1 In which change do the particles move further apart?

1 A gas is heated from 0 °C to 25 °C.

2 Pressure is applied to a gas at a constant temperature.

3 Steam condenses to form water.

4 Water evaporates at room temperature.

A 1 and 2 **B** 1 and 4 **C** 2 and 3 **D** 3 and 4

2 A student accidentally mixed 50 cm^3 of oil and 5 g of solid calcium nitrate.

Which sequence of procedures would allow him to obtain a pure sample of solid calcium nitrate most easily?

A dissolve in ethanol → filtration → crystallisation
B dissolve in water → filtration
C dissolve in water → separating funnel → crystallisation
D simple distillation → crystallisation

3 Which mixture of gases would **not** change the colour of damp blue litmus paper?

A carbon dioxide and oxygen
B chlorine and nitrogen
C hydrogen and ammonia
D neon and hydrogen chloride

4 The rate of diffusion of two gases is measured at different temperatures but at constant pressure.

Which would diffuse most quickly?

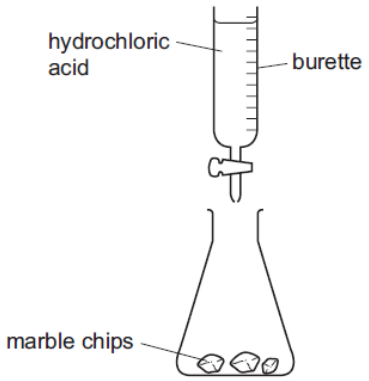
A argon at 15 °C
B argon at 40 °C
C carbon dioxide at 15 °C
D carbon dioxide at 40 °C

5 A student follows the rate of the reaction between marble chips, $CaCO_3$, and dilute hydrochloric acid.

$$CaCO_3 + 2HCl \rightarrow CaCl_2 + CO_2 + H_2O$$

Which diagrams show apparatus that is suitable for this experiment?

1



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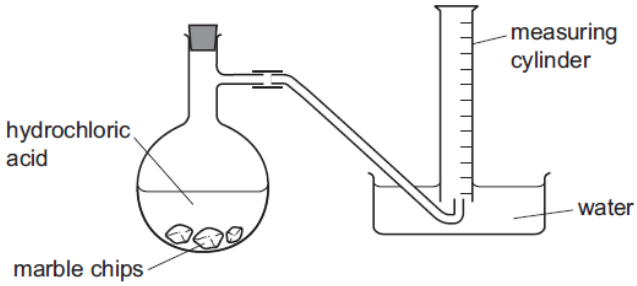

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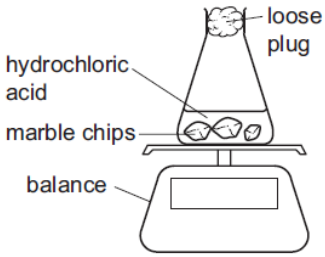

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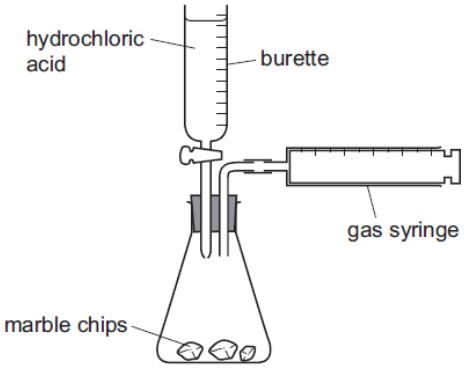


A 1 and 3 **B** 2 and 3 only **C** 2 and 4 **D** 2, 3 and 4

6 The following observations were made by reacting three salt solutions with excess aqueous sodium hydroxide and excess aqueous ammonia.

solution	1	2	3
add excess aqueous sodium hydroxide	colourless solution	colourless solution	white ppt
add excess aqueous ammonia	white ppt	colourless solution	colourless solution

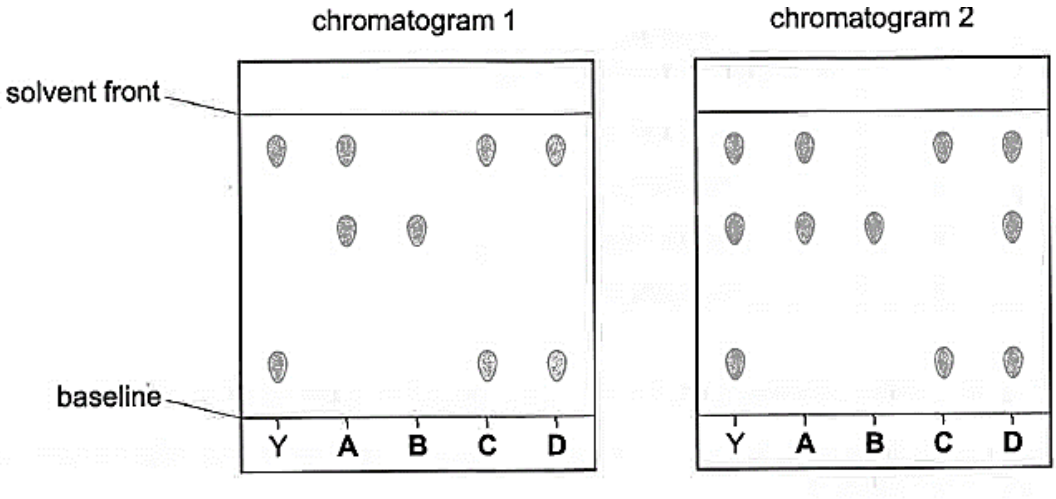
Which cations are present in each solution?

	1	2	3
A	Al^{3+}	Ca^{2+}	Zn^{2+}
B	Al^{3+}	Zn^{2+}	Ca^{2+}
C	Ca^{2+}	Zn^{2+}	Al^{3+}
D	Zn^{2+}	Al^{3+}	Ca^{2+}

7 Solution Y contains a mixture of flavourings. Solution Y and four other solutions, A, B, C and D, are analysed by chromatography.

Chromatogram 1 shows the result of the experiment.

Chromatogram 2 shows the results of Chromatogram 1 when sprayed with a locating agent.



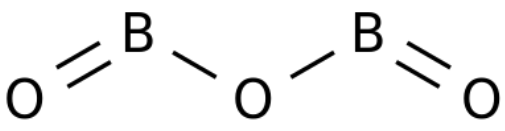
Which solution contains the same mixture of flavourings as solution Y?

8 Substances can be classified as elements, compounds or mixtures.

Which <u>underlined substance</u> best represents a mixture?

A <u>black powder</u> burns in air to form a colourless gas as the only product
B <u>green powder</u> leaves a black residue and a colourless gas upon heating
C <u>grey solid</u> that conducts electricity
D <u>white solid</u> that melts from 56 °C to 58 °C

9 Boron oxide has the structure shown.



How many valence electrons in a molecule of boron oxide are **not** involved in bonding?

A 0 **B** 10 **C** 12 **D** 22

10 An isotope of element Q can be written as $^{32}_{16}Q$.

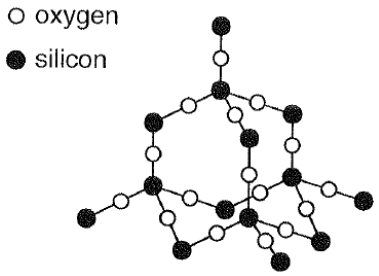
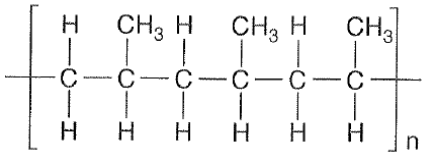
Particle R has four more neutrons, one more proton and one more electron than the isotope of Q.

Particle S has two more neutrons, same number of protons and one less electron than the isotope of Q.

What represents R and S?

	R	S
A	$^{37}_{17}R^-$	$^{34}_{16}S^+$
B	$^{37}_{17}R$	$^{34}_{16}S^-$
C	$^{37}_{17}R^-$	$^{34}_{16}S^-$
D	$^{37}_{17}R$	$^{34}_{16}S^+$

11 The structure and melting points of two compounds are shown below.

name	silicon dioxide	poly(propene)
structure		
melting point	1600 °C	160 °C

Which statement about the compounds is correct?

A Poly(propene) has a low melting point due to the weak covalent bonds between atoms.
B Silicon dioxide has a high melting point due to the numerous strong covalent bonds between atoms.
C Silicon dioxide has a high melting point due to the strong intermolecular forces of attraction.
D Both compounds have a similar three-dimensional arrangement to diamond.

12 Which substance conducts electricity using mobile electrons in the liquid state?

A copper
B diamond
C magnesium chloride
D methane

13 The fertiliser ammonium nitrate (NH_4NO_3, $M_r = 80$) is manufactured from ammonia ($M_r = 17$) by a two-stage process.

stage 1	$NH_3 + 2O_2 \rightarrow HNO_3 + H_2O$
stage 2	$HNO_3 + NH_3 \rightarrow NH_4NO_3$

What is the maximum mass of ammonium nitrate fertiliser that can be made if a total of 17 tonnes of ammonia are available for both stage 1 and stage 2?

A 34 tonnes
B 40 tonnes
C 80 tonnes
D 97 tonnes

14 Aerials in portable radios are made of a mixture of the oxides of calcium and iron known as 'ferrite'.

It contains 18.5% calcium and 51.9% iron by mass.

Which is the empirical formula of 'ferrite'?

A $CaFe_2O$
B $CaFe_2O_4$
C Ca_2FeO_2
D Ca_4Fe_2O

15 A chemist adds 8.0 g of pure calcium oxide to an excess of dilute nitric acid.

$$CaO + 2HNO_3 \rightarrow Ca(NO_3)_2 + H_2O$$

12.6 g of pure, dry calcium nitrate crystals is formed.

What is the percentage yield of calcium nitrate?

A 53.8%
B 63.5%
C 67.1%
D 76.0%

16 Which quantity is the same for one mole of ethanol and one mole of ethane?

A mass
B number of atoms
C number of molecules
D volume at room temperature and pressure

17 Hydrated nickel(II) sulfate crystals have the formula $NiSO_4 \cdot 5H_2O$ in which one mole of nickel(II) sulfate is combined with 5 moles of water.

What is the percentage by mass of oxygen in hydrated nickel(II) sulfate crystals?

[A_r: Ni, 59; S, 32; O, 16; H,1]

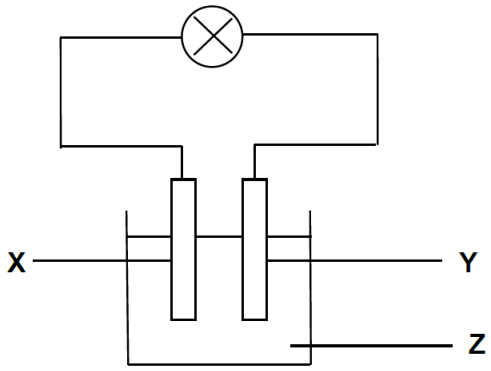
A $\frac{5 \times 16}{155} \times 100$

B $\frac{7 \times 16}{245} \times 100$

C $\frac{9 \times 16}{155} \times 100$

D $\frac{9 \times 16}{245} \times 100$

18 A simple cell was set up to light up a bulb as shown in the diagram below.



What should **X**, **Y** and **Z** be for the bulb to light up the brightest?

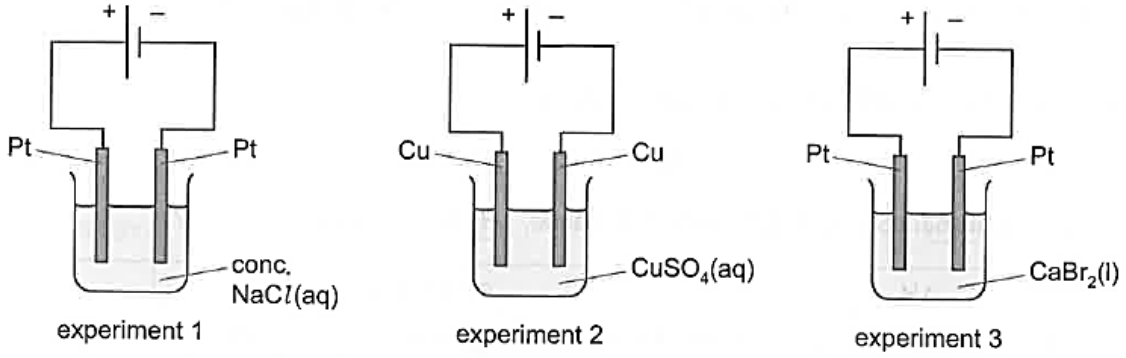
	X	Y	Z
A	magnesium	iron	dilute ethanoic acid
B	magnesium	iron	dilute sulfuric acid
C	magnesium	zinc	dilute ethanoic acid
D	magnesium	zinc	dilute sulfuric acid

19 Aqueous silver nitrate is electrolysed using a positive silver electrode and a negative carbon electrode.

Which row shows the ionic equations at each electrode?

	positive electrode	negative electrode
A	$Ag(s) \rightarrow Ag^+(aq) + e^-$	$2H^+(aq) + 2e^- \rightarrow H_2(g)$
B	$4OH^-(aq) \rightarrow O_2(g) + 2H_2O(l) + 4e^-$	$Ag^+(aq) + e^- \rightarrow Ag(s)$
C	$4OH^-(aq) \rightarrow O_2(g) + 2H_2O(l) + 4e^-$	$2H^+(aq) + 2e^- \rightarrow H_2(g)$
D	$Ag(s) \rightarrow Ag^+(aq) + e^-$	$Ag^+(aq) + e^- \rightarrow Ag(s)$

20 Three different compounds are electrolysed.



Which experiments produce a gas at the cathode?

A 1 only **B** 2 only **C** 1 and 3 **D** 2 and 3

21 The complete combustion of ethane is an exothermic reaction.

Which statement about the reaction is correct?

A The activation energy is greater than the energy taken in when the bonds are formed.
B The activation energy is greater than the energy released when the bonds are formed.
C The activation energy is less than the energy taken in when the bonds are formed.
D The activation energy is less than the energy released when the bonds are formed.

22 The equation for the combustion of hydrogen is shown.

$$2H_2\,(g) + O_2\,(g) \rightarrow 2H_2O\,(g)$$

The bond energies of the bonds are given in the following table.

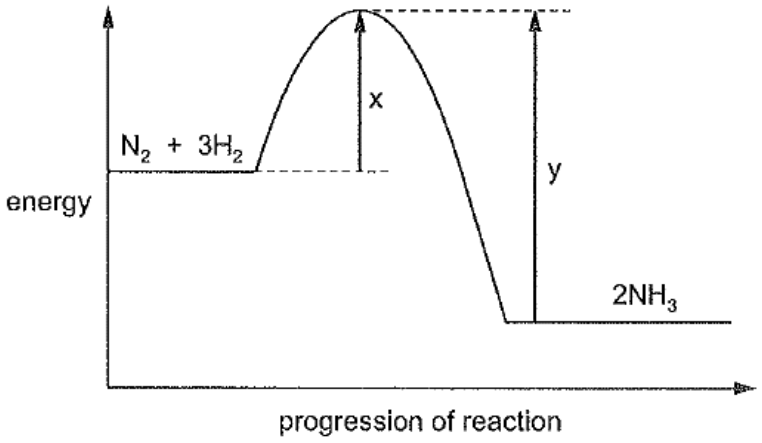
bond	bond energy (kJ/mol)
H–H	436
O–H	463
O=O	498

What is the enthalpy change of this reaction?

A –482 kJ/mol **B** –444 kJ/mol **C** +444 kJ/mol **D** +482 kJ/mol

23 The equation and the energy profile diagram for the reversible reaction in the Haber process are shown.

$N_2 + 3H_2 \rightleftharpoons 2NH_3$



Which statement about the reactions is correct?

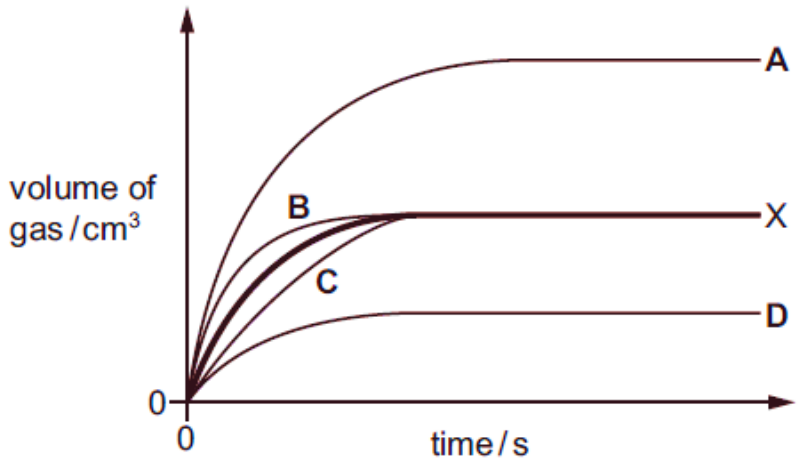
A The activation energy for the forward reaction is y – x.
B The activation energy for the reverse reaction is x.
C The enthalpy change for the reverse reaction is positive.
D The enthalpy change decreases when a catalyst is used.

24 A student adds excess carbonate to 100 cm^3 of 0.1 mol/dm^3 hydrochloric acid and measures the volume of carbon dioxide gas produced at regular time intervals.

The results give line X on the graph.

The student repeats the experiment using 100 cm^3 of 0.2 mol/dm^3 hydrochloric acid while keeping all other conditions constant.

Which line shows the results for the second experiment?



25 Colour changes are often observed when redox reactions occur.

Which colour change is due to the reduction of the underlined reagent?

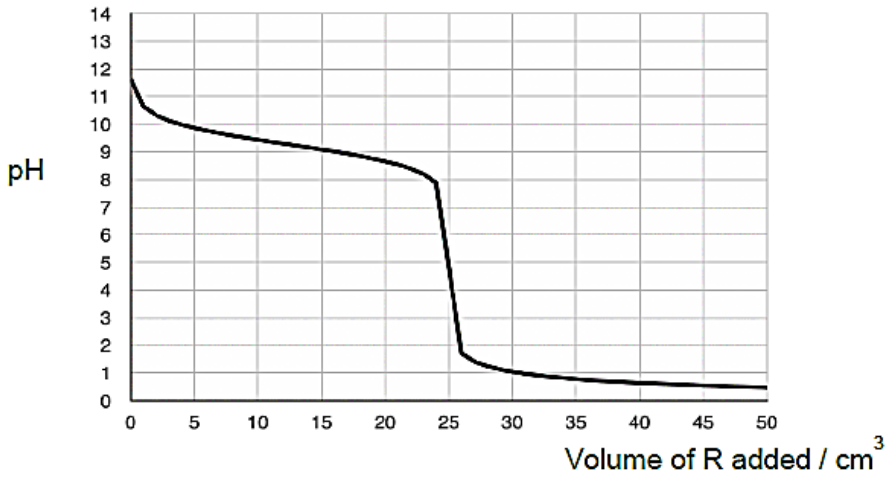
A $\underline{CuO}$ changes to $CuSO_4$
B $\underline{KI}$ changes to I_2
C $\underline{FeCl_2}$ changes to $FeCl_3$
D $\underline{MnO_4^-}$ changes to Mn^{2+}

26 Which of the following is **not** a redox reaction?

A $2Ag + Br_2 \rightarrow 2AgBr$
B $2CO + O_2 \rightarrow 2CO_2$
C $Na_2CO_3 + CuCl_2 \rightarrow 2NaCl + CuCO_3$
D $Fe + 2HCl \rightarrow FeCl_2 + H_2$

27 Aqueous solution R is gradually added to aqueous solution S.

The changes in pH are shown in the graph below.



What could be the identifies of R and S?

	R	S
A	aqueous ammonia	ethanoic acid
B	ethanoic acid	aqueous ammonia
C	hydrochloric acid	aqueous ammonia
D	sodium hydroxide	hydrochloric acid

28 Which method of preparation would be suitable for making these salts?

	titration	metal + acid	precipitation
A	barium nitrate	barium sulfate	zinc sulfate
B	barium nitrate	zinc sulfate	barium sulfate
C	barium sulfate	zinc sulfate	barium nitrate
D	barium sulfate	barium nitrate	zinc sulfate

29 Which statement is correct?

A Compounds containing transition elements are always coloured blue or green.
B The highest oxidation state that a transition element shows is +6.
C The positive ions in a transition element form a metallic lattice in a 'sea of electrons'
D Transition elements have a low density.

30 The information of some metals, P, Q, R and S is shown in the table.

metal	action of heat on metal carbonate	action of hydrogen on heated metal oxide	action of dilute sulfuric acid on metal
P	decomposed	reduced	no reaction
Q	no reaction	no reaction	effervescence
R	decomposed	no reaction	effervescence
S	decomposed	reduced	effervescence

What is the order of reactivity of the metals, in descending order?

	most reactive → least reactive			
A	Q	S	R	P
B	Q	R	S	P
C	R	S	P	Q
D	R	Q	P	S

31 Copper(II) nitrate is made by reacting an excess of a powdered solid with an aqueous solution.

The mixture is filtered and the filtrate is crystallised.

Which row identifies a solid and an aqueous solution that can be used to make a pure sample of copper(II) nitrate?

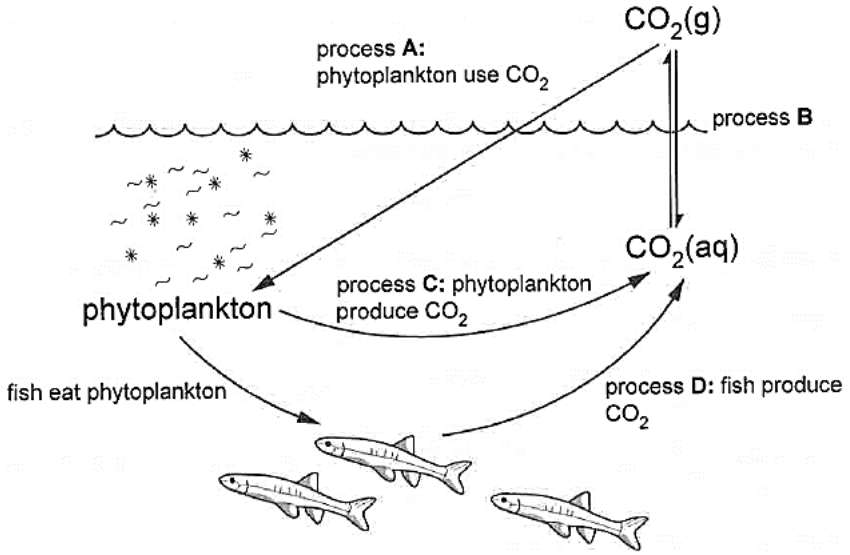
	solid in excess	aqueous solution
A	copper	zinc nitrate
B	copper	silver nitrate
C	copper(II) oxide	dilute sulfuric acid
D	copper(II) sulfate	dilute nitric acid

32 Which of the following statements about the Haber Process is correct?

A The final yield is increased by operating at a high pressure.
B The final yield is increased by adding a catalyst.
C The rate of reaction is increased by operating at low temperature.
D The rate of reaction is increased by operating at low pressure.

33 Phytoplankton are tiny plants that live near the surface of the sea, where they absorb energy from the sun.

The figure shows how phytoplankton are involved in the carbon cycle. Each letter **A**, **B**, **C** and **D** represents a process.



Which statement is correct?

A Process **A** converts carbon dioxide and glucose into oxygen and water.
B Process **B** is a reversible process.
C Process **C** is an endothermic process.
D Process **D** is decomposition.

34 A catalytic converter in a car exhaust system changes pollutants into less harmful products.

Which change does **not** occur in a catalytic converter?

A carbon dioxide → carbon
B carbon monoxide → carbon dioxide
C nitrogen oxides → nitrogen
D unburnt hydrocarbons → carbon dioxide

35 Which comparison of the properties of pentane, C_5H_{12}, and propane is true?

A Propane has a higher melting point.
B Propane has a lower boiling point.
C Propane is less flammable.
D Propane is more viscous.

36 5 g of vegetable oil (M_r = 800) reacted completely with 900 cm^3 of hydrogen gas, measured at room temperature and pressure, to form margarine, a saturated fat.

How many carbon-carbon double bonds are there in one molecule of vegetable oil?

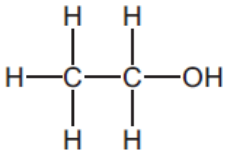
A 3 **B** 4 **C** 5 **D** 6

37 Compound X decolourises acidified aqueous potassium managanate(VII).

Compund X has the empirical formula C_2H_5O.

Some possible structures of X are shown.

1



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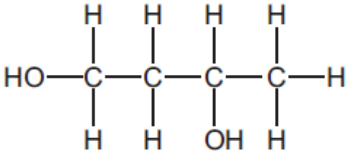

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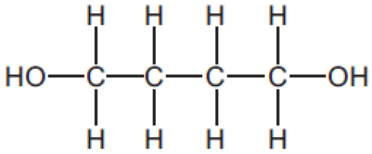

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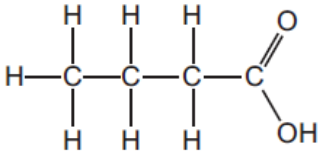


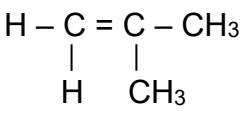
Which structures could be correct for compound X?

A 1 only **B** 2 and 3 only **C** 3 and 4 **D** 1, 2 and 3

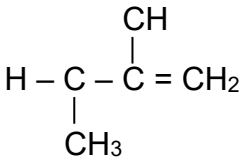
38 Addition of hydrogen to an unknown alkene gives the alkane $CH_3CH(CH_3)_2$.

What is the unknown alkene?

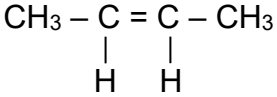
A



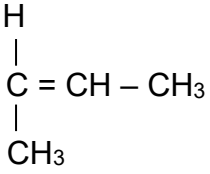
B



C



D



39 The table contains statements comparing two sources of energy, petrol and bioethanol, which are used as fuel for motor vehicles.

	petrol	bioethanol
1	obtained from the cracking of long-chain alkane molecules in crude oil	obtained from the addition reaction of ethene molecules with steam
2	produces less carbon dioxide emissions per litre of fuel	produces more carbon dioxide emissions per litre of fuel
3	produces other pollutants like carbon monoxide and soot due to incomplete combustion	burns cleanly in air
4	non-renewable source of energy	renewable source of energy

Which rows are correct?

A 1 and 2 **B** 2 and 3 **C** 3 and 4 **D** 1, 3 and 4

40 An alcohol and a carboxylic acid are reacted together to form an ester.

Which statement is correct?

A The ester molecule has fewer oxygen atoms than the carboxylic acid molecule.
B The ester molecule has the same number of oxygen atoms as the alcohol molecule.
C The ester molecule has more oxygen atoms than the alcohol molecule.
D The ester molecule has less carbon atoms than the carboxylic acid molecule

—End of Paper—

Section A

Answer **all** questions.

1 Choose from the following substances to answer the questions below.

ammonia
carbon dioxide
iron
methane
nickel
potassium iodide
potassium manganate(VII)
silicon
sodium hydroxide
nitrogen

Each substance can be used once, more than once, or not at all.

Name a substance which

(a) is a catalyst used in the manufacturing of margarine from vegetable oils.

……...

(b) is a white solid with a high melting point that dissolves in water to form an alkaline solution.

……...

(c) is a molecule with 14 protons.

……...

(d) is a product of fermentation.

……...

(e) can be used to test for the presence of sulfur dioxide.

……...

[Total: 5]

2 In recent years, scientists have made tube-shaped structures of carbon called nanotubes shown in Figure 2.1.

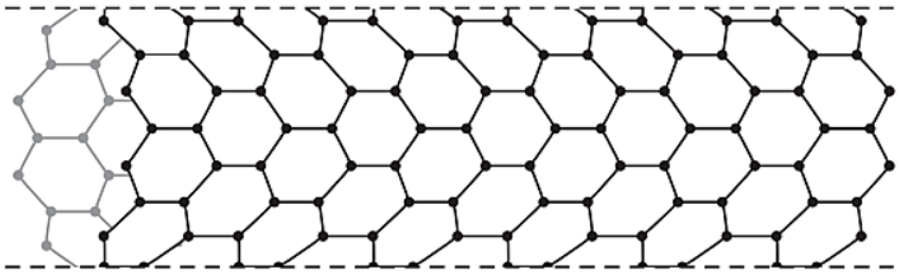


Fig. 2.1

(a) State **one** difference between the structure of a carbon nanotube and the structure of diamond.

……...

……...
[1]

(b) Carbon nanotubes are fifty times stronger than steel.

With reference to structure and bonding, explain why these nanotubes are so strong.

……...

……...

……...

……...

……...
[2]

(c) Carbon nanotubes are used in many areas of technology such as electronics.

Explain why carbon nanotubes display remarkable electrical conductivity.

……...

……...

……...

……...

……...
[2]
[Total: 5]

3 **(a)** Table 3.1 shows information about the preparation of pure samples of solid salts.

Complete the table by filling in the missing information. Include state symbols with any formulae.

Table 3.1

name of salt	formulae of reagents used	method used
lead(II) nitrate	…… HNO_3 (aq)	addition of excess solid to acid filtration evaporation, crystallisation and drying
……..	KOH (aq) HC*l* (aq)	…… evaporation, crystallisation and drying
barium sulfate	…… ……	…… ……

[3]

(b) Lead(II) sulfate is obtained when solution **X** was added to aqueous lead(II) nitrate.

When a few drops of aqueous ammonia was added to solution **X**, a white precipitate **Y** was obtained. **Y** dissolves when an excess of aqueous ammonia was added.

Identify substances **X** and **Y**.

X: …….

Y: …….

[2]

[Total: 5]

4 Angelic acid is found in the roots of many plants such as carrots. The structure of angelic acid is shown in Figure 4.1.

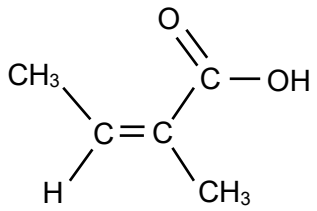


Fig 4.1

(a) Angelic acid is said to be a weak acid.

(i) Explain the term *weak acid*.

……

……

[1]

(ii) Write a balanced chemical equation for the reaction between angelic acid, C_4H_7COOH and sodium carbonate.

……

[1]

(b) When angelic acid was heated with hydrogen gas over a catalyst, a saturated compound was formed.

(i) Write the molecular formula for the saturated compound formed.

……

[1]

(ii) Suggest a chemical test to confirm that all the angelic acid has reacted completely with hydrogen gas. State your observations clearly.

test ……

observations ……

……

……

……

……

[2]

(c) Angelic acid reacts with methanol, CH_3OH to form an ester.
Draw the full structural formula of the ester.

[1]

(d) Figure 4.2 shows a segment of the polymer chain of nylon 6,10. Nylon 6,10 is recycled in waste treatment plants to make new products.

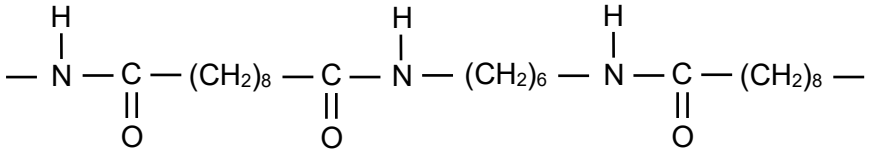


Fig. 4.2

(i) After the pre-treatment process, nylon waste is broken down into its respective monomers through acid hydrolysis.

Draw in the space below the monomers of nylon 6,10.

[2]

(ii) State an environmental issue that might arise from recycling plastics.

……

……

[1]

[Total: 9]

5 This question is about ammonia.

(a) Ammonia is manufactured through the Haber process using iron as a catalyst.

(i) With reference to collision of particles, describe and explain how the use of **powdered iron catalyst** increases the rate of reaction.

……

……

……

……

……

……

……

……

……

[3]

(ii) State the **other** conditions required for the Haber process to function optimally.

……

[1]

(b) Ammonia is also produced when solid sodium hydroxide is warmed with aqueous ammonium sulfate.

$$2NaOH\ (s) + (NH_4)_2SO_4\ (aq) \rightarrow Na_2SO_4\ (aq) + 2H_2O\ (l) + 2NH_3\ (g)$$

3.50 g of sodium hydroxide is added to 40.0 cm^3 of 0.80 mol/dm^3 aqueous ammonium sulfate.

(i) Calculate the number of moles of sodium hydroxide added.

[1]

(ii) Calculate the number of moles of ammonium sulfate added.

[1]

(iii) Hence, calculate the volume of ammonia gas produced at room temperature and pressure.

[2]

(c) Hydrazine, $H_2N - NH_2$ is a colourless flammable liquid used as fuel in the thrusters of space shuttles.

(i) Draw the dot-and-cross diagram for a molecule of hydrazine. Show **all** electrons.

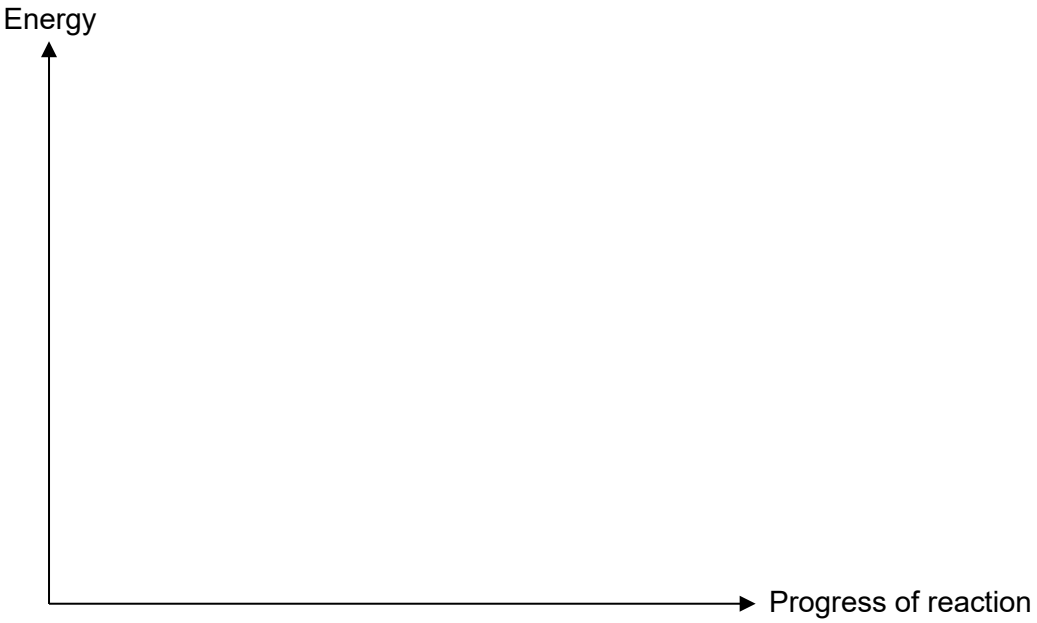
[2]

(ii) When hydrazine is passed over a catalyst, it decomposes to form ammonia and nitrogen gas. The reaction is exothermic.

$$3N_2H_4 \rightarrow 4NH_3 + N_2$$

Complete the energy profile diagram for the above reaction.

Your diagram should include:
- the reactants and products of the reaction
- labels to show the enthalpy change, ΔH and activation energy, E_a



[2]

[Total: 12]

6 Magnalium is an alloy of aluminium and magnesium. It is commonly used in the manufacture of aircrafts.

Table 6.1 shows how the composition of metals in magnalium affects its relative strength.

Table 6.1

composition of magnalium		relative strength
aluminium	magnesium	
95	5	2.4
85	15	3.0
75	25	3.6
65	35	4.1

(a) How does the composition of magnalium affect its relative strength?

……...

……...

[1]

(b) Using your knowledge of the structure of metals, explain why magnalium is stronger than pure aluminium.

……...

……...

……...

……...

……...

……...

……...

[2]

(c) A piece of magnalium alloy was added to dilute sulfuric acid and the mixture was stirred for 5 minutes. It was observed that the piece of magnalium only partially dissolved, leaving behind some silvery-grey powder.

Explain the observation.

……...

……...

……...

……...

……...

……...

[2]

(d) Table 6.2 shows a list of metals and metal oxides.

Table 6.2

metal	metal oxide
lead	copper(II) oxide
magnesium	iron(III) oxide
silver	potassium oxide
zinc	sodium oxide

(i) Which metal and which metal oxide are most likely to react together to give the most vigorous reaction?

metal: …….. *metal oxide:* ……..

[1]

(ii) Zinc metal reacts with steam. Give the names of the products of this reaction.

……

[1]

[Total: 7]

7 **(a)** A solution of green aqueous nickel(II) chloride was electrolysed in the set-up shown in Figure 7.1.

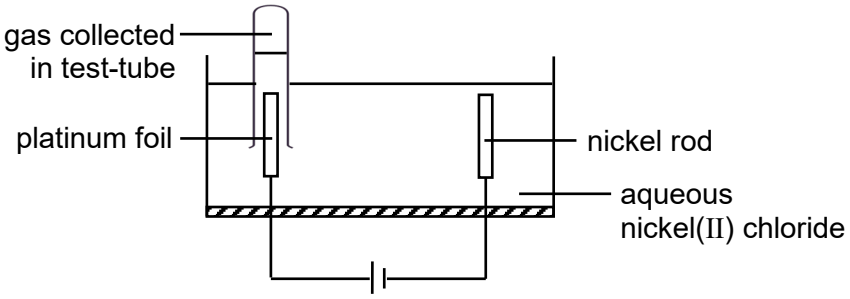


Fig. 7.1

During electrolysis, a silvery-white solid was deposited on the nickel rod and a gas was produced and collected at the platinum foil.

(i) Construct the equations for the reactions occurring at the respective electrodes during the electrolysis of aqueous nickel(II) chloride.

nickel rod .....

platinum foil .....

[2]

(ii) Describe the expected observations to the electrolyte during the electrolysis. Explain your reasoning.

.....

.....

.....

.....

[2]

(iii) At the end of the electrolysis, the volume of gas collected at the platinum foil was found to be 5.0 cm^3 less than expected. Suggest why this happens.

.....

.....

[1]

(iv) The same apparatus can be used to electrolyse concentrated nickel(II) chloride.

Give **one** difference between the products of the electrolysis of dilute and concentrated nickel(II) chloride.

.....

.....

[1]

(b) A student arranged a different set-up in Figure 7.2 to investigate how different factors affect the electrolysis of aqueous nickel(II) chloride.

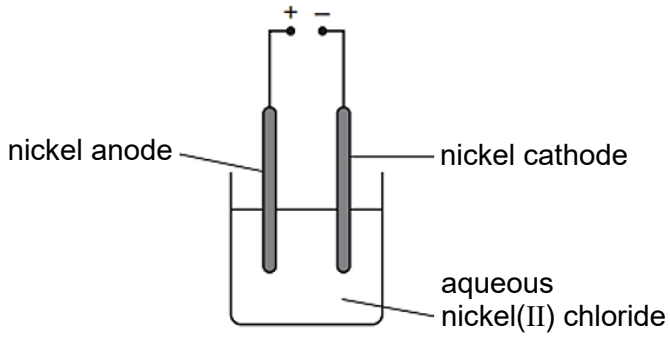


Fig. 7.2

The student weighs the nickel cathode before and after the electrolysis. Information about the experiments is shown in Table 7.1.

Table 7.1

experiment number	current used / A	duration of electrolysis / s	mass of nickel cathode	
			before starting / g	after electrolysis / g
1	2.0	120	1.32	1.49
2	4.0	120	1.18	1.52
3	2.0	240	1.24	1.58

(i) Construct the equation for the reaction occurring at the nickel anode in Fig 7.2.

……

[1]

(ii) In experiment 1, the student also measures the mass of the anode before and after the electrolysis.

At the start, the anode has a mass of 1.27 g. Determine the mass of the anode at the end of the electrolysis.

final mass of anode …… g [1]

(iii) The student does a fourth experiment. Information about the experiment is given in Table 7.2.

Table 7.2

experiment number	current used / A	duration of electrolysis / s	mass of nickel cathode	
			before starting / g	after electrolysis / g
4	8.0	60	1.21	

Predict the mass of the cathode at the end of the electrolysis.

……

[1]

(c) Electroplating coats a thin layer of the desired metal onto an object.

Draw a clearly labelled diagram to illustrate how to electroplate a nickel coin with a thin layer of silver.

[2]

[Total: 11]

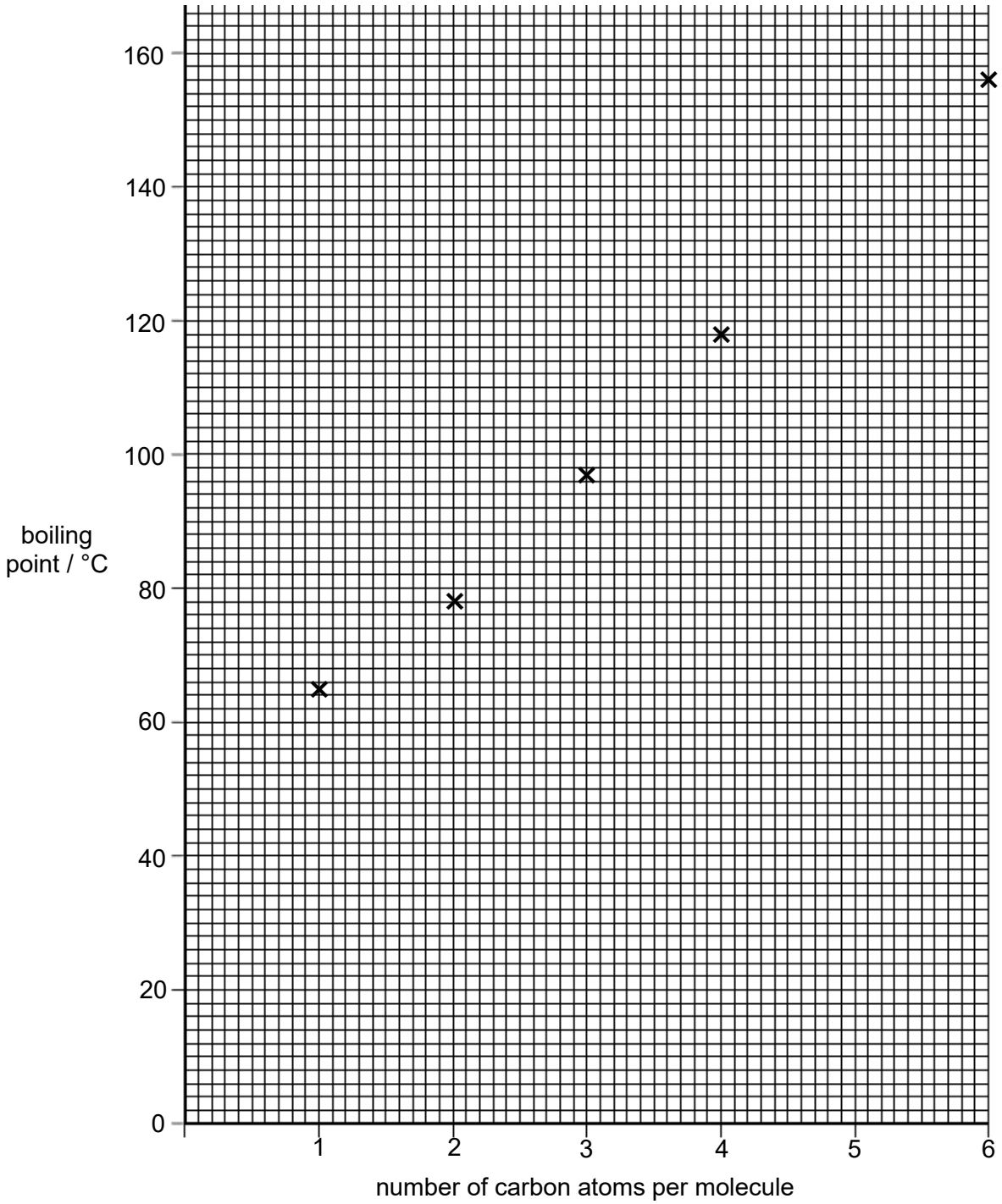
8 Table 8.1 shows the densities and solubilities of some straight chain alcohols.

Table 8.1

name of alcohol	formula	density / g/cm^3	solubility in water at 25 °C
methanol	CH_3OH	0.79	miscible
ethanol	C_2H_5OH	0.79	miscible
propan-1-ol	C_3H_7OH	0.80	miscible
butan-1-ol	C_4H_9OH	0.81	9.1%
pentan-1-ol	$C_5H_{11}OH$	0.82	2.7%
hexan-1-ol	$C_6H_{13}OH$	0.82	0.6%

Graph 8.1 shows the boiling points of some straight chain alcohols plotted against the number of carbon atoms in each alcohol molecule.

Graph 8.1



(a) What trends are shown by the data in Table 8.1 and Graph 8.1?

……

……

[2]

(b) Pentan-1-ol has the formula $C_5H_{11}OH$.

Predict the boiling point of pentan-1-ol.

……

[1]

(c) The flashpoint of a compound is the minimum temperature at which the compound gives off sufficient vapour to burn in air. Compounds with lower flashpoints evaporate and burn more easily at lower temperatures.

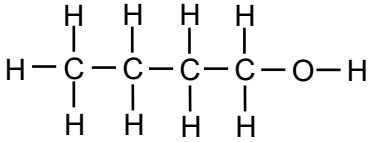
Isomerisation is used to convert straight chain alcohols into branched alcohols.
Straight chain and branched chain isomers of the alcohols have different flashpoints. The more branched the isomer is, the lower its flashpoint.

Table 8.2 shows the flashpoints of butan-1-ol and two of its branched chain isomers.

Table 8.2

	number of carbon atoms in molecule	flashpoint / °C
butan-1-ol	4	29
branched alcohol 1	4	27
branched alcohol 2	4	11

The displayed formula of butan-1-ol is shown below.



Draw the displayed formula for the two isomers of butan-1-ol in the space provided according to their respective flashpoints in Table 8.2.

branched alcohol 1	branched alcohol 2

[2]

(d) Halogenoalkanes are alkanes with one or more hydrogen atoms replaced by halogen atoms. Halogenoalkanes have *chloro*, *bromo* or *iodo* in their names.

An example would be chloroethane shown in Figure 8.1. It can be formed from ethane.

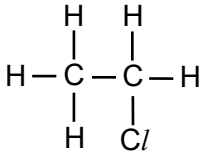


Fig. 8.1

State the type of reaction and the reagents and conditions needed for the formation of chloroethane from ethane.

type of reaction ……..

reagents and conditions ……..

[2]

(e) Halogenoalkanes react with water to form its respective alcohol and halide ion.

$$CH_3CH_2\mathbf{X} + H_2O \rightarrow CH_3CH_2OH + H^+ + \mathbf{X}^- \qquad \text{where } \mathbf{X} = Cl, Br \text{ or } I$$

The rate of reaction between halogenoalkane and water can be measured by adding fixed volumes of aqueous silver nitrate to the reaction mixture of halogenoalkane and water. The time taken for a precipitate of a silver halide to form is measured.

The results for three experiments are given in Table 8.3.

Table 8.3

experiment	halogenoalkane	volume of silver nitrate added / cm^3	time taken / s
1	bromoethane	2	40
2	chloroethane	2	287
3	iodoethane	2	3

(i) What is observed in experiment 3 when aqueous silver nitrate was added to the reaction mixture?

……

[1]

(ii) Using the data in Table 8.3, describe how the order of reactivity of the halogenoalkanes in water compare with the order of reactivity of the halogens?

……

……

……

……

[2]

[Total: 10]

9 **(a)** A student investigates the rate of decomposition of three metal carbonates using the set-up shown in Figure 9.1. He measured the time taken for a white precipitate to be formed in the limewater when each metal carbonate is decomposed.

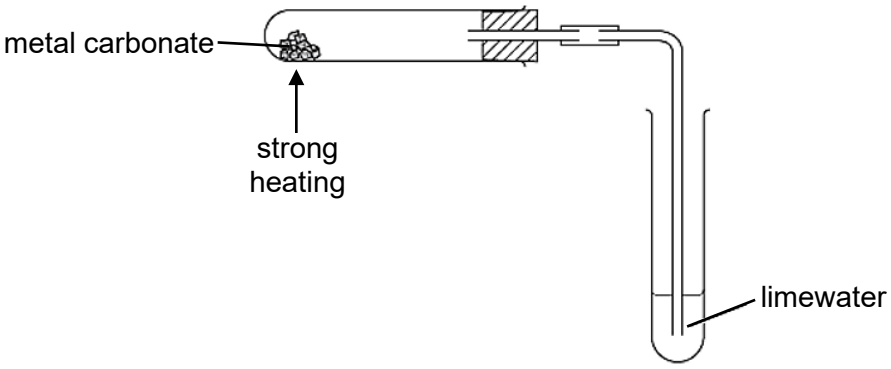


Fig. 9.1

The results of the investigation are shown in in Table 9.1.

Table 9.1

metal carbonate	time taken for white precipitate to form / s
copper(II) carbonate	250
iron(II) carbonate	340
magnesium carbonate	480

(i) Identify the white precipitate formed in limewater.

……

[1]

(ii) He repeated the experiment using lead(II) carbonate.

Predict the time taken for the white precipitate to form in limewater. Explain your prediction.

time taken ……

explanation ……

……

……

……

……

……

[3]

(b) The student proceeds to investigate the decomposition of zinc nitrate. He heated a sample of powdered zinc nitrate in a crucible as shown in Figure 9.2.

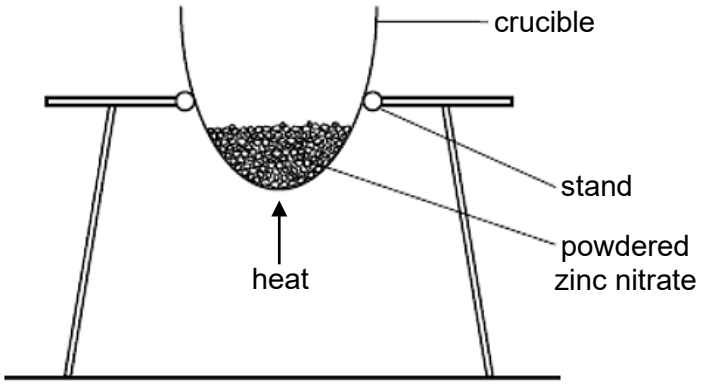


Fig. 9.2

During the reaction, white zinc nitrate powder decomposes on heating to form zinc oxide, brown nitrogen dioxide gas and oxygen.

(i) Complete the chemical equation for the thermal decomposition of zinc nitrate.

$2Zn(NO_3)_2 \rightarrow$ ……

[1]

(ii) Nitrogen dioxide is an atmospheric pollutant. It dissolves in rainwater to form acid rain.

Describe **one** effect of acid rain on the environment.

……

……

[1]

[Total: 6]

Section B

Answer **one** question in this section.

10 Group 1 metals are highly reactive metals.

(a) A student added a piece of lithium metal to a beaker of cold water during an experiment.

(i) Write a balanced chemical equation, including state symbols for the reaction.

……

[1]

(ii) Describe what the student would see differently when potassium was used instead of lithium. Explain your answer with reference to the size of their atoms.

observations:

……

explanation:

……

……

……

[3]

(iii) Name a metal that reacts very slowly with cold water but vigorously with steam.

……

[1]

(b) Sodium hydride is formed when sodium metal is burned in hydrogen.

$$2Na + H_2 \rightarrow 2NaH$$

Use changes in oxidation states to determine the role of hydrogen in the reaction.

……...

……...

……...

[2]

(c) Group 1 metals like sodium have relatively lower melting and boiling points compared to metals such as chromium.

(i) Describe the trend in the melting and boiling points of Group 1 metals down the group.

……

[1]

(ii) Describe one **other** difference in the physical properties of sodium and chromium.

……

[1]

(d) Figure 8.1 shows information about the atomic radii of Group 1 metals.

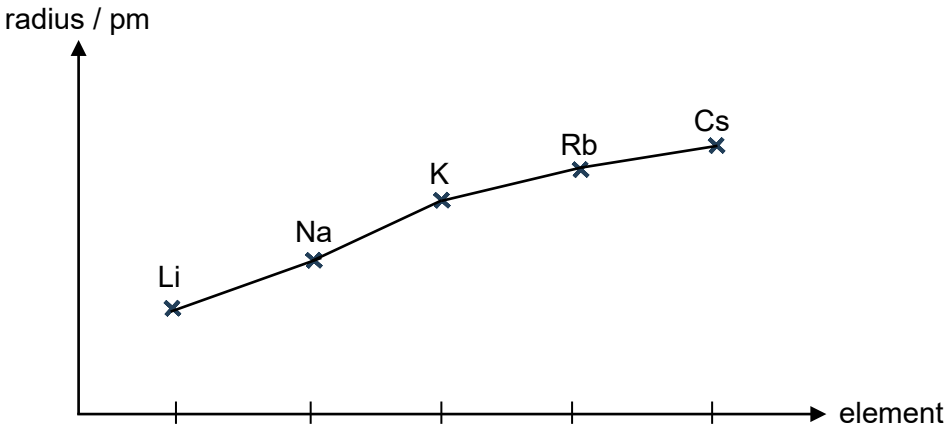


Fig. 8.1

Sketch the trend for the ionic radii of the Group 1 metal cations on Figure 8.1.

[1]

[Total: 10]

11 Table 11.1 shows the melting and boiling points of some Group 17 elements.

Table 11.1

element	melting point / °C	boiling point / °C
fluorine	–220	–188
chlorine	–101	–35
bromine	–7	
iodine	114	184

(a) Estimate the boiling point of bromine.

……...

[1]

(b) Describe and explain the general trend in the melting point of Group 17 elements down the group.

……...

……...

……...

……...

[2]

(c) During an experiment, chlorine gas was bubbled into a test-tube containing aqueous sodium bromide.

(i) Construct an ionic equation for the reaction.

……

[1]

(ii) State your observations for the reaction in **(c)(i)**.

……

[1]

(d) Aqueous iodine was added to a separate test-tube containing sodium bromide.
Explain why the colour of the resultant solution is brown.

……...

……...

……...

[2]

(e) Chlorine gas reacts with sodium hydroxide to form sodium chloride and sodium hypochlorite.

$$Cl_2\,(g) + 2NaOH\,(aq) \rightarrow NaCl\,(aq) + NaClO\,(aq) + H_2O\,(l)$$

Determine the oxidation state of chlorine in the following substances.

substance	oxidation state of Cl
Cl_2	
NaCl	
NaClO	

[2]

(f) Hydrated titanium(III) chloride has the formula $TiCl_3 \cdot \boldsymbol{x}H_2O$.
It has the relative formula mass of 262.5.

Calculate the value of ***x***.

[1]
[Total: 10]

– End of Paper –

2024 Secondary 4 Pure Chemistry (6092)
Prelim Paper 1
Suggested Answers

1	2	3	4	5	6	7	8	9	10
B	**C**	**C**	**B**	**D**	**B**	**D**	**D**	**C**	**D**
11	12	13	14	15	16	17	18	19	20
B	**A**	**B**	**B**	**A**	**C**	**D**	**B**	**D**	**A**
21	22	23	24	25	26	27	28	29	30
D	**A**	**C**	**A**	**D**	**C**	**C**	**B**	**C**	**B**
31	32	33	34	35	36	37	38	39	40
B	**A**	**B**	**A**	**B**	**D**	**B**	**A**	**C**	**C**

2024 Sec 4E Pure Chemistry
Prelim Examinations
Suggested Answers

Section A:

1	**(a)**	**nickel**	1
	(b)	**sodium hydroxide**	1
	(c)	**nitrogen**	1
	(d)	**carbon dioxide**	1
	(e)	**potassium manganate(VII)**	1
			[Total: 5]
2	**(a)**	**In diamond, each carbon atom is covalently bonded to 4 other carbon atoms while in a carbon nanotube, each carbon atom is covalently bonded to 3 other carbon atoms.** *OR* **The carbon atoms in diamond are arranged in a tetrahedral arrangement while the carbon atoms in a carbon nanotube form hexagonal rings.**	1
	(b)	**Carbon nanotubes have a giant molecular structure / giant covalent structure with numerous strong covalent bonds between carbon atoms. [1]** **As large amounts of energy / force are required to overcome the strong bonds, hence carbon nanotubes are strong. [1]**	2
	(c)	**Only three out of four valence electrons of each carbon atom in carbon nanotubes are used in bonding. [1]** **Hence, there are delocalised electrons that serve as mobile charge carriers to conduct electricity. [1]**	2
			[Total: 5]

3 (a)

name of salt	formulae of reagents used	method used
lead(II) nitrate	**$PbCO_3$ (s)** *OR* **Pb (s)** *OR* **PbO (s) [✓]** HNO_3 (aq)	addition of excess solid to acid filtration evaporation, crystallisation and drying
potassium chloride [✓]	KOH (aq) HCl (aq)	**titration [✓]** evaporation, crystallisation and drying
barium sulfate	**$Ba(NO_3)_2$ (aq)** *OR* **$BaCl_2$ (aq)** **Na_2SO_4 (aq) [✓]**	**precipitation [✓]** **filtration and drying [✓]**

2 to 3 [✓]: 1 mark 4 to 5 [✓]: 2 marks 6 [✓]: 3 marks

3

(b) **X**: **zinc sulfate / $ZnSO_4$ [1]** **Y**: **zinc hydroxide / $Zn(OH)_2$ [1]** 2

[Total: 5]

4 (a)(i) **A weak acid partially dissociates in water to form a low concentration of hydrogen ions.** 1

(a)(ii) $2C_4H_7COOH + Na_2CO_3 \rightarrow 2C_4H_7COONa + CO_2 + H_2O$ 1

(b)(i) $C_5H_{10}O_2$ **(reject: C_4H_9COOH)** 1

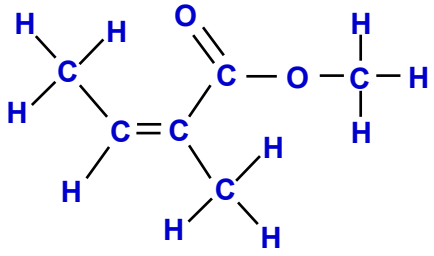
(b)(ii) *test:* **Add aqueous bromine to the product. [1]**

observations:

If the aqueous bromine remains red-brown, this indicates that the reaction is complete.

If the red-brown aqueous bromine decolourises, this indicates that the reaction is incomplete. [1] 2

(c)

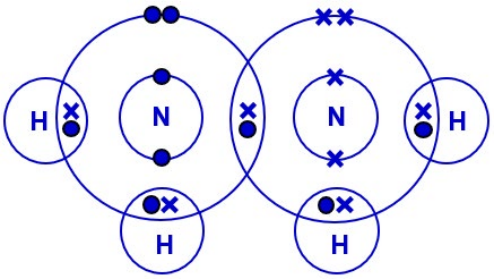
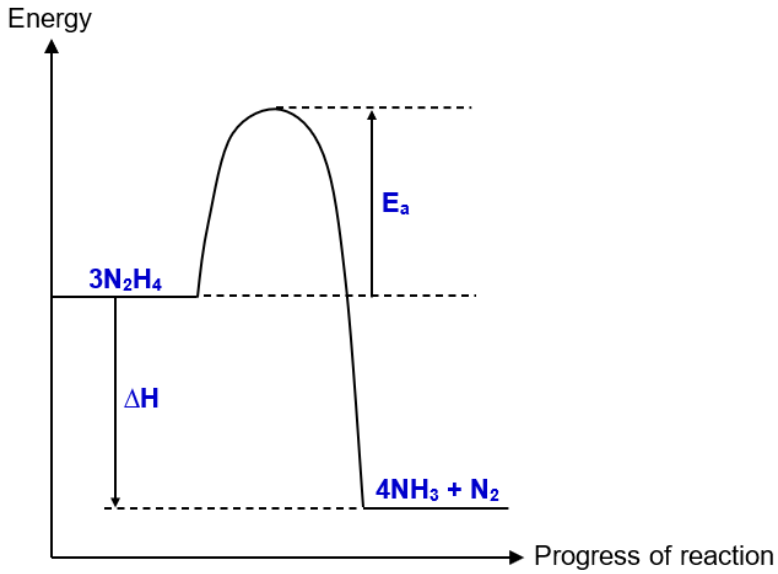


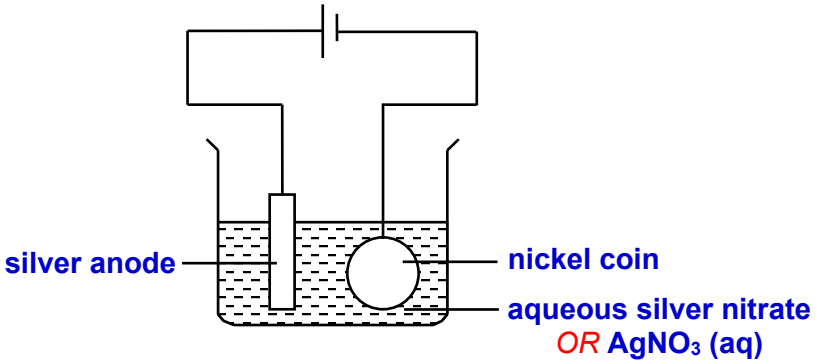
1

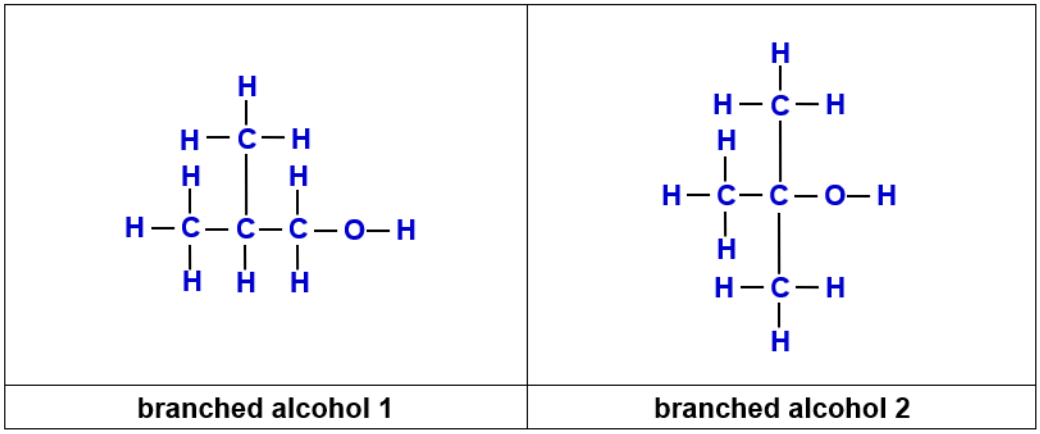
(d)(i)

1 mark for each correctly drawn monomer 2

	(d)(ii)	Discharging of untreated wastewater from recycling process into water bodies will contaminate the water and cause water pollution. *OR* Breakdown of plastic waste through cracking requires high temperatures that is obtained through the burning of fossil fuel. Burning of fossil fuels produce greenhouse gases that causes global warming.	1
			[Total: 9]
5	(a)(i)	The powdered iron has a smaller particle size. [✓] This increases the total exposed surface area in contact with reactant particles. [✓] In addition, iron serves as the catalyst which provides an alternative reaction pathway with a lower activation energy. [✓] This increases the number of reactant particles colliding with energy greater than or equal to the activation energy. [✓] This increases the frequency of effective collisions, hence the rate of reaction increases. [✓] 2 [✓]: 1 mark, 3 to 4 [✓]: 2 marks, 5 [✓]: 3 marks	3
	(a)(ii)	250 atm of pressure and a temperature of 450 °C	1
	(b)(i)	Number of moles of NaOH $= \frac{3.50}{23 + 16 + 1}$ $= 0.0875$ mol [1]	1
	(b)(ii)	Number of moles of $(NH_4)_2SO_4$ $= 0.80 \times \frac{40.0}{1000}$ $= 0.0320$ mol [1]	1
	(b)(iii)	Mole ratio of NaOH : $(NH_4)_2SO_4$ = 2 : 1 $(NH_4)_2SO_4$ is the limiting reagent. Mole ratio of $(NH_4)_2SO_4$: NH_3 = 1 : 2 Number of moles of NH_3 = 2 × 0.0320 = 0.0640 mol [1] Volume of NH_3 = 0.0640 × 24 = 1.54 dm^3 [1] ECF was given for volume of NH_3 calculation as long as correct limiting reagent was identified.	2

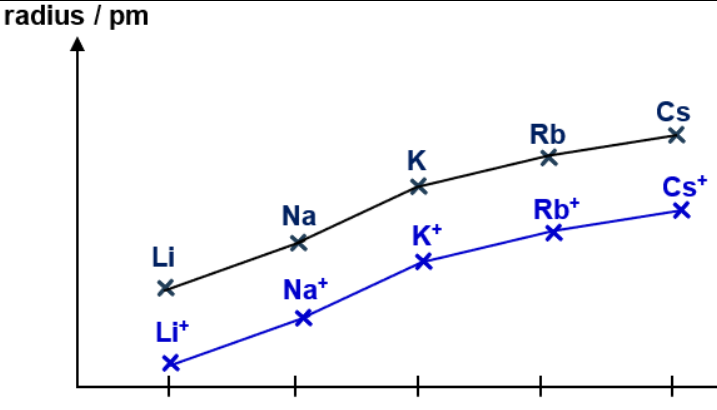
	(c)(i)	 **1 mark for correct shared electrons in N_2H_4** **1 mark for correct valence electrons for N_2H_4**	2
	(c)(ii)	 **1 mark: reactant and products and correct shape of graph** **1 mark: ΔH and E_a**	2
			[Total: 12]
6	**(a)**	**As the composition of magnesium in magnalium increases, the relative strength of magnalium increases.**	1
	(b)	**Pure aluminium consist of atoms of the same size arranged in a regular manner. When a force is applied, layers of atoms can slide over each other easily. Hence, pure metals are soft. [1]** **In magnalium, the insertion of magnesium atoms which are of different sizes disrupts the regular arrangement of atoms. This irregularity makes it more difficult for layers of atoms to slide over each other, causing magnalium to be stronger and harder. [1]**	2
	(c)	**The magnesium metal in the alloy is a reactive metal that reacts readily with sulfuric acid and dissolves to form magnesium sulfate. [1]** **However, the aluminium metal in the alloy has a layer of aluminium oxide on its surface that protects the aluminium metal from reaction with the sulfuric acid. [1] Hence, it remained undissolved as the silvery-grey powder.**	2
	(d)(i)	*metal:* **magnesium** *metal oxide:* **copper(II) oxide**	1

	(d)(ii)	**zinc oxide and hydrogen gas**	1
			[Total: 7]
7	**(a)(i)**	*nickel rod*: **Ni^{2+} (aq) + $2e^-$ → Ni (s) [1]** *platinum foil*: **$4OH^-$ (aq) → O_2 (g) + $2H_2O$ (*l*) + $4e^-$ [1]**	2
	(a)(ii)	**During electrolysis, the green electrolyte decolourises. [1]** **This is because, Ni^{2+} is preferentially discharged / reduced to form nickel solid at the cathode, there is decrease in the concentration of Ni^{2+} in the solution, causing the decolourisation of the green electrolyte.** *OR* **The solution becomes more diluted as Ni^{2+} is preferentially discharged. [1]**	2
	(a)(iii)	**Some of the oxygen gas produced dissolved in water during the collection process.**	1
	(a)(iv)	**For the *dilute solution*, oxygen gas will be collected at the anode.** **However, when a *concentrated solution* is used, chlorine gas will be collected instead.**	1
	(b)(i)	**Ni (s) → Ni^{2+} (aq) + $2e^-$**	1
	(b)(ii)	***Gain in mass at the cathode = loss of mass at the anode*** ***For experiment 1, since the gain in mass at cathode = 1.49 – 1.32*** ***= 0.17 g*** **Final mass of anode = 1.27 – 0.17** **= 1.10 g**	1
	(b)(iii)	***As the current used doubles or duration of electrolysis doubles, the mass of nickel deposited at the cathode doubles.*** ***However, in experiment 4, the current used is double that of experiment 2 but the duration of electrolysis is halved. Hence, the increase in the mass of the cathode will remain the same as experiment 2 at 0.34 g.*** **Final mass of cathode = 1.21 + 0.34** **= 1.55 g**	1
	(c)	 	2

		Correct positioning of battery [✓], anode [✓], cathode [✓], electrolyte [✓] with labels **2 to 3 [✓]: 1 mark, 4 [✓]: 2 marks**	
			[Total: 11]
8	**(a)**	**As the number of carbon atoms per molecule increases , the density increases [✓] and boiling point of the alcohol increases [✓] but the solubility of the alcohol in water decreases [✓].** **3 [✓]: 2 mark, 1 to 2 [✓]: 1 mark**	2
	(b)	**138 °C** ***accept values between 128 to 142 °C***	1
	(c)	 **branched alcohol 1** **branched alcohol 2**	2
	(d)	*type of reaction:* **substitution [1]** reagents and conditions: **chlorine gas/ Cl_2 and UV light/ sunlight [1]**	2
	(e)(i)	**A yellow precipitate of silver iodide will be observed.**	1
	(e)(ii)	**From Table 8.3, as the time taken for the reaction to complete / precipitate to form decreases from chloroethane to bromoethane to iodoethane, this indicates the reactivity of halogenoalkanes increases down the group. [1]** **However, the reactivity of halogens decreases down the group. [1]**	2
			[Total: 10]
9	**(a)(i)**	**calcium carbonate / $CaCO_3$**	1
	(a)(ii)	*time taken:* **300 s [1] accept any logical answer between 250 and 340 s** *explanation:* **As lead is more reactive than copper [1], lead(II) carbonate would be more thermally stable than copper(II) carbonate / more stable to heat / less easily decomposed [1] and will take a longer time to completely decompose.** *OR* **As lead is less reactive than iron [1], lead(II) carbonate would be less thermally stable than iron(II) carbonate / less stable to heat / more easily decomposed [1] and will take a shorter time to completely decompose.**	3

	(b)(i)	$2Zn(NO_3)_2 \rightarrow$ **$2ZnO + 4NO_2 + O_2$**	1
	(b)(ii)	***Any one:*** • **Acid rain leaches nutrients from soil** • **Acid rain reacts with aluminium hydroxide in soil to produce toxic Al^{3+} resulting in the death of plants.** • **Acid rain damages vegetation / aquatic life**	1
			[Total: 6]

Section B:

10	**(a)(i)**	**$2Li\ (s) + 2H_2O\ (l) \rightarrow 2LiOH\ (aq) + H_2\ (g)$**	1
	(a)(ii)	*observations:* **More vigorous effervescence / more violent reaction will be observed** *OR* **Lilac flame will be observed. [1]** *explanation:* **Potassium has a larger atomic radius / size of atom compared to lithium. [1]** **Hence, the valence electron is further away from the nucleus / valence electron less strongly attracted to nucleus and more easily lost. Thus, potassium is more reactive than lithium. [1]**	3
	(a)(iii)	**magnesium**	1
	(b)	**The oxidation state of H decreases from 0 in H_2 to –1 in NaH. [1]** **Hence, H_2 is reduced and is the oxidising agent. [1]**	2
	(c)(i)	**The melting and boiling points of Group 1 metals decreases down the group.**	1
	(c)(ii)	**Sodium has a lower density than chromium.** *OR* **Sodium is a soft metal compared to chromium which is a hard metal.**	1
	(d)	 **Accept a straight line drawn for ionic radii without labelling as long as sketch shows that ionic radii of cations is smaller than that of atomic radii**	1
			[Total: 10]

<table>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td>11</td><td>(a)</td><td>58 °C accept values between 40 °C to 85 °C</td><td>1</td></tr>
<tr><td></td><td>(b)</td><td>Down the group, the size of the halogen / Group 17 molecule increases. [✓]

Hence, the strength of the intermolecular forces of attraction increases. [✓]
As more energy is required to overcome [✓] these forces of attraction, the melting point increases [✓] down the group.
2 to 3 [✓]: 1 mark, 4 [✓]: 2 marks</td><td>2</td></tr>
<tr><td></td><td>(c)(i)</td><td>Cl_2 (g) + $2Br^-$ (aq) → $2Cl^-$ (aq) + Br_2 (aq)</td><td>1</td></tr>
<tr><td></td><td>(c)(ii)</td><td>Colourless solution turns reddish-brown.</td><td>1</td></tr>
<tr><td></td><td>(d)</td><td>Iodine is less reactive than bromine. It is unable to displace the bromide ions in sodium bromide. Hence, no displacement reaction occurs. [1]

The brown solution is the colour of the unreacted aqueous iodine present in the resultant solution. [1]</td><td>2</td></tr>
<tr><td></td><td>(e)</td><td><table><tr><th>substance</th><th>oxidation state of Cl</th></tr><tr><td>Cl_2</td><td>0</td></tr><tr><td>NaCl</td><td>–1</td></tr><tr><td>NaClO</td><td>+1</td></tr></table>1 to 2 correct: 1 mark, 3 correct: 2 mark</td><td>2</td></tr>
<tr><td></td><td>(f)</td><td>M_r of $TiCl_3 \cdot xH_2O$ = 262.5
$48 + 3(35.5) + x[2(1) + 16]$ = 262.5
x = 6</td><td>1</td></tr>
<tr><td colspan="4">[Total: 10]</td></tr>
</table>