

GCE AS

WJEC Eduqas GCE AS in CHEMISTRY

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SPECIMEN ASSESSMENT MATERIALS

Teaching from 2015



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Candidate Name	Centre Number				Candidate Number				

**AS CHEMISTRY****COMPONENT 1****The Language of Chemistry, Structure of Matter and Simple Reactions****SPECIMEN PAPER****1 hour 30 minutes**

For Examiner's use only		
Question	Maximum Mark	Mark Awarded
Section A 1. to 7.	10	
Section B 8.	11	
9.	13	
10.	13	
11.	7	
12.	7	
13.	12	
14.	7	
Total	80	

ADDITIONAL MATERIALS

In addition to this examination paper, you will need a data sheet and a calculator.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen. Do not use correction fluid.

Write your name, centre number and candidate number in the spaces at the top of this page.

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

INFORMATION FOR CANDIDATES

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

1. By inserting arrows to represent electrons, complete the boxes below to show the electronic configuration of a calcium atom. [1]

1s	2s	2p	3s	3p	3d	4s

2. An oxide of nitrogen has a relative molecular mass of 92. It contains 30.4 % of nitrogen and 69.6 % of oxygen, by mass.

(a) Calculate the empirical formula of this oxide. Show your working. [1]

Empirical formula

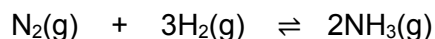
(b) Calculate its molecular formula. [1]

Molecular formula

3. Complete the table below. [2]

Molecule	Number of bonding pairs of electrons in outer shell	Number of lone pairs of electrons in outer shell	Shape of molecule
BeCl ₂		0	linear
PCl ₃	3	1	

4. Ammonia is produced from hydrogen and nitrogen in the Haber process.



Write the expression for the equilibrium constant in terms of concentration, K_c , for this reaction.

[1]

5. Write the equation that represents the **second** ionisation energy of gallium. [1]

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6. Calculate the mass of methane, CH_4 , that contains the same number of molecules as there are in 96 g of silane, SiH_4 . [1]

Mass = g

7. The emission spectrum of sodium includes a bright yellow line corresponding to an energy of $3.4 \times 10^{-19} \text{ J}$. Calculate the frequency, in Hz, of this line. [2]

$$h = 6.6 \times 10^{-34} \text{ Js}$$

Frequency = Hz

10

SECTION B

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

8. Potassium metal was discovered in 1807 by the British chemist Sir Humphrey Davy.

- (a) The mass spectrum of a naturally occurring sample of potassium gave the following results.

Isotope	% abundance
^{39}K	93.26
^{40}K	0.0117
^{41}K	6.730

Calculate the relative atomic mass of the sample, giving your answer to the appropriate number of significant figures. [2]

Relative atomic mass =

- (b) This mass spectrum was produced by potassium ions in a mass spectrometer.

- (i) State how a solid sample of potassium is made into potassium ions in a mass spectrometer. [2]

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- (ii) Describe how potassium ions are separated in a mass spectrometer. [2]

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- (c) Potassium-40 is a radioactive isotope that decays with a half-life of 1.25×10^9 years.

(i) Describe how it decays by electron capture to form argon-40. [2]

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(ii) Calculate how long it will take for the activity of the isotope to decay to $\frac{1}{8}$ th of its original activity. [1]

Time taken = years

- (d) Some information relating to three other radioisotopes are given in the table.

Isotope	Half-life	Radioactive emission
^{60}Co	5 years	γ
^{63}Ni	100 years	β
^{66}Cu	30 seconds	β

Use all the information to suggest which radioisotope would be the most suitable for use in a gauge to measure the thickness of aluminium foil. Explain your reasoning. [2]

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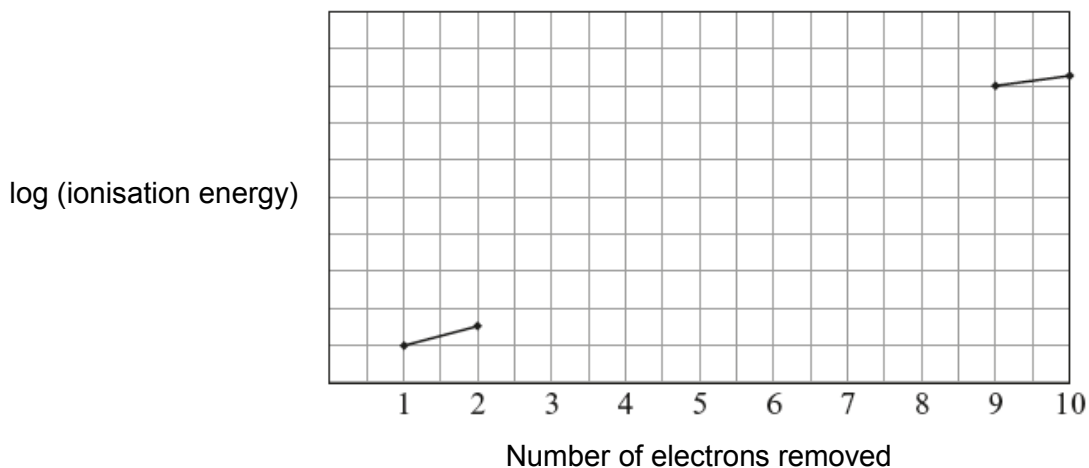
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9. The noble gases (Group 0) are a group of very unreactive elements. The first members of the group (helium, neon and argon) do not form any compounds, however it is possible to form a few compounds of krypton and xenon.

(a) Neon has ten electrons in each atom. The sketch below shows the first two and the final two ionisation energies for a neon atom.

- (i) Sketch the pattern you would expect to see for the remaining six ionisation energies of neon. [2]



- (ii) Explain any significant changes in slope on the graph you have sketched. [2]

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- (b) (i) The first compound of a noble gas was formed from Xe atoms and PtF_6 . It was the ionic compound $\text{Xe}^+ \text{PtF}_6^-$. Explain why it is not possible to form a similar ionic compound of argon, $\text{Ar}^+ \text{PtF}_6^-$. [2]

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- (ii) Draw the likely shape for the PtF_6^- ion. [1]

- (c) Helium was identified in the Sun by its atomic absorption spectrum. Explain how an atomic absorption spectrum forms. [3]

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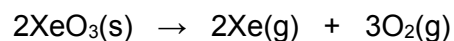
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- (d) Xenon trioxide, XeO_3 , is a compound which decomposes explosively according to the following equation at 323 K and 1 atm pressure.



Calculate the volume of gas, in dm^3 , released by the decomposition of 1 mol of XeO_3 under these conditions. [3]

[1 mol of any gas at 298 K and 1 atm occupies a volume of 24.0 dm^3]

Volume = dm^3

13

10. Sodium hydroxide and chlorine are important industrial chemicals made from sodium chloride solution (brine). This can take place in the mercury cell and the diaphragm cell.

Process	Operation	Quality of product
diaphragm cell	diaphragm must be regularly replaced high electrical current needed	contains unreacted sodium chloride concentration varies and is relatively low
mercury cell	no diaphragm used high electrical current needed	pure sodium hydroxide solution produced at high concentration

- (a) (i) Use the table to suggest **one** important consideration when choosing which process to use. [1]

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- (ii) If a new process is to be developed as an alternative to the two processes outlined above, suggest **two** environmental or technical factors that should be considered. [2]

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- (b) Some students obtained a sample of the sodium hydroxide solution from the diaphragm cell process.
- (i) This solution was too concentrated to be used in a normal titration. It needed to be diluted exactly 10 times using water to produce 250 cm³ of solution. Describe how this dilution should be carried out. Include the names of all pieces of apparatus used and any essential details. [3]
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- (ii) 20.0 cm³ of the diluted sodium hydroxide solution reacted with 0.00512 mol of hydrochloric acid.
- I Calculate the concentration of the original sodium hydroxide solution. [3]

Concentration = mol dm⁻³

- II One of the students carried out the titration using a 2.0 mol dm⁻³ hydrochloric acid solution whilst the other used a 0.2 mol dm⁻³ solution. State which student is likely to have got the more accurate result for the concentration of the sodium hydroxide solution. Justify your answer. [2]
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-
- III Calculate the pH of a 0.2 mol dm⁻³ hydrochloric acid solution. [2]

pH =

11. (a) Chloroethane, $\text{C}_2\text{H}_5\text{Cl}$, can be made from ethene by the addition of hydrogen chloride, HCl .



M_r values 28.0 36.5 64.5

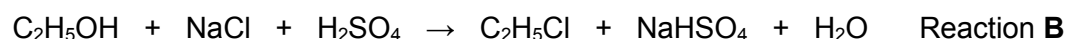
- (i) Calculate the maximum possible mass of chloroethane obtainable from 42.0 g of ethene and 43.8 g of hydrogen chloride. [3]

Mass = g

- (ii) The actual mass of chloroethane obtained from 42.0 g of ethene in an experiment was 65.0 g. Calculate the percentage yield in this experiment. [1]

Percentage yield = %

- (b) Chloroethane can be formed by another reaction as in the following equation.



M_r values 46 58.5 98

- (i) The atom economy for reaction **A** is 100 %. Calculate the atom economy for reaction **B**. [2]

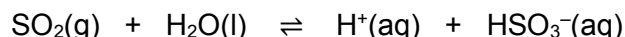
Atom economy for reaction **B** = %

- (ii) Suggest **one** possible reason for choosing to produce chloroethane by reaction **B** rather than reaction **A**. [1]

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12. Polluting gases such as sulfur dioxide, produced by power stations, can cause the acidification of lakes far from the source of the pollution.

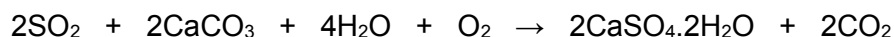
(a) An equation for the reaction of sulfur dioxide with water is shown below.



Use Le Chatelier's principle to explain how the concentration of hydrogen ions, $\text{H}^+(\text{aq})$, would change if more sulfur dioxide were dissolved in a solution that had reached dynamic equilibrium. [2]

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(b) One method of removing sulfur dioxide from power station emissions is to react the flue gases with moist calcium carbonate (limestone) giving hydrated calcium sulfate (gypsum) and carbon dioxide.



One advantage of this process is that the gypsum can be used for the production of plaster. Other than cost, state **two** disadvantages of this method of sulfur dioxide removal. [2]

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- (c) Some students wanted to measure the concentration of sulfur dioxide in the air. They pumped air at a rate of $2.2 \times 10^4 \text{ cm}^3$ per hour for 5 days through a solution that absorbed the sulfur dioxide present. The resulting solution was then treated to give 0.0047 g of barium sulfate, BaSO_4 .

- (i) Calculate the total volume of air passed through the solution in 5 days. Give your answer in dm^3 .

[1]

Volume = dm^3

- (ii) Calculate the number of moles of sulfur dioxide present in the sampled air. You should assume that 1 mol of sulfur dioxide gives 1 mol of barium sulfate.

[2]

Number of moles = mol

7

13. (a) Outline the way in which pure dry calcium carbonate could be prepared in the laboratory using a precipitation reaction. Include an ionic equation for the reaction taking place. [6]

(Your ability to construct an extended response will be assessed in this question.)

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- (b) Limestone contains calcium carbonate. A 0.497 g sample of ground limestone was placed in a flask and exactly 25.0 cm³ of hydrochloric acid of concentration 0.515 mol dm⁻³ was added using a volumetric pipette. The mixture was stirred until no more bubbles of carbon dioxide were formed. The unreacted acid in the flask was titrated against 0.188 mol dm⁻³ sodium hydroxide and required 24.8 cm³ for neutralisation.

- (i) Calculate the number of moles of hydrochloric acid used up in the reaction with limestone. [3]

Number of moles = mol

- (ii) Calculate the percentage of calcium carbonate in the limestone sample.

[3]

Percentage of calcium carbonate = %

12

14. (a) Ice and graphite both have crystalline structures containing covalent bonds.

(i) Describe the bonding and structure in ice. [3]

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(ii) Explain why graphite conducts electricity whilst ice does not. [2]

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(b) Iodine, I_2 , also contains covalent bonds. Explain why solid iodine can be converted into a vapour at a much lower temperature than graphite. [2]

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Candidate Name	Centre Number				Candidate Number				

**AS CHEMISTRY****COMPONENT 2****Energy, Rate and Chemistry of Carbon Compounds****SPECIMEN PAPER****1 hour 30 minutes**

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Section A 1. to 8.	10	
Section B 9.	12	
10.	10	
11.	7	
12.	8	
13.	14	
14.	7	
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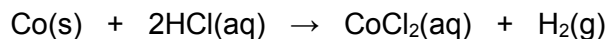
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SECTION A

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

1. Cobalt reacts with hydrochloric acid to give cobalt(II) chloride and hydrogen gas.



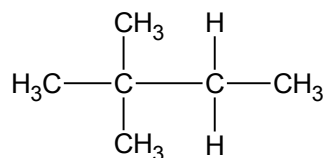
- (a) Suggest a method for measuring the rate of this reaction. [1]

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- (b) State what could be done to the cobalt to increase the rate of the reaction. [1]

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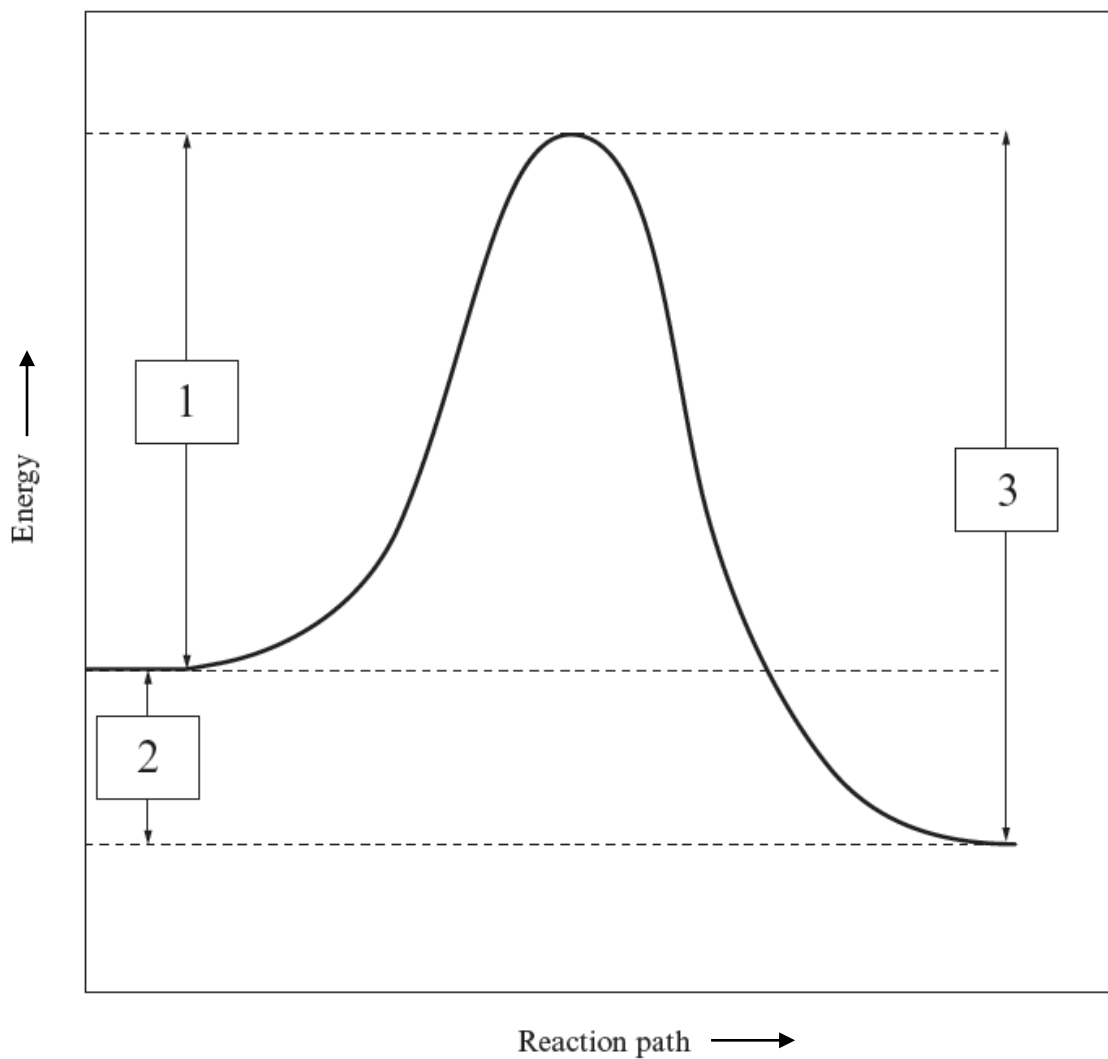
2. Give the systematic name for the compound with the following structure. [1]



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3. Draw the **skeletal** formula of methylpropan-1-ol. [1]

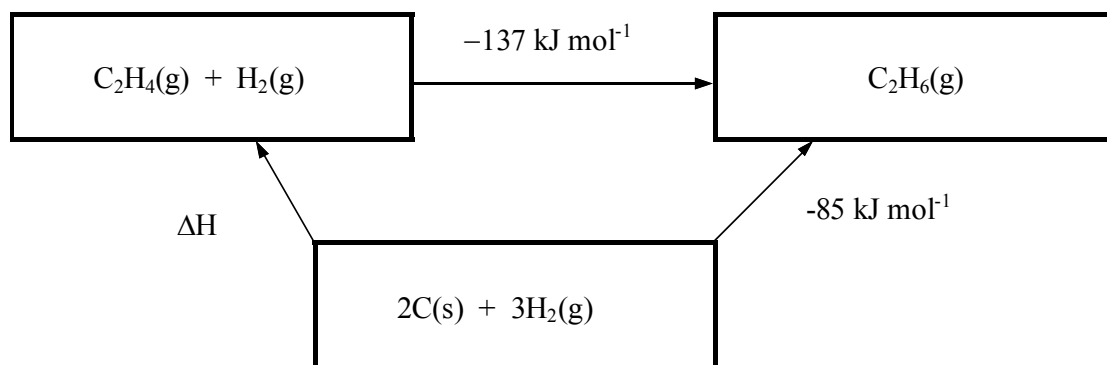
4. The diagram below shows the reaction profile for a chemical reaction. Three energy differences are marked on it with arrows labelled 1, 2 and 3.



Complete the table below by entering the numbers which correspond to the energy differences shown. [1]

activation energy of reverse reaction	
enthalpy change of reaction	

5. Determine the value of ΔH , in kJ mol^{-1} , in the energy cycle below. [2]



$\Delta H = \dots\dots\dots \text{kJ mol}^{-1}$

6. Name an instrumental technique that can be used to identify which bonds are present in an organic compound. [1]

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7. Write an equation for the reaction between ethanoic acid, CH_3COOH , and sodium hydroxide, NaOH . [1]

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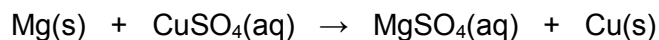
8. Give the name of the critical piece of glassware used in carrying out a distillation and a reflux procedure. [1]

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SECTION B

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

9. (a) Lisa was asked to measure the molar enthalpy change for the reaction between magnesium and copper(II) sulfate solution.



She accurately measured 50.0 cm³ of copper(II) sulfate solution of concentration 0.505 mol dm⁻³ into a well-insulated polystyrene cup. The temperature of the solution was 20.5 °C. She then added 0.90 g of powdered magnesium and stirred the mixture thoroughly.

Lisa observed the temperature rise and recorded a maximum temperature of 30.1 °C.

- (i) Calculate the heat given out during **this** experiment. You must show your working.
 [Assume that the density of the solution is 1.00 g cm⁻³ and its specific heat capacity is 4.18 J °C⁻¹ g⁻¹] [2]

Heat = J

- (ii) Determine which reagent is present in excess and calculate the molar enthalpy change, ΔH , for the reaction. You must show your working. [3]

Enthalpy change = kJ mol⁻¹

- (iii) Explain why it is better to use powdered magnesium rather than a strip of magnesium ribbon. [2]

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- (iv) The data book value for this molar enthalpy change is $-93.1 \text{ kJ mol}^{-1}$. (If you do not have an answer in (iii) assume that the molar enthalpy change is -65 kJ mol^{-1} , although this is not the correct answer).

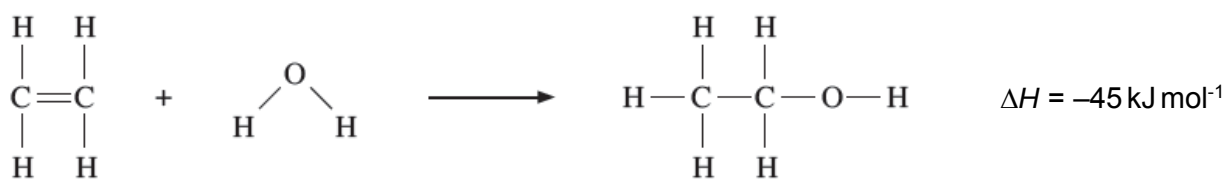
Suggest **one** reason for Lisa's low value in this experiment and suggest **one** change to the method that would improve her result. [2]

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- (b) Use the average bond enthalpy values in the table below and the enthalpy change for the direct hydration of ethene to calculate the average bond enthalpy of an O—H bond. [3]



Bond	Average bond enthalpy / kJ mol ⁻¹
C – C	348
C = C	612
C – H	412
C – O	360
O – H	?

Average bond enthalpy of an O—H bond = kJ mol⁻¹

12

10. (a) Petroleum (crude oil) is one of the most important resources in the world. It is a mixture of saturated hydrocarbons. These are separated into fractions by fractional distillation. Some fractions are used to make important chemicals such as propene while others are used as fuels.

Explain why hydrocarbons containing few carbon atoms distil at lower temperatures than hydrocarbons with many carbon atoms. [2]

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- (b) Propene and two other hydrocarbon products are formed by cracking dodecane, $C_{12}H_{26}$.



Suggest displayed formulae for products X and Y. [2]

- (c) Propene and cyclopropane are isomers of formula C_3H_6 . Name an instrumental technique that can be used to distinguish between these isomers. Explain your answer. [2]

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- (d) (i) Draw the structural formula representing the saturated secondary alcohol containing four carbon atoms. [1]

- (ii) Quantitative analysis of an alcohol shows that it contains 67.9 % carbon and 13.7 % hydrogen. The remainder is oxygen. Calculate its empirical formula. [3]

Empirical formula

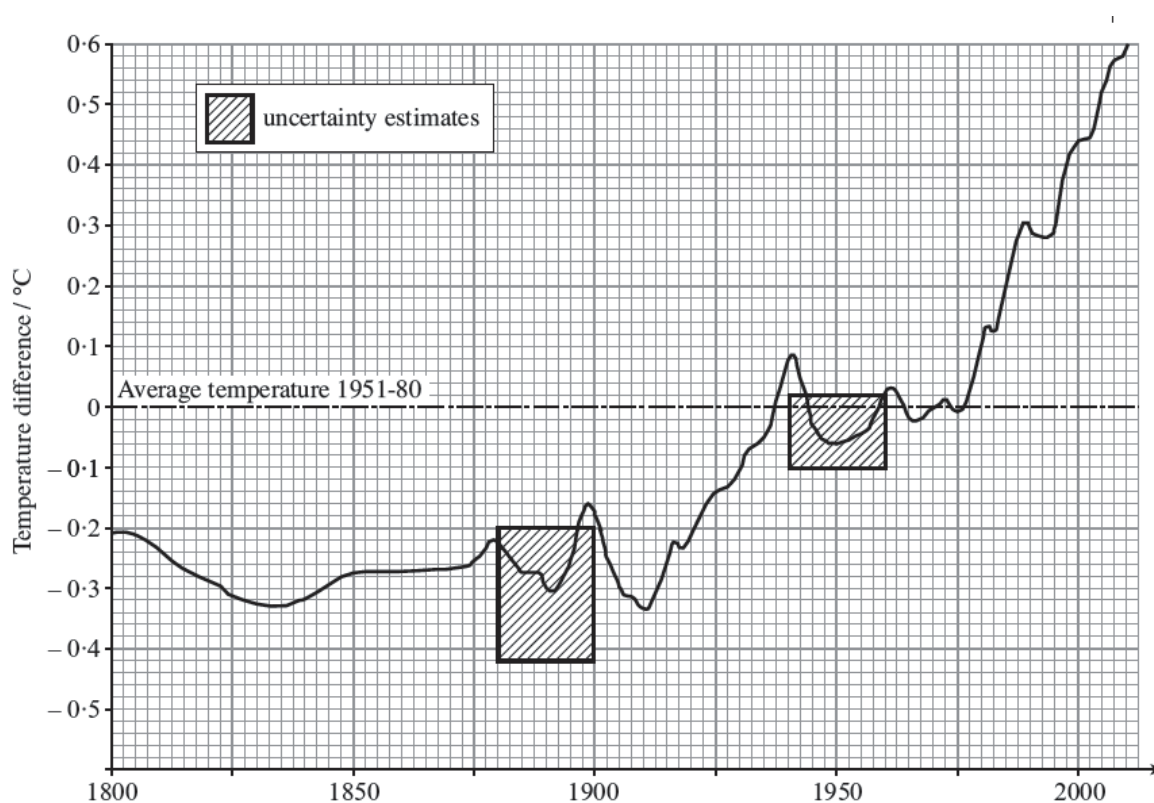
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11. During the last 200 years, the average temperature of the Earth has risen.

The table below shows the concentration of carbon dioxide in the atmosphere.

	Year				
	1800	1850	1900	1950	2000
Concentration of carbon dioxide in the atmosphere (% by volume)	0.0282	0.0288	0.0297	0.0310	0.0368

The graph below shows the annual global temperature relative to the average temperature between 1951 and 1980. It is based on data from NASA research.



One hypothesis put forward by many scientists is that the increase in annual global temperature is due to the increased concentrations of carbon dioxide and other greenhouse gases in the atmosphere.

- (a) Suggest **two** reasons why the uncertainty in the measurements is greater during the period from 1880-1900 than it is from 1940-1960. [2]

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- (b) Give **two** reasons for the significant change in carbon dioxide concentration after 1900. [2]

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- (c) Ozone is another greenhouse gas. 47 kg of ozone occupies 24 m³ at 298 K and 101000 Pa. Use this information to show that the formula of ozone is O₃. [3]
- (gas constant, R = 8.31 J K⁻¹ mol⁻¹)

12. Chloromethane can be produced by the radical chlorination of methane gas.

- (a) Write the equation(s) for the propagation stage(s) to produce chloromethane starting with methane and a chlorine radical. [2]

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- (b) Apart from chloromethane, a range of other compounds are produced in small amounts during the reaction.

Show how ethane is formed. [1]

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

- (i) Write a balanced equation for this reaction. [1]

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

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- (iii) Explain why the boiling temperature of methanol is higher than the boiling temperature of chloromethane. [3]

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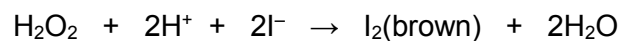
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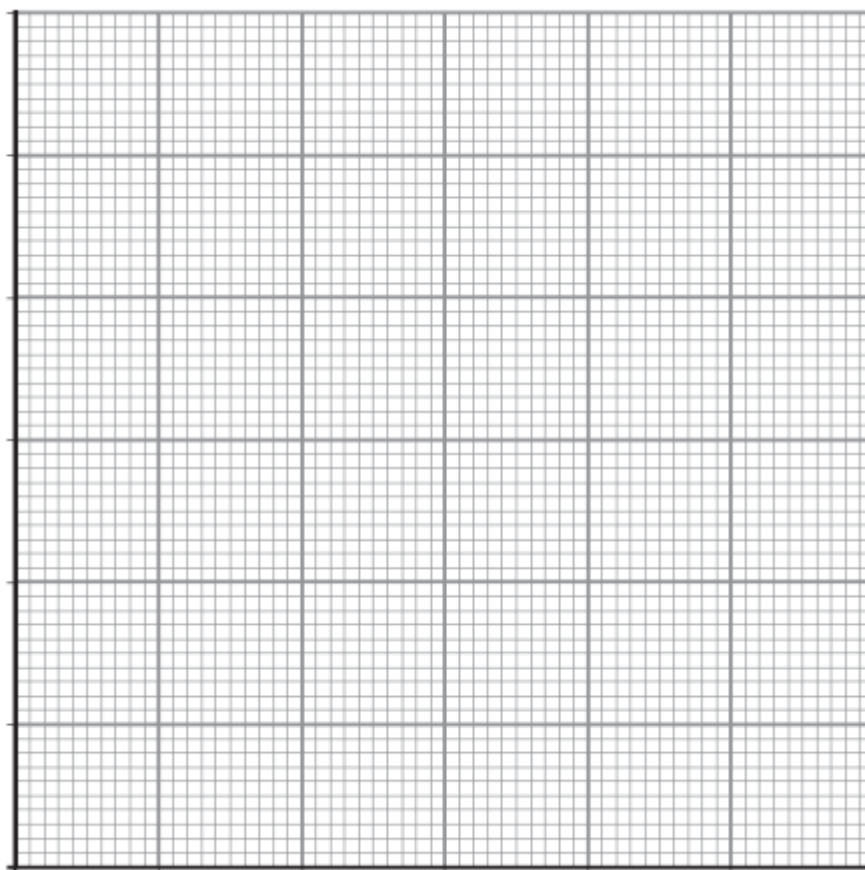
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13. (a) The following results were obtained in an experiment to measure the rate of oxidation of iodide ions by hydrogen peroxide in acid solution as shown in the equation. The reaction was carried out at a temperature of 20 °C.



Time (s)	0	100	200	300	400	500
Concentration of I_2 (mol dm^{-3})	0	0.0115	0.0228	0.0347	0.0420	0.0509

- (i) Plot these results on the grid below, labelling the axes and selecting a suitable scale. Draw the line of best fit. [3]



- (ii) Use the graph to calculate the initial rate of reaction and give the units. [2]

Rate =

Units

- (iii) Describe briefly the key features of the method that would have been used to obtain these results. [3]

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- (iv) A similar experiment was carried out using hydrogen peroxide and iodide solutions of different concentrations. The initial rates calculated for each reaction are shown in the table.

Concentration of H_2O_2 (relative units)	Concentration of I^- (relative units)	Initial rate (relative units)
0.60	0.050	4.1×10^{-4}
1.2	0.050	7.9×10^{-4}
1.2	0.10	1.6×10^{-3}

Analyse the data and state the relationship between the concentration of hydrogen peroxide and iodide ions and the initial rate of reaction.

[2]

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- (b) The rate of a chemical reaction varies with temperature. Draw the Boltzmann energy distribution curve and use this to explain why the rate of the reaction in part (a) would increase if it were carried out at a higher temperature. [4]

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14

- 14.** (a) In an experiment, 1-chlorobutane and 1-bromobutane are separately heated with aqueous sodium hydroxide and the resulting solutions acidified. Aqueous silver nitrate is added to both.

Describe and explain what is observed in each case and illustrate your answer with relevant equations.

[4]

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- (b) The following table shows the formulae of some halogenoalkanes including various halogen atoms. Many of these cause significant damage to the ozone layer.

The amount of damage caused by each compound is expressed as its relative ozone depletion potential (RODP). The higher its value the more destructive its effect. CCl_3F is given a value of 1.00.

Compound	Relative ozone depletion potential (RODP)
CHF_3	0.01
CHClF_2	0.05
CCl_2F_2	0.86
CCl_3F	1.00
CBrClF_2	10.0

- (i) Give the systematic name for the compound with an RODP value of 0.86. [1]

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- (ii) Use the information given in the table to describe how the number and type of halogen atoms per molecule are related to the destructive effects of these compounds on ozone. [2]

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- 15.** (a) Describe the mechanism of the reaction that occurs between propene and hydrogen bromide and use this to explain the products formed. [6]

(Your ability to construct an extended response will be assessed in this question.)

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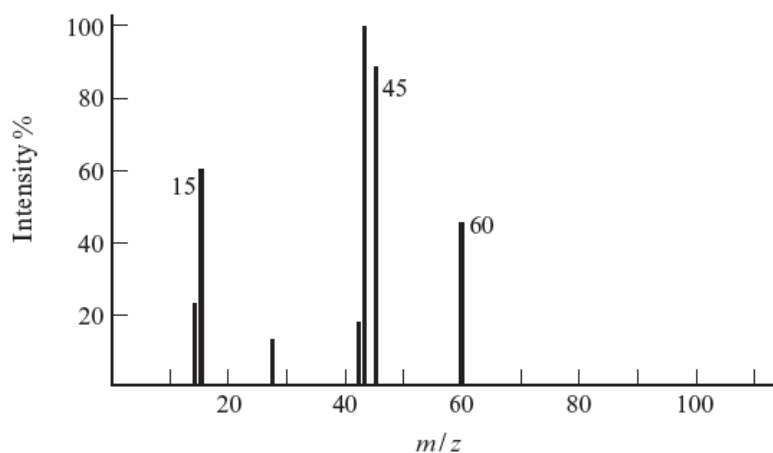
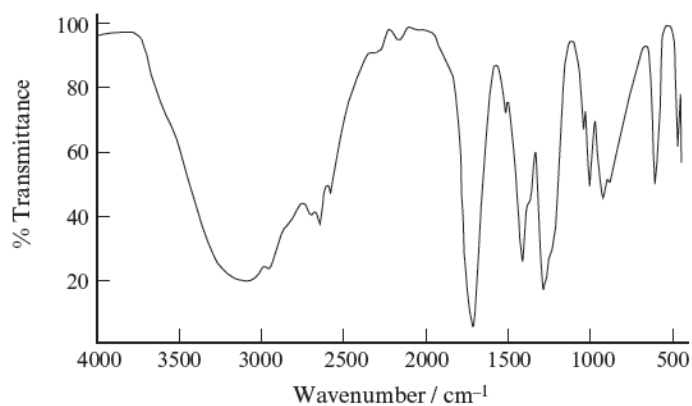
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- (b) A reaction of ethanol gives a product that is analysed in an IR spectrometer and a mass spectrometer. The following spectra are recorded.



- (i) Use **all** the information to suggest the identity of the product formed. Explain your reasoning. [4]

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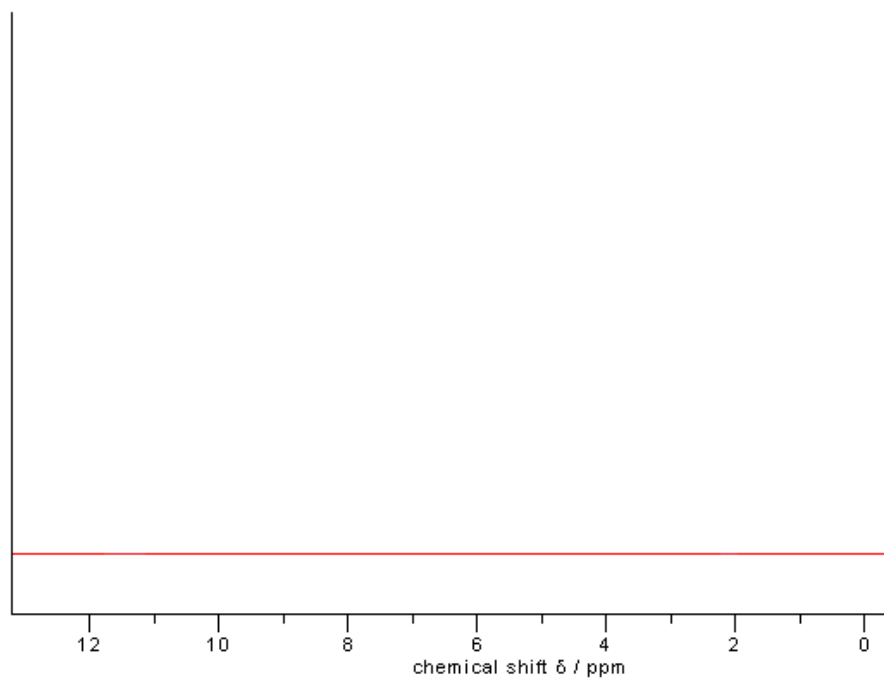
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- (ii) Predict what the ^1H NMR spectrum of the product identified in part (i) would look like. Draw the signals corresponding to its hydrogen atoms on the spectrum below. [2]



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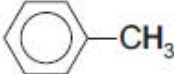
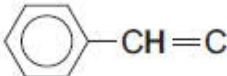
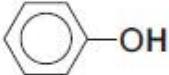
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Data Booklet

Infrared absorption values

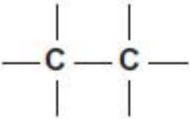
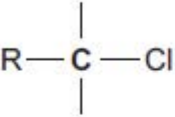
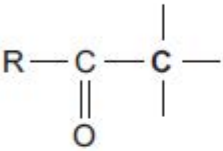
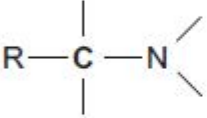
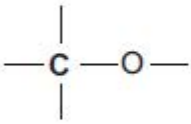
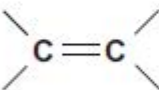
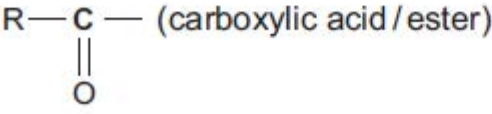
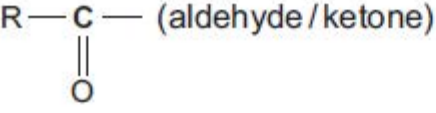
Bond	Wavenumber (cm^{-1})
C—Br	500 to 600
C—Cl	650 to 800
C—O	1000 to 1300
C=C	1620 to 1670
C=O	1650 to 1750
C≡N	2100 to 2250
C—H	2800 to 3100
O—H (carboxylic acid)	2500 to 3200 (very broad)
O—H (alcohol/ phenol)	3200 to 3550 (broad)
N—H	3300 to 3500

¹H NMR chemical shifts relative to TMS = 0

Type of proton	Chemical shift, δ (ppm)
$-\text{CH}_3$	0.1 to 2.0
$\text{R}-\text{CH}_3$	0.9
$\text{R}-\text{CH}_2-\text{R}$	1.3
$\text{CH}_3-\text{C}\equiv\text{N}$	2.0
$\text{CH}_3-\text{C}(=\text{O})-$	2.0 to 2.5
$-\text{CH}_2-\text{C}(=\text{O})-$	2.0 to 3.0
	2.2 to 2.3
$\text{R}-\text{CH}_2\text{Cl}$	3.3 to 4.3
$\text{R}-\text{OH}$	4.5 *
$-\text{C}=\text{CH}-\text{CO}$	5.8 to 6.5
	6.5 to 7.5
	7.0 *
$\text{R}-\text{C}(=\text{O})\text{H}$	9.8 *
$\text{R}-\text{C}(=\text{O})\text{OH}$	11.0 *

*variable figure dependent on concentration and solvent

^{13}C NMR chemical shifts relative to TMS = 0

Type of carbon	Chemical shift , δ (ppm)
	5 to 40
	10 to 70
	20 to 50
	25 to 60
	50 to 90
	90 to 150
$\text{R}-\text{C}\equiv\text{N}$	110 to 125
	110 to 160
 (carboxylic acid / ester)	160 to 185
 (aldehyde / ketone)	190 to 220

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COMPONENT 1: THE LANGUAGE OF CHEMISTRY, STRUCTURE OF MATTER AND SIMPLE REACTIONS

MARK SCHEME

GENERAL INSTRUCTIONS

Recording of marks

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One tick must equate to one mark, apart from extended response questions where a level of response mark scheme is applied.

Question totals should be written in the box at the end of the question.

Question totals should be entered onto the grid on the front cover and these should be added to give the script total for each candidate.

Extended response question

A level of response mark scheme is applied. The complete response should be read in order to establish the most appropriate band. Award the higher mark if there is a good match with content and communication criteria. Award the lower mark if either content or communication barely meets the criteria.

Marking rules

All work should be seen to have been marked.

Marking schemes will indicate when explicit working is deemed to be a necessary part of a correct answer.

Crossed out responses not replaced should be marked.

Marking abbreviations

The following may be used in marking schemes or in the marking of scripts to indicate reasons for the marks awarded.

cao	=	correct answer only
ecf	=	error carried forward
bod	=	benefit of doubt

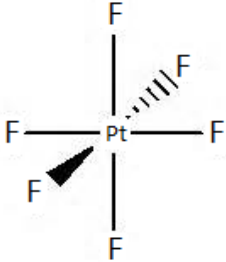
Credit should be awarded for correct and relevant alternative responses which are not recorded in the mark scheme.

Section A

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
1.				1s 2s 2p 3s 3p 3d 4s ↑↓ ↑↓ ↑↓ ↑↓ ↑↓ ↑↓ ↑↓ ↑↓ ↑↓ ↑↓		1		1		
2.	(a)			NO ₂ must show some working		1		1	1	
	(b)			N ₂ O ₄		1		1		
3.				2 (1) pyramidal (1)	2			2		
4.				$K_c = \frac{[\text{NH}_3]^2}{[\text{N}_2][\text{H}_2]^3}$	1			1	1	
5.				Ga ⁺ (g) → Ga ²⁺ (g) + e ⁻		1		1		
6.				48		1		1	1	
7.				$f = \frac{E}{h}$ or $f = \frac{3.4 \times 10^{-19}}{6.6 \times 10^{-34}}$ (1) 5.2 × 10 ¹⁴ (1) award (2) for correct answer only (cao)	1	1		2	2	
Section A total					4	6	0	10	5	0

Section B

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
8.	(a)			$A_r = \frac{(39 \times 93.26) + (40 \times 0.0117) + (41 \times 6.730)}{100} \quad (1)$ $= 39.1 \quad (1)$ (answer must be given to 3 sig figs)		2		2	2	
	(b)	(i)		atomised / turned into a gas (1) (atoms) bombarded by electrons / electron gun (1)	2			2		
		(ii)		passed through magnetic field / electromagnet (1) (potassium) particles of different masses are deflected by different amounts (1)	2			2		
	(c)	(i)		proton captures an electron (from inner orbital) forming a neutron (1) atomic number decreases to 18 which is that of argon (mass number remains unchanged) (1)	1	1		2		
		(ii)		3.75×10^9 years		1		1	1	
	(d)			^{63}Ni no mark for selection without reasoning must be a β -emitter as γ -rays pass easily through thin foil (1) must have a long half-life (1)			2	2		
				Question 9 total	5	4	2	11	3	0

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
9.	(a)	(i)		all ionisation energies showing gradual increase and one large jump (1) large jump occurs after 8 electrons (1)		1	1	2		
		(ii)		eighth and ninth electrons come from different shells (1) ninth electron is much closer to nucleus / has less or no shielding / has greater effective nuclear charge (1)	2			2		
	(b)	(i)		ionisation energy of argon is much higher than that of xenon (1) because the outer electron is closer to nucleus / has less shielding / has greater effective nuclear charge (1)	2			2		
		(ii)		 must be attempt to show 3D structure ignore charge		1		1		

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
9.	(c)			electrons move from lower to higher energy levels (1) by absorbing specific frequencies of light (1) dark lines correspond to light absorbed (1)	3			3		
	(d)			1 mol of XeO_3 released 2.5 mol gas products (1) 2.5 mol of gas occupies $24.0 \times 2.5 = 60 \text{ dm}^3$ (1) $\frac{60}{298} \times 323 = 65 \text{ dm}^3$ (1) error carried forward (ecf) possible award (3) for cao credit alternative method of calculation	1	2		3	3	3
				Question 10 total	8	4	1	13	3	3

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
10.	(a)	(i)		any one for (1) • whether pure sodium hydroxide is needed • whether less pure sodium hydroxide is acceptable to the customer • whether high concentration sodium hydroxide is needed • whether lower concentration sodium hydroxide is acceptable to the customer • whether the cost of replacement diaphragms is an important economic consideration			1	1		1
		(ii)		any two for (1) each up to max 2 • can it operate at a lower current / using less energy (1) • does it give a pure product (thereby avoiding need for purification) (1) • does it use or produce (other) toxic materials (1) • do parts need replacing regularly (1)			2	2		2
	(b)	(i)		measure out exactly 25.0 cm ³ using a pipette / burette (1) reference to volumetric flask and dropping pipette (1) dilute with (distilled) water up to the mark and shake (1)	1	1 1		3		3

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
10.	(b)	(ii)	I	0.00512 mol NaOH (1) $\frac{0.00512}{0.020} = 0.256$ (1) 2.56 (1) ecf possible award (3) for cao		1				
			II	more accurate result using 0.2M HCl credit for reasons only requires significant volume (1) percentage error is greater in measuring smaller volume (1)					1	
			III	$[H^+] = 0.2$ (1) $pH = 0.7$ (1)		1				
						1		2	1	2
				Question 11 total	1	7	5	13	2	13

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
11.	(a)	(i)		42.0 g of ethene needs 54.75 g of HCl therefore ethene in excess (1) n(HCl) = 1.2 (1) mass chloroethane = $1.2 \times 64.5 = 77.4$ g (1) award (3) for cao		3		3	3	
		(ii)		$\frac{65.0}{77.4} \times 100$ allow ecf from part (i) 84.0		1		1		1
	(b)	(i)		$\frac{64.5}{202.5} \times 100$ (1) 31.9 (1) award (2) for cao		1 1		2		
		(ii)		any one for (1) - comparison of availability of reactants e.g. ethene comes mainly from a non-renewable source / crude oil but ethanol can be produced renewably / plentiful supply of NaCl / H₂SO₄ - less energy used / higher yield / higher rate linked to lower costs or improved sustainability			1	1		
				Question 12 total	0	6	1	7	3	1

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
12.	(a)			concentration of hydrogen ions / $[H^+]$ would increase (1) as an increase in the concentration of reactants moves the position of equilibrium to the right (1)	1		1	2		
	(b)			limestone required, problems associated with quarrying (1) carbon dioxide produced, contributes to global warming (1)			2	2		
	(c)	(i)		2640 dm ³		1		1	1	1
		(ii)		$M_r \text{ BaSO}_4 = 233.1$ (1) $\frac{0.0047}{233.1} = 2.02 \times 10^{-5}$ (1) ecf possible		2		2		2
				Question 13 total	1	3	3	7	1	3

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
13.	(a)			Indicative content - choice of two appropriate soluble reagents e.g. calcium nitrate and sodium carbonate - dissolve solids in water / use aqueous solutions - mix solutions - filter, wash (with water) and dry precipitate $\text{Ca}^{2+}(\text{aq}) + \text{CO}_3^{2-}(\text{aq}) \rightarrow \text{CaCO}_3(\text{s})$ 5-6 marks: Each point included in the correct order; correct ionic equation. <i>The candidate constructs a relevant, coherent and logically structured account including all key elements of the indicative content. A sustained and substantiated line of reasoning is evident and scientific conventions and vocabulary are used accurately throughout.</i> 3-4 marks: A calcium salt and a carbonate named; reference to solutions and mixing; some attempt at ionic equation with correct formula for CaCO_3. <i>The candidate constructs a coherent account including most of the key elements of the indicative content and little irrelevant material. Some reasoning is evident in the linking of key points and use of scientific conventions and vocabulary is generally sound.</i> 1-2 marks: Minimum of two from the following included in some form of description – calcium salt, carbonate, dissolve/solution, mix, filter, precipitate. <i>The candidate attempts to link at least two relevant points from the indicative content. Coherence is limited by omission and/or inclusion of irrelevant material. There is some evidence of appropriate use of scientific conventions and vocabulary.</i> 0 marks: <i>The candidate does not make any attempt or give an answer worthy of credit.</i>	3	2	1	6		6

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
13.	(b)	(i)		NaOH reacted $0.188 \times 0.0248 = 4.66 \times 10^{-3} \text{ mol}$ (1) 1 mol HCl : 1 mol NaOH therefore $4.66 \times 10^{-3} \text{ mol}$ HCl left over after reaction with limestone (1) $\text{HCl used up} = 1.29 \times 10^{-2} - 4.66 \times 10^{-3} = 8.24 \times 10^{-3} \text{ mol}$ (1) ecf possible		1			1	
							2	3	1	3
		(ii)		2 mol HCl : 1 mol CaCO_3 therefore $4.12 \times 10^{-3} \text{ mol}$ CaCO_3 in 0.497 g limestone (1) $\text{mass CaCO}_3 = 4.12 \times 10^{-3} \times 100.1 = 0.412 \text{ g}$ (1) $\frac{0.412}{0.497} \times 100 = 82.9 \%$ (1) ecf possible		1				
						1			1	
						1		3	1	3
				Question 14 total	3	6	3	12	4	12

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
14.	(a)	(i)		each oxygen atom is covalently bonded to two hydrogen atoms (1) hydrogen bonds between oxygen in one molecule and hydrogen in another (1) hexagonal arrangement of water molecules (1) full credit could be gained from a correctly drawn and well labelled diagram	3			3		
		(ii)		delocalised electrons in graphite can move to carry a current (1) ice has no delocalised electrons (1)	2			2		
	(b)			van der Waals forces between molecules of iodine and covalent bonds between atoms in graphite (1) van der Waals forces are much weaker than covalent bonds (1)	2			2		
				Question 15 total	7	0	0	7	0	0

COMPONENT 1: THE LANGUAGE OF CHEMISTRY, STRUCTURE OF MATTER AND SIMPLE REACTIONS**SUMMARY OF MARKS ALLOCATED TO ASSESSMENT OBJECTIVES**

Question	AO1	AO2	AO3	Total	Maths	Prac
Section A	4	6	0	10	5	0
8.	5	4	2	11	3	0
9.	8	4	1	13	3	3
10.	1	7	5	13	2	13
11.	0	6	1	7	3	1
12.	1	3	3	7	1	3
13.	3	5	4	12	4	12
14.	7	0	0	7	0	0
Totals	29	35	16	80	21	32

COMPONENT 2: ENERGY, RATE AND CHEMISTRY OF CARBON COMPOUNDS

MARK SCHEME

GENERAL INSTRUCTIONS

Recording of marks

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Extended response question

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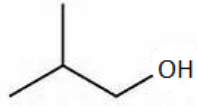
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ecf	=	error carried forward
bod	=	benefit of doubt

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Section A

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
1.	(a)			volume of gas produced over time		1		1		1
	(b)			break into smaller pieces / powder	1			1		1
2.				2,2-dimethylbutane		1		1		
3.						1		1		
4.				3 in top box 2 in bottom box – both needed		1		1		
5.				$\Delta H + (-137) = -85$ (1) no error carried forward (ecf) 52 (1) award (2) for correct answer only (cao)		2		2		
6.				infrared / IR spectroscopy	1			1		
7.				$\text{CH}_3\text{COOH} + \text{NaOH} \rightarrow \text{CH}_3\text{COONa} + \text{H}_2\text{O}$		1		1		
8.				condenser	1			1		1
Section A total					3	7	0	10	0	3

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
9.	(a)	(i)		$50 \times 4.18 \times 9.6$ (1) $2006 / 2006.4$ (1)		2		2		2
		(ii)		$n(\text{CuSO}_4) = 0.02525$ and $n(\text{Mg}) = 0.0370$ (1) $\Delta H = \frac{2.006}{0.02525}$ (1) $= -79.4$ must be negative value (1) no ecf possible		1 1	1	3	1 1	3
		(iii)		reaction has a higher rate / is quicker / powder has greater surface area (1) heat given out more quickly allowing more accurate determination of maximum temperature (1)	1		1	2		2
		(iv)		heat is lost to the environment (1) place a lid on the polystyrene cup (1) or no cooling correction for highest temperature recorded (1) measure temperature at time intervals, plot graph and extrapolate (1)			2	2		2

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(b)			bonds broken = $1648 + 612 + 2(\text{O—H})$ bonds formed = $2060 + 348 + 360 + (\text{O—H})$ (1) both required $-45 = [2260 + 2(\text{O—H})] - [2768 + (\text{O—H})]$ $(\text{O—H}) = 463$ (2) award (2) overall for -463 ecf possible		3		3	3	
				Question 9 total	1	7	4	12	5	9

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
10.	(a)			van der Waals forces must be overcome in order for boiling to occur (1) the greater the number of carbon atoms the more van der Waals forces (1)	2			2		
	(b)			correct combination for example $\begin{array}{c} \text{H} & & \text{H} \\ & \diagdown & / \\ & \text{C} = \text{C} \\ & / & \diagdown \\ \text{H} & & \text{H} \end{array}$ $\begin{array}{cccccccc} \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} \\ & & & & & & & \\ \text{H}-\text{C}-\text{C}-\text{C}-\text{C}-\text{C}-\text{C}-\text{C}-\text{H} \\ & & & & & & & \\ \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} \end{array}$		2		2		
	(c)			technique e.g. IR spectroscopy; ^1H NMR (1) relevant explanation e.g. propene has absorption due to C=C bond but this is not present in cyclopropane; propane has 3 peaks in its ^1H NMR spectrum but cyclopropane has only 1 (1) accept answers based on other appropriate techniques	1	1		2		2

Question				Marking details	Marks available							
					AO1	AO2	AO3	Total	Maths	Prac		
10.	(d)	(i)		H H H H H H OH H H C C C C H		1		1				
		(ii)		oxygen 18.4% (1) 67.9 12.0 : 13.7 1.01 : 18.4 16.0 5.66 : 13.56 : 1.15 (1) 5.66 1.15 : 13.56 1.15 : 1.15 1.15 C ₅ H ₁₂ O (1) ecf possible					1		3	3
				Question 10 total	3	7	0	10	2	5		

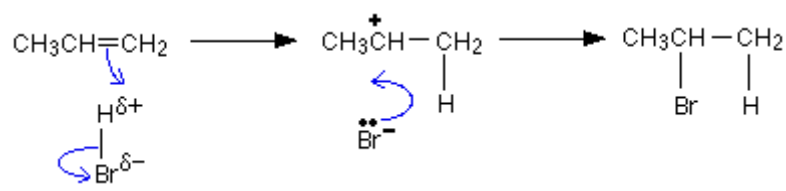
Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
11.	(a)			the instruments were less accurate during the earlier period (1) there were fewer records / measurements made / temperatures are estimates during the earlier period (1)			2	2		
	(b)			any two for (1) each up to max 2 - more fossil fuels burned (1) - more industry / transportation (1) - deforestation (1)	2			2		
	(c)			$n = \frac{pV}{RT} = \frac{101000 \times 24}{8.31 \times 298}$ (1) $n = 979$ (1) molar mass is 48 which is the molar mass of O_3 (1)	1		1 1		3	
				Question 11 total	3	0	4	7	3	0

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
12.	(a)			$\text{CH}_4 + \text{Cl}\cdot \rightarrow \text{CH}_3\cdot + \text{HCl} \quad (1)$ $\text{CH}_3\cdot + \text{Cl}_2 \rightarrow \text{CH}_3\text{Cl} + \text{Cl}\cdot \quad (1)$	2			2		
	(b)			two $\text{CH}_3\cdot$ radicals combine (in a termination reaction)	1			1		
	(c)	(i)		$\text{CH}_3\text{Cl} + \text{OH}^- \rightarrow \text{CH}_3\text{OH} + \text{Cl}^-$		1		1		
		(ii)		nucleophilic substitution	1			1		
		(iii)		methanol has hydrogen bonding between molecules (1) chloromethane has van der Waals forces / dipole-dipole forces between molecules (1) hydrogen bonding is stronger than van der Waals / dipole-dipole forces (1)	1	2		3		
				Question 12 total	5	3	0	8	0	0

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
13.	(a)	(i)		labelled axes with units (1)	1				1	
				points correctly plotted – within half a small square (1)	1				1	
				appropriate straight line drawn (1)		1		3		3
		(ii)		1.1×10^{-4} (1) accept range $\pm 0.1 \times 10^{-4}$						
				$\text{mol dm}^{-3} \text{ s}^{-1}$ (1)		2		2	2	2
		(iii)		colorimetry method (1) calibrate colorimeter with iodine solution of known concentration (1) measure light passing through to determine concentration at intervals (1)	1	1	1	3		3
		(iv)		concentration of hydrogen peroxide is directly proportional to the rate/doubling the concentration of hydrogen peroxide doubles the rate (1)					1	
				concentration of iodide ions is directly proportional to the rate/doubling the concentration of iodide ions doubles the rate (1)			2	2		2

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
13.	(b)			Boltzmann distribution curve two curves with appropriate shape, clearly labelled to show different temperatures and increased number of particles having energy greater than E_a at higher temperature (2) [award (1) for one curve with appropriate shape and E_a indicated if all above criteria not met] at higher temperature, more particles have energy greater than E_a (1) therefore greater proportion of collisions will result in reaction (1)	4			4		
				Question 13 total	7	4	3	14	5	10

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
14.	(a)			hydrolysis / nucleophilic substitution reaction occurs / $\text{C}_4\text{H}_9\text{X} + \text{OH}^- \rightarrow \text{C}_4\text{H}_9\text{OH} + \text{X}^-$ (1) white precipitate of silver chloride is formed (1) cream precipitate of silver bromide is formed (1) $\text{Ag}^+(\text{aq}) + \text{X}^-(\text{aq}) \rightarrow \text{AgX}(\text{s})$ or $\text{AgNO}_3(\text{aq}) + \text{X}^-(\text{aq}) \rightarrow \text{AgX}(\text{s}) + \text{NO}_3^-(\text{aq})$ (1)	1	2		4		2
	(b)	(i)		dichlorodifluoromethane / difluorodichloromethane		1		1		
		(ii)		compounds containing bromine most destructive to ozone / compounds containing fluorine least destructive to ozone (1) increasing the number of chlorine/bromine atoms increases destructive effect (1)			2	2		
				Question 14 total	1	4	2	7	0	2

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
15.	(a)			Indicative content  - dipole shown on H—Br molecule both curly arrows shown in first stage - charges and curly arrow in second stage - two different carbocations can form leading to two different products – 2-bromopropane and 1-bromopropane - secondary carbocation is more stable than primary carbocation - more 2-bromopropane formed (than 1-bromopropane) 5-6 marks: All dipoles, curly arrows and charges shown; comparison of relative stabilities of carbocations; both products named; correct main product <i>The candidate constructs a relevant, coherent and logically structured account including all key elements of the indicative content. A sustained and substantiated line of reasoning is evident and scientific conventions and vocabulary are used accurately throughout.</i> 3-4 marks: Dipoles, some curly arrows and charges shown correctly; one carbocation represented and one correctly identified product; recognition that two products are formed. <i>The candidate constructs a coherent account including most of the key elements of the indicative content and little irrelevant material. Some reasoning is evident in the linking of key points and use of scientific conventions and vocabulary is generally sound.</i>	6			6		

			1-2 marks: Correct dipole shown on HBr; reference to carbocation; one carbocation or product represented. <i>The candidate attempts to link at least two relevant points from the indicative content. Coherence is limited by omission and/or inclusion of irrelevant material. There is some evidence of appropriate use of scientific conventions and vocabulary.</i> 0 marks: <i>The candidate does not make any attempt or give an answer worthy of credit.</i>							
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Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
15.	(b)	(i)		any three for (1) each up to max 3 infrared absorption at 1750 corresponds to C=O (1) infrared absorption at 3200 corresponds to O–H (1) molecular ion peak at 60 gives relative molecular mass of 60 (1) fragments at 15 and 45 correspond to CH ₃ and COOH respectively (1) fourth mark reserved for product ethanoic acid / CH ₃ COOH (1)		1 1	1	4		3
		(ii)		peaks at approximately 2 and 11 (1) height ratio of 3:1 for peak at 2 to peak at 11 (1)		1	1	2		2
				Question 15 total	6	3	3	12	0	5

COMPONENT 2: ENERGY, RATE AND CHEMISTRY OF CARBON COMPOUNDS**SUMMARY OF MARKS ALLOCATED TO ASSESSMENT OBJECTIVES**

Question	AO1	AO2	AO3	Total	Maths	Prac
Section A	3	7	0	10	0	3
9.	1	7	4	12	5	9
10.	3	7	0	10	2	5
11.	3	0	4	7	3	0
12.	5	3	0	8	0	0
13.	7	4	3	14	5	10
14.	1	4	2	7	0	2
15.	6	3	3	12	0	5
Totals	29	35	16	80	15	34