

CHEMISTRY PAPER 2

11.45 am – 12.45 pm (1 hour)

This paper must be answered in English

INSTRUCTIONS

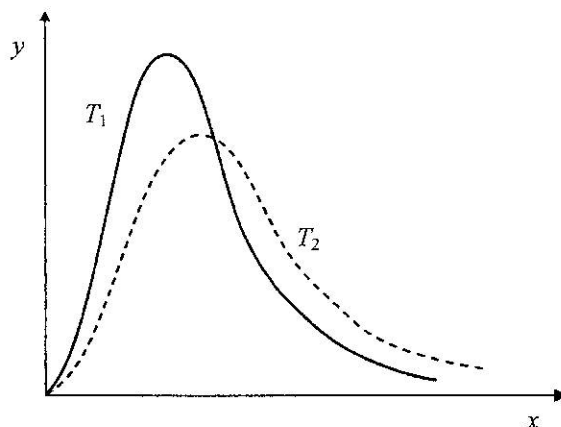
- (1) This paper consists of **THREE** sections, Section A, Section B and Section C. Attempt **ALL** questions in any **TWO** sections.
- (2) Write your answers in the **DSE(D)** Answer Book provided. Start each question (not part of a question) on a new page.
- (3) A Periodic Table is printed on page 8 of this Question Paper. Atomic numbers and relative atomic masses of elements can be obtained from the Periodic Table.

Section A Industrial Chemistry

Answer **ALL** parts of the question.

1. (a) For gaseous reactions, an increase in temperature leads to an increase in reaction rate.

(i) The graph below shows the Maxwell-Boltzmann distribution curves of molecular kinetic energies of a gas at two temperatures T_1 and T_2 .

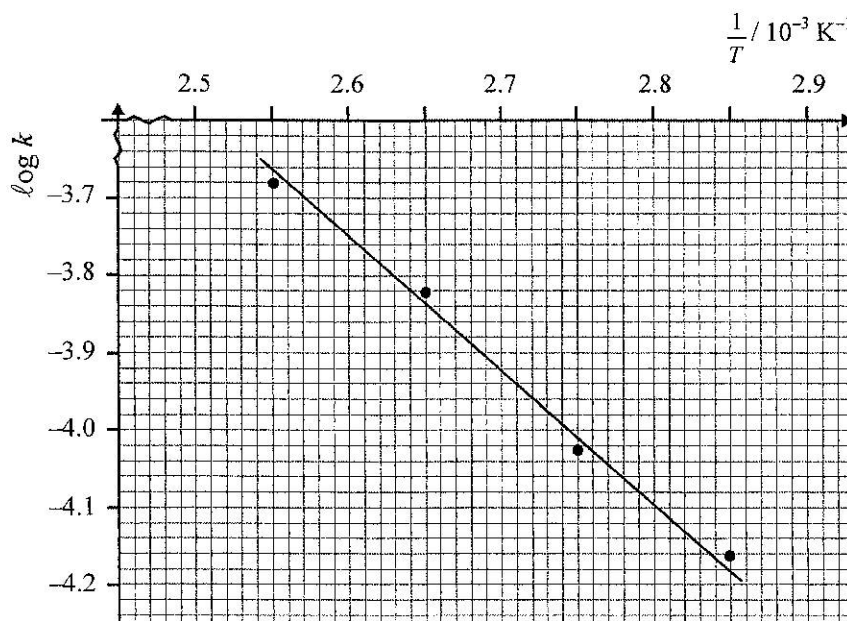


- (1) What do the axes, x and y , in the above graph respectively represent ?
- (2) With reference to the above graph, suggest why an increase in temperature can lead to an increase in the reaction rate of a gaseous reaction.

(5 marks)

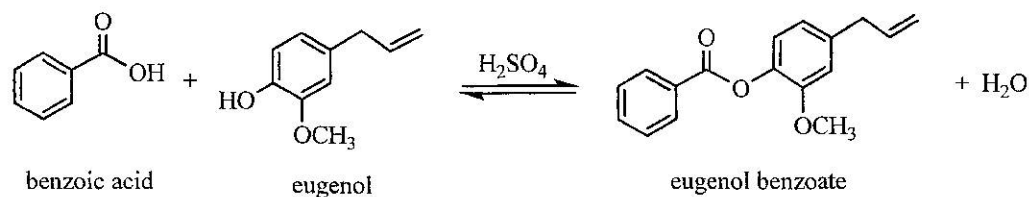
(ii) In a chemical kinetics experiment, the rate constants (k) of a reaction at various temperatures (T) were determined. The graph below shows the plot of $\log k$ against $\frac{1}{T}$. Calculate the activation energy of this reaction.

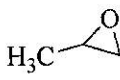
(Gas constant, $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$)



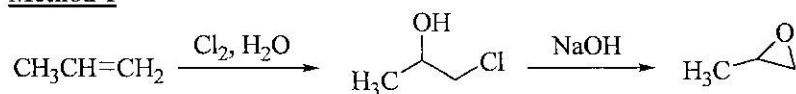
(3 marks)

1. (b) Eugenol benzoate is a commonly used food flavouring agent. Eugenol benzoate can be synthesised from the reaction of eugenol with benzoic acid in the presence of sulphuric acid as a homogeneous catalyst.



- (i) Suggest why a catalyst can speed up a reaction. (1 mark)
- (ii) For the above reaction, would the use of concentrated sulphuric acid or that of dilute sulphuric acid give a better yield of eugenol benzoate? Explain your answer. (1 mark)
- (iii) Eugenol benzoate can also be synthesised from the reaction of eugenol with benzoic acid in the presence of a solid acid as a heterogeneous catalyst. With reference to the synthesis of eugenol benzoate, state ONE advantage of using a homogeneous catalyst and ONE advantage of using a heterogeneous catalyst. (2 marks)
- (c) Propylene oxide () is a chemical commonly used in the plastics industry. Two methods for producing propylene oxide are shown below:

Method 1



Method 2



- (i) The Cl₂ and NaOH used in Method 1 are products of the chloroalkali industry. Briefly describe how these two chemicals are produced. (3 marks)
- (ii) The atom economy of Method 1 is 29.7%. Calculate the atom economy of Method 2. (1 mark)
- (iii) Discuss, from TWO different perspectives, whether Method 1 or Method 2 is greener. (2 marks)
- (iv) Comment on the following statement, and explain your answer:
'A reaction with a high atom economy should also have a high yield.' (2 marks)

END OF SECTION A

Section C **Analytical Chemistry**

Answer ALL parts of the question.

3. (a) Outline how hex-1-ene can be obtained from a mixture of hex-1-ene, octane and water by physical methods.

(Boiling points: hex-1-ene = 63°C, octane = 125°C, water = 100°C)

(4 marks)

- (b) Both white wine and red wine contain SO₂ preservative which is fixed in different forms. A volumetric analysis experiment was performed to determine the total concentration of SO₂ in a sample of white wine. In the experiment, 25.00 cm³ of the wine sample was transferred to a conical flask. Following certain stipulated procedures, NaOH(aq) and H₂SO₄(aq) were successively added to the flask to liberate all SO₂ from the wine. The resultant solution was immediately titrated with 0.00412 mol dm⁻³ I₂(aq) using freshly prepared starch solution as indicator. The experiment was repeated several times, and the mean volume of I₂(aq) required to reach the end point was 10.50 cm³.

- (i) A reaction must fulfill certain conditions in order that it can be used in volumetric analysis. State ONE such condition.

(1 mark)

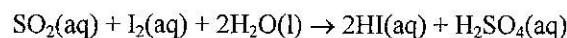
- (ii) Explain why the resultant solution needed to be titrated immediately.

(1 mark)

- (iii) State the expected colour change at the end point of the titration.

(1 mark)

- (iv) The chemical equation for the reaction involved in the titration is as follows:



Calculate the total concentration of SO₂, in mg dm⁻³, in the white wine sample.

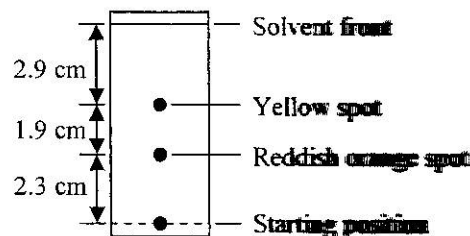
(4 marks)

- (v) Explain whether the total concentration of SO₂ in a sample of red wine can be determined in such an experiment.

(1 mark)

- (c) The main pigments in a certain brand of tomato paste are lycopene (reddish orange) and β-carotene (yellow). In order to isolate lycopene from the tomato paste, an experiment involving solvent extraction, thin-layer chromatography (TLC) and column chromatography was performed.

- (i) The result of TLC is shown below:



Calculate the R_f value for the lycopene spot.

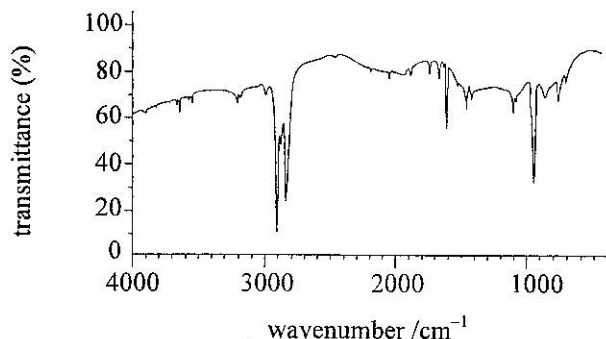
(1 mark)

- (ii) With reference to the result of TLC, explain whether the first-collected coloured fraction in the column chromatography is lycopene or β-carotene, if the same stationary phase and mobile phase are used.

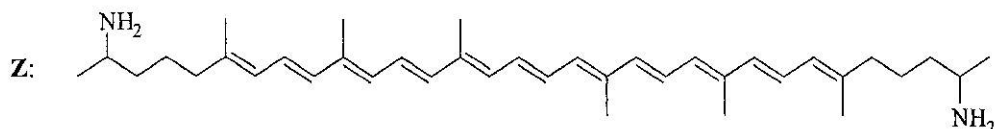
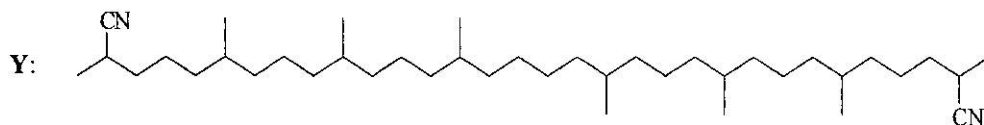
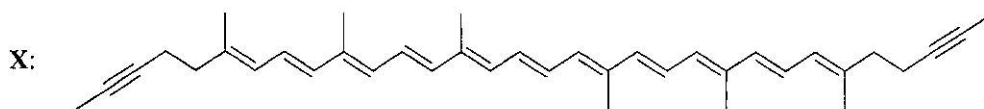
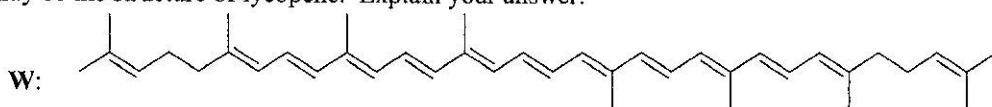
(1 mark)

3. (c) (iii) Suggest an instrumental method that can be used to determine the concentration of lycopene in the collected lycopene fraction. State the physical property of the lycopene fraction that needs to be measured. (2 marks)

- (iv) The infra-red spectrum of lycopene is shown below:



By referring to the Characteristic Infra-red Absorption Wavenumber Ranges (Stretching modes) given in the table below, suggest which of the following structures (W, X, Y or Z) may be the structure of lycopene. Explain your answer.



(4 marks)

Characteristic Infra-red Absorption Wavenumber Ranges
(Stretching modes)

Bond	Compound type	Wavenumber range /cm ⁻¹
C=C	Alkenes	1610 to 1680
C=O	Aldehydes, ketones, carboxylic acids and derivatives	1680 to 1800
C≡C	Alkynes	2070 to 2250
C≡N	Nitriles	2200 to 2280
O-H	Acids (hydrogen-bonded)	2500 to 3300
C-H	Alkanes, alkenes, arenes	2840 to 3095
O-H	Alcohols, phenols (hydrogen-bonded)	3230 to 3670
N-H	Amines	3350 to 3500

END OF SECTION C
END OF PAPER