Examiner only

SECTION B

Answer **all** *questions in the spaces provided.*

5. *(a)* The Solvay process is used to make sodium compounds from sodium chloride.

(i) The first step in the process requires ammonia, which can be made by reacting ammonium chloride with calcium hydroxide, as shown in the equation below.

$$2NH_4Cl + Ca(OH)_2 \longrightarrow CaCl_2 + 2H_2O + 2NH_3$$

molar masses	2×53.5 g	74 g	111 g	2×18 g	2×17 g

Calculate the atom economy of this reaction where ammonia is the required product.

$$\text{atom economy} = \frac{\text{theoretical mass of required products} \times 100}{\text{total mass of reactants used}} \ \%$$

[2]

.....

.....

(ii) A disadvantage of the Solvay process is that the chloride ions from the sodium chloride are converted into calcium chloride, for which there has been little demand. However, recently, concentrated aqueous solutions of calcium chloride have been used in the oil industry.
A typical solution contains 45 g of calcium chloride in 100 cm^3 of solution.
Use the molar mass of calcium chloride, given in (i), to calculate the concentration of this solution in mol dm^{-3}. [2]

.....

.....

..... mol dm^{-3}

(iii) Give the equation for the reaction of calcium metal with hydrochloric acid to give calcium chloride as one of the products. [1]

.....

(iv) Calcium ions can be identified in a solution of calcium chloride by a flame test.
State the colour of the flame obtained. [1]

.....

(v) Describe how you would test for the presence of chloride ions in a solution of calcium chloride, giving the reagent used and an observation.

Reagent ..... [1]

Observation ..... [1]

(vi) Calcium chloride is an ionic compound.
Draw a dot and cross diagram for this compound, showing the outer electrons for both calcium and chlorine atoms, the outer electrons for each ion and any charges produced. [2]

(vii) Anhydrous calcium chloride, $CaCl_2$, can be used as a drying agent for some organic liquids. During this process, hydrated calcium chloride, $CaCl_2.2H_2O$, is formed.

$$CaCl_2(s) + 2H_2O \longrightarrow CaCl_2.2H_2O$$

M_r 111

In a drying process, 5.55 g of anhydrous calcium chloride, $CaCl_2$, was used.
Calculate how much water can be removed from the organic liquid. [2]

.....

.....

.....

(viii) Calcium chloride is unsuitable for drying ethanol as the ethanol bonds to the calcium chloride using a co-ordinate bond.

State what is meant by the term **co-ordinate** bond. [1]

.....

.....

Total [13]

Examiner only

(b) (i) Explain why sodium chloride is soluble in water. [2]

.....

.....

.....

(ii) A student was finding the solubility of sodium chloride in water.
He heated a saturated solution of sodium chloride to dryness, using an evaporating basin.
The following table of results was obtained.

Mass of evaporating basin + sodium chloride solution	=	140.57 g
Mass of evaporating basin	=	72.00 g
∴ Mass of sodium chloride solution	=	g

Mass of evaporating basin + dry sodium chloride	=	90.57 g
Mass of evaporating basin	=	72.00 g
∴ Mass of dry sodium chloride	=	g

I. Calculate and record the missing values in the table of results. [1]

II. State the mass of water in the sodium chloride solution ..... g [1]

III. Calculate the solubility of sodium chloride in water in g / 100 g of water.

.....

.....

Solubility = ... g / 100 g water [1]

IV. State what should have been recorded so that the solubility obtained can be compared against known values. [1]

.....

(c) State why sodium is described as an s-block element. [1]

.....

(d) Titanium metal is obtained by heating titanium(IV) chloride with sodium.

$$4Na + TiCl_4 \longrightarrow Ti + 4NaCl$$

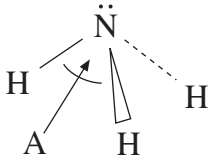
State the oxidation number (state) of each element present and use these to explain which species has been oxidised in this reaction. [2]

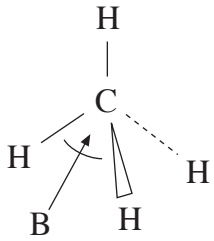
.....

.....

Total [13]

9. *(a)* (i) Explain why angle **A** in an ammonia molecule is less than angle **B** in a methane molecule. [1]





.....

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(ii) A student wrote that *'the bonds in an ammonia molecule are not purely covalent'*. Explain why this statement is correct. [2]

.....

.....

(b) The d-block element, nickel, has a number of important uses.

(i) Nickel is used as the catalyst in the hydrogenation of alkenes.
Using an alkene of your choice, write an equation, using displayed formulae, for this hydrogenation, naming your product. [2]

(ii) In recent years, nickel-containing 'smart alloys' have been developed.
A particular smart alloy changes shape when a force is applied but returns to its original shape when the force is removed.
Suggest a use for this type of smart alloy. [1]

.....

(iii) Nickel is purified using nickel tetracarbonyl, $Ni(CO)_4$.
This is a tetrahedral molecule with the same shape as methane.

State the bond angle in such tetrahedral molecules. ..... [1]

Examiner only

10. The electronegativities and melting temperatures of some of the elements in Groups 1-7 of the Periodic Table are shown in the table below.
Some values have been omitted.

		Group						
		1	2	3	4	5	6	7
Period 2	Element	Li	Be	B	C graphite	N	O	F
	Electronegativity	1.0	1.5	2.0	2.5	3.0	3.5	4.0
	Melting temperature / K	453	1550	2600	3730	63	54	53
Period 3	Element	Na	Mg	Al	Si	P	S	Cl
	Electronegativity	0.9	1.2	1.5	1.8	2.1	2.5	3.0
	Melting temperature / K	371	923		1680	317	392	172
Period 4	Element	K						Br
	Electronegativity	0.8						2.8
	Melting temperature / K	337						266

(a) (i) Explain the meaning of the term ***electronegativity***. [1]

.....

.....

(ii) State the trend shown in electronegativity across a period. [1]

.....

(iii) Explain this trend. [2]

.....

.....

.....

Examiner only

(b) (i) State the trends shown in melting temperature across Period 2. [2]

.....

.....

.....

(ii) Suggest a value for the melting temperature of aluminium. [1]

.....

(iii) Explain why the melting temperature of magnesium is higher than that of sodium. [2]

.....

.....

.....

(iv) Explain why the melting temperatures of the Group 7 elements increase down the group. [2]

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(c) Explain, in terms of bonding and structure, why graphite has a very high melting temperature. [2]

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.....

.....

Total [13]

Examiner only

SECTION B

Answer **all** *questions in the spaces provided.*

7. *(a)* Sulfur hexafluoride, SF_6, is a colourless gas that is used as an insulator in electrical transformers.

(i) Complete the table below, giving the number of bonding and lone pairs for the sulfur atom in a molecule of gaseous sulfur hexafluoride.

Use your answers to deduce an F — $\hat{S}$ — F angle and name the shape of the SF_6 molecule. [4]

Number of bonding pairs	Number of lone pairs	F — $\hat{S}$ — F	Shape

(ii) The S — F bond in sulfur hexafluoride is a polar covalent bond.
Describe what is meant by bond polarity and how it arises in this bond. [2]

.....

.....

.....

(iii) Sulfur hexafluoride reacts with hydrogen sulfide in a redox reaction.

$$SF_6 + 3H_2S \longrightarrow 6HF + 4S$$

Complete the table below, giving the oxidation states (numbers) of the sulfur atoms present and use these to explain how hydrogen sulfide is the reducing agent in this reaction. [2]

Oxidation state of sulfur in SF_6	Oxidation state of sulfur in H_2S	Oxidation state of sulfur in sulfur, S

.....

.....

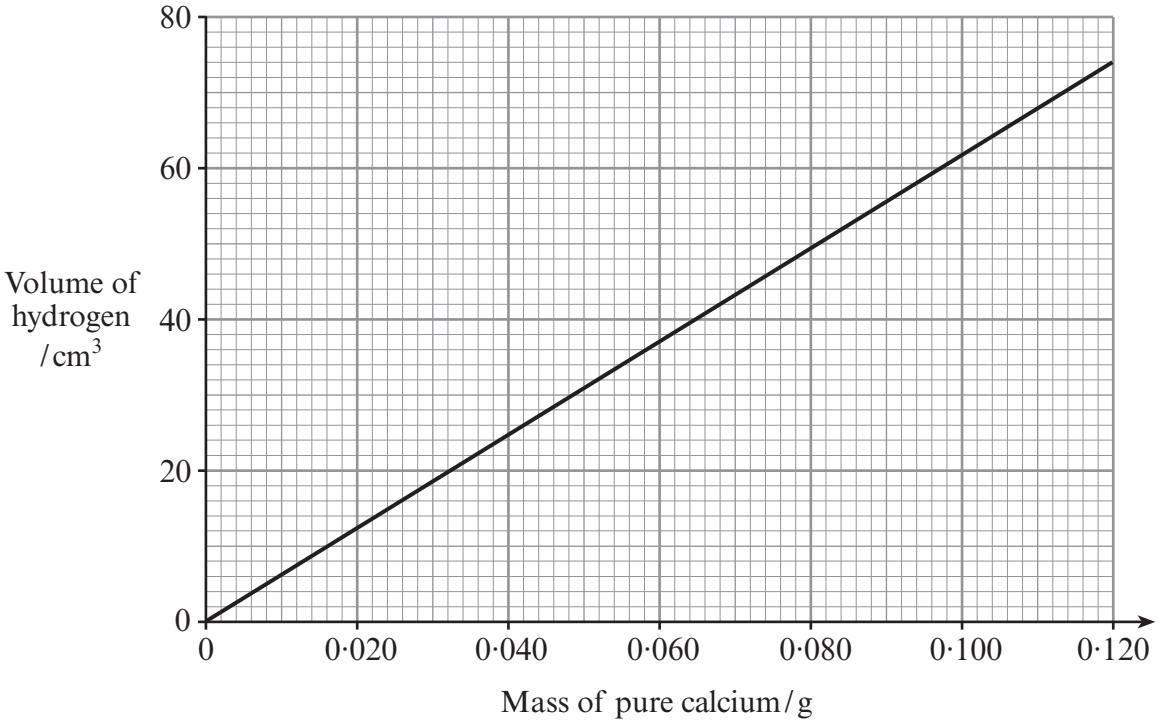
.....

Examiner only

8. *(a)* (i) 0.115 g of impure calcium metal was added to water. Hydrogen gas and calcium hydroxide were formed.
Give the equation for this reaction. [1]

.....

(ii) All the hydrogen produced was collected and gave a volume of 64.0 cm^3.



Use the graph to find the mass of pure calcium present and hence the percentage purity of the calcium used. [2]

.....

.....

(iii) Jonathan added a piece of strontium metal to water. He noticed that the reaction was more vigorous than when using calcium. He said that one reason for this was that the strontium ion, Sr^{2+}, was formed more easily than the calcium ion, Ca^{2+}.

Explain why this statement is true, in terms of the electronic structures of the two metals. [2]

.....

.....

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Examiner only

(b) A solution, giving an apple-green colour to a flame, was suspected to be aqueous barium hydroxide.

Describe **two** simple tests to confirm this conclusion, giving the result of each test. [2]

1. .....

.....

2. .....

.....

(c) Both solid strontium metal and solid graphite are conductors of electricity.
Describe the structures of these two materials and explain how they are both able to conduct electricity. You may use diagrams in your answer. [5]

QWC [1]

Strontium

.....

.....

Graphite

.....

.....

(d) There is much interest in carbon nanotubes as drug delivery agents.
Describe how the structure of carbon nanotubes is related to the structure of graphite. [2]

.....

.....

.....

Total [15]

Examiner only

10. *(a)* Bromine is produced commercially from bromide ions in sea water by reaction with chlorine.

(i) Give the equation for this reaction. [1]

.....

(ii) Although both bromine and chlorine are oxidising agents, this reaction proceeds because chlorine is a stronger oxidising agent than bromine.

I. Explain what is meant by the term *oxidising agent*. [1]

.....

.....

II. Explain why chlorine is the stronger oxidising agent. [2]

.....

.....

(iii) Air is then blown through the bromine-containing mixture to remove bromine as its vapour.
Iodine can be produced in a similar way from the iodide ions present in sea water but it is more difficult to produce iodine vapour from its solution because iodine is less volatile than bromine.
Explain, in terms of bonding, why iodine is less volatile than bromine. [2]

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.....

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(b) One important use of a bromine compound is as a very concentrated aqueous solution of calcium bromide, in the oil industry.

(i) The concentration of a calcium bromide solution is 1200 g dm^{-3}.
Calculate the concentration of this solution in mol dm^{-3}. [2]

.....

.....

(ii) Many of the metals present in compounds of Group 2 can be identified by a flame test.
Complete the table below showing the flame colours (if any) obtained using magnesium bromide and calcium bromide. [2]

Compound	Flame colour (if any)
magnesium bromide	
calcium bromide	

Examiner only

5. Use the electronegativity values given in the table below to answer the questions that follow.

Atom	B	H	C	O	Cl
Electronegativity value	2.0	2.1	2.5	3.5	3.0

(a) Identify any dipoles present in the following bonds, marking their polarity clearly.

O—H C—H B—Cl C═O [2]

(b) State which of the bonds in *(a)* will have the largest dipole. [1]

.....

6. XeF_2 is one of the few noble gas compounds known. It reacts with water in the presence of a base according to the equation below.

$$2XeF_2 + 2H_2O \longrightarrow 2Xe + 4HF + O_2$$

Complete the table below to give the initial and final oxidation states of the xenon and oxygen atoms, noting whether oxidation or reduction has occurred. [2]

Element	Initial oxidation state	Final oxidation state	Oxidation or reduction
xenon			
oxygen			

Total Section A [10]

Examiner only

SECTION B

Answer **all** *questions in the spaces provided.*

7. Carnallite is a hydrated chloride mineral that is used as a source of both potassium and magnesium chlorides. It has a formula of $KMgCl_3.xH_2O$. It can also be crystallised from the water of some lakes and seas.

(a) A sample of carnallite is dissolved in water to form a colourless solution. When this solution is tested it behaves as if it is a mixture of potassium chloride and magnesium chloride. Give the expected observations when **each** of the following tests is carried out on a sample of carnallite solution.

Test	Observation
Flame test	.....
Addition of nitric acid followed by aqueous silver nitrate	.....
Addition of sodium hydroxide solution	.....

[3]

(b) Describe how a crystalline sample of hydrated carnallite could be obtained from its aqueous solution. [3]

.....

.....

.....

.....

Examiner only

(c) In an experiment, a sample of 3.20 g of hydrated carnallite, $KMgCl_3.xH_2O$, was heated until all water was lost. The mass of the remaining anhydrous sample was 1.95 g.

(i) Calculate the mass, in grams, of water vapour lost from this sample. [1]

.....

(ii) Calculate the relative molecular mass of anhydrous carnallite, $KMgCl_3$. [1]

.....

.....

(iii) Calculate the value of x in the formula $KMgCl_3.xH_2O$. [2]

.....

.....

.....

(d) Magnesium is extracted from carnallite in an industrial process. In order to do this, $MgCl_2$ is initially prepared from carnallite according to the equation below.

$$KMgCl_3 \longrightarrow KCl + MgCl_2$$

Assuming that all the magnesium chloride present can be extracted, calculate the mass of magnesium chloride that could be produced from 100 kg of anhydrous carnallite, $KMgCl_3$. [3]

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.....

.....

.....

Total [13]

Examiner only

(d) Calcium metal reacts quickly with a range of dilute acids.

(i) Write an equation for the reaction of calcium metal, Ca, with phosphoric acid, H_3PO_4, to produce calcium phosphate and hydrogen gas only. [2]

.....

(ii) A piece of calcium metal would react quickly with most dilute acids but would not react significantly with dilute sulfuric acid under the same conditions. Explain this lack of reactivity with dilute sulfuric acid. [2]

.....

.....

.....

Total [11]

Examiner only

11. Part of the Periodic Table is shown below.

Group	1	2	3	4	5	6
	Li		B	C		O
	Na	Mg	Al	Si	P	S
	K	Ca				

(a) Answer the following questions about the elements shown.

Each element may be used once, more than once or not at all.

Write the symbol of

(i) the element with one electron in its 2s orbital, ... [1]

(ii) the element with the lowest first ionisation energy, ... [1]

(iii) an element that forms a basic oxide, ... [1]

(iv) the element with the lowest melting temperature. ..... [1]

Examiner only

SECTION A

Answer **all** *questions in the spaces provided.*

1. barium sulfate

calcium carbonate

magnesium hydroxide

sodium carbonate

From the list above, choose the compound that

(a) gives a brick-red flame test, [1]

.....

(b) is the **most** soluble in water. [1]

.....

2. Complete the table below to show the type or types of bonding present in the following solids. [2]

Solid	Type or types of bonding
calcium	
iodine	

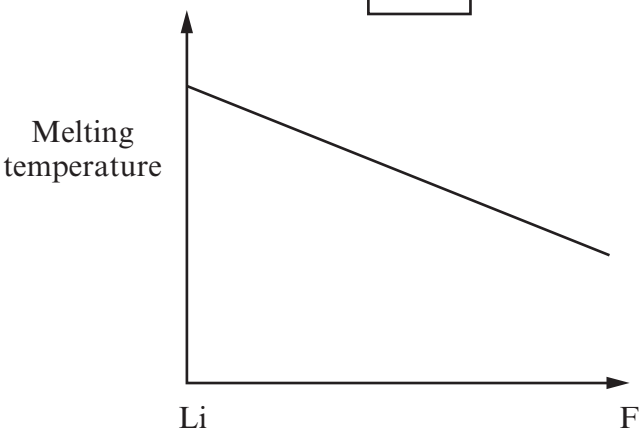
3. Calcium phosphate is found widely in nature, e.g. in bones and in the leaves of plants. The formula for the phosphate ion is PO_4^{3-}. Write the formula for calcium phosphate. [1]

.....

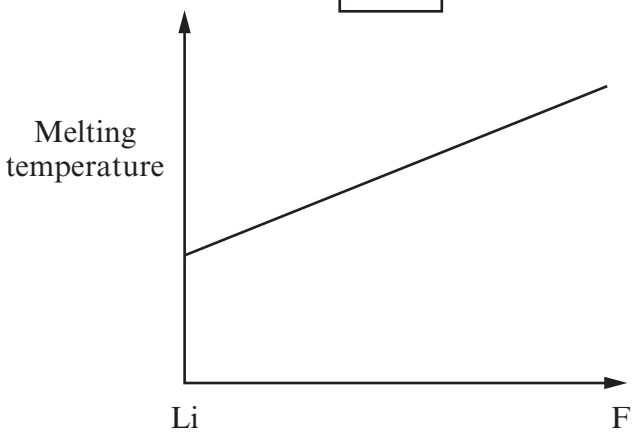
Examiner only

4. State which one of the following graphs best shows how melting temperature changes across period 2 in the Periodic Table. [1]

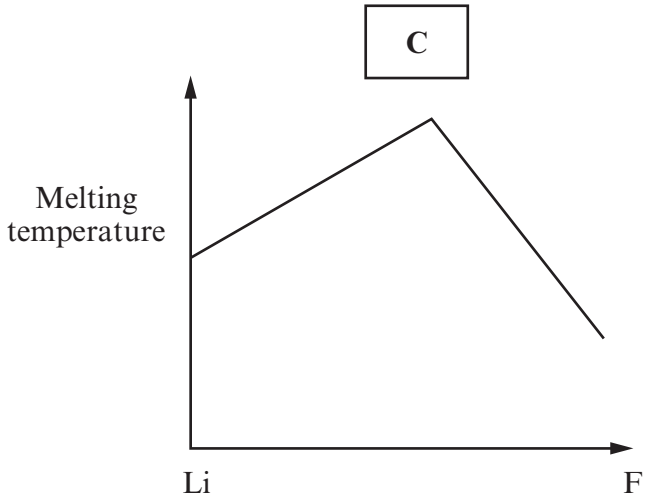
A



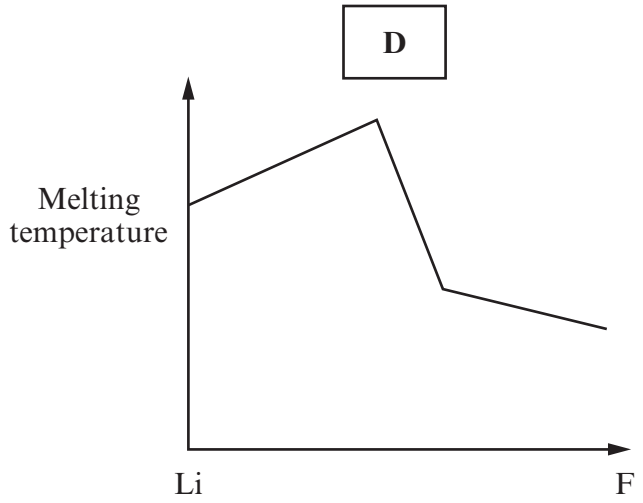
B



C



D



.....

5. In recent years scientists have developed a range of materials known as smart materials. State what is meant by a *smart material*. [1]

.....

.....

Examiner only

10. Because of its many uses, over 100 million tonnes of ammonia are manufactured each year.

(a) One of the main uses of ammonia is in the production of nitric acid. In the first part of this process a mixture of ammonia and air is passed over a catalyst at 850 °C.

$$\square\ NH_3(g) + \square\ O_2(g) \longrightarrow \square\ NO(g) + \square\ H_2O(g)$$

(i) Balance the equation above. [1]

(ii) Complete the table below, giving the oxidation states (numbers) of each element present and use these to explain which species has been oxidised in this reaction. [3]

Element	Initial oxidation state	Final oxidation state
nitrogen		
hydrogen		
oxygen		

.....

.....

(iii) Explain in terms of VSEPR theory why ammonia, NH_3, and boron trifluoride, BF_3, have different shapes. [3]

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.....

.....

Examiner only

11. Dr Ballard carries out a series of experiments in the laboratory using Group 1 metals.

(a) In the first experiment, he ignites potassium and puts it in a gas jar containing oxygen to form potassium oxide.

(i) State what he would **see** as the reaction proceeds. [2]

.....

.....

.....

(ii) Write a balanced equation for the reaction. [1]

.....

(iii) He repeats the experiment with rubidium.
State whether you would expect rubidium to be more reactive or less reactive than potassium. Give a reason for your answer. [2]

.....

.....

.....

(b) In the second experiment, Dr Ballard reacts sodium with water at room temperature.

$$2Na(s) + 2H_2O(l) \longrightarrow 2NaOH(aq) + H_2(g)$$

(i) If the mass of sodium is 0.098 g, calculate the number of moles of sodium used in the experiment. [1]

.....

.....

(ii) Calculate the volume of hydrogen produced in this reaction at room temperature. [2]

(1 mole of gas occupies 24.0 dm^3 at room temperature)

.....

.....

(iii) If the volume of water used was 200 cm^3 calculate the concentration, in mol dm^{-3}, of the sodium hydroxide solution formed. [2]

.....

.....

Examiner only

(c) In the final experiment, Dr Ballard heats a piece of sodium and puts it in a gas jar containing chlorine to form sodium chloride.

(i) Apart from wearing safety goggles, give **one** precaution that Dr Ballard should take when using chlorine. [1]

.....

(ii) Sodium chloride is a solid with a melting temperature of 801°C.

I State the crystal co-ordination numbers for sodium chloride. [1]

.....

II Explain in terms of bonding why its melting temperature is high. [2]

.....

.....

.....

.....

Total [14]

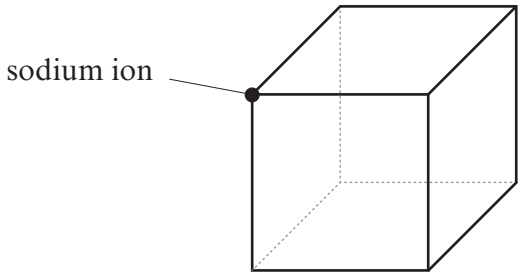
Section B Total [70]

Examiner only

SECTION B

Answer **all** *questions in the spaces provided.*

6. *(a)* A section of the crystal structure of sodium chloride is shown below.



(i) Indicate, with a cross, the position of any chloride ion on this diagram. [1]

(ii) State the crystal co-ordination number of a **chloride** ion in the structure of sodium chloride. [1]

.....

(b) 'Rock salt', used on roads in winter, consists mainly of crystalline sodium chloride that is contaminated by a small quantity of insoluble mudstone.
Gwen added powdered rock salt to water and filtered out the insoluble material. She then evaporated the filtrate to dryness to produce pure white crystals of sodium chloride.
State **two** steps that she should have carried out to ensure that she obtained the **maximum** amount of sodium chloride from her rock salt crystals. [2]

.....

.....

(c) The minerals 'rock salt', NaCl, and kainite, $KCl.MgSO_4.3H_2O$, both contain chloride ions.

(i) Give a chemical test that produces the same result for both of these compounds. You should state the reagent(s) used and the result of the test. [2]

.....

.....

(ii) Give a chemical test, other than a flame test, that will show that these two compounds are different. You should assume that they are present as aqueous solutions.
Give the reagent(s) used and the result of the test for each compound. [2]

.....

.....

.....

Examiner only

(d) A common reaction of the halogens is the formation of the anion, X^-.

(i) State, in terms of electronic structure, why this occurs. [1]

.....

.....

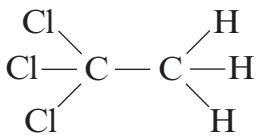
(ii) Give a reason why the tendency to form the X^- ion decreases down the halogen group. [1]

.....

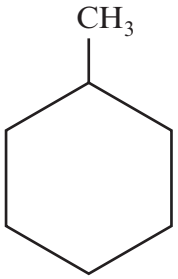
.....

.....

(e) One compound previously used in correction fluid was 1,1,1-trichloroethane, but this has been replaced by compounds such as methylcyclohexane, which has a much less adverse effect on the environment.



1,1,1-trichloroethane



methylcyclohexane

(i) Explain, in terms of bond strengths, why 1,1,1-trichloroethane has an effect on the ozone layer but methylcyclohexane does not. [2]

.....

.....

.....

(ii) Hept-1-ene is an isomer of methylcyclohexane.

$$CH_3—CH_2—CH_2—CH_2—CH_2—CH=CH_2$$

Describe a chemical test that gives a positive result for hept-1-ene but not for methylcyclohexane. [2]

Reagent(s) .....

Observation .....

Total [14]

Examiner only

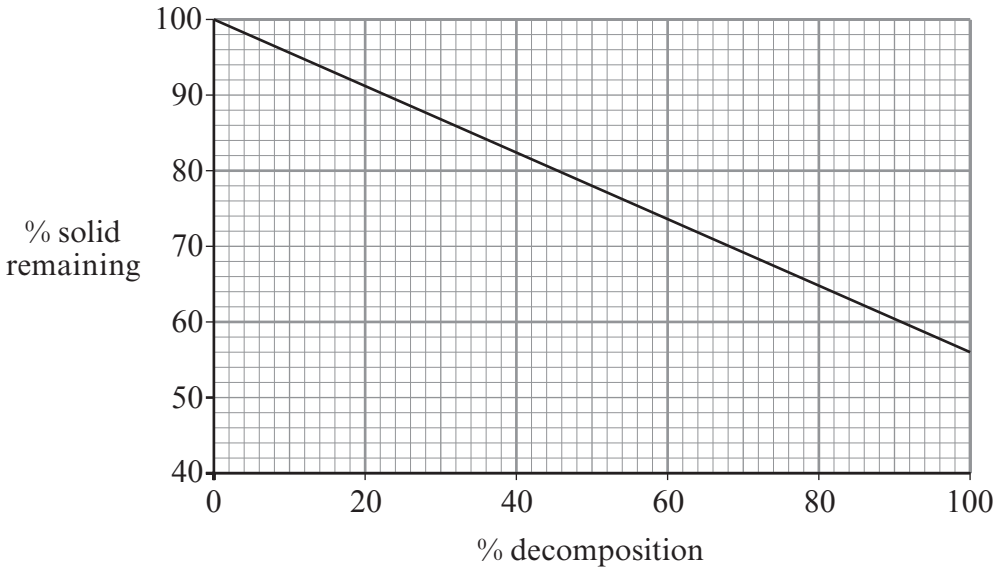
7. *(a)* In industry calcium oxide is made by heating limestone (a form of calcium carbonate) to a high temperature.

$$CaCO_3(s) \longrightarrow CaO(s) + CO_2(g)$$

(i) This experiment can be repeated in the laboratory by strongly heating a marble chip. Unless the temperature is high enough the reaction is often incomplete. In an experiment the following results were obtained.

Mass of marble chip before heating = 3.24 g
Mass of solid after heating = 2.01 g

Use the graph to help you calculate the percentage decomposition of the marble chip into calcium oxide and carbon dioxide. [2]



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.....

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Examiner only

(ii) The solid from (i) was carefully added to cold distilled water in order to produce a solution of calcium hydroxide, together with unreacted solid calcium carbonate. The solubility of calcium hydroxide in water was found from the resulting solution. The instructions that were being followed stated

- add the solid to about 1200 cm^3 of distilled water
- stir the mixture for ten minutes
- filter the mixture

I. State why the solid was added to **distilled** water. [1]

.....

.....

II. State why the mixture was stirred for ten minutes. [1]

.....

.....

(iii) 1.00 dm^3 of the solution, produced in (ii), was then titrated with hydrochloric acid of a known concentration.

$$Ca(OH)_2 + 2HCl \longrightarrow CaCl_2 + 2H_2O$$

It was found that 0.0450 mol of hydrochloric acid reacted with all the calcium hydroxide present in the solution.

I. State the number of moles of calcium hydroxide that reacted with the hydrochloric acid. [1]

.....

II. Calculate the solubility of calcium hydroxide in this solution in $g\,dm^{-3}$.
[The molar mass of calcium hydroxide is 74.1 $g\,mol^{-1}$] [1]

.....

Solubility = ... $g\,dm^{-3}$

(iv) Calcium carbonate will also react with hydrochloric acid.
State why any unreacted calcium carbonate from the marble chip cannot interfere with the experiment in (iii). [1]

.....

1092 010007

Examiner only

(b) Dolomite, $MgCO_3.CaCO_3$, is a mineral found in Italy. State the colour given by dolomite in a flame test, giving a reason for your choice. [2]

.....

.....

(c) A solution of calcium hydroxide is reacted with aqueous sulfuric acid. A faint white precipitate is seen, as the calcium ions react with the sulfate ions. Give the **ionic** equation for this reaction. [1]

.....

(d) The hard mineral fluorapatite, $CaF_2.3Ca_3(PO_4)_2$, is found in tooth enamel.
One weakness with this material is that there are tiny holes between each 'molecule' of fluorapatite and these may be a cause of sensitive teeth.
Recently a manufacturer has suggested that nano-sized fluorapatite particles in a toothpaste may help solve this problem by filling the holes. Suggest what should be done before this nano-sized material is licensed for use. [1]

.....

.....

(e) Fluorapatite occurs naturally as a rock and can be used to make the fertiliser 'superphosphate'. 5.0 tonnes of fluorapatite give a maximum yield of 8.6 tonnes of superphosphate.
Calculate the mass of superphosphate made from 5000 tonnes of fluorapatite if the percentage yield is 93%. [2]

.....

.....

.....

(f) Radium and calcium are elements in Group 2. Explain why radium carbonate, $RaCO_3$, has a similar formula to calcium carbonate, $CaCO_3$. [1]

.....

.....

.....

Total [14]

Examiner only

9. During 2010 a serious leak of petroleum (crude oil) occurred in the Gulf of Mexico. This loss of millions of litres of petroleum caused an environmental and ecological disaster.

(a) Petroleum consists largely of a mixture of alkanes that do not dissolve in sea water but form a surface layer. The main reason that these alkanes cannot dissolve in water is because they are unable to hydrogen bond with water. Explain what is meant by *hydrogen bonding* and use this to explain why alkanes do not dissolve in water. [4]

QWC [1]

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.....

.....

.....

.....

(b) (i) Some of the leaking oil was collected by tankers and taken to oil refineries. The petroleum was then separated into fractions by the process of fractional distillation. Describe what is meant by *fractional distillation*. [2]

.....

.....

(ii) One of the fractions was then further refined into fuel for vehicles.
During refining, most of the sulfur compounds present in the fuel are removed in order to reduce the amount of oxides of sulfur released in exhaust gases.
One stage in the process is to convert unpleasant-smelling thioalcohols (R—SH) into disulfides (R—S—S—R) using copper chloride, $CuCl_2$.

$$2R—SH + 2CuCl_2 \longrightarrow R—S—S—R + 2CuCl + 2HCl$$

Explain, using the oxidation states (numbers) of copper, why copper chloride, $CuCl_2$, is reduced in this reaction. You should assume that the oxidation state of chlorine is –1. [2]

.....

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Examiner only

9. Calcium is present in teeth in the form of calcium phosphates. These do not react with water. The element calcium, however, reacts with water to produce calcium hydroxide and hydrogen gas.

$$Ca(s) + 2H_2O(l) \longrightarrow Ca(OH)_2(aq) + H_2(g)$$

(a) A student investigated the reaction between calcium and cold water. He added 2.0 g of calcium to some water and collected the hydrogen gas formed.

Draw a labelled diagram of an apparatus that would be suitable for carrying out this reaction and measuring the volume of hydrogen produced. [2]

(b) The student repeated the reaction using the same mass of barium. He noticed that the volume of gas, still at the same temperature and pressure, was less.

(i) Give the reason why the volume of gas produced was less. [1]

.....

.....

(ii) Suggest another difference that the student would observe when barium was used in place of calcium. Explain your answer. [2]

.....

.....

.....

(c) The student did not label the flasks containing the solutions after the reactions with calcium and with barium.

Give a test that would distinguish between these solutions. Include the result of your test for both solutions. [2]

.....

.....

.....

Examiner only

12. The elements in Group 7 in the Periodic Table can be described as *p*-block elements.

(a) State why these are described as *p*-block elements. [1]

.....

.....

(b) All halogens are oxidising agents.

(i) Why are the halogens oxidising agents? [1]

.....

.....

(ii) State, giving a reason, which halogen is the strongest oxidising agent. [1]

.....

.....

(c) $NaClO_3$ was used as a weedkiller. Give the oxidation state of chlorine in $NaClO_3$.

Oxidation state ..... [1]

(d) Methane reacts with chlorine when exposed to sunlight. The first two stages of the mechanism of this reaction are initiation and propagation.

(i) Give the equation for the initiation reaction. [1]

.....

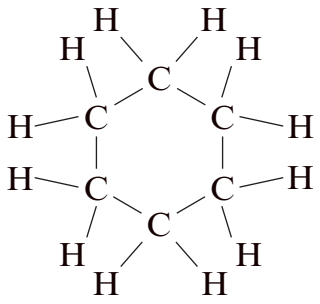
(ii) Give equations for **two** propagation steps involved in the formation of chloromethane. [2]

.....

.....

Examiner only

4. Cyclohexane is an example of a hydrocarbon containing a ring of carbon atoms. Its structure is shown below.



Give the **empirical** formula of this compound. [1]

.....

5. *(a)* Write the letter corresponding to the correct electronic structure of an atom that is a member of the *d*-block in the box below. [1]

A $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^1$

B $1s^2 2s^2 2p^6 3s^2 3p^6 3d^6$

C $1s^2 2s^2 2p^6 3s^2 3p^6 3d^6 4s^2$

D $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$

(b) Write the letter corresponding to the electronic structure of the atom with the highest first ionisation energy in the box below. [1]

A $1s^2 2s^2 2p^6 3s^2 3p^6$

B $1s^2 2s^2 2p^6$

C $1s^2 2s^2 2p^6 3s^2$

D $1s^2 2s^2 2p^6 3s^2 3p^4$

Examiner only

6. The gas oxygen, O_2, is converted into ozone, O_3, in the upper atmosphere. The equation for this process is:

$$3O_2 \longrightarrow 2O_3$$

Use oxidation states to explain why this is not a redox reaction. [2]

.....

.....

.....

7. Recent advances in chemistry have produced a range of smart materials.

Give the meaning of the term *smart material*. [1]

.....

.....

.....

Total Section A [10]

Examiner only

SECTION B

Answer **all** *questions in the spaces provided.*

8. Barium chloride is a highly toxic compound that is frequently used in the laboratory.

(a) Aqueous barium chloride can be used to test for sulfate ions in solution.

(i) Write an **ionic** equation for the reaction that occurs when aqueous barium chloride is added to a solution containing sulfate ions. [1]

.....

(ii) Give the observation expected for a positive result in this chemical test. [1]

.....

(b) A solution of barium chloride can be identified using separate tests for barium ions and chloride ions.

(i) A flame test can be used to prove that the solution contains barium ions. State the flame colour that would be seen. [1]

.....

(ii) Give a chemical test to show that the solution contains chloride ions. Your answer should include the reagent(s) and expected observation(s). [2]

Reagent(s) .....

Observation(s) .....

(c) The solubility of barium chloride at two different temperatures is given in the table below.

Temperature / °C	Solubility of $BaCl_2$ / g dm^{-3}
0	312
20	358

Calculate the mass of solid barium chloride that would be obtained by cooling 200 cm^3 of a saturated solution of barium chloride from 20 °C to 0 °C. [2]

Mass = ... g

Examiner only

(d) When solid barium chloride is crystallised from solution, it produces the hydrate $BaCl_2.xH_2O$. The relative molecular mass (M_r) of this hydrate was found to be 244. Calculate the value of x in this formula. [2]

x = ...

(e) Jack wishes to prepare a solution of barium chloride starting with the insoluble solid barium carbonate and dilute hydrochloric acid.

(i) Write the equation for this reaction. [1]

.....

(ii) Jack measured 50.0 cm^3 of hydrochloric acid of concentration 0.500 mol dm^{-3}.

I Calculate the number of moles of hydrochloric acid in this solution. [2]

Moles of hydrochloric acid = ... mol

II He added an excess of solid barium carbonate to the dilute hydrochloric acid. Suggest how a pure solution of barium chloride could be obtained from the reaction mixture. [1]

.....

III Calculate the maximum mass of hydrated barium chloride (M_r = 244) that could be produced in this reaction. [2]

Maximum mass of hydrated barium chloride = ... g

Total [15]

1092 010007

Examiner only

SECTION A

Answer **all** *questions in the spaces provided.*

1. State which **one** of the following formulae represents an **alkane**. [1]

A C_8H_{16}

B C_8H_{17}

C C_8H_{18}

D C_8H_{20}

2. In order to form a magnesium atom, a magnesium ion must: [1]

A gain one electron

B gain two electrons

C lose two electrons

D lose two protons

3.

ammonium nitrate	calcium chloride	magnesium carbonate
potassium hydroxide	sodium sulfate	

From the list of compounds above choose one that

(a) gives a brick-red flame test, [1]

.....

(b) is insoluble in water, [1]

.....

(c) in solution forms a white precipitate with aqueous barium chloride. [1]

.....

Examiner only

10. *(a)* The Group 7 elements chlorine and iodine can both be produced from brine and can be used as disinfectants.

(i) Give the physical states of chlorine and iodine at room temperature. [1]

chlorine .....

iodine .....

(ii) State what is **observed** (if anything) when chlorine and iodine are added separately to potassium bromide solution. Write an equation for any reaction. [3]

Observations .....

.....

.....

Equation(s) .....

.....

(b) Chlorine can react with water to produce oxygen.

$$2Cl_2 + 2H_2O \longrightarrow 4HCl + O_2$$

Explain why this reaction is classified as a redox reaction. [2]

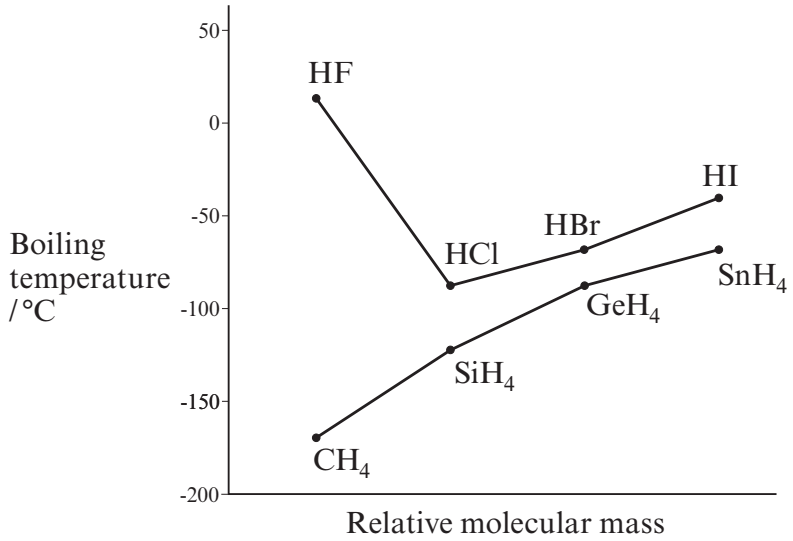
.....

.....

.....

Examiner only

(c) The diagram below shows a plot of boiling temperature against relative molecular mass for the hydrides of Group 7 and Group 4.



(i) Describe the trends in boiling temperatures for the hydrides of Group 7 and Group 4, noting any anomalies. [2]

.....

.....

.....

.....

(ii) By reference to the types of intermolecular force present, explain the shape of the plot for the hydrides of Group 7. [3]

QWC [1]

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QUESTION 10 CONTINUES ON PAGE 14

Examiner only

11. Jennifer and Marged carry out some experiments with Group 2 metals.

(a) In the first experiment, Jennifer reacts calcium with oxygen to form calcium oxide.

(i) Write an equation for the reaction. [1]

.....

(ii) Using outer electrons only, draw a dot and cross diagram to show the transfer of electrons involved in the formation of calcium oxide. Show the charges on the ions formed. [2]

(b) Jennifer then adds water to the calcium oxide. Some of it reacts to form a solution of calcium hydroxide.

(i) Write the formula of calcium hydroxide. [1]

.....

(ii) Suggest the pH of this solution. [1]

.....

(c) Jennifer reacts the solution of calcium hydroxide with an aqueous solution of sodium carbonate and a white precipitate is seen. Write the **ionic** equation for this reaction. Include the relevant state symbols in the equation. [1]

.....

Examiner only

(d) Marged adds a strip of magnesium to dilute hydrochloric acid.

$$Mg + 2HCl \longrightarrow MgCl_2 + H_2$$

(i) State what she would **observe** as this reaction proceeds. [2]

.....

.....

(ii) If the mass of the magnesium strip is 0.503 g and the concentration of the acid is 1.60 mol dm^{-3}, calculate the minimum volume of acid required to react completely with the magnesium, giving your answer to **three** significant figures. [3]

Volume of acid = ... cm^3

(iii) Calculate the volume at room temperature of the hydrogen produced in this reaction. [1]

[1 mol of gas occupies 24.0 dm^3 at room temperature]

Volume of hydrogen = ... dm^3

(iv) Give a test which would confirm the presence of chloride ions in aqueous magnesium chloride, stating the result of the test. [2]

.....

.....

QUESTION 11 CONTINUES ON PAGE 18

Examiner only

10. *(a)* A solution of calcium chloride was obtained by adding 0.40 g of calcium metal to 80 cm^3 of hydrochloric acid of concentration 0.20 mol dm^{-3}. The equation for the reaction is

$$Ca + 2HCl \longrightarrow CaCl_2 + H_2$$

(i) Use the information given to show that an excess of calcium metal was used. [3]

(ii) State **one** observation made during the reaction apart from the mixture becoming warm. [1]

.....

(b) A sample of a calcium compound **E** of mass 1.50 g was added to 200 cm^3 of cold water and the mixture heated until it all dissolved.

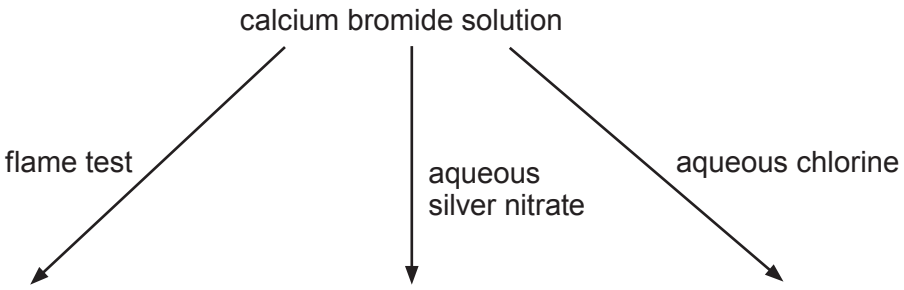
Use relevant information from the table to calculate the mass of compound **E** that crystallised when the solution was cooled to 0 °C. [2]

Solubility of compound **E** / g per 100 g of water	Temperature / °C
0.13	0
0.75	50
1.22	100

Mass that crystallised = ... g

Examiner only

(c) A student was given a solution of calcium bromide and asked to carry out the reactions shown in the diagram below.



(i) State the colour given in the flame test. [1]

.....

(ii) State what was seen when aqueous silver nitrate was added. [1]

.....

(iii) Give the **ionic** equation for the reaction occurring in (ii). [1]

.....

(iv) State what was seen when aqueous chlorine was added to the solution of calcium bromide. [1]

.....

(v) Explain why chlorine reacted as described in (iv).
Your answer should include

- the type of bonding and the species present in calcium bromide
- the type of reaction occurring
- why chlorine is able to react in this way
- an appropriate equation

[5]
QWC [1]

.....

.....

.....

.....

.....

.....

.....

.....

Total [16]

Examiner only

(c) Methane reacts with chlorine in a substitution reaction.

(i) The first stage of the reaction is as follows.

$$Cl_2 \longrightarrow 2Cl\bullet$$

State an essential condition for this stage. [1]

.....

(ii) State what is meant by the term *propagation stage*. [1]

.....

.....

(iii) Write an equation that represents a propagation stage of this reaction. [1]

.....

QUESTION CONTINUES ON PAGE 18

Examiner only

SECTION B

Answer **all** *questions in the spaces provided.*

7. Ewan and Gwyneth are given four unlabelled bottles. They know that these contain the following four solutions:

potassium carbonate *sodium hydroxide* *barium chloride* *magnesium nitrate*

(a) Ewan predicted what will happen when each of the four solutions is added to the others, and presented this information in the grid below.

	magnesium nitrate	barium chloride	sodium hydroxide
potassium carbonate	white precipitate	white precipitate	no visible change
sodium hydroxide			
barium chloride			

(i) Complete the three empty boxes with the observations expected in each of these cases. [2]

(ii) Name the white precipitate formed when magnesium nitrate is mixed with potassium carbonate, and write an **ionic** equation for its formation. [2]

Name of precipitate .....

Ionic equation .....

Examiner only

(b) Gwyneth uses different tests to identify the four solutions. Each test allows her to distinguish between some of the solutions. For each test state the solution(s) that would give a visible change and the observation(s) that would be made.

(i) Addition of litmus solution [1]

.....

.....

.....

.....

(ii) Flame test [2]

.....

.....

.....

.....

(iii) Addition of sodium sulfate solution [2]

.....

.....

.....

.....

1092 010007

Examiner only

(c) Ewan and Gwyneth are provided with a white solid that they believe to be sodium bromide or sodium iodide.

(i) They dissolve the solid in water to make a solution. Explain what occurs when an ionic solid such as sodium bromide dissolves in water. [2]

.....

.....

.....

.....

(ii) Gwyneth uses aqueous silver nitrate to identify the solution. Give the observations expected when silver nitrate is added separately to solutions of sodium bromide and sodium iodide. [2]

Observation with sodium bromide .....

.....

Observation with sodium iodide .....

.....

(iii) Ewan thinks that a further test is needed after addition of the silver nitrate to distinguish between sodium bromide and sodium iodide. Give the reagent and observations for this further test. [2]

Reagent .....

Observation with sodium bromide .....

.....

Observation with sodium iodide .....

.....

(iv) When bromine water is added to a solution of sodium iodide, a reaction occurs. Write an equation for this reaction. [1]

.....

Total [16]

Examiner only

9. Haematite is an ore of iron that contains Fe_2O_3. Iron is extracted from this ore in a blast furnace.

(a) Balance the equation for the extraction of iron from Fe_2O_3. [1]

..... Fe_2O_3 + ... CO ⟶ ..... Fe + ... CO_2

(b) Use oxidation states to show that the reaction in *(a)* is a redox reaction. [2]

.....

.....

.....

.....

(c) A different oxide of iron is iron(II) oxide, FeO. The ions in this compound adopt an arrangement similar to that of sodium chloride.

(i) Give the crystal co-ordination numbers for the ions in FeO. [1]

.....

(ii) Draw the arrangement of oxide ions around each iron ion. [1]

(d) Iron can be extracted from FeO according to the equation below.

$$FeO + CO \longrightarrow Fe + CO_2$$

Calculate the mass of iron that could be extracted from 20.0 kg of iron(II) oxide, FeO. [3]

Mass of iron = ... kg