

Name:		Index Number:		Class:	
-------	--	---------------	--	--------	--

**Preliminary Examination 3
Secondary 4**

CHEMISTRY

5073/01

Paper 1 Multiple Choice

19 September 2016

1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.

Do not use staples, pencil clips, glue or correction fluid.

Write your name, index number and class on the Answer Sheet in the spaces provided.

There are **forty** questions in this Paper. Answer **all** questions. For each question there are four possible answers **A, B, C** and **D**.

Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.

Any rough working should be done in this booklet.

A copy of the Periodic Table is given on page 19.

The use of an approved scientific calculator is expected, where appropriate.

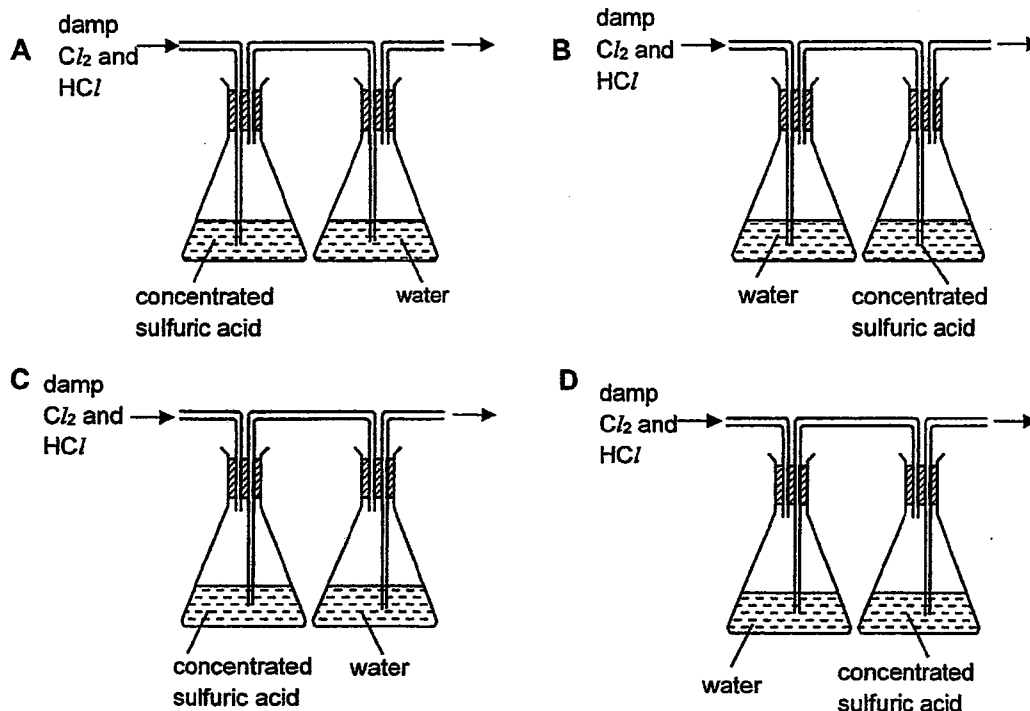
For examiner's use only:

Paper 1	/ 40
Total	/ 40

This document consists of **19** printed pages and **1** blank page.

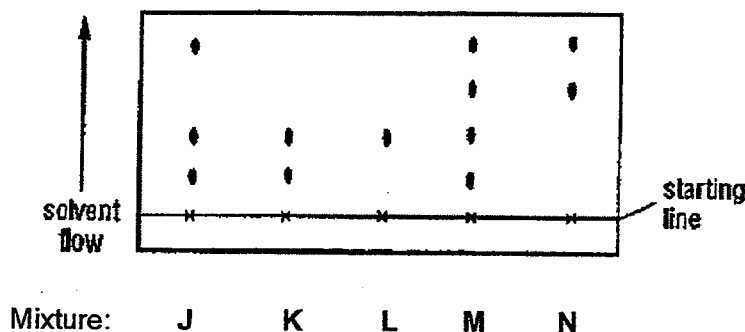
END OF MARKING SCHEME

1. Hydrogen chloride gas is very soluble in water, whereas chlorine gas is only slightly soluble in water. Which diagram below shows the correct method to obtain dry chlorine gas from damp chlorine gas containing a small amount of hydrogen chloride gas?



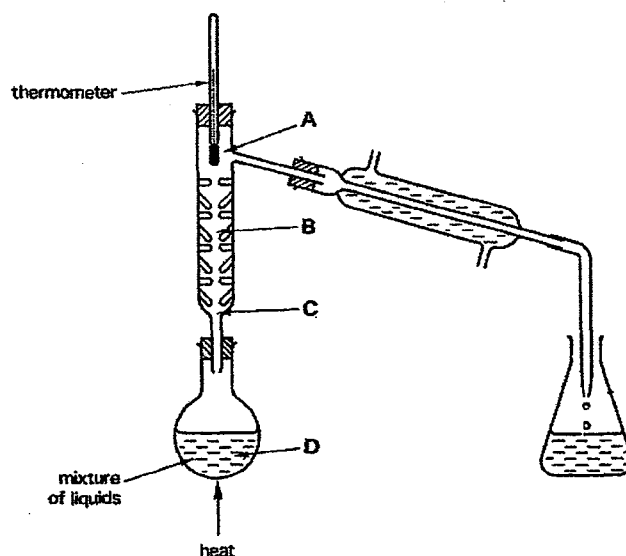
2. J, K, L, M and N are five different mixtures of amino acids. The diagram shows a chromatogram of these five different mixtures.

A protein is made up of all the amino acids found in these five mixtures. How many different amino acids are present in the protein?



- A** 0
B 4
C 5
D 12

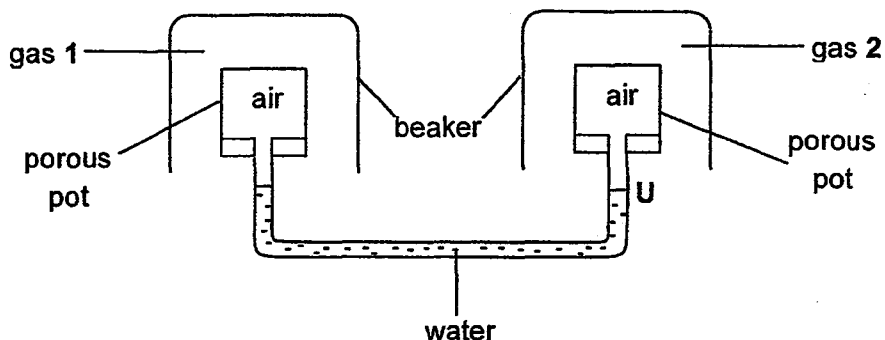
3. A mixture containing equal volumes of hexane (boiling point, 68°C) and heptane (boiling point, 98°C) is separated using the apparatus shown below.



When the temperature first shows a steady reading, at which labelled point will there be a highest proportion of hexane?

4. Solid samples of ammonium chloride, lead(II) chloride and potassium chloride were accidentally mixed together. Which of the following outline the best method to obtain the pure dry sample for each substance?
- A dissolving, filtration, sublimation, crystallisation
 - B dissolving, filtration, sublimation, evaporation
 - C sublimation, dissolving, filtration, crystallisation
 - D sublimation, dissolving, filtration, evaporation

5. The apparatus is set up, using different gases in the two inverted beakers.



Which pair of gases would cause an upward movement of the water level at U?

	gas 1	gas 2
A	N ₂	F ₂
B	N ₂	H ₂
C	Cl ₂	F ₂
D	Cl ₂	H ₂

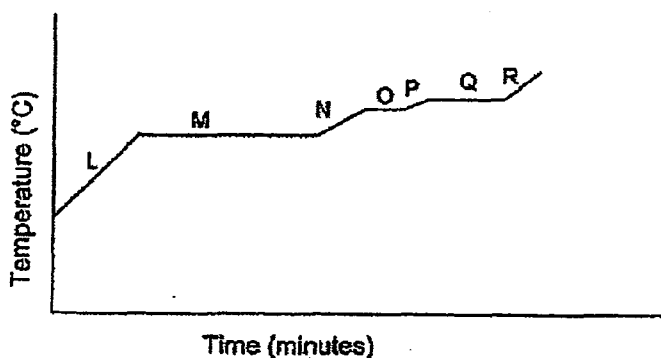
6. The three main components of liquid air are nitrogen, oxygen and argon. Their respective boiling points are:

Nitrogen -196°C

Oxygen -183°C

Argon -186°C

Liquid air can be separated into its three main components by fractional distillation. The graph shows the temperature of a liquid air mixture as it is heated.



In section N of the graph, the mixture remaining consists of

- A liquid oxygen only.
- B liquid nitrogen only.
- C liquid argon and oxygen only.
- D liquid argon and nitrogen only.

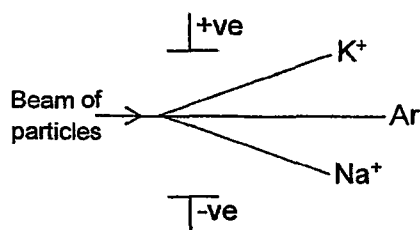
7. When chocolate is heated, it softens and melts over a range of temperatures. Which statement explains this behaviour of chocolate?

- A It is a mixture.
- B It is a macromolecule.
- C It expands before melting.
- D It forms other substances when heated.

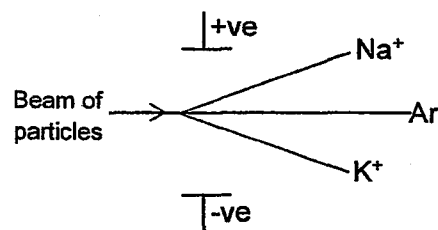
8. A beam of particles contains Na^+ , K^+ and Ar. The beam is passed between charged plates.

Which diagram shows how the particles are affected by the plates?

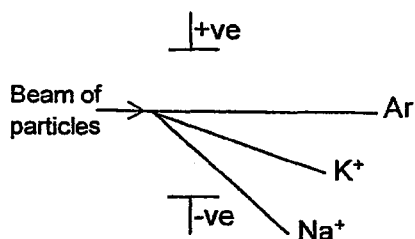
A



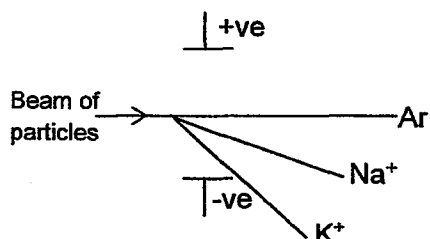
B



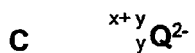
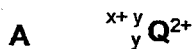
C



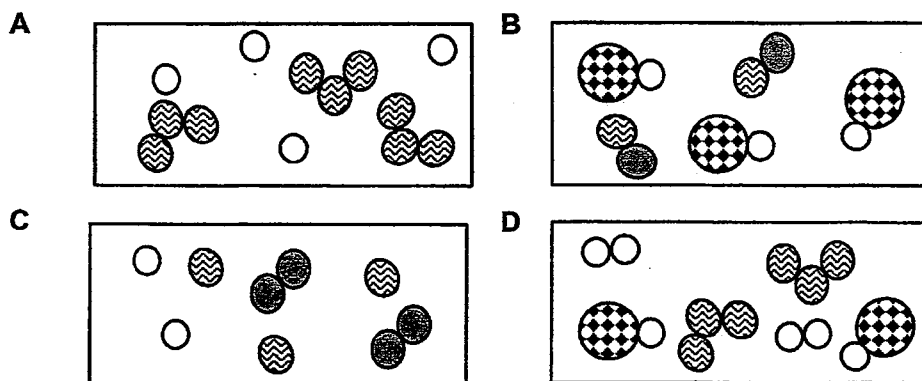
D



9. An element **Q** has x neutrons and y protons. Which of the following symbol can be used to represent the ion of **Q** if it belongs to group VI?



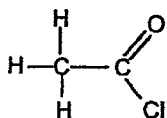
10. Which of the following diagrams correctly represent a mixture of element(s) and compound(s)?



11. Which of the following correctly shows the colour change when sulfur dioxide is bubbled into acidified KI and acidified KMnO_4 ?

	effect on KI	effect on KMnO_4
A	remains colourless	changes from purple to colourless
B	remains colourless	changes from colourless to purple
C	changes from colourless to brown	changes from purple to colourless
D	changes from brown to colourless	changes from colourless to purple

12. Ethanoyl chloride has the following structure.



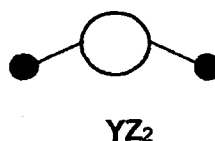
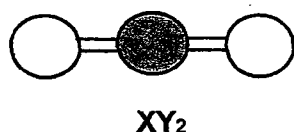
What is the total number of electrons not used for bonding?

- A 10
 B 14
 C 16
 D 26

13. Element C, D and E are three consecutive members in the Periodic Table. Given that C is in group VII of the Periodic Table, which of the following statement is true for the compound formed between C and E?

- A The compound formed is soluble in ethanol.
- B The compound formed has a simple molecular structure.
- C The compound formed has a high melting point and boiling point.
- D The compound formed can conduct electricity due to mobile electrons.

14. The models and formulae for some molecules are shown below.

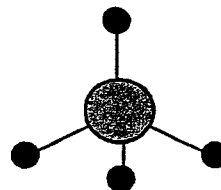


Which is the correct model for a molecule of the compound formed between X and Z?

A



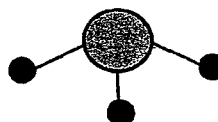
B



C



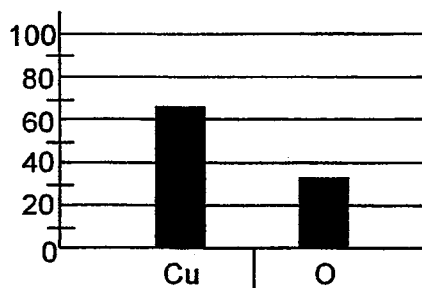
D



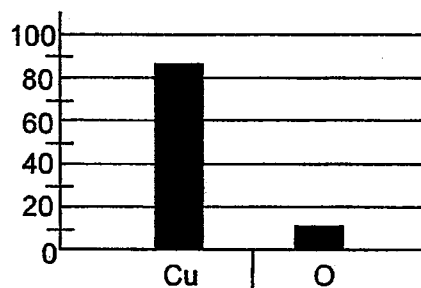
15. X is a metal which reacts with cold water and its oxide is stable to heat. Which of the following methods is most suitable to extract X from its ores?

- A electrolysis of its molten chloride
- B reduction of its oxide with carbon
- C electrolysis of its aqueous chloride solution
- D displacement from its aqueous chloride solution with iron

19. A 100g sample of copper oxide was analysed. The results of the analysis are shown in the following graphs.



Percentage proportion of atoms



Percentage proportion by mass

These data suggests that the formula for copper oxide is _____.

- A CuO
B Cu₂O
C CuO₂
D Cu₂O₃
20. Which of the following contains the same number of ions as the value of Avogadro's constant?
- A 0.25 mol Na₃PO₄
B 0.50 mol CO
C 0.50 mol Cs₂O
D 1.00 mol CaO
21. Which of the following statement(s) correctly describes the information necessary for finding the concentration of an unknown monobasic acid by titration with KOH?
- 1 The concentration of the base.
2 The volume of acid.
3 The volume of the base used to reach the end-point.
- A 1 only
B 1 and 3 only
C 2 and 3 only
D 1, 2 and 3

22. The formula of a nitride of element X is X_3N_2 .
 23.8 g of X_3N_2 contains 4.5 g of X.
 How many moles of X does 4.5 g of the element contain?

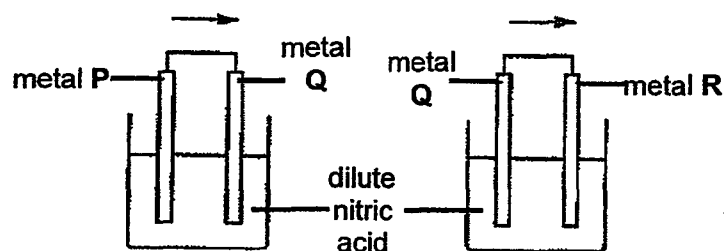
- A $\frac{19.3}{14} \times \frac{2}{3}$ B $\frac{19.3}{14} \times \frac{3}{2}$
 C $\frac{23.8}{14} \times \frac{2}{3}$ D $\frac{23.8}{14} \times \frac{3}{2}$

23. In an electrolysis experiment, the same amount of charge deposited 14 g of iron and 6.875 g of manganese. The charge on the iron ion was 2+.
 [Ar: Mn, 55; Fe, 56]

What was the charge on the manganese ion?

- A 1+
 B 2+
 C 3+
 D 4+

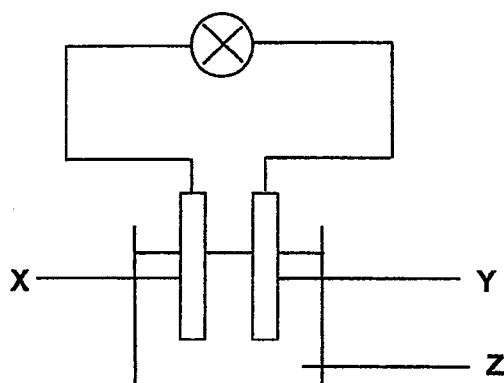
24. Two cells were set up as shown in the diagram. The arrow shows the direction of electron flow in the external circuit.



Which set of metals would give the electron flows in the direction shown?

	metal P	metal Q	metal R
A	Ag	Cu	Zn
B	Ag	Zn	Cu
C	Cu	Zn	Ag
D	Zn	Cu	Ag

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

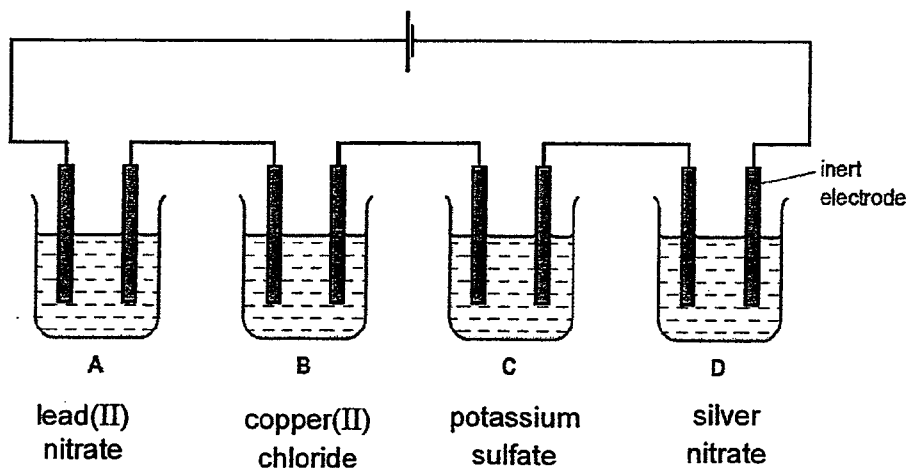


What should X, Y and Z be for the bulb to light up the brightest?

	X	Y	Z
A	lead	zinc	dilute salt solution
B	lead	iron	dilute sugar solution
C	silver	zinc	dilute salt solution
D	silver	iron	dilute sugar solution

26. When electrolysed using inert electrodes, which dilute solution would produce the greatest increase in mass of the cathode?

[Ar: Pb, 207; Cu, 64; K, 39; Ag, 108]



27. Which substance is **not** an essential raw material in the extraction of iron in a blast furnace?

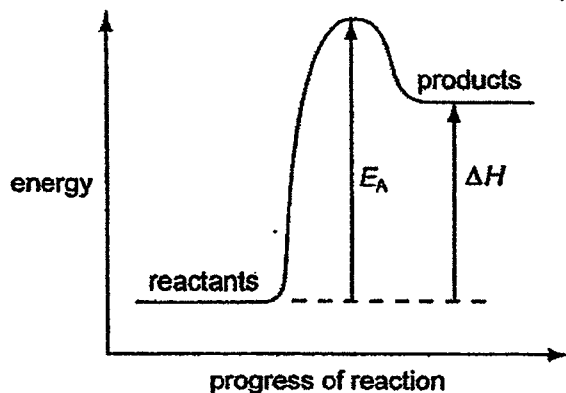
- | | | | |
|---|-----------|---|------|
| A | air | B | coke |
| C | limestone | D | sand |

28. Commercially available 'cold packs' and 'heat packs' use reactions to cause a change in temperature.

One type of pack consists of two bags; an inner bag containing water, and an outer bag containing ammonium nitrate. When the inner bag of water is broken by squeezing the package, water that is released dissolves the ammonium nitrate. When this occurs, the temperature of the solution decreases.

Based on the information provided, ammonium nitrate is used in a

- A cold pack because it undergoes an exothermic dissolution process.
 - B cold pack because it undergoes an endothermic dissolution process.
 - C heat pack because it undergoes an exothermic dissolution process.
 - D heat pack because it undergoes an endothermic dissolution process.
29. The diagram shows the energy profile for a chemical reaction.



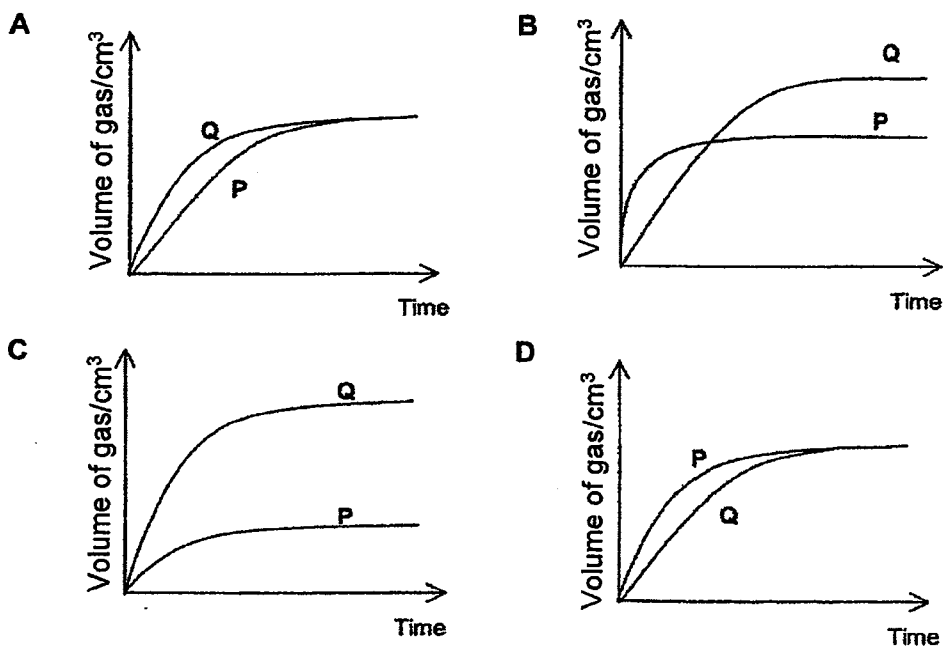
What is the effect of a catalyst on E_A and ΔH ?

- | | E_A | ΔH |
|---|-----------|------------|
| A | decreases | decreases |
| B | decreases | no change |
| C | no change | decreases |
| D | decreases | increases |

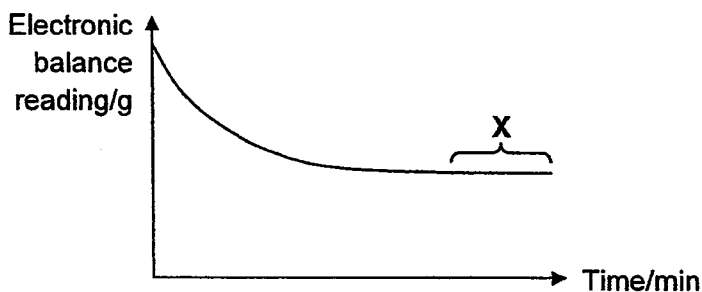
30. The effect of temperature and concentration on the rate of reaction between excess solid zinc carbonate and dilute nitric acid was investigated. The table below shows the conditions used for the two experiments, P and Q.

experiment	temperature /°C	concentration of acid /mol dm ⁻³	volume of acid used /cm ³
P	35	2.00	50
Q	25	1.00	150

The volume of gas given off was plotted against time. Which one of the following graphs shows correctly the results obtained in experiments P and Q?



31. A little powdered limestone is added to excess hydrochloric acid in a beaker and the mass is recorded at various times. The graph below shows the result.



Which statement about the section of graph labelled X is correct?

- A No more gas is being produced.
 - B Half the limestone has been used up.
 - C Half the hydrochloric acid has been used up.
 - D The rate of reaction has reached its maximum.
32. Germanium (Ge) is in the same group of the Periodic Table as carbon and silicon. Which is the correct formula for its chloride, hydride and oxide?

	chloride	hydride	oxide
A	GeCl	GeH	GeO
B	GeCl	GeH ₄	GeO ₂
C	GeCl ₄	GeH	GeO
D	GeCl ₄	GeH ₄	GeO ₂

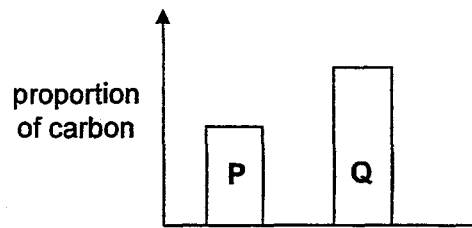
33. Part of the Periodic Table is shown. The letters are not the symbols of the elements.

Period	Group									
	I	II		III	IV	V	VI	VII	0	
1										
2	V	W						X		
3	Y							Z		

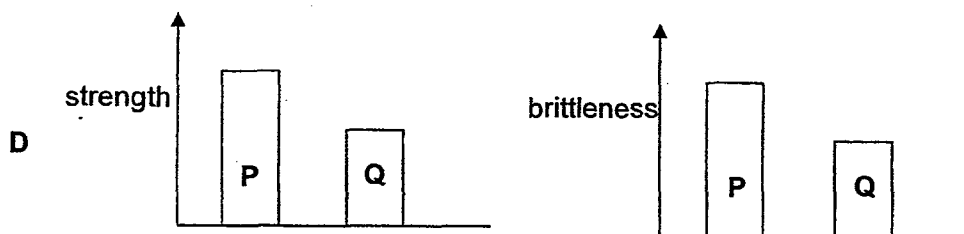
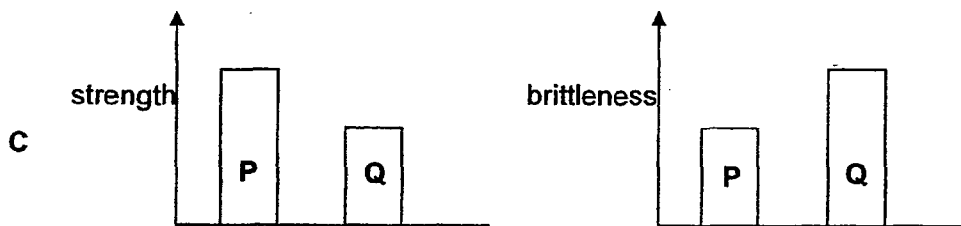
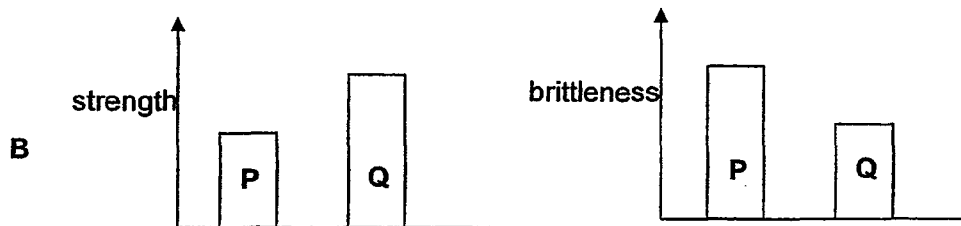
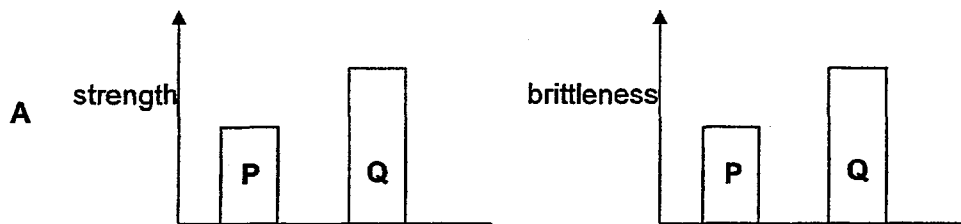
Which statement is correct?

- A V is more reactive than Y.
- B W has more metallic character than V.
- C Y has a lower melting point than V.
- D Z is more reactive than X.

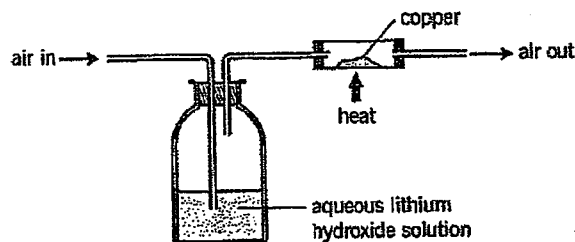
34. The diagram compares the proportion of carbon in two steels, P and Q.



Which two diagrams correctly compare the strength and brittleness of P and Q?

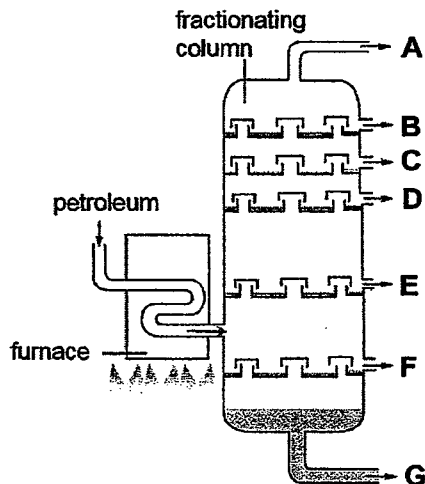


35. A sample of air is slowly passed through aqueous lithium hydroxide and then over heated copper as shown below.



Which substances will **not** be found in the composition of air after passing through this experimental setup?

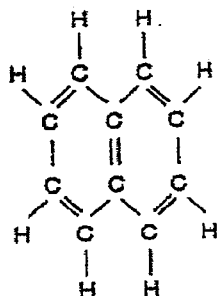
- A oxygen and nitrogen
 - B oxygen and carbon dioxide
 - C water vapour and nitrogen
 - D water vapour and carbon dioxide
36. The diagram shows a fractionating column used for the separation of crude oil.



Which of the following statement is correct?

- A A burns less easily than D.
- B B has a higher viscosity than E.
- C C has a higher boiling point than F.
- D D is more flammable than G.

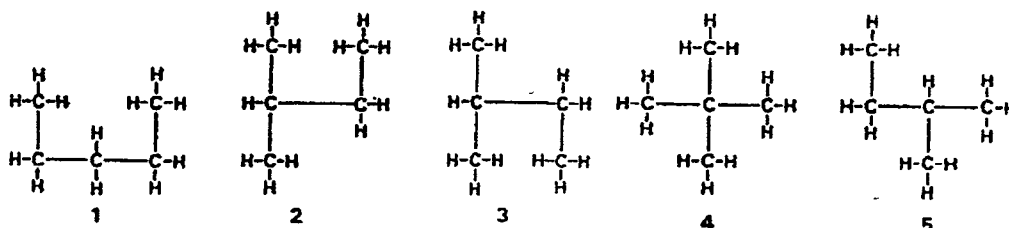
37. Mothballs are small balls of chemical pesticide and deodorant used when storing clothing and other articles susceptible to damage from mould or moth larvae. The main ingredient of traditional mothballs is naphthalene which has the following structure.



Which of the following about naphthalene is likely to be incorrect?

- A It is an unsaturated hydrocarbon.
- B It can be represented by the empirical formula C_5H_4 .
- C It undergoes complete combustion to form carbon dioxide and water.
- D When it boils, the carbon-carbon and carbon-hydrogen bonds are broken.

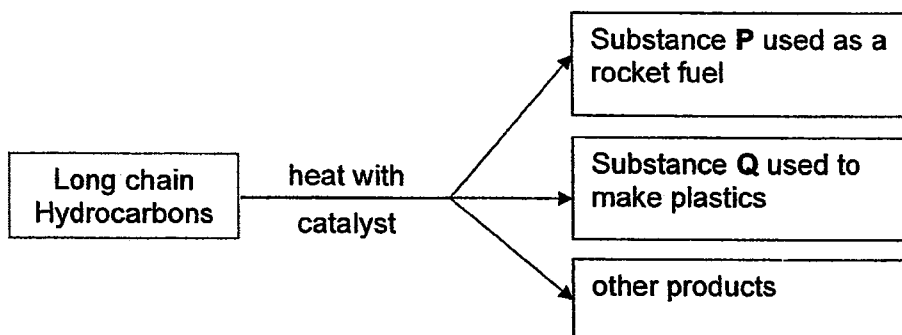
38. Five structural formulae are shown below.



Which of the compounds are isomers?

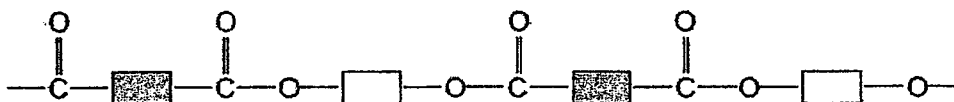
- A 1 and 4 only
- B 4 and 5 only
- C 1, 2 and 4 only
- D All of the above

39. The diagram shows how useful products can be obtained by cracking long chain hydrocarbons.



	substance P	substance Q
A	ethanol	ethane
B	ethanol	ethene
C	hydrogen	ethane
D	hydrogen	ethene

40. Part of a polyester chain is shown below:



Which compound, when added to the reactants during polymerization, would stop the polymer chain from becoming too long?

- A
- B
- C
- D

- End of Paper 1 -

Name:		Index Number:		Class:	
-------	--	---------------	--	--------	--

**Preliminary Examination 3
Secondary 4**

A

CHEMISTRY

5073/02

Paper 2

15 September 2016
1 hour 45 minutes

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, index number and class on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Section A

Answer all questions in the spaces provided.

For examiner's use only:

Questions	Marks
A1	/3
A2	/9
A3	/9
A4	/4
A5	/7
A6	/12
A7	/6
Total	/50

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [] at the end of each question or part question.

A copy of the Periodic Table is printed on page 13.

The use of an approved scientific calculator is expected, where appropriate.

This document consists of 13 printed pages and 1 blank page.

[Turn over]

Section A

Answer all questions in this section in the spaces provided.
The total mark for this section is 50.

- A1** The table shows the name of some compounds and their reactions with a few drops of aqueous sodium hydroxide and acidified barium nitrate.

Formula of compound	Colour of aqueous solution	Reaction of aqueous solution with a few drops of	
		aqueous sodium hydroxide	acidified barium nitrate
		blue precipitate	white precipitate
Fe(NO ₃) ₂	pale green		
KI			no precipitate

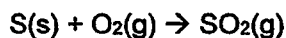
[3]

Complete the table by filling in the missing blanks above.

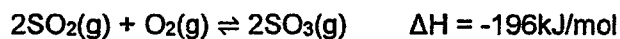
[Total: 3]

- A2** The manufacture of sulfuric acid is described below.

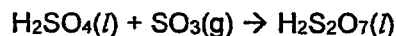
step 1: Sulfur is burnt in excess air to form sulfur dioxide.



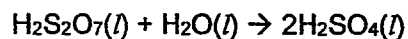
step 2: Sulfur dioxide reacts with more oxygen to form sulfur trioxide.



step 3: Sulfur trioxide is dissolved in concentrated sulfuric acid to form oleum, H₂S₂O₇.



step 4: Oleum can then react safely with water to produce concentrated sulfuric acid.



(a) Is step 3 a redox reaction? Use ideas about oxidation states to explain your answer.

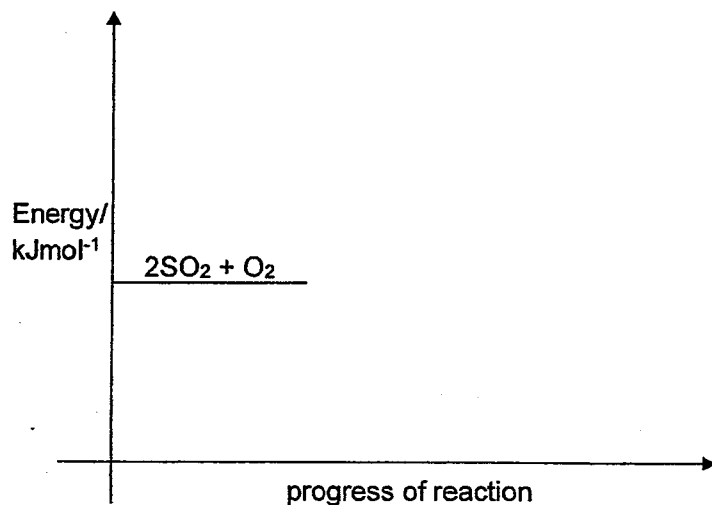
.....
.....
..... [1]

(b) State one factor which can increase the rate of reaction for step 1. Using the idea of collisions between reacting particles, explain how this factor increases the rate of reaction.

.....
.....
.....
..... [3]

(c) (i) Complete the energy profile diagram below for the reaction of sulfur dioxide and oxygen to produce sulfur trioxide. The activation energy for this reaction is 2200 kJ/mol.

Label clearly the reaction enthalpy change and the activation energy.



[3]

- (ii) State the values of the enthalpy change and the activation energy of the reverse reaction.

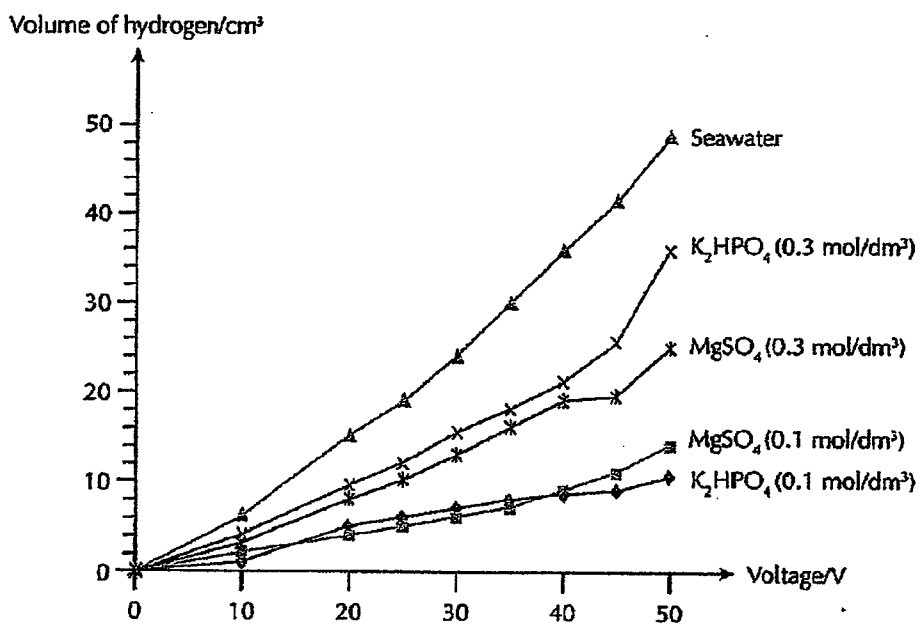
$\Delta H = \dots\dots\dots$ kJ/mol

$E_a = \dots\dots\dots$ kJ/mol

[2]

[Total: 9]

- A3 During the electrolysis of some aqueous salt solutions using inert electrodes, hydrogen gas is produced at the cathode. The graph below shows the volume of hydrogen gas collected in 1 hour at different voltages when different solutions were used.



- (a) Using the graph above, state the relationship between the concentration of the solution and the volume of hydrogen gas produced.

.....

.....

[1]

(b) (i) Write the half equations for the electrolysis of aqueous magnesium sulfate.

cathode:

anode: [2]

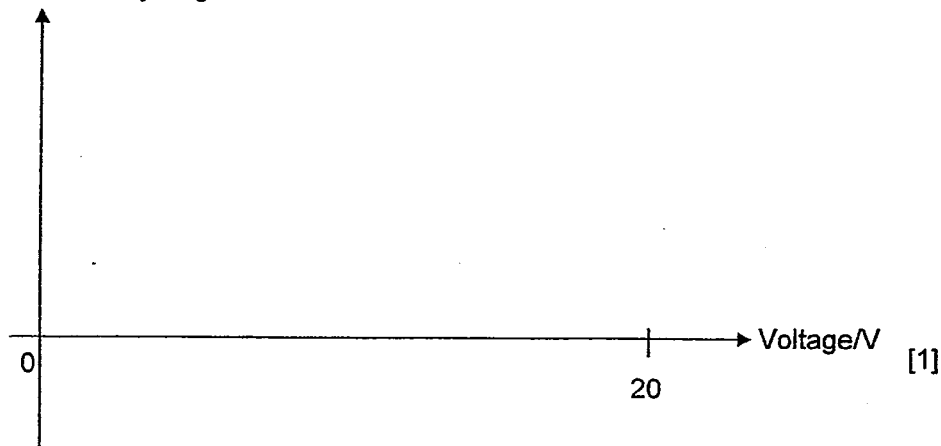
(ii) Use the information from the graph to calculate the volume of gas formed at the **anode** at room temperature and pressure when the electrolysis was carried out at 40 V using 0.3 mol/dm^3 aqueous magnesium sulfate.

[3]

(c) A student conducted another electrolysis experiment using distilled water at different voltages.

(i) Sketch a graph of the volume of hydrogen against voltage for the electrolysis of distilled water.

Volume of hydrogen/cm³



(ii) Explain your answer in c(i).

.....
.....

[2]

[Total: 9]

A4 Chlorofluorocarbons (CFCs) are organic compounds that contain only carbon, fluorine and chlorine. When CFC molecules diffuse high up into the atmosphere, they destroy the ozone molecules which are present in the stratosphere, a layer of atmosphere at about 20-50 km above the Earth.

A list of some CFCs in current use and their possible replacements is given.

	formula	code number	potential for destroying the ozone layer (scaled)
compounds in current use	CCl_3F	11	1.00
	CCl_2F_2	12	1.00
possible replacement compounds	CHClF_2	22	0.05
	$\text{CF}_3\text{CCl}_2\text{H}$	123	0.02
	$\text{CF}_3\text{CH}_2\text{F}$	134a	0.00
	$\text{CH}_3\text{CCl}_2\text{F}$	141b	0.12
	CH_3CHF_2	152a	0.00

(a) The most common form of CFCs is dichlorodifluoromethane, CCl_2F_2 .

(i) CCl_2F_2 can be produced from methane. What type of reaction is used in the production process?

..... [1]

- (ii) Draw a 'dot-and-cross' diagram to show the bonding in a molecule of dichlorodifluoromethane.

You only need to show outer shell electrons.

[2]

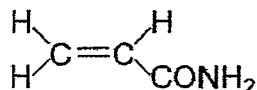
- (b) Suggest a reason for the difference in the potential for destroying ozone between compounds 134a and 152a and compounds 22, 123 and 141b.

.....

..... [1]

[Total: 4]

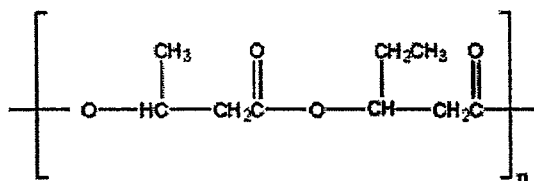
- A5 (a)** Researchers in Europe and the United States have found acrylamide in certain foods that were heated to a temperature above 120 °C. Potato chips and french fries were found to contain higher levels of acrylamide compared to other foods. The World Health Organisation and the Food and Agriculture Organisation of the United Nations stated that the levels of acrylamide in foods pose a risk to human health. Acrylamide has the following structure.



- (i) Acrylamide readily polymerises to polyacrylamide. Draw the structural formula of the polymer formed.

[1]

- (ii) Foods are commonly stored in food containers. One common polymer used for such purpose is poly(3-hydroxybutyrate-co-3-hydroxyvalerate), commonly known as PHBV. It is a type of polyester that is obtained from renewable sources and is biodegradable. The structure of this polymer is shown below.



Draw the structural formulae of the two monomers used to make PHBV.

[2]

- (iii) Describe two differences between addition and condensation polymerization.

.....

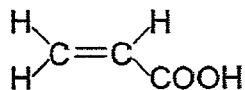
.....

.....

.....

[2]

- (b) Acrylamide hydrolyses to form acrylic acid. The structural formula of acrylic acid is shown below.



- (i) What is observed for the reaction between acrylic acid and aqueous bromine?

.....

..... [1]

- (ii) Write the equation for the above reaction, showing the structural formulae of the organic compounds.

[1]

[Total: 7]

- A6** 30 cm³ of 1 mol/dm³ hydrochloric acid is added to four different test tubes containing substances **A** to **D**. The results are recorded in the table below.

Substance	Appearance of substance	Gas produced	Colour of solution formed
A	green solid	gas formed white precipitate with limewater.	pale blue
B	silvery solid	gas extinguished a lighted splint with a 'pop' sound.	colourless
C	black solid	no gas produced	pale blue
D	reddish brown solid	no visible change	

- (a) Suggest the name of substance **A** and write down a balanced chemical equation for the reaction between **A** and dilute hydrochloric acid.

.....

..... [2]

- (b) (i) Substance D is a metal. State two observations when B is added to a chloride solution of D.

.....
..... [2]

- (ii) Use the information in the table to explain why these changes occur.

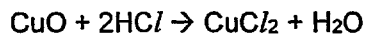
.....
.....
..... [2]

- (c) Substance C is impure copper(II) oxide. The mass of C in the test tube is 3 g. To test for the purity of substance C, the following is carried out. It is assumed that the impurities do not react with dilute hydrochloric acid.

- (i) The excess hydrochloric acid that did not react with C was titrated with 1 mol/dm^3 of dilute sodium hydroxide. The average volume of sodium hydroxide required for the titration was 10.00 cm^3 . Calculate the number of moles of excess hydrochloric acid and hence, calculate the number of moles of hydrochloric acid that has reacted with substance C.

[3]

- (ii) The reaction between copper(II) oxide and hydrochloric acid is given by the equation below.



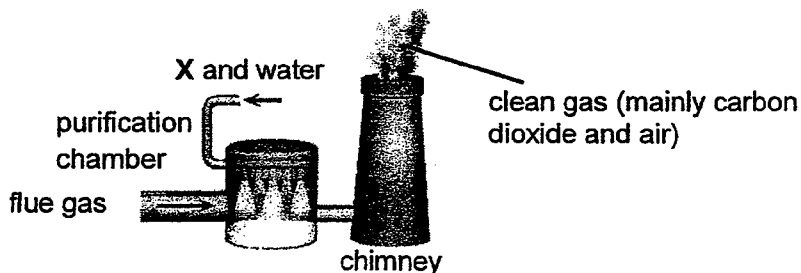
Calculate the percentage purity of C in the test tube.

[3]

[Total: 12]

- A7 Coal-burning power stations generate large amount of heat from the combustion of coal to convert water into steam which in turn drives turbine generators to produce electricity. Flue gas that is produced contains sulfur dioxide and oxides of nitrogen. These two gases cause acid rain.

Sulfur dioxide can be removed from the flue gas by several methods. One method uses a 'scrubber' that contains wet compound X.



- (a) Identify compound X that is added to the purification chamber to remove sulfur dioxide and write a chemical equation to represent the reaction between X and sulfur dioxide.

.....
..... [2]

- (b) Oxides of nitrogen generally consist of a mixture of nitrogen monoxide and nitrogen dioxide. In flue gas, nitrogen monoxide is the main component in the oxides of nitrogen produced. Explain how nitrogen monoxide cause acid rain even though it is a neutral oxide.

.....
..... [2]

- (c) Acid rain impacts farming greatly as it often causes the soil to be overly acidic and results in the leaching of nutrients. In order to alleviate the effects of acid rain, a farmer has been advised to treat the soil to reduce the acidity.

The table below gives the solubility of some calcium compounds.

	calcium hydroxide	calcium oxide	calcium carbonate
Solubility in water (g per 100ml of water)	0.173	immediately reacts with water on contact to form an alkaline solution	6.17×10^{-4}

Using the information in the table given, suggest why calcium carbonate is less effective at reducing acidity than calcium hydroxide and calcium oxide.

.....
.....
.....
..... [2]

[Total: 6]

- End of Section A -

Name:		Index Number:		Class:	
-------	--	---------------	--	--------	--

**Preliminary Examination 3
Secondary 4**

B

CHEMISTRY

5073/02

Paper 2

15 September 2016
1 hour 45 minutes

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, index number and class on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Section B

Answer all **three** questions, the last question is in the form either/or.
Answer **all** questions in the spaces provided.

For examiner's use only:

Question	Marks
B8	/10
B9	/10
B10 either/or	/10
Total	/30

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [] at the end of each question or part question.

A copy of the Periodic Table is printed on page 11.

The use of an approved scientific calculator is expected, where appropriate.

This document consists of 11 printed pages and 1 blank page.

[Turn over]

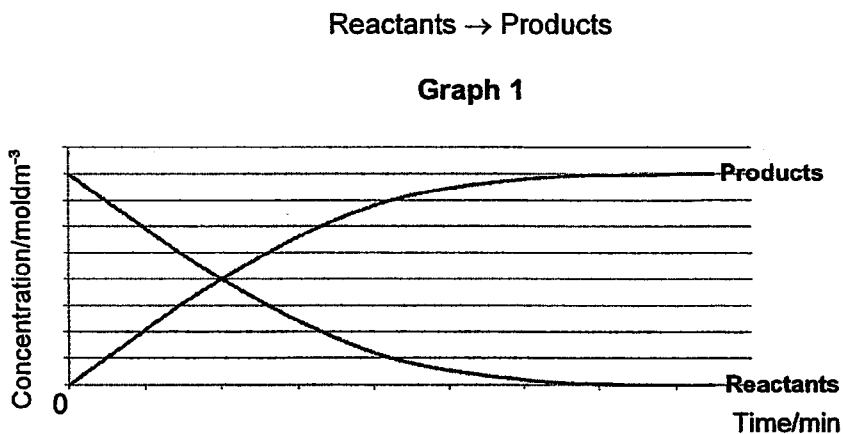
Section B

Answer all **three** questions in this section.

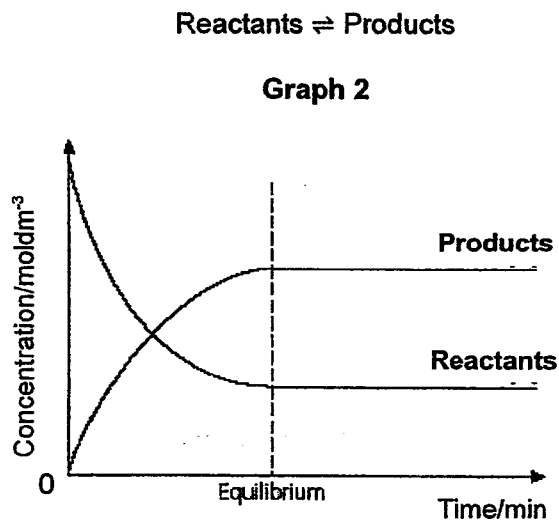
The last question is in the form of an either/or and only one of the alternatives should be attempted.

B8 Reactions can be classified as reversible or irreversible reactions.

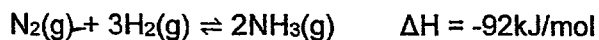
Graph 1 shows how the concentration of reactants and products change with time for irreversible reactions.



Graph 2 shows how the concentration of reactants and products change with time for reversible reactions.

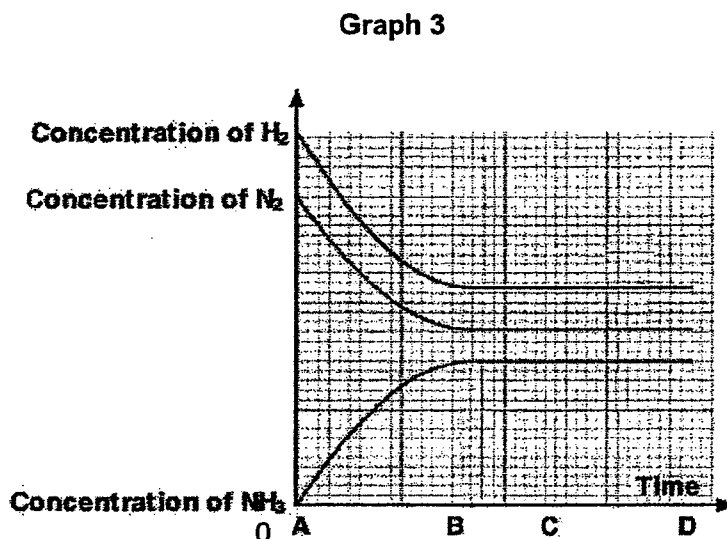


Many chemical reactions are reversible. An example of a reversible reaction is the Haber process:



If the above reaction takes place in a closed system (i.e. one whereby there is no exchange of matter between the reaction mixture and its surroundings), a dynamic equilibrium is reached when the rate of the forward reaction (reactants \rightarrow products) is the same as the rate of the backward reaction (products \rightarrow reactants). The concentrations of nitrogen, hydrogen and ammonia remain constant when the system is in dynamic equilibrium.

Graph 3 shows how the concentration of N_2 , H_2 and NH_3 changes with time.



Le Chatelier's Principle states that when the system in dynamic equilibrium is subjected to a change in conditions such as temperature, pressure and concentration, the system will respond in a way to counteract the effect of change and re-establish the equilibrium.

For example, in a system that is in dynamic equilibrium, when the concentration of nitrogen is increased, the position of the equilibrium will shift to the right to favour the forward reaction. This results in an increase in the concentration of ammonia at equilibrium while decreasing the concentration of the nitrogen and hydrogen.

- (a) Using Graph 1 and Graph 2, state and explain one difference between reversible and irreversible reactions.

.....

.....

.....

.....

[2]

(b) (i) On Graph 3, sketch a graph showing only the concentration of NH_3 , to illustrate what happens when the reaction is carried out at a lower temperature- Label this graph I. [2]

(ii) Explain the shape of graph I in terms of the position of equilibrium and the rate of reaction.

.....
.....
.....
.....
..... [3]

(iii) State the temperature used in the Haber process and explain how this optimal temperature is selected.

.....
.....
.....
..... [3]

[Total: 10]

B9 Properties of elements across Period 3.

Table 1 shows the properties of the oxides formed by elements in Period 3.

Table 1

Element	Formula of oxide	Melting point of oxide/ $^{\circ}\text{C}$	Boiling point of oxide/ $^{\circ}\text{C}$
Na	Na_2O	1132	1950
Mg	MgO	2852	3600
Al	Al_2O_3	2072	2977
Si	SiO_2	1600	2230
P	P_4O_6	24	173
	P_4O_{10}	340	360
S	SO_2	-72	-10
	SO_3	17	45
Cl	Cl_2O	-121	2
	Cl_2O_7	-92	82

- (a) (i) Describe the general trend in the melting points of the oxides formed by elements in Period 3.

.....
.....
..... [1]

- (ii) Explain the trend in terms of structure and bonding.

.....
.....
.....
.....
.....
.....
.....
.....
..... [3]

- (b) Suggest a reason for the difference in the melting and boiling points between the two oxides of sulfur.

.....

[2]

- (c) Table 2 shows the variation of atomic and ionic radius across Period 3.

Table 2

Element	Atomic radius/nm	Simple ion	Ionic radius/nm	Number of shells of electrons in simple ion
Na	0.191	Na ⁺	0.102	
Mg	0.160	Mg ²⁺	0.072	
Al	0.130	Al ³⁺	0.054	
Si	0.118	*	-	-
P	0.110	P ³⁻	0.212	
S	0.102	S ²⁻	0.184	
Cl	0.099	Cl ⁻	0.181	
Ar	0.095	-	-	-

* Si does not form simple ions and thus the data is omitted from the table.

- (i) Complete the table to show the number of shells of electrons in the ions of period 3 elements. [2]
- (ii) Use the information from table 2 to explain why the radii of cations are generally smaller than that of anions in the same period.

.....

[1]

(iii) Suggest why there is no value stated for the ionic radius of argon.

.....
.....
..... [1]

[Total: 10]

Either

B10 The table below shows a study of a precipitation reaction between dilute sulfuric acid and aqueous calcium hydroxide.

Test tubes 1 to 6 contain different volumes of calcium hydroxide and dilute sulfuric acid as stated in the table. To each test tube, two drops of methyl orange indicator is added. Precipitation occurs in all the test tubes and after 10 minutes, the height of the precipitate in each test tube is measured and recorded.

Test tube	1	2	3	4	5	6
volume of 0.50 mol/dm ³ of calcium hydroxide/cm ³	5.0	5.0	5.0	5.0	5.0	5.0
volume of 1.00 mol/dm ³ of sulfuric acid/cm ³	1.0	1.5	2.0	2.5	3.0	3.5
height of precipitate/cm	2.5	3.0	3.5	4.0	4.0	

(a) Write a balanced chemical equation, including state symbols, to represent the precipitation reaction between aqueous calcium hydroxide and dilute sulfuric acid.

..... [2]

(b) State the colour of methyl orange indicator in

test tube 1:

test tube 5: [1]

- (c) Predict the height of the precipitate collected in test tube 6 after 10 minutes. Explain your answer with the aid of calculation.

Prediction cm

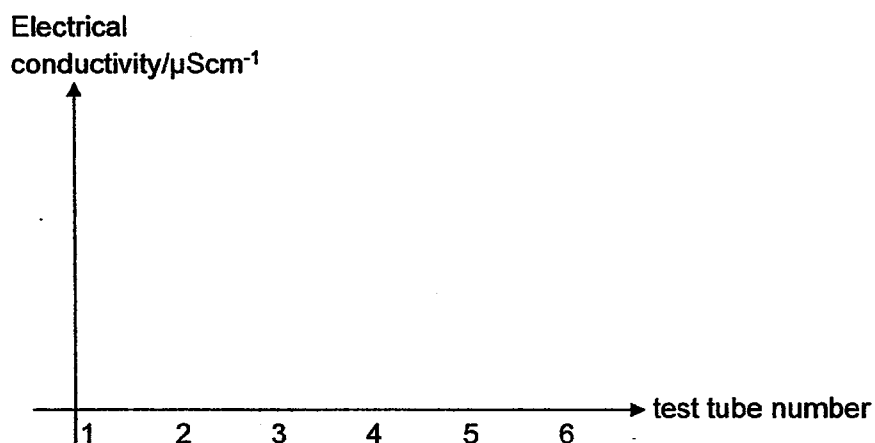
Explanation

.....

.....

..... [3]

- (d) (i) The electrical conductivity of the mixture in each test tube was measured. Sketch a graph of electrical conductivity against the test tube number.



[1]

- (ii) Explain your graph in (d)(i).

.....

.....

.....

.....

..... [3]

[Total: 10]

Or

B10 Sulfamic acid, SO_3NH_2 , is a strong monobasic acid which melts at 205°C before decomposing at higher temperatures.

Although acids speeds up corrosion of iron, they are also often used as cleaning agents to remove rust. Sulfamic acid is commonly used as a replacement for hydrochloric acid in removing rust. It does not react with hypochlorite based products such as bleach to produce chlorine gas, unlike hydrochloric acid. In general, the sulfamate salts of iron and calcium formed are water-soluble.

The table shows the comparison between using hydrochloric acid and sulfamic acid to remove rust and limescale.

	hydrochloric acid	sulfamic acid
relative corrosivity on aluminium	5.3	1
relative corrosivity on copper	6.7	1
relative corrosivity on steel	4.2	1
cost per tonne	US \$200	US \$500

* Relative corrosivity refers to the relative ease of corroding the metal.

(a) Describe what happens to the arrangement and movement of the particles in sulfamic acid when dissolved in water.

.....
.....
.....
..... [2]

(b) One student explains that sulfamic acid is a strong acid because there is a high concentration of hydrogen ions present. Do you agree with this statement? Explain your reasoning.

.....
..... [1]

(c) (i) Explain why aqueous sulfamic acid can be used to remove rust.

.....
..... [2]

(ii) One way of protecting underground iron pipes from rusting is through the use of sacrificial protection. Describe how sacrificial protection works.

.....
.....
..... [2]

(d) Use the information provided to discuss the advantage(s) and disadvantage(s) of using sulfamic acid to replace hydrochloric acid in the removal of rust.

.....
.....
.....
.....
..... [3]

[Total: 10]

The Periodic Table of the Elements

		Group																																																																																																																																																		
I	II	III	IV	V	VI	VII	0																																																																																																																																													
7 Li lithium 3	9 Be beryllium 4	11 B boron 5	12 C carbon 6	13 Al aluminium 13	14 Si silicon 14	15 P phosphorus 15	16 S sulfur 16	17 Cl chlorine 17	18 Ar argon 18	19 K potassium 19	20 Ca calcium 20	21 Sc scandium 21	22 Ti titanium 22	23 V vanadium 23	24 Cr chromium 24	25 Mn manganese 25	26 Fe iron 26	27 Co cobalt 27	28 Ni nickel 28	29 Cu copper 29	30 Zn zinc 30	31 Ga gallium 31	32 Ge germanium 32	33 As arsenic 33	34 Se selenium 34	35 Br bromine 35	36 Kr krypton 36	37 Rb rubidium 37	38 Sr strontium 38	39 Y yttrium 39	40 Zr zirconium 40	41 Nb niobium 41	42 Mo molybdenum 42	43 Tc technetium 43	44 Ru ruthenium 44	45 Rh rhodium 45	46 Pd palladium 46	47 Ag silver 47	48 Cd cadmium 48	49 In indium 49	50 Sn tin 50	51 Sb antimony 51	52 Te tellurium 52	53 I iodine 53	54 Xe xenon 54	55 Cs caesium 55	56 Ba barium 56	57 La lanthanum 57	58-71 Lanthanoid series	72 Hf hafnium 72	73 Ta tantalum 73	74 W tungsten 74	75 Re rhenium 75	76 Os osmium 76	77 Ir iridium 77	78 Pt platinum 78	79 Au gold 79	80 Hg mercury 80	81 Tl thallium 81	82 Pb lead 82	83 Bi bismuth 83	84 Po polonium 84	85 At astatine 85	86 Rn radon 86	87 Fr francium 87	88 Ra radium 88	89 Ac actinium 89	90-103 Actinoid series	91 Th thorium 90	92 Pa protactinium 91	93 U uranium 92	94 Pu plutonium 94	95 Am americium 95	96 Cm curium 96	97 Bk berkelium 97	98 Cf californium 98	99 Es einsteinium 99	100 Fm fermium 100	101 Md mendelevium 101	102 No nobelium 102	103 Lr lawrencium 103	104-109 Lanthanoid series	110 Dh dubnium 110	111 Ds dubnium 111	112 Fl flerovium 112	113 Nh nihonium 113	114 Lv livermorium 114	115 Ts tennessine 115	116 Og oganesson 116	117 Uue unbinilium 117	118 Uuo ununoctium 118	119 Uuq unquincium 119	120 Uuq unquincium 120	121 Uub unbium 121	122 Uub unbium 122	123 Uut untrium 123	124 Uuq unquincium 124	125 Uuq unquincium 125	126 Uuq unquincium 126	127 Uuh unhexium 127	128 Uuq unquincium 128	129 Uuq unquincium 129	130 Uuq unquincium 130	131 Uuq unquincium 131	132 Uuq unquincium 132	133 Uuq unquincium 133	134 Uuq unquincium 134	135 Uuq unquincium 135	136 Uuq unquincium 136	137 Uuq unquincium 137	138 Uuq unquincium 138	139 Uuq unquincium 139	140 Uuq unquincium 140	141 Uuq unquincium 141	142 Uuq unquincium 142	143 Uuq unquincium 143	144 Uuq unquincium 144	145 Uuq unquincium 145	146 Uuq unquincium 146	147 Uuq unquincium 147	148 Uuq unquincium 148	149 Uuq unquincium 149	150 Uuq unquincium 150	151 Uuq unquincium 151	152 Uuq unquincium 152	153 Uuq unquincium 153	154 Uuq unquincium 154	155 Uuq unquincium 155	156 Uuq unquincium 156	157 Uuq unquincium 157	158 Uuq unquincium 158	159 Uuq unquincium 159	160 Uuq unquincium 160	161 Uuq unquincium 161	162 Uuq unquincium 162	163 Uuq unquincium 163	164 Uuq unquincium 164	165 Uuq unquincium 165	166 Uuq unquincium 166	167 Uuq unquincium 167	168 Uuq unquincium 168	169 Uuq unquincium 169	170 Uuq unquincium 170	171 Uuq unquincium 171	172 Uuq unquincium 172	173 Uuq unquincium 173	174 Uuq unquincium 174	175 Uuq unquincium 175

Key

a	X
b	

a = relative atomic mass
 X = atomic symbol
 b = proton (atomic) number

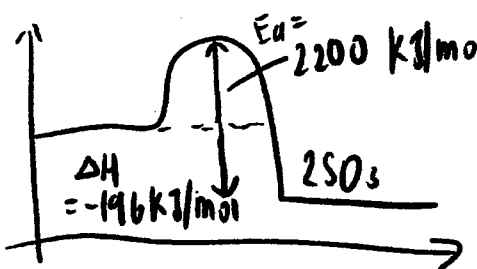
The volume of one mole of any gas is 24 dm³ at room temperature and pressure (r.t.p.).

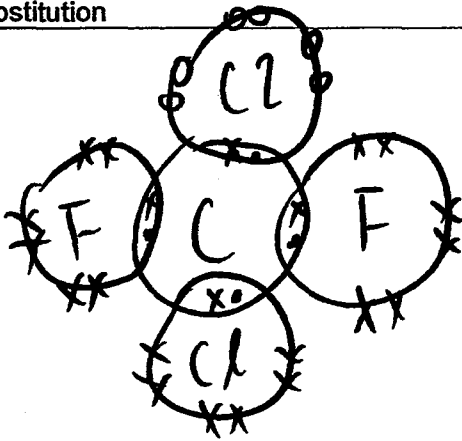
Marking Scheme for 2016 Sec 4 Prelim 3

Paper 1

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

Section A

A1		CuSO ₄ ; Blue Green precipitate; No precipitate Colourless; No precipitate	[1] [1] [1]
A2	(a)	No. The <u>oxidation state</u> of S, O and H <u>remains the same</u> at +6, -2 and +1 respectively in both reactants and products.	[1]
	(b)	Use <u>powdered sulfur</u> . There are <u>larger surface area</u> for the particles to collide on, thus <u>frequency of effective collision increase</u> . OR <u>Increase the pressure</u> . There will be <u>more particles per unit area</u> , thus <u>frequency of effective collision increase</u> . OR <u>Increase the temperature</u> . The <u>particles move faster</u> and <u>more particles have energy greater or equal to the activation energy</u> , thus <u>frequency of effective collision increase</u> .	[1] [1] [1] [1] [1] [1] [1]
	(c) (i)		[3]

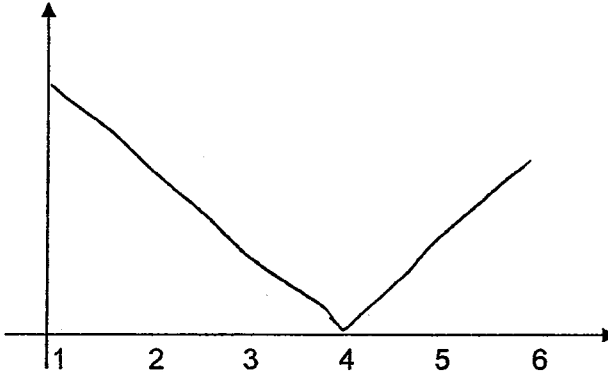
		(ii)	$\Delta H = +196$ kJ/mol $E_a = 2396$ kJ/mol	[1] [1]
A3	(a)		As the concentration increases , the volume of hydrogen produced increases .	[1]
	(b)	(i)	Cathode: $2H^+ (aq) + 2e \rightarrow H_2(g)$ Anode: $4OH^- (aq) \rightarrow 2H_2O (l) + O_2 (g) + 4e$	[1] [1]
		(ii)	Mol of H_2 produced = $0.02/24 = 0.0008333$ mol Mol of $e = 0.0008333 \times 2 = 0.001667$ mol Mol of $O_2 = 0.001667/4 = 0.0004167$ mol Vol of $O_2 = 0.0004167 \times 24 = 0.0100$ dm ³ or 10.0cm ³ Can accept (18 to 20 cm ³) Ans: 9.00cm ³ to 10.0 cm ³	[1] [1] [1]
	(c)	(i)	Vol of $H_2 = 0$ cm ³ (horizontal line)	[1]
		(ii)	Distilled water contains very few ions/no mobile ions and thus is a poor conductor of electricity. Hence, no electrolysis occur and thus no hydrogen gas is produced. /No discharge of H^+ ions.	[1] [1]
A4	(a)	(i)	Substitution	[1]
		(ii)	 <p>Legend ○ → Cl ○ → F x → C</p>	[2]
	(b)		Compounds 134a and 152a do not contain chlorine atoms which react with ozone molecules.	[1]

	(b)	(i)	Reddish brown solid formed. Colour of solution changes from blue to colourless .	[1] [1]
		(ii)	Since B can react with acid but not D , B is more reactive than D . Thus B can displace D from its aqueous solution , forming D which is a reddish brown solid and a chloride solution of B .	[1] [1]
	(c)	(i)	$\text{NaOH} + \text{HCl} \rightarrow \text{NaCl} + \text{H}_2\text{O}$ Mol of NaOH = $10/1000 \times 1 = 0.01$ mol Mol of HCl = 0.01 mol Mol of HCl added initially = $30/1000 \times 1 = 0.03$ mol Mol of HCl that react with $\text{CuCO}_3 = 0.03 - 0.01 = 0.02$ mol	[1] [1] [1]
		(ii)	Mol of CuO = $0.02/2 = 0.01$ mol Mass of CuO = $0.01 \times 80 = 0.8$ g % purity = $0.8/3 \times 100 = 26.7\%$	[1] [1] [1]
A7		(a)	CaCO_3 / calcium carbonate $\text{CaCO}_3 + \text{SO}_2 \rightarrow \text{CaSO}_3 + \text{CO}_2$	[1] [1]
		(b)	NO will be oxidised by oxygen in the air to form nitrogen dioxide. Nitrogen dioxide will then react with oxygen and water in the air to form nitric acid which causes acid rain.	[1] [1]
		(c)	Calcium carbonate is very much less soluble, with a solubility of 6.17×10^{-4} g/100ml than calcium oxide (dissolves to give alkaline solution) and calcium hydroxide (0.173g/100ml) Thus CaCO_3 reacts slowly with acid/effective only in reducing acidity on soil/surface in contact/ cannot penetrate soil to neutralise acid deeper down [1].	[1] [1]

Section B

B8	(a)		For irreversible reactions, concentration of reactants becomes zero (used up) eventually, while for reversible reactions, there will still be reactants left (concentration of reactants do not react zero concentration) OR For irreversible reaction, limiting reactant is used up but reversible reaction there will be a mixture of reactants and products at all time. This is because irreversible reaction goes to completion while reversible reaction does not go to completion .	[1] [1]
----	-----	--	---	------------

			OR For reversible reaction, products are constantly converted back to reactants as reactants react to form product.	
	(b)	(i)	<p>1m for slower speed 1m for higher conc of ammonia</p>	[2]
		(ii)	<p>Concentration of NH_3 in the equilibrium mixture increases as the position of equilibrium is shifted to the right to favour the forward exothermic reaction to increase the temperature/counteract the change.</p> <p>The graph is <u>less steep</u> as the <u>rate of reaction is decreased</u> as <u>temperature decreases</u>.</p>	[1] [1] [1]
		(iii)	<p>The lower the temperature, the <u>higher the yield of ammonia</u> as the <u>forward reaction is favoured</u>. However, a lower temperature also results in a <u>slower reaction</u>. Thus a temperature of 450°C is chosen.</p>	[1] [1] [1]
B9	(a)	(i)	The melting and boiling points <u>show an increase from Na to Mg, then decrease from Mg to Cl</u> .	[1]
		(ii)	<p>Na_2O, MgO and Al_2O_3 has a <u>giant ionic lattice structure</u>. Thus <u>large amount of energy</u> is needed to overcome the <u>strong electrostatic FOA</u> between the <u>ions</u>.</p> <p>SiO_2 has a <u>giant molecular structure</u>. <u>Large amount of energy</u> is needed to overcome the <u>strong covalent bond</u> between the <u>atoms</u>.</p>	[1] [1]
				[1]

			Oxides of P, S and Cl have a simple molecular structure . Small amount of energy is needed to overcome the weak intermolecular FOA .	
	(b)		SO ₃ has a higher melting and boiling point compared to SO ₂ because it has a relative molecular mass/ larger surface area/more electrons . Thus the intermolecular forces of attraction is stronger . More energy is needed to overcome it.	[1] [1]
	(c)	(i)	2;2;2; 3;3;3	[1] [1]
		(ii)	anions consist of 1 more electron shells compared to cations, thus radius of cations are generally smaller.	[1]
		(iii)	Argon has a stable electronic configuration and thus do not form ions.	[1]
B10 (E)	(a)		$\text{Ca(OH)}_2 (\text{aq}) + \text{H}_2\text{SO}_4 (\text{aq}) \rightarrow \text{CaSO}_4 (\text{s}) + 2\text{H}_2\text{O} (\text{l})$	[2]
	(b)		Test tube 1: yellow Test tube 5:red	[1]
	(c)		4cm Mol of calcium hydroxide = $0.5 \times 0.005 = 0.0025 \text{ mol}$ Mol of sulfuric acid = $1 \times 0.0035 = 0.0035 \text{ mol}$ Since mol ratio of calcium hydroxide: sulphuric acid = 1:1, Calcium hydroxide is the limiting reagent.	[1] [1] [1]
	(d)	(i)	Electrical conductivity/ μScm^{-1} 	[1]
		(ii)	The electrical conductivity decreases from test tube 1 and reaches 0 at test tube 4 because CaSO₄ is being precipitated out and thus ions decreases .	[1] [1]

		<p>In test tube 4, all the reactants have been used up and thus there is <u>no ions left</u> in the mixture.</p> <p>The electrical conductivity <u>increases</u> from reaction tube 4 to 6 as now <u>sulfuric acid is in excess</u>, thus there is an <u>increase in the number of mobile ions</u> as sulphuric acid is being added.</p>	[1]
B10 (or)	(a)	<p>The particles changes from <u>vibrate about fixed position</u> to <u>moving freely throughout the liquid</u>.</p> <p>The particles changes from <u>pack closely together in an orderly arrangement</u> to <u>slightly further apart in disorderly arrangement</u>.</p>	[1] [1]
	(b)	No, It is a strong acid as it <u>dissociate completely in water</u> and <u>not</u> due to it having high concentration of hydrogen ions.	[1]
	(c)	(i) Acid can <u>react with Fe₂O₃</u> which is a <u>basic oxide</u> to give <u>soluble salt and water</u> .	[1] [1]
		(ii) <u>Attach a more reactive metal</u> such as zinc to the underground pipes. It will <u>corrode in place of iron</u> , thus protecting iron from rusting.	[1] [1]
	(d)	<p>Advantages:</p> <ul style="list-style-type: none"> - Sulfamic acid will <u>corrode the metals</u> that it is cleaning to a <u>smaller extend</u> compared to hydrochloric acid as the corrosivity of HCl on steel is 4.2 times that of sulfamic acid. - It is <u>safer</u> to use sulfamic acid as it <u>will not react with bleach to produce Cl₂ which is toxic</u>. <p>Disadvantage:</p> <ul style="list-style-type: none"> - It is <u>2.5 times more expensive</u> than HCl. 	[1] [1] [1]