1 Sodium hydrogencarbonate decomposes on heating as shown by the equation below.

$$2NaHCO_3 \rightarrow Na_2CO_3 + H_2O + CO_2$$

The volume of carbon dioxide, measured at 298 K and 101 kPa, obtained by heating 0.0500 mol of sodium hydrogencarbonate is

A 613 cm^3

B 1226 cm^3

C 613 dm^3

D 1226 dm^3

(Total 1 mark)

2 Use the information below to answer this question.

A saturated solution of magnesium hydroxide, $Mg(OH)_2$, contains 0.1166 g of $Mg(OH)_2$ in 10.00 dm^3 of solution. In this solution the magnesium hydroxide is fully dissociated into ions.

Which one of the following is the concentration of $Mg^{2+}(aq)$ ions in the saturated solution?

A 2.82×10^{-2} mol dm^{-3}

B 2.00×10^{-3} mol dm^{-3}

C 2.82×10^{-3} mol dm^{-3}

D 2.00×10^{-4} mol dm^{-3}

(Total 1 mark)

3 (a) A sample of ethanol vapour, C_2H_5OH (M_r = 46.0), was maintained at a pressure of 100 kPa and at a temperature of 366K.

(i) State the ideal gas equation.

.....

(ii) Use the ideal gas equation to calculate the volume, in cm^3, that 1.36 g of ethanol vapour would occupy under these conditions.
(The gas constant $R = 8.31\ J\ K^{-1}\ mol^{-1}$)

.....

.....

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.....

.....

(5)

(b) Magnesium nitride reacts with water to form magnesium hydroxide and ammonia.

(i) Balance the equation, given below, for the reaction between magnesium nitride and water.

$$Mg_3N_2 + H_2O \rightarrow Mg(OH)_2 + NH_3$$

(ii) Calculate the number of moles, and hence the number of molecules, of NH_3 in 0.263 g of ammonia gas.
(The Avogadro constant $L = 6.02 \times 10^{23}\ mol^{-1}$)

.....

.....

.....

.....

.....

(4)

(c) Sodium carbonate is manufactured in a two-stage process as shown by the equations below.

$$NaCl + NH_3 + CO_2 + H_2O \rightarrow NaHCO_3 + NH_4Cl$$

$$2NaHCO_3 \rightarrow Na_2CO_3 + H_2O + CO_2$$

Calculate the maximum mass of sodium carbonate which could be obtained from 800 g of sodium chloride.

.....

.....

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.....

.....

(4)

(Total 13 marks)

4 When chlorine reacts with trichloromethane, tetrachloromethane, CCl_4, is formed.

(a) (i) Write the overall equation for this reaction.

.....

(ii) State **one** essential condition for this reaction.

.....

(2)

(b) The mechanism for the chlorination of trichloromethane is free-radical substitution, which proceeds by a series of steps. Write equations for the steps named below in this chlorination.

Initiation step

.....

First propagation step

.....

Second propagation step

.....

A termination step

.....

(4)
(Total 6 marks)

5 Butan-1-ol was converted into butyl propanoate by reaction with an excess of propanoic acid. In the reaction, 6.0 g of the alcohol gave 7.4 g of the ester. The percentage yield of ester was

A 57

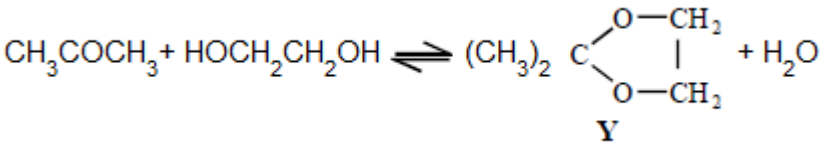
B 70

C 75

D 81

(Total 1 mark)

6 This question is about the reaction between propanone and an excess of ethane-1,2-diol, the equation for which is given below.



Y

In a typical procedure, a mixture of 1.00 g of propanone, 5.00 g of ethane-1,2-diol and 0.100 g of benzenesulphonic acid, $C_6H_5SO_3H$, is heated under reflux in an inert solvent. Benzenesulphonic acid is a strong acid.

If 1.00 g of propanone was vapourised at 100 °C and 100 kPa pressure, the volume in m^3 of gas formed would be

A 31.0

B 8.31

C 0.534

D 5.34×10^{-4}

(Total 1 mark)

7 (a) Calculate the concentration, in mol dm^{-3}, of the solution formed when 19.6 g of hydrogen chloride, HCl, are dissolved in water and the volume made up to 250 cm^3.

.....

.....

.....

(3)

(b) The carbonate of metal **M** has the formula M_2CO_3. The equation for the reaction of this carbonate with hydrochloric acid is given below.

$$M_2CO_3 + 2HCl \rightarrow 2MCl + CO_2 + H_2O$$

A sample of M_2CO_3, of mass 0.394 g, required the addition of 21.7 cm^3 of a 0.263 mol dm^{-3} solution of hydrochloric acid for complete reaction.

(i) Calculate the number of moles of hydrochloric acid used.

.....

.....

(ii) Calculate the number of moles of M_2CO_3 in 0.394 g.

.....

.....

(iii) Calculate the relative molecular mass of M_2CO_3

.....

.....

(iv) Deduce the relative atomic mass of **M** and hence suggest its identity.

*Relative atomic mass of **M*** .....

.....

*Identity of **M*** .....

(6)
(Total 9 marks)

8 When a sample of liquid, **X,** of mass 0.406 g was vaporised, the vapour was found to occupy a volume of 2.34×10^{-4} m^3 at a pressure of 110 kPa and a temperature of 473 K.

(a) Give the name of the equation $pV = nRT$.

.....

(1)

(b) Use the equation $pV = nRT$ to calculate the number of moles of **X** in the sample and hence deduce the relative molecular mass of **X.**
(The gas constant R = 8.31 J K^{-1} mol^{-1})

*Moles of **X*** .....

.....

.....

*Relative molecular mass of **X*** .....

.....

(4)

(c) Compound **X,** which contains carbon, hydrogen and oxygen only, has 38.7% carbon and 9.68% hydrogen by mass. Calculate the empirical formula of **X**.

.....

.....

.....

.....

(3)

(d) Using your answers to parts (b) and (c) above, deduce the molecular formula of **X**.

.....

.....

(1)
(Total 9 makrs)

9 The alkanes form an homologous series of hydrocarbons. The first four straight-chain alkanes are shown below.

methane	CH_4
ethane	CH_3CH_3
propane	$CH_3CH_2CH_3$
butane	$CH_3CH_2CH_2CH_3$

(a) (i) State what is meant by the term *hydrocarbon.*

.....

.....

(ii) Give the general formula for the alkanes.

.....

(iii) Give the molecular formula for hexane, the sixth member of the series.

.....

(3)

(b) Each homologous series has its own general formula. State **two** other characteristics of an homologous series.

.....

.....

.....

(2)

(c) Branched-chain structural isomers are possible for alkanes which have more than three carbon atoms.

(i) State what is meant by the term *structural isomers.*

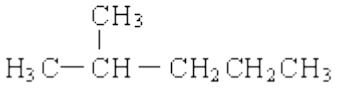
.....

.....

.....

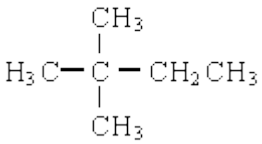
(ii) Name the **two** isomers of hexane shown below.

Isomer 1



Name ….....

Isomer 2



Name .....

(iii) Give the structures of **two** other branched-chain isomers of hexane.

Isomer 3 *Isomer 4*

(6)

(d) A hydrocarbon, **W,** contains 92.3% carbon by mass. The relative molecular mass of **W** is 78.0

(i) Calculate the empirical formula of **W**.

.....

.....

.....

.....

(ii) Calculate the molecular formula of **W**.

.....

.....

(4)
(Total 15 marks)

10 Nitrogen dioxide dissociates according to the following equation.

$2NO_2(g) \rightleftharpoons 2NO(g) + O_2(g)$

When 21.3 g of nitrogen dioxide were heated to a constant temperature, *T*, in a flask of volume 11.5 dm^3, an equilibrium mixture was formed which contained 7.04 g of oxygen.

(a) (i) Calculate the number of moles of oxygen present in this equilibrium mixture and deduce the number of moles of nitrogen monoxide also present in this equilibrium mixture.

Number of moles Of O_2 at equilibrium .....

.....

Number of moles of NO at equilibrium .....

(ii) Calculate the number of moles in the original 21.3 g of nitrogen dioxide and hence calculate the number of moles of nitrogen dioxide present in this equilibrium mixture.

Original number of moles of NO_2 .....

.....

Number of moles of NO_2 at equilibrium .....

.....

(4)

(b) Write an expression for the equilibrium constant, K_c, for this reaction. Calculate the value of this constant at temperature T and give its units.

Expression for K_c .....

.....

Calculation .....

.....

.....

.....

.....

(4)

(c) The total number of moles of gas in the flask is 0.683. Use the ideal gas equation to determine the temperature *T* at which the total pressure in the flask is 3.30×10^5 Pa. (The gas constant $R = 8.31$ J $K^{-1}mol^{-1}$)

.....

.....

.....

.....

.....

(3)

(d) State the effect on the equilibrium yield of oxygen and on the value of K_c when the same mass of nitrogen dioxide is heated to the same temperature *T*, but in a different flask of greater volume.

Yield of oxygen .....

Value of K_c .....

(2)

(Total 13 marks)

11 This question relates to the equilibrium gas-phase synthesis of sulphur trioxide:

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

Thermodynamic data for the components of this equilibrium are:

Substance	$\Delta H_f^{\ominus}$ / kJ mol^{-1}	$S^{\ominus}$ / J K^{-1} mol^{-1}
$SO_3(g)$	−396	+257
$SO_2(g)$	–297	+248
$O_2(g)$	0	+204

This equilibrium, at a temperature of 585 K and a total pressure of 540 kPa, occurs in a vessel of volume 1.80 dm^3. At equilibrium, the vessel contains 0.0500 mol of $SO_2(g)$, 0.0800 mol of $O_2(g)$ and 0.0700 mol of $SO_3(g)$.

At equilibrium in the same vessel of volume 1.80 dm^3 under altered conditions, the reaction mixture contains 0.0700 mol of $SO_3(g)$, 0.0500 mol of $SO_2(g)$ and 0.0900 mol of $O_2(g)$ at a total pressure of 623 kPa. The temperature in the equilibrium vessel is

A 307 °C

B 596 K

C 337 °C

D 642 K

(Total 1 mark)

12 The percentage of copper in a copper(II) salt can be determined by using a thiosulphate titration. 0.305 g of a copper(II) salt was dissolved in water and added to an excess of potassium iodide solution, liberating iodine according to the following equation:

$$2Cu^{2+}(aq) + 4I^-(aq) \rightarrow 2CuI(s) + I_2(aq)$$

The iodine liberated required 24.5 cm^3 of a 0.100 mol dm^{-3} solution of sodium thiosulphate:

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

The percentage of copper, by mass, in the copper(II) salt is

A 64.2

B 51.0

C 48.4

D 25.5

(Total 1 mark)

13 (a) The mass of one mole of $_1$H atoms is 1.0078 g and that of one $_1$H atom is 1.6734×10^{-24} g.
Use these data to calculate a value for the Avogadro constant accurate to five significant figures. Show your working.

.....

.....

.....

(2)

(b) How does the number of atoms in one mole of argon compare with the number of molecules in one mole of ammonia?

.....

(1)

(c) A sample of ammonia gas occupied a volume of 0.0352 m^3 at 298 K and 98.0 kPa. Calculate the number of moles of ammonia in the sample.
(The gas constant R = 8.31 J K^{-1} mol^{-1})

.....

.....

.....

.....

(3)

(d) A solution containing 0.732 mol of ammonia was made up to 250 cm^3 in a volumetric flask by adding water. Calculate the concentration of ammonia in this final solution and state the appropriate units.

.....

.....

.....

(2)

(e) A different solution of ammonia was reacted with sulphuric acid as shown in the equation below.

$$2NH_3(aq) + H_2SO_4(aq) \rightarrow (NH_4)_2SO_4(aq)$$

In a titration, 25.0 cm^3 of a 1.24 mol dm^{-3} solution of sulphuric acid required 30.8 cm^3 of this ammonia solution for complete reaction.

(i) Calculate the concentration of ammonia in this solution.

.....

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.....

.....

(ii) Calculate the mass of ammonium sulphate in the solution at the end of this titration.

.....

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.....

.....

(6)

(f) The reaction of magnesium nitride, Mg_3N_2, with water produces ammonia and magnesium hydroxide. Write an equation for this reaction.

.....

(2)
(Total 16 marks)

14 (a) State the relative charge and relative mass of a proton, of a neutron and of an electron. In terms of particles, explain the relationship between two isotopes of the same element. Explain why these isotopes have identical chemical properties.

(7)

(b) Define the term *relative atomic mass*. An element exists as a mixture of three isotopes. Explain, in detail, how the relative atomic mass of this element can be calculated from data obtained from the mass spectrum of the element.

(7)
(Total 14 marks)

15 On heating, magnesium reacts vigorously with element **X** to produce compound **Y**. An aqueous solution of **Y**, when treated with aqueous silver nitrate, gives a white precipitate that is readily soluble in dilute aqueous ammonia. What is the minimum mass of **X** that is needed to react completely with 4.05 g of magnesium?

A 11.83 g

B 5.92 g

C 5.33 g

D 2.67 g

(Total 1 mark)

16 1,3-dinitrobenzene can be prepared by heating nitrobenzene with a mixture of fuming nitric acid and concentrated sulphuric acid. The reaction can be represented by the following equation.

If the yield of the reaction is 55%, the mass of 1,3-dinitrobenzene produced from 12.30 g of nitrobenzene is

A 16.90 g

B 16.80 g

C 9.30 g

D 9.24 g

(Total 1 mark)

17 The chloride of an element **Z** reacts with water according to the following equation.

$$ZCl_4(l) + 2H_2O(l) \rightarrow ZO_2(s) + 4HCl(aq)$$

A 1.304 g sample of ZCl_4 was added to water. The solid ZO_2 was removed by filtration and the resulting solution was made up to 250 cm^3 in a volumetric flask. A 25.0 cm^3 portion of this solution was titrated against a 0.112 mol dm^{-3} solution of sodium hydroxide, of which 21.7 cm^3 were required to reach the end point.

Use this information to calculate the number of moles of HCl produced and hence the number of moles of ZCl_4 present in the sample. Calculate the relative molecular mass, M_r, of ZCl_4.
From your answer deduce the relative atomic mass, A_r, of element **Z** and hence its identity.

(Total 9 marks)

18 Which one of the following contains the smallest number of moles of carbon dioxide gas?

A 2.65 g

B 0.0150 m^3 at 1000 K and 33.0 kPa

C 1.50 dm^3 at 327 °C and 200 kPa

D 1500 cm^3 at 300 K and 100 kPa

(Total 1 mark)

19 Which one of the following compounds contains the smallest percentage, by mass, of oxygen?

A $CH_3OCH_2CH_3$

B $CH_3OCH_2NH_2$

C COS

D $C_4H_9Al(OH)_2$

(Total 1 mark)

20 When one mole of ammonia is heated to a high temperature, 50% dissociates according to the following equilibrium.

$$2NH_3(g) \rightleftharpoons N_2(g) + 3H_2(g)$$

What is the total number of moles of gas present in the equilibrium mixture?

A 1.5

B 2.0

C 2.5

D 3.0

(Total 1 mark)

21 Aqueous $C_2O_4^{2-}$ ions react with MnO_4^- ions in acidic solution according to the equation

$$5\ C_2O_4^{2-} + 2MnO_4^- + 16H^+ \rightarrow 2Mn^{2+} + 10CO_2 + 8H_2O$$

Under the same conditions Fe^{2+} ions also react with MnO_4^- ions. How many moles of MnO_4^- ions are required to react exactly with one mole of $Fe(C_2O_4).2H_2O$?

A 0.4

B 0.6

C 2.5

D 7.5

(Total 1 mark)

22 On complete combustion, 0.0150 mol of an organic acid produced 735 cm^3 of carbon dioxide (measured at 101 kPa and 298 K). The same amount of acid required 15.0 cm^3 of 2.00 M sodium hydroxide solution for neutralisation. Which one of the following could be the formula of the acid?

A HCOOH

B CH_3COOH

C HOOCCOH

D $HOOCCH_2CH_2COOH$

(Total 1 mark)

23 An excess of methanol was mixed with 12 g of ethanoic acid and an acid catalyst. At equilibrium the mixture contained 8 g of methyl ethanoate. The percentage yield of ester present was

A 11

B 20

C 54

D 67

(Total 1 mark)

24 Which one of the following samples of gas, when sealed into a vessel of volume 0.10 m^3, is at the highest pressure?

A 1.6 g of helium (He) at 100 K

B 1.6 g of methane (CH_4) at 100 K

C 1.6 g of oxygen (O_2) at 600 K

D 1.6 g of sulphur dioxide (SO_2) at 1200 K

(Total 1 mark)

25 In a titration, 0.52 g of a diprotic acid, H_2X, reacts exactly with 100 cm^3 of 0.10 M sodium hydroxide.

$$H_2X + 2NaOH \rightarrow Na_2X + 2H_2O$$

The acid could be

A ethanedioic

B propanedioic

C butanedioic

D pentanedioic

(Total 1 mark)

26 0.00125 mol of a compound was heated with an excess of a solution of potassium hydroxide and the ammonia evolved required 17.0 cm^3 of 0.220 M hydrochloric acid for neutralisation. Which one of the following could be the formula of this compound?

A BF_3NH_3

B $VCl_3(NH_3)_3$

C $CrCl_2(NH_3)_2$

D $[Be(NH_3)_4]Cl_2$

(Total 1 mark)

27 What is the volume occupied by 10.8 g of the freon CCl_2F_2 at 100 kPa and 273 K?

A 2.02 dm^3

B 2.05 dm^3

C 2.02 cm^3

D 2.05 cm^3

(Total 1 mark)

28 Which one of the following contains the greatest number of moles of methanol? (The Avogadro number (L) is 6.02×10^{23}, the relative molecular mass (M_r) of methanol is 32.)

A 6.6×10^{22} molecules

B 3.3 g of methanol

C 2.5×10^{-3} m^3 of methanol vapour at 300 K and 100 kPa

D 70 cm^3 of 1.5 M aqueous methanol

(Total 1 mark)

29 An alkane contains 30 hydrogen atoms per molecule. Its empirical formula is

A C_6H_{15}

B C_7H_{15}

C $C_{14}H_{30}$

D $C_{15}H_{30}$

(Total 1 mark)

30 Hydrolysis of the ester, $CH_3COOCH_2CH_2CH_3$, produces ethanoic acid. In an experiment, 2.04 g of the ester was used and 0.90 g of ethanoic acid was produced. The percentage yield of ethanoic acid was:

A 44

B 59

C 75

D 90

(Total 1 mark)

31 Which one of the following samples of gas occupies the largest volume?

A 1.0 g of ozone (O_3) at l00 kPa and 300 K

B 1.0 g of oxygen at 100 kPa and 300 K

C 1.0 g of water vapour at 250 kPa and 450 K

D 1.0 g of methane at 333 kPa and 500 K

(Total 1 mark)

32 Copper(II) ions can be estimated volumetrically by the addition of an excess of potassium iodide followed by titration of the liberated iodine with sodium thiosulphate solution. The following equations apply:

$$2Cu^{2} + 4I^{-} \rightarrow 2CuI + I_2$$

$$I_2 + 2S_2O_3^{2-} \rightarrow S_4O_6^{2-} + 2I$$

What volume (in cm^3) of 0.1 M $Na_2S_2O_3$ would be required to react with the iodine produced from 1.249 g of $CuSO_45H_2O$ (M_r 249.7)?

A 10

B 25

C 50

D 100

(Total 1 mark)

33 A "drink-driving" offence is committed if the blood alcohol level of a driver is over 80 mg of ethanol per 100 cm^3 of blood.

What is the concentration (in mol dm^3) of ethanol if there are 80 mg of ethanol per100 cm^3 of blood?

A 0.0017

B 0.017

C 0.080

D 0.80

(Total 1 mark)

34 When vanadium reacts with chlorine at 400°C, a brown compound is obtained. When an aqueous solution containing 0.193 g of this compound was treated with aqueous silver nitrate all the chlorine in the compound was precipitated as silver chloride. The mass of silver chloride (AgCl) produced was 0.574 g. Which one of the following could be the formula of the brown compound?

A VCl

B VCl_2

C VCl_3

D VCl_4

(Total 1 mark)

35 The oxidation of ethanedioate (*oxalate*) ions by manganate(VII) ions can be represented by the half equations:

$$C_2O_4^{2-}(aq) \rightarrow 2CO_2(g) + 2e^-$$

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

What volume (in cm^3) of 0.02 M $KMnO_4$ is required to oxidise completely a solution containing 0.02 mol of ethanedioate ions?

A 25

B 40

C 250

D 400

(Total 1 mark)

36 CH_2O is the empirical formula of

A methanol

B methyl methanoate

C ethane-1,2-diol

D butanal

(Total 1 mark)

37 When $TiCl_4$ is reduced with hydrogen under certain conditions, a new compound is produced which contains 68.9% chlorine by mass. Which one of the following could be the formula of the new compound?

A TiH_2Cl_2

B TiCl

C $TiCl_2$

D $TiCl_3$

(Total 1 mark)

38 A brand of fluoride tablets, recommended by a dentist to strengthen the enamel on teeth, contains 2.2×10^{-3} sodium fluoride per tablet. The total mass of fluoride ion present in 100 tablets is

A $2.2 \times 10^{-3} \times \frac{19}{42} \times 100$

B $2.2 \times 10^{-3} \times \frac{19}{23} \times 100$

C $2.2 \times 10^{-3} \times \frac{9}{20} \times 100$

D $\frac{100 \times 19}{2.2 \times 10^{-3}}$

(Total 1 mark)

Mark schemes

1 A **[1]**

2 D **[1]**

3 (a) (i) pV = nRT **(1)**

(ii) Moles ethanol = n = 1.36/46 (=0.0296 mol) **(1)**

$V = nRT/p = \frac{0.0296 \times 8.31 \times 366}{100000}$ **(1)**

if V = p/nRT lose M3 and M4

$= 8.996 \times 10^{-4}$ (m^3) **(1)**

= 899 (900) cm^3 **(1)** *range = 895 – 905*

If <u>final</u> answer = 0.899 award (2 + M1); if = 0.899 dm^3 ***or*** *if = 912 award (3 + M1)*

Note: *If 1.36* ***or*** *46 or 46/1.36 used as number of moles (**n**) then M2 and M4 not available*

Note: *If pressure = 100 then, unless answer = 0.899* ***dm^3****, deduct M3 and mark consequentially*

5

(b) (i) $Mg_3N_2 + \mathbf{6}H_2O \rightarrow \mathbf{3}Mg(OH)_2 + \mathbf{2}NH_3$ **(1)**

(ii) Moles $NH_3 = \frac{0.263}{17}$ (=0.0155 mol) **(1)**

Number of molecules of $NH_3 = 0.0155 \times 6.02 \times 10^{23}$ **(1)**

[mark conseq] = 9.31×10^{21} **(1)**

[range 9.2×10^{21} to 9.4×10^{21}]

*Conseq (**min** 2 sig fig)*

4

(c) Moles NaCl = 800/58.5 (= 13.68) **(1)**

Moles of $NaHCO_3$ = 13.68 **(1)**

Moles of Na2CO_3 = 13.68/2 = 6.84 **(1)**

Mass of Na_2CO_3 = 6.84 × 106 = 725 g **(1)** **[**range = 724 – 727]

[1450 g (range 1448 – 1454) is worth 3 marks]

Accept valid calculation method, e.g. reacting masses or calculations via the mass of sodium present. Also, candidates may deduce a direct 2:1 ratio for NaCl:Na_2CO_3

4

[13]

4

(a) (i) $CHCl_3 + Cl_2 \rightarrow CCl_4 + HCl$ **(1)**

(ii) UV light / sunlight OR <u>high</u> T OR T ≥ 500°C **(1)**

maxT = 1000°C
NOT heat / light
Ignore pressure

2

(b) *Initial step*: $Cl_2 \rightarrow 2Cl\cdot$ **(1)**

Condition could be on first equation arrow

First propagation step: $CHCl_3 + Cl\cdot \rightarrow \dot{C}Cl_3 + HCl$ **(1)**

Second propagation step: $\dot{C}Cl_3 + Cl_2 \rightarrow CCl_4 + Cl\cdot$ **(1)**

A termination step: $\dot{C}Cl_3 + Cl\cdot \rightarrow CCl_4$ **(1)**

OR $2\dot{C}Cl_3 \rightarrow C_2Cl_6$

Not $2Cl\cdot \rightarrow Cl_2$

Ignore additional termination steps

4

[6]

5 B

[1]

6 D

[1]

7 (a) Moles HCl = $\frac{\text{mass}}{M_r}$ = $\frac{19.6}{36.5}$ **(1)** (= 0.537)

Concentration = $\frac{0.537}{0.25}$ **(1)**

= 2.15 (mol dm^{-3}) **(1)**

Conseq on $\frac{mass}{M_r}$ *correct*

min 2 d.p. 2.14 to 2.15
Ignore wrong units
A.E. lose one mark

3

(b) (i) $\frac{21.7}{1000} \times 0.263$ = 5.7**(1)** × 10^{-3} (mol) **(1)**

5.7 to 5.71 × 10^{-3}

(ii) $\frac{5.71 \times 10^{-3}}{2}$ = 2.85 × 10^{-3} (mol) **(1)**

Conseq

(iii) $\frac{0.394}{2.85 \times 10^{-3}}$ = 138 **(1)**

Conseq

(iv) *Relative atomic mass of* ***M***: 138 - 60 = 78 **(1)**

$\frac{78}{2}$ **=** 39 **(1)**
Identify of ***M***: Potassium or K or K^+ **(1)**

Conseq
If 78 = M_r then M = selenium

6

[9]

8 (a) Ideal gas equation law **(1)**

1

(b) *Moles of **X***: $n = \frac{PV}{RT}$ **(1)** $= \frac{110000 \times 2.34 \times 10^{-4}}{8.31 \times 473}$

$= 6.55 \times 10^{-3}$ **(1)**

6.5 to 6.6 × 10^{-3} , min 2 sig figs

If write n = $\frac{RT}{PV}$ *zero here, but can score M_r*

*Relative molecular mass of **X***: $M_r = \frac{m}{n}$ **(1)**

$= 62$ **(1)**

61.5 to 62.5

4

(c) % oxygen = 51.6 **(2)**

C =38.7 / 12 H = 9.68 / 1 O = 57.6**(2)** / 16 **(1)**

= 3.23 = 9.68 = 3.23

1 : 3: 1 ∴ CH_3O **(1)**

If no % O or if wrong A_r used then max 1
Correct empirical formula earns all three marks

3

(d) $(\frac{62}{31} \times CH_3O) = C_2H_6O_2$ **(1)**

1

[9]

9 (a) (i) Molecule/compound/consists/composed/made up of hydrogen and carbon only **(1)**

(ii) C_nH_{2n+2} **(1)**

(iii) C_6H_{14} only **(1)**
Do not credit structures alone or in addition.

3

(b) Chemically similar / react in same way / same chemistry
Differ by CH_2
gradation in physical properties OR specified trend e.g. b.p.
same functional group

Any 2, 2 marks 1 + 1

Not same molecular formula

2

(c) (i) Same molecular formula **(1)**

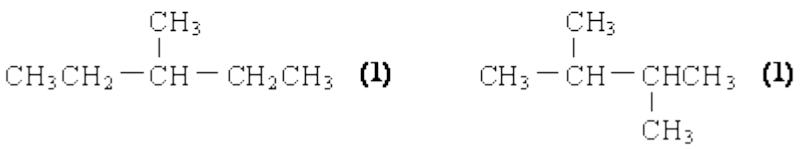
NOT same Mr

different structural formula / structures **(1)**
(or atoms arranged in different way)

NOT different spatial arrangements
Only credit M2 if M1 correct

(ii) 2-methylpentane **(1)**
2,2-dimethylbutane **(1)**

(iii) *Isomer 3* either order *Isomer 4*



(1) **(1)**

OR correct condensed / structural formula

Penalise "sticks" once
Penalise absence of vertical bonds once
penalise badly drawn bonds once (vertical between H atoms)

6

(d) (i) M1 % by mass of H = 7.7(0)% **(1)**
M2 mol H = 7.70 / 1 = 7.70
mol C = 92.3 / 12 = 7.69 **(1)**

M3 (ratio 1:1 ∴) CH

Credit variations for M2 e.g. $78 \times \frac{77}{100} = 6$

and $\frac{78}{12} \times \frac{92.3}{100} = 6$

Correct answer = 3 marks

(ii) (CH has empirical mass of 13 and $\frac{78}{13}$ = 6 ∴) C_6H_6 **(1)**

Correct answer 1 mark

4

[15]

10 (a) (i) *Number of moles of O_2 at equilibrium:* $\frac{7.04}{32}$ = 0.22 **(1)**

Number of moles of NO at equilibrium: 0.44 **(1)**
OR 2 × mol of oxygen

3

(ii) *Original number of moles of NO_2:* $\frac{21.3}{46}$ = 0.46(3) **(1)**

Number of moles of NO_2 at equilibrium:
0.46(3) – 0.44 = 0.02(3) **(1)**
OR conseq on mol NO above

1

(b) *Expression for K_C*: $K_C = \frac{[NO]^2[O_2]}{[NO_2]}$ **(1)**

Calculation: $K_C = \frac{\left(\frac{0.44}{11.5}\right)^2 \times \left(\frac{0.22}{11.5}\right)}{\left(\frac{0.023}{11.5}\right)^2}$ = 7.0(0) mol dm^{-3}

(1) (1) (1)

If mol NO_2 = 0.02; K_C = 9.26 (9.3)
or conseq on values from (a)
If vol missed, score only K_C and units
If K_C wrong: max 2 for correct use of vol and conseq units
If K_C wrong and no vol: max 1 for conseq units

3

(c) pV = nRT **(1)**

$T = \frac{pV}{nR} = \frac{(3.30 \times 10^5) \times (11.5 \times 10^{-3})(\ 1)}{0.683 \times 8.31}$ =

(1) for using 11.5 × 10^{-3} as V

T = 669 K **(1)**

4

(d) *Yield of oxygen:* increased **(1)**
Value of K_c: no effect **(1)**

2

[13]

11 D

[1]

12 B

[1]

13 (a) $L = \frac{1.0078}{1.6734 \times 10^{-24}}$ **(1)** or $\frac{\text{mass of 1 mol}}{\text{mass of 1 atom}}$

must show working

$= 6.0225 \times 10^{23}$ **(1)**

Ignore wrong units

NB answer only scores 1

2

(b) equal **(1)**

Or same or 1:1

1

(c) $PV = nRT$ (or $n = \frac{PV}{RT}$) **(1)**

$= \frac{98000 \times 0.0352}{8.31 \times 298}$ **(1)**

$= 1.39$ **(1)**

Allow 1.390 to 1.395

ignore units even if incorrect

answer = 1.4 loses last mark

3

(d) $0.732 \times \frac{1000}{250} = 2.93$ **(1)** mol.dm^{-3} **(1)**

OR M, mol/dm^3, mol.l^{-1}

allow 2.928 to 2.93

Note unit mark tied to current answer but allow unit mark if answer = 2.9 or 3

2

(e) (i) moles $H_2SO_4 = \frac{25}{1000} \times 1.24 = 0.0310$ **(1)**

If use $m_1v_1 = m_2v_2$ scores 3 if answer is correct otherwise zero

moles NH_3 in 30.8 $cm^3 = 0.0310 \times 2 = 0.0620$ **(1)**

Mark is for ×2

CE if × 2 not used

moles of NH_3 in 1 $dm^3 = 0.620 \times \frac{1000}{30.8} = 2.01$ **(1)** (mol dm^{-3})

Allow 2.010 to 2.015

No units OK, wrong units lose last mark

(ii) moles $(NH_4)_2SO_4$ = moles $H_2SO_4 = 0.310$ **(1)**

Allow consequential wrong moles in part (i) if clear H_2SO_4= $(NH_4)SO_4$

Wrong formula for $(NH_4)_2SO_4$ CE=0

M_r $(NH_4)_2SO_4 = 132.1$ **(1)**

Allow (132)

mass = moles × $M_r = 0.0310 \times 132.1 = 4.10$ **(1)**

if moles of $(NH_4)_2SO_4$ not clear CE

(g) wrong unit loses mark

Allow 4.09 – 4.1 – 4.11

6

(f) $Mg_3N_2 + 6H_2O \rightarrow 3Mg(OH)_2 + 2NH_3$

Formulae (1)

Balanced equation (1)

2

[16]

14 (a) Proton: mass 1, charge + 1 **(1)**
Neutron: mass 1, charge 0 **(1)**
Electron mass 1/1840, charge -1 **(1)**

Allow mass = 0, or negligible, or 1/1800 to 1/2000

Isotopes have the same number of protons **(1)**

OR atomic number

different number of neutrons **(1)**

Isotopes have the same electronic configuration **(1)**

OR same number of electrons

Chemical properties depend on electrons **(1)**

7

(b) $\frac{\text{average (1) mass of an atom/isotopes}}{\text{mass of 1 atom of } {}^{12}C} \times 12$ **(1)**

OR $\frac{\text{mass of 1 mol of atoms}}{\text{mass of 1 atom of } {}^{12}C}$ *× 12 or in words*

Spectrum gives (relative) abundance **(1)**

OR % or amount

And *m/z* **(1)**
Multiply *m/z* by relative abundance for each isotope **(1)**

Allow instead of m/z mass no, A_r or actual value from example

Sum these values **(1)**
Divide by the sum of the relative abundances **(1)**

only award this mark if previous 2 given

Max 2 if e.g. has only 2 isotopes

7

[14]

15 A **[1]**

16 D **[1]**

17

moles NaOH used = vol / 1000 × conc **(1)** = 21.7 *(if uses 25 here only scores first of first 4 marks)*/ 1000 × 0.112
= 0.00243 **(1)** (consider 0.0024 as an arithmetic error loses 1 mark)
(range 0.00242 to 0.00244)

moles HCl in 25 cm^3 = 0.00243 **(1)** (or 1 mol HCl reacts with 1 mol NaOH)

moles of HCl in 250 cm^3 = 0.0243 **(1)**

moles ZCl_4 = 0.0243 / 4 = 0.006075 **(1)** (or 0.006076 or 0.006 mark is for / 4)

M_r = mass / no. Moles **(1)** (method mark also 1.304 / 0.006075)
= 214.7 **(1)** (or 0.006 gives 217) *(allow 214 to 215)*

A_r = 214.7 - 142 = 72.7 **(1)** (217 gives 75, 142 is 35.5 × 4)

Therefore element is Germanium **(1)** (allow conseq correct from A_r)
(75 gives As)

If not / 4 C.E. from there on but can score 2 independent marks for (mass / moles / method and identity of element)
(for candidates who use $m_1v_1 = m_2v_2$ and calculate [HCl] = 0.0972 allow 1st 3 marks
if 25 and 21.7 wrong way round only award 1/3)

[9]

18 B **[1]**

19 B **[1]**

20 A **[1]**

21 B **[1]**

22 C **[1]**

23 C **[1]**

24 A **[1]**

25 B **[1]**

26 B **[1]**

27	A	[1]
28	A	[1]
29	B	[1]
30	C	[1]
31	C	[1]
32	C	[1]
33	B	[1]
34	D	[1]
35	D	[1]
36	B	[1]
37	D	[1]
38	A	[1]