Name	Date started	Target end date

GCE AS / A LEVEL — CHEMISTRY UNIT 1 QUESTION PACK

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

REVISE
.wales

CHEMISTRY — UNIT 1 · FORMULAE, EQUATIONS & REDOX

Topic 1.1 — Chemical formulae, balanced equations and oxidation numbers

Writing and balancing equations (full and ionic), assigning oxidation numbers, deducing redox half-equations, and identifying oxidising and reducing agents.

LEGACY 2008 SPECIFICATION

Estimated time for entire question pack: ~1 h 28 min

Derived from the legacy CH1 paper's pace of ~1.1 min/mark, padded for long-prose answers (55 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 1.1.

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 09 Q2	2	
2	Jan 09 Q3	2	
3	Jan 09 Q9	12	
4	Jun 09 Q2	3	

Q	Source	Max	Mark
5	Jan 11 Q6	13	
6	Jun 12 Q6	13	
7	Jan 14 Q10	10	
	Total	55	

Formulae, Equations & Redox — 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 1.1.

Writing equations

- Balance for atoms *and* charge.
- Use state symbols (s), (l), (g), (aq).
- Ionic equations: show only ions that change.
- Spectator ions are omitted.

Oxidation numbers

- Elements in their standard state = 0.
- Group 1 = +1; Group 2 = +2; F = −1.
- H = +1 (except in metal hydrides, −1).
- O = −2 (except peroxides −1, OF_2 +2).
- Sum of oxidation numbers = overall charge.

Redox half-equations

- Oxidation = loss of electrons (LEO).
- Reduction = gain of electrons (GER).
- Balance atoms; add H_2O / H^+ / e^-.
- Combine half-equations so e^- cancel.

Oxidising / reducing agents

- Oxidising agent is itself reduced.
- Reducing agent is itself oxidised.
- Common: MnO_4^-, $Cr_2O_7^{2-}$ (oxidising); Fe^{2+}, I^-, SO_2 (reducing).

Formulae, Equations & Redox in one page

Quick-reference notes — revisit before each question.

Balancing checklist

Atoms balance on both sides.

Charges balance for ionic equations.

Add state symbols last.

Oxidation number rules

Elements = 0; ion = charge.

H = +1 (except metal hydrides −1).

O = −2 (except peroxides −1, F_2O +2).

Common O.N. for ions

SO_4^{2-}: S = +6.

NO_3^{-}: N = +5.

MnO_4^{-}: Mn = +7.

$Cr_2O_7^{2-}$: Cr = +6.

Half-equation recipe

1. Balance everything except O and H.
2. Add H_2O for O.
3. Add H^+ for H.
4. Add e^- to balance charge.

Oxidising agents

$MnO_4^-/H^+ \rightarrow Mn^{2+}$.

$Cr_2O_7^{2-}/H^+ \rightarrow Cr^{3+}$.

$Cl_2 + 2e^- \rightarrow 2Cl^-$.

Reducing agents

$Fe^{2+} \rightarrow Fe^{3+} + e^-$.

$2I^- \rightarrow I_2 + 2e^-$.

$SO_2 + 2H_2O \rightarrow SO_4^{2-} + 4H^+ + 2e^-$.

Questions begin overleaf.

SECTION A

Answer all the questions in the spaces provided.

1. An isotope of magnesium, ^{27}Mg, is used to detect leaks in water pipes.

(a) It decays by β–emission with a half life of 9·5 minutes.

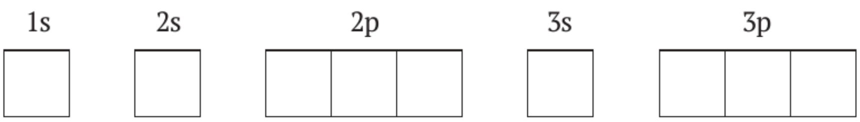
(i) Give the symbol and mass number of the atom formed by the loss of one β particle from an atom of ^{27}Mg. [1]

....

(ii) Calculate how long it will take for the activity of the isotope to decay to $\frac{1}{16}^{th}$ of its original activity. [1]

.... minutes

(b) Complete the boxes below, by inserting arrows to represent electrons, to show the electronic configuration of an atom of magnesium. [1]



2. Calculate oxide is made by heating calcium carbonate in air.

$$\underset{\text{1 mole}}{CaCO_3} \longrightarrow \underset{\text{1 mole}}{CaO} + CO_2$$

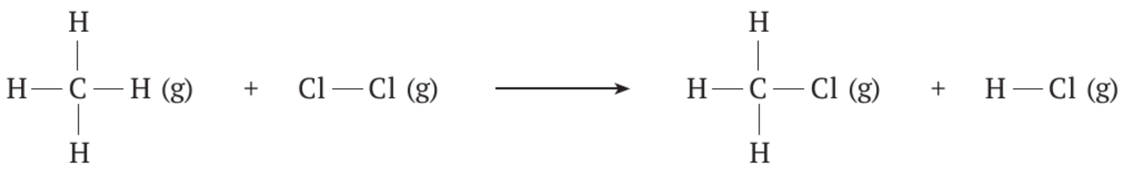
Calculate the maximum mass of calcium oxide formed when 0·500 mole of pure calcium carbonate is heated. [2]

....

....

....

3. Chloromethane, CH_3Cl, is made by reacting methane, CH_4, with chlorine.



(i) The total enthalpy changes of formation from gaseous atoms (calculated from bond energies) of the species involved are shown in the table below.

Species	Total enthalpy change of formation from gaseous atoms / kJ mol^{-1}
CH_4	1652
Cl_2	243
CH_3Cl	1585
HCl	432

Use the values in the table to calculate the enthalpy change for the reaction above. [1]

....

....

.... kJ mol^{-1}

(ii) The atom economy of a reaction is given by the formula

$$\text{atom economy} = \frac{\text{theoretical mass of required product} \times 100}{\text{total mass of reactants used}} \%$$

Calculate the atom economy of the reaction above, where chloromethane, CH_3Cl, is the required product. [1]

....

....

9. Sodium hydroxide and chlorine are important industrial chemicals.
Two methods for making them from sodium chloride solution (brine) are the mercury cell and the diaphragm cell.

Process	Operation	Quality of product
Diaphragm cell	Needs diaphragm replacing regularly. High electrical current needed.	Contains unreacted sodium chloride. Concentration varies and is relatively low.
Mercury cell	No diaphragm used. High electrical current.	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]

....

(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 when developing this new process. [2]

1. ....

....

2. ....

....

(b) Some students obtained a sample of the sodium hydroxide solution from the diaphragm cell process.

(i) This solution was too concentrated for a normal titration and they needed to dilute it exactly ten times using water.
Describe, stating the apparatus used and any essential details, how this dilution was done.
You should assume that you need 250 cm^3 of the diluted solution. [4]
QWC [2]

....

....

....

....

....

....

(ii) 20·0 cm^3 of the diluted sodium hydroxide solution reacted with 0·00500 mole of hydrochloric acid.

$$NaOH + HCl \longrightarrow NaCl + H_2O$$

I. State the number of moles of sodium hydroxide present in the 20·0 cm^3 sample. [1]

II. Calculate the concentration of the diluted sodium hydroxide solution. [2]

.... mol dm^{-3}

III. State the concentration of the original sodium hydroxide solution. [1]

.... mol dm^{-3}

IV. State how you would identify the end-point of this titration. [1]

Total [14]

Section B Total [70]

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

$$Co(s) + 2HCl(aq) \longrightarrow CoCl_2(aq) + H_2(g)$$

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

....

....

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

....

....

(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, SO_2. [1]

A 3 g

B 6 g

C 12 g

D 64 g ....

Examiner only

SECTION B

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

6. Potassium metal was discovered in 1807 by the British chemist Sir Humphrey Davy. Its name derives from the word 'potash' since potassium was isolated by the electrolysis of molten caustic potash, KOH.

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

Isotope	% abundance
^{39}K	93.26
^{40}K	0.012
^{41}K	6.730

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

(i) Explain the term *relative atomic mass*. [2]

....

....

....

(ii) Calculate the relative atomic mass of the potassium sample, giving your answer to **four** significant figures. [2]

....

....

....

(b) The mass spectrum which provided these results was produced by potassium ions in a mass spectrometer.

(i) State how potassium ions are formed in a mass spectrometer. [1]

....

....

(ii) State how potassium ions are separated in a mass spectrometer. [1]

....

....

Examiner only

(c) Potassium-40, $^{40}_{19}K$, is a radioactive isotope that decays by β-emission and has a half-life of 1.25×10^9 years.

(i) Write an equation for the process by which a potassium-40 isotope emits a β-particle. [2]

....

(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]

....

....

(d) The first and second ionisation energies of potassium and sodium are shown in the table below.

	1st ionisation energy / $kJ\,mol^{-1}$	2nd ionisation energy / $kJ\,mol^{-1}$
potassium	419	3051
sodium	496	4562

(i) Explain the term *molar first ionisation energy*. [2]

....

....

....

(ii) Explain why

I potassium has a lower first ionisation energy than sodium, [2]

....

....

....

....

II there is a large difference between the first and second ionisation energies of potassium. [2]

....

....

....

....

Total [15]

Turn over.

Examiner only

SECTION B

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

6. Magnesium is best known for burning with a characteristic brilliant white light, however in industry it is the third most commonly used structural metal. The metal itself was first produced by Sir Humphry Davy in 1808 by the electrolysis of a mixture of magnesia and mercury oxide.

(a) Magnesium has three stable isotopes ^{24}Mg, ^{25}Mg and ^{26}Mg.

(i) State the number of protons present in an atom of ^{24}Mg. [1]

....

(ii) Deduce the number of neutrons present in an atom of ^{26}Mg. [1]

....

(iii) In order to calculate the relative atomic mass of magnesium, what would you need to know in addition to the relative mass of each isotope? [1]

....

(b) Magnesium also has a radioactive isotope ^{28}Mg which has a half-life of 21 hours.

(i) If you started with 2.0 g of ^{28}Mg, calculate the mass of this isotope remaining after 84 hours. [1]

....

....

(ii) Name **one** useful radioactive isotope and briefly describe how it is used in medicine, industry or analysis. [2]

....

....

Examiner only

(c) In order to obtain a mass spectrum of a gaseous sample of magnesium, the sample must be ionised.

(i) State how the magnesium atoms are ionised in the sample. [1]

....

....

(ii) Give a reason why it is necessary to ionise the magnesium atoms in the sample. [1]

....

....

(iii) State how the ions of magnesium are separated. [1]

....

....

(d) Magnesium reacts with nitrogen forming magnesium nitride, which is an ionic compound.

By inserting arrows to represent electrons, complete the boxes below to show the electronic configuration of a nitride ion, N^{3-}. [1]

1s	2s	2p			3s	3p		
☐	☐	☐	☐	☐	☐	☐	☐	☐

(e) Magnesium nitride reacts with water to form magnesium hydroxide and ammonia.

$$\square\ Mg_3N_2 + \square\ H_2O \longrightarrow \square\ Mg(OH)_2 + \square\ NH_3$$

(i) Balance the equation above. [1]

(ii) Calculate the minimum mass of magnesium nitride required to form 1.75 g of magnesium hydroxide, giving your answer to **three** significant figures. [3]

....

....

....

....

Total [14]

Examiner only

10. *(a)* Sodium carbonate can be manufactured in a two-stage process as shown by the following equations.

$$NaCl + NH_3 + CO_2 + H_2O \longrightarrow NaHCO_3 + NH_4Cl$$

$$2NaHCO_3 \longrightarrow Na_2CO_3 + H_2O + CO_2$$

Calculate the maximum mass of sodium carbonate which could be obtained from 900 g of sodium chloride. [3]

Maximum mass of sodium carbonate = ... g

(b) Sodium carbonate can form a hydrate, $Na_2CO_3.xH_2O$.

When 4.64 g of this hydrate was heated, 2.12 g of anhydrous Na_2CO_3 remained.

(i) State the mass of water in 4.64 g of the hydrate. [1]

....

(ii) Calculate the number of moles of sodium carbonate and the number of moles of water in 4.64 g of the original hydrate. Use these values to calculate the value of x in $Na_2CO_3.xH_2O$. [2]

x = ...

QUESTION 10 CONTINUES ON PAGE 16

Examiner only

(c) Hannah is given an impure sample of anhydrous sodium carbonate and she carries out an experiment to determine the percentage of sodium carbonate in the sample. She finds that she needs 18.0 cm^3 of hydrochloric acid of concentration 0.50 mol dm^{-3} to react completely with 0.55 g of the impure sample. The impurity does not react with hydrochloric acid. The equation for the reaction is given below.

$$Na_2CO_3 + 2HCl \longrightarrow 2NaCl + H_2O + CO_2$$

(i) Calculate the number of moles of HCl used in the titration. [1]

Number of moles of HCl = ... mol

(ii) Deduce the number of moles of Na_2CO_3 that reacted with the HCl. [1]

....

(iii) Calculate the mass of Na_2CO_3 in the sample. [1]

Mass of Na_2CO_3 *in sample* = ... g

(iv) Calculate the percentage by mass of Na_2CO_3 in the sample. [1]

Percentage by mass = ... %

Total [10]

Section B Total [70]

END OF PAPER

END OF QUESTION PACK

7 questions · 55 marks · ~1 h 28 min

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

Curated for WJEC Chemistry 2015 spec AS Unit 1 — Topic 1 (1.1)