



National Open University of Nigeria
Plot 91, Cadastral Zone, Nnamdi Azikiwe Expressway, Jabi - Abuja
Faculty of Science
OCTOBER/NOVEMBER, 2019 EXAMINATIONS

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 (22 MARKS)

(a) State any FOUR experimental methods of rate studies (4 marks)

(b) State the name of a suitable experimental method that can be followed to monitor the reaction rate in each of the following cases.

i. $\text{H}_2(g) + \text{Br}_2(g) \rightarrow 2\text{HBr}(g)$ **Hint:** Bromine absorbs strongly in the visible region, while hydrogen and hydrogen bromide are not.

ii. $\text{CH}_3\text{COOC}_2\text{H}_5(aq) + \text{OH}^-(aq) \rightarrow \text{CH}_3\text{COO}^-(aq) + \text{C}_2\text{H}_5\text{OH}(aq)$

iii. $\text{CH}_3\text{CHO}(g) \rightarrow \text{CH}_4(g) + \text{CO}(g)$ (at constant volume conditions) (3 marks)

(c) The reaction $\text{A} + 2\text{B} \rightarrow \text{products}$ has the rate law: $R = k[\text{A}][\text{B}]^3$. If the concentration of B is doubled while that of A is unchanged, by what factor will the reaction rate increase? (2 marks)

(d) The rate law for the reaction $2\text{A} + \text{B} \rightarrow \text{C} + 3\text{D}$ was expressed as $\text{rate} = k[\text{A}]^2[\text{B}]$, what are the units of k? (3 marks)

(e) Given a second-order reaction of the type: $2\text{A} \rightarrow \text{Products}$

The initial concentration of A and concentration after time t are $[\text{A}]_0$ and $[\text{A}]_t$ respectively. Derive the integrated form of the rate equation. i.e. $\frac{1}{[\text{A}]_t} = \frac{1}{[\text{A}]_0} + kt$. (6 marks)

(f) State (i) the Grotthuss-Draper Law of photochemistry (ii) the Stark-Einstein Law of Photochemical Equivalence. (4 marks)

Question 2 (12 MARKS)

(a) Consider the reaction: $\text{P}_4 + 6 \text{H}_2 \rightarrow 4 \text{PH}_3$. Kinetic study of this reaction was conducted at 298 K. The data that were obtained are shown in the table.

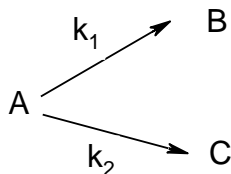
Expt.	[P ₄], mol/L	[H ₂], mol/L	Initial Rate, mol/(L . s)
1	0.0110	0.0075	3.20×10^{-4}
2	0.0110	0.0150	6.40×10^{-4}
3	0.0220	0.0150	6.39×10^{-4}

- What is the order with respect to P₄ (2 marks)
- What is the order with respect to H₂ (3 marks)
- Write the rate law for this reaction. (2 marks)
- Determine the value and units of the rate constant, k. (2 marks)

(b) At 323 K, the rate of reaction for the decomposition of N₂O₅ at a particular instant is $2.74 \times 10^{-4} \text{ Ms}^{-1}$. Calculate the rate of formation of O₂. The reaction is represented below:

**Question 3 (12 MARKS)**

(a) Given two parallel reactions depicted below:



Show that the ratio of product concentrations is equal to the ratio of the respective rate constants (6 marks)

(b) Differentiate between Physisorption and Chemisorption (6 marks)

Question 4 (12 MARKS)

(a) A solution of the red complex formed by Fe²⁺ ion with 1,10-phenanthroline is taken in a cell of the thickness 1.00 cm. If ϵ for the complex is $1.11 \times 10^3 \text{ m}^2 \text{ mol}^{-1}$ and the absorbance of the solution is 0.391, calculate the concentration of the complex in mol m^{-3} . (3 marks)

(b) In an experiment to measure the quantum efficiency of a photochemical reaction, the absorbing substance was exposed to 320 nm radiation from an 87.5 W source for 28.0 min. The intensity of the transmitted light was 0.257 that of the incident light. As a result of irradiation, 0.324 mol of the absorbing substance decomposed. Determine the quantum efficiency. (9 marks)

(Question 5

- (a) The rate expression for the reaction, below is given as: Overall rate = $k [\text{NO}_2]^2$
 $\text{NO}_2 (g) + \text{CO} (g) \rightarrow \text{NO} (g) + \text{CO}_2 (g)$.
Spectroscopically, NO_3 radical has been detected. Suggest a mechanism in keeping with these facts. **(4 marks)**
- (b) (i) What is the difference between positive and negative catalyst? (2 marks)
(ii) In three sentences, state major mechanism or step involved in catalysis (3 marks)
- (c) (i) Give four examples of complex reactions (2 marks)
(ii) Write equations for the half-life of a second order reaction (1 mark)

Question 6 (12 MARKS)

- (a) Discuss briefly the adsorption of gases on solids **(5 marks)**
- (b) In Photochemical decomposition of acetone using 313 nm light, 7.57×10^{-6} mol of carbon monoxide is formed in 20 minutes. If the light absorbed corresponds to $2.41 \times 10^{-3} \text{ J s}^{-1}$, calculate the quantum efficiency for the formation of carbon monoxide. **(8 marks)**