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Chemistry Higher level Paper 2

18 May 2026

Zone A morning | Zone B morning | Zone C morning

Session number

2 hours 30 minutes

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Instructions to students

- Write your session number in the boxes above.
- Do not open this examination paper until instructed 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 **[90 marks]**.



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

1. Hydrobromic acid, HBr(aq) , and hydrochloric acid, HCl(aq) , are strong acids and methanoic acid, HCOOH(aq) , is a weak acid.

(a) 20.0 cm^3 of 0.250 mol dm^{-3} HBr(aq) was titrated with potassium hydroxide solution, KOH(aq) .

- (i) Calculate the initial pH of the hydrobromic acid. Use section 1 of the data booklet. [1]

- (ii) Write the equation for the neutralization reaction between HBr(aq) and KOH(aq) . [1]

- (iii) Calculate the amount, in mol, of KOH(aq) needed to neutralize the solution of HBr(aq) . Use section 1 of the data booklet. [1]

- (iv) Calculate the volume of 0.220 mol dm^{-3} KOH(aq) required for neutralization. Use section 1 of the data booklet. [1]

(This question continues on the following page)



(Question 1 continued)

- (v) Suggest one method, and the expected result, that could distinguish between unlabelled solutions of HBr(aq) and HCOOH(aq) of the same concentration. [2]

Method:

 Expected result:

- (vi) Deduce the formula and $\text{p}K_{\text{b}}$ of the conjugate base of HCOOH . [2]

$$\text{p}K_{\text{a}}(\text{HCOOH}) = 3.75$$

Formula of conjugate base:
 $\text{p}K_{\text{b}}$:

(This question continues on page 5)



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will not be marked.



(Question 1 continued)

- (vii) Calculate the pH when 20.0 cm³ of 0.250 mol dm^{–3} HCOOH (aq) has been neutralized by 22.0 cm³ of KOH (aq) of a different concentration.

Assume that the volumes of dilute solutions are additive.

[3]

$$K_b = \frac{[\text{HCOOH}][\text{OH}^-]}{[\text{HCOO}^-]} = 5.62 \times 10^{-11}$$

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- (viii) Suggest a suitable indicator for this titration of HCOOH (aq) with KOH (aq). Use section 18 of the data booklet.

[1]

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- (ix) Explain, using equations, why colour of an indicator changes with pH.

Use HInd to represent the indicator.

[3]

Equilibrium in HInd (aq) solution:

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Adding H⁺:

.....

Adding OH[–]:

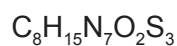
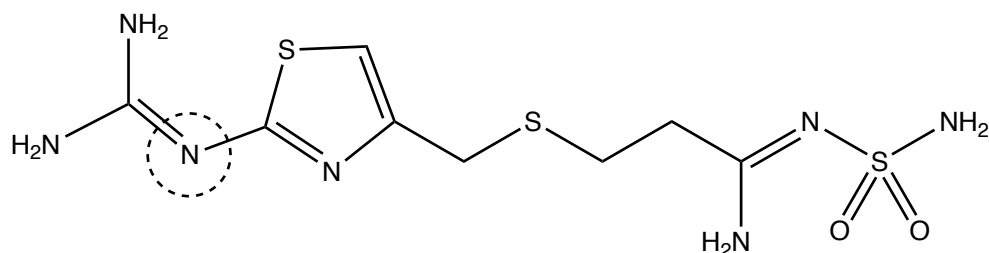
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(Question 1 continued)

- (b) Famotidine is a drug that reduces the production of stomach acid which contains HCl(aq).



$$M_r = 337.51$$

- (i) Deduce the hybridization of the circled N atom. [1]

.....

- (ii) Describe how sigma (σ) and pi (π) bonds form between S and O in famotidine. [2]

sigma (σ) bond:

.....

pi (π) bond:

.....

(This question continues on the following page)



(Question 1 continued)

- (iii) Deduce the number of signals and their relative areas in the famotidine ^1H NMR spectrum.

[2]

Number of signals:

Relative areas:

- (iv) Calculate the percentage by mass of nitrogen in a molecule of famotidine. Use section 7 of the data booklet.

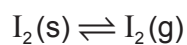
[1]

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2. Iodine occurs naturally in seawater.

- (a) Iodine crystals, $I_2(s)$, were placed in a sealed flask. Some of the solid turned into purple vapour as equilibrium was reached.



- (i) State the name of the change from $I_2(s)$ to $I_2(g)$, and the type of force which is overcome. [2]

Change of state:

Type of force:

- (ii) Explain why the purple vapour became darker as temperature increased. [2]

.....

- (iii) Explain why the pressure in the flask increased as temperature increased. [2]

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(This question continues on the following page)

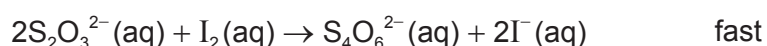
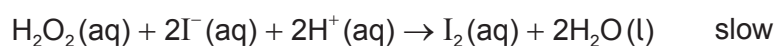


(Question 2 continued)

- (iv) At equilibrium, 2.05×10^{-3} g of iodine was present as vapour in a 500 cm^3 flask at 25°C .

Calculate the pressure, in kPa, in the flask due to the iodine vapour. [3]

- (b) An ‘iodine clock’ experiment involves two reactions occurring at the same time.



When the $\text{S}_2\text{O}_3^{2-}$ has all reacted, excess I_2 reacts with starch indicator to produce a dark blue complex.

- (i) Deduce the oxidation state of O in H_2O_2 . [1]

- (ii) Write a redox half-equation for the conversion of $\text{S}_2\text{O}_3^{2-}$ to $\text{S}_4\text{O}_6^{2-}$. [1]

- (iii) Suggest one change that would decrease the time for the dark blue colour to appear. [1]

(This question continues on page 11)



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(Question 2 continued)

- (c) Outline what is known about the electron configuration of an iodine atom from its position in the periodic table.

[2]

Information from group number:

.....

Information from period number:

.....



3. Metals are widely used in industry.

(a) Aluminium is used by itself and in alloys.

(i) Describe the structure of aluminium and the forces holding the metal together. [2]

Structure:

 Forces:

(ii) Explain why aluminium is malleable. [1]

.....

(iii) Explain why aluminium has a higher melting point than gallium. [2]

.....

(iv) State the electron configuration of gallium. [1]

.....

(This question continues on the following page)



(Question 3 continued)

- (v) Outline why the first ionization energy of aluminium is lower than that of magnesium.

[2]

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- (b) An alloy of aluminium and lithium is used in aerospace applications.

- (i) Suggest why the addition of lithium creates a material that is stronger and less flexible than aluminium alone.

[2]

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- (ii) Suggest why adding lithium to aluminium is a good choice for an aerospace alloy.

[1]

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(This question continues on page 15)



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(Question 3 continued)

(c) Lithium is a reactive metal.

(i) Write an equation for the reaction between lithium and water, including state symbols.

[2]

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(ii) Describe an **observation** from the reaction in (c)(i).

[1]

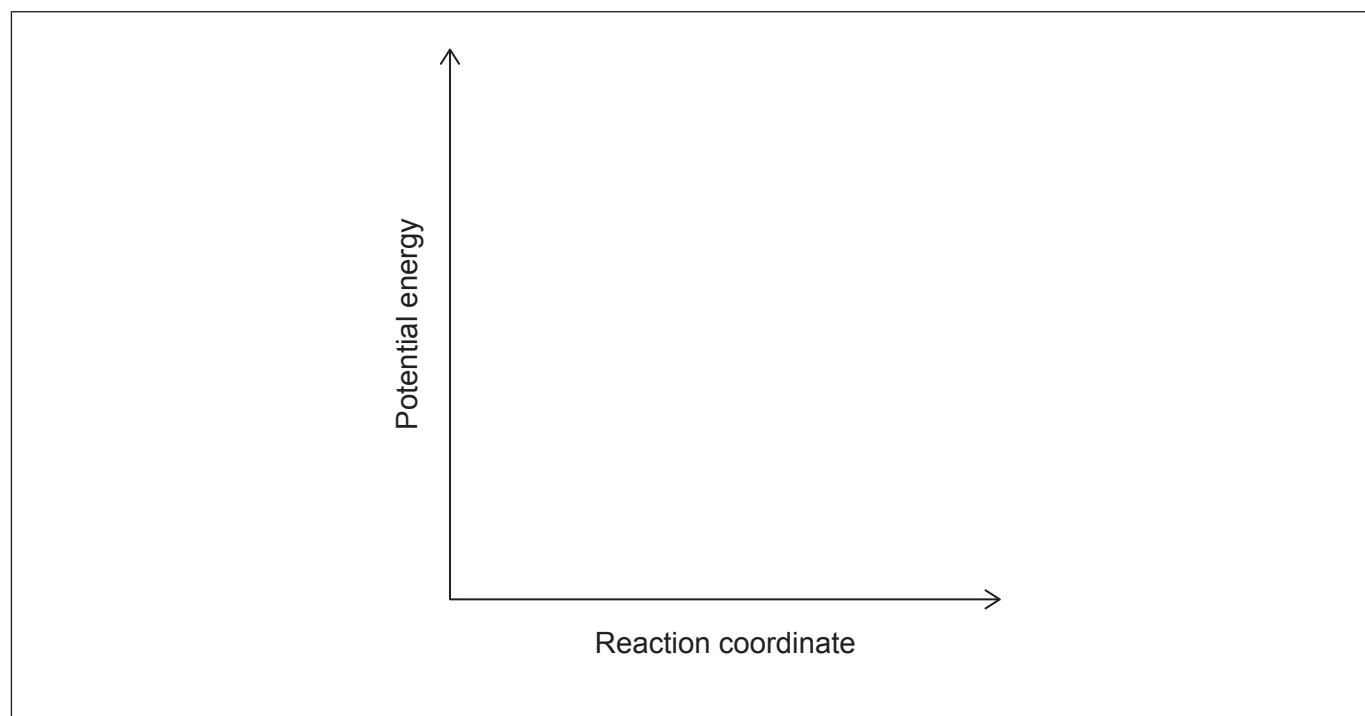
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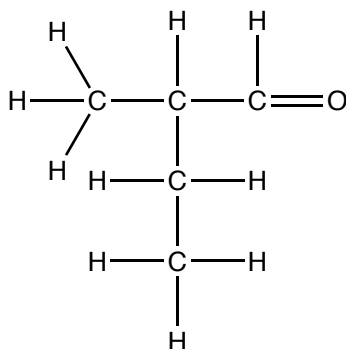
(iii) Sketch an energy profile for the reaction between lithium and water, showing activation energy, E_a and enthalpy change of reaction, ΔH .

[2]



4. Organic compounds are the main constituents of living organisms.

(a) Compound **X** is found in plant and animal cells.



Compound **X**

(i) State the IUPAC name of compound **X**. [1]

.....

(ii) State the name of the C=O functional group in compound **X**. [1]

.....

(iii) Predict the H–C=O bond angle in compound **X**. [1]

.....

(iv) Predict the IR absorption range for the C=O bond in compound **X**. Use section 20 of the data booklet. [1]

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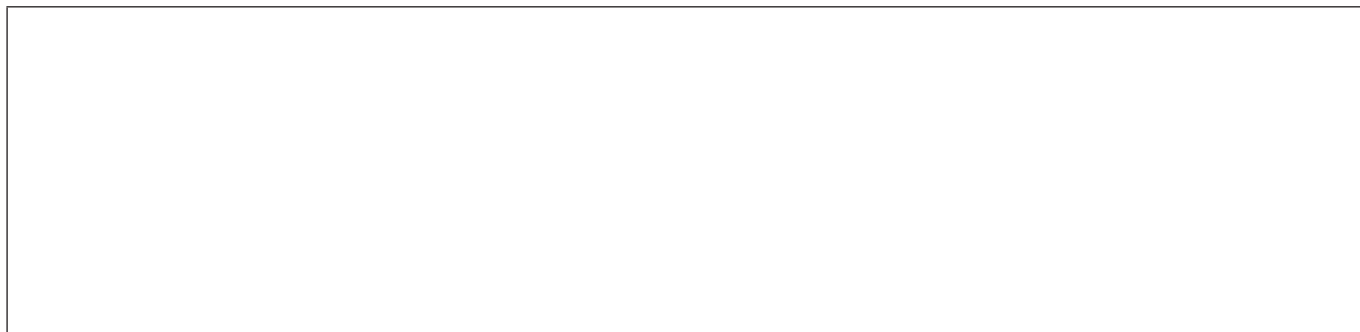
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(Question 4 continued)

- (v) Sketch the full structural formula of the product formed from the reaction of compound **X** with a reducing agent.

[1]



(This question continues on the following page)



(Question 4 continued)

(b) 1-Bromopropane is used as a solvent and a building block for organic molecules.

- (i) Predict the organic product formed when 1-bromopropane reacts with hydroxide ions. [1]

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- (ii) Deduce, with a reason, the reaction type in (b)(i). [1]

.....

- (iii) Sketch the mechanism of the reaction between 1-bromopropane and hydroxide ions, using curly arrows to show the movement of electron pairs. [3]

(This question continues on the following page)



(Question 4 continued)

- (c) Ethane reacts with chlorine gas in the presence of UV radiation to produce chlorinated hydrocarbons.

- (i) Explain, using an equation, the homolytic fission of chlorine. [1]

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- (ii) Explain, using two equations, the propagation steps for the reaction between ethane and chlorine. [2]

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(Question 4 continued)

- (d) Ethene can be reduced by hydrogen gas in the presence of a nickel catalyst at 150 °C.

Outline how the catalyst increases the reaction rate.

[2]

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- (e) Ethene reacts with hydrogen bromide at room temperature.



- (i) Calculate the change in entropy, $\Delta S^\ominus$, for this reaction in $\text{J K}^{-1} \text{ mol}^{-1}$. Use section 13 of the data booklet.

[1]

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- (ii) Explain the sign of the entropy change.

[1]

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(Question 4 continued)

- (iii) Calculate the change in Gibbs energy, $\Delta G^\ominus$, in kJ mol^{-1} , using sections 1 and 4 of the data booklet.

If you were unable to get an answer to (e)(i), use $\Delta S^\ominus = -200 \text{ J K}^{-1} \text{ mol}^{-1}$, although this is not the correct value.

[2]

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- (iv) Explain why the formation of bromoethane becomes less spontaneous as temperature increases.

[2]

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- (v) Calculate the temperature, in K , above which the reaction becomes non-spontaneous. Use section 1 of the data booklet.

If you were unable to get an answer to (e)(i), use $\Delta S^\ominus = -200 \text{ J K}^{-1} \text{ mol}^{-1}$, although this is not the correct value.

[1]

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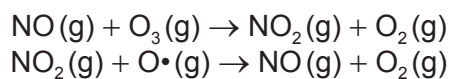


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5. Nitrogen(II) oxide reacts with ozone in the stratosphere.



Species	$\Delta H_f^\ominus / \text{kJ mol}^{-1}$
NO	90.25
NO ₂	33.18
O•	249.2
O ₃	142.7

- (a) Determine the enthalpy change, in kJ mol^{-1} , for the overall reaction. [2]

Overall reaction:

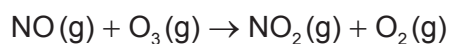
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$\Delta H_{\text{reaction}}^\ominus$:

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- (b) Calculate the enthalpy change, in kJ mol^{-1} , for the first reaction.



Use section 12 of the data booklet and the information provided. [3]

Bond	Bond enthalpy / kJ mol^{-1}
Between N and O in NO molecule	632
Between N and O in NO ₂ molecule	469
Between O and O in O ₃ molecule	302

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6. The rate of reaction between methanoic acid and bromine solution can be monitored using a colorimeter.

Initial rates of reaction were determined using different initial concentrations of the reactants.

$[\text{Br}_2] / \text{mol dm}^{-3}$	$[\text{HCOOH}] / \text{mol dm}^{-3}$	Initial rate / $\text{mol dm}^{-3} \text{s}^{-1}$
2.4×10^{-3}	5.0×10^{-1}	1.1×10^{-5}
4.8×10^{-3}	5.0×10^{-1}	2.2×10^{-5}
4.8×10^{-3}	2.5×10^{-1}	1.1×10^{-5}

- (a) Deduce the order of reaction with respect to each reactant and the rate equation. [2]

Order of reaction with respect to Br_2 :

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Order of reaction with respect to HCOOH :

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Rate equation:

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- (b) Calculate the value, including units, of the rate constant, k , using data from the table. [2]

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(Question 6 continued)

- (c) Outline how the activation energy, E_a , can be determined.

Details of experimental procedure are not required.

[3]

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7. Copper forms different coloured complex ions with a variety of ligands.

Complex ion	$[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$	$[\text{Cu}(\text{NH}_3)_4(\text{H}_2\text{O})_2]^{2+}$	$[\text{CuCl}_4]^{2-}$
Colour	blue	dark blue	green

- (a) Outline the type and formation of the bond between the copper ion and the ligand. [2]

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- (b) Explain why the copper complexes are coloured. [3]

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