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# **KIBABII UNIVERSITY**

**UNIVERSITY EXAMINATIONS  
2024/2025 ACADEMIC YEAR**

**FIRST YEAR FIRST SEMESTER  
MAIN EXAMINATIONS**

**FOR THE DEGREE OF MSc. (CHEMISTRY)**

**COURSE CODE: SCH 850E**

**COURSE TITLE: PRINCIPLES OF PHYSICAL CHEMISTRY**

**TIME: 2 HOURS**

**DATE: 22/04/25**

**TIME: 8-10AM**

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**INSTRUCTIONS TO CANDIDATES:**

**ANSWER ANY THREE QUESTIONS**

**THIS PAPER CONTAINS 3 PRINTED PAGES**

**KIBU OBSERVES ZERO TOLERANCE TO examination cheating**

### QUESTION ONE (20 MARKS)

- (a) Using Gibbs equation:  $\Delta G = \Delta H - T\Delta S$ , show that adsorption is both a spontaneous and exothermic process (3 marks)
- (b) Define the following terms (3 marks)
- Adsorbate
  - Surface tension
  - Adsorption
- (c) (i) Define the term surface energy (1 marks)
- (ii) At high temperatures there is a tendency for glasses to change shape into a sphere. The surface energy of a glass at  $650^\circ\text{C}$  is  $0.3 \text{ J.m}^{-2}$ . If the glass changes, from a cylinder of length 100 mm and diameter  $20\mu\text{m}$ , into a sphere, find the energy released (3 marks)
- (d) State any four differences between physisorption and chemisorption (4 marks)
- (e) Explain how the following factors affect adsorption process (2 marks)
- Surface area
  - Pressure
  - Activation of solid adsorbent

### QUESTION TWO (20 MARKS)

- (i) A razor blade inserted into the edge of a thin sheet of mica in high vacuum drives a crack to an equilibrium length along the central cleavage plane parallel to the sheet faces. The surface energy is measured as  $5.0 \text{ J.m}^{-2}$ . When air is let in, then the crack length increases 1.9 times. Find the surface energy of mica in air. (5 marks)
- (ii) (a) Define intermolecular forces (2 marks)
- (b) State the two classification of intermolecular forces (2 marks)
- (iii) (a) Briefly describe the of perturbation theory (4 marks)
- (b) In the Perturbation Theory of Intermolecular Forces at Long Range explain why Hamiltonian is better than Lagrangian. (3 marks)
- (c) Suppose that we have a wave function  $\Psi^A (1, 2 \dots n_A)$  that describes molecule A (a function of the coordinates of its  $n_A$  electrons), and a wave function  $\Psi^B (1', 2' \dots n'_B)$  describing the  $n_B$  electrons of molecule B. Deduce the overlap function between the antisymmetrized product and the original product of the two functions. (4 marks)

### QUESTION THREE (20 MARKS)

- (a) In adsorption experiment to investigate the effect of initial solute concentration, the following data was obtained. 100mL of the analyte with initial metal ion concentration (20, 40, 80, 100, 120, 150, 180 mg/L) was shaken with 0.1g of activated charcoal as adsorbent to equilibration. The mixture was then filtered and equilibrium concentrations determined by atomic absorption spectrometer (AAS) as (5, 16, 37, 57, 75, 91 and 113).
- Determine the  $q_e$  values for this experimental (10 marks)
  - Graphically using Langmuir adsorption isotherm, determine the adsorption capacity ( $Q_{\text{max}}$ ) of the activated charcoal (10 marks)

### QUESTION FOUR (20 MARKS)

- (a) Derive Langmuir adsorption isotherm equation, given the gas pressure at equilibrium is P and the equilibrium fraction of the surface covered by adsorbate is  $\theta$ . (5 marks)

- (b) Capillary tube with an inside diameter of 250  $\mu\text{m}$  can support a 100mm column of liquid that has a density of 930  $\text{kg.m}^{-3}$ . The observed contact angle is  $15^\circ$ . Find the surface tension of the liquid. (5 marks)
- (c) Briefly explain Fracture method of determining surface energy . (5 marks)
- (d) State any five applications of adsorption. (5 marks)

**QUESTION FIVE (20 MARKS)**

- (a) Long range effects are examples of types of electrostatic interactions in molecules. Briefly explain the following three kinds of long range effects
- i. Resonance interactions (2 marks)
  - ii. Magnetic interactions (2 marks)
  - iii. Dispersion (2 marks)
- (b) Describe capillary action as method of determining surface tension (3 marks)
- (c) Briefly describe conductivity test method of emulsion (3 marks)
- (d) What is inversion of emulsion? (2 marks)
- (e) Briefly describe the mechanism of sintering (3 marks)
- (f) State any three factors affecting sintering (3 marks)

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