AP WORKSHEET 07ABCDEFGHIJKLMN: Equilibrium Summary

PART A: Equilibrium Concepts

(a) Describe carefully what is meant by the term *dynamic equilibrium*. (1)

(b) Write an expression for Kc for the following reaction. (1)

$$4NH_{3(g)} + 5O_{2(g)} \leftrightarrows 4NO_{(g)} + 6H_2O_{(g)}$$

(c) State Le Chatelier's Principle. (1)

(d) Determine *and explain* the direction of the shift in equilibrium when these external changes are made to the EXOTHERMIC equilibrium.

$$4NH_{3(g)} + 5O_{2(g)} \leftrightarrows 4NO_{(g)} + 6H_2O_{(g)}$$

(i) An increase in temperature. (2)

(ii) A decrease in pressure. (2)

(iii) Removal of water$_{(g)}$ from the system. (2)

PART B: Equilibrium Calculations

TYPE 1: EASY (Plug the equilibrium concentrations directly into the Kc expression)

(a) At a certain temperature equilibrium for the following reaction was established

$$PCl_{5(g)} \leftrightarrows PCl_{3(g)} + Cl_{2(g)}$$

Analysis of the mixture showed that the equilibrium concentrations of $PCl_{3(g)}$, $Cl_{2(g)}$ and $PCl_{5(g)}$ were 0.0175 mol L^{-1}, 0.0150 mol L^{-1} and 0.118 mol L^{-1} respectively.

Calculate the value of Kc at this temperature. (2)

(b) In the following equilibrium

$$H_{2(g)} + I_{2(g)} \leftrightarrows 2HI_{(g)}$$

At a particular temperature Kc = 47.1. The equilibrium concentrations of H_2 and HI were found to be 0.480×10^{-2} mol L^{-1} and 3.53×10^{-2} mol L^{-1} respectively.

Calculate the equilibrium concentration of $I_{2(g)}$ under these conditions. (2)

TYPE 2: HARDER (Using initial concentrations)

In the following equilibrium

$$H_{2(g)} + I_{2(g)} \leftrightarrows 2HI_{(g)}$$

Initial amounts of 2.57 moles of hydrogen and 5.20 moles of iodine were allowed to reach equilibrium. At this point the mixture contained 1.22 moles of HI. Calculate Kc. (4)

TYPE 3a: HARDER STILL (Using initial concentrations and quadratics)

In the following equilibrium ethanoic acid (CH_3CO_2H) reacts with ethanol to produce an ester plus water.

$$CH_3CO_2H_{(g)} + C_2H_5OH_{(g)} \leftrightarrows CH_3CO_2C_2H_{5(g)} + H_2O_{(g)}$$

5.00 mols of ethanoic acid and 6.00 mols of ethanol are placed in a 4.50 L beaker. What is the equilibrium moles of water under these conditions, given that Kc = 4.50? (6)

TYPE 3b: HARDER STILL (Using initial concentrations where volume does not cancel)

Ethyl ethanoate ($CH_3CO_2C_2H_5$) can be formed by the reaction of ethene (C_2H_4) with ethanoic acid (CH_3COOH) in an inert solvent according to the reaction below.

$$C_2H_{4(aq)} + CH_3COOH_{(aq)} \leftrightarrows CH_3CO_2C_2H_{5(aq)}$$

0.500 moles of ethene are allowed to react with 0.200 moles of ethanoic acid, the total volume being made up to 250. mL. When equilibrium had been established the mixture was found to contain 0.175 moles of ethyl ethanoate. Calculate the value of Kc under these conditions. (6)

TYPE 4: EVEN HARDER STILL (Using initial concentrations and quadratics where reacting ratio is NOT 1:1)

In the following equilibrium

$$2HI_{(g)} \leftrightarrows H_{2(g)} + I_{2(g)}$$

An initial amount of 1.50 mols of iodine and 2.20 moles of hydrogen were allowed to reach equilibrium. Calculate the equilibrium amounts of all the substances present, given that Kc = 0.0200. (6)

TYPE 5: HARDEST (Combining initial concentrations with ratios that are NOT 1:1 and the use of grams rather than moles)

In the equilibrium reaction

$$Br_{2(g)} + Cl_{2(g)} \leftrightarrows 2BrCl_{(g)}$$

It is found that 82.4g of Bromine monochloride are formed at equilibrium after starting with 2.00 moles of $Br_{2(g)}$ and 4.00 moles of $Cl_{2(g)}$. Calculate Kc. (6)

PART C: Ksp (including common ion)

(a) Will a precipitate form when 65.0 mL of 0.0200 M Ag_2SO_4 is mixed with 50.0 mL of 0.00500 M K_2CO_3? (Ksp for silver carbonate is 8.00×10^{-12}). (4)

(b) A solution containing lead(II) ions and a solution containing chloride ions are mixed and a precipitate starts to form. If the concentration of chloride ions is 0.25 M, what is the concentration of Pb^{2+} ions? (Ksp for Lead(II) chloride = 1.7×10^{-5}). (4)

(c) Calculate the Ksp for lead(II) chloride that has a solubility of 1.585×10^{-2}M at 298K. (2)

(d) Calculate the molar solubility of $BaSO_4$ (Ksp = 1.1×10^{-10}M) in, water AND in a solution containing 1.0 M barium ions. (4)