



Chemistry

Standard Level

Paper 2 — Mock Examination

Mock Exam 3

Calculator required

Time allowed: **1 hour 30 minutes**

Maximum mark: **50 marks**

Candidate information

Candidate name:

Session number:

Date:

Topic emphasis: models of the particulate nature of matter, the periodic table and periodicity, models of bonding and structure, what drives chemical reactions, how much and how fast, proton transfer reactions, and the mechanisms of chemical change.

Instructions to candidates

- Write your session number in the box on the cover.
- Do not open this examination paper until you are told to do so.
- Answer **all** questions.
- Answers must be written within the answer boxes provided.
- A calculator is required for this paper.
- A clean copy of the **chemistry data booklet** is required for this paper.
- The maximum mark for this examination paper is **[50 marks]**.

The mark allocation is shown in square brackets at the end of each question or part question. Where a numerical answer is required, values of constants, molar masses and electronegativities should be taken from the chemistry data booklet unless they are given in the question. Show your working for all calculations; marks are available for correct method even where the final answer is incorrect.

Take the molar volume of an ideal gas at STP to be $22.7 \text{ dm}^3 \text{ mol}^{-1}$, Avogadro's constant to be $6.02 \times 10^{23} \text{ mol}^{-1}$ and the ideal gas constant to be $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$. All questions refer to standard conditions and to a temperature of 298 K unless otherwise stated.

Mark allocation

Question	Marks
Question 1 — Chlorine and the halogens	[17]
Question 2 — Organic chemistry and reaction mechanisms	[17]
Question 3 — Energetics, kinetics and acid–base reactions	[16]
Total	[50]

Answer **all** questions. Answers must be written within the answer boxes provided.

- 1.** Chlorine is a group 17 element used in water treatment and in the manufacture of plastics. A sample of chlorine has the following composition:

^{35}Cl : 75.77 % ^{37}Cl : 24.23 %

- (a) (i) Contrast the atomic structures of the two isotopes.

[1]

.....

.....

.....

- (ii) Calculate the relative atomic mass of chlorine in this sample, giving your answer to two decimal places.

[2]

.....

.....

.....

.....

- (iii) State the number of protons, neutrons and electrons in one $^{37}\text{Cl}^-$ ion.

[1]

.....

.....

.....

(Question 1 continued)

- (b) (i) Deduce the full electron configuration of the chloride ion, Cl^- . **[1]**

.....

.....

- (ii) Explain why the atomic radius decreases from sodium to chlorine across period 3. **[2]**

.....

.....

.....

.....

.....

- (iii) Explain why the ionic radius of Cl^- is greater than the atomic radius of chlorine. **[1]**

.....

.....

.....

- (c) (i) Chlorine solution is added to aqueous potassium bromide.
- Write the equation for the reaction and state the colour change observed. **[2]**

Equation:

Colour change:

(Question 1 continued)

- (ii) Explain why reactivity decreases down group 17.

[2]

.....

.....

.....

.....

- (d) (i) Deduce the Lewis formula of hydrogen chloride, HCl, and deduce the type of bond present. Use section 9 of the data booklet.

[2]

Type of bond:

- (ii) Explain why hydrogen chloride has a lower boiling point than hydrogen fluoride.

[2]

.....

.....

.....

- (iii) Write the equation for the reaction of dilute hydrochloric acid with magnesium carbonate, MgCO_3 .

[1]

.....

.....

- 2.** Alkanes, alkenes, halogenoalkanes and alcohols are four homologous series that are closely linked in the petrochemical industry.

(a) (i) State the IUPAC name of $\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_3$. **[1]**

.....

.....

(ii) Explain why the boiling points of the alkanes increase as the chain length increases. **[2]**

.....

.....

.....

.....

.....

(b) (i) State the name of the product formed when propene reacts with bromine. **[1]**

.....

.....

(ii) State the type of reaction and describe what is observed. **[2]**

.....

.....

.....

.....

(Question 2 continued)

(c) 1-chloropropane reacts with warm aqueous sodium hydroxide to form propan-1-ol.

(i) Explain why the carbon atom bonded to chlorine is attacked by a nucleophile.

[1]

.....

.....

.....

(ii) Sketch the mechanism of the reaction, showing structural formulas and using curly arrows to represent the movement of electron pairs.

[3]

(Question 2 continued)

(d) Propan-2-ol is warmed with acidified potassium dichromate(VI).

(i) Deduce the name and the structural formula of the organic product. **[2]**

Name of product:

(ii) State the colour change observed. **[1]**

.....
.....

(e) Ethanol reacts with ethanoic acid to form ethyl ethanoate, $C_4H_8O_2$.

46.0 g of ethanol was reacted with an excess of ethanoic acid and 70.4 g of ethyl ethanoate was obtained.

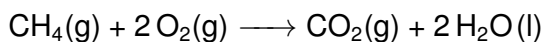
(i) Calculate the percentage yield. Use section 7 of the data booklet. **[3]**

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

(ii) State the name of the ester formed from methanol and methanoic acid. **[1]**

.....
.....

3. Methane is the main component of natural gas. It burns completely in oxygen.



The standard enthalpies of formation, in kJ mol^{-1} , are:

$\text{CH}_4(\text{g})$: -74.6

$\text{CO}_2(\text{g})$: -393.5

$\text{H}_2\text{O}(\text{l})$: -285.8

- (a) Calculate the standard enthalpy change of combustion of methane, in kJ mol^{-1} , showing your working. **[3]**

.....

.....

.....

.....

.....

.....

- (b) (i) Define the term *activation energy*.

[1]

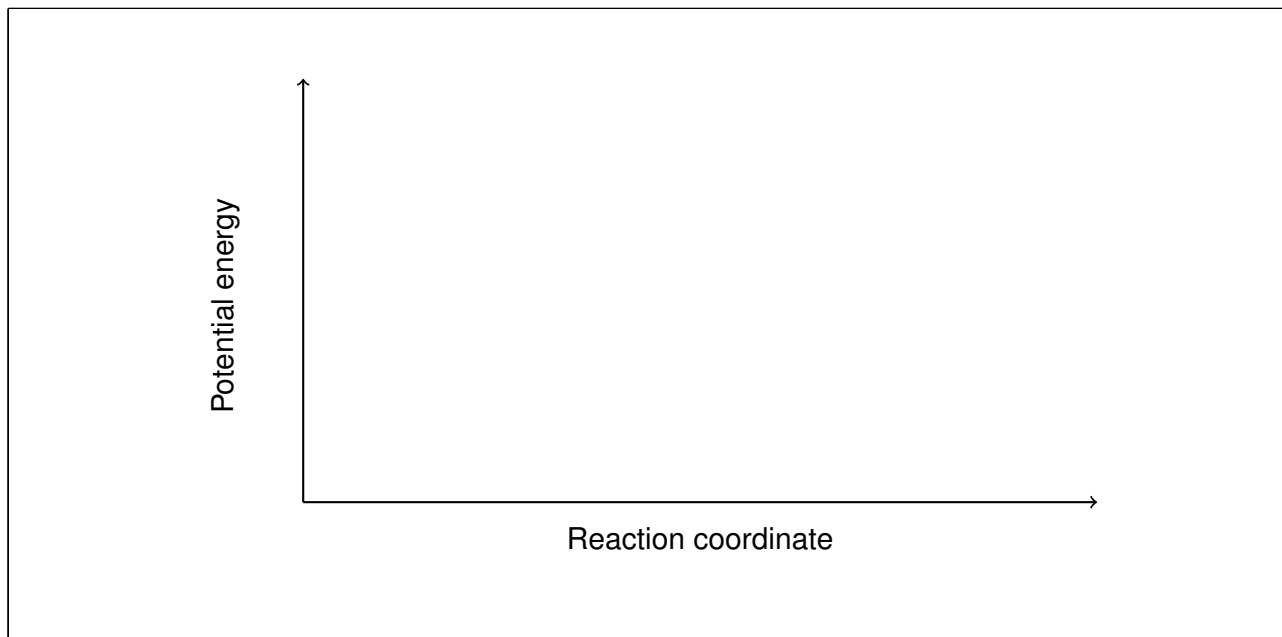
.....

.....

.....

(Question 3 continued)

- (ii) Sketch the energy profile for the combustion of methane on the axes below, labelling the activation energy, E_a , and the enthalpy change, ΔH . **[3]**



- (iii) Explain, in terms of collision theory, why increasing the concentration of a reactant increases the rate of reaction. **[2]**

.....

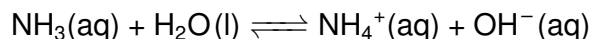
.....

.....

.....

(Question 3 continued)

(c) Ammonia acts as a base in aqueous solution.



(i) Identify the two conjugate acid–base pairs in this equilibrium.

[2]

Acid: Conjugate base:

Base: Conjugate acid:

(ii) Calculate the pH of $0.0100 \text{ mol dm}^{-3}$ hydrochloric acid.

[1]

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

(iii) Calculate the volume, in cm^3 , of $0.100 \text{ mol dm}^{-3}$ sodium hydroxide required to neutralize 25.0 cm^3 of $0.150 \text{ mol dm}^{-3}$ sulfuric acid.

[2]

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

(Question 3 continued)

- (iv) Distinguish between a strong base and a weak base, giving one example of each. **[2]**

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

End of examination.

Total: 50 marks