National Open University of Nigeria
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Faculty of Science
Department of Pure and Applied Science
2021_2 Examination 45678

Course Code: CHM407
Course Title: Reaction Kinetics
Credit: 3 Units
Time Allowed: 3 Hours
Instruction: Answer Question ONE (1) and any other FOUR (4) Questions
In all calculations R = 8.314 J/mol/K

Question 1

1(a) During the kinetic study of the reaction, $2A + B \rightarrow C + D$, following results were obtained:

Run	**[A]/mol L^{-1}**	**[B]/mol L^{-1}**	**Initial rate of formation of D/mol L^{-1} min^{-1}**
I	0.1	0.1	6.0×10^{-3}
II	0.3	0.2	7.2×10^{-2}
III	0.3	0.4	2.88×10^{-1}
IV	0.4	0.1	4.0×10^{-2}

(i) Determine the order of the reaction (8 marks)

(ii) Calculate the value of the rate constant (3 marks)

(iii) Write the rate law for the reaction (2 marks)

(b) (b)(i) State what is expected for the reaction profile (in terms of activation complexes) of a catalysed and uncatalyzed reaction (2 marks)

(ii) Differentiate between positive and a negative catalyst (2 marks)

(iii) Based on the heat content of product and reactant, state conditions for exothermic and endothermic reaction (2 marks)

(iv) How does a catalyst influence the rate of reaction (2 marks).

(v) Considering the speed of a reaction, state the criteria for determining the rate determining step, hence define molecularity of a reaction (1 mark)

Question 2

2. (a) The thermal decomposition of acetaldehyde is given by the following equation, $CH_3CHO \rightarrow CH_4 + CO$. Experiment reveals that the reaction is a chain reaction and occurs through the following mechanism,

$$CH_3CHO \xrightarrow{k_1} CH_3^* + CHO$$

$$CH_3CHO + CH_3^* \xrightarrow{k_2} CH_4 + CH_3CO^*$$

$$CH_3CO \xrightarrow{k_3} CH_3^* + CO$$

$$CH_3^* + CH_3^* \xrightarrow{k_4} C_2H_6$$

Derive the kinetic equation for the formation of methane, in terms of measurable quantities.

(10 marks

b) In writing rate equation, explain (with reason) if the concentration of the product or reactant would be negative or positive. (2 mark)

Question 3

3(a) (i) Write equations to show how catalytic converter in automobile exhaust convert poisonous hydrocarbon (PHC), NO and NO_2 gases to non-poisonous gases. (3 marks)

(ii) Write equations to show Ostwald catalytic process (4 marks)

(b) The kinetic of enzyme reaction can be described in terms of Michaelis Menton equation,

$$E + S \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} ES^* \xrightarrow{k_2} E + P$$

where E is the enzyme, S is the substrate, ES* is the enzyme-substrate complex and P is the product of the catalysed reaction. If the rate of reaction is represented as, Rate = $k_2[ES^*]$, show that $Rate = \frac{k_2[E_0][S]}{k_m + [S]}$. where $k_m = \frac{k_{-1} + k_2}{k_1}$ is the Michaelis Menton constant (5 marks)

Question 4

4(a) The major and first step in acid catalysis is the transfer of proton from acid to the substrate as shown in the following equation

$$S + AH \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} SH^* + A^-$$

Answer the following questions

(i) Highlight the two major processes that can succeed the above reaction: (3 marks)

(ii) Show that for the protolytic mechanism the rate is given as $\frac{d[P]}{dt} = \frac{k_1 k_2 [S][AH]}{k_{-1}[A^-] + k_2}$ (7 marks)

(iii) If in the protolytic mechanism, $k_2 \gg k_{-1}[A^-]$,, explain the new kinetic (2 marks)

Question 5

5(a) (i). Write an equation to show the fusion reaction that generate high temperature in the range of 25, 000, 000 °C in the sun interior. (2 marks)

ii. Derive an equation that can be used to estimate the interior temperature of the sun (3 marks)

iii. Use Einstein law to show that the energy of radiation can be written as $E = \frac{1.1925 \times 10^5}{\lambda} kJ/mole$. Hence Calculate the energy that can be generated by a radiation whose wavelength is 10 nm (3 marks)

iv. State the two major laws of photochemistry (2 marks)

(b) A solution displays a transmittance of 20 % when taken in a cell of 2.5 cm thickness. Calculate its concentration if the molar absorption coefficient is 12, 000 dm^3/mol.cm (2 marks)]

Question 6

6(a) Given that temperature is related to the activation according to $\frac{dlnk}{dT} = \frac{E_a}{RT^2}$, derive expression for Arrhenius equation with when

(i) five different temperatures and the corresponding rate constants are known (5 marks)

(ii) Two temperature and corresponding two rate constants are known (4 marks)

(b) A rate constant of a chemical reaction is 1.78 x 10^{-4}Lmol^{-1}s^{-1} at 40 °C and 1.38 x 10^{-3}Lmol^{-1}s^{-1}at 80 °C. Evaluate the activation energy for the reaction. (3 marks)