



## Chemistry Model Paper 2 2025

**Time Allowed: 1 hour 45 minutes**

**Total Marks: 65**

You must bring a soft pencil (preferably type B or HB), a clean eraser, and a dark blue or black pen.

Before attempting the paper, write your name, candidate number, centre name, and centre number clearly in the designated spaces.

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### Instructions for Candidates

- All questions are compulsory.
- Read each question carefully before answering.
- You may use a simple calculator if needed.
- You should show all your working and use appropriate units.
- Do not use an erasable pen or correction fluid.
- Avoid writing over any barcodes printed on the paper.

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### Information for Candidates

- This paper consists of a total of **65 marks**.
- The number of marks for each question or part question is shown in brackets [ ].
- A copy of the periodic table will be provided with this paper.

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Please read all questions carefully and follow the instructions exactly to ensure your responses are properly evaluated.

Answer all questions. Show all working where appropriate.

**Question 1 (10 marks)**

Hydrogen iodide decomposes according to the equation:



Standard enthalpy changes of formation:

- $\text{HI(g)}$ :  $+26 \text{ kJ mol}^{-1}$
- $\text{H}_2\text{(g)}$ :  $0 \text{ kJ mol}^{-1}$
- $\text{I}_2\text{(g)}$ :  $+62 \text{ kJ mol}^{-1}$

(a) Calculate the enthalpy change  $\Delta H$  for the reaction:

(Use  $\Delta H = \Sigma\Delta H_f(\text{products}) - \Sigma\Delta H_f(\text{reactants})$ ) [3]

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(b) Define entropy and explain why entropy changes are important in determining spontaneity. [3]

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(c) At 298 K, the entropy change  $\Delta S = +125 \text{ J K}^{-1} \text{ mol}^{-1}$ .

Calculate  $\Delta G$  and state whether the reaction is feasible.

(Use  $\Delta G = \Delta H - T\Delta S$ .) [4]

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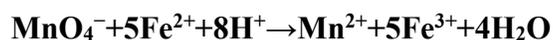
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**Question 2 – Redox (9 marks)**

A student investigates the reaction between acidified manganate(VII) and iron(II) ions.



(a) Assign oxidation numbers to Mn in  $\text{MnO}_4^-$  and  $\text{Mn}^{2+}$ . [2]

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(b) Identify:

(i) the oxidising agent : \_\_\_\_\_

(ii) the reducing agent: \_\_\_\_\_ [2]

(c) A titration uses  $25.00 \text{ cm}^3$  of  $0.0200 \text{ mol dm}^{-3} \text{ KMnO}_4$ .

Calculate the concentration of  $\text{Fe}^{2+}$  in a  $250 \text{ cm}^3$  flask. [3]

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(d) Explain why  $\text{KMnO}_4$  does not require an indicator. [1]

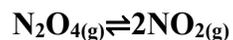
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(e) Suggest one source of systematic error in this titration. [1]

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**Question 3 (14 marks)**

Consider the equilibrium:



Colourless  $\rightleftharpoons$  Brown gas

(a) State Le Chatelier's principle. [2]

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(b) Predict and explain the colour change when temperature is increased. [3]

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(c) At 350 K,  $K_c = 0.36$ .

A container has 0.400 mol  $\text{N}_2\text{O}_4$  and 0.100 mol  $\text{NO}_2$  in 1  $\text{dm}^3$ .

Calculate whether the mixture is at equilibrium. Compute  $Q_c$  and compare with  $K_c$ . [5]

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(d) Explain why catalysts do not affect the position of equilibrium. [2]

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(e) Suggest why industrial equilibria often operate at moderate temperatures. [2]

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**Question 4 (15 marks)**

(a) Draw a labelled Maxwell–Boltzmann distribution and show the effect of increased temperature. [3]



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(a) Name the mechanism for the reaction between 1-chloropropane and aqueous NaOH [1]

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(b) Using curly arrows, outline the mechanism. [3]

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(c) Explain why iodoalkanes react faster than chloroalkanes. [2]

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(d) Predict the major organic product when 2-bromopropane reacts with alcoholic KOH.[2]

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**Question 6 (9 marks)**

(a) State how IR spectroscopy distinguishes alcohols from alkanes. [2]

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(b) A mass spectrum shows a molecular ion peak at  $m/z = 74$ .  
Suggest the molecular formula. [2]



## Chemistry Model Paper II 2025

Marking Scheme

Total Marks: 65

### General Marking Principles

- Award marks according to the detailed mark scheme.
- Give credit for correct alternative answers where appropriate.
- Units must be included where required.
- Allow error carried forward (ecf) where appropriate.

1(a)	$\Delta H = [0 + 62] - [2 \times 26] = 62 - 52 = +10 \text{ kJ mol}^{-1}$ <ul style="list-style-type: none"> <li>• Substitution into formula [1]</li> <li>• Correct calculation [1]</li> <li>• Correct sign and unit [1]</li> </ul>	3
1(b)	<ul style="list-style-type: none"> <li>• Entropy: measure of disorder/randomness</li> <li>• Spontaneity depends on both <math>\Delta H</math> and <math>\Delta S</math></li> <li>• Reference to Gibbs free energy</li> </ul>	3
1(c)	<ul style="list-style-type: none"> <li>• Convert <math>\Delta S</math> to kJ: <math>125 \text{ J} = 0.125 \text{ kJ}</math> [1]</li> <li>• <math>\Delta G = 10 - (298 \times 0.125) = -27.25 \text{ kJ}</math> [2]</li> <li>• Negative <math>\Delta G \rightarrow</math> feasible [1]</li> </ul>	4
2(a)	<ul style="list-style-type: none"> <li>• Mn in <math>\text{MnO}_4^- = +7</math>;</li> <li>• <math>\text{Mn}^{2+} = +2</math></li> </ul>	2
2(b)	<ul style="list-style-type: none"> <li>• Oxidising agent: <math>\text{MnO}_4^-</math></li> <li>• Reducing agent: <math>\text{Fe}^{2+}</math></li> </ul>	2
2(c)	<ul style="list-style-type: none"> <li>• Moles <math>\text{KMnO}_4 = 0.0200 \times 0.02500 = 5.00 \times 10^{-4} \text{ mol}</math></li> <li>• Moles <math>\text{Fe}^{2+} = 5 \times \text{moles KMnO}_4 = 2.50 \times 10^{-3} \text{ mol}</math></li> <li>• Concentration <math>\text{Fe}^{2+} = 0.0100 \text{ mol dm}^{-3}</math></li> </ul>	3
2(d)	Self-indicating (purple to colourless)	1
2(e)	Example: burette reading error / parallax / incomplete transfer	1
3(a)	System shifts to oppose change	2
3(b)	<ul style="list-style-type: none"> <li>• Forward reaction endothermic;</li> <li>• increase T shifts right;</li> <li>• darker brown</li> </ul>	3
3(c)	<ul style="list-style-type: none"> <li>• (c) <math>Q_c = (0.100^2) / 0.400 = 0.025</math> [2]</li> <li>• Compare with <math>K_c = 0.36</math> [1]</li> <li>• <math>Q_c &lt; K_c \rightarrow</math> shifts right [2]</li> </ul>	5
3(d)	<ul style="list-style-type: none"> <li>• Catalyst lowers activation energy equally both directions;</li> <li>• no change in position</li> </ul>	2
3(e)	Compromise between rate and yield / energy cost	2
4(a)	Correct axes; curve; higher T curve lower peak and shifted right	3

4(b)	More molecules exceed $E_a$ ; exponential increase	3
4(c)	$Q_{10} = 2$	2
4(d)	Any two methods: gas syringe; mass loss; titration; pressure sensor	4
4(e)	Alternative pathway; lowers $E_a$ ; more successful collisions	3
5(a)	Nucleophilic substitution (SN2)	1
5(b)	Curly arrow from $\text{OH}^-$ ; C-Cl bond breaks; correct product	3
5(c)	C-I bond weaker; better leaving group	2
5(d)	Propene (elimination)	2
6(a)	Alcohol: broad O-H stretch $\sim 3200\text{--}3600\text{ cm}^{-1}$ ; alkane lacks	2
6(b)	$M_r = 74 \rightarrow \text{C}_4\text{H}_{10}\text{O}$	2
6(c)	Ethanol ( $\text{CH}_3\text{CH}_2\text{OH}$ )	3
6(d)	Gas chromatography or paper chromatography; brief description	2