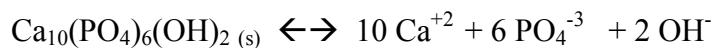# Lecture Notes Z: Solubility III

## 1) pH effects on solubility

**Tooth Decay**

The enamel covering of your teeth contains the mineral hydroxyapatite, $Ca_{10}(PO_4)_6(OH)_2$, which dissolves in water to give:
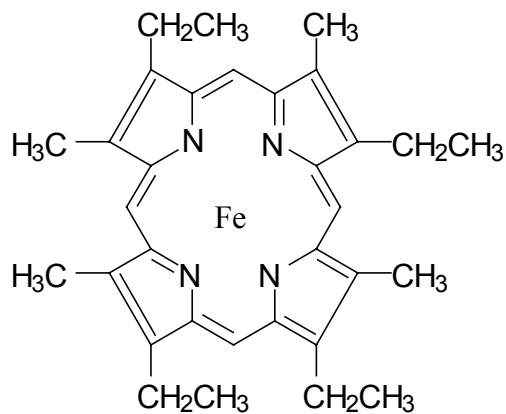
$$Ca_{10}(PO_4)_6(OH)_{2\ (s)} \longleftrightarrow 10\ Ca^{+2} + 6\ PO_4^{-3} + 2\ OH^-$$

*Concept*

Is hydroxyapatite more soluble in:

a) acidic solution      b) neutral water      c) basic solution

## 2) *Complex ion formation*

[Structure of an iron porphyrin complex with substituents: CH₂CH₃, CH₃, H₃C, CH₂CH₃, Fe center, H₃C, CH₃, CH₂CH₃, CH₂CH₃]

**Ligands binding to metals**
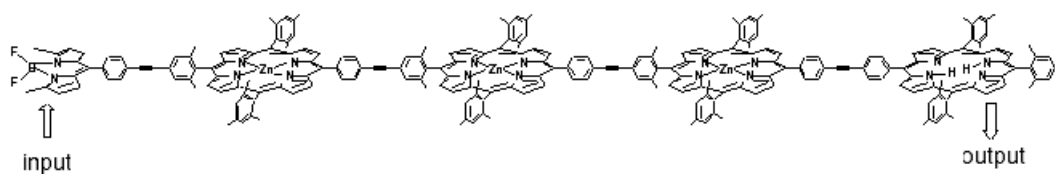
Research of Jonathan S. Lindsey (http://www2.ncsu.edu/ncsu/chemistry/jsl.html)

A Light-Harvesting Array
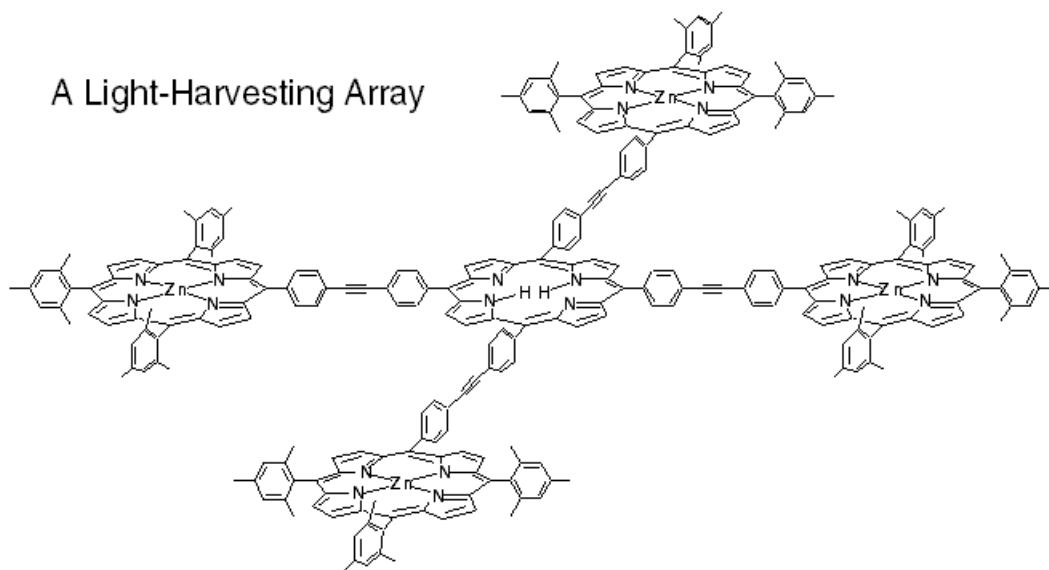
A Molecular Photonic Wire

input                                                                      output

### Problem

$$Zn^{+2} \qquad + NH_3 \longleftrightarrow Zn(NH_3)^{+2} \qquad K_1 = 1.5 \times 10^2$$
$$Zn(NH_3)^{+2} \quad + NH_3 \longleftrightarrow Zn(NH_3)_2^{+2} \qquad K_2 = 1.8 \times 10^2$$
$$Zn(NH_3)_2^{+2} \quad + NH_3 \longleftrightarrow Zn(NH_3)_3^{+2} \qquad K_3 = 2 \times 10^2$$
$$Zn(NH_3)_3^{+2} \quad + NH_3 \longleftrightarrow Zn(NH_3)_4^{+2} \qquad K_4 = 90$$

$$Zn^{+2} \qquad + 4NH_3 \longleftrightarrow Zn(NH_3)_4^{+2} \qquad K_f = 4.9 \times 10^8$$
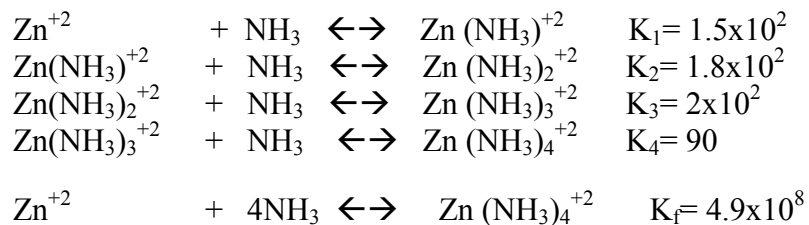
A solution is made that is 0.10M in $ZnCl_2$ and 1.0M in $NH_3$. What is the concentration of $Zn^{+2}$, $Zn(NH_3)_4^{+2}$ and $Zn(NH_3)_3^{+2}$ in the solution.

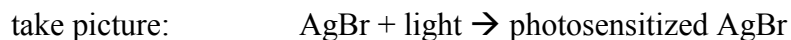$$Zn^{+2} \quad + \quad 4NH_3 \longleftrightarrow Zn(NH_3)_4^{+2} \qquad K_f = 4.9 \times 10^8$$

Init:
Start:
Eq:
Assume

$$K_4 = 90 = \frac{[Zn(NH_3)_4^{+2}]}{[Zn(NH_3)_3^{+2}][NH_3]} =$$

**Black and white photography**

The film is prepared by making an emulsion of silver halides (AgBr) in gelatin. When exposed to light, photochemical reactions convert the silver halide to a photosensitized form:
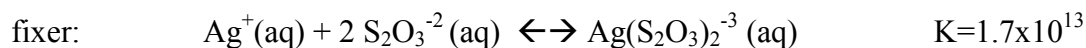
take picture:           AgBr + light $\rightarrow$ photosensitized AgBr

When exposed to hydroquinone developer, the photosensitized AgBr is reduced to metallic silver.

developer:           photosensitized AgBr + hydroquinone $\rightarrow$ Ag
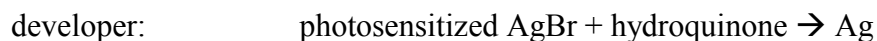
This development process is stopped with a "stopper" solution KBr, which is first put on the film and then washed off with water.

A fixer solution of sodium thiosulfate ($Na_2S_2O_3$), also called hypo, is then used to remove the unexposed AgBr. The $S_2O_3^{=}$ complexes with the silver, and makes the KBr soluble.

fixer:           $Ag^+(aq) + 2\ S_2O_3^{-2}(aq) \longleftrightarrow Ag(S_2O_3)_2^{-3}(aq)$           $K=1.7 \times 10^{13}$

The fixer also contains an acid that hardens the gelatin. The hypo is then washed off, otherwise it turns the films yellow by forming sodium sulfate ($Na_2SO_4$).

So the part of the film that was exposed to light now contains Ag metal. This gives a negative image. You must now repeat the process, to form a positive image on paper.
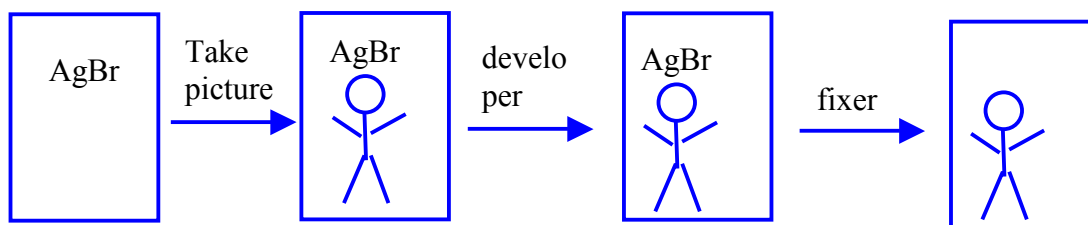
Compare the solubility of AgBr in water with that in a 0.2M solution of $Na_2S_2O_3$.  ($K_{sp}$ (AgBr) = $7.7 \times 10^{-13}$).