



**KENYATTA UNIVERSITY**  
**UNIVERSITY EXAMINATIONS 2009/2010**  
**SPECIAL / SUPPLEMENTARY EXAMINATION FOR THE DEGREE OF**  
**MASTER OF SCIENCE**

**SCH 552: HETEROGENEOUS KINETICS AND EQUILIBRIA**

**DATE:** Wednesday 29<sup>th</sup> September, 2010

**TIME:** 9.00 a.m – 12.00 Noon

**INSTRUCTIONS: Answer ALL Question**

$R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1}$

$T = 273 \text{ K}$

$P = nRT$

**QUESTION ONE (18 MARKS)**

- a) Relate the 1<sup>st</sup> law of thermodynamics to Gibbs free energy. [ 4 marks]
- b) i) Give an expression for the same if the expected substance is of a pure product. [ 2 marks]
- ii) If the expected contains any other components [ 2 marks]
- c) Explain the relationships between diffusion and rate of reaction in
- i) Homogenous processes [ 2 marks]
- ii) Heterogeneous processes [ 4 marks]
- d) Distinguish between a steady and unsteady states in a chemical process.[4 marks]

**QUESTION TWO (16 MARKS)**

- a) Define an expression of  $H_1$  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 non- spontaneous
- b) Relate chemical potential  $\mu$  to free energy of a system  $\Delta G$  [4 marks]
- c) Consider a chemical  $i$  distribution between two phases i.e  $\alpha$  and  $\beta$  at a constant  $T$  and  $P$ . If  $dn_i$  moles of  $i$  are transferred from  $\alpha$  and  $\beta$ .
- i) Give an expression for differential change in Gibbs free energy. [4 marks]
- ii) Give an expression for the acquired equilibrium, between the two phases. [ 2 marks]

### QUESTION THREE (18 MARKS)

- a) i) State the Le Chatelier's principle and relate it to chemical equilibrium [4 marks]
- ii) Based on the above principle explain the effect of enthalpy change of heterogeneous reaction. [4 marks]
- iii) If the two phases  $\alpha$  and  $\beta$  are gas and liquid respectively determine the concentration of Nitrogen dissolved in water under atmospheric conditions given that partial pressure of nitrogen gas in the atmosphere is 0.78 atm. [4 marks]

### QUESTION FOUR

Consider a mass transfer process in a thin film of solution

- i) Based on Stokes' law given an expression for mass balance
- ii) If the diffusion rate is equal to the diffusion flux, then give an expression for differential equation subject to the 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 the same. [2 marks]

### QUESTION FIVE

- a) Explain what you expect to happen when you extract charged species from an aqueous solution. [2 marks]
- b) Sulphur trioxide decomposes at high temperature in a sealed container.
- i) Give the equilibrium reaction for the process.
- ii) If the vessel is charged at 1000 K with  $\text{SO}_3(\text{g})$  at concentration of  $6.0 \times 10^{-3} \text{ M}$ . At equilibrium the  $\text{SO}_3$  concentration is  $2.44 \times 10^{-3} \text{ M}$ . Calculate the value of  $K_C$  at 1000 K. [6 marks]