NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF APPLIED SCIENCES

DEPARTMENT OF APPLIED CHEMISTRY

PHYSICAL CHEMISTRY 1

SCH2104

First Semester Examination Paper

December 2015

This examination paper consists of 4 pages

Time Allowed: **3 hours**

Total Marks: **100**

Examiner's Name: **Dr. S. Majoni**

Useful information: $R = 8.314 JK^{-1} mol^{-1}$; 1 atm = 101 325 Pa; 1 bar = 100000 Pa

INSTRUCTIONS

1. Answer ALL questions in section A and any three (3) questions in section B.
2. Each question in section A carries 10 marks and in section B carries 20 marks.
3.

MARK ALLOCATION

QUESTION	MARKS
A1.	**10**
A2.	**10**
A3.	**10**
A4.	**10**
B1	**20**
B2	**20**
B3	**20**
B4	**20**
TOTAL	**100**

SECTION A

1. Discuss any two colligative properties and for one of them explain its applications. [10 Marks]

2. a) State the first law of thermodynamics [2 Marks]

   b) Differentiate the following types of equilibria:

   (i) Chemical Equilibrium

   (ii) Mechanical Equilibrium

   (iii) Thermal Equilibrium

   (iv) Phase Equilibrium [8 Marks]

3. Calculate the heat capacity of an aluminium block that must absorb 629 J of heat from its surroundings in order for its temperature to rise from 22 °C to 145 °C. [4 Marks]

   b) Calculate the final temperature when 100 g of water at 80°C is poured into 100 g of water at 10°C in an insulated system. [6 Marks]

4. a) Internal energy (U) and enthalpy (H) are state functions. Explain what is a state function and give two more examples of state functions [5 Marks]

   b) Calculate the work done during the adiabatic expansion step of a Carnot cycle that is operating between 300 K and 200K. Given that $C_{v,m} = \frac{3}{2}R$. [5 marks]

SECTION B

1. a) Describe the Zeroth Law of thermodynamics and state its applications.

[5 Marks]

b) Show that ΔS for a system composed of a perfect gas undergoing a reversible Isothermal Expansion is given by: $\Delta S = -nR\ln\left(\frac{P_f}{P_i}\right)$ [10 Marks]

c) State the properties of the walls of a closed system. [5 marks]

2. a) K_c for the reaction $I_2(g) \rightleftarrows 2I(g)$ is 5.6×10^{-12} at 500K; A mixture has $[I_2] = 0.0020$ M and $[I] = 3.7 \times 10^{-7}$ M. Is the reaction at equilibrium (at 500K)? If not, which way must the reaction proceed to attain equilibrium? [6 marks]

b) The total pressure in a flask containing N_2O_4 (g) and NO_2 (g) at 25°C is 1.50 bar, the value of *Kp* at 25°C is 0.148, what fraction of N_2O_4 has dissociated to NO_2. N_2O_4 decomposes to NO_2 according to the following reaction

$$N_2O_4(g) \rightleftharpoons 2NO_2(g)$$

[8 Marks]

c) An unknown substance of concentration 31.2 kg m^{-3} has an osmotic pressure of 5.30×10^4 Pa at 298 K. Determine the molecular weight if the density of the solution is 997 kg m^{-3}. [6 Marks]

3. a) Define the following terms as used in thermodynamics

i) Open thermodynamic system

ii) Isolated thermodynamic system

iii) Equilibrium state

iv) Isochoric change

v) Adiabatic change [10 Marks]

b) The following reaction is at equilibrium:

$$4NH_3(g) + 3O_2(g) \rightleftarrows 6H_2O(g) + 2N_2(g)$$

Explain Le-Chartlier's prediction on how the equilibrium will shift if a lit match is placed inside the container [6 Marks]

c) Discus the fundamental differences between ΔH and ΔU. Of the two which one is a more useful parameter under ordinary laboratory conditions? [4 Marks]

4. a) The heat pump can be represented as the Carnot cycle traversed in reverse. Give a fully labelled graphical representation of the heat pump. [10 marks]

b) What is the fundamental difference between the heat pump and the heat engine? Use the Carnot cycle to formulate the second law of thermodynamics. [10 Marks]

End of Question Paper!!!