BONDO UNIVERSITY COLLEGE

UNIVERSITY EXAMINATION 2012/2013

3RD YEAR 2ND SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF EDUCATION SCIENCE WITH IT (REGULAR)

COURSE CODE: SCH 301

TITLE: CHEMICAL THERMODYNAMICS AND EQUILIBRIUM

DATE: 26/11/2012 **TIME: 14.00-16.00PM**

DURATION: 2HOURS

INSTRUCTIONS

1) **This paper contains TWO sections**
2) **Answer ALL questions in section A COMPULSORY and ANY other TWO [2] questions in section B.**
3) **Write ALL answers in the booklet provided.**

Section A This section contains ONE COMPULSORY question

QUESTION 1 (Compulsory -30 marks)

I. State Le Chetalier's Principle. (2 marks)

II. a moles of hydrogen and b moles of iodine were sealed in a vessel of volume V and were heated to a temperature above 673K. After equilibrium had been established, the vessel was rapidly cooled to freeze the reaction mixture. It was found that x moles of iodine had been consumed. Obtain an expression for the equilibrium constant K_c. (3 marks)

III. Which direction would you expect the reaction in (II) above to move on increased pressure and why? (2 marks)

IV. State the Second Law of Thermodynamics. (2 marks)

V. Define homogenous and heterogeneous equilibrium and give an example of each. (2 marks)

VI. What do you understand by the term 'Gibbs Free Energy'? (2 marks)

VII. Differentiate between ΔG and ΔG^0. (2 marks)

VIII. Predict whether the entropy change of the system in each of the following reactions is positive or negative.

a. $AgCl(s) \longrightarrow Ag^+ (aq) + Cl^- (aq)$ (1.5 marks)

b. $NH_4 CL(s) \longrightarrow NH_3(g) + HCL (g)$ (1.5 marks)

IX. Of what significance is the Boltzamn factor $\mathbf{e^{-E/RT}}$ in chemistry? (2 marks)

X. State Dalton's law of partial pressures. (2 marks)

XI. State the first law of Thermodynamics. (2 marks)

XII. What is a phase diagram (2 marks)

XIII. Consider the following equilibrium process;

$N_2 F_{4(g)} \rightleftharpoons 2NF_{2(g)} \qquad \Delta H^0 = -38.5$ kJ

Predict the changes in the equilibrium if;

a. The reacting mixture is heated at constant volume (1 mark)

b. NF_2 gas is removed from the reacting mixture at constant temperature and volume (1 mark)

c. The pressure on the reacting mixture is decreased at constant temperature (1 mark)

d. An inert gas, such as helium, is added to the reaction mixture at constant volume and temperature. (1 mark)

Section B: This section contains FOUR questions. Answer ONLY TWO questions.

Question Two (Optional, 20 marks)

a) Write the equilibrium constant K_c for the reaction; (3 marks)

$$N_{2(g)} + 3H_{3(g)} \rightleftharpoons 2NH_{2(g)}$$

b) Why do equilibrium constants have temperature specified? (2 marks)

c) Write the equilibrium expression for the decomposition of two moles of HI gas to hydrogen gas and iodine gas. (6 marks)

d) Given the above reaction, with the initial concentration of HI being 0.100 M at 520^0 C; at equilibrium the concentration of H is 0.010M

Calculate

i. The concentration of iodine (3 marks)
ii. The concentration of HI (3 marks)
iii. K_c (3 marks)

Question Three (Optional, 20 marks)

a) Show how the equilibrium constants K_1 and K_2 for the respective reactions:

$$H_{2(g)} + Cl_{2(g)} \rightleftharpoons 2HCl_{(g)}$$

$$2H_{2(g)} + O_{2(g)} \rightleftharpoons 2H_2O_{(g)}$$

Are related to the equilibrium constants K_3 for the reaction;

$$4HCl_{(g)} + O_{2(g)} \rightleftharpoons 2H_2O_{(g)} + 2Cl_{2(g} \quad \text{(8 marks)}$$

b) Would you expect the standard entropy change ΔS^0 (298K) to increase, decrease, or remain approximately constant in the following reactions?

$$2NH_{3(g)} \rightleftharpoons N_{2(g)} + 3H_{2(g)} \quad \text{(3 marks)}$$

$$2Mg_{(s)} + O_{2(g)} \rightleftharpoons 2MgO_{(s)} \quad \text{(3 marks)}$$

c) Calculate the Standard free energy change for the following reaction at 1atm and 298K from the following data;

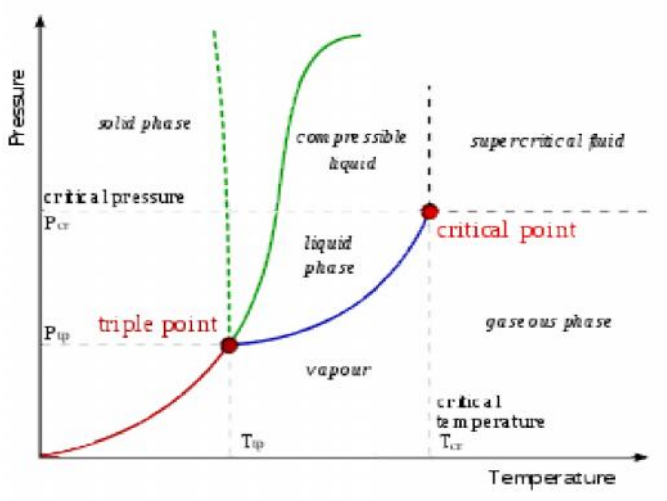
$$H_{2(g)} + Cl_{2(g)} \longrightarrow 2HCl_{(g)} \quad \text{(6 marks)}$$

ΔH^0 (298K) HCl = -92.3 KJ mol^{-1}, S^0 (298K)H_2 = 131 J K^{-1} mol^{-1}

S^0 (298K) Cl_2 = 223 J K^{-1} mol^{-1}, S^0 (298K)HCl = 187 J K^{-1} mol^{-1}

Question Four (Optional, 20 marks)

a) What are ebullioscopy and cryoscopy? (6 marks)



b) The phase diagram of water is shown above.

I. What is the significance of the triple point and at what temperature does it occur? (2 marks)

II. What is the critical point and at what temperature does it occur? (2 marks)

III. Describe the sublimation curve. (2 marks)

IV. Describe the vaporization curve. (2 marks)

c) For the reaction in the equilibrium system

$$2NO_{2(g)} \rightleftharpoons N_2O_{4(g)} \qquad \Delta H^0 = -58.0 \text{ kJ}$$

Predict the effect of increasing temperature on K_c and thus on the proportion of $N_2O_{4(g)}$ in a specific equilibrium mixture at constant pressure. (6 marks).

Question Five (Optional, 20 marks)

a) What are colligative properties? (2 marks)

b) Calculate ΔG and ΔG^0 for a process given that;

Ksp = 1.6×10^{-10} at 25^0 C for the reaction

$$AgCl(s) \longrightarrow Ag^+(aq) + Cl^-(aq)$$ (6 marks)

c) A gaseous compound AB dissociates into its respective elements according to the following equation;

$$AB \rightleftharpoons \tfrac{1}{3}B + A$$

The reaction is assumed to be balanced with respect to the individual elements. Its K_c at 300^0 C is 1.65×10^{-7} . Assuming ideal behaviour of the gas, calculate the corresponding K with partial pressures in atmospheres. (6 marks)

d) Consider the reaction in a closed vessel

$$N_2O_{4(g)} \rightleftharpoons 2NO_{2(g)}$$

Initially there is 1 mole of N_2O_4 present. At equilibrium $\propto$ moles of N_2O_4 has dissociated to form NO_2 . Derive an expression of K_c in terms of $\propto$ and the partial pressure p. (6 marks)

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