-(aq)] = 1.0\times10^{-14}$ mol^2 dm^{-6}, calculate the pH of the NaOH(aq) solution prepared in Trial 2.

(2 marks)

(c) Based on the information provided, deduce one factor which affects the rate of this reaction.

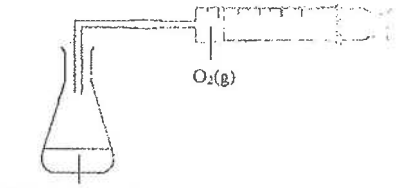
(2 marks)

(d) Detection of color change using naked eye is not accurate enough. Suggest an instrumental method that can be used to more accurately detect the color change.

(1 mark)

DSE17_10 [Similar as ASL01(II)_07]

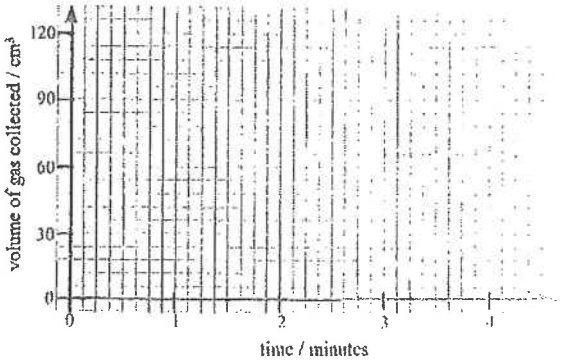
In an experiment performed under room conditions as shown below, 5.00 cm^3 of $H_2O_2(aq)$ decomposed into $O_2(g)$ and $H_2O(l)$ in the presence of a catalyst. $O_2(g)$ was continuous released from the start of the experiment until the third minute when a total of 60 cm^3 of gas was collected. After that, no more gas was collected.



(a) Calculate the initial concentration of $H_2O_2(aq)$, in mol dm^{-3}.

(2 marks)

(b) In the graph below, sketch the variation of the volume of gas collected with time in the first 4 minutes.



(2 marks)

(c) The experiment is repeated using $H_2O_2(aq)$ at a higher temperature but other conditions remain unchanged. Explain whether the total volume of gas obtained would still be 60 cm^3. (The volume of gas is measured at room conditions.)

(1 mark)

(d) Suggest another method that can be used to follow the progress of this reaction.

(1 mark)

DSE18_02

This question involves the preparation of ammonia gas and the investigation of the properties of ammonia gas in a laboratory.

(a) Solid calcium hydroxide reacts with solid ammonium chloride to form ammonia gas. Draw a labelled diagram to show the set-up involved and how ammonia gas is collected.

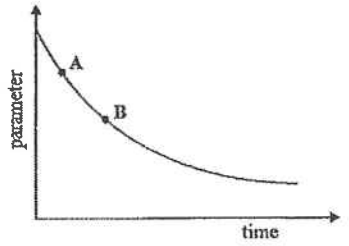
(2 marks)

DSE18_11

Consider the following reaction:

$$Br_2(aq) + HCO_2H(aq) \longrightarrow 2HBr(aq) + CO_2(g)$$

In an experiment to study the rate of consumption of $Br_2(aq)$, equal volumes of 0.01 M $Br_2(aq)$ and 1.0 M $HCO_2H(aq)$ were mixed. The progress of the reaction was followed by measuring a certain parameter of the reaction system using a colorimeter. The graph below shows the results from the start of the reaction.



(a) Assume that the rate of change of the parameter with time can represent the rate of reaction.

(i) According to the shape of the curve above, suggest what the parameter should be.

(1 mark)

(ii) The initial rate of the reaction can be determined by a suitable sketch on the above graph. Draw the suitable sketch on the above graph, and describe how the initial rate of the reaction can be obtained from the sketch.

(2 marks)

(iii) According to the graph above, the rate of reaction at A is higher than that at B. Explain this at molecular level.

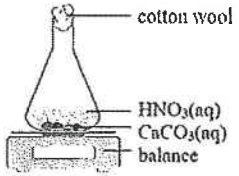
(2 marks)

(b) Suggest another method that can follow the progress of the reaction.

(1 mark)

DSE19_11

Two trials of an experiment were performed using the set-up below to study the reaction between nitric acid and calcium carbonate. A gas was formed in the reaction.



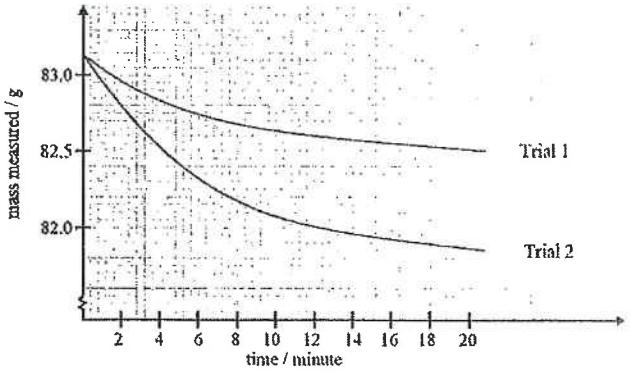
The chemicals used are listed in the table below while other experimental conditions were the same.

Trial	Mass of $CaCO_3(s)$ added / g	Volume of 3.0 M $HNO_3(aq)$ added / cm^3	Volume of $H_2O(l)$ added / cm^3
1	3.0	10.0	20.0
2	3.0	20.0	10.0

(a) Write the chemical equation for the reaction between nitric acid and calcium carbonate.

(1 mark)

(b)



(i) Calculate the average rate of formation of the gas from the 2nd minute to the 12th minute for Trial 2.

(2 marks)

(ii) Explain ONE difference in the shape of the curves for Trial 1 and Trial 2.

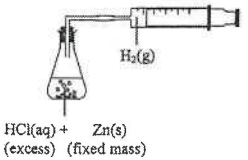
(2 marks)

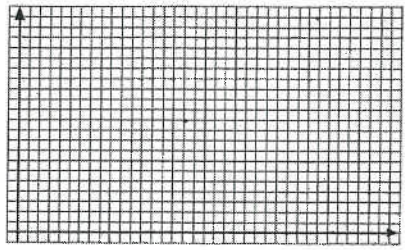
(c) Suggest how the effect of surface area of solid reactant on the rate of reaction can be studied using the above set-up.

(1 mark)

DSE20_13 *13. With reference to the set-up shown below, describe how the effect of concentration of HCl(aq) on the rate of the reaction can be studied. Your answer should include **TWO** labelled curves sketched on the graph below, one using **solid line** and the other one using **dotted line**. Label all curves and axes.

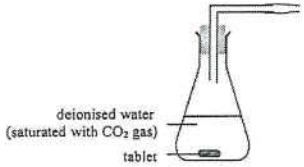
(6 marks)





DSE21_10 10. A tablet contains solid sodium hydrogencarbonate and solid citric acid (water soluble). An experiment was performed under room conditions to study the rate of formation of CO_2 gas when the tablet was placed in deionised water.

(a) The diagram below shows an incomplete set-up for the experiment :

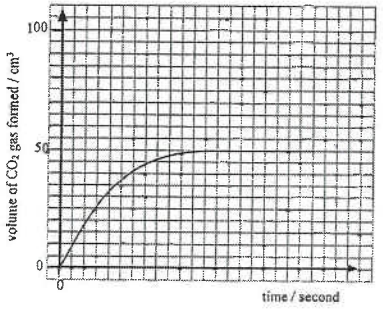


(i) Explain why the deionised water used should be saturated with CO_2 gas before the start of the experiment.

(ii) Add suitable drawing (with label) to the above diagram to show how the volume of the CO_2 gas formed can be measured.

(2 marks)

10. (b) (i) The graph below shows the variation of the volume of CO_2 gas formed with time for the experiment :



Assuming that citric acid was in excess and no other substances reacted with sodium hydrogencarbonate, calculate the mass of sodium hydrogencarbonate in the tablet.
(Molar masses : sodium hydrogencarbonate = 84.0 g, citric acid = 192.0 g;
Molar volume of gas at room conditions = 24 dm^3)

(ii) Sketch another curve (using **dotted line**) on the above graph to show the expected experimental result if the tablet is ground into a powder, with all other experimental conditions remaining unchanged.

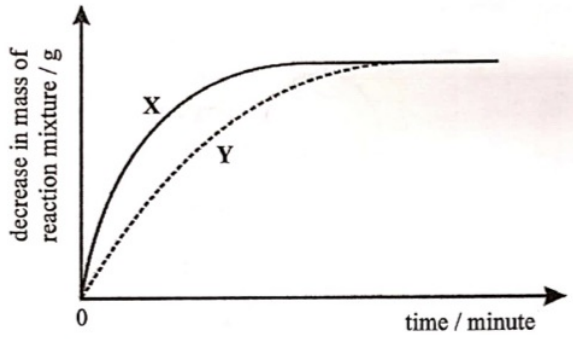
(3 marks)

25. A mixture consists of methane and ethane. 50 cm^3 of this mixture completely burns in oxygen to form 80 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 dm^3)

A. 10 cm^3
B. 20 cm^3
C. 30 cm^3
D. 40 cm^3

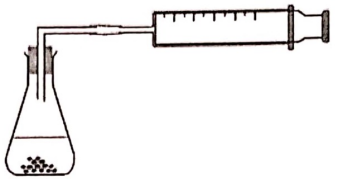
26. 50 cm^3 of 0.10 M HCl(aq) reacts with excess calcium carbonate powder in an open conical flask giving curve **X** in the graph below.



Which of the following changes may give curve **Y** ?

A. Increase the temperature by 10 °C.
B. Use 25 cm^3 of 0.10 M HCl(aq) instead of 50 cm^3 of 0.10 M HCl(aq).
C. Use 50 cm^3 of 0.05 M HCl(aq) instead of 50 cm^3 of 0.10 M HCl(aq).
D. Use the same mass of calcium carbonate granules instead of calcium carbonate powder.

31. Consider the experimental set-up shown below :

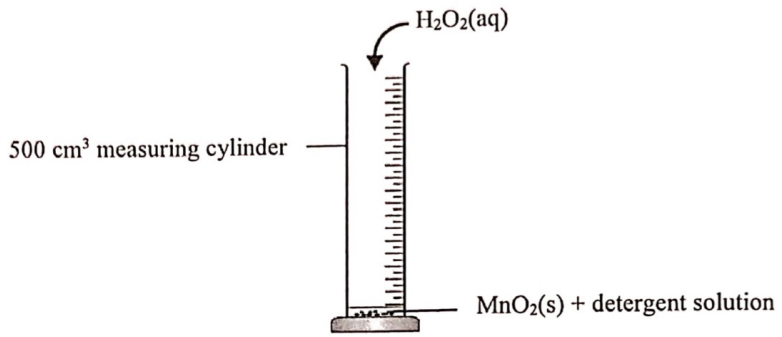


Under room conditions, which of the following pairs of reactants can the progress of their reaction be followed by the above set-up ?

(1) $Zn(OH)_2(s)$ and $HNO_3(aq)$
(2) Mg(s) and HCl(aq)
(3) KBr(s) and $Cl_2(aq)$

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

10. At room conditions, $H_2O_2(aq)$ would decompose into $O_2(g)$ and $H_2O(l)$ very slowly in the absence of $MnO_2(s)$. An experiment was performed as shown in the set-up below :



When 10.0 cm^3 of 3.00 M $H_2O_2(aq)$ was mixed with a small amount of $MnO_2(s)$ and detergent solution at room conditions, $O_2(g)$ started to be released rapidly and foam was produced. The $MnO_2(s)$ remained chemically unchanged at the end of the reaction.

(a) Write a chemical equation for the decomposition of $H_2O_2(aq)$.

10. (c) Upon completion of the reaction, all the $H_2O_2(aq)$ was used up. Calculate the theoretical volume of $O_2(g)$ released at room conditions.
(Molar volume of gas at room conditions = 24 dm^3)

(2 marks)

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

Section C Analytical Chemistry

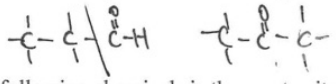
Answer **ALL** parts of the question.

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)

(b) A solid sample consists of a compound **Y** and a small amount of an impurity **Z**. The following steps were performed in an experiment to obtain pure **Y**(s) from this solid sample.
(Given : **Y** is more soluble in deionised water at 80 °C than at 25 °C.)

Step (1) : 1.40 g of this solid sample was added to 50 cm^3 of deionised water and heated to 80 °C.
Step (2) : Water-insoluble activated charcoal was then added to remove **Z**. The mixture obtained was filtered when it was still hot.
Step (3) : The hot filtrate obtained was allowed to cool slowly to 25 °C. **Y**(s) was formed.
Step (4) : The cooled mixture was filtered to collect **Y**(s). After washing and drying, 0.75 g of **Y**(s) was collected.

(i) It is given that no more than 3.04 g of **Y**(s) can dissolve in 100 cm^3 of deionised water at 80 °C. Show, by calculation, that all of **Y** in this solid sample should have dissolved in Step (1).

(1 mark)

(ii) Explain why the mixture was filtered in Step (2).

(1 mark)

(iii) Name the process of the formation of **Y**(s) in Step (3).

(1 mark)

(iv) Suggest one reason why the mass of **Y**(s) collected in Step (4) was smaller than the mass of **Y** in this solid sample.

(1 mark)

(v) **Y** and **Z** can be separated by chromatography. Thin layer chromatography (TLC) and column chromatography were performed separately with this solid sample using the same stationary phase and mobile phase.
(Given : R_f value of **Y** is greater than that of **Z**.)

(1) Sketch a labelled chromatogram of TLC to show the expected result.

(2) Explain whether the first-collected fraction in the column chromatography is **Y** or **Z**.

(3 marks)

Marking Scheme

MCQ

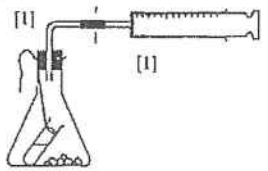
CE90_08	A	CE90_11	A	CE91_03	C	CE91_32	B
CE93_09	B	CE94_47	C	CE95_31	D	CE96_11	B
CE96_19	C	CE96_32	B	CE97_17	C	CE97_34	B
CE98_28	B	CE98_46	C	CE99_16	D	CE01_10	C
CE01_27	B	CE01_33	C	CE02_16	B	CE03_06	B (63%)
CE03_20	A (41%)	CE05SP_38	B	CE05SP_50	C	CE04_03	A (35%)
CE04_06	C (58%)	CE05_35	C (68%)	CE05_44	A (52%)	CE06_41	B (57%)
CE06_50	C (54%)	CE07_39	A (42%)	CE07_40	A (43%)	CE08_32	A (32%)
CE08_50	B (24%)	CE08_39	D (54%)	CE09_33	A (51%)	CE09_40	C (60%)
CE09_43	B (49%)	CE10_37	B (67%)	CE10_46	B (51%)	CE11_33	C (65%)
CE11_45	D (72%)	DSE11SP_25	A	DSE11SP_32	B	DSE11SP_33	C
DSE12PP_07	B	DSE12PP_25	A	DSE12PP_29	C	DSE12PP_32	B
DSE12_25	A (69%)	DSE13_25	D (79%)	DSE13_33	B (81%)	DSE14_25	A (73%)
DSE15_28	D (78%)	DSE15_36	C (60%)	DSE16_25	C (77%)	DSE16_33	D (72%)
DSE16_34	B (77%)	DSE17_27	C (73%)	DSE17_28	D (57%)	DSE18_25	D (76%)
DSE18_33	A (58%)	DSE18_36	C (65%)	DSE19_34	D	DSE19_35	B

DSE20_25 C
DSE20_35 A

Structural Questions

CE90_02b

(i) [1] [1] [2]



(ii) at X, the rate is faster. Concentration of acid for reaction is higher and the mass of calcium carbonate is larger. [1]

OR, at Y, the rate is slower. All the calcium carbonate is used up and the reaction stops.

(iii) More carbon dioxide gas is collected from B (120 cm^3) than from A (96 cm^3) [1]
thus sample B has a higher purity (or less impurities) than sample A [1]
The initial rate of sample A is greater than that of sample B (steeper slope for A than B) [1]
thus more surface area / smaller particle size in A than in B [1]

(iv) (1) volume of CO_2 = 120 cm^3 [1]

(2) $CaCO_3 + 2HCl \longrightarrow CO_2 + H_2O + CaCl_2$

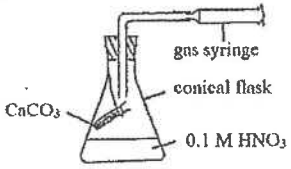
$$\text{mole of } CaCO_3 = \text{moles of } CO_2 = \frac{0.12}{24} = 0.005$$ [1]

mass of $CaCO_3 = 0.005 \times (40 + 12 + 16 \times 3) = 0.5$ g [1]

$$\%\text{ of } CaCO_3 = \frac{0.5}{0.8} \times 100\% = 62.5\%$$ [1]

CE92_02c

(i) [2]



(ii) $CaCO_3 + 2HNO_3 \longrightarrow CO_2 + H_2O + Ca(NO_3)_2$

$$\text{moles of } CaCO_3 = \frac{0.1}{40 + 12 + 16 \times 3} = 0.01$$

$$\text{moles of } HNO_3 = 0.1 \times \frac{50}{1000} = 0.005$$ [1]

0.005 mole of HNO_3 can only react 0.0025 mole $CaCO_3$, so $CaCO_3$ is in excess.
mole of $CaCO_3$ reacted = mole of CO_2 formed = 0.0025 mole [1]
volume of $CO_2 = 0.0025 \times 24 = 0.06$ dm^3 or 60 cm^3 [1]

(iii) The actual volume of CO_2 formed is smaller than the theoretical volume because some CO_2 formed dissolves in water. [1]

CE92_03b

(i) 8 electrons [1]

(ii) Neon has a stable octet structure with 8 outermost shell electrons. [1]

(iii) Isotopes are atoms with same number of protons but different number of neutrons. [1]

(iv) (1) $\text{Relative atomic mass of Ne} = \frac{20 \times 90.52 + 21 \times 0.31 + 22 \times 9.17}{100} = 20.19$ [2]

(2) $\text{Density of Ne gas} = \frac{20.19}{24} = 0.84\ \text{g dm}^{-3}$ [2]

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^+ is 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. [1]

Finally, as H^+ and Cl^- are preferentially discharged, Na^+ and OH^- are left. [1]

(iii)

Oxidation:	$2Cl^-(aq) \longrightarrow Cl_2(g) + 2e^-$
Reduction:	$2e^- + 2H^+(aq) \longrightarrow H_2(g)$
Overall:	$2Cl^-(aq) + 2H^+(aq) \longrightarrow Cl_2(g) + H_2(g)$

When 1 mole H_2 if formed, 2 moles of Cl^- is used.

$\text{moles of NaCl used} = \frac{234}{23 + 35.5} = 4$ [1]

$\text{moles of } H_2 \text{ formed} = \frac{4}{2} = 2$ [1]

$\text{volume of } H_2 \text{ formed} = 2 \times 2.4 = 48\ \text{dm}^3$ [1]

CE93_04b

(i) $CaCO_3 + 2HCl \longrightarrow CaCl_2 + H_2O + CO_2$ [1]

(ii) 1 mole $CaCO_3$ gives 1 mole of CO_2

$\text{moles of } CO_2 \text{ formed} = \frac{67 \times 10^{-3}}{24} = 0.0028$ [1]

$\text{mass of } CaCO_3 = 0.0028 \times (40 + 12 + 16 \times 3) = 0.028\ \text{g}$ [1]

$\%\text{ mass of } CaCO_3 \text{ in egg shell} = \frac{0.28}{0.3} \times 100\% = 93\%$ [1]

(iii) method: crush the egg shell into small piece [1]

reason: to increase the reacting surface area [1]

method: heating [1]

reason: heating can increase the energy of the particles of reactants [1]

CE94_08a

(i) $2H_2O_2 \longrightarrow 2H_2O + O_2$ [1]

(ii) The rate of decomposition of H_2O_2 in descending order is A > B > C.

The rate of decomposition depends on the concentration of H_2O_2.

The concentration of H_2O_2 is highest at A, so the rate of decomposition is the fastest. [1]

At C, all the H_2O_2 are used up, the reaction stops. [1]

(iii) $\text{moles of } O_2 = \frac{84 \times 10^{-3}}{24} = 0.0035$ [1]

$\text{moles of } H_2O_2 = 0.0035 \times 2 = 0.0070$ [1]

$[H_2O_2] = \frac{0.007}{50 \times 10^{-3}} = 0.14\ \text{M}$ [1]

(iv) No, the slope of the curve will increase

As MnO_2 is a catalyst [1]

powdered MnO_2 increase the surface area of catalyst that can increase the rate of reaction. [1]

CE95_07a

(i) Citric acid / vitamin C (ascorbic acid) when dissolves in water gives $H^+(aq)$ [1]

which reacts with calcium carbonate to give gas (CO_2) bubbles. [1]

$CaCO_3 + 2H^+ \longrightarrow Ca^{2+} + CO_2 + H_2O$ [1]

(ii) (1) $CaCO_3 + 2H^+ \longrightarrow Ca^{2+} + CO_2 + H_2O$

no. of moles of CO_2 evolved = no. of moles of $CaCO_3$ present [1]

$\text{moles of } CaCO_3 \text{ present} = \frac{625 \times 10^{-3}}{100} = 6.25 \times 10^{-3}$ [1]

[1]

Theoretical volume of gas = $6.25 \times 10^{-3} \times 24 = 0.15\ \text{dm}^3$ [1]

(2) Some of the CO_2 produced dissolved in water / CO_2 is (fairly) soluble in water. [1]

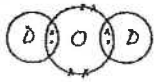
CE96_07a

(i) isotope [1]

(ii) One / 1 [1]

(iii) (1) H and D have the same electronic structure (or electronic arrangement). [1]

(DO NOT accept H and D have same no. of electrons in their outermost shells)

(2)  [1]

(3) The reaction is exothermic / gives out heat / release energy [1]

(4) Formula mass = 2 + 2 + 16 = 20 [1]

(5) $2D_2(g) + O_2(g) \longrightarrow 2D_2O(l)$

In the mixture, no. of moles of D_2 = no. of moles of O_2

$\text{moles of } D_2 = \frac{100 \times 10^{-3}}{24} = 0.004167$ [1]

O_2 is in excess, no. of moles of D_2O produced = 0.004167 mole

mass of D_2O produced = $0.004167 \times 20 = 0.0833\ \text{g}$ (0.083 – 0.084 g) [2]

CE00_09a

(i) Reactivity: Y < Z < X [1]

Y is the least reactive because only the oxide of Y decomposes on heating and the oxides of X and Z are stable to heat. [1]

X is the most reactive metal because only X can react with water but Y and Z do not react with water. [1]

(ii) $moles\ of\ O_2\ produced = \frac{60 \times 10^{-3}}{24} = 2.5 \times 10^{-3}$ [1]

$2YO \longrightarrow 2Y + O_2$

$moles\ of\ YO\ heated = \frac{2.5 \times 10^{-3}}{2} = 1.25 \times 10^{-3}$

$1.25 \times 10^{-3} = \frac{mass}{molar\ mass\ of\ YO} = \frac{1.08}{atomic\ mass\ of\ Y + 16}$ [1]

So, relative atomic mass of Y = 200 [1]

CE03_06a

(i) $2NH_4Cl + CaO \longrightarrow CaCl_2 + H_2O + 2NH_3$ [1]

(ii) The water vapour produced will condense near the mouth of the test tube. [1]

The test tube will crack when the cold water flows back to the hot test tube. [1]

(iii) (II) should be used [1]

Ammonia is less dense than air [1]

and is very soluble in water. [1]

(iv) $2NH_4Cl + CaO \longrightarrow CaCl_2 + H_2O + 2NH_3$ [1]

$moles\ of\ NH_4Cl = \frac{1}{53.5} = 0.01869$ [1]

$Theoretical\ volume\ of\ NH_3(g) = 0.01869 \times 24 = 0.45\ dm^3$ [1]

CE04_08a

(i) $CaCO_3(s) + 2H^+(aq) \longrightarrow Ca^{2+}(aq) + H_2O(l) + CO_2(g)$ [1]

OR, $CaCO_3(s) + 2HCl(aq) \longrightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$

(ii) (1) $moles\ of\ CO_2\ collected = \frac{78 \times 10^{-3}}{24} = 3.25 \times 10^{-3}$ [2]

(2) $mass\ of\ CaCO_3\ in\ the\ sample = 3.25 \times 10^{-3} \times 100 = 0.325\ g$ [1]

$\%\ by\ mass\ of\ CaCO_3 = \frac{0.325}{0.36} \times 100\% = 90.27\%$ [2]

(iii) Any ONE of the following: [1]

- the sample of coral contains other substances which react with HCl(aq) to liberate a gas
- some $CO_2(g)$ dissolves in water

CE06_12

Chemical knowledge [6]

Description of procedure (max. 4M)

Use sand paper to remove oxide layer on the magnesium ribbon.

Weigh the piece of magnesium ribbon in grams (w).

Put the piece of magnesium ribbon in a conical flask connected to a gas syringe.

Add 2M hydrochloric acid to the Mg ribbon until in excess.

Collect the hydrogen gas liberated using the syringe.

Measure the volume of $H_2(g)$ collected ($v\ cm^3$).

Treatment of data

$Mg(s) + 2H^+(aq) \longrightarrow Mg^{2+}(aq) + H_2(g)$

Molar volume of $H_2(g)$

$= \frac{v}{w} \times$ molar mass of Mg (cm^3)

Effective communication [3]

CE09_10

(a) (i) catalyst / increase the rate of the reaction (decomposition). [1]

(ii) Gas evolved in the reaction. / Oxygen affects the pressure. [1]

(iii) $H_2O_2 \longrightarrow 2H_2O + O_2$ [1]

Oxidation number of hydrogen remains unchanged. [1]

Oxidation number of oxygen (increases) from -1 to 0, [1]

and (decreases) from -1 to -2.

(b) (i) At A: The rate of reaction is high because the concentration of H_2O_2 is high. [1]

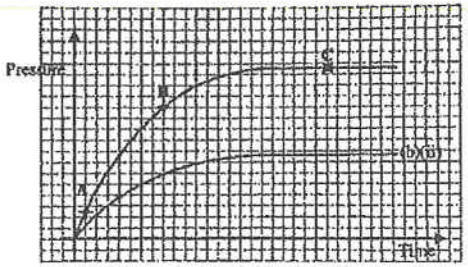
At B: The rate of reaction decreases because the concentration of H_2O_2 decreases during reaction. [1]

At C: The reaction stops because all the H_2O_2 has been used up. [1]

(ii) Curve: [1]

The slope of curve is smaller.

The value at the end of the curve is about half the original one.



AL09(I)_07

Any TWO of the following: [2]

Lower the temperature of the sample of reaction mixture removed by immersing it in ice/ice-salt mixture.

Dilute the sample with water / an appropriate solvent.

Remove one of the reactant/catalyst by adding an appropriate quenching agent.

ASL09(II)_11

(a) $CaCO_3(s) + 2HCl(aq) \longrightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$ [2]

(b) Allow $CO_2(g)$ to escape but prevent the splashing of hydrochloric acid out of the flask. [1]

(c) Draw a tangent line to the curve at point *N*. [1]

Determine the slope of the tangent line. [1]

(d) At the point *M* (beginning), the concentration (amount) of hydrochloric acid is the highest, and the reaction rate increases with the amount of acid. [1]

From point *M* to *N*, the concentration (amount) of hydrochloric acid decreases gradually, and the reaction rate also decreases with decreasing concentration of acid. [1]

At point *P*, all acid is used up and the reaction stop. ∴ reaction rate drops to zero. [1]

(e) Slope of curve: smaller [1]

Maximum height of the curve: reduced by half

ASL00(II)_07

(a) $Mg(s) + 2H^+(aq) \longrightarrow Mg^{2+}(aq) + H_2(g)$

Mole of HCl used = $1 \times 15 \times 10^{-3} = 0.015$ [1]

Mole of Mg used = $\frac{0.12}{24.3} = 4.94 \times 10^{-3}$ [1]

Since mole ratio of Mg to HCl is 1 : 2, Mg is a limiting reagent.

(b) (i) Acid is firstly used to dissolve the oxide layer on magnesium, and no H_2 gas forms at the beginning. [1]

$MgO(s) + 2H^+(aq) \longrightarrow Mg^{2+}(aq) + H_2O(l)$

Once MgO layer is removed, acid starts to react to Mg to give H_2 gas and build up the pressure. [1]

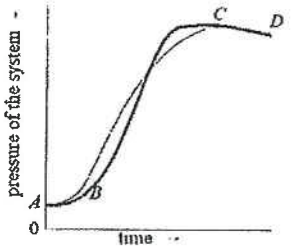
$Mg(s) + 2H^+(aq) \longrightarrow Mg^{2+}(aq) + H_2(g)$

(ii) Acid reacts with Mg to give H_2 gas and the reaction rate decreases with time as the concentration of acid gradually decreases. Hence, the increases in pressure gradually decrease till point *C*. [1]

(iii) When the Mg ribbon is completely used, no more H_2 gas formed, and the pressure of the system reaches the maximum. [1]

Reaction stops and solution cools down to the room temperature. Volume of H_2 gas shrinks and reduces the pressure. [1]

(c)



[2]

Similar shape of the curve.

Higher rate from *B* to *C*

Same level of maximum pressure built in the system.

Explanation:

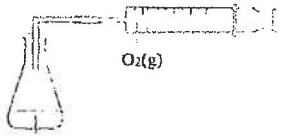
As the concentration of hydrochloric acid used increases from 1.0 M to 2.0 M, which turns to increase in the reaction rate at the beginning. [1]

As the mass of magnesium ribbon remains unchanged and Mg is a limiting reagent, there is no change in the total amount of H_2 gas formation. [1]

∴ pressure reaches the same level earlier, as the one using 1.0 M hydrochloric acid.

ASL01(II)_07

(a)



[2]

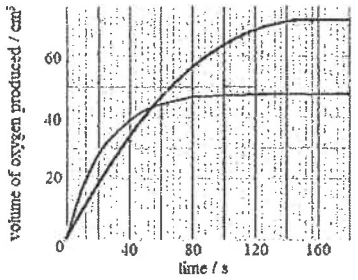
$H_2O_2(aq)$ + catalyst

(b) At the beginning, $H_2O_2(aq)$ has the highest concentration, and the reaction rate reaches the maximum. [1]

As time goes by, the reaction rate decreases as the concentration of $H_2O_2(aq)$ decreases with time. [1]

The reaction stops when all $H_2O_2(aq)$ are used up. No more O_2 gas produces after 120th second. [1]

(c) [1]



Lower reaction rate

Maximum reaches 72 cm^3

(d) Manganese(IV) oxide / MnO_2 / potassium iodide / KI [1]

ASL02(II)_11

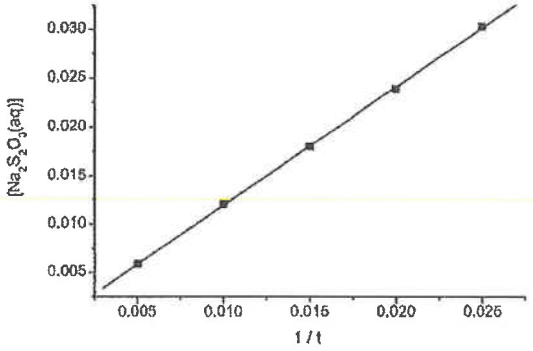
(a) (i) To keep the same total volume of solution in different trial. [1]

(ii) Cross is masked by sufficient amount of suspended sulphur particle formed in the reaction. [1]

(b)

Experiment	$[Na_2S_2O_3(aq)]$	$1/t$
1	0.005	0.00588
2	0.010	0.0120
3	0.015	0.0179
4	0.020	0.0238
5	0.025	0.0303

[1]



[2]

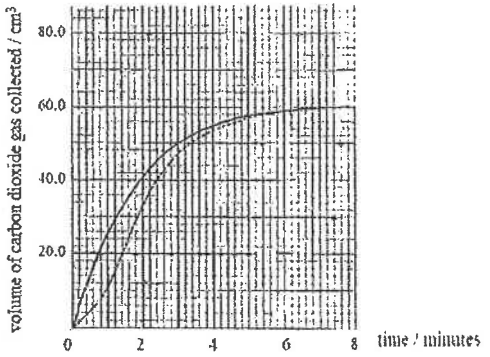
(c) A straight line passing those the original of the graph. It shows that the reaction rate $(1/t)$ is inversely proportional to the concentration of $Na_2S_2O_3(aq)$. [1]

(d) 28 sec [1]

ASL03(II)_10

(a) (i) Add a suitable amount of marble chips to the acid until the acid is saturated with dissolved CO_2. [1]

(ii)



[1]

(b) (i) Draw a tangent line to the curve at the particular time. [1]

Determine the slope of the tangent line. [1]

(ii) HCl is consumed during the reaction. ∴ The concentration of hydrochloric acid in the mixture drops during the course of the reaction. [1]

(c) (i) The rate increases because powdered $CaCO_3(s)$ has greater surface area. [1]

(ii) The rate decreases because CH_3COOH is a weak acid and hence the solution contains a lower concentration of $H^+(aq)$ ions. [1]

ASL04(I)_05

(a) Propane-1,2,3-triol [1]

(b) (i) $4C_3H_5N_3O_9(l) \longrightarrow 12CO_2(g) + 10H_2O(g) + 6N_2(g) + O_2(g)$ [1]

(ii) ∵ water vapor condenses back to liquid at 298 K.

∴ 1 mole of nitroglycerin gives 4.75 moles of gaseous product after cooling.

Mole of trinitroglycerine $= \frac{1}{227} = 4.41 \times 10^{-3}$ [1]

Volume of gases left behind

$= 4.41 \times 10^{-3} \times 4.75 \times 24 = 0.502\ dm^3 = 502\ cm^3$ [1]

(iii) $4C_3H_5N_3O_9(l) \longrightarrow 12CO_2(g) + 10H_2O(g) + 6N_2(g) + O_2(g)$

$4\Delta H^\circ_{rxn} = 12\Delta H^\circ_f[CO_2(g)] + 10\Delta H^\circ_f[H_2O(g)] - 4\Delta H^\circ_f[C_3H_5N_3O_9(l)]$

$4\Delta H^\circ_{rxn} = 12(-394) + 10(-242) - 4(-364)$ [1]

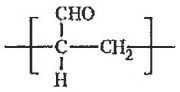
$\Delta H^\circ_{rxn} = -1423\ kJ\ mol^{-1}$ [1]

(iv) Any TWO of the following: [2]

- The decomposition of trinitroglycerine is highly exothermic.
- The decomposition of trinitroglycerine is very rapid.
- It is a chain reaction with low activation energy.
- Trinitroglycerine contains a hydrocarbon chain which is combustible and NO_2 groups which are oxidizing groups.

(c) (i) Shake the sample with acidified $KMnO_4(aq)$, presence of acrolein can decoloize purple color of $KMnO_4(aq)$. [1]

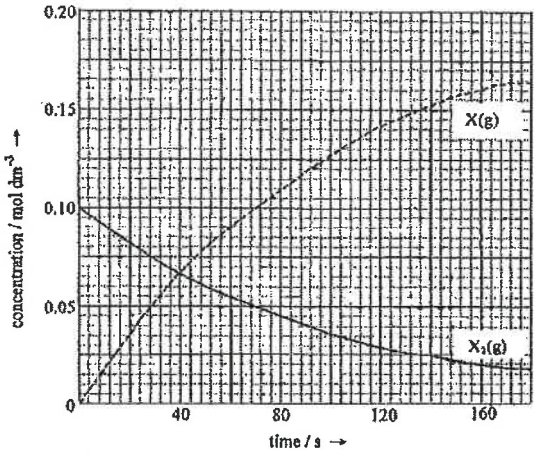
OR, Shake with Tollen's reagent, presence of acrolein can form a silver mirror. [1]

(ii)  [1]

ASL05(II)_08

(a) Change in concentration = $0.100 - 0.067 = 0.033$ mol dm^{-3} [1]

Average rate $= \frac{0.033}{40} = 8.25 \times 10^{-4}$ mol dm^{-3} s^{-1} [1]

(b) 

[2]

(c) The kinetic energy of molecules increases with temperature. [1]

At a higher temperature, the percentage of molecules with K.E. greater than the activation energy increases. [1]

∴ rate of decomposition increases

ASL06(I)_07

(a) Increase, because there is an increase in the total surface area for the contact of reactants. [1]

(b) Decrease, because 2 M ethanoic acid solution has a smaller concentration of $H^+(aq)$ than 2 M hydrochloric acid. [1]

(c) Increase, because higher temperature leads to an increase in the fraction of reactant particles with energy not less than the activation energy / in effective collision frequency. [1]

ASL06(II)_10

(a) rate of consumption of $O_2 = \frac{5}{4}(1.24 \times 10^{-4})$ mol dm^{-3} s^{-1} [1]

$= 1.55 \times 10^{-4}$ mol dm^{-3} s^{-1} [1]

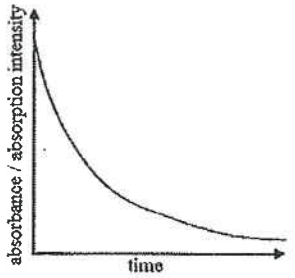
(b) Catalyst is a substance which can change the rate of reaction but itself remains chemically unchanged after the reaction. [1]

(c) Nitric acid / nitrogenous fertilizers, etc. [1]

ASL08(I)_07

(a) Colorimeter [1]

(b) Absorbance [1]

(c) 

[1]

AL08(I)_08a

(i) The polymerization is an exothermic reaction. [1]

A lot of heat is evolved at the initial stage of the reaction as the concentration of the monomer is high and the rate of reaction is fast. [½]

When the reaction has proceeded from some time, the chain of polymer grows and the viscosity of the reaction mixture increases. Rate of reaction decreases. [½]

OR, Reaction stops at the end and heat is lost to surrounding.

(ii) NaOH(aq) can catalyze the polymerization better than $H_2O(l)$. [1]

ASL10(I)_02

Accept both 'yes' and 'no' answers. Mark will be awarded only to the elaboration.

The rate of reaction depends on the collision frequency of the reactant molecules. [½]

Only those colliding molecules with KE greater than activation energy (E_a) of the reaction can react. [1]

When temperature increases, average KE of molecules increases. [½]

Chance of collision between molecules increases and, more importantly, a greater percentage of colliding molecules has KE> E_a [1]

AL10(II)_02b

(i) $2MnO_4^-(aq) + 5C_2O_4^{2-}(aq) + 16H^+(aq) \longrightarrow 2Mn^{2+}(aq) + 10CO_2(g) + 8H_2O(l)$ [1]

(ii) (I) Colorimetry [1]

(II) The reaction of $MnO_4^-(aq)$ with $C_2O_4^{2-}(aq)$ is slow possibly because both $MnO_4^-(aq)$ and $C_2O_4^{2-}(aq)$ are negatively charged (repulsion) / the reaction involves breaking the strong non-polar C–C bond. [1]

It is likely that one of the products ($Mn^{2+}(aq)$) is a catalyst for the reaction (autocatalysis). [1]

The rate of reaction is slow at the beginning because of the low concentration of $Mn^{2+}(aq)$. When $[Mn^{2+}(aq)]$ builds up, the reaction will proceed rapidly. When $MnO_4^-(aq)$ ions are almost used up, the rate slows down. [1]

DSE11SP_10

(a) From the curve, 1 mole of P(g) reacts with 2 moles of Q(g) to give 1 mole of R(g). [1]

$P(g) + 2Q(g) \longrightarrow R(g)$ [1]

(b) The time required will become longer.

In a larger container, the concentrations of reactants become less and hence the collision frequency decreases. [1]

(c) Colliding molecules will undergo reaction only if they possess an energy greater than the activation energy and collide in the right orientation. [1]

DSE12PP_10

(a) Colorimetry / using colorimeter [1]

(b) (i) The rate of consumption of $MnO_4^-(aq)$ ions is slow at the beginning (from 0 to 180 s) and then increases rapidly (from 200 to 340 s). [1]

It is likely to be due to the building up of the concentration of the products which catalyzes the reaction. [1]

(ii) Repeat the experiment with a few drops of $Mn^{2+}(aq)$ firstly added to the reaction mixture. [1]

Consumption of $MnO_4^-(aq)$ ions will be faster at the beginning if $Mn^{2+}(aq)$ is a catalyst. [1]

DSE12_II

(a) Initial rate $= \frac{60}{4} = 15\ cm^3/min\ (0.25cm^3/s)$ (Accept 14.8 - 15.2) [1]

(b) **HCl is a monobasic acid, while H_2SO_4 is a dibasic acid. Initial rate increases if H_2SO_4 is used. / Initial rate increases as the concentration of H^+ increases in 2.0 M H_2SO_4.** [1]

Therefore, the frequency of effective collisions increases.

(c) Mole of Zn $= \frac{2}{65.4} = 0.0306$ [1]

Vol of H_2 formed $= 0.0306 \times 24000$ [1]

$= 734\ cm^3$ / $0.734\ dm^3$ (Accept 730 – 744 cm^3 / 0.73 – 0.74 dm^3) [1]

DSE13_II

(a) The airbag has to be inflated instantly when a car crash occurs.

Fine powder can greatly increase the reaction rate / can give a fast reaction by providing a (very) large surface area for a reaction involving solid reactants. [1]

(b) Reaction 1:

Mole of N_2 produced from the decomposition of $NaN_3 = \frac{100}{65} \times \frac{3}{2} = 2.31$ [1]

Reaction 2:

Moles of Na produced $= \frac{100}{65} = 1.54$

Moles of KNH_3 produced $= \frac{200}{101.1} = 1.98$

Since 5 mol of Na react with 1 mol of KNO_3, KNO_3 is in excess

No. of mole of N_2 produced from reaction 2 $= \frac{100}{65} \times \frac{1}{10} = 0.154$ [1]

Volume of gas produced $= (2.31 + 0.154) \times 24 = 59.1\ dm^3$ [1]

Accept: 58.8 – 59.2 dm^3

(c) KNO_3 is added to react with sodium which is (highly) reactive / corrosive / flammable / strongly reducing. [1]

(d) (i) $\frac{0.01 - 0.005}{10} = 0.0005\ mol\ dm^{-3}s^{-1}$ $(5.0 \times 10^{-4}\ mol\ dm^{-3}s^{-1})$ [1]

(Accept 0.0005 M s^{-1} / 0.03 mol dm^{-3} min^{-1} / 1.8 mol dm^{-3} hr^{-1})

(ii) Determine the slope of the tangent of curve at t = 10 s. [1]

DSE14_10

- Proper way to follow the progress of the reaction (e.g. measure the volume of CO_2 evolved / measure the loss in mass of the reaction mixture over a certain time interval / measure the pressure of the CO_2 formed in a sealed reaction vessels.) (accept graphical representation) [1]
- Dilute 1M HCl to different concentrations by adding water. [1]
- Repeat the experiment with dilute HCl. [1]
- State one requirement for carrying out fair comparison (e.g. $CaCO_3$ used should be of the same amount / under same experimental conditions such as same temperature or pressure) [1]
- Communication mark [1]

DSE15_09

(a) Save cost (on chemicals) / minimize (chemical) hazards / save time on carrying out experiment / reduce the consumption of chemicals / reduce chemical waste. [1]

(b) Prevent sucking back of water / prevent water from entering the reacting flask. [1]

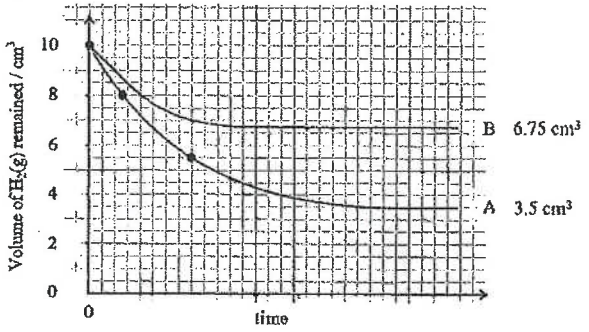
(c) Water level inside the measuring cylinder rises / The gas volume inside the measuring cylinder reduces. [1]

(d) Mole of methyl oleate use $= \frac{0.08}{298} = 2.70 \times 10^{-4}$ [1]

Minimum volume of $H_2(g)$ required $= 2.70 \times 10^{-4} \times 24\ dm^3$ [1]

$= 6.49\ dm^3$ [1]

(e) (i), (ii)



[2]

DSE16_11

(a) To ensure fair comparisons between the trials. [1]

OR, To ensure the concentration of NaOH(aq) / reactant is the only variable.

OR, The volume of NaOH(aq) used can represent the concentration of NaOH(aq) / reactant in the reaction mixtures.

(Not accept if the answer is expressed in terms of "amount of NaOH(aq)")

(b) $[OH^-(aq)] = 2.0 \times (4.0/5.0) = 1.6\ mol\ dm^{-3}$ [1]

$pH = 14 - (-\log[OH^-(aq)])$

$= 14 - (-\log(1.6)) = 14.20$ [1]

(c) The concentration of NaOH(aq) [1]

The shorter the time for the (pink) color disappeared, the faster the reaction. An increase in concentration of NaOH(aq) (reactant) will result in an increase in the reaction rate. [1]

(d) Using colorimeter / measuring relative transmittance / absorbance of the mixture / spectrophotometer [1]

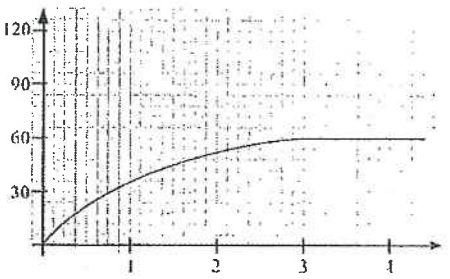
DSE17_10

(a) $\frac{60}{24000} \times 2 = 0.005y$ [1]

$y = 1.0\ mol\ dm^{-3}$ [1]

(Accept maximum 3 decimal places)

(b)



The curve starts from point (0, 0), the slope decreases and becomes a horizontal line at the 3rd minute. [1]

The total volume of gas obtained is 60 cm^3. [1]

(c) 60 cm^3 of gas would be collected because the number of moles of H_2O_2 is the same for both experiments. [1]

OR, 60 cm^3 of gas would be collected because increasing the temperature will only increase the rate of the reaction, but not affect the amount of product formed.

(Not accept ambiguous answer like "same amount of H_2O_2").

(d) Follow the change in (total) pressure / mass in the system. [1]

(Accept: monitor the system with a pressure gauge / an electronic balance.)

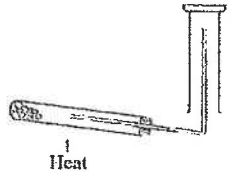
DSE18_02

(a) Set-up for preparation – boiling tube with reagents and HEAT (with stopper) [1]

(Accept heating the reagents in a flask)

Upward delivery of ammonia gas (without stopper) [1]

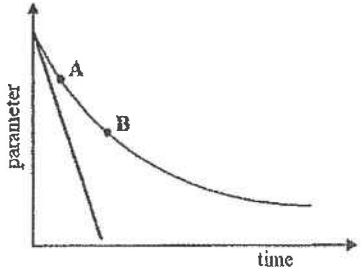
(Accept collecting the gas with a gas syringe.)



DSE18_I1

(a) (i) Color intensity / absorbance (Not accept transmittance) [1]

(ii) [1]



(On the graph) Plot a tangent (a straight line) at time = 0 on the curve.

The initial rate equals to the slope of the tangent / straight line. [1]

(iii) The absorbance is (directly) proportional to [Br_2(aq)] / number of Br_2 molecules in the reaction mixture. [1]

OR [Br_2(aq)] / number of Br_2 molecules in the reaction mixture at A is higher than that at B,

therefore the frequency of (effective) collisions between molecules at A is higher than that at B. [1]

(b) Any ONE of the followings: [1]

Measure the volume of CO_2 gas formed (at different time)

Measure the (total pressure) of the system (at different time). (the reaction proceeds in a closed system)

Measure the mass of the reaction mixture (at different time).

NOT accept measuring the pH of the reaction mixture

DSE19_I1

(a) $CaCO_3(s) + 2H^+(aq) \longrightarrow Ca^{2+}(aq) + CO_2(g) + H_2O(l)$ [1]

OR, $CaCO_3(s) + 2HNO_3(aq) \longrightarrow Ca(NO_3)_2(aq) + CO_2(g) + H_2O(l)$

(b) (i) $\frac{82.8 - 82.0}{12 - 2} = 0.08\ g\ min^{-1}$ $(or\ 1.33 \times 10^{-3}\ g\ s^{-1})$ [2]

Not accept 1.30×10^{-3} g s^{-1}, 1.3333×10^{-3} g s^{-1}, correct unit is required

(ii) • The slope / curvature (of the tangent) of the curve (at t=0) for Trial 2 is larger than that for Trial 1. [1]

• Showing a higher (initial) rate of reaction as the concentration of HNO_3 / H^+ in Trial 2 is higher than that in Trial 1. [1]

OR

• The decrease in mass for Trial 1 is smaller than that for Trial 2.

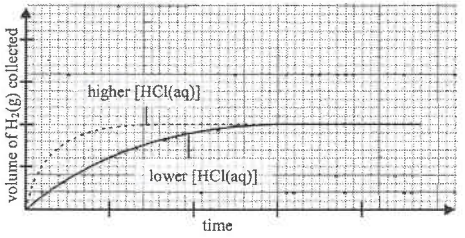
• In Trial 1 less CO_2 is given out because the number of moles of HNO_3 / H^+ used in Trial 1 is less than that in Trial 2.

(c) Use same mass of calcium carbonate of different sizes to perform the experiment. [1]

All other conditions of the experiment should be kept unchanged.

13. • Correct sketch of both curves (Correct shape of the curves, and the two curves merged at the later stage of the experiment) 1

• Correct labels for the two curves (The curve representing a higher concentration of HCl(aq) has a higher initial slope.), and correct labels of the graph (y-axis: volume of H_2(g) collected, x-axis: time) 1



(Any 3 points from below: 1 mark for each point) 3

• Measure the volume of H_2(g) formed at different time intervals (and plot a curve).

• The slope of the curve represents the rate of reaction.

• Repeat the experiment with different concentrations of HCl(aq).

• Fair comparison - other than concentration of HCl(aq), all other conditions should be the same. (or explicitly give at least one condition that have to be kept constant.)

• Communication mark 1

(Chemical knowledge = 0 to 3, communication mark = 0

Chemical knowledge = 4 to 5, communication mark = 0 or 1

Incomplete answer or difficult to understand, communication mark = 0)