CHEMISTRY 225 SEMESTER 04-2016
REVISION ON EQUILIBRIA

1) Write an expression for the equilibrium constant (K) for each of the following reactions:
   a) $N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$
   b) $Cl_2(g) + 3F_2(g) \rightleftharpoons 2ClF_3(g)$
   c) $2Fe(s) + Cr_2O_7^{2-}(aq) + 14H^+(aq) \rightleftharpoons 2Fe^{3+}(aq) + 2Cr^{3+}(aq) + 7H_2O(l)$
   d) $C_2H_5OH(l) \rightleftharpoons C_2H_5OH(g)$
   e) $3O_2(g) \rightleftharpoons 2O_3(g)$
   f) $Ag(s) + Fe^{3+}(aq) \rightleftharpoons Ag^+(aq) + Fe^{2+}(aq)$
   g) $CaCO_3(s) \rightleftharpoons CO_2(g) + CaO(s)$
   h) $NH_4Cl(s) \rightleftharpoons NH_3(g) + HCl(g)$

2) In the following questions, consider the equilibrium:

$$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$$

   for which $K_p = 1{\cdot}70$ at 250°C
   a) If 1 mol of $PCl_5(g)$ is placed in a 1000 cm^3 flask at 250®C and allowed to come to equilibrium, find the equilibrium partial pressure of each species present.
   b) If PCl_5 is 48·5% dissociated at 200°C, 1 atm, and 97% dissociated at 300®C, 1 atm, explain whether the decomposition reaction is exothermic, or endothermic.
   c) If 5 mol of $PCl_5(g)$ were initially present as in (a) calculate the equilibrium partial pressure of each species.
   d) Using your results from (a) and (c) or otherwise calculate the degree of dissociation of the PCl_5 in each case.
   e) Proceed as in (a) and (c) for the following initial mixtures of species:
      i) 1 mol of PCl_3 and 1 mol of Cl_2.
      ii) 0·5 mol of PCl_5 and 1 mol of Cl_2.

3) Suppose 3 mol of HCl and 2 mol of O_2 are introduced into a 5000 cm^3 vessel and the temperature held constant at 450°C until equilibrium is attained according to the reaction:

$$4HCl(g) + O_2(g) \rightleftharpoons 2H_2O(g) + 2Cl_2(g) \quad \Delta H = -113 \text{ kJ mol}^{-1}$$

   From this data, could the equilibrium constant be calculated? If so, find its value. If not, what further data would be needed?

4) For the system:

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \quad \Delta H = -98 \text{ kJ mol}^{-1}$$

   state the effect on individual concentrations, equilibrium position, reaction rates and the value of K_c of
   a) adding more oxygen.
   b) increasing the pressure.
   c) adding finely divided platinum, which acts as a catalyst.
   d) increasing the temperature.

5) Hydrogen and iodine are introduced into a sealed vessel at a temperature at which both are gases and allowed to react until equilibrium is reached. Sketch a graph of concentration against time showing

the concentrations of hydrogen, iodine and hydrogen iodide. Sketch a second graph showing the rate of production of hydrogen iodide (one curve) and the rate of its reaction (ie. destruction) as a function of time.

6) The equilibrium constant (K_c) for the reaction

$$A(g) + B(g) \rightleftharpoons C(g) + D(g)$$

is 4. If in an equilibrium mixture [A] = 5, [B] = 2 and [D] = 4, find [C]

7) Given the following equilibria:

$$2C(s) + O_2(g) \rightleftharpoons 2CO \ldots (1), K_1 = 4.0$$

$$3O_2(g) \rightleftharpoons 2O_3(g) \ldots (2), K_2 = 8.0$$

$$2CO(g) + O_2(g) \rightleftharpoons 2CO_2(g) \ldots (3), K_3 = 6.0$$

Find a relationship between the above equilibria or equilibrium constants, and that for:

$$3C(s) + 2O_3(g) \rightleftharpoons 3CO_2(g) \ldots (4), K_4$$

and hence, or otherwise, calculate K_4.