Examiner only

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

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.....

.....

(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.

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

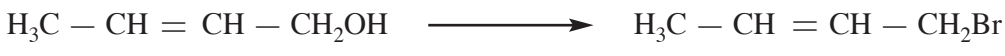
State the oxidation number (state) of each element present and use these to explain which species has been oxidised in this reaction. [2]

.....

.....

Total [13]

(b) 1-Bromobut-2-ene can be made from but-2-en-1-ol.



	but-2-en-1-ol	1-bromobut-2-ene
boiling temperatures / °C	121	98

(i) Use the infrared absorption frequencies given in the **Data Sheet** to explain how you would know if a sample of 1-bromobut-2-ene contains unreacted but-2-en-1-ol. [2]

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(ii) Use your understanding of intermolecular forces to explain why but-2-en-1-ol has a higher boiling temperature than 1-bromobut-2-ene.
Your answer should include:
• a description of **all** the intermolecular forces present for each compound;
• the relative strengths of the intermolecular forces present. [6]

(QWC) [2]

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Total [15]

Examiner only

SECTION A

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

1. State which **one** of the following bonds is generally the **weakest**. [1]

A Covalent

B Hydrogen

C Ionic

D Van der Waals .....

2. State which **one** of the following formulae represents a compound that can show hydrogen bonding. [1]

A CH_3CH_3

B CH_3OCH_3

C HCl

D HF .....

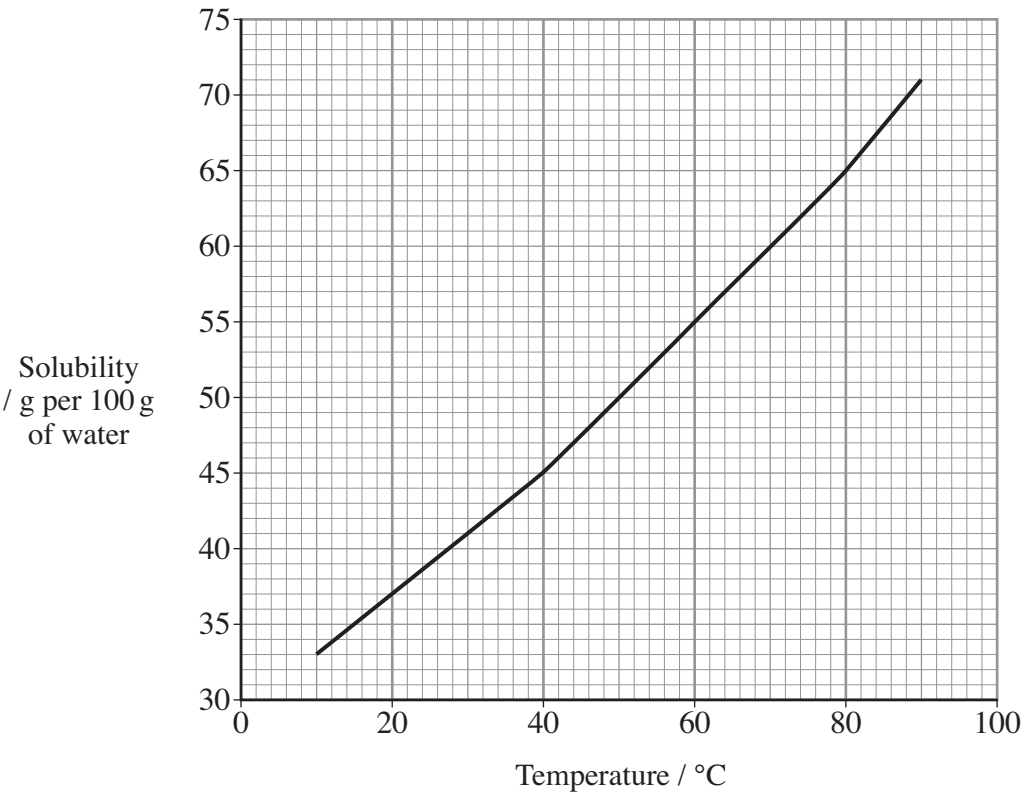
3. Complete the table below by inserting the number of bonding pairs of electrons and name the shapes of the molecules involved. [3]

Molecule	*Number of bonding pairs of electrons in outer shell*	*Number of lone pairs of electrons in outer shell*	*Shape*
$BeCl_2$		0	Linear
PCl_3	3	1	
CCl_4	4	0	

Examiner only

4. Using **outer** electrons only, draw a dot and cross diagram to show the bonding in sodium oxide. Show the charges on the ions formed. [2]

5. The solubility curve for ammonium chloride is shown below.



Calculate the mass of ammonium chloride that dissolves in 50 g of water to form a saturated solution at 30 °C. [2]

.....

.....

6. Draw the skeletal formula of 2-chloro-3-methylhexane. [1]

Section A Total [10]

Examiner only

11. *(a)* Edmund carries out two experiments with calcium.

(i) In the first experiment, he adds pieces of calcium to water.

I. State what he would **observe** in this reaction. [2]

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.....

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II. Write a balanced chemical equation for the reaction. [2]

.....

III. He repeats the experiment with strontium.

State whether you would expect strontium to be more or less reactive than calcium. Explain your answer clearly. [2]

.....

.....

(ii) In the second experiment, Edmund reacts pieces of calcium with 20.0 cm^3 of 2.00 mol dm^{-3} hydrochloric acid.

$$Ca(s) + 2HCl(aq) \longrightarrow CaCl_2(aq) + H_2(g)$$

I. Calculate the number of moles of acid used in the experiment. [1]

.....

.....

II. Calculate the minimum mass of calcium needed to react completely with the acid. [2]

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.....

III. Give a test which would confirm the presence of calcium ions in aqueous calcium chloride, stating the result of the test. [2]

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Examiner only

(b) Edmund wants to prepare aqueous sodium chloride using the same method as in *(a)*(ii) opposite. Explain why he should not use this method and state what reagents he could use to obtain aqueous sodium chloride. [2]

.....

.....

(c) For both calcium chloride and calcium metal:

- state the conditions necessary for each to conduct electricity;
- explain, in terms of bonding and structure, how this process occurs. [4]

QWC [2]

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Total [19]

Section B Total [70]

Examiner only

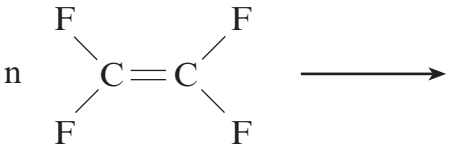
(b) Sodium fluoride is a white, ionic solid that has the same crystal structure as sodium chloride.
Give the formula of each ion present and its crystal co-ordination number. [2]

Sodium ion ..... *Crystal co-ordination number* .....

Fluoride ion ..... *Crystal co-ordination number* .....

(c) Tetrafluoroethene, C_2F_4, can be polymerised to give poly(tetrafluoroethene), PTFE, in a similar way to the polymerisation of ethene.

(i) Complete and balance the equation below, showing a repeating section of the structural formula of poly(tetrafluoroethene). [1]



(ii) A stretched form of PTFE is marketed under the name 'Goretex'. This is used to make waterproof materials that can 'breathe'. Gaseous water molecules can escape from tiny 'holes' in the fabric but larger liquid water droplets cannot enter. These liquid water droplets contain water molecules that are hydrogen bonded to each other.

Draw a diagram to show hydrogen bonding between water molecules. [3]

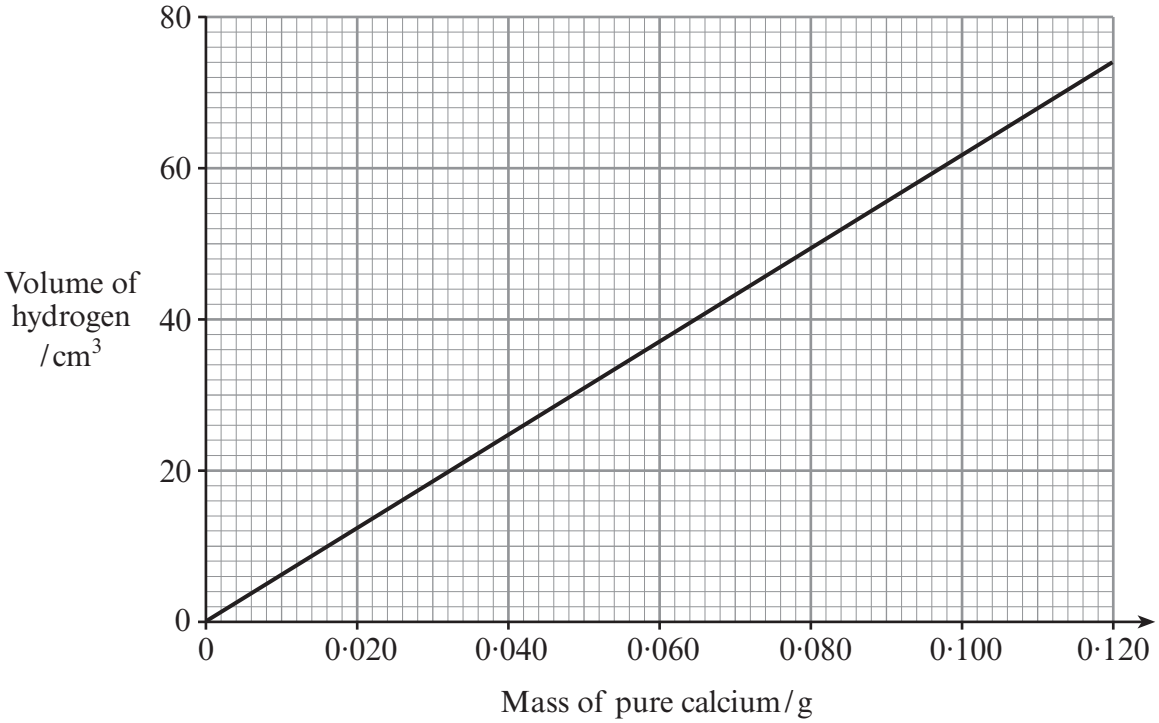
Total [14]

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]

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.....

(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

(d) The boiling temperatures of 1-chloropentane, pentan-1-ol and propan-1-ol are given below.

Compound	Boiling temperature / °C
propan-1-ol	97
1-chloropentane	107
pentan-1-ol	138

(i) Explain why the boiling temperature of pentan-1-ol is higher than that of 1-chloropentane. [2]

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(ii) Explain why the boiling temperature of pentan-1-ol is higher than that of propan-1-ol. [2]

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(iii) State which one of the three compounds in the table above is likely to be the most soluble in water. Explain your answer. [3]

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Examiner only

(e) It is possible to test for the presence of halogen atoms in a halogenoalkane by hydrolysing the molecule and testing for the halide ions released, using silver nitrate solution. This is a nucleophilic substitution reaction with the nucleophile attacking the $C^{\delta+}$ of the C-halogen bond. In each case, a precipitate is formed.

The hydrolysis of three compounds was performed under identical conditions, and the time required for a precipitate of silver halide to form was measured. The results were as follows:

Compound	Time for precipitate to form / minutes
1-chloropentane	17
1-bromopentane	4
1-iodopentane	Less than 1

The carbon-halogen bond energies and the electronegativity differences for each bond are given below.

Bond	Average bond enthalpy / kJ mol^{-1}	Electronegativity difference
C—Cl	338	0.61
C—Br	276	0.41
C—I	238	0.11

Examiner only

Use both tables to comment on the factors that affect the rate of reaction. Your answer should discuss:

- The trend in relative bond strengths for the halogenoalkanes;
- The trend in the rate of reaction expected if bond strength is the main factor affecting the ease of hydrolysis in these compounds;
- The trend in size of the δ+ charges on the carbon atoms of each halogenoalkane;
- The trend in the rate of reaction expected if dipole size is the main factor affecting the ease of hydrolysis in these compounds. [4]

QWC [1]

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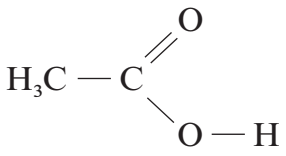
Total [19]

Examiner only

(c) The crystal structure of ethanoic acid shows that the molecules are found in pairs with hydrogen bonds between each pair.

(i) Complete the diagram to show how **two** molecules of CH_3COOH can join together through hydrogen bonding. [1]



(ii) Describe what is meant by *hydrogen bonding*. [3]
QWC [1]

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(d) Ethanoic acid can be formed from the oxidation of ethanol by potassium dichromate(VI).

(i) State the conditions required for this reaction to take place. [1]

.....

(ii) State what you would observe during the reaction. [1]

.....

(e) The boiling temperature of ethanol is 78 °C. Giving a reason in **both** cases, state how you would expect the boiling temperatures of the following compounds to differ from that of ethanol. [2]

Propane .....

.....

.....

Butan-1-ol .....

.....

.....

Total [13]

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]

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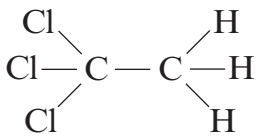
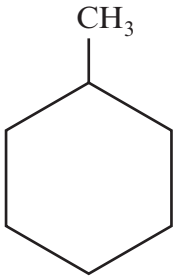
(e) One compound previously used in correction fluid was 1,1,1-trichloroethane, but this has been replaced by compounds such as methylcyclohexane, which has a much less adverse effect on the environment.



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]

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(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

(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

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]

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.....

(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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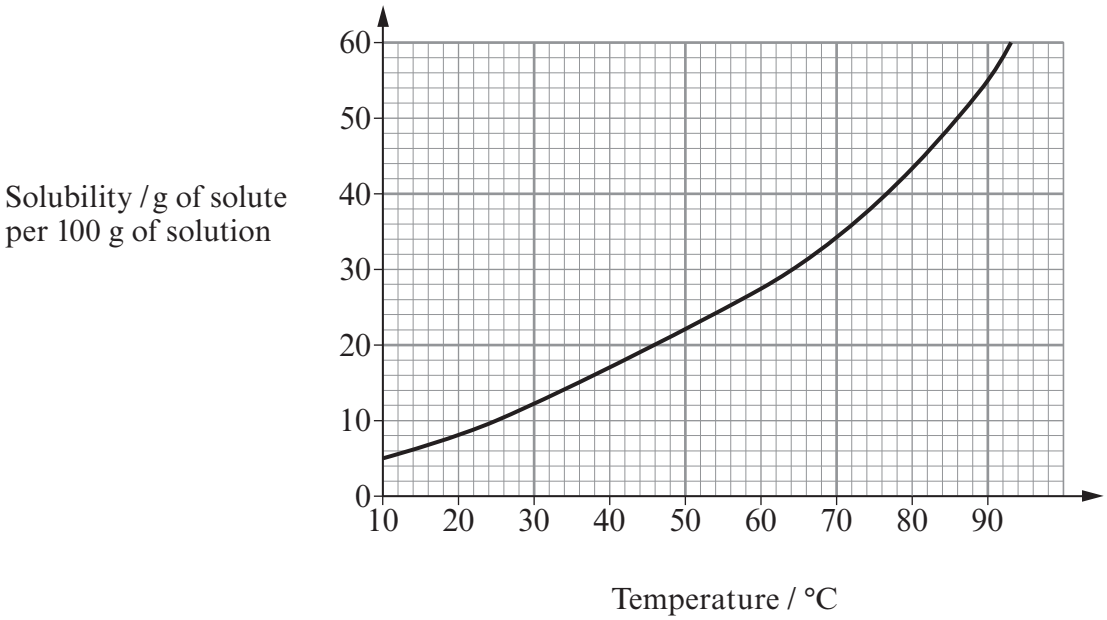
Examiner only

5. A solid was prepared in an impure state and it was then purified by recrystallisation. The solid was dissolved in the minimum amount of water at 90 °C and the solution was cooled to 25 °C.

The solubility curve for the solid in water is shown below.



(a) Use the solubility curve to find the maximum mass of solid that would form from 100 g of solution cooled from 90 °C to 25 °C. [1]

Maximum mass ..... g

(b) What effect would it have on your answer to *(a)* if more hot solvent had been used to dissolve the impure solid? Give a reason for your answer. [1]

.....

.....

1092 010003

Examiner only

6. When the temperature is increased, both solid iodine and diamond change directly into their gaseous state – they sublime.

(a) In each case, name the force or bond that is being overcome when the solid changes into a gas. [2]

Iodine .....

Diamond .....

(b) State, with a reason, which solid would have the higher sublimation temperature. [1]

.....

.....

Total Section A [10]

Examiner only

10. *(a)* Explain the fact that the melting temperature of sodium is much lower than the melting temperature of magnesium.

You should include reference to the type(s) of bonding involved and how this bonding affects melting temperatures. You may include a diagram if you consider it helpful.

[3]

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(b) In an experiment, 1-chlorobutane was heated with aqueous sodium hydroxide and the resulting solution was acidified. Aqueous silver nitrate was then added and a white precipitate was observed.

The experiment was repeated using 1-bromobutane and in this case a cream precipitate was observed.

Explain these observations.

You should include:

- the type of reaction that occurs between the halogenoalkane and sodium hydroxide
- an equation for this reaction
- the identity of the coloured precipitates
- an equation to show the formation of these precipitates. [4]

QWC [1]

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Examiner only

(c) Describe how the structures of sodium chloride and caesium chloride are similar and how they are different. Give a reason for any difference.
You may include a diagram if you consider it helpful. [3]

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(d) When hydrogen bromide, HBr, is added to propene, C_3H_6, two different products are possible. In practice, however, more of one of the products is formed.
Explain why more of one product is formed.

You should:

- state the type of reaction involved
- identify the two possible products
- state which of the two products predominates
- give the reason why more of this product is formed. [4]

QWC [1]

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Total [16]

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

(d) Chloromethane can be converted into methanol by reaction with hydroxide ions.

(i) Classify the mechanism of this reaction. [1]

.....

(ii) The boiling temperatures of chloromethane and methanol are given in the table below.

Compound	Boiling temperature / K
chloromethane, CH_3Cl	249
methanol, CH_3OH	338

Explain why the boiling temperature of methanol is higher than the boiling temperature of chloromethane. [3]

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(iii) Methanol can then be converted to methanoic acid. Give the reagent(s) and condition(s) required for this reaction. [2]

Reagent(s) .....

Condition(s) .....

Examiner only

(b) The boron atom in boron chloride, BCl_3, is described as being electron deficient. Draw a dot and cross diagram for BCl_3 and use it to show what is meant by the term *electron deficient*. [2]

.....

.....

(c) Nitrogen chloride, NCl_3, is insoluble in cold water whilst the similar compound ammonia, NH_3, is very soluble. Explain this difference in behaviour. [2]

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(d) Aluminium chloride, $AlCl_3$, forms a dimer that contains both covalent bonds and coordinate bonds. Describe what is meant by the terms *covalent bond* and *coordinate bond*. [2]

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Total [14]

Examiner only

(e) Covalent compounds like methane and butane are gases at room temperature, however metals are generally solids with high melting temperatures.

(i) State, giving a reason, whether you would expect butane to have a higher or lower boiling temperature than methane. [1]

.....

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(ii) Describe briefly the nature of metallic bonding and use this to explain why metals are malleable (can be hammered into shape) and conduct electricity. [4]
QWC [1]

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Total [13]

Examiner only

(iii) Suggest why the boiling temperature of HCl is greater than that of SiH_4. [1]

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Total [13]

Examiner only

(e) Marged repeats the experiment with beryllium. State whether you would expect beryllium to be more or less reactive than magnesium. Explain your answer clearly. [2]

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Total [16]

Total Section B [70]

END OF PAPER

Examiner only

SECTION A

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

1. State which **one** of the following is a correct statement.

A The first ionisation energy of the elements increases down Group 1

B The melting temperature of the elements decreases down Group 7

C The first ionisation energy of the elements increases across Period 2

D The elements in Group 2 become more electronegative down the group

[1]

2. Chlorine monofluoride has the following formula.

Cl — F

(a) Indicate the polarity in the bond shown by use of the symbols δ^+ and δ^-, giving a reason for your answer. [1]

.....

.....

(b) Draw a dot and cross diagram to illustrate the bonding between the two atoms in chlorine monofluoride. Include **all** *outer* shell electrons. [1]

3. State why a fluoride ion, F^-, is more stable than a fluorine atom. [1]

.....

.....

Examiner only

9. *(a)* The table below shows some physical properties of six carboxylic acids.

Acid	Formula	Boiling temperature / °C	Solubility in water
ethanoic	CH_3COOH	118	solubility decreasing ↓
propanoic	CH_3CH_2COOH	141	
butanoic	$CH_3(CH_2)_2COOH$		
pentanoic	$CH_3(CH_2)_3COOH$		
hexanoic	$CH_3(CH_2)_4COOH$	205	
heptanoic	$CH_3(CH_2)_5COOH$	223	

(i) Suggest the boiling temperature of butanoic acid. [1]

.....

(ii) Describe the trend in boiling temperature as the number of carbon atoms in the acids increases and suggest a reason for this effect. [3]

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(iii) Explain why the acids become less soluble in water as the sizes of the molecules increase. [2]

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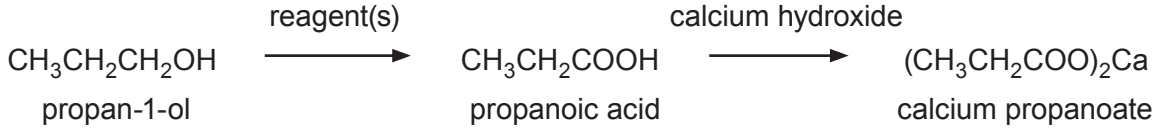
Examiner only

(b) Calcium propanoate, $(CH_3CH_2COO)_2Ca$, is added to bread to prevent mould formation. It can be made from propan-1-ol by the following reactions.



(i) State the name of the reagent(s) used in the first stage. [1]

.....

(ii) Propanoic acid, in its liquid state, exists as a dimer, where two molecules of the acid bond together using hydrogen bonding.

Draw the structural formula of this dimer and show the hydrogen bonding between the two molecules. [1]

1092 010009

(iii) In an experiment to make calcium propanoate, 50.0 cm^3 of a solution of propanoic acid of concentration 1.00 $mol\,dm^{-3}$ was completely neutralised by calcium hydroxide.

I Calculate the number of moles of propanoic acid used. [1]

..... mol

II State the number of moles of calcium hydroxide needed to just react with all the propanoic acid. [1]

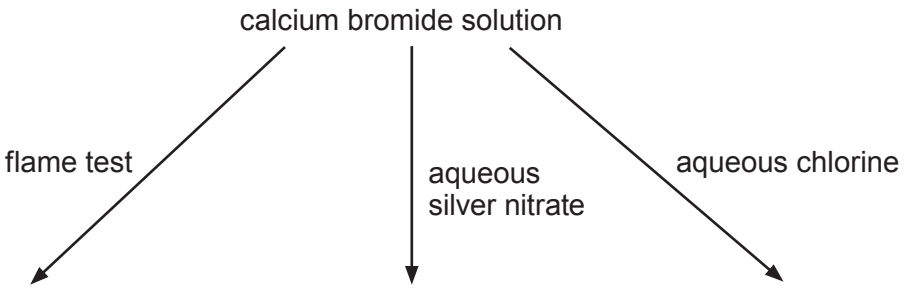
..... mol

III Calculate the maximum mass of calcium propanoate ($M_r = 186$) which could be formed. [1]

..... 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]

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Total [16]

Examiner only

SECTION A

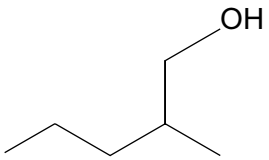
Answer **all** *questions in the spaces provided.*

1. Put the following in order of increasing strength. [1]

covalent bonds *hydrogen bonds* *van der Waals' forces*

weakest ..... *strongest*

2. Give the **systematic** name of the compound whose structure is shown below. [1]



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3. Draw dot-and-cross diagrams to show the formation of calcium chloride from atoms of chlorine and calcium. [2]

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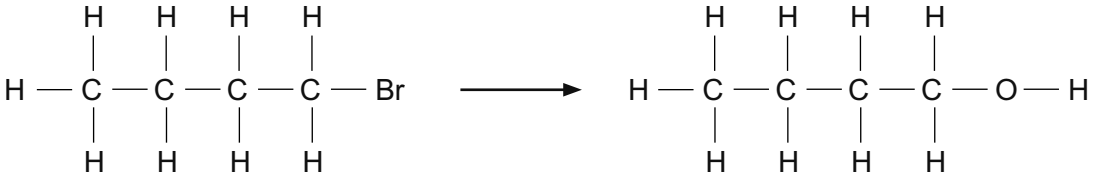
10. *(a)* 1-bromobutane is a liquid that is insoluble in water. It can be converted to butan-1-ol in a one-step reaction.



(i) Give the reagent(s) and condition(s) required for this reaction. [2]

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(ii) Explain why butan-1-ol is soluble in water whilst 1-bromobutane is not. [3]

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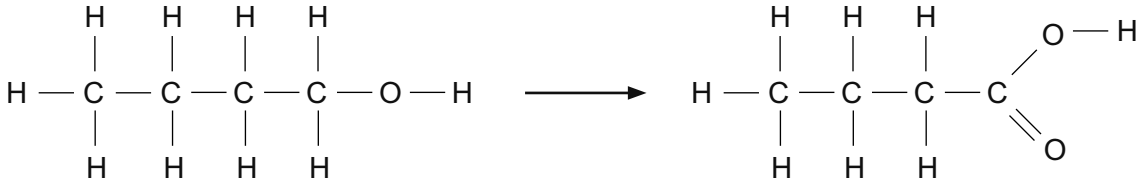
(b) Butan-1-ol can be converted into liquid butanoic acid in a one-step reaction.



(i) Give the reagent(s) and condition(s) required for this reaction. [2]

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(ii) Explain why butanoic acid has a much higher boiling temperature than 1-bromobutane. [3]

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(iii) The reaction above frequently produces a mixture containing unreacted butan-1-ol and butanoic acid. State how these two liquids could be separated. [1]

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Total [11]