Name	Date started	Target end date

GCE AS / A LEVEL — CHEMISTRY UNIT 1 QUESTION PACK

1091-01 (Legacy CH1) · New spec Unit 1 Topic 3 · AS unit, first sat 2016, 80 marks, 1h 30min paper

REVISE
.wales

CHEMISTRY — UNIT 1 · MASS SPECTROMETRY

Topic 1.2 — Mass spectrometer interpretation, m/z and isotope abundances

Interpreting mass spectra to deduce isotope composition, identify molecular ions, and calculate relative atomic masses of multi-isotope elements.

LEGACY 2008 SPECIFICATION

Estimated time for entire question pack: ~1 h 22 min

Derived from the legacy CH1 paper's pace of ~1.1 min/mark, padded for long-prose answers (51 marks over 7 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 1.2.

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.

For Examiner's use only

Q	Source	Max	Mark
1	Jan 10 Q7	14	
2	Jun 10 Q3	2	
3	Jun 11 Q3	1	
4	Jun 13 Q9	13	
5	Jan 14 Q6	8	
6	Jun 14 Q9	11	
7	Jun 16 Q4	2	
	Total	51	

Mass Spectrometry — 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 1.2.

How the mass spectrometer works

- Sample is vaporised, ionised, accelerated, deflected, detected.
- Ionisation: electron impact knocks out one electron ⇒ +1 cation.
- Heavier ions deflect less; lighter ions deflect more.
- Detector signal converted to mass spectrum (m/z vs % abundance).

Reading a mass spectrum

- Each peak = a unique isotope or fragment.
- x-axis = m/z (mass-to-charge ratio); y-axis = relative abundance.
- Tallest peak = base peak (most abundant ion).
- Molecular ion (M^+) gives the relative molecular mass.

Calculating relative atomic mass

- $A_r = \Sigma$ (isotope mass × % abundance) / 100.
- Worked example: Cl is 75% ^{35}Cl + 25% ^{37}Cl ⇒ A_r = 35.5.

Diatomic / polyatomic ions

- Cl_2: peaks at m/z 70 (^{35}-^{35}), 72 (^{35}-^{37}), 74 (^{37}-^{37}).
- Intensity ratios reveal isotope composition.
- Br_2: 79-79, 79-81, 81-81 in 1:2:1 ratio.

Mass Spectrometry in one page

Quick-reference notes — revisit before each question.

Five-step process

1. Vaporisation.
2. Ionisation (electron impact).
3. Acceleration.
4. Deflection (magnetic field).
5. Detection (current proportional to abundance).

Spectrum axes

x-axis: m/z (since charge usually +1, this equals mass).

y-axis: relative abundance.

Calculating A_r

Multiply each isotope mass by its abundance.

Sum and divide by 100.

Worked: Ne 90% ^{20}, 10% ^{22} ⇒ A_r = 20.2.

Cl_2 spectrum

3 molecular ion peaks at m/z 70, 72, 74.

Ratio 9:6:1 (from 75% × 75% etc.).

Br_2 spectrum

Bromine: 50% ^{79}, 50% ^{81}.

Br_2: peaks at 158, 160, 162 in 1:2:1.

Fragmentation

Beyond AS: molecular ion can fragment to smaller ions.

Each fragment gives a peak.

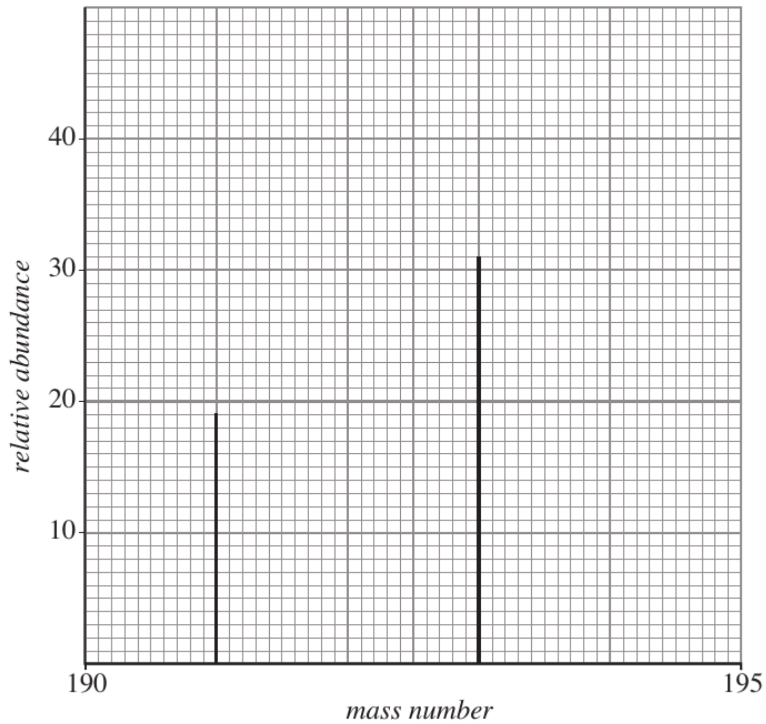
Examiner only

SECTION B

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

7. Iridium, Ir, is the element with atomic number 77.

(a) Its mass spectrum shows that iridium has two naturally-occurring isotopes.



(i) Explain the term *isotopes*. [1]

....

....

(ii) State the numbers of electrons, neutrons and protons present in **each** of the two isotopes. [2]

....

....

....

(iii) Measure the height of each peak and hence calculate the percentage abundance of each isotope in naturally-occurring iridium. [2]

....

....

Examiner only

(b) A further man-made, radioactive isotope of iridium, ^{192}Ir, is manufactured by bombarding naturally-occurring iridium with neutrons in a nuclear reactor. ^{192}Ir is used in the radiotherapy of certain cancers.

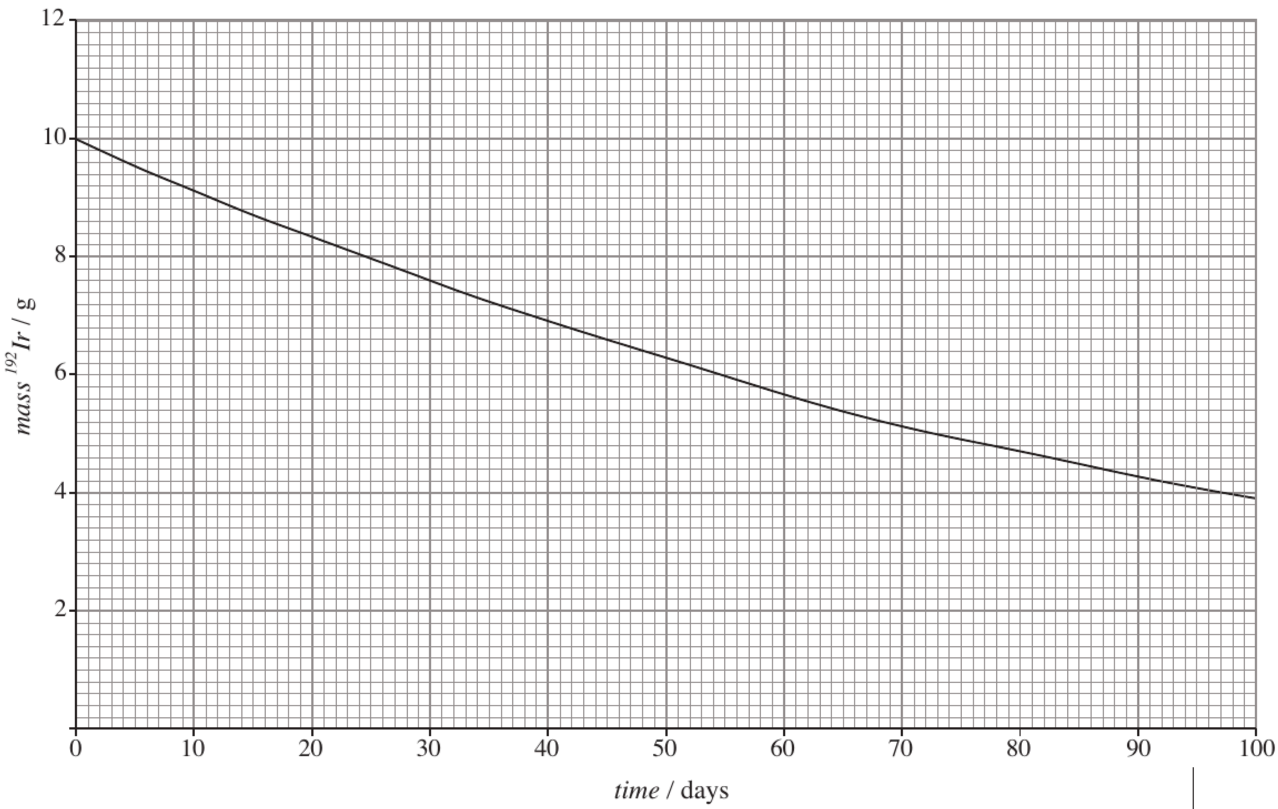
(i) ^{192}Ir decays by β–emission. Explain what is meant by β–emission. [1]

....

(ii) Give the mass number and symbol of the product atom in (b)(i). [2]

Mass number .... *Symbol* ....

(c) The decay of a 10g sample of ^{192}Ir with time is shown in the graph.



(i) Explain the term *half-life*. [1]

....

....

(ii) Determine the half-life of ^{192}Ir from the graph. [1]

....

Examiner only

(iii) Determine the total time required for the 10 g mass of ^{192}Ir to decay to 1.25 g. [2]

....

....

(iv) Calculate, from the graph, the rate of decay of ^{192}Ir (g day^{-1}) during the first 20 days. [2]

....

....

....

(d) Compound **P**, one of the most important compounds of iridium, is a black solid containing 10.2 % sodium, Na, 42.6 % iridium, Ir, and 47.2 % chlorine, Cl, by mass.

(i) Calculate the empirical formula (which is also the molecular formula) of compound **P**.

$A_r(Na) = 23.0$; $A_r(Cl) = 35.5$; $A_r(Ir) = 192$. [2]

....

....

....

(ii) Compound **P** is made by reacting a mixture of sodium chloride, NaCl, and an iridium chloride, $IrCl_x$. There is only one product of the reaction. By constructing a balanced equation, or otherwise, determine the value of **x** in the iridium chloride formula, $IrCl_x$. [1]

....

....

Total [17]

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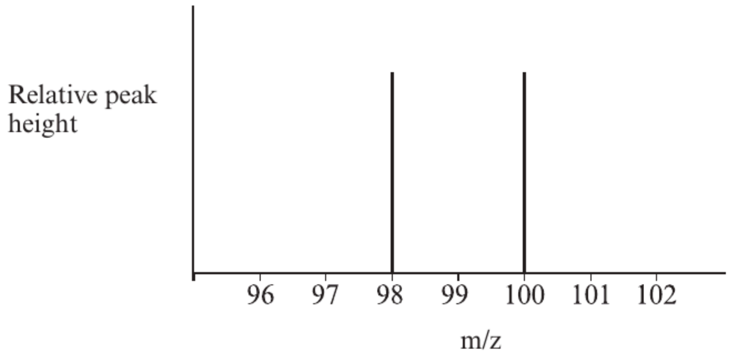
3. The mass spectrum of the colourless gas bromine fluoride, $Br^{19}F$, shows two molecular ions.



(i) State the mass numbers of the two bromine isotopes present in bromine fluoride. [1]

.... and ....

(ii) Bromine fluoride is unstable and readily gives $Br^{19}F_3$.
State the mass/charge (m/z) value for the molecular ion $Br^{19}F_3^{\ +}$, when all the bromine is present as the isotope ^{85}Br. [1]

....

4. The first two standard molar ionisation energies for magnesium are shown in the table.

Electron removed	Standard molar ionisation energy / kJ mol^{-1}
first	736
second	1450

State which of the following is the value for the third molar standard ionisation energy, in kJ mol^{-1}, of magnesium. [1]

A 457

B 923

C 2170

D 7740 ....

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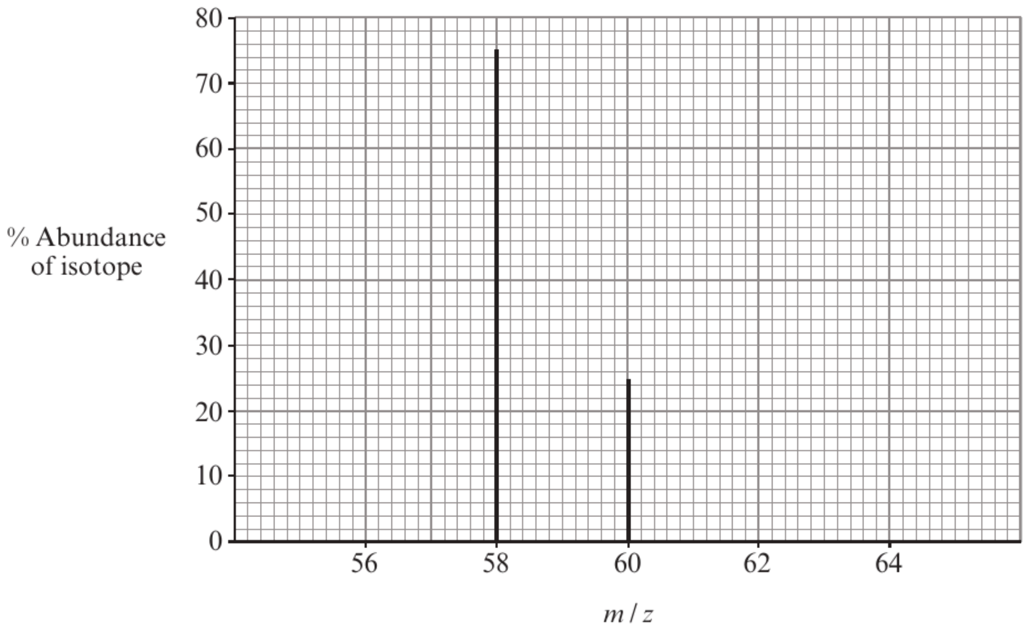
3. The mass spectrum of a sample of nickel is shown below.



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

....

....

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 ....

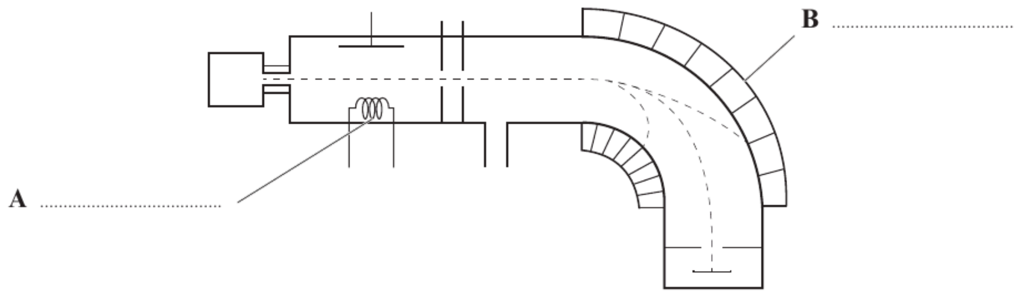
Examiner only

9. Selenium is a Group 6 element that is needed in the human body in trace amounts for the correct functioning of some enzymes. Only small amounts are required as large doses are harmful.

(a) A mass spectrometer can be used to find the relative atomic mass of a sample of selenium. The following diagram shows a typical mass spectrometer.

(i) Label parts **A** and **B**. [1]

(ii) Describe what happens to a sample introduced into the mass spectrometer. [4]
QWC [2]



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(b) Some selenium is found amongst the decay products in a nuclear reactor. The mass spectrum found for this sample of selenium had the isotopic composition below.

Isotope	Abundance
^{78}Se	12.2%
^{79}Se	26.4%
^{80}Se	61.4%

Calculate the relative atomic mass of this sample of selenium.
Give your answer to **3 significant figures**. [3]

Relative atomic mass = ...

(c) ^{81}Se is a radioactive isotope of the element selenium, which decays by β-emission with a half life of 18.75 minutes.

(i) The decay of ^{81}Se is shown by the equation below.

$$^{81}Se \longrightarrow {}^{a}X + {}^{0}_{-1}\beta$$

Identify a and X in this equation. [1]

a .... X ....

(ii) 2.72 g of ^{81}Se is used by a scientist for an experiment. Calculate the mass of ^{81}Se that would remain after 75 minutes. [2]

Mass = ... g

Total [13]

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 (1091-01)

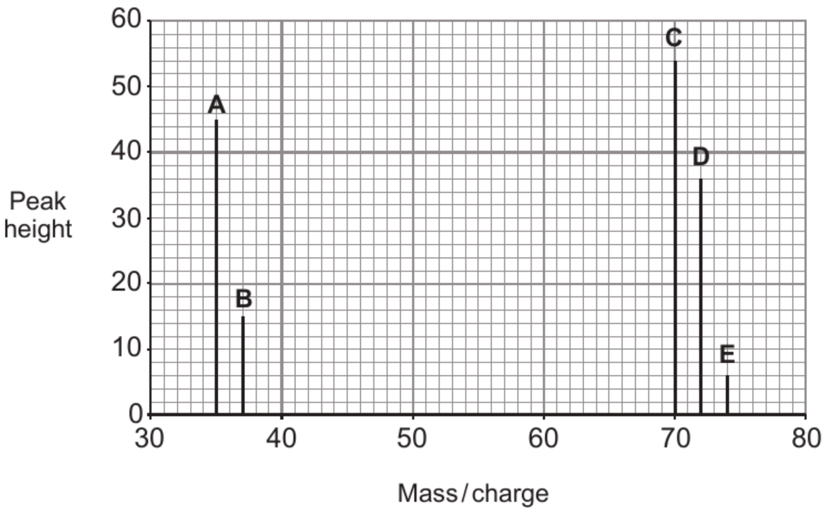
Turn over.

Examiner only

SECTION B

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

6. *(a)* The mass spectrum of chlorine, Cl_2, is shown below.



(i) Identify the positive ions that are responsible for the peaks **B** and **C**. [2]

Peak **B** ....

Peak **C** ....

(ii) Use the mass spectrum to calculate the ratio of peak height **C** : peak height **E**. [2]

Ratio ....

(iii) Explain why the peak heights of **C** and **E** are in this ratio. [2]

....

....

....

....

....

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Examiner only

(b) Another element in Group 7 is bromine, Br.

Its mass spectrum shows that bromine has two naturally-occurring isotopes.
The abundance of each isotope is given below.

Isotope	Percentage abundance / %
^{79}Br	50.69
^{81}Br	49.31

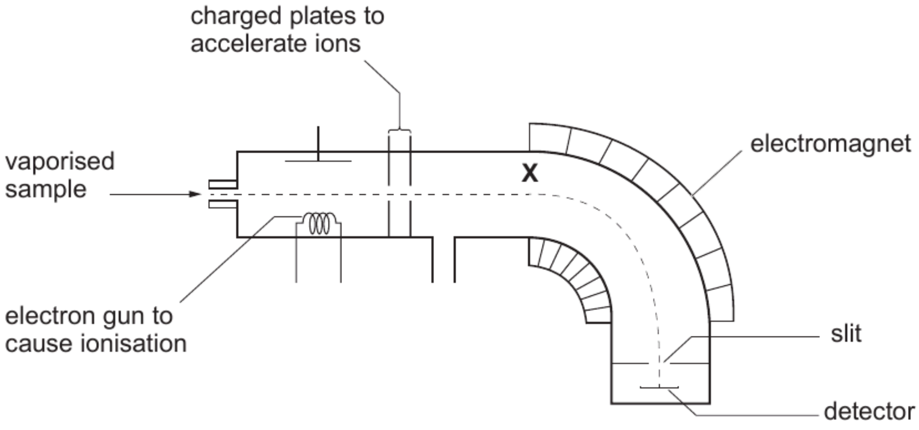
Calculate the relative atomic mass of bromine, giving your answer to **four** significant figures. [2]

Relative atomic mass = ...

Total [8]

Examiner only

9. The diagram shows the principal parts in one type of mass spectrometer.



(a) (i) The line labelled **X** shows the path of ion **X** passing through the slit and being detected.

Ion **Y** has a higher mass to charge ratio than ion **X**. Draw a line on the diagram to show the path of ion **Y**. [1]

(ii) Without altering the shape of the mass spectrometer, what change could be made to allow ion **Y**, with its higher mass to charge ratio, to pass through the slit and be detected? [1]

....

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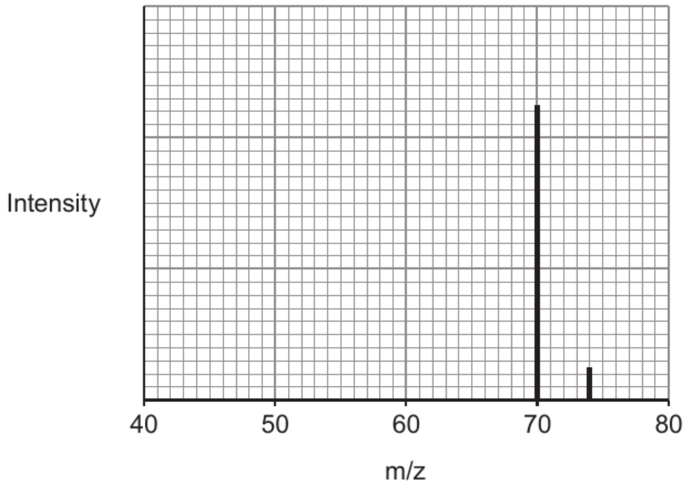
Examiner only

(b) The diagram shows an incomplete mass spectrum for a sample of chlorine, Cl_2.



(i) What ion is responsible for the peak at m/z = 74? .... [2]

(ii) Draw on the spectrum another peak that you would expect to see. You should show the mass to charge ratio at which you would see the peak **and** the height of the peak. [2]

(c) A compound **Z** contains only carbon, hydrogen and chlorine. It is analysed and found to contain 10.04 % carbon and 89.12 % chlorine by mass.

(i) Find the empirical formula of compound **Z**. [3]

Empirical formula ....

(ii) What other information would you need to decide whether this empirical formula is also the molecular formula of **Z**? [1]

....

(iii) What feature of a mass spectrum gives the information needed in part (ii)? [1]

....

....

....

Total [11]

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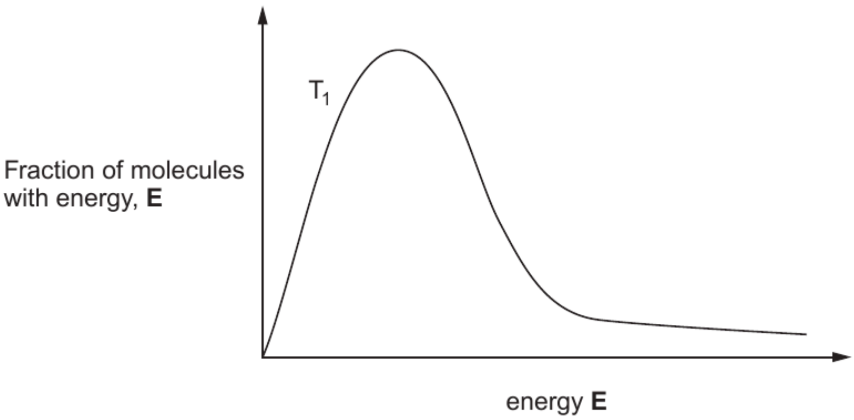
Examiner only

4. The mass spectrum of bromine trifluoride, $Br^{19}F_3$, shows two molecular ion peaks of equal intensity at m/z 136 and 138.

State what can be deduced about the relative isotopic masses of the bromine atoms present and their percentage abundances. [2]

5. The graph shows the distribution of energies in a sample of gas at a certain temperature, T_1.



Sketch on the graph the curve obtained at a higher temperature, T_2. [1]

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END OF QUESTION PACK

7 questions · 51 marks · ~1 h 22 min

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

Curated for WJEC Chemistry 2015 spec AS Unit 1 — Topic 3 (1.2)