

Equilibrium

1. If $\text{Pb}(\text{NO}_3)_2$ solution and KI solution are mixed, a precipitate is formed.

a) Write an equation for this reaction.

b) Sketch a graph showing what happens to the amount of Pb^{2+} ions, I^- ions and the precipitate during the course of this reaction.

c) How do you know that the reaction has reached equilibrium?

d) How could you show that the reaction has not stopped at equilibrium?

a) _____

c) _____

d) _____

2. Study the equilibrium graph shown here.

a) What substances are present at equilibrium?

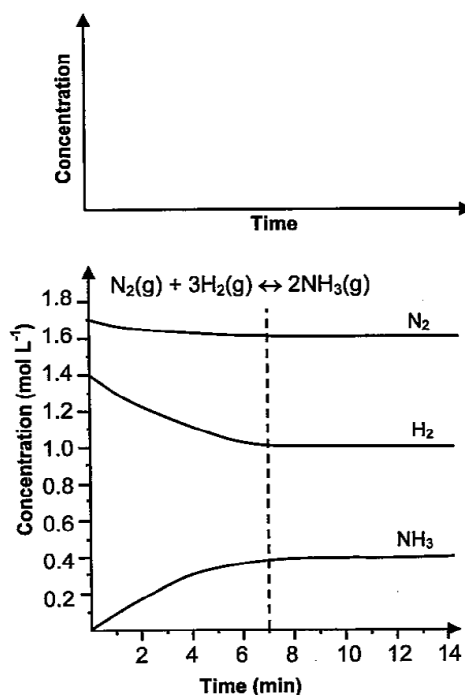
b) What is the final concentration of each of these substances?

c) What is the concentration of each of these substances at time = 3 minutes?

d) When did the concentration of H_2 reach 1.2 mol L^{-1} ?

e) When did the reaction reach equilibrium?

f) What is the concentration of each substance at equilibrium?



4. In an aqueous solution of a mixture of $\text{K}_2\text{Cr}_2\text{O}_7$ and K_2CrO_4 in equilibrium, what would be the effect of adding the following:

a) Sodium hydroxide solution _____

b) Hydrochloric acid solution _____

c) Water _____

6. When copper carbonate is heated, it decomposes into copper oxide and carbon dioxide. Explain both at molecular level and macroscopic level, what happens in this reaction if performed in a) an open container, b) sealed container.

a) _____

b) _____

7. What effect would decreasing the pressure have on each of the following systems in equilibrium:

a) $\text{CO(g)} + 2\text{H}_2\text{(g)} \rightleftharpoons \text{CH}_3\text{OH(g)}$? _____

b) $\text{H}_2\text{(g)} + \text{Cl}_2\text{(g)} \rightleftharpoons 2\text{HCl(g)}$? _____

c) $2\text{HgO(s)} \rightleftharpoons 2\text{Hg(l)} + \text{O}_2\text{(g)}$? _____

d) $2\text{H}_2\text{O(g)} + 2\text{I}_2\text{(g)} \rightleftharpoons 4\text{HI(g)} + \text{O}_2\text{(g)}$? _____

8. What effect would raising the reaction temperature have on the equilibrium position of each of the following equilibrium systems:

a) $\text{SO}_3\text{(g)} + \text{CO(g)} \rightleftharpoons \text{SO}_2\text{(g)} + \text{CO}_2\text{(g)}$ $\Delta H = -120 \text{ kJ mol}^{-1}$

b) $\text{S(s)} + \text{O}_2\text{(g)} \rightleftharpoons \text{SO}_2\text{(g)}$ $\Delta H = -297 \text{ kJ mol}^{-1}$

c) $\text{COCl}_2\text{(g)} \rightleftharpoons \text{CO(g)} + \text{Cl}_2\text{(g)}$ $\Delta H = 108 \text{ kJ mol}^{-1}$

a) _____

b) _____

c) _____

9. What would be the effect of lowering the temperature in the above systems?

a) _____

b) _____

c)  _____

10. Write the equilibrium expressions for the following reactions:

a) $\text{Ca(OH)}_2\text{(s)} \rightleftharpoons \text{Ca}^{2+}\text{(aq)} + 2\text{OH}^-\text{(aq)}$ _____

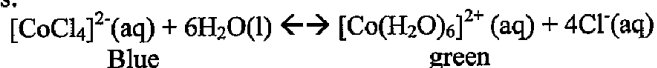
b) $\text{N}_2\text{(g)} + 3\text{H}_2\text{(g)} \rightleftharpoons 2\text{NH}_3\text{(g)}$ _____

c) $2\text{NO(g)} + \text{O}_2\text{(g)} \rightleftharpoons 2\text{NO}_2\text{(g)}$ _____

d) $\text{MnO}_4^-\text{(aq)} + 5\text{Fe}^{2+}\text{(aq)} + 8\text{H}^+\text{(aq)} \rightleftharpoons \text{Mn}^{2+}\text{(aq)} + 5\text{Fe}^{3+}\text{(aq)} + 4\text{H}_2\text{O}$ _____

e) $2\text{MnO}_4^-\text{(aq)} + 5\text{H}_2\text{C}_2\text{O}_4\text{(aq)} + 6\text{H}^+\text{(aq)} \rightleftharpoons 2\text{Mn}^{2+}\text{(aq)} + 10\text{CO}_2\text{(g)} + 8\text{H}_2\text{O(l)}$ _____

11. A paper dipped in cobalt chloride solution (blue) can be used as an indicator of humidity in air (turns green). The paper soaked in the solution and dried will absorb moisture from the air as follows:

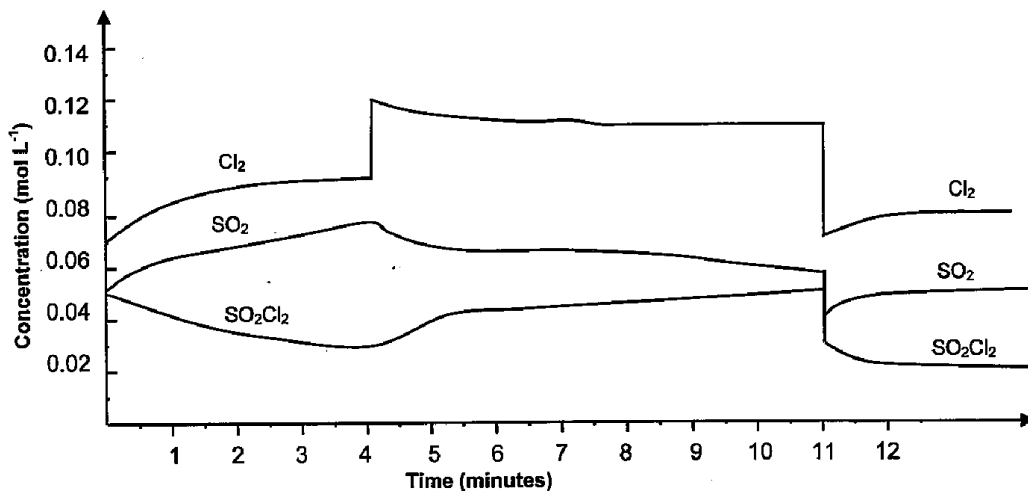


a) Write an equilibrium expression for the reaction.

b) If you sprinkle some common salt solution (Cl^{-} ions) on the paper, what will you observe? Explain your observation.

c) On a dry day, what change will you observe in a blue cobalt chloride paper and on a green cobalt paper? Explain your observation.

12. The graph below shows an experiment in which the effects of changes to equilibrium in the reaction, $\text{SO}_2\text{Cl}_2(\text{g}) \rightleftharpoons \text{SO}_2(\text{g}) + \text{Cl}_2(\text{g})$ $\Delta H = 67\text{kJ mol}^{-1}$ are indicated.



a) What substances are present at the beginning of the reaction and what are their concentrations?

b) How long did it take for the reaction to reach its first equilibrium?

c) Write an equilibrium expression for this reaction.

d) Describe the change introduced and the effects that followed at time, $t = 4$ min.

e) When did the system reach equilibrium next?