

## All kinds of Equilibria Practice

Answer the following questions showing all your work!

Use <https://www.chem.purdue.edu/gchelp/howtosolveit/Equilibrium/ICEchart.htm> and <http://users.stlcc.edu/gkrishnan/solubilityproduct.html>

### Part I. ICE diagrams and other Equilibrium Practice besides K<sub>sp</sub>

1. Given the following reaction at equilibrium: 
$$\text{N}_2\text{O}_4(\text{g}) \leftrightarrow 2\text{NO}_2(\text{g})$$

Initially, 0.0400 mol  $\text{N}_2\text{O}_4(\text{g})$  are placed in a previously evacuated flask and heated to 100°C. When equilibrium is established at 100°C, the equilibrium concentration of  $\text{N}_2\text{O}_4(\text{g})$  is found to be 0.0134 M. The volume of the flask is 1.00 L.

(A) Calculate the equilibrium concentration of  $\text{NO}_2(\text{g})$ .

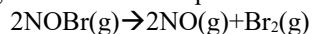
(B) Calculate the equilibrium constant,  $K_c$ , for the reaction at 100°C.

(C) In another experiment, equilibrium was approached from the other direction by injecting a quantity of  $\text{NO}_2(\text{g})$  into a previously evacuated flask. After equilibrium is established in this system at 100°C, the equilibrium concentration of  $\text{NO}_2$  is found to be 0.0243 M. Find the equilibrium concentration of  $\text{N}_2\text{O}_4$  in the system.

2.  $K_c$  for the reaction: 
$$2\text{ICl}(\text{g}) \leftrightarrow \text{I}_2(\text{g}) + \text{Cl}_2(\text{g})$$

is 0.11 at a certain temperature. Suppose the initial concentrations (mol/L) of  $\text{ICl}$ ,  $\text{I}_2$ , and  $\text{Cl}_2$  are 0.20 M, 0.00 M, and 0.00 M, respectively. Some of the  $\text{ICl}$  decomposes and the system reaches equilibrium. What is the equilibrium concentration of each species?

3. The following reaction has an equilibrium constant  $K_c$  equal to  $3.07 \times 10^{-4}$  at 24°C.



For each of the following compositions, decide whether the reaction mixture is at equilibrium. If it is not, decide which direction the reaction should go.

A)  $[\text{NOBr}] = 0.0610\text{M}$ ,  $[\text{NO}] = 0.0151\text{M}$ ,  $[\text{Br}_2] = 0.0108\text{M}$

B)  $[\text{NOBr}] = 0.115\text{M}$ ,  $[\text{NO}] = 0.0169\text{M}$ ,  $[\text{Br}_2] = 0.0142\text{M}$

C)  $[\text{NOBr}] = 0.181\text{M}$ ,  $[\text{NO}] = 0.0123\text{M}$ ,  $[\text{Br}_2] = 0.0201\text{M}$

## Part II. K<sub>sp</sub>

- Write an equation that describes the equilibrium present in a saturated solution of Cu<sub>3</sub>PO<sub>4</sub>.
- 53 g of Na<sub>2</sub>CO<sub>3</sub> are dissolved in sufficient water to make 5.0 L of solution.
  - Write the equation for the dissolution of Na<sub>2</sub>CO<sub>3</sub> into its aqueous ions.
  - Calculate the concentration of each ion in solution.
  - Describe the change in entropy as the Na<sub>2</sub>CO<sub>3</sub> dissolves.
- Write an equilibrium equation and a K<sub>sp</sub> expression for only those salts that have low solubility:
  - Cu<sub>2</sub>S
  - PbI<sub>2</sub>
  - Al<sub>2</sub>(SO<sub>4</sub>)<sub>3</sub>
- A 1.0 M solution of sodium sulphide is added to a 1.0 M solution of copper (II) chloride resulting in the formation of a precipitate.
  - Write the formula of the precipitate.
  - Write the formula equation for the reaction.
  - Write the net ionic equation for the reaction.
- Calculate the concentration of each ion in the following saturated solutions:
  - Al(OH)<sub>3</sub>    K<sub>sp</sub> = 3.0 x 10<sup>-33</sup>
  - Pb(IO<sub>3</sub>)<sub>2</sub>        K<sub>sp</sub> = 3.7 x 10<sup>-13</sup>
- A suspension of barium sulphate is used to improve the quality of X-rays in the digestive system. If the patient is required to drink 0.400 L of this suspension, calculate the actual mass in grams of the dissolved BaSO<sub>4</sub>.
- What maximum [F<sup>-</sup>] exists in a solution in which the [Sr<sup>2+</sup>] = 4.4 x 10<sup>-3</sup> M?
- Show by calculation if a precipitate forms when 10.0 mL of 0.010 M AgNO<sub>3</sub> are mixed with an equal volume of 0.10 M Na<sub>2</sub>CO<sub>3</sub>.