

Name	Date started	Target end date
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GCE AS / A LEVEL – CHEMISTRY UNIT 1 QUESTION PACK

1091-01 (Legacy CH1) · New spec Unit 1 Topic 5 · AS unit, first sat 2016, 80 marks, 1h 30min paper

REVISE

.wales

CHEMISTRY – UNIT 1 · MOLES, AVOGADRO & REACTING MASSES

Topic 1.3 – The mole, Avogadro's constant, gas volumes and reacting-mass calculations

Defining the mole, calculating relative formula masses, using Avogadro's constant and molar gas volume, and working through reacting-mass and percentage-yield problems.

LEGACY 2008 SPECIFICATION

Estimated time for entire question pack: ~2 h 30 min

Derived from the legacy CH1 paper's pace of ~1.1 min/mark, padded for long-prose answers (94 marks over 17 questions).

You are advised to **not** attempt to complete all of this in one sitting.

ABOUT THIS QUESTION PACK

This is a **comprehensive practice question pack**, not a single mock paper. It contains every question from the legacy WJEC CH1 papers (2008 modular spec, Jan 2009 – Jun 2016) that maps onto the new-spec AS Unit 1 Topic 1.3.

Questions are ordered by source paper date.

INSTRUCTIONS

Use black ink or black ball-point pen. Show all working – quality of written communication will affect marks. A calculator is allowed. You may need the WJEC Periodic Table / Data Booklet.

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Q	Source	Max	Mark	Q	Source	Max	Mark	
1	Jun 09 Q3	1		10	Jun 13 Q8	8		
2	Jan 10 Q3	2		11	Jun 13 Q11	10		
3	Jun 10 Q6	1		12	Jan 14 Q2	1		
4	Jan 11 Q2	2		13	Jun 14 Q4	2		
5	Jan 11 Q8	12		14	Jun 14 Q12	14		
6	Jun 11 Q4	0		15	Jun 15 Q3	2		
7	Jun 11 Q8	12		16	Jun 15 Q4	2		
8	Jun 12 Q3	1		17	Jun 16 Q11	12		
9	Jan 13 Q8	12						
						Total	94	

Moles, Avogadro & Reacting Masses – what the new spec asks

WJEC GCE AS / A Level Chemistry (from 2015) · Unit 1: The Language of Chemistry, Structure of Matter & Simple Reactions · Topic 1.3.

The mole

- 1 mol = 6.022×10^{23} particles (Avogadro's constant N_A).
- Moles = mass / molar mass ($n = m / M$).
- Molar mass = A_r in g mol^{-1} .

Gas volumes

- Molar gas volume $V_m \approx 24.0 \text{ dm}^3 \text{ mol}^{-1}$ at room T&P.
- Moles of gas = $V (\text{dm}^3) / V_m$.
- Ideal gas: $pV = nRT$ (full version in Unit 2).

Concentration

- $c = n / V$; n in mol, V in dm^3 .
- Conc in mol dm^{-3} : also g dm^{-3} – convert via M .
- Diluting: n stays constant $\Rightarrow c_1V_1 = c_2V_2$.

Reacting masses & % yield

- Use balanced equation: ratio of moles = ratio of coefficients.
- % yield = (actual / theoretical) $\times 100$.
- Atom economy = $(M \text{ of useful product} / \Sigma M \text{ reactants}) \times 100$.
- Limiting reagent is the one fully consumed.

Moles, Avogadro & Reacting Masses in one page

Quick-reference notes – revisit before each question.

Core equation

$$n = m / M.$$

For solutions: $n = c \times V$.

For gases: $n = V / V_m$ ($V_m \approx 24 \text{ dm}^3 \text{ mol}^{-1}$).

Avogadro use

$$1 \text{ mol} = N_A = 6.022 \times 10^{23} \text{ particles.}$$

Atoms in n mol of A_x : $n \times x \times N_A$.

Step-by-step

1. Balanced equation.
2. Convert known quantity to moles.
3. Mole ratio from equation.
4. Convert to target (mass / volume / concentration).

% yield

$$(\text{actual} / \text{theoretical}) \times 100.$$

Theoretical from limiting reagent & mole ratio.

Atom economy

M of desired product / ΣM of all products – or \times molar ratios.

Higher = greener process.

Common pitfalls

Watch units: $\text{cm}^3 \rightarrow \text{dm}^3: \div 1000$.

$\text{g} \rightarrow \text{kg}: \div 1000$.

Always check moles ratio before scaling.

2. (a) Cobalt reacts with hydrochloric acid to give cobalt chloride and hydrogen.



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

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.....

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

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.....

- (b) A radioactive isotope of cobalt has a half-life of 71 days. Starting with 16 g, calculate the mass of this isotope remaining after 213 days. [1]

.....
.....

3. State the mass of carbon that contains the same number of atoms as there are molecules in 16 g sulfur dioxide, SO₂. [1]

- A 3g
B 6g
C 12g
D 64g

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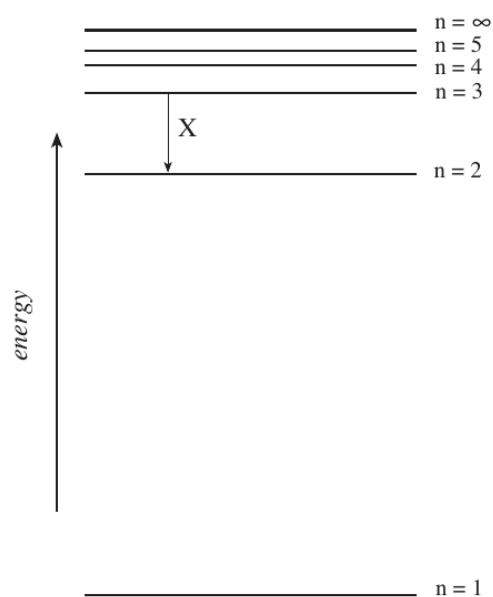
3. (a) Complete the following definition of the *mole*: [1]

A mole is the amount of material containing the same number of particles as there are atoms in

- (b) State the number of moles of sulfur atoms, S, in 0.3 mol iron(III) sulfate, Fe₂(SO₄)₃. [1]

.....

4. The diagram below shows the electron energy levels for a hydrogen atom.



- (a) State which one of the following correctly describes the transition represented by arrow X: [1]

- A The first line in the Lyman series
- B The second line in the Lyman series
- C The first line in the Balmer series
- D The second line in the Balmer series

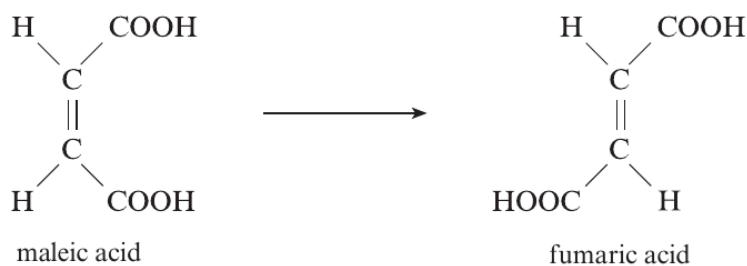
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- (b) Draw on the energy level diagram an arrow to represent the transition which occurs when a hydrogen atom is ionised. [1]

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Examiner
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5. One industrial method of preparing fumaric acid is to heat maleic acid in the presence of a catalyst.



- (i) Deduce the atom economy of this reaction. [1]
 %
- (ii) Data from a manufacturer states that the percentage yield of fumaric acid is 95% using a 150 kg batch of maleic acid.
 Calculate the mass of fumaric acid formed. [1]
 kg
6. Choose the mass of methane, CH_4 , that contains the same number of molecules as there are molecules in 96 g of silane, SiH_4 . [1]
- A 36 g
 B 48 g
 C 96 g
 D 144 g

Total Section A [10]

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]



2. (a) Calculate the molar mass, in g mol^{-1} , of calcium sulfate dihydrate, $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$. [1]

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- (b) Calculate the percentage of water, by mass, in calcium sulfate dihydrate. [1]

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.....

3. Ions of two isotopes of the metal lithium are shown below.



State which **one** of the following statements is **correct**. [1]

- A** The electron arrangement of both these Li^+ ions is $1s^2 2s^1$.
- B** The ${}^7\text{Li}^+$ ion will have more protons in its nucleus than the ${}^6\text{Li}^+$ ion.
- C** The ${}^7\text{Li}^+$ ion will be deflected more than the ${}^6\text{Li}^+$ ion in a mass spectrometer.
- D** Both of these Li^+ ions have the same number of electrons.

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Examiner only

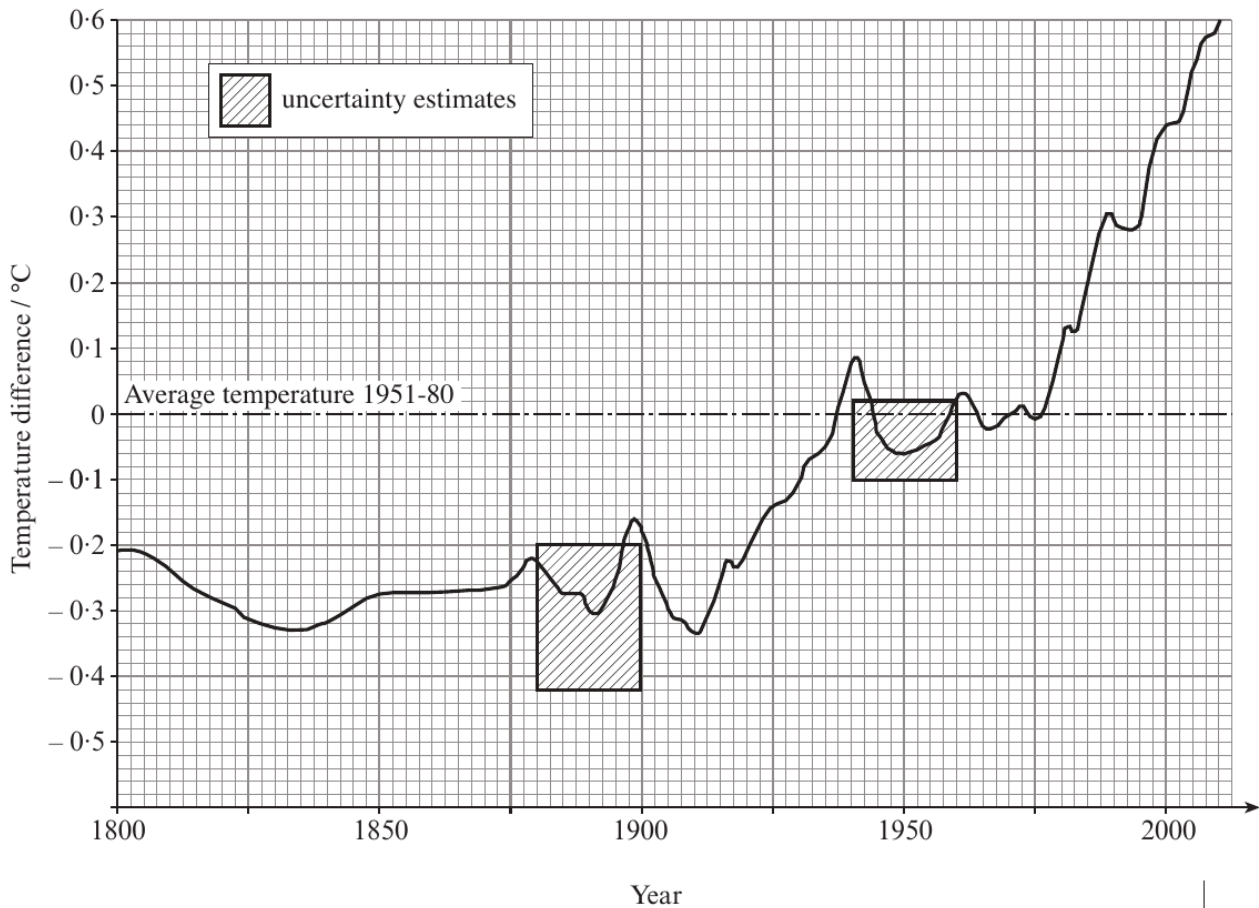
8. (a) During the last 200 years, the average temperature of the Earth has risen. One hypothesis put forward by many scientists is that this is due to increased concentrations of carbon dioxide and other greenhouse gases in the atmosphere.

The table below shows the concentration of carbon dioxide in the atmosphere at 50 year intervals since 1800.

	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 following graph based on data from NASA research, shows the annual global temperature relative to the average temperature between 1951 and 1980.

Global Temperature



Examiner
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(i) Explain how these two sets of data led many scientists to this hypothesis. [2]
QWC [1]

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.....

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(ii) Suggest why the data does not convince all scientists that this hypothesis is true.[1]

.....

.....

(iii) Suggest **two** reasons why the uncertainty is greater in the period 1880-1900 than the period 1940-1960. [2]

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(iv) Give **two** reasons for the changing amounts of carbon dioxide in the atmosphere after 1900. [2]

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.....

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Examiner
only

(b) In fizzy drinks, carbon dioxide is dissolved in water under pressure and when the pressure is released the ‘fizz’ appears.

In a bottle of fizzy drink, the following chemical equilibrium exists:



(i) Chemical equilibria are often described as dynamic equilibria.
Explain the term *dynamic equilibrium*.

[1]

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.....

(ii) When the top is removed from a bottle of fizzy drink it goes ‘flat’ because much of the dissolved carbon dioxide comes out of solution.
Explain why this happens in terms of chemical equilibria.

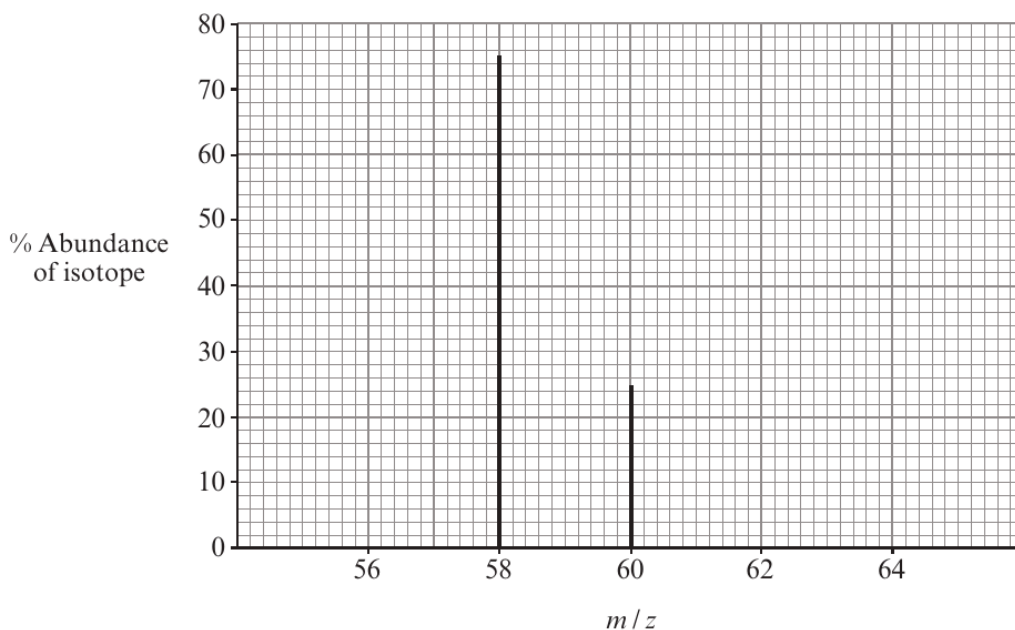
[2]
QWC [1]

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Total [12]

Examiner only

3. The mass spectrum of a sample of nickel is shown below.



Use the data to calculate the relative atomic mass of this sample to **three** significant figures. **You must show your working.** [1]

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.....

4. State which of the following letters corresponds to the number of moles of each element in 53 g of sodium carbonate, Na_2CO_3 , which has an M_r of 106.

	Na	C	O
A	0.5	0.5	0.5
B	1	0.5	3
C	1	0.5	1.5
D	2	1	3

[1]

Letter

Examiner only

8. (a) Chloroethane, C₂H₅Cl, 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 (theoretical) mass of chloroethane obtainable from 42.0 g of ethene. [2]

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- (ii) The actual mass of chloroethane obtained from 42.0 g of ethene in an experiment was 79.0 g. Calculate the percentage yield in this experiment. [2]

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



M_r values 46.0 58.5 98.0 64.5 120 18.0

- (i) Describe what is meant by *atom economy*. [1]

.....

.....

- (ii) Calculate the % atom economy for reactions A and B. [2]

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- (iii) State which of reactions A and B is preferred, giving your reason. [1]

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Examiner
only

(c) Describe how industry is adapting to the challenges of *Green Chemistry*. Your answer should include reference to the

- overall aim of Green Chemistry,
- materials used or produced,
- energy used.

[3]

QWC [1]

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Total [12]

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SECTION A

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

1. Sketch a diagram to show the shape of a *p* orbital. [1]

2. Complete the following definition of *relative atomic mass*: [1]

The relative atomic mass of an element is the average mass of one atom of the element relative to

.....
.....

3. State which **one** of the following contains the greatest number of molecules. [1]

A 3 g of hydrogen

B 32 g of oxygen

C 36 g of water

D 66 g of carbon dioxide

4. Phosgene is a compound of carbon, oxygen and chlorine. It is used to make polyurethanes and polycarbonates. Its percentage composition, by mass, is as follows.

C 12.1% O 16.2% Cl 71.7%

- (a) Calculate the **empirical** formula of this compound. [2]

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- (b) What other information would you need to know to be able to deduce the **molecular** formula of this compound? [1]

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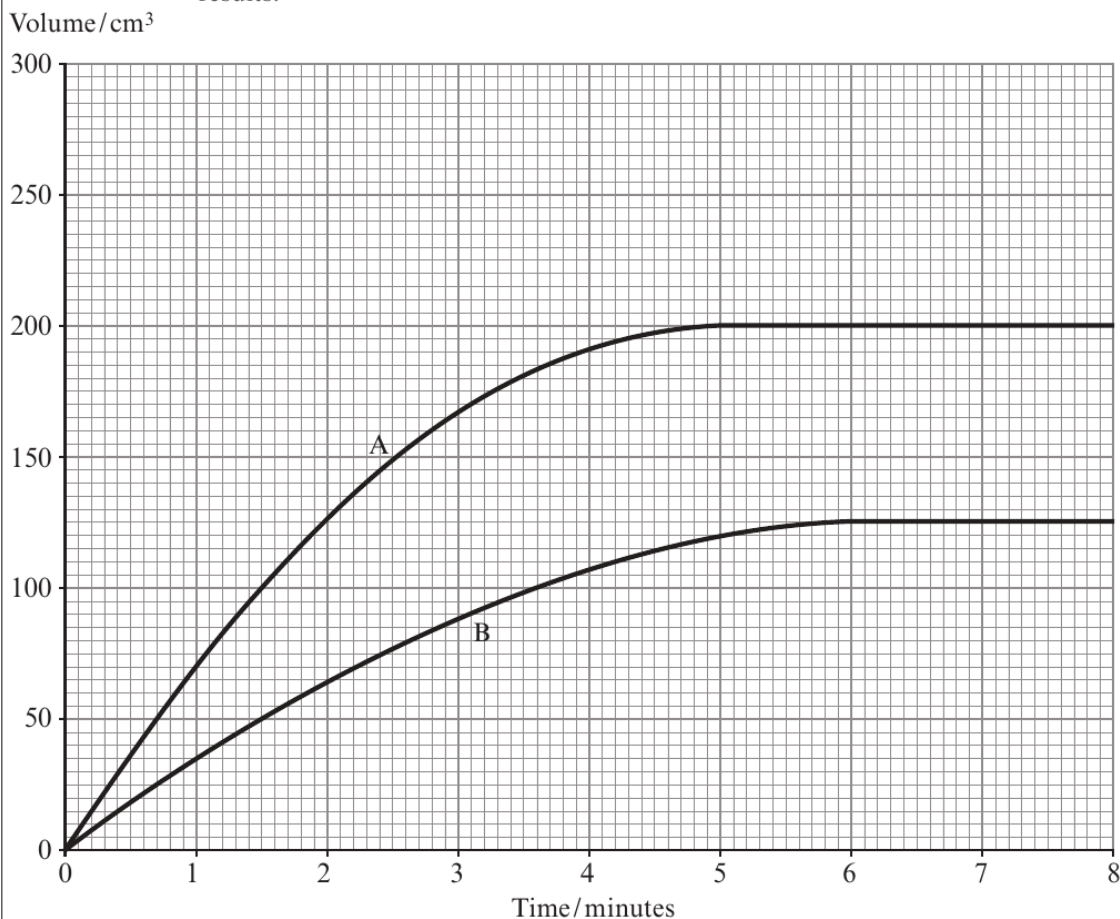
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Examiner only

8. Dolomite, $MgCO_3 \cdot CaCO_3$, is a mineral containing magnesium carbonate and calcium carbonate.

(a) Some students were asked to react samples of dolomite, each of mass 0.50 g, with an excess of dilute hydrochloric acid and to follow the rate of the reaction by measuring the volume of carbon dioxide evolved at suitable time intervals.

(i) Line A on the graph shows Natalie's results. Her teacher said that this was correct. David's line is labelled B. Although his line represents his results, the teacher said that he must have done something wrong during the experiment to obtain these results.



Suggest and explain **two** things that he might have done wrongly to obtain these results. [2]

1.
2.



0 8

Examiner
only

- (ii) Explain why, in Natalie’s experiment, 0.25 g of the dolomite has reacted in 1.5 minutes but the remaining 0.25 g has taken a further 3.5 minutes to react. [2]

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- (iii) Emma asked what the volume of carbon dioxide collected from the samples would be if the temperature rose from 298 K to 323 K.
The teacher explained that, if the pressure remained the same, volume V (in cm³) and temperature T (in Kelvin) were linked by the equation

$$V = k \times T \quad \text{where } k \text{ is constant.}$$

The volume of carbon dioxide evolved at 298 K is 130 cm³. By finding the value of k, or by other means, calculate the volume of this carbon dioxide when its temperature is raised to 323 K. [2]

Volume of carbon dioxide = cm³

1 091
0 10009



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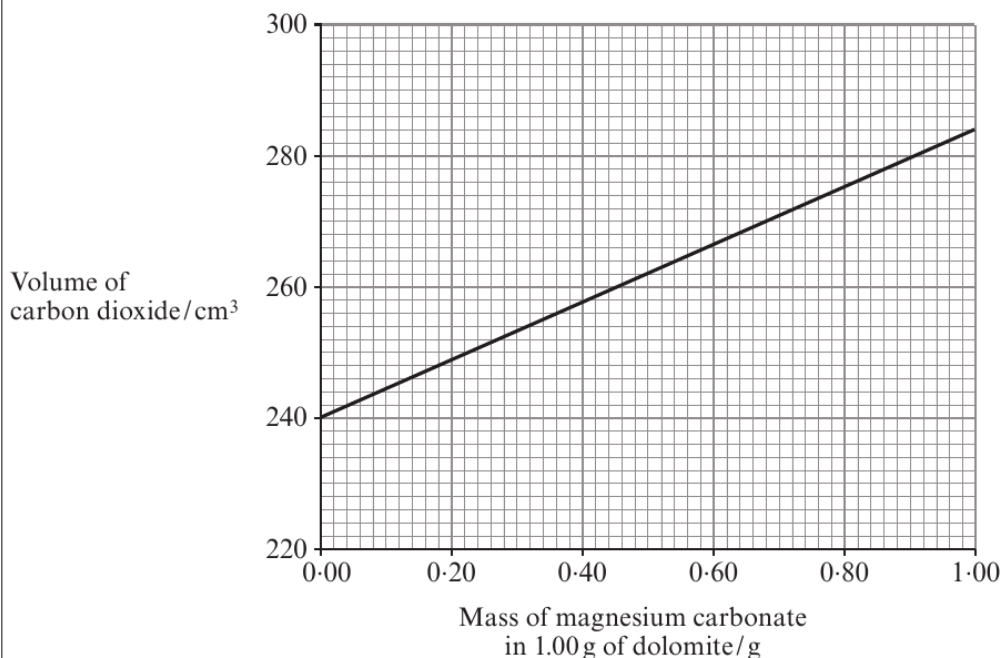
Examiner
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(b) In another experiment 0.623 g of dolomite reacted with an excess of dilute hydrochloric acid. The total volume of carbon dioxide evolved was 162 cm³.

(i) Calculate the total volume of carbon dioxide that would be evolved if a sample of dolomite of mass 1.00 g was used under the same conditions. [1]

Volume of carbon dioxide = cm³

(ii) Use the graph below to find the mass of magnesium carbonate present in this 1.00 g sample of dolomite. [1]



Mass of magnesium carbonate = g



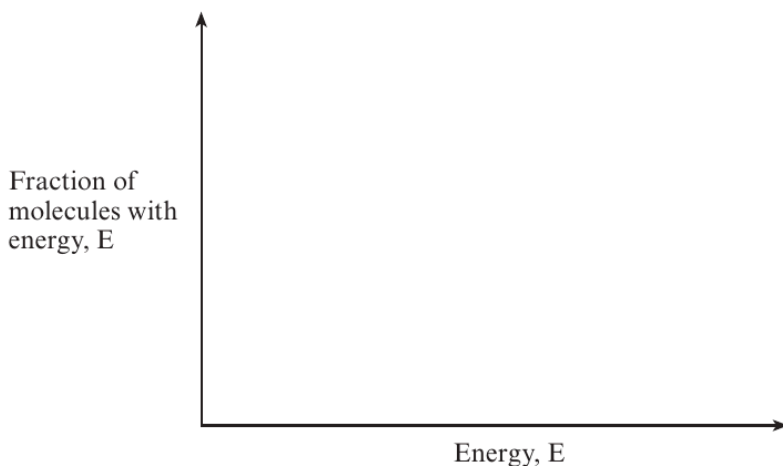
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(c) The rate of the reaction between dolomite and hydrochloric acid increases by a large amount if the temperature is increased.

Complete the following energy distribution curve diagram by drawing two lines that show the distribution of energies at two different temperatures. Label the line at lower temperature T_1 and the line at higher temperature T_2 . Use the diagram to help you explain why the rate increases as the temperature increases.

[3]
QWC [1]



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(d) Briefly outline a different method of following the rate of the reaction between dolomite and hydrochloric acid. [2]

Total [14]



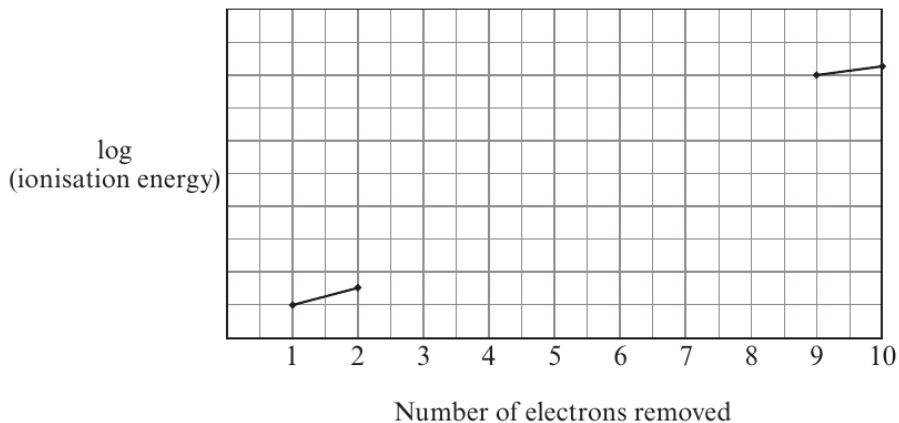
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Examiner only

8. 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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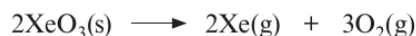
Examiner
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- (b) The first compound of a noble gas was formed from Xe atoms and PtF_6 . It was the ionic compound $\text{Xe}^+ \text{PtF}_6^-$.

Explain why it is not possible to form a similar ionic compound of argon, $\text{Ar}^+ \text{PtF}_6^-$. [2]

- (c) Helium was identified in the Sun before it was discovered on Earth. When light from the Sun is split into its different colours by a prism, dark lines are observed against a coloured background which show the atomic absorption spectrum of helium. Explain how an atomic absorption spectrum forms. [2]

- (d) Xenon trioxide, XeO_3 , is a compound which decomposes explosively at 25°C according to the following equation.



Calculate the volume of gas, in dm^3 , released by the decomposition of 1 mol of XeO_3 under these conditions. [2]

[1 mol of any gas at 25°C occupies a volume of 24.0 dm^3]

Volume = dm^3

Total [10]

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0 7

Examiner
only

11. The combustion of fossil fuels provides much of the energy we use today. Nonane, C_9H_{20} , is one of the compounds present in the fuel kerosene.

(a) (i) The equation for the combustion of nonane is given below.



Use the values given in the table to calculate the standard enthalpy of combustion of nonane. [3]

Substance	Standard enthalpy of formation, $\Delta H_f^\ominus / \text{kJ mol}^{-1}$
$C_9H_{20}(l)$	-275
$O_2(g)$	0
$CO_2(g)$	-394
$H_2O(l)$	-286

Standard enthalpy of combustion = kJ mol^{-1}

(ii) Standard enthalpy changes are measured under standard conditions. Give the standard conditions of temperature and pressure, including units for each. [2]

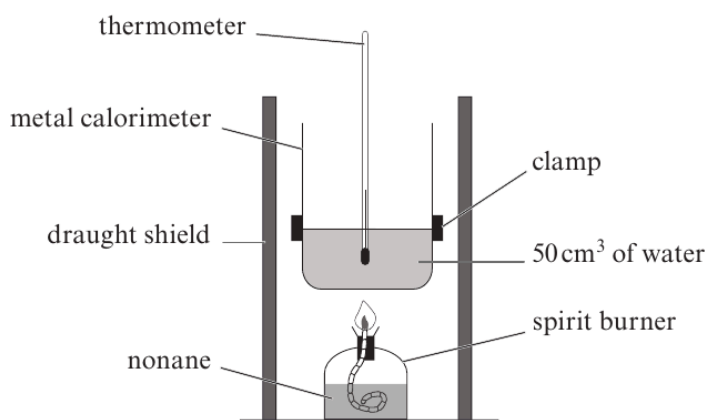
Temperature

Pressure



Examiner
only

- (b) Iwan wished to confirm the value he had calculated for the enthalpy of combustion of nonane, and he used the apparatus below.



- (i) Iwan measured the mass of the spirit burner at the start and end of the experiment and found that 0.20 g of nonane had been burned. Calculate the number of moles of nonane present in 0.20 g. [2]

Number of moles = mol

- (ii) During this experiment, the temperature of the water increased by 42.0°C. Use the formula below to calculate the enthalpy change of combustion of nonane, in kJ mol⁻¹. [2]

$$\Delta H = \frac{-mc\Delta T}{n}$$

m is the mass of water

c is the specific heat capacity of water which is 4.18 J °C⁻¹ g⁻¹

ΔT is the temperature change in °C

n is the number of moles of nonane

ΔH = kJ mol⁻¹

QUESTION 11 CONTINUES ON PAGE 14



1 3

- (iii) Give **one** reason why the experimental value that Iwan obtained differs from the theoretical value calculated in part (a). [1]

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Total [10]

Examiner
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1 4

Examiner
only

SECTION A

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

1. An element, X, has an atomic number of 9 and forms an ion X^- . State which **one** of the following shows the numbers of protons and electrons in this **ion**. [1]

	protons	electrons	
A	8	9	
B	9	8	
C	9	9	
D	9	10	

2. State which **one** of the following shows the mass of aluminium that contains the same number of atoms as there are molecules in 11.0g of carbon dioxide, CO_2 . [1]

A	6.75g	
B	13.5g	
C	27.0g	
D	54.0g	

3. The isotope ^{32}P is radioactive. It decays by β -emission and has a half-life of 14 days.
 (a) State what is meant by β -emission. [1]

.....

- (b) Give the mass number **and** symbol of the atom formed by the loss of one β -particle from an atom of ^{32}P . [1]

.....

- (c) State what is meant by the term *half-life*. [1]

.....

- (d) Calculate how long it will take a sample of ^{32}P to decay from 8g to 1g. [1]

Time taken = days

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

1. Complete the electronic structure for the sulfide ion present in Na_2S . [1]

$1s^2$

2. Which isotope is the standard used in defining relative atomic masses? [1]

.....

3. State **one** example of an industrially or environmentally important heterogeneous catalyst. You should identify the reaction catalysed and name the catalyst. [1]

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.....

4. Hydrated sodium carbonate has the formula $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$.

- (a) Calculate the relative molecular mass (M_r) of $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$. [1]

$M_r =$

- (b) Calculate the mass of $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$ needed to make 250cm^3 of a 0.10 mol dm^{-3} solution. [1]

Mass = g



0 2

Examiner
only

12. Hydromagnesite is a mixture of magnesium carbonate and soluble impurities. A student crushed some hydromagnesite and added a sample of mass 0.889g to excess dilute hydrochloric acid so that the magnesium carbonate component reacted fully.

(a) Explain why the rock was crushed before being added to the acid. [1]

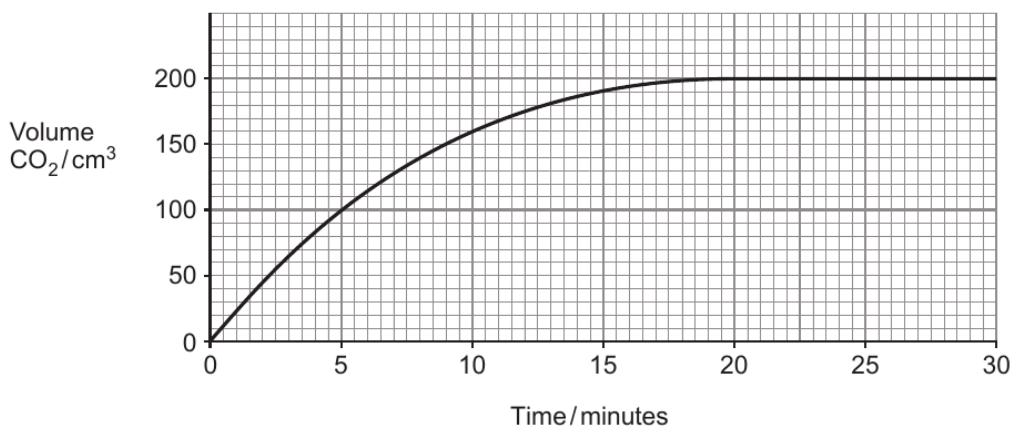
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(b) Write the equation for the reaction between magnesium carbonate and dilute hydrochloric acid. [1]

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(c) The gas formed was collected in a gas syringe and its volume was measured over a period of time. The volumes and times were plotted. The volume of 1 mol of gas under these conditions is 24.0 dm³.



Describe what happened to the rate of the reaction over the 30 minute period. Explain why any changes in the rate occurred. [3]

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- (d) Other than by using an indicator, how would the student know that hydrochloric acid was in excess? [1]

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- (e) (i) Use the graph to calculate how many moles of magnesium carbonate reacted with the hydrochloric acid. [2]

Number of moles MgCO₃ = mol

- (ii) Find the mass of magnesium carbonate that reacted and hence the percentage of magnesium carbonate present in hydromagnesite. [2]

Percentage of magnesium carbonate = %

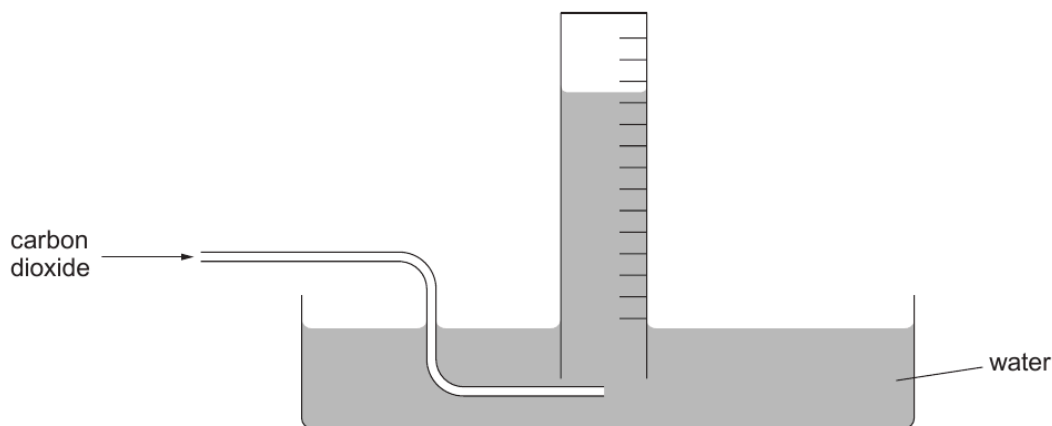
Examiner
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Examiner only

- (f) A student wanted to carry out this experiment on another sample of hydromagnesite. He did not have a gas syringe and therefore he decided to collect the carbon dioxide over water in a measuring cylinder.



Explain what effect this would have on the results of the experiment. You should assume that the gas syringe and the measuring cylinder can both be read to the same precision. [2]

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- (g) When magnesium carbonate is heated it decomposes to make magnesium oxide and carbon dioxide.



Magnesium oxide has a very high melting temperature and so can be used to line furnaces.

What is the atom economy for the production of magnesium oxide from magnesium carbonate? [2]

Atom economy = %

Total [14]

Section B Total [70]

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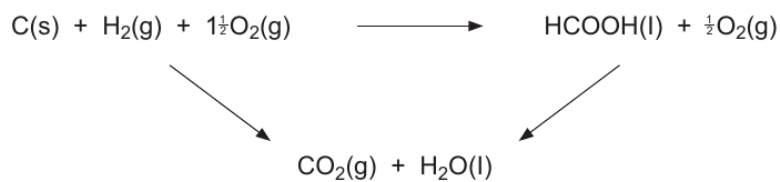


Examiner
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3. Methanoic acid is the simplest carboxylic acid and occurs naturally, most notably in ant venom. It has a molar mass of 46.02 g mol^{-1} .

(a) State what is meant by *molar mass*. [1]

(b) Use the values in the table below to calculate the enthalpy change of formation for methanoic acid. [1]



Substance	Enthalpy change of combustion, $\Delta H_c^\theta / \text{kJ mol}^{-1}$
C	-394
H ₂	-286
HCOOH	-263

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

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010003

03

Examiner
only

4. A sample of 0.50g of calcium carbonate completely reacts with 50 cm³ of hydrochloric acid solution of concentration 2.0 mol dm⁻³ to give calcium chloride, carbon dioxide and water.

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

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.....

(b) State, giving a reason, what effect using 100 cm³ of hydrochloric acid solution of concentration 2.0 mol dm⁻³ would have on the initial rate of this reaction. [1]

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Section A Total [10]



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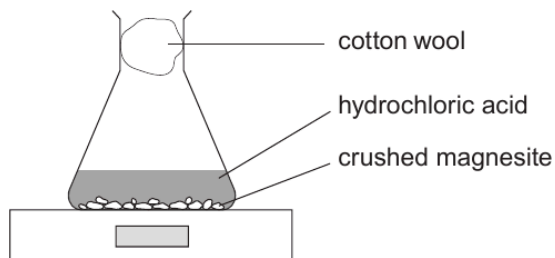
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05

11. Magnesite is a mineral that consists largely of magnesium carbonate. A sample of crushed magnesite of mass 6.72 g and an excess of dilute hydrochloric acid of concentration 2 mol dm^{-3} were placed in a conical flask on a balance.

Examiner
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Carbon dioxide was given off during the reaction and the loss in mass was recorded at set intervals.

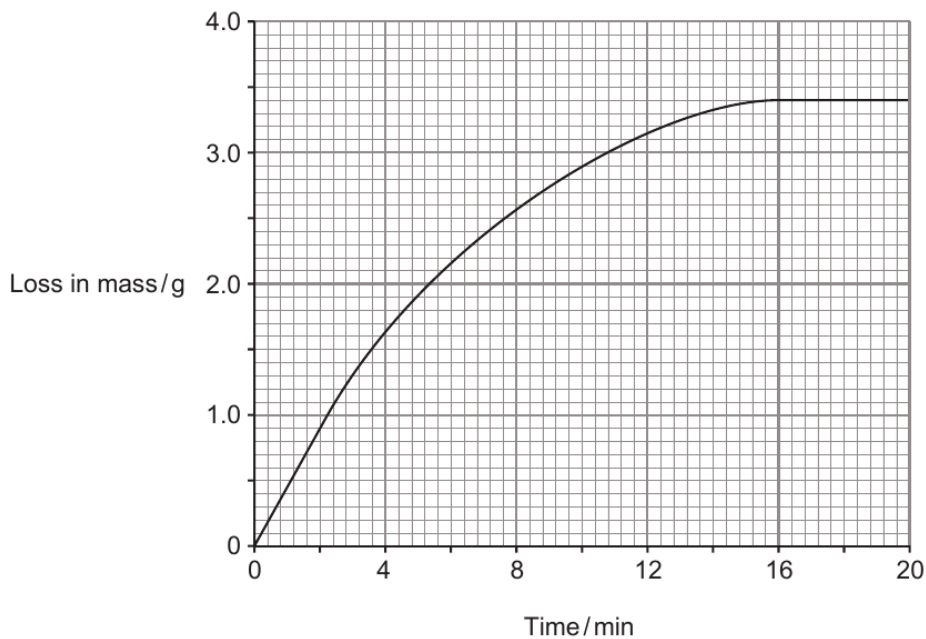
- (a) Suggest why cotton wool was placed in the neck of the flask. [1]

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Examiner
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(b) The results from the experiment were plotted in a graph.



- (i) Use the graph to find the time taken for half of the original mass of magnesium to react. [1]

Time = min

- (ii) Use the graph to calculate the initial rate of the reaction, giving its unit. [2]

Rate =

Unit

Examiner
only

(iii) Use collision theory to explain how the rate of the reaction changes during the reaction. You should consider **both** reactants in your answer. [3]

QWC [1]

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(iv) The experiment was repeated using the same mass of magnesite but in a lump form.

Sketch on the graph (previous page) the resulting line for this experiment. [2]

(c) In a further experiment an excess of magnesite was added to some hydrochloric acid. At the end of the reaction a neutral solution of magnesium chloride and some unreacted magnesite remained.

Outline how the pH of the mixture would change during this reaction, suggesting pH values where appropriate. [2]

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Total [12]

Section B Total [70]

END OF PAPER

END OF QUESTION PACK

17 questions · 94 marks · ~2 h 30 min

Source: WJEC CH1 (2008 modular spec, Jan 2009 – Jun 2016)

Curated for WJEC Chemistry 2015 spec AS Unit 1 – Topic 5 (1.3)

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