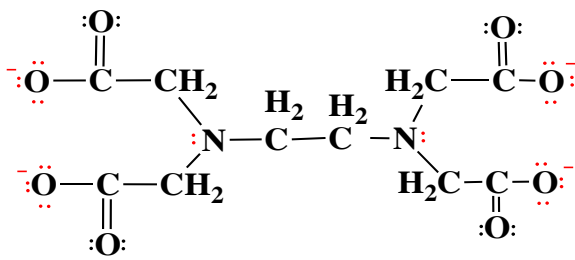


CONCEPT: EDTA

In its fully protonated form EDTA exists as a hexaprotic acid: _____ .



Ethylenediaminetetraacetate ion (EDTA⁴⁻)

$$pK_{a1} = 0.00$$

$$pK_{a2} = 1.50$$

$$pK_{a3} = 2.00$$

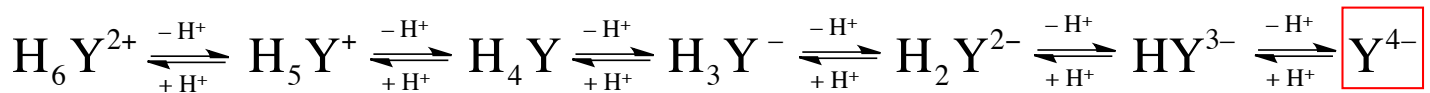
$$pK_{a4} = 2.69$$

$$pK_{a5} = 6.13$$

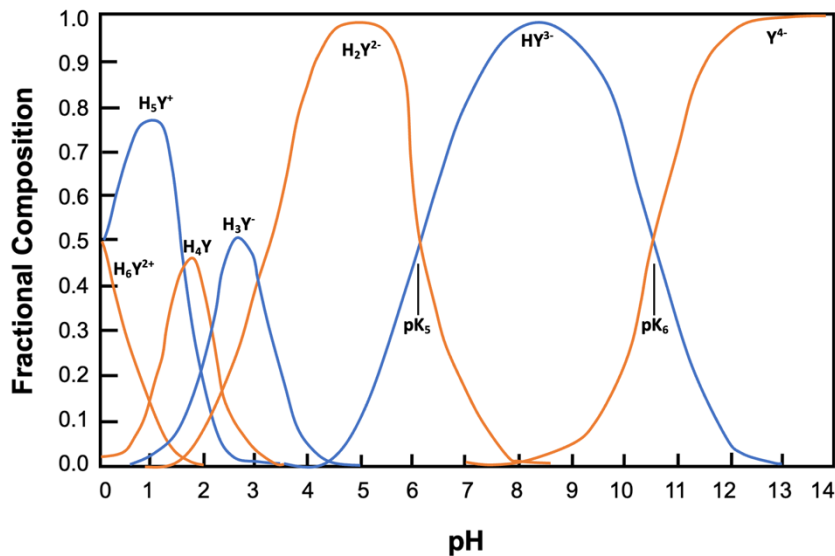
$$pK_{a6} = 10.37$$

In order to form metal-complexes these acidic hydrogens must first be lost.

- EDTA can exist in up to 7 different forms depending on the pH of the solution.



EDTA



To calculate the fraction of EDTA in its basic form we can utilize the following equation:

$$\alpha_{Y^{4-}} = \frac{[Y^{4-}]}{[EDTA]} = \frac{[Y^{4-}]}{[H_6Y^{2+}] + [H_5Y^+] + [H_4Y] + [H_3Y^-] + [H_2Y^{2-}] + [HY^{3-}] + [Y^{4-}]}$$

$$\alpha_{Y^{4-}} = \frac{K_{a1}K_{a2}K_{a3}K_{a4}K_{a5}K_{a6}}{[H^+]^6 + [H^+]^5K_{a1} + [H^+]^4K_{a1}K_{a2} + [H^+]^3K_{a1}K_{a2}K_{a3} + [H^+]^2K_{a1}K_{a2}K_{a3}K_{a4} + [H^+]K_{a1}K_{a2}K_{a3}K_{a4}K_{a5} + K_{a1}K_{a2}K_{a3}K_{a4}K_{a5}K_{a6}}$$

PRACTICE: EDTA CALCULATIONS 1

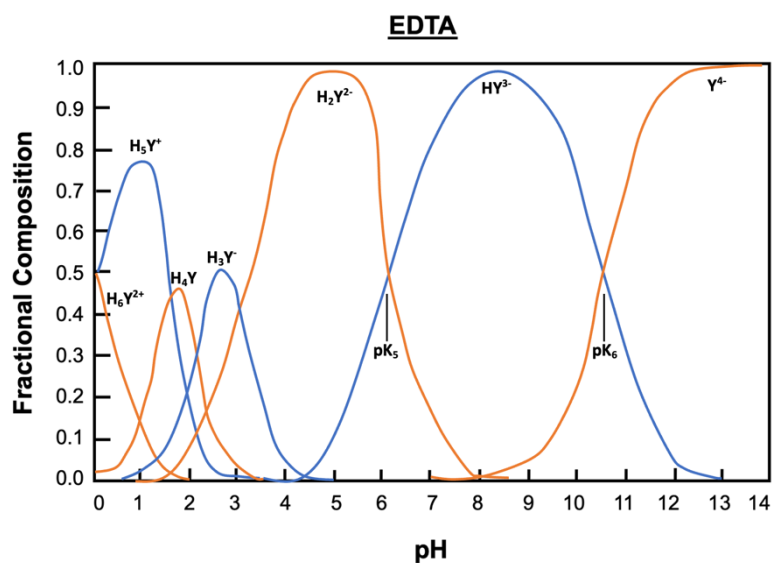
EXAMPLE 1: The formal concentration of EDTA is 1.50 mM. What is the concentration of the Y^{4-} form at a pH of 5.0?

pH	$\alpha_{Y^{4-}}$
0	1.3×10^{-23}
1	1.4×10^{-18}
2	2.6×10^{-14}
3	2.1×10^{-11}
4	3.0×10^{-9}
5	2.9×10^{-7}
6	1.8×10^{-5}
7	3.8×10^{-4}
8	4.2×10^{-3}
9	0.041
10	0.30
11	0.81
12	0.98
13	1.00
14	1.00

* 25 °C and $\mu = 0.10$ M

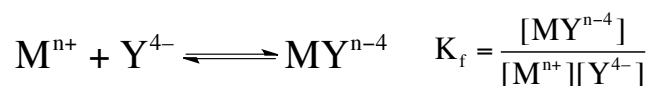
EXAMPLE 2: Determine the $\alpha_{Y^{4-}}$ for EDTA when the pH = 8.50.

PRACTICE: Determine the pH where $\alpha_{Y^{4-}}$ equals 0.20.



CONCEPT: EDTA COMPLEXES

The _____ represents the equilibrium constant for the reaction between a ligand and a metal.



The formation constants for metal-EDTA complexes are given below:

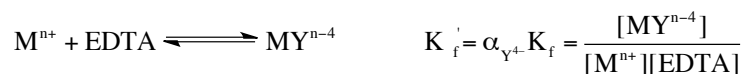
Ion	logK _f	Ion	logK _f	Ion	logK _f
Li ⁺	2.95	V ³⁺	25.9 ^a	Tl ³⁺	35.3
Na ⁺	1.86	Cr ³⁺	23.4 ^a	Bi ³⁺	27.8 ^a
K ⁺	0.8	Mn ³⁺	25.2	Ce ³⁺	15.93
Be ²⁺	9.7	Fe ³⁺	25.1	Pr ³⁺	16.30
Mg ²⁺	8.79	Co ³⁺	41.4	Nd ³⁺	16.51
Ca ²⁺	10.65	Zr ⁴⁺	29.3	Pm ³⁺	16.9
Sr ²⁺	8.72	Hf ⁴⁺	29.5	Sm ³⁺	17.06
Ba ²⁺	7.88	VO ²⁺	18.7	Eu ³⁺	17.25
Ra ²⁺	7.4	VO ₂ ⁺	15.5	Gd ³⁺	17.35
Sc ³⁺	23.1 ^a	Ag ⁺	7.20	Tb ³⁺	17.87
Y ³⁺	18.08	Tl ⁺	6.41	Dy ³⁺	18.30
La ³⁺	15.36	Pd ²⁺	25.6 ^a	Ho ³⁺	18.56
V ²⁺	12.7 ^a	Zn ²⁺	16.5	Er ³⁺	18.89
Cr ²⁺	13.6 ^a	Cd ²⁺	16.5	Tm ³⁺	19.32
Mn ²⁺	13.89	Hg ²⁺	21.5	Yb ³⁺	19.49
Fe ²⁺	14.30	Sn ²⁺	18.3 ^b	Lu ³⁺	19.74
Co ²⁺	16.45	Pb ²⁺	18.0	Th ⁴⁺	23.2
Ni ²⁺	18.4	Al ³⁺	16.4	U ⁴⁺	25.7
Cu ²⁺	18.78	Ga ³⁺	21.7		
Ti ³⁺	21.3	In ³⁺	24.9		

a: 20 °C and $\mu = 0.1$ M
b: 20 °C and $\mu = 1.0$ M

Only a portion of EDTA exists in its basic form and the lower the pH the more the other forms predominate.

$$[Y^{4-}] = \alpha_{Y^{4-}} [EDTA]$$

Under a fixed pH, $\alpha_{Y^{4-}}$ becomes a constant and can be used in determining the conditional formation constant because it represents the formation of MY^{n-4} at any pH value.



EXAMPLE: Find $[Ba^{2+}]$ in 0.10 M BaY^{2-} at pH = 10.00.

PRACTICE: EDTA COMPLEXES CALCULATIONS 1

EXAMPLE 1: Determine the conditional formation constant for $\text{Co}(\text{EDTA})^-$ at $\text{pH} = 8.00$.

EXAMPLE 2: Find the concentration of free Sn^{2+} in $0.20 \text{ M } \text{K}_2[\text{Sn}(\text{EDTA})]$ at $\text{pH} = 9.00$.

PRACTICE: Find the concentration of free Na^+ in $0.15 \text{ M } \text{Li}_3[\text{Na}(\text{EDTA})]$ at $\text{pH} = 10.00$.