Equilibrium and Le Châtelier's Principle

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1 Discussion

1. $\mathrm{NaCl}_{(s)} \rightleftharpoons \mathrm{Na}^{+}_{(aq)} + \mathrm{Cl}^{-}_{(aq)}$

   For this system, HCl is added to apply a stress by introducing Cl^{-} ions. This forces the system to the left which then precipitates sodium chloride from the solution. This is because the system wants to move away from the extra chlorine ions due to Le Châtlier's Principle.

2. $\underbrace{\mathrm{HIn}_{(aq)}}_{\text{yellow}} \rightleftharpoons \mathrm{H}^{+}_{(aq)} + \underbrace{\mathrm{In}^{-}_{(aq)}}_{\text{blue}}$

   First, HCl is added which adds hydrogen ions to the system. Then, NaOH is added which reduces the amount of hydrogen ions since they combine with the hydroxide ions. Adding hydrogen ions made the solution turn yellow and removing the hydrogen ions made the solution turn blue. This means that HCl drives the reaction to the left whereas the NaOH drives it to the right. In the first case, the added HCl increases the concentration of hydrogen ions which then wants to go to the left, and in the second case the reduction in hydrogen ions makes the hydrogenated indicator break apart and shift the concentrations to the right.

3. $\underbrace{\mathrm{Fe}^{3+}_{(aq)}}_{\text{colorless}} + \underbrace{\mathrm{SCN}^{-}_{(aq)}}_{\text{colorless}} \rightleftharpoons \underbrace{\mathrm{FeSCN}^{2+}_{(aq)}}_{\text{red}-\text{brown}}$

   First, KSCN crystals are added. The solution becomes a darker brown. The added thiocyanate ions stress the system and move it to the right, which corresponds to more Iron (III) thiocyanate ions making a darker brown color. To minimize the change, by Le Châtlier's Principle, the reaction must shift to the right.

   Second, Iron (III) nitrate is added to stress the system which makes it redder. This means the reaction moves to the right. Due to the increase in Iron (III) ions, the

system must shift to the right in accordance with Le Châtlier's Principle since the change must be minimized.

Third, Na_2HPO_4 is added. This makes the solution become colorless, which corresponds to a shift to the left. Since adding this to the solution is equivalent to removing iron ions, a decrease in the Fe^{3+} concentration is made. Then, to fix the instability, the reaction shifts to the left, reducing the Iron (III) thiocyanate ion concentration which clears the red-brown color.

4. $\underbrace{Co(H_2O)_6{}^{2+}_{(s)}}_{\text{pink}} + 4Cl^-_{(s)} + 50kJ \rightleftharpoons \underbrace{CoCl_4{}^{2-}_{(aq)}}_{\text{blue}} + 6H_2O^{2+}_{(l)}$

Adding distilled water to the alcoholic cobalt solution has the effect of making it turn to a more lavender color, which is pinker. This is a shift to the left. Since water appears on the right side of the reaction, the increase in concentration will force the reaction to the left.

The addition of hydrochloric acid makes the solution turn bluer (cyan), which is a shift to the right. This is because chlorine ions are added, and the increase of the concentration of chlorine on the right side makes the reaction shift to the left, turning it blue due to the $CoCl_4{}^{2-}$ ions.

Sodium chloride made the solution turn a bit bluer, so there is a right shift. This is due to the same reasoning for hydrochloric acid. The extra chlorine ions shift the reaction to the right due to Le Châtlier's Principle.

The addition of silver nitrate made the solution turn pinker. This corresponds to a shift to the left. The silver nitrate reacts with the chloride ions to make silver chloride which precipitates, reducing the concentration of chloride ions. According to Le Châtlier's Principle, the sudden decrease in chlorine ions will be accompanied by an increase of compounds on its side, so there is a shift to the left, making the solution pinker.

Heating the solution of alcoholic cobalt solution makes it blue and cooling it makes it a pink. So, when it is warm, the reaction is shifted to the right, and when it is cool, the reaction is shifted to the left. Since an increase in temperature is an increase in energy, there is a greater amount of energy on the left side at a higher temperature, making the reaction shift to the right, turning the solution blue. At a lower temperature, there is less energy on the right side, so the concentrations on the right side decrease to compensate and shift to the left, turning the solution pink.