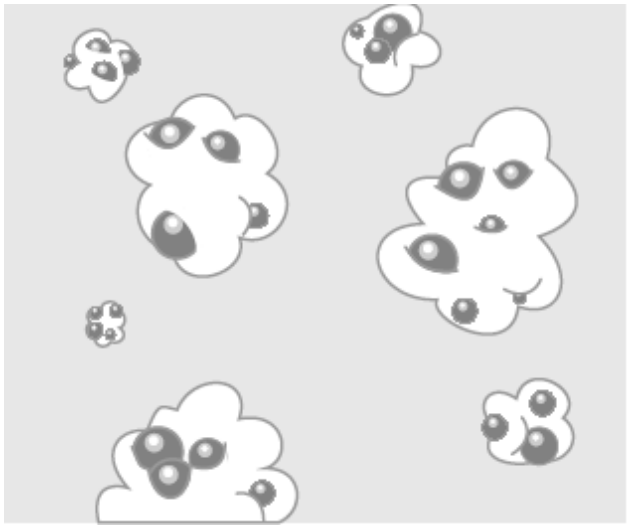
Coagulation Chemistry

- **Mechanism 1**. Alum [$Al_2(SO_4)_3 \cdot nH_2O$] and ferric chloride ($FeCl_3$) dissociate to release highly charged ions.
  - $Al_2(SO_4)_3 \cdot nH_2O \rightarrow 2\,Al^{3+} + 3\,SO_4^{2-} + nH_2O$
  - $FeCl_3 \rightarrow Fe^{3+} + 3\,Cl^-$
- These ions tend to bind either directly to particle surfaces (adsorb) or to NOM on those surfaces. Either way, they reduce the negative charge associated with the particles and reduce repulsion. Ideally, the charge is brought to near zero, and repulsion is almost eliminated.

Coagulation Chemistry

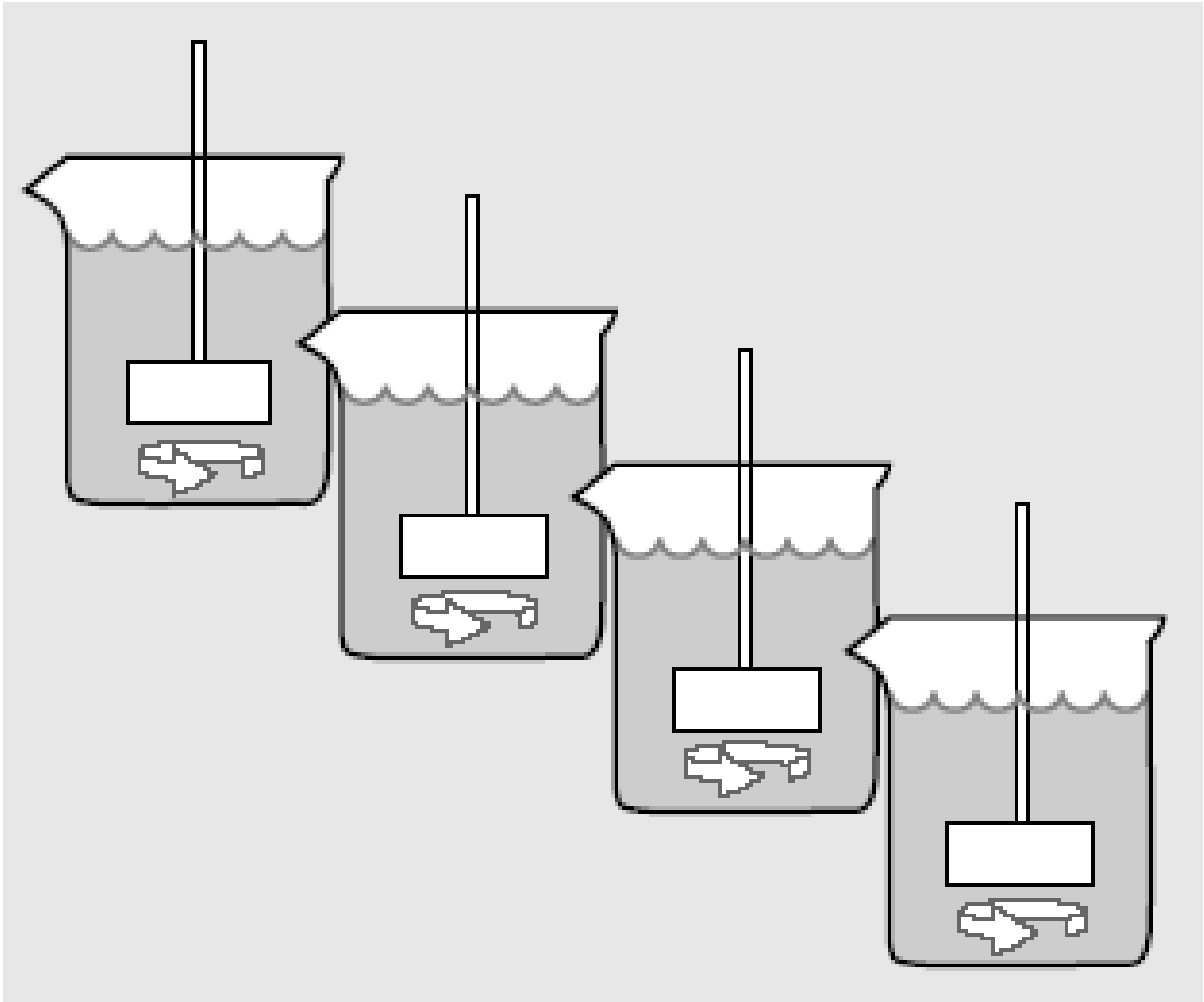
- **Mechanism 2**. At higher concentrations and pH, solids can precipitate and enmesh the colloids in a "sweep floc".

  - $Al^{3+} + 3OH^- \rightarrow Al(OH)_3(s)$
  - $Fe^{3+} + 3OH^- \rightarrow Fe(OH)_3(s)$



Optimizing Coagulation and Flocculation Conditions

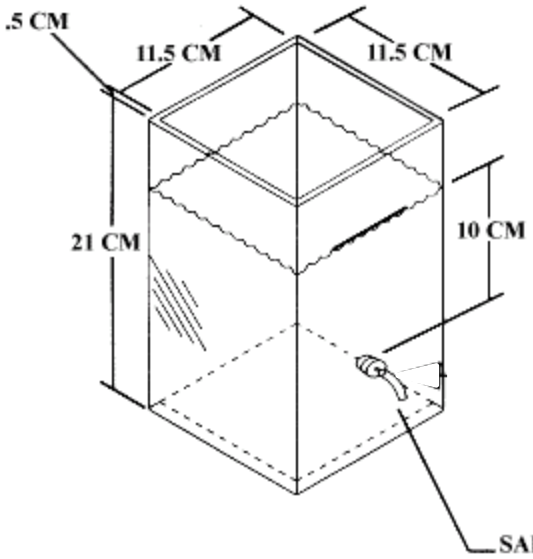
The optimum coagulant dose and mixing rate are determined by simulating both coagulation and flocculation in “jar tests.”



A Standard Jar-Test Apparatus

TYPICAL MIXING REGIME

RPM	MIN	G (s^{-1})
300	0.5	290
90	1.5	86
50	3.0	42
20	15	14



Coagulation Chemistry: Effects on the Acid/Base Balance

- Via chemical equilibrium reactions, consumption of OH^- in the precipitation step has a domino effect on the concentrations of H^+, OH^-, H_2CO_3, HCO_3^-, and CO_3^{2-}. The net changes can be determined by solving the equations for acid/base equilibrium:

$$\left(H^+\right)\left(OH^-\right)=10^{-14.0} \quad \frac{\left(H^+\right)\left(HCO_3^-\right)}{\left(H_2CO_3\right)}=10^{-6.3} \quad \frac{\left(H^+\right)\left(CO_3^{2-}\right)}{\left(HCO_3^-\right)}=10^{-10.3}$$

$$\left(H_2CO_3\right)+\left(HCO_3^-\right)+\left(CO_3^{2-}\right)=TOTCO_3$$

Coagulation Chemistry: Effects on the Acid/Base Balance

- The exact results can be obtained numerically, but the approximate change is conversion of one HCO_3^- to H_2CO_3 for each OH^- consumed, while *TOT*CO_3 remains constant:

$$\mathrm{Al^{3+} + 3\ OH^- \rightarrow Al(OH)_3(s)}$$

$$\mathrm{3\ H_2O \rightarrow 3\ H^+ + 3\ OH^-}$$

$$\mathrm{3\ HCO_3^- + 3\ H^+ \rightarrow 3\ H_2CO_3}$$

$$\mathrm{Al^{3+} + 3\ HCO_3^- + 3\ H_2O \rightarrow Al(OH)_3(s) + 3\ H_2CO_3}$$