

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 2 · AS unit, first sat 2016, 80 marks, 1h 30min paper

REVISE

.wales

CHEMISTRY – UNIT 1 · ATOMIC STRUCTURE & ISOTOPES

Topic 1.2 – Protons, neutrons, electrons, isotopes and relative atomic mass

Counting subatomic particles in atoms and ions, identifying isotopes, and calculating relative atomic mass from isotopic abundances.

LEGACY 2008 SPECIFICATION

Estimated time for entire question pack: ~1 h 42 min

Derived from the legacy CH1 paper's pace of ~1.1 min/mark, padded for long-prose answers (64 marks over 16 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.

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Q	Source	Max	Mark	Q	Source	Max	Mark
1	Jun 09 Q1	3		9	Jan 13 Q3	2	
2	Jun 10 Q1	2		10	Jun 13 Q1	2	
3	Jan 11 Q3	1		11	Jun 13 Q2	2	
4	Jun 11 Q1	0		12	Jan 14 Q1	1	
5	Jan 12 Q2	1		13	Jun 14 Q2	1	
6	Jan 12 Q9	19		14	Jun 14 Q8	14	
7	Jun 12 Q2	1		15	Jun 15 Q1	2	
8	Jan 13 Q1	1		16	Jun 15 Q7	12	
Total						64	

Atomic Structure & Isotopes – 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.

Subatomic particles

- Proton: charge +1, mass 1.
- Neutron: charge 0, mass 1.
- Electron: charge -1, mass $\sim 1/1836$.
- Atomic number Z = protons (and electrons in atom).
- Mass number A = protons + neutrons.

Isotopes

- Same Z , different A – same proton number, different neutrons.
- Identical chemistry (same electron arrangement).
- Different physical properties (mass, density, rates of diffusion).

Relative atomic mass

- A_r = weighted mean of isotope masses, on the $^{12}\text{C} = 12.000$ scale.
- $A_r = \Sigma (\text{isotope mass} \times \text{abundance}) / 100$.
- ^{12}C is the international standard.

Ions

- Cations: lose electrons; fewer e^- than protons.
- Anions: gain electrons; more e^- than protons.
- Charge = (protons) - (electrons).

Atomic Structure & Isotopes in one page

Quick-reference notes – revisit before each question.

Counting particles

Protons = Z .

Neutrons = $A - Z$.

Electrons in atom = Z . In ion: $Z - \text{charge}$.

Isotope notation

A_ZX – A is mass number, Z is atomic number, X is symbol.

Same $Z \leftrightarrow$ same element.

A_r from abundances

$A_r = \sum (m_i \times \%) / 100$.

E.g. Cl: $75 \times 35 + 25 \times 37 = 3550$; $/100 = 35.5$.

Cation / anion

Loss of e^- : cation, smaller (no outer shell).

Gain of e^- : anion, larger (more repulsion).

Isotope properties

Same chemistry (same e^- arrangement).

Different mass \Rightarrow different density, diffusion rate.

Some isotopes radioactive.

Periodic table use

A_r values from WJEC data booklet.

Z = position in periodic table.

SECTION A

Answer all the questions in the spaces provided.

1. The symbols $^{35}_{17}\text{Cl}$, $^{37}_{17}\text{Cl}$ and $^{39}_{19}\text{K}$, represent chlorine atoms and potassium atoms respectively.

(a) Use these symbols to explain the meaning of the terms

(i) atomic number, [1]

.....
.....

(ii) isotope. [1]

.....
.....

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



SECTION A

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

1. A gaseous isotope of hydrogen, tritium, ${}^3_1\text{H}$, is produced in the upper atmosphere.

(i) State which of the following correctly describes an atom of tritium. [1]

	Number of protons	Number of neutrons	Number of electrons
A	1	1	1
B	1	1	2
C	1	2	1
D	1	2	0

-
- (ii) Tritium is a radioactive gas with a half-life of 12.5 years. A sample of tritium has a mass of 0.960 g.
Calculate the mass of tritium remaining after 37.5 years. [1]

-
-
2. Cyanogen is a compound containing only carbon and nitrogen.
It has a relative molecular mass of 52.

(i) State the molecular formula of cyanogen. [1]

(ii) State the empirical formula of cyanogen. [1]

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]

.....

.....

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

.....

.....

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.

.....

SECTION A

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

1. Enter the number of protons, neutrons and electrons present in the atoms/ions listed in the table below.

Atom/ion	Number of protons	Number of neutrons	Number of electrons
^{24}Mg			
^{26}Mg			
$^{24}\text{Mg}^{2+}$			

[3]

2. By inserting arrows to represent electrons, complete the boxes below to show the electronic configuration of an iron atom, Fe. The 1s, 2s and 2p orbitals are assumed to be already filled.

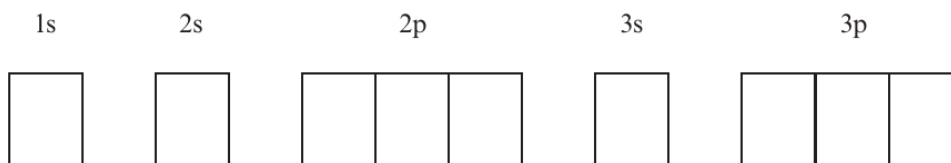


[1]

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 sulfur atom. [1]



2. State the number of protons present in an aluminium ion, Al^{3+} . [1]

- A 10
B 13
C 14
D 16
-

3. Weak *acids* establish a *dynamic equilibrium* when dissolved in water. Give brief explanations of what is meant by the following terms. [2]

Acid

.....

Dynamic equilibrium

.....

.....



Examiner only

9. The metal lead was one of the first in common use and even as far back as two thousand years ago, tens of thousands of tonnes of the metal were being produced every year in the Roman Empire. It is still in common use today, although many of its former uses have declined due to the toxic nature of the element.

(a) Lead is commonly extracted from lead(II) sulfide, PbS. Initially this ore is heated in a limited supply of air to produce lead(II) oxide, PbO, giving off sulfur dioxide gas, SO₂.



If 20 kg of lead(II) sulfide were heated in air, calculate the mass of lead(II) oxide formed. [3]

.....
.....
.....
.....

Mass of lead(II) oxide formed = kg

(b) Metallic lead can then be obtained from lead(II) oxide by one of two methods:

Method 1: Reduction with a fresh supply of lead(II) sulfide in the absence of air



Method 2: Reduction by carbon monoxide in a blast furnace



(i) Both methods for producing lead release waste gases. Give an environmental problem associated with each of these gases. [2]

Sulfur dioxide, SO₂

Carbon dioxide, CO₂

(ii) The atom economy for producing lead by method 1 is 90.7%.

I. Calculate the atom economy for producing lead by method 2. [2]

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.....
.....



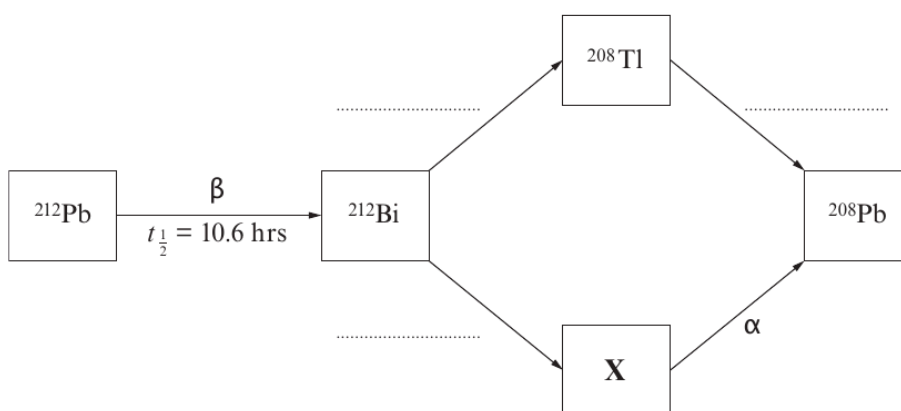
Examiner
only

II. Atom economy is one factor used in ‘Green Chemistry’ to assess the advantages and disadvantages of different routes to produce the same product. State, giving a reason, which of the two alternative methods would be considered to have the more advantageous atom economy. [1]

.....

.....

(c) Lead has a wide range of isotopes, some of which are stable and others that are radioactive. Radioactive lead-212 decays to eventually form the stable isotope ^{208}Pb . This process involves the decay of ^{212}Pb into ^{212}Bi followed by two alternative routes that both lead to ^{208}Pb , as shown in the scheme below.



(i) Give the correct symbol and mass number of the isotope indicated by **X** on the scheme above. [2]

Symbol Mass Number

(ii) Two arrows have been labelled with α and β . Label the remaining **three** arrows to indicate the nature of the radioactive decay occurring in each step. [2]



Examiner
only

- (iii) It is not possible to identify whether γ -radiation is also produced during any of the radioactive decay processes from the information given in the scheme.

State what is meant by γ -radiation and why it cannot be identified from the information given in the scheme. [2]

.....

.....

.....

- (iv) A sample of 24 mg of ^{212}Pb was allowed to stand for 31.8 hours. Calculate the mass of ^{212}Pb that would remain after this time. [2]

.....

.....

..... mg

- (d) Naturally-occurring lead consists of a mixture of stable isotopes which include ^{206}Pb , ^{207}Pb and ^{208}Pb . The relative amounts of these isotopes can vary between different sources. The abundance of each isotope in a sample is given below.

Isotope	Relative isotopic mass	Percentage abundance
^{206}Pb	206.0	25.48%
^{207}Pb	207.0	22.12%
^{208}Pb	208.0	52.40%

Calculate the relative atomic mass (A_r) for this sample of lead. Give your answer to **four significant figures**. [3]

.....

.....

.....

.....

Total [19]



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Turn over.

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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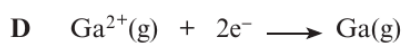
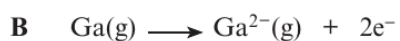
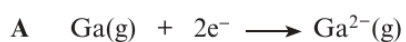
SECTION A

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

1. The mass number of an isotope of gallium is 70.

State the number of neutrons in an atom of this isotope. [1]

2. Write the letter which represents the correct equation for the **second** ionisation energy of gallium in the box below. [1]



3. An enriched isotopic mixture of lithium contains ${}^6\text{Li}$ 12.0% and ${}^7\text{Li}$ 88.0% by mass. Showing your working, calculate the relative atomic mass of this sample of lithium. Give your answer to **three** significant figures. [2]

Relative atomic mass =



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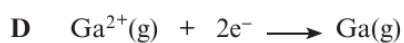
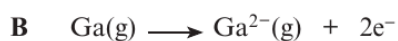
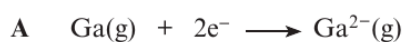
SECTION A

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Relative atomic mass =



0 2

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

1. Carbon-14 is a radioactive isotope of carbon. Give the numbers of protons, neutrons and electrons present in an atom of carbon-14. [2]

Number of protons

Number of neutrons

Number of electrons

2. Circle **all** of the following that carry a negative charge. [2]

electron α -particle γ -ray proton neutron β -particle

3. Many industrial processes use catalysts.
Explain how a catalyst increases the rate of a chemical reaction. [2]

.....
.....
.....

4. Sketch the shape of **one** *p*-orbital. [1]



0 2

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

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Explain how a catalyst increases the rate of a chemical reaction. [2]

.....
.....
.....

4. Sketch the shape of **one** *p*-orbital. [1]



0 2

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 Na₂S. [1]

1s²

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]

.....

.....

4. Hydrated sodium carbonate has the formula Na₂CO₃·10H₂O.

- (a) Calculate the relative molecular mass (*M_r*) of Na₂CO₃·10H₂O. [1]

M_r =

- (b) Calculate the mass of Na₂CO₃·10H₂O needed to make 250 cm³ of a 0.10 mol dm⁻³ solution. [1]

Mass = g



0 2

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

8. (a) Hydrogen exists as three isotopes with relative masses of 1, 2 and 3.

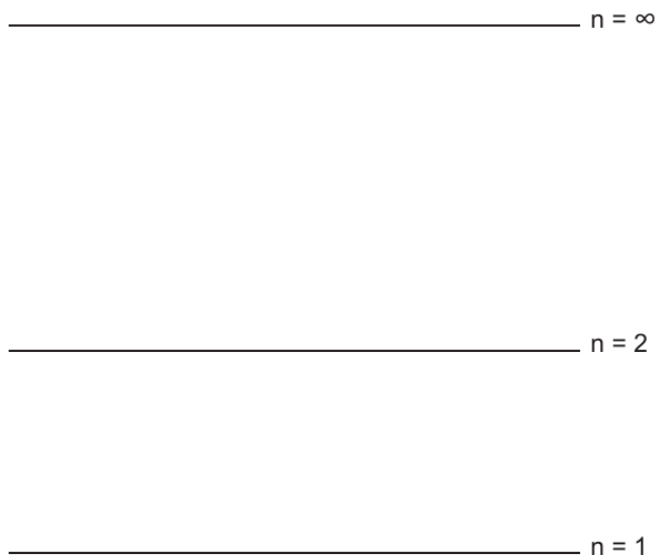
State the similarities and differences in the composition of these specific isotopes. [2]

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.....

.....

- (b) The first two electronic energy levels in a hydrogen atom are shown on the diagram.



- (i) Complete the diagram to show energy levels $n = 3$, $n = 4$ and $n = 5$. [1]
- (ii) Mark with an arrow the energy change corresponding to the ionisation energy of hydrogen. [2]



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(c) A student said that the ionisation energy of hydrogen could be calculated using the Balmer Series of lines.

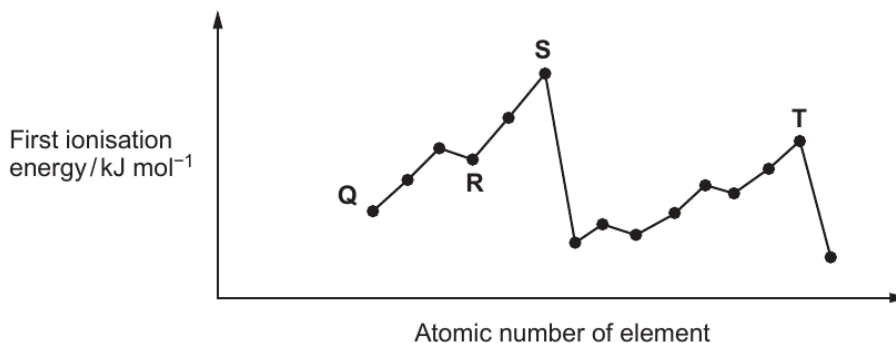
(i) In which part of the electromagnetic spectrum does the Balmer Series appear? [1]

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(ii) Explain whether or not this student was correct. [2]

.....
.....
.....

(d) The diagram shows part of a plot of the first ionisation energy of elements against their atomic numbers. Letters Q–T do **not** represent the symbols of the elements.



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(i) Write the equation for the change occurring for the first ionisation energy of element Q. [1]

.....

(ii) In which group of the Periodic Table is element R found? [1]

.....

(iii) Explain why the first ionisation energy of S is greater than that of T. [3]

QWC [1]

.....
.....
.....
.....

Total [14]



0 7

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

1. Complete the table below to show the composition of the following species. [2]

Species	Protons	Neutrons	Electrons
${}_{10}^{20}\text{Ne}$			
${}_{8}^{18}\text{O}^{2-}$			

2. The isotope ${}^{226}\text{Ra}$ is radioactive. It decays by α -emission and has a half-life of 1600 years.
- (a) Give the mass number and symbol of the species formed by the loss of one α -particle from an atom of ${}^{226}\text{Ra}$. [1]
-
- (b) State what is meant by the term *half-life*. [1]
-
-
- (c) A sample of ${}^{226}\text{Ra}$, of initial mass 1.00 g, decays for 3200 years. Calculate the number of **moles** of ${}^{226}\text{Ra}$ left after this period. [2]

Number of moles = mol



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7. (a) Lithium was discovered in 1817 by the Swedish chemist Johan August Arfwedson. Its name derives from the Greek word *lithos*, meaning 'stone', to reflect its discovery in a solid mineral, as opposed to potassium, which had been isolated from plant ashes 10 years earlier. Naturally occurring lithium is composed of two stable isotopes – ${}^6\text{Li}$ and ${}^7\text{Li}$.

In a mass spectrometer, a sample of lithium must be ionised before it can be analysed.

(i) Describe how vaporised atoms of Li are converted into Li^+ ions in a mass spectrometer. [2]

.....

.....

.....

(ii) Suggest why no more than the minimum energy is used to ionise the sample of lithium. [1]

.....

.....

(iii) State the difference, if any, between the chemical properties of the isotopes ${}^6\text{Li}$ and ${}^7\text{Li}$, giving a reason for your answer. [2]

.....

.....

.....

(b) The mass spectrum of a naturally occurring sample of lithium gave the following results.

Isotope	% abundance
${}^6\text{Li}$	7.25
${}^7\text{Li}$	92.75

These results can be used to determine the relative atomic mass of the lithium sample.

(i) Calculate the relative atomic mass of the sample. [2]

Relative atomic mass =



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only

- (ii) State and explain which of the Li^+ ions formed from the isotopes of Li will be deflected more in a mass spectrometer. [1]

.....

.....

- (c) Lithium hydroxide reacts with ammonium sulfate to form ammonia, lithium sulfate and water as shown in the equation below.



A 2.06 g sample of ammonium sulfate reacted exactly with 29.80 cm³ of a lithium hydroxide solution.

- (i) Calculate the amount, in moles, of $(\text{NH}_4)_2\text{SO}_4$ in 2.06 g of ammonium sulfate. Give your answer to **three** significant figures. [2]

Number of moles = mol

- (ii) Calculate the concentration, in mol dm⁻³, of the lithium hydroxide solution used. [2]

Concentration = mol dm⁻³

- (iii) Calculate the percentage atom economy for the production of ammonia in the reaction between ammonium sulfate and lithium hydroxide. [2]

Atom economy = %

Total [14]



END OF QUESTION PACK

16 questions · 64 marks · ~1 h 42 min

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

Curated for WJEC Chemistry 2015 spec AS Unit 1 – Topic 2 (1.2)

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