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GCE AS / A LEVEL – CHEMISTRY UNIT 1 QUESTION PACK

1091-01 (Legacy CH1) · New spec Unit 1 Topic 6 · AS unit, first sat 2016, 80 marks, 1h 30min paper

REVISE

.wales

CHEMISTRY – UNIT 1 · EMPIRICAL & MOLECULAR FORMULAE

Topic 1.3 – Empirical and molecular formula determination from composition data

Calculating empirical formulae from percentage-mass or combustion data, then deducing the molecular formula using the relative molecular mass.

LEGACY 2008 SPECIFICATION

Estimated time for entire question pack: ~50 min

Derived from the legacy CH1 paper's pace of ~1.1 min/mark, padded for long-prose answers (31 marks over 8 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
1	Jun 10 Q2	2	
2	Jan 11 Q5	3	
3	Jun 11 Q6	2	
4	Jan 12 Q6	3	
5	Jun 12 Q4	3	
6	Jan 13 Q6	2	
7	Jan 14 Q5	2	
8	Jun 16 Q7	14	
Total		31	

Empirical & Molecular Formulae – 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.

Empirical formula

- Simplest whole-number ratio of atoms.
- Steps: % → mass → moles → divide by smallest → ratio.
- Multiply through to clear fractions ($\times 2$ or $\times 3$).

Molecular formula

- Molecular formula = (empirical formula) $\times n$.
- $n = M_r / \text{mass of empirical unit}$.
- Always requires M_r data alongside composition.

Combustion analysis

- Burn known mass \Rightarrow mass of CO_2 & H_2O .
- Mass of C from CO_2 mass; mass of H from H_2O mass.
- Mass of O = total - (C + H).

Hydrated salts

- $M \cdot x\text{H}_2\text{O}$ – heat to constant mass to drive off water.
- Moles of salt vs moles of H_2O lost \Rightarrow ratio gives x .
- Common: $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$, $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$.

Empirical & Molecular Formulae in one page

Quick-reference notes – revisit before each question.

Empirical from % composition

1. Assume 100 g sample.
2. % → mass each element.
3. Divide by A_r → moles.
4. Divide all by smallest mole value.
5. Round to whole-number ratio.

Molecular from M_r

$n = M_r$ (given) / mass of empirical unit.
Multiply empirical subscripts by n .

Combustion calcs

g of CO_2 → mass C: $\times 12 / 44$.
g of H_2O → mass H: $\times 2 / 18$.
O mass = total - (C + H).

Hydrated salts

Heat to constant mass.
Mass loss = mass of H_2O .
Moles ratio (anhydrous : H_2O) =
formula ratio.

Worked example

40% C, 6.7% H, 53.3% O, $M_r = 60$.
moles: 3.33, 6.67, 3.33 ⇒ 1:2:1.
Empirical CH_2O ($M = 30$) → molecular
 $\text{C}_2\text{H}_4\text{O}_2$.

Significant figures

Empirical: usually integers.
Quote final answer to 3 s.f.

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

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(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]

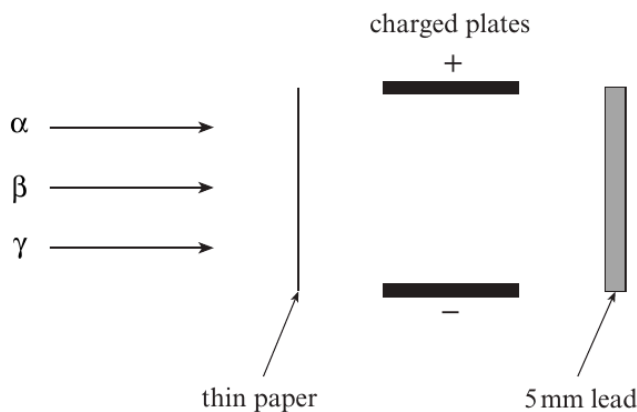
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2. Cyanogen is a compound containing only carbon and nitrogen.
It has a relative molecular mass of 52.

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

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

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4. Complete the diagram below to show how radiation is affected by an electric field and by materials of different thickness. [3]



5. A compound of carbon, hydrogen and oxygen has a relative molecular mass of 180. The percentage composition by mass is C 40.0%; H 6.70%; O 53.3%.

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

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(b) Determine the molecular formula of this compound. [1]

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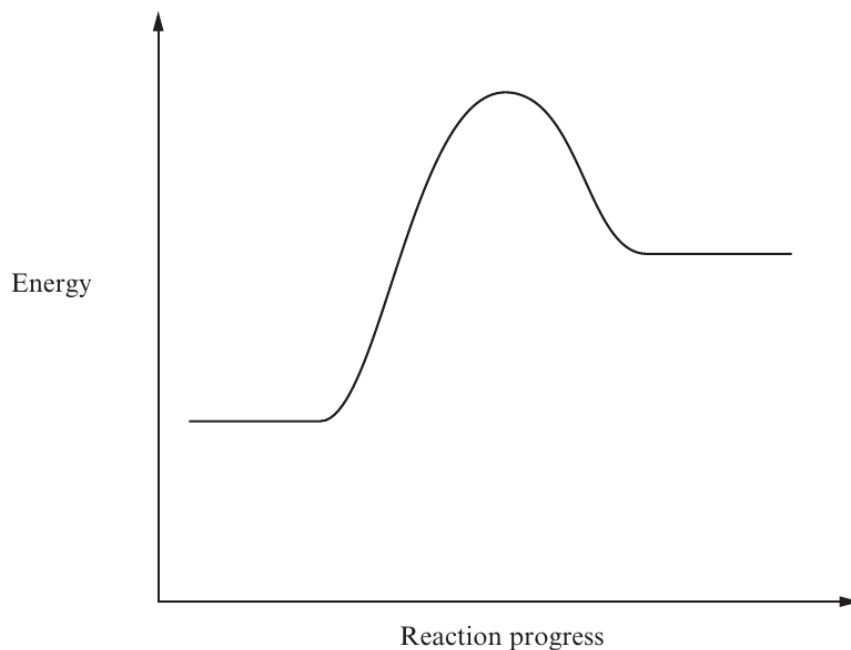
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Section A Total [10]

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5. Label clearly on the energy profile diagram below the forward (E_f) and reverse (E_b) activation energies and the enthalpy change (ΔH) for the reaction. [2]



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

Calculate

- (a) the empirical formula, [1]

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- (b) the molecular formula of this oxide. [1]

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Section A Total [10]

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6. (a) Mesitylene is a hydrocarbon composed of 89.9% carbon and 10.1% hydrogen by mass. Calculate the **empirical** formula of this compound. [2]

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- (b) The relative molecular mass of mesitylene is 120.1. Give the **molecular** formula of this compound. [1]

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Total Section A [10]1 091
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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

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.....

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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6. An oxide of titanium contains 60% of titanium by mass. Calculate the empirical formula of this oxide of titanium. [2]

$$[A_r(\text{Ti}) = 48]$$

Empirical formula

Section A Total [10]

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5. Silver tarnishes because it reacts with hydrogen sulfide in the air to form silver sulfide.

A 1.24 g sample of silver sulfide contains 0.16 g of sulfur. Calculate the empirical formula of this compound. **Show your working.** [2]

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Empirical formula

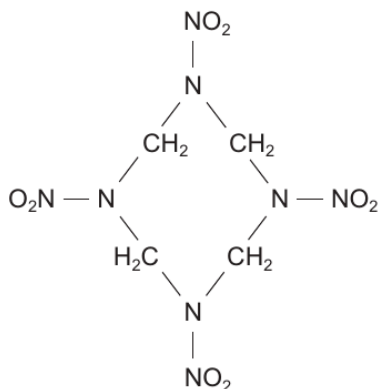
Section A Total [10]

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SECTION B

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

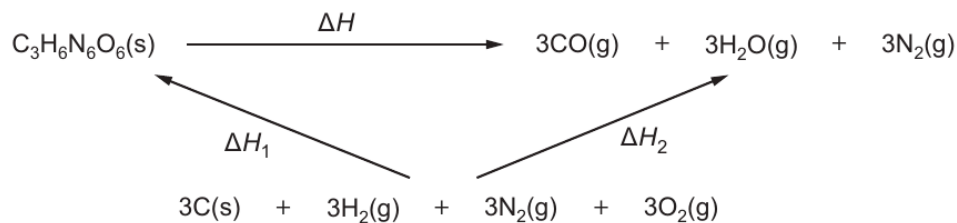
7. (a) The explosive HMX has the following structural formula. State its empirical formula. [1]



Empirical formula

- (b) Another explosive, RDX, has the formula
- $C_3H_6N_6O_6$
- .

- (i) Use the data table and the Hess cycle below to calculate the enthalpy of detonation,
- ΔH
- , of RDX. [3]

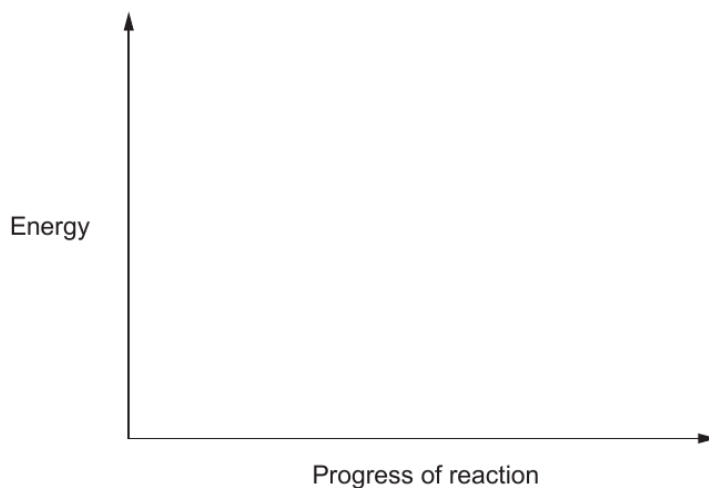


Compound	Enthalpy of formation $\Delta H_f / \text{kJ mol}^{-1}$
RDX(s)	+62
CO(g)	-111
H ₂ O(g)	-242

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

- (ii) The result from (b)(i) can be used to help you sketch the reaction profile for the explosive detonation of RDX.

Draw this profile using the axes given below. Label your profile with reactants, products and the activation energy. [2]



- (iii) The activation energy for the explosive detonation of RDX is 199 kJ mol^{-1} whereas the activation energy for the explosive detonation of mercury fulminate is 105 kJ mol^{-1} .

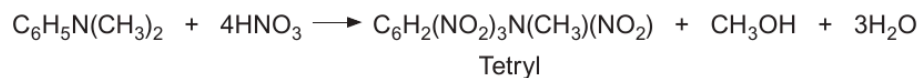
Define the term *activation energy* and hence comment on the relative stability of these two explosives. [2]

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- (c) The explosive Tetryl is made by adding concentrated nitric acid to N,N-dimethylphenylamine under suitable conditions. An equation for this is shown below.



- (i) State why the atom economy for this reaction is not 100%. [1]

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- (ii) Tetryl produced in this reaction needs further treatment. It can be purified by dissolving it in propanone and then adding water, or by recrystallisation using benzene as the solvent.

State any factor in the purification of Tetryl that **does not** fit with the principles of Green Chemistry. [1]

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(d) Many fireworks contain metal compounds that emit visible light. The colours given by barium and calcium compounds and their wavelengths are given in the table.

Metal	Colour	Wavelength / nm
barium	green	554
calcium	orange-red	616

(i) State which of these two colours has the higher energy, giving a reason for your answer. [1]

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(ii) The colours seen are as a result of the emission of visible light. State how these colours are produced. [3]

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Total [14]

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END OF QUESTION PACK

8 questions · 31 marks · ~50 min

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

Curated for WJEC Chemistry 2015 spec AS Unit 1 – Topic 6 (1.3)

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