



KENYATTA UNIVERSITY

UNIVERSITY EXAMINATIONS 2010/2011

INSTITUTIONAL BASED PROGRAMME (IBP) – DECEMBER SESSION

EXAMINATION FOR THE DEGREE OF MASTER OF SCIENCE

SCH 552: HETEROGENEOUS KINETICS

DATE: Wednesday, 27th April, 2011

TIME: 2.00 p.m. – 5.00 p.m.

INSTRUCTIONS:

Answer **ALL** questions.

$$R = 8.21 \times 10^2 \text{ L-atm l-mol}^{-1}\text{-K}^{-1}$$

$$T = 273 \text{ K}$$

$$P = \frac{n R T}{V}$$

$$V$$

Question 1 (18 MARKS)

- a) Relate the 1st law of Thermodynamics to Gibbs free energy. (5 marks)
- b)
 - i) Give an expression for the same if the expected substance is of a pure product. (2 marks)
 - ii) If the expected substance contains any other components. (2 marks)
- c) For a process that occurs at a constant temperature and pressure and the value of ΔG is positive.
 - i) What can you conclude about the process? (4 marks)
 - ii) What is the relationship between ΔG for the process and the rate at which it occurs? (5 marks)

Question 2 (16 MARKS)

- a) Derive an expression for H , the Enthalpy of a system if
- i) The reaction in question is spontaneous in the forward direction. (2 marks)
 - ii) The reaction in question is at equilibrium. (2 marks)
 - iii) If the forward reaction in the forward direction is nonspontaneous (2 marks)
- b) Relate chemical potential μ to free energy of a system ΔG . (4 marks)
- c) Consider a chemical distribution between two phases in α and β at a constant T and P .
If dn_i moles at i are transferred from α to β , then
- i) Give an expression for differential change in Gibbs free energy
 - ii) Give an expression for the acquired equilibrium between the two phases. (2 marks)

Question 3 (18 MARKS)

- a) Define the term Partition coefficient and relate it to Henry's Law. (6 marks)
- b) Mention the two mathematical models which can be used to describe the process of Diffusion. (4 marks)
- c) If the two phase i.e. α and β are gas and liquid respectively
- i) Determine the concentration of CO_2 in a soft drink that is bottled with a partial pressure of CO_2 of 6.0 atm over the liquid at 25°C given that the Henry's Law constant for CO_2 at the given temperature is $4.1 \times 10^{-2} \text{ mol l}^{-1} \text{ atm}^{-1}$. (4 marks)
 - ii) After the bottle is opened and equilibrates at the same temperature, calculate the concentration at CO_2 . (4 marks)

Question 4 (10 MARKS)

Consider a mass transfer process in a thin film of solution.

- i) Based on Stoke's Law, give an expression for mass balance. (2 marks)
- ii) If the diffusion rate is equal to the diffusion flux, then give an expression for differential equation subject to two boundary conditions. (2 marks)

- iii) Define and give an expression for the concentration profile. (2 marks)
- iv) Determine the flux if the system is in a steady state. (2 marks)
- v) Draw a diagram to summarize. (2 marks)

Question 5 (8 MARKS)

The efficiency at extraction can be expressed as

$$E = \frac{100D}{[D + V_a/V_o]}$$

- i) What are D, V_a and V_o values?
- ii) At what stage of the process do you expect the efficiency of the extraction to be equal to.

$$E = \frac{100D}{D+1}$$

(2 marks)

- iii) What is the extraction considered to be qualitative? (2 marks)