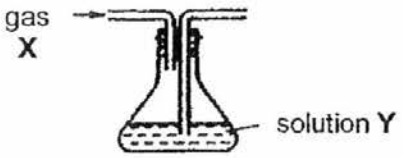
Section A [25 marks]
Answer all questions by shading on the OTAS.

A1 A sample of gas **X** may be dried by using solution **Y**. Which of the following is the most suitable piece of apparatus to use to obtain a dry sample of gas?

A



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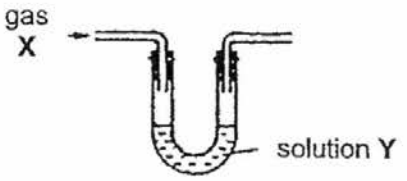

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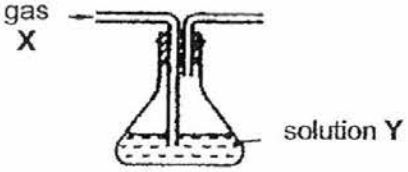

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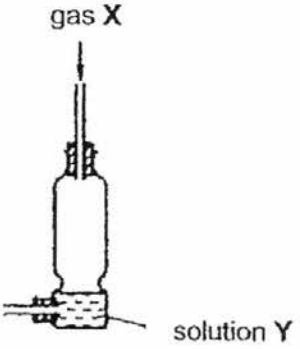


A2 Five students each dissolved an indigestion tablet containing magnesium hydroxide in 100 cm^3 of water. They then carried out titration using 25.0 cm^3 of their solutions with 1.0 mol/dm^3 of dilute hydrochloric acid, using the same indicator.

The results are shown in the table below.

student number	**1**	**2**	**3**	**4**	**5**
volume of hydrochloric acid / cm^3	20.4	20.5	20.4	20.6	22.3

Which statement best explains the result obtained by student number 5?

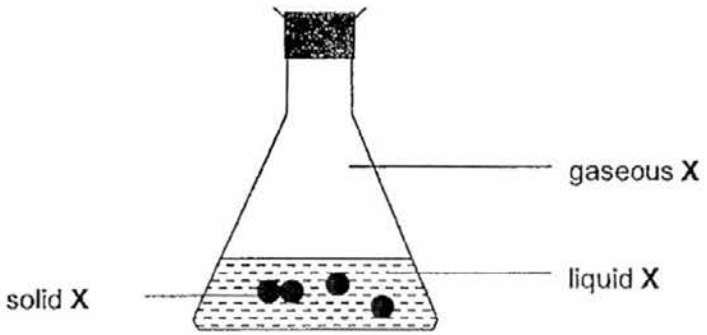
A The burette was washed with hydrochloric acid.

B The burette was washed with distilled water.

C The pipette was washed with the tablet solution.

D The conical flask was washed with the tablet solution.

A3 The conical flask contains compound **X** which is present in the solid, liquid and gaseous states.



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

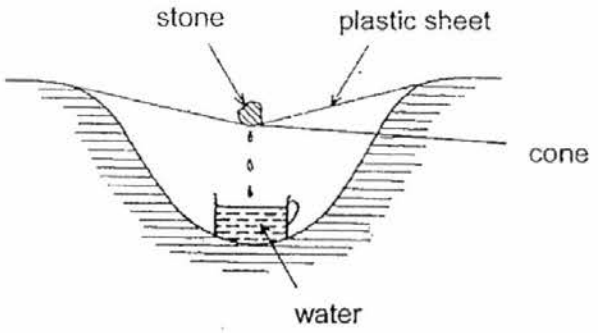
A Heat energy is released when **X** changes from liquid to solid.

B A gaseous **X** molecule has a lower mass than a liquid **X** molecule.

C A liquid **X** molecule and a solid **X** molecule possess the same amount of energy.

D Liquid **X** molecules vibrate about fixed positions.

A4 A desert survival kit contains a plastic sheet and a cup. A hole is dug in the ground and the sheet is stretched over the hole whilst a stone is placed in the middle of the sheet as shown below.



In the heat of the sun, moisture from the ground collects on the underside of the sheet, runs down to the point of the cone and drips into the cup. The **overall** process that takes place is an example of _____.

A condensation
B distillation
C filtration
D evaporation

A5 Some crystals of a compound were washed, filtered and then dried. A melting point determination gave a value of 197°C. The same crystals were then washed and dried again. The melting point this time was found to be 205°C.

Which one of the following statement is the best explanation for the above observation?

A The crystals were impure when the first melting point determination was carried out.

B The crystals were impure when the second melting point determination was carried out.

C The thermometer was faulty and gave inconsistent results.

D A smaller quantity of crystals was used for the first melting point determination.

A6 New paints are being developed for cars to give them a nice polishing finish. These paints are manufactured based on small flakes of silica, SiO_2.

In the structure of silica,

- Each silicon atom is bonded to **x** oxygen atoms.
- Each oxygen atom is bonded to **y** silicon atoms
- Each bond is a **z** type of bond.

What is the correct combination of **x**, **y** and **z** in these statements?

	x	y	z
A	2	1	ionic
B	2	1	covalent
C	4	2	ionic
D	4	2	covalent

A7 Naturally occurring iridium has a relative atomic mass of 192.2 and consists of two isotopes, $^{191}_{77}Ir$ and $^{193}_{77}Ir$. What is the percentage of the $^{191}_{77}Ir$ isotopes?

A 20 % **B** 40 % **C** 60 % **D** 80 %

A8 The equation below shows the reaction between the oxide of the metallic element **G** and dilute sulfuric acid.

$$GO\,(aq) + H_2SO_4\,(aq) \rightarrow GSO_4\,(aq) + H_2O\,(l)$$

Which particles are responsible for the electrical conductivity in G, GO and GSO_4?

	G	GO	GSO_4
A	electrons	electrons	cations and anions
B	cations	electrons	electrons
C	cations and anions	cations	electrons
D	electrons	cations and anions	cations and anions

A9 A sample of 0.10 mole of metal **Z** (A_r = 27) was burnt in oxygen. The resulting metal oxide has a mass of 5.1 g. What is the number of moles of oxygen that combined with 0.10 mole of metal **Z**?

A 0.075 mol
B 0.10 mol
C 0.15 mol
D 1.5 mol

A10 Chlorine gas is a severe irritant to the eyes and respiratory system. The maximum safe tolerance level of chlorine gas in the air is 0.005 mg/dm^3.
How many chlorine atoms are present in 1 dm^3 of air at this tolerance level?

A $\frac{0.005}{71} \times 6 \times 10^{23}$

B $\frac{0.005}{6 \times 10^{23}} \times 71$

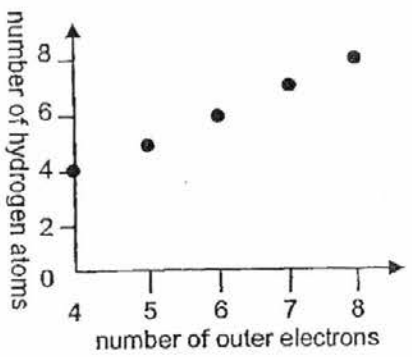
C $\frac{0.005}{1000} \times \frac{1}{71} \times 2 \times 6 \times 10^{23}$

D $\frac{0.005}{6 \times 10^{23}} \times 71 \times 2 \times 6 \times 10^{23}$

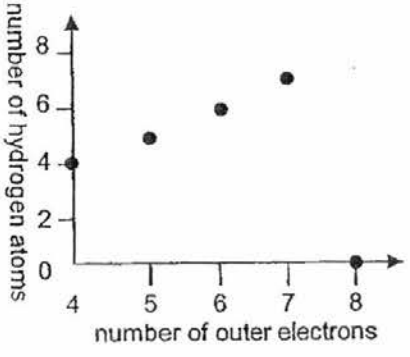
A11 25.0 cm^3 of 0.20 mol/dm^3 of acid **X** requires 30.0 cm^3 of 0.50 mol/dm^3 of sodium hydroxide for complete neutralisation. What is the basicity of acid **X**?

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

A12 Which of the following diagrams best represents the relationship between the number of outer electrons in an atom and the number of hydrogen atoms that can combine with the atom?



A



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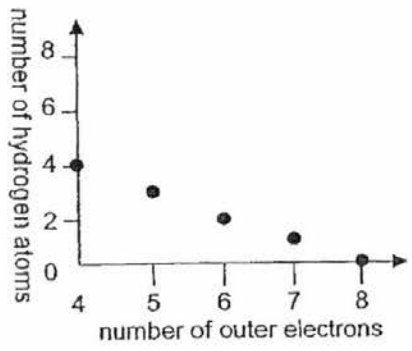

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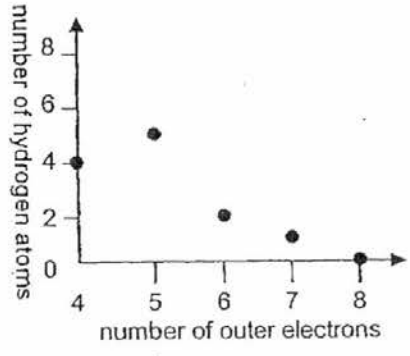


D

A13 Element R forms compounds with the following chemical formulae:

MgR H_2R CR_2 Li_2R

Which group of the Periodic Table does element R belong to?

A Group I
B Group II
C Group IV
D Group VI

A14 Which of the following statements is **false** about the elements in the Periodic Table?

A I and J are in the same period. I and J can have the same valency.

B T and U are two consecutive elements in the Periodic Table. U has greater atomic number. The relative atomic mass of U must be higher than that of T.

C X is a metal, Y is a non-metal. X and Y can be in the same group.

D Z forms an oxide of formula ZO_2. Z must be in Group VI.

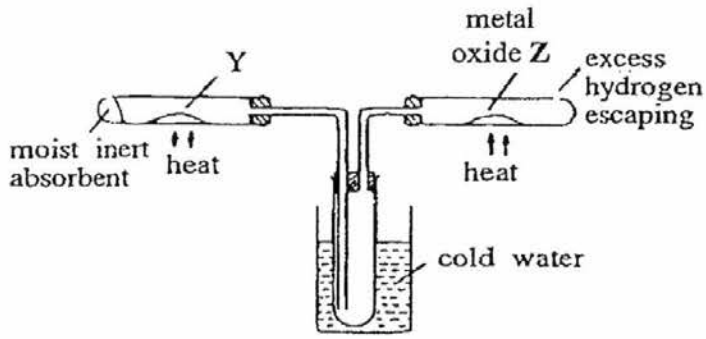
A15 The table below shows the method of extraction of metals **X**, **Y** and **Z** from their ores.

metal	method
X	reduction by carbon
Y	electrolysis
Z	reduction by hydrogen

Which of the following shows the correct order of the reactivity of metals from the least reactive to the most reactive?

A Y, X, Z
B X, Y, Z
C Z, X, Y
D X, Z, Y

A16 The diagram below shows an experimental set-up used to demonstrate the reduction of a metallic oxide **Z** by hydrogen which is produced by the action of steam on the metal **Y**.



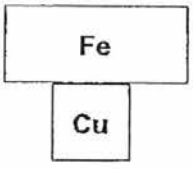
Which of the following could **Y** and **Z** be?

	Y	Z
A	zinc	copper (II) oxide
B	copper	zinc oxide
C	sodium	potassium oxide
D	magnesium	calcium oxide

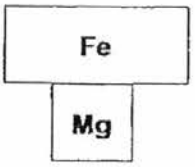
A17 Metal **X** is more reactive than metal **Y** which is more reactive than metal **Z**.
The sulfates of **X** and **Z** are colourless; the sulfate of **Y** is blue.
Which observation is correct?

	metal added to solution of sulfate	solution of sulfate	colour change
A	X	Y	blue → colourless
B	Y	X	colourless → blue
C	Y	Z	blue → colourless
D	Z	Y	blue → colourless

A18 Two large pieces of iron are placed in water.
In experiment **I**, a small piece of copper is attached to the iron.
In experiment **II**, a small piece of magnesium is attached to the iron.



experiment I



experiment II

Which are the equations for reactions that would take place in experiment **I** and experiment **II**?

	reaction in experiment I	reaction in experiment II
A	$Cu\ (s) \rightarrow Cu^{2+}\ (aq) + 2e^-$	$Fe\ (s) \rightarrow Mg^{2+}\ (aq) + 2e^-$
B	$Cu\ (s) \rightarrow Cu^{2+}\ (aq) + 2e^-$	$Mg\ (s) \rightarrow Mg^{2+}\ (aq) + 2e^-$
C	$Fe\ (s) \rightarrow Fe^{2+}\ (aq) + 2e^-$	$Fe\ (s) \rightarrow Mg^{2+}\ (aq) + 2e^-$
D	$Fe\ (s) \rightarrow Fe^{2+}\ (aq) + 2e^-$	$Mg\ (s) \rightarrow Mg^{2+}\ (aq) + 2e^-$

A19 Dry crystals of citric acid are placed on a piece of dry blue litmus paper. The litmus paper will _____.

A turn red

B remain blue

C become bleached

D turn red then bleached

A20 Elements **R**, **S** and **T** are found in the Periodic Table. The table below shows the properties of the elements or the compounds of the elements **R**, **S** and **T**.

R	S	T
• Oxide of **R** dissolves readily in water to form a solution which reacts with potassium carbonate to produce a gas which forms a white precipitate in limewater.	• Oxide of **S** dissolves in water to form a solution with a pH greater than 7. • **S** reacts vigorously with cold water to produce a gas which gives off a 'pop' sound with a lighted splint.	• Oxide of **T** is insoluble in water, and reacts with both hydrochloric acid and dilute aqueous sodium hydroxide to form a salt.

Which of the following are the correct identities of **R**, **S** and **T**?

	R	S	T
A	sulfur	magnesium	sodium
B	sulfur	sodium	lead
C	carbon	nitrogen	lead
D	lead	potassium	nitrogen

A21 Most lead salts do not dissolve in water, but lead (II) chloride is soluble in boiling water and lead (II) nitrate is soluble in both hot and cold water.

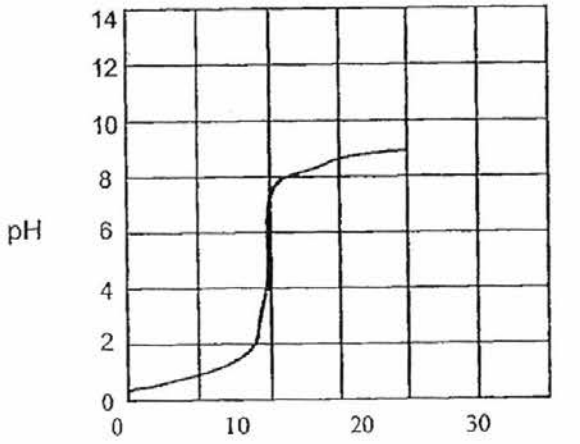
From this information, which of the following methods could **not** be used to prepare the product listed?

	method	**solid product**
A	Boil lead (II) chloride in water, then add dilute sulfuric acid	lead (II) sulfate
B	Add dilute nitric acid to lead (II) carbonate, then add aqueous sodium iodide	lead (II) iodide
C	Add dilute sulfuric acid to lead (II) carbonate	lead (II) sulfate
D	Add aqueous sodium carbonate to aqueous lead (II) nitrate	lead (II) carbonate

A22 Different indicators change colour over different pH ranges and it is important to choose the correct indicator to obtain an accurate result in a titration.

indicator	pH range for the colour change	colour	
		lower pH	higher pH
indigo carmine	11.6 to 14.0	blue	yellow
methyl red	4.2 to 6.3	red	yellow
methyl violet	0.0 to 1.6	yellow	violet
phenolphthalein	8.2 to 10.0	colourless	pink

If a certain weak base is added to a strong acid, the following curve is obtained showing the variation of pH with the volume of weak base added.



Which of the indicators below would be the best choice to use in the titration?

A indigo carmine
B phenolphthalein
C methyl violet
D methyl red

A23 Excess aqueous barium nitrate was added to a sample of sodium sulfate solution. The precipitate formed was filtered out. What are the ions present in the filtrate?

A Ba^{2+}, Na^{+}, NO_3^{-}
B Ba^{2+}, SO_4^{2-}
C Na^{+}, NO_3^{-}
D Na^{+}, SO_4^{2-}

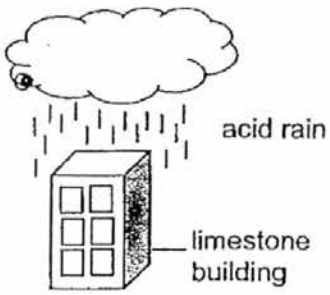
A24 Clare needed to prepare an aqueous sulfate solution using a metal hydroxide, according to the reaction as follows:

$\mathbf{M}(OH)_2\ (s) + H_2SO_4\ (aq) \rightarrow \mathbf{M}SO_4\ (aq) + 2H_2O\ (l)$ where **M** = metal

Which metal hydroxide is **not** suitable for the method Clare is using?

A zinc hydroxide
B magnesium hydroxide
C iron (III) hydroxide
D barium hydroxide

A25 The diagram below shows a building made of limestone showing signs of corrosion by acid rain.



What could be found near the area of this limestone building?

A A city that has many cars and nearby coal stations.
B A city that uses a large amount of CFCs.
C Vegetation undergoing bacterial decay.
D Vegetation undergoing bacterial decay and usage of CFCs.

Section B [45 marks]
Answer **all** questions in the spaces provided.

B1 Table B1.1 shows the properties of six substances, **A** to **F**.

substance	density (g/cm^3)	melting point (^0C)	boiling point (^0C)	electrical conductivity	other properties
A	0.97	89	883	conductor	forms a basic oxide
B	3.51	> 3550	4827	non-conductor	forms an acidic oxide
C	2.25	3680	4827	conductor	forms an acidic oxide
D	3.12	-7	59	non-conductor	does not burn
E	0.001	-169	-104	non-conductor	burns to form CO_2 and H_2O
F	2.17	801	1413	non-conductor when solid: conductor when molten	dissolves in water

Table B1.1

With reference to Table B1.1,

(a) State which substance is a metal. **[1]**

.....

(b) State which substance has a giant ionic lattice structure. **[1]**

.....

(c) Suggest why substance E has an arrangement of widely spaced particles at room temperature and pressure (25°C). **[1]**

.....

(d) Substance **B** and **C** are different forms of the same element with an atomic number of 6.

(i) Give evidence from Table B1.1 that indicates that **B** and **C** are non-metals. **[1]**

.....

(ii) Suggest why there is a difference in electrical conductivity between substances **B** and **C**. **[2]**

.....

.....

.....

B2 The essential oil extracted from the fresh flowers of the lavender plant is widely used for medicinal and aromatic purposes. Lavender oil is antiseptic and anti-bacterial. It can be applied directly to burns and stings, where it soothes the pain. It also stimulates blood flow to the affected area, thus promoting healing.

Table B2.1 shows how the oil is extracted from the lavender plant.

step	description
1	The lavender plants are harvested
2	
3	The crushed plants are mixed with water
4	
5	The lavender oil and a little water evaporate.
6	
7	
8	The lavender oil is separated and piped away.

Table B2.1

(a) Match statements **A**, **B**, **C** and **D** with steps **2**, **4**, **6** and **7** in Table B2.1. **[2]**

A. The vapours are cooled and condensed.
B. The mixture is heated in a distillation flask.
C. The lavender oil floats on top of the water.
D. The lavender plants are crushed.

Write your answers in Table B2.2.

step	statement
2	
4	
6	
7	

Table B2.2

(b) Suggest how lavender oil is separated from the mixture in step **8.** **[1]**

.....

B3 Sir James Jeans was an English physicist who once described an atom of carbon as being like six bees buzzing around a space that is equivalent to the size of a football stadium.

(a) Suggest what the 'bees' represented in the above description of the carbon atom. **[1]**

.....

(b) Explain, using your knowledge of the atomic structure, what prevents the 'bees' from flying out of the football stadium. **[1]**

.....

.....

(c) State what is missing from Sir James Jeans' description of an atom of carbon. **[1]**

.....

B4 A plasma is a gaseous mixture in which all the atoms lose all their electrons, leaving behind only their nucleus.

When a sample of plasma is passed between two electrically charged plates, **A** and **B**, ^{1}H and ^{4}He nuclei are deflected as seen in Figure B4.1. The angle of deflection of the ^{1}H and ^{4}He nuclei are 2° and 4° respectively.

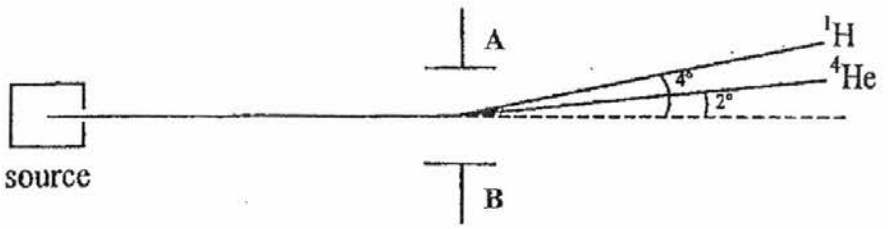


Figure B4.1

(a) Complete Table B4.2 to show the number of sub-atomic particles in the nuclei of ^{1}H and ^{4}He. **[3]**

	^{1}H nucleus	^{4}He nucleus
no. of protons		
no. of electrons		
no. of neutrons		

Table B4.2

(b) Deduce a factor that affects the angle of deflection of the ^{1}H and ^{4}He nuclei when passed between the two charged plates, **A** and **B**, as shown in Figure B4.1 **[1]**

.....

.....

B5 In 1886, Henri Moissan succeeded in obtaining fluorine by the electrolysis of molten potassium hydrogendifluoride, KHF_2, which is an ionic compound containing one cation and one anion.

(a) State the chemical formula of the anion present in potassium hydrogendifluoride. **[1]**

.....

(b) Predict and explain in terms of bonding, whether potassium hydrogendifluoride will have a low or high melting point. **[2]**

.....

.....

(c) Fluoride ions are often added to household water supplies to help prevent tooth decay. Fluoride ions strengthen tooth enamel by converting the hydroxyapatite, $Ca_3(PO_4)_2.Ca(OH)_2$, present in tooth enamel, into fluoroapatite, $Ca_3(PO_4)_2.CaF_2$.

Suggest why hydroxyapatite is soluble in the acids, formed from sugars in food, whereas fluoroapatite is not. **[1]**

.....

.....

(d) Fluorine is also part of the compound, fluoroacetonitrile, CH_2FCN, which is commonly used in medicinal creams. The structural formula of fluoroacetonitrile is shown in Figure B5.1. Draw a 'dot-and-cross' diagram to show the bonding present in fluoroacetonitrile. Show only the outer electrons. **[3]**

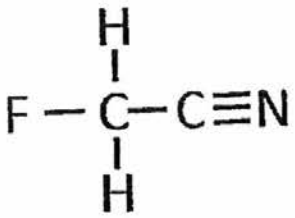


Figure B5.1

B6 Potassium hydroxide solution is used to peel peaches commercially. The peaches are placed in a 7% potassium hydroxide solution (7.0 g of potassium hydroxide per 100 cm^3 of solution) for 3 minutes. The peaches are then washed, cut in half and frozen.

(a) Calculate the concentration, in mol/dm^3, of the 7% potassium hydroxide solution. **[2]**

(b) The concentration of the potassium hydroxide solution must not fall below 1.0 mol/dm^3 in the process above. This is checked at intervals by the titration of 25.0 cm^3 of the potassium hydroxide solution with 0.75 mol/dm^3 of sulfuric acid.

(i) Construct a balanced chemical equation for the complete neutralization of sulfuric acid and potassium hydroxide. [1]

.....

(ii) Calculate the lowest volume of sulfuric acid required for complete neutralisation of potassium hydroxide at 1.0 mol/dm^3. [3]

B7 Aluminium is used to make drink cans.
Aluminium for making cans is produced either from recycling used cans or by extraction from bauxite ore by electrolysis.
Table B7.1 shows information about these processes.

process	recycling used cans	extraction from bauxite
separation	Physical sorting. Steel and aluminium cans are separated using a magnet. Aluminium cans are shredded into small pieces.	Physical extraction and breaking up of ore. Concentrated sodium hydroxide is used to dissolve aluminium oxide to separate it from insoluble metal oxide impurities.
main process	Heating to 700°C.	Dissolving in ionic solvent at 900°C. Electrolysis to form molten aluminium. Carbon dioxide is formed in the process.
finishing	Cooling and shaping of molten aluminium.	Cooling and shaping of molten aluminium.

Table B7.1

(a) Use the information in Table B7.1 to estimate the melting point of aluminium. **[1]**

.....

(b) The extraction of aluminium from bauxite uses 95% more energy than the recycling of used aluminium cans.

Use the information from Table B7.1 to explain why. **[2]**

.....

.....

(c) The extraction of aluminium from bauxite creates waste products that cause harm to the environment.

Two of these waste products are concentrated sodium hydroxide and carbon dioxide.

Why would each of these two waste products cause harm if they were released directly into the environment? **[2]**

.....

.....

.....

(d) Recycling used cans uses less energy and produces less waste than extraction from bauxite.

Give one other reason why recycling metals such as aluminium is important. **[1]**

.....

.....

(e) Some aluminium is used to make Duralumin. Duralumin has many uses, including to build aircraft.

Duralumin is a mixture of aluminium with added copper, magnesium and manganese.

(i) What is the name given to a mixture such as Duralumin? **[1]**

.....

(ii) Suggest why Duralumin is more useful for building aircraft than pure aluminium. **[1]**

.....

B8 A thin layer of ozone, O_3, is present high in the Earth's atmosphere.

(a) Explain why the ozone layer is important in terms of human health. **[1]**

.....

.....

(b) Chlorofluorocarbons, CFCs, speed up the conversion of ozone to oxygen. Construct a balanced chemical equation for this reaction. **[1]**

.....

(c) Figure B6.1 shows how both the world's CFC production and the amount of high level ozone at the South Pole have changed over the last 26 years.

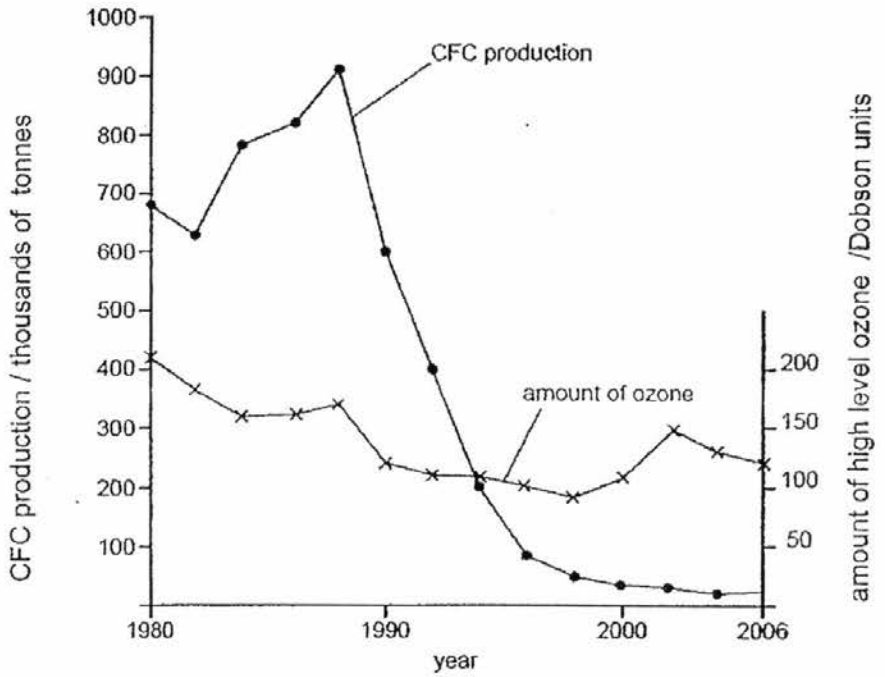


Figure B8.1

With reference to the data shown in Figure B8.1, describe and explain the general trend between the world's CFC production and the amount of high-level ozone in the atmosphere at the South Pole from 1980 to 1990. **[2]**

.....

.....

.....

B9 Table B9.1 shows the properties of the different types of oxides formed by the elements in Group IV.

element	formula of oxides formed	stability of oxide	type of oxide
carbon	CO	readily oxidized to dioxide	neutral
	CO_2	stable even at high temperatures	acidic
silicon	SiO	readily oxidized to dioxide	neutral
	SiO_2	stable even at high temperatures	acidic
germanium	GeO	readily oxidized to dioxide	amphoteric
	GeO_2	stable even at high temperatures	amphoteric
lead	PbO	stable	amphoteric
	PbO_2	decomposes to PbO on warming	amphoteric

Table B9.1

(a) Elements in the same group of the Periodic Table have similar chemical properties. With reference to Table B7.1, state one similarity in the formula of the oxides formed by the Group IV elements. **[1]**

.....

.....

(b) Using information from Table B9.1, describe two trends in terms of the stability and type of the oxides when going down Group IV. **[2]**

.....

.....

.....

(c) What does the trend in the nature of the oxides suggest about the metallic character of the elements down Group IV? **[1]**

.....

.....

Section C [30 marks]

Answer questions C1 and C2 and choose EITHER question C3 or C4.
Write your answers in the spaces provided.

C1 An experiment is conducted using the set-up shown in Figure C1.1 to investigate the electrical conductivity of various substances. The electrical conductivity can be measured by obtaining the conductance value using a datalogger. The higher the conductance value, the higher the electrical conductivity of the substance. The results obtained are shown in Table C1.2.

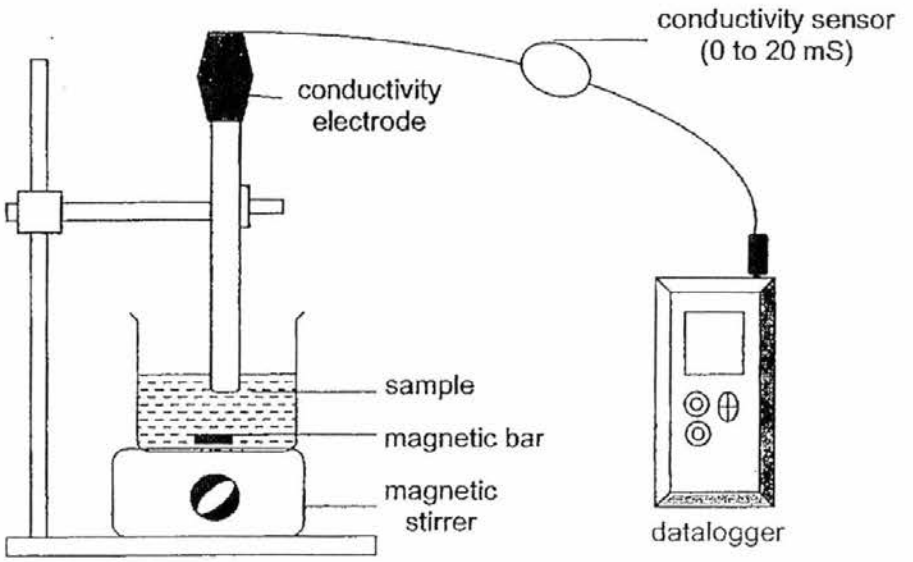


Figure C1.1

no.	sample	conductance value / mS
1	distilled water	0.00
2	solid magnesium oxide	0.00
3	0.10 mol/dm^3 aqueous sodium hydroxide	17.40
4	1.00 mol/dm^3 dilute sulfuric acid	31.40
5	0.10 mol/dm^3 dilute sulfuric acid	31.40
6	0.01 mol/dm^3 dilute sulfuric acid	6.11
7	1.00 mol/dm^3 dilute ethanoic acid	1.39
8	cooking oil	0.00

Table C1.2

(a) 1.00 mol/dm^3 dilute sulfuric acid is diluted ten times and hundred times in order to obtain 0.10 mol/dm^3 and 0.01 mol/dm^3 of dilute sulfuric acid respectively. With reference to Table C1.2, what can you conclude about the effects of dilution on electrical conductivity of 1.00 mol/dm^3 of sulfuric acid? **[2]**

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(b) A student made the following conclusion about the results shown in Table C1.2.

"All compounds which have ions can conduct electricity"

Do you agree or disagree with the conclusion? Explain your reasoning. **[3]**

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(c) (i) With reference to Table C1.2, describe the relationship between the strength of acid and its electrical conductivity. **[1]**

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(ii) Explain the relationship described in (c)(i) with examples provided in Table C1.2. **[3]**

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(d) Sulfuric acid can react with sodium hydroxide to produce two salts. State the chemical formulae of the two salts produced from the reaction. **[1]**

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C2 Insoluble salts are prepared by precipitation.

(a) Preparation of the insoluble salt, calcium fluoride, is described in Table C2.1.

step	description
1	30 cm^3 of 1.00 mol/dm^3 aqueous sodium fluoride is added to 20 cm^3 of 1.00 mol/dm^3 aqueous calcium chloride.
2	The mixture is filtered and the residue is washed with distilled water.
3	The residue, calcium fluoride, is heated in an oven.

Table C2.1

(i) Write a balanced chemical equation for the above precipitation reaction, including state symbols. **[2]**

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(ii) Show, by means of calculation, which of the reagents is added in excess to prepare calcium fluoride. **[3]**

(iii) Explain why the residue needs to be washed with distilled water and heated in an oven. **[2]**

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(b) The chemical formulae of insoluble compounds can be found by precipitation reactions. The following experiment was carried out to find out the formula of the phosphate of metal **T**.

12.0 cm^3 of an aqueous solution of the nitrate of metal **T** was added to different volumes of phosphate solution. The concentration of both solutions used was 1.00 mol/dm^3. When the precipitate had settled, its height was measured, as shown in Figure C2.1.

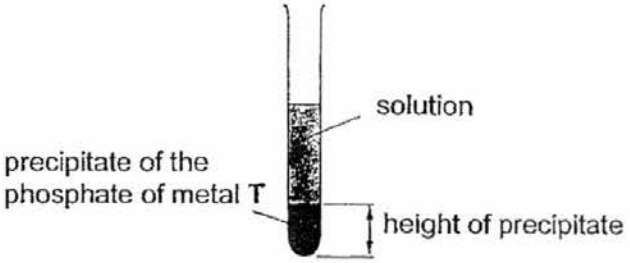

Figure C2.1

The results obtained from the experiment is shown in Figure C2.2.

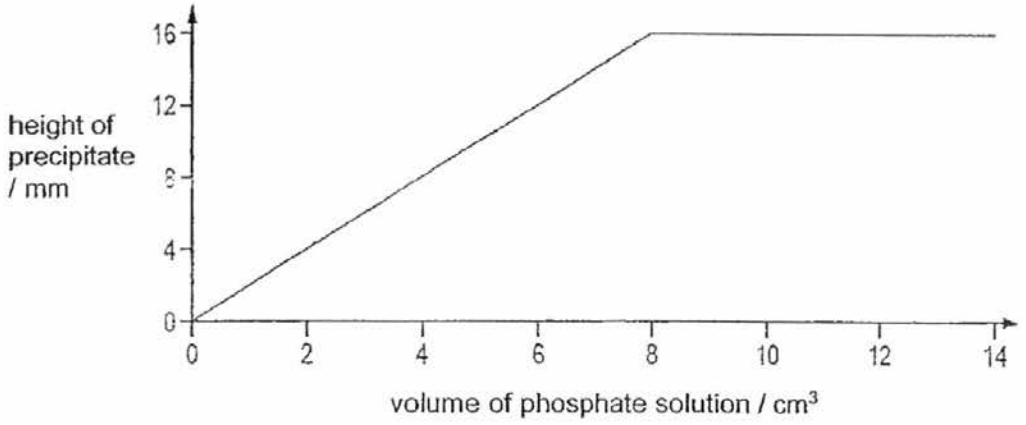

Figure C2.2

With reference to the data from Figure C2.2, work out the formula of the phosphate of metal **T**. [3]

EITHER

C3 Some companies manufacture products such as soil improvers to sell to farmers. Compounds in the soil improvers neutralize acidic soil.

Table C3.1 shows information about some substances that companies use to make these soil improvers.

substance	chemical composition	effectiveness at neutralising acidic soil	other points
limestone	$CaCO_3$	fair	insoluble in water needs to be ground to a very fine powder
quicklime	CaO	very high	made by heating limestone to a high temperature reacts with water to form an alkaline solution, giving off a lot of heat in the process
slaked lime	$Ca(OH)_2$	very high	made by adding water to quicklime to form an alkaline solution, giving off a lot of heat in the process
blast furnace slag (solid waste from the blast furnace)	mixture of $CaCO_3$ and $CaSiO_3$ with other impurities	fair	insoluble in water impurities include silicon oxides and other non-metal compounds composition of mixture varies

Table C3.1

(a) Use the information in Table C3.1 to suggest why limestone is less effective at neutralizing the acidic soil as compared to quicklime and slaked lime. **[2]**

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(b) (i) Suggest an advantage of manufacturing soil improvers from blast furnace slag rather than the other substances. **[1]**

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(ii) Blast furnace slag may also contain impurities of Group IV oxides and Group V oxides.

These impurities cause the blast furnace slag to be less effective at neutralising acidic soil.

Explain why Group IV and Group V oxides cause the blast furnace slag to be less effective at neutralising acidic soil. **[2]**

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(c) The calcium content of the soil improvers is important because it provides minerals to the soil. Show by calculation that quicklime has a higher percentage mass of calcium than slaked lime. **[2]**

(d) Quicklime is made by strongly heating limestone in a kiln. The reaction produces carbon dioxide. A kiln can hold 25 tonnes of limestone. (1 tonne = 1×10^6 g)

Assuming that limestone is pure calcium carbonate, calculate the volume of carbon dioxide produced when 25 tonnes of limestone is heated. **[3]**

OR

C4 Figure C4.1 shows the solubility curves of various substances, and how the solubilities of substances vary with temperature. The solubility of a substance refers to the maximum mass of solute dissolved in a fixed volume of water at a certain temperature. In this experiment, all the substances were dissolved in 100 g of water.

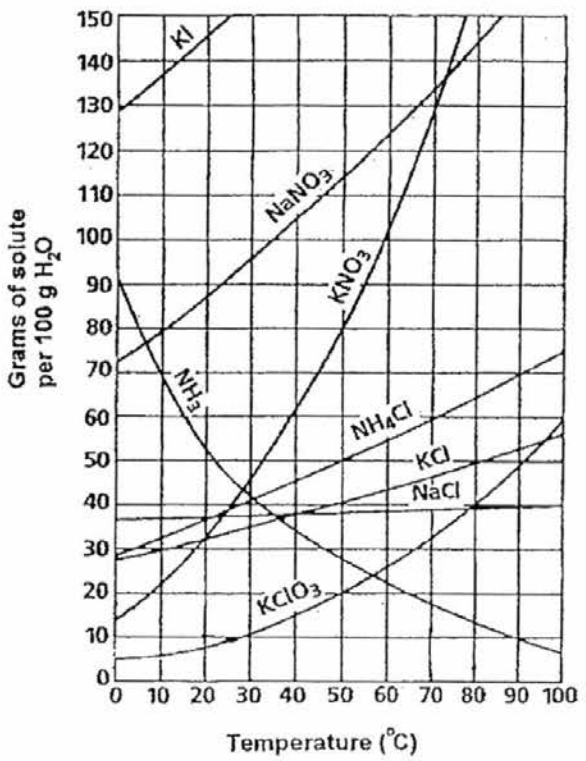

Figure C4.1

(a) Describe the relationship between solubility and temperature for the substances shown in Figure C4.1. **[2]**

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(b) Give a conclusion based on the solubility curves for the chloride and nitrate salts in Figure C4.1. **[1]**

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(c) Two saturated solutions, sodium chloride and sodium nitrate, are allowed to cool from 70°C to room temperature (25°C).

With reference to Figure C4.1, which solution produced more crystals?

Explain how you arrive at your conclusion. **[2]**

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(d) Based on your answer in **(c)**, explain why crystallization is never used to obtain sodium chloride crystals from a sample of sodium chloride solution. **[1]**

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(e) Describe how a sample of sodium chloride solution can be prepared in a laboratory. Name the chemical reagents used. **[4]**

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End of Paper

The Periodic Table of the Elements

Group I	Group II											Group III	Group IV	Group V	Group VI	Group VII	Group 0
							1 H hydrogen 1										4 He helium 2
7 Li lithium 3	9 Be beryllium 4											11 B boron 5	12 C carbon 6	14 N nitrogen 7	16 O oxygen 8	19 F fluorine 9	20 Ne neon 10
23 Na sodium 11	24 Mg magnesium 12											27 Al aluminium 13	28 Si silicon 14	31 P phosphorus 15	32 S sulfur 16	35.5 Cl chlorine 17	40 Ar argon 18
39 K potassium 19	40 Ca calcium 20	45 Sc scandium 21	48 Ti titanium 22	51 V vanadium 23	52 Cr chromium 24	55 Mn manganese 25	56 Fe iron 26	59 Co cobalt 27	59 Ni nickel 28	64 Cu copper 29	65 Zn zinc 30	70 Ga gallium 31	73 Ge germanium 32	75 As arsenic 33	79 Se selenium 34	80 Br bromine 35	84 Kr krypton 36
85 Rb rubidium 37	88 Sr strontium 38	89 Y yttrium 39	91 Zr zirconium 40	93 Nb niobium 41	96 Mo molybdenum 42	– Tc technetium 43	101 Ru ruthenium 44	103 Rh rhodium 45	106 Pd palladium 46	108 Ag silver 47	112 Cd cadmium 48	115 In indium 49	119 Sn tin 50	122 Sb antimony 51	128 Te tellurium 52	127 I iodine 53	131 Xe xenon 54
133 Cs caesium 55	137 Ba barium 56	139 La lanthanum 57 *	178 Hf hafnium 72	181 Ta tantalum 73	184 W tungsten 74	186 Re rhenium 75	190 Os osmium 76	192 Ir iridium 77	195 Pt platinum 78	197 Au gold 79	201 Hg mercury 80	204 Tl thallium 81	207 Pb lead 82	209 Bi bismuth 83	– Po polonium 84	– At astatine 85	– Rn radon 86
– Fr francium 87	– Ra radium 88	– Ac actinium 89 †															

58-71 Lanthanoid series

90-103 Actinoid series

140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	– Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	162 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
232 Th thorium 90	– Pa protactinium 91	238 U uranium 92	– Np neptunium 93	– Pu plutonium 94	– Am americium 95	– Cm curium 96	– Bk berkelium 97	– Cf californium 98	– Es einsteinium 99	– Fm fermium 100	– Md mendelevium 101	– No nobelium 102	– Lr lawrencium 103

Key: a / X / b — a = relative atomic mass; X = atomic symbol; b = proton (atomic) number

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

East Spring Secondary School
3E Pure Chemistry 2SE 2016
Marking Scheme

Section A (25m)

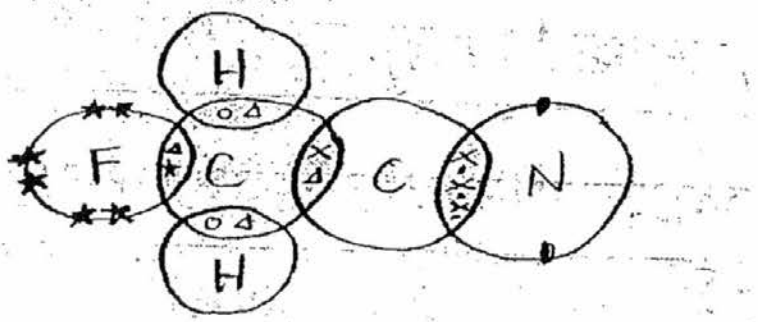
1	2	3	4	5	6	7	8	9	10
B	D	A	B	A	D	B	D	A	C
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
C	B	D	D	C	A	A	D	B	B
21	**22**	**23**	**24**	**25**					
C	D	A	D	A					

Section B (45m)

Qn. No	Answer	Marks
B1a	A	1
B1b	F	1
B1c	It has the **melting point and boiling point below 25°C/ boiling point below 25°C /** It is a **gas.**	1
B1di	They form **acidic oxides.**	1
B1dii	For substance **B**, **all four valence electrons / all valence electrons are used up for bonding**. Hence there are **no free moving / mobile electrons** to carry electrical charges; For substance **C**, there is **one** valence **electron not involved in bonding / one unbonded electron** that will be **delocalised**. These delocalised **free moving / mobile electrons** carry electrical charges / conduct electricity	1 1
B2a	2 - **D** 4 - **B** 6 - **A** 7 - **C**	4c – 2M 2 – 3c – 1M 1c – 0M
B2b	The lavender oil is separated from water using a **separating funnel**.	1
B3a	Electrons	1
B3b	It is due to the electrostatic **forces of attraction** between the **electrons/bees** and the **positively charged nucleus**	1
B3c	Neutrons / the nucleus / protons	1

<table>
<tr><td></td><td></td><td></td></tr>
<tr><td>B4a</td><td>
<table>
<tr><td></td><td>^{1}H nucleus</td><td>^{4}He nucleus</td></tr>
<tr><td>No. of protons</td><td>1</td><td>2</td></tr>
<tr><td>No. of electrons</td><td>0</td><td>0</td></tr>
<tr><td>No. of neutrons</td><td>0</td><td>2</td></tr>
</table>
</td><td>6c – 3M
4 – 5c – 2M
2 – 3c – 1M
1c - 0M</td></tr>
<tr><td>B4b</td><td><u>Mass</u> of particle</td><td>1</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>B5a</td><td>HF_2^-</td><td>1</td></tr>
<tr><td>B5b</td><td><u>High</u> melting point;

<u>Large amount of energy</u> required to <u>overcome strong ionic bonds between ions</u></td><td>1

1</td></tr>
<tr><td>B5c</td><td>Hydroxyapatite <u>contains a base/ hydroxide / calcium hydroxide</u> which can <u>react with</u> the <u>acids</u> present in food.</td><td>1</td></tr>
<tr><td>B5d</td><td> 

Key: electron of C – X
electron of C – Δ
electron of N – •
electron of F – ★</td><td>Corr sharing of e between C and N – 1M

Corr sharing of e between C and H, C and F, C and C – 1M

Corr e.c. for C, F, H and N – 1M

Total 3M</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>B6a</td><td>No of mol of KOH = 7/ (39+16+1) = 0.125 mol
Concentration of KOH = 0.125/(100/1000) = <u>1.25 mol/dm^3</u></td><td>M1
A1</td></tr>
<tr><td>B6bi</td><td>H_2SO_4 + 2 KOH → K_2SO_4 + 2 H_2O</td><td>1</td></tr>
<tr><td>B6bii</td><td>No of mol of KOH = 25/1000 dm^3 x 1.0 mol/dm^3 = 0.025 mol

Given : Find
KOH : H_2SO_4
2 : 1</td><td>M1</td></tr>
</table>

	No. of mol of H_2SO_4 = 0.025 /2 = **0.0125 mol** volume of H_2SO_4 = mol / conc = 0.0125 / 0.75 = **0.0167 dm^3 (3.s.f)**	M1 A1
B7a	Any temperature between 650°C to below 700°C	1
B7b	Extraction of aluminum requires a **higher** operating **temperature of 900°C** compared to recycling of used cans which is **700°C**; **Electrolysis/electricity/electrical energy** is needed to extract aluminium from bauxite;	1 1
B7c	Concentrated sodium hydroxide is a **strong alkali**, as such it causes an **increase in the pH of the soil/make soil alkaline/increase alkalinity of the soil, causing crops not to grow well** / Concentrated sodium hydroxide is a **strong alkali**, as such it causes **water bodies/lakes/rivers to become alkaline and kill aquatic life**; Carbon dioxide is a **greenhouse gas** which leads to **global warming**, causing **climate change/average global temperature to rise and ice caps or glaciers to melt leading to rising sea levels that cause low-lying areas to flood**;	1 1
B7d	**Aluminium ore** is a **finite/limited** resource, hence there is a need to **conserve/save** them to ensure there is **sufficient for future generation**;	1
B7ei	Alloy	1
B7eii	Duralumin is **stronger and harder** than pure aluminium Reject explanation of why alloy is stronger or harder	1
B8a	ozone **absorbs harmful ultraviolet radiation / light / rays prevents excessive ultraviolet rays from reaching the Earth's surface** thus preventing **eye cataracts / skin cancer.**	1
B8b	$2O_3 \rightarrow 3O_2$	1
B8c	As the amount of **CFC production increases**, the amount of **ozone decreases**; This is because **CFC leads to the depletion of the ozone layer.**	1 1
B9a	All the elements form **two types of oxides / one monoxide and a dioxide / oxides with one and two oxygen atoms respectively**	1
B9b	Going **down the group**, the **dioxide becomes less stable while the monoxide becomes more stable**; **Going down the group**, the **oxides become more basic / change from**	1

	neutral/acidic to amphoteric	1
B9c	**Metallic character increases** down the group.	1

Section C (30 M)

Qn. No	Answer	Marks
C1a	When the solution is **diluted ten times**, there is **no effect** on the electrical conductivity / electrical conductivity **remains the same.** However, when the solution is **diluted one hundred times**, **electrical conductivity decreases.**	1 1
C1b	**Disagree**; This is because **solid magnesium oxide** is an ionic compound but it **does not conduct electricity** while **aqueous sodium hydroxide, dilute sulfuric acid and ethanoic acid conduct electricity**; as there are **no free moving / mobile ions in the solid state,** as the **ions are in fixed positions** in the **giant ionic lattice**. In **aqueous state, acids / alkalis dissociates** to produce **free moving / mobile ions**, thus it is able to conduct electricity. In the **aqueous state**, there are **free moving / mobile ions** to conduct electricity.	1 1 1
C1ci	The **stronger the acid, the higher the electrical conductivity / the better it can conduct electricity.** OR The **weaker the acid, the lower the electrical conductivity / the lesser the ability to conduct electricity.**	1
C1cii	**Sulfuric acid** is a **strong acid that ionises / dissociates completely in water** ; **Ethanoic acid** is a **weak acid** that **ionises / dissociates partially in water**. Thus, sulfuric acid has a **higher concentration of mobile hydrogen ions / mobile ions** in water, and has a **higher electrical conductivity**.	1 1 1
C1d	$NaHSO_4$ and Na_2SO_4	1
C2ai	$2NaF\ (aq) + CaCl_2\ (aq) \rightarrow CaF_2\ (s) + 2NaCl\ (aq)$	Corr eqn – 1M Corr s.s – 1M
C2aii	No. of mol of NaF = 30/1000 x 1 = **0.03 mol**	No. of mol

	No. of mol of $CaCl_2$ = 20/1000 x 1 = **0.02 mol** Assume NaF as limiting reactant. Given : Find NaF : $CaCl_2$ 2 : 1 0.03 mol : **0.015 mol needed** Hence **$CaCl_2$ is in excess**.	of NaF and $CaCl_2$ – 1M M1 A1 Total 3M
C2aiii	Residue needs to be washed with distilled water to **remove impurities** such as the excess calcium chloride reagent; Residue is heated to **evaporate / remove the water** to **obtain a dry** sample of precipitate	1 1
C2b	No of mol of PO_4^{3-} = 8/1000 x 1 = **0.008 mol** No of mol of T^{n+} ions = 12/1000 x 1 = **0.012 mol.** Mole Ratio T^{n+} : PO_4^{3-} 0.012 mol : 0.008 mol 3 : 2 Therefore, 2 mol of phosphate ion precipitates 3 mol of metal T, the formula of phosphate of metal T is **$T_3(PO_4)_2$**	M1 M1 A1
C3a	**Limestone is insoluble** in water, whereas **quicklime** can **react with water/ dissolve in water / soluble in water** and **slaked lime** is in **aqueous state / is a solution.** Therefore, both quicklime and slaked lime **dissociate to produce hydroxide ions**, thus neutralizing the acidic soil.	1 1
C3bi	It is a **waste product**, hence it is **cheap / readily available** .	1
C3bii	They can form **acidic oxides** which will (dissolve in water to form acids / acidic solutions); Due to the **non-metallic character** of the element	1 1
C3c	Percentage by mass of calcium in quicklime (CaO) = $\frac{40}{56}$ × 100% = **71.4% (to 3 s.f.)** Percentage by mass of calcium in $Ca(OH)_2$	1

	$= \frac{40}{74} \times 100\%$ **= 54.1% (to 3 s.f.)** *Note: accept 4/ 5s.f.	1
C3d	$CaCO_3 \rightarrow CaO + CO_2$ No. of mol of $CaCO_3 = \frac{25\ 000\ 000}{100}$ **= 250 000 mol** No. of mol of CO_2 produced **= 250 000 mol** Volume of CO_2 produced = 250 000 × 24 = **6 000 000 dm^3**	M1 M1 A1
C4a	For **ammonia**, the **solubility decreases as temperature increases.** For **other substances**, the **solubility increases as the temperature increases.**	1 1
C4b	**Nitrates are more soluble / have a higher solubility than chlorides** at temperatures of **30°C and above**.	1
C4c	**Sodium nitrate;** **Difference in solubiltiy for sodium nitrate is greater than sodium chloride.**	1 1
C4d	The **solubility of sodium chloride does not decrease much when temperature decreases** hence **very little crystals are obtained.**	1
C4e	**Pipette** 25.0 cm^3 of **sodium carbonate / sodium hydroxide / dilute hydrochloric acid** into a conical flask; **Add** a suitable **indicator** into **sodium hydroxide / dilute hydrochloric acid;** **Fill burette with hydrochloric acid / sodium hydroxide / sodium carbonate;** Add hydrochloric acid to sodium hydroxide / sodium hydroxide to hydrochloric acid until there is a **permanent colour change;** **Record the volume** of hydrochloric acid / sodium hydroxide added; **Repeat the titration without adding an indicator**.	Corr reactants – 1M 6c – 3M 4-5c -2M 2-3c – 1M 1c – 0M Total 4M