Practice Question Set For A-Level
Subject : Chemistry
Paper-2 Topic: Rate Equations

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Name of the Student:_____
Max. Marks : 27 Marks **Time : 27 Minutes**

Q1.

The thermal decomposition of but-3-en-1-ol is investigated at different temperatures (*T*).

$$CH_2{=}CHCH_2CH_2OH \rightarrow CH_2{=}CHCH_3 + HCHO$$

The results from the investigation are used to calculate the rate constant, *k*, at each temperature.

The table below shows some of the results.

T / K	$\frac{1}{T}$ / K^{-1}	k / s^{-1}	ln k
553	1.81×10^{-3}	4.6×10^{-4}	–7.68
563	1.78×10^{-3}	8.4×10^{-4}	–7.08
573		15.6×10^{-4}	
583	1.72×10^{-3}	28.0×10^{-4}	–5.88
593	1.69×10^{-3}	49.9×10^{-4}	–5.30

(a) Complete the table with the missing values at 573 K

(1)

(b) The overall order of the reaction can be deduced from a piece of information in one of the column headings in the table.

Identify this piece of information and deduce the overall order.

Piece of information _____

Overall order _____

(2)

(c) The Arrhenius equation can be written in the form shown.

$$\ln k = \ln A - \frac{E_a}{RT}$$

On the grid in below figure plot a graph of ln *k* against $\frac{1}{T}$

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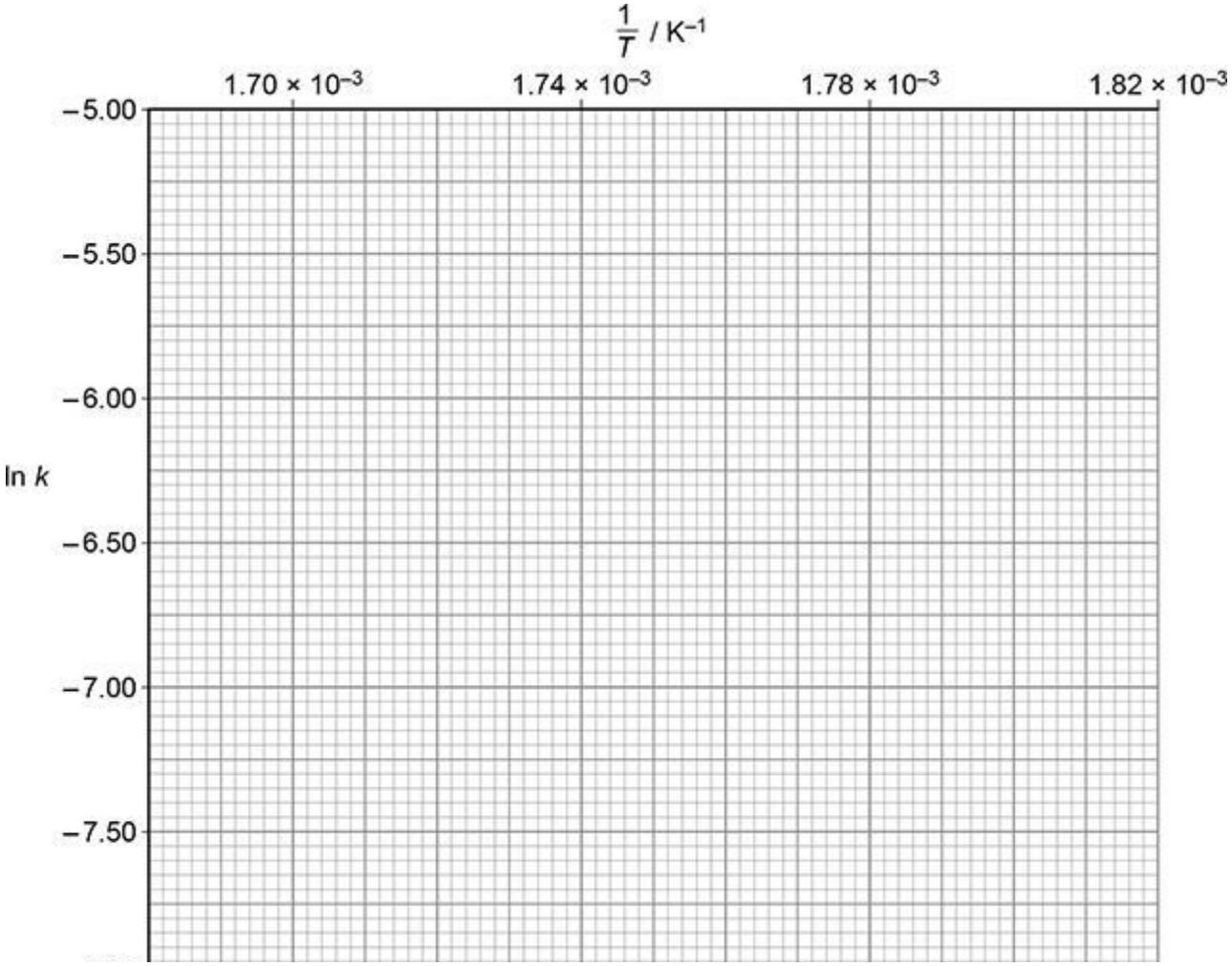

(2)

(d) Use your graph from part (c) to calculate a value for E_a, in kJ mol^{-1}, for the thermal decomposition of but-3-en-1-ol.

The gas constant, R = 8.31 J K^{-1} mol^{-1}

E_a _____ kJ mol^{-1}

(3)

(e) 2-Methylpent-4-en-2-ol decomposes in a similar way to but-3-en-1-ol, to produce an alkene and a carbonyl compound.

Deduce the structures of the alkene and the carbonyl compound.

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$CH_2=CHCH_2C(CH_3)_2OH \rightarrow$ _____ + _____

(2)

(Total 10 marks)

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Q2.

A and B react together in the presence of an acid catalyst.

$$A(aq) + 2\ B(aq) \rightarrow C(aq) + D(aq)$$

The rate equation for this reaction is

$$rate = k[B]^2[H^+]$$

The table below shows how the values of the relative initial rate vary with different concentrations of each reagent at the same temperature.

Experiment	**[A] / mol dm^{-3}**	**[B] / mol dm^{-3}**	**[H$^+$] / mol dm^{-3}**	**Relative initial rate**
1	0.40	0.20	0.10	1.00
2	0.50	0.20	0.10	
3	0.40		0.10	0.64
4	0.50	0.30	0.06	

(a) Complete the table by calculating the missing values.

(3)

(b) A suggested mechanism for the reaction is shown.

Step 1 $B + H^+ \rightarrow BH^+$

Step 2 $BH^+ + B \rightarrow B_2H^+$

Step 3 $B_2H^+ + A \rightarrow C + D$

Deduce the rate-determining step for this reaction.

Give a reason for your answer.

Rate-determining step _____

Reason _____

_____

_____

(2)

(Total 5 marks)

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Q3.

This question is about ethanoic anhydride.

In the gas phase, ethanoic anhydride $(CH_3CO)_2O$ decomposes to form ethenone.

The equation is

$$(CH_3CO)_2O \rightarrow \underset{\text{Ethenone}}{H_2C{=}C{=}O} + CH_3COOH$$

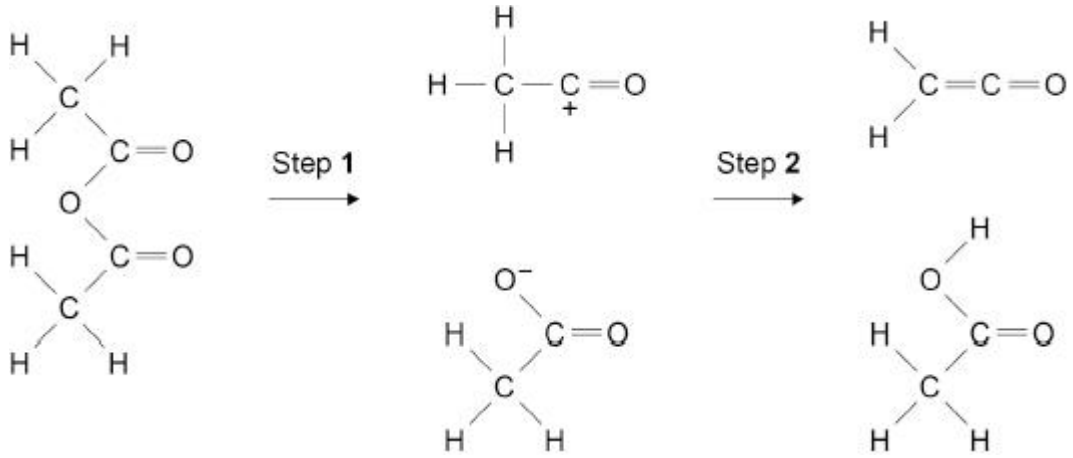
(a) Ethenone is the simplest member of the ketene homologous series.
Ketenes all contain one C=C double bond and one C=O double bond.

Deduce the general formula for the ketene homologous series.

_____

(1)

(b) The figure below shows an incomplete suggested mechanism for the decomposition of ethanoic anhydride.



Complete the mechanism in the figure above by adding three curly arrows and any relevant lone pairs of electrons.

(3)

(c) For a chemical reaction the relationship between the rate constant, k, and the temperature, T, is shown by the Arrhenius equation.

$$k = Ae^{\frac{-E_a}{RT}}$$

For the decomposition of gaseous ethanoic anhydride

the activation energy, E_a = 34.5 kJ mol^{-1}
the Arrhenius constant, A = 1.00 × 10^{12} s^{-1}

At temperature T_1 the rate constant, k = 2.48 × 10^{8} s^{-1}

Calculate T_1

The gas constant, R = 8.31 J K^{-1} mol^{-1}

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T_1 _____ K

(3)

(d) Sketch the Maxwell–Boltzmann distribution of molecular energies for gaseous ethanoic anhydride at temperature T_1 and at a higher temperature T_2

Include a label for each axis, and mark on the appropriate axis a typical position for the activation energy.

Explain why the rate of reaction is faster at T_2

Explanation

_____

_____

_____

(5)

(Total 12 marks)

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