Multiprotic acids

Phosphoric acid (triprotic)

$$H_2O + H_3PO_4 \leftrightarrow H_3O^+ + H_2PO_4^- \Rightarrow K_{a1} = \frac{[H_3O^+][H_2PO_4^-]}{[H_3PO_4]}$$

$$H_2O + H_2PO_4^- \leftrightarrow H_3O^+ + HPO_4^{2-} \Rightarrow K_{a2} = \frac{[H_3O^+][HPO_4^{2-}]}{[H_2PO_4^-]}$$

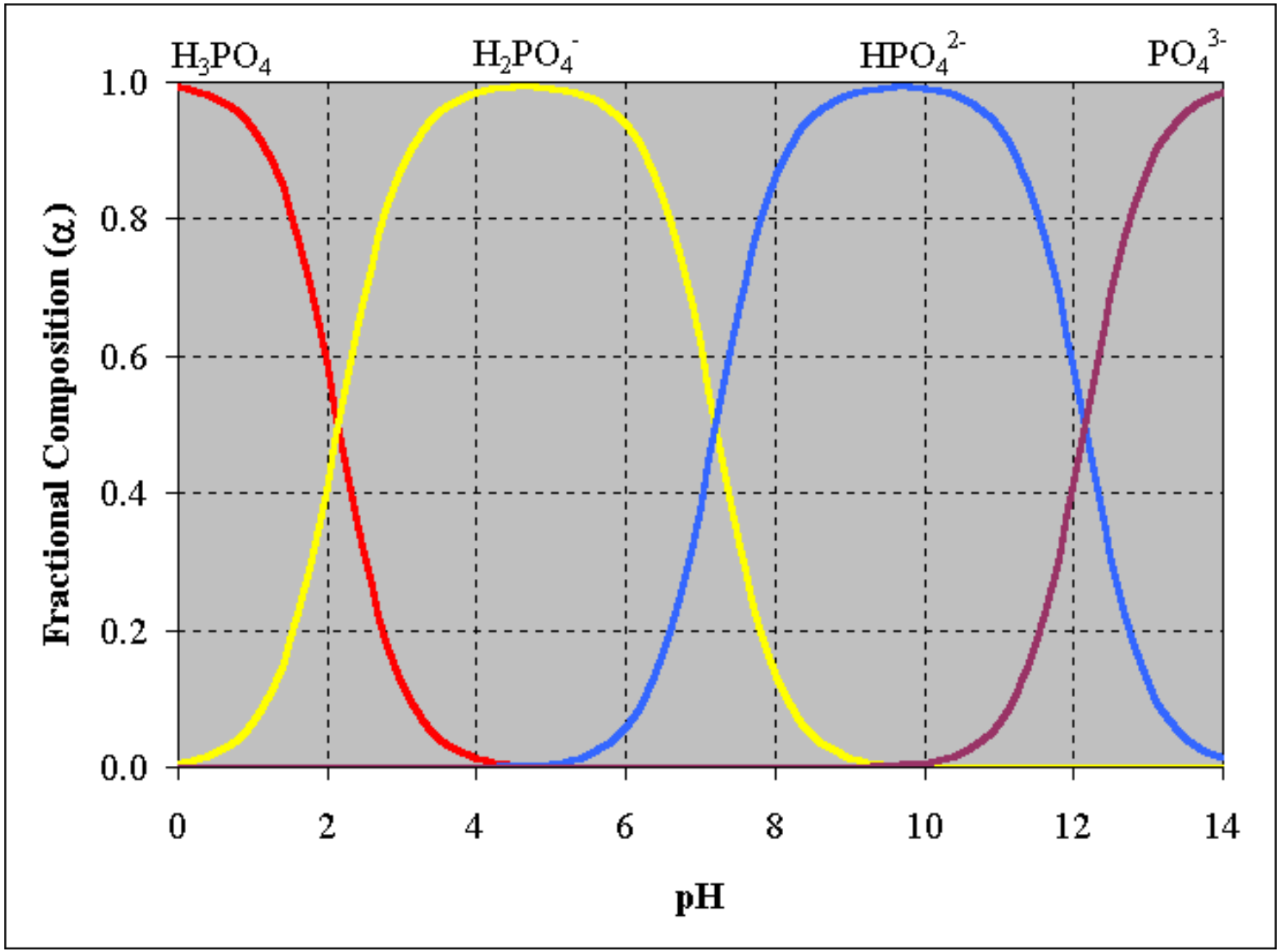
$$H_2O + HPO_4^{2-} \leftrightarrow H_3O^+ + PO_4^{3-} \Rightarrow K_{a3} = \frac{[H_3O^+][PO^{3-}]}{[HPO_4^{2-}]}$$

$$\alpha_{H_3A} = \frac{[H_3O^+]^3}{[H_3O^+]^3 + [H_3O^+]^2 K_{a1} + [H_3O^+] K_{a1} K_{a2} + K_{a1} K_{a2} K_{a3}}$$

$$\alpha_{H_2A^-} = \frac{[H_3O^+]^2 K_{a1}}{[H_3O^+]^3 + [H_3O^+]^2 K_{a1} + [H_3O^+] K_{a1} K_{a2} + K_{a1} K_{a2} K_{a3}}$$

$$\alpha_{HA^{2-}} = \frac{[H_3O^+] K_{a1} K_{a2}}{[H_3O^+]^3 + [H_3O^+]^2 K_{a1} + [H_3O^+] K_{a1} K_{a2} + K_{a1} K_{a2} K_{a3}}$$

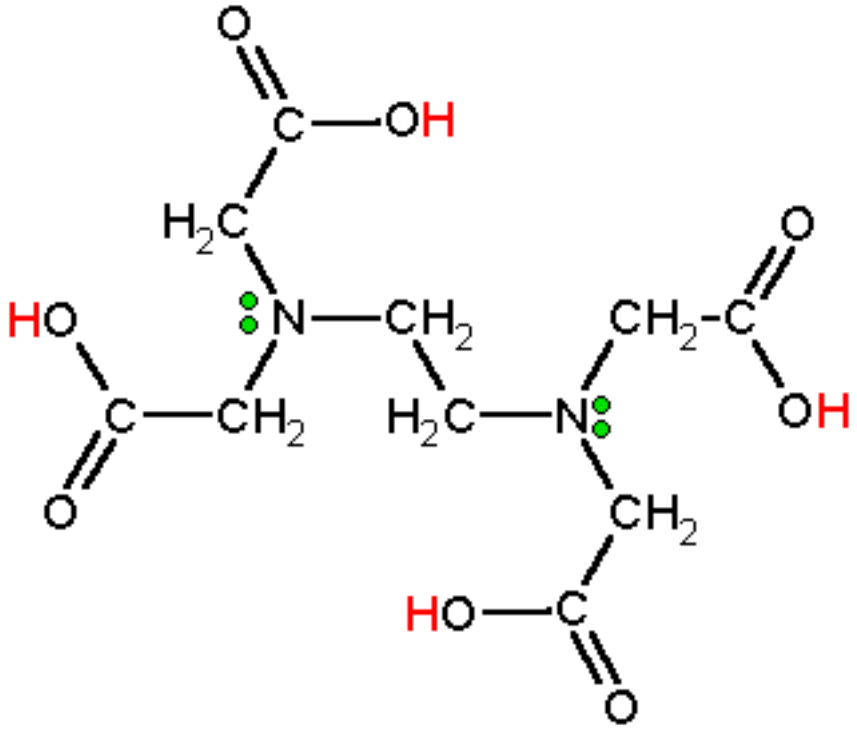
$$\alpha_{A^{3-}} = \frac{K_{a1} K_{a2} K_{a3}}{[H_3O^+]^3 + [H_3O^+]^2 K_{a1} + [H_3O^+] K_{a1} K_{a2} + K_{a1} K_{a2} K_{a3}}$$



Ca^{2+} precipitates with HPO_4^{2-} $K_{sp} = 2.6 \times 10^{-7}$

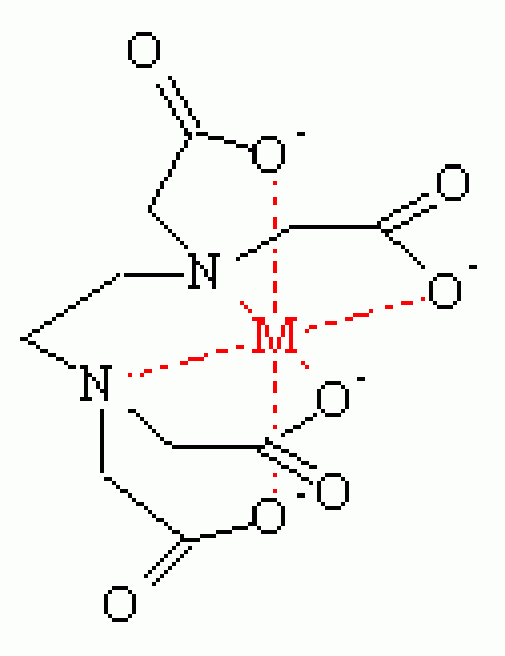
EDTA = ethylene diamine tetra-acetic acid

Polyprotic acid abbreviated H_4Y. It has five different charged states but only the Y^{4-} state forms stable complexes with metal cations.

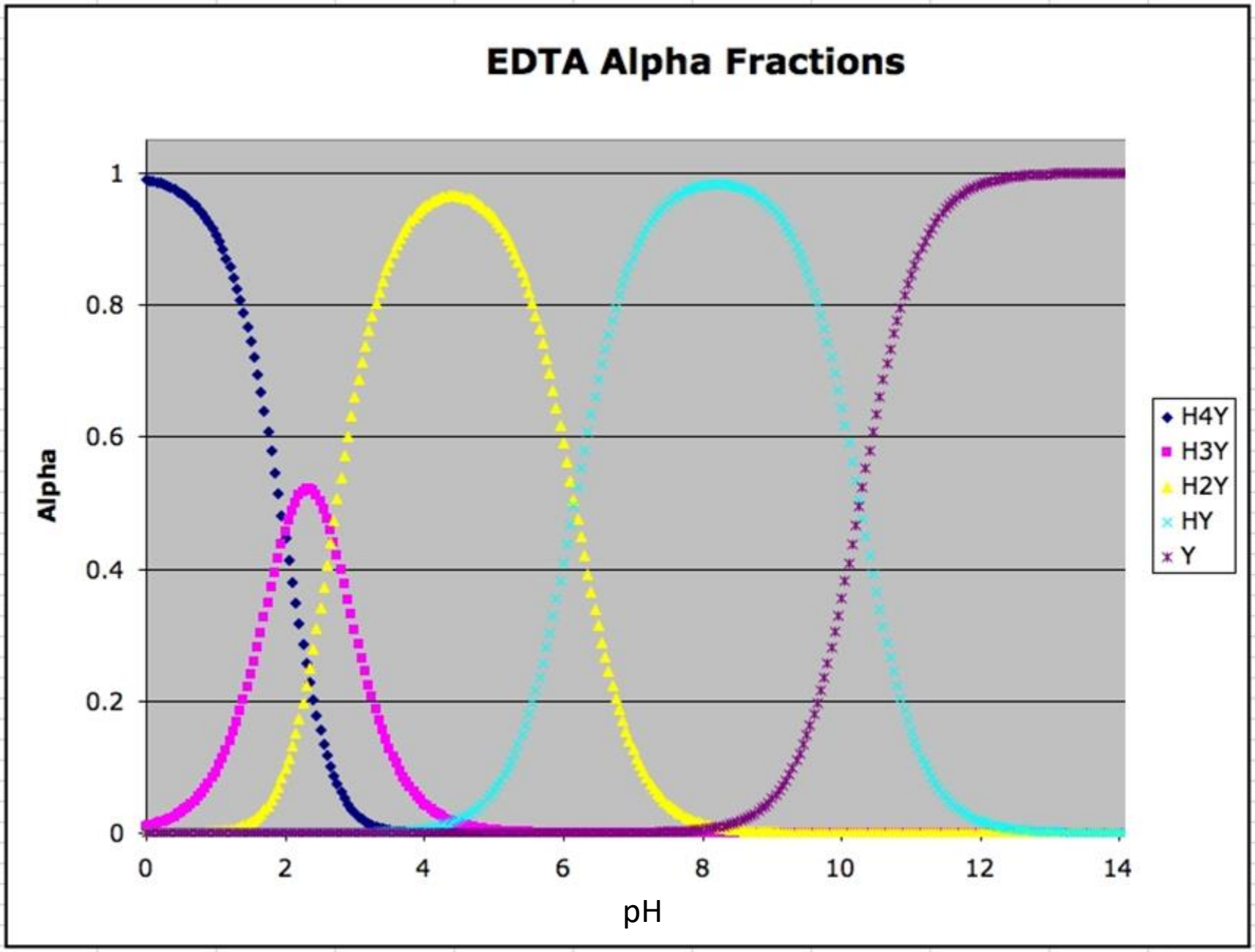


Complexation with Ca^{2+} occurs with Y^{4-}:

$$Ca^{2+} + Y^{4-} = CaY^{2-}$$



M = Ca^{2+}


EDTA Alpha Fractions
Alpha
1
0.8
0.6
0.4
0.2
0
0
2
4
6
8
10
12
14
pH
H4Y
H3Y
H2Y
HY
Y