(iii) State the **type** of reaction occurring in part (ii). [1]

.....

(iv) The empirical formula of a substance is $C_4H_5ClO_2$.
State what additional information is needed so that its molecular formula can be found. [1]

.....

4. There is continued debate about the safety of adding fluoride ions to drinking water.

(i) Give the **ionic** half equation for the formation of fluoride ions from fluorine gas. [1]

.....

(ii) Explain why there is a strong tendency for fluorine to form fluoride ions. [1]

.....

.....

Section A Total [10]

(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]

.....

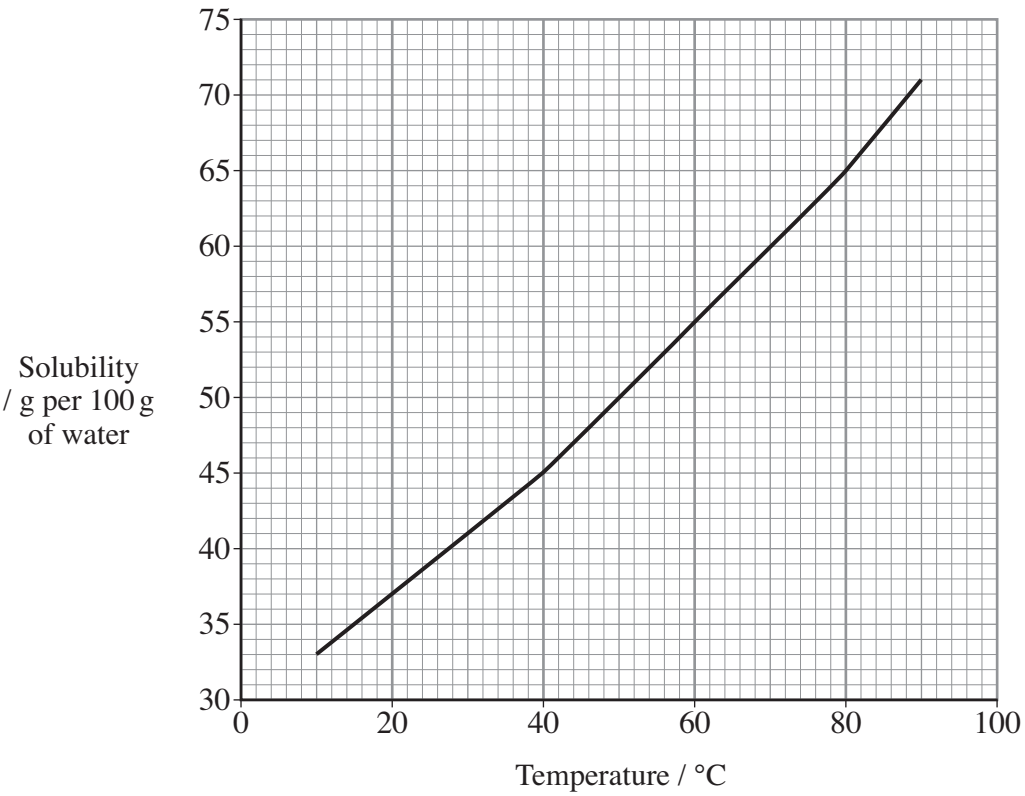
.....

Total [13]

Examiner only

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

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]

.....

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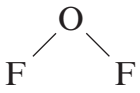
Examiner only

SECTION A

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

1. The covalent compound difluorine oxide has the formula



(i) Showing **outer** electrons only, draw a dot and cross diagram for difluorine oxide. [1]

(ii) Difluorine oxide reacts with magnesium metal to produce magnesium oxide and magnesium fluoride, MgF_2.
Give the equation for this reaction. [1]

.....

2. Potassium chloride can be used by those who need a low-salt diet.
Its solubility in water at two temperatures is shown in the table.

Temperature / °C	Solubility / g per 100 g of water
15	32.7
100	56.5

Calculate the mass of solid potassium chloride produced when a saturated solution containing 500 g of water is cooled from 100 °C to 15 °C. [2]

..... g

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

(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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.....

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Total [19]

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

(d) Describe the structure of and bonding in an ethene molecule. [3]
QWC [1]

You may use a diagram in your answer.

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.....

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(e) Name the type of reaction mechanism occurring when ethene reacts with aqueous bromine and draw the displayed formula of the product formed. [2]

Type of reaction mechanism .....

Displayed formula

(f) Ethene can be used as the starting material in the industrial preparation of ethanol. The conditions for the reaction are a temperature of 300 °C and a pressure of 60-70 atm.

Name the catalyst used in this reaction. [1]

.....

(g) Another way to prepare ethanol is by the fermentation of glucose.

$$C_6H_{12}O_6 \longrightarrow 2C_2H_5OH + 2CO_2$$

Calculate the minimum mass of glucose required to give 230 g of ethanol. [3]

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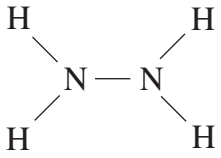
Total [16]

8. *(a)* In 1941 the Germans began to develop a rocket-powered aircraft, the Me 163, for use in the Second World War. The fuel used was based on hydrazine, which reacted with hydrogen peroxide, H_2O_2.



hydrazine

(i) Steam was needed to mix the rocket fuel and the hydrogen peroxide. This was produced by mixing some hydrogen peroxide with the catalyst calcium manganate, $Ca(MnO_4)_2$.
Deduce the oxidation state (number) of manganese in calcium manganate. [1]

.....

.....

(ii) The aqueous hydrogen peroxide used contained 76.5 g of hydrogen peroxide in 100 cm^3 of its solution. Calculate the concentration of the hydrogen peroxide in mol dm^{-3}. [2]

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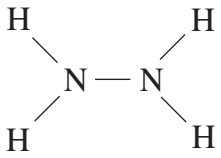
(iii) Hydrazine contains a polar covalent bond between a nitrogen and a hydrogen atom. State what is meant by a *polar covalent bond* and explain how this arises. [2]



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(iv) Hydrazine is a weak base and forms hydrazinium chloride, $N_2H_5^+Cl^-$, which contains a co-ordinate bond. State what is meant by the term *co-ordinate bond*. [1]

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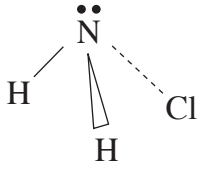
Examiner only

(v) Hydrazine is manufactured from the compound monochloramine, NH_2Cl.



A probable shape for a molecule of monochloramine is as shown above. The bond angles H—$\hat{N}$—H and H—$\hat{N}$—Cl are around 107°.

Use the valence shell electron pair repulsion theory (VSEPR) and the information given to explain the shape and bond angles. [2]

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.....

.....

(b) (i) The decomposition of hydrogen peroxide may involve hydroxyl radicals.

State why this is described as a radical. [1]

.....

(ii) Another reaction that produces radicals is the reaction of chlorine with methane.

I. Give the equation for the reaction of a methyl radical and chlorine. [1]

.....

II. State why the reaction in I above is described as a propagation reaction. [1]

.....

.....

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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.....

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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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.....

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Examiner only

SECTION A

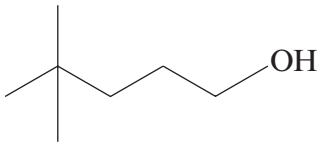
Answer **all** *questions in the spaces provided.*

1. Calcium and magnesium are essential elements in living things. Give **one** use of each element in biological systems. [1]

Magnesium .....

Calcium .....

2. Give the **systematic** name of the molecule shown below. [1]



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3. The electronegativity values of the halogens are listed below.

Atom	F	Cl	Br	I	At
Electronegativity value	4.0	3.0	2.9	2.6	2.2

(a) Define the term *electronegativity.* [1]

.....

.....

(b) Use the data in the table to identify any dipoles present in the following bonds, marking their polarity clearly. [1]

F — Cl At — Cl

Examiner only

4. Classify the following species as electrophile, nucleophile or radical by completing the table below. [2]

Species	Cl•	NH_3
Classification		

5. Nanoscience involves the study of very small particles. Nano-sized silver particles have antibacterial and antifungal properties. Give **one** use of nano-sized silver particles. [1]

.....

.....

6. State and explain which two of the following elements combine to form the **most** ionic bond. [2]

chlorine magnesium potassium sulfur

.....

.....

Total Section A [10]

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

(d) Sulfuryl fluoride reacts rapidly with calcium hydroxide to give calcium sulfate, calcium fluoride and water as the only products.

Give the equation for this reaction. [2]

.....

(e) Bromomethane, CH_3Br, was formerly used as a fumigant gas to remove insect infestation but has now been largely replaced by sulfuryl fluoride. One reason for this change is that bromomethane has an adverse effect on the ozone layer.

(i) Explain how **both** bromomethane and CFCs have an adverse effect on the ozone layer.

The table below should be used to help you in your response. [3]

Bond	Bond enthalpy/ kJ mol^{-1}
C—H	412
C—F	484
C—Cl	338
C—Br	276
S—F	410

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.....

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.....

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(ii) Use the information in the table in (i) above to state why sulfuryl fluoride is now preferred to bromomethane as a fumigant. [1]

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.....

.....

Total [12]

Examiner only

SECTION A

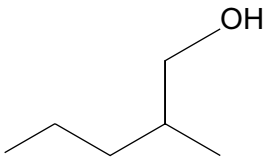
Answer **all** *questions in the spaces provided.*

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]



.....

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

Examiner only

4. The table below gives the electronegativity values of some elements.

Atom	H	N	O	Al	Cl
Electronegativity value	2.1	3.0	3.5	1.6	3.0

(a) Use the data in the table to identify any dipoles present in the following bonds. Mark their polarity clearly. [1]

N — H O — Cl

(b) Use the data to give a reason why aluminium chloride is considered to be a covalent compound, while aluminium oxide is an ionic compound. [1]

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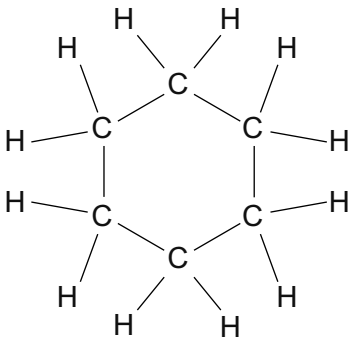
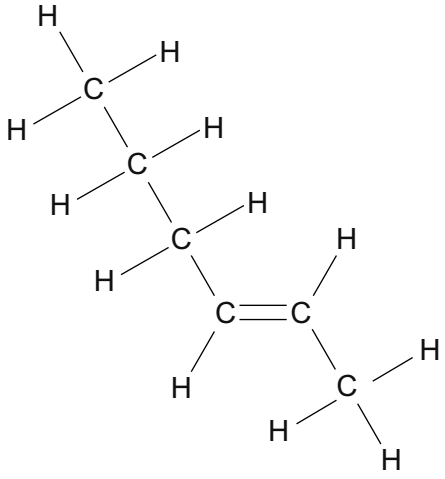
5. Cyclohexane and hex-2-ene are isomers. Give a chemical test to distinguish between these two compounds. [2]



cyclohexane



hex-2-ene

Reagent(s) .....

Observations .....

.....