The M-CATs

SEMINAR 8

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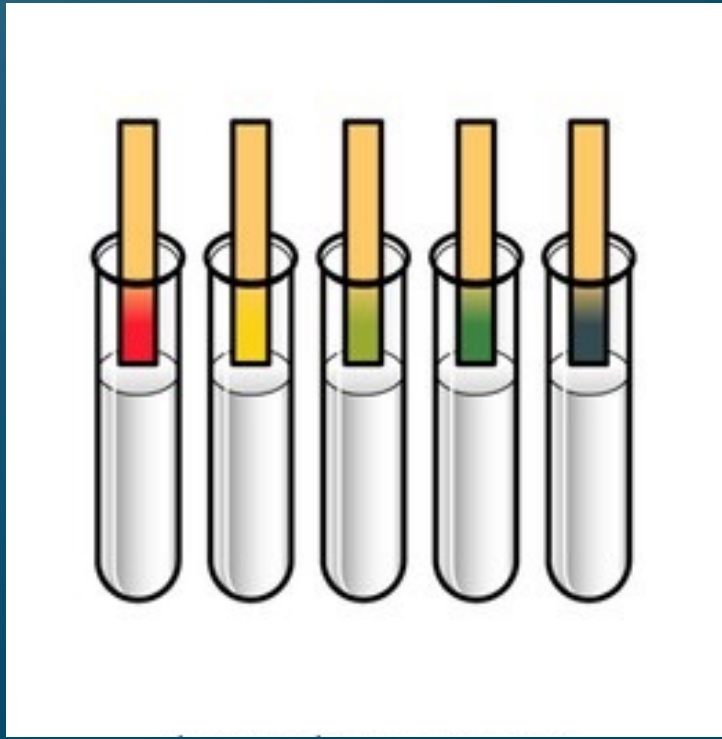
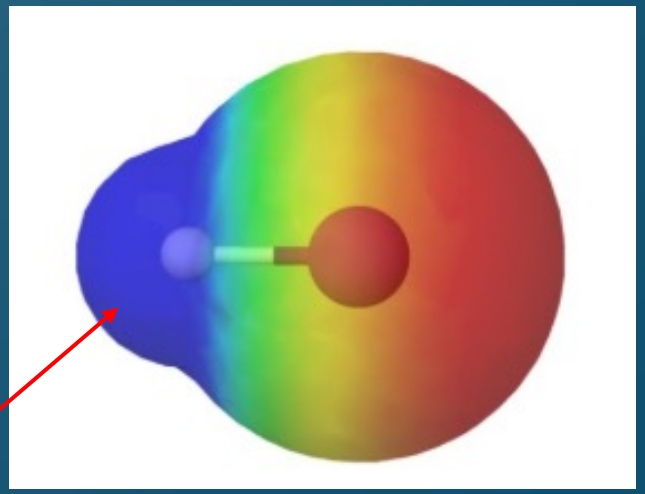
Acids & Bases

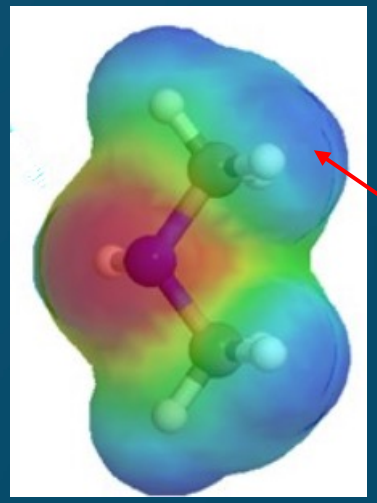


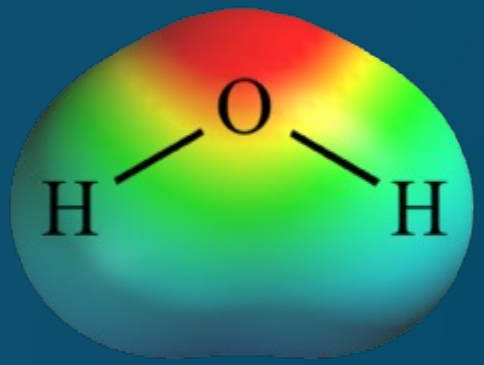
Basic Definition

Acid:
(+)



Base:
(-)





Arrhenius Theory

Acid: produces H+ (aq)

$$HCl\,(aq) \rightleftharpoons H^{+}(aq) + Cl^{-}(aq)$$

HCl, H2SO4, HClO4, HF…

Base: produces OH- (aq)

$$NaOH(aq) \rightleftharpoons Na^{+}(aq) + OH^{-}\,(aq)$$

NaOH, Ca(OH)2, KOH…

Brønsted-Lowry Theory

Acid: H^+ donor

Base: H^+ acceptor

$$HBr + NH_3 \rightleftharpoons Br^- + NH_4^+$$

10.1: Definitions

$$HCl\,(aq) \rightleftharpoons H^+(aq) + Cl^-(aq)$$
$$H^+\,(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq)$$

$$NaOH(aq) \rightleftharpoons Na^+(aq) + OH^-\,(aq)$$
$$OH^-(aq) + H_2O\,(l) \rightleftharpoons H_2O(l) + OH^-$$

Lewis Theory

Acid: e^- acceptor

Base: e^- donor

$$BF_3 + NH_3 \rightleftharpoons NH_3BF_3$$

10.1: Definitions

$$HBr + NH_3 \rightleftharpoons Br^- + NH_4^+$$

$$H^+\,(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq)$$

$$OH^-(aq) + H_2O\,(l) \rightleftharpoons H_2O(l) + OH^-(aq)$$

Autoionization of Water

$$H_2O(l) \rightleftharpoons OH^-(aq) + H^+\ (aq)$$

$$K_w = [H_3O^+][OH^-]$$

$$= (10^{-7}M)(10^{-7}M) = 10^{-14}\ (25^oC)$$

pH=-log[H^+]=log(1/[H+])]

pOH=-log[OH^-]=log(1/[OH^-])

pH+pOH=14

Question

(a). An unknown powder is dissolved in 2.0L of water at standard ambient temperature and pressure. The resulting solution contains 0.0035 mol of H+.

What is the pH of the solution?

A. 3.4
B. 2.8
C. 2.2
D. 6.7

(b)What is the pOH?

A. 11.2
B. 10.5
C. 10.8
D. 6.7

Ionization of Acids and Bases (aq)

Acid:

$$HA(aq) + H_2O(l) \rightleftharpoons A^-(aq) + H_3O^+\ (aq)$$

$$K_a = \frac{[A^-][H_3O^+]}{[HA]}$$

Base:

$$B(aq) + H_2O(l) \rightleftharpoons HB^+(aq) + OH^-\ (aq)$$

$$K_b = \frac{[OH^-][HB^+]}{[B]}$$

pH+pOH=14 @ SATP

Strong Acids and Bases (aq)

$$K_a or\ K_b \gg 1$$

$$HA + H_2O(l) \rightarrow A^-(aq) + H_3O^+\ (aq)$$
$$B + H_2O(l) \rightarrow HB^+(aq) + OH^-\ (aq)$$

Acid:

$IF\ [HA] \gg 10^{-7}M$: $\quad pH = -\log[HA]$

$IF\ [HA] \approx 10^{-7}M$: $\quad \mathrm{pH} = -\log([\mathrm{x} + \mathrm{HA}])$

$K_w = [H^+][OH^-] = [HA + x][x] = 10^{-14}$

HCl, HBr, HI, HNO3, H2SO4, HClO4, HClO3

Base:

$IF\ [B] \gg 10^{-7}M$: $\quad pOH = -\log[B]$

$IF\ [B] \approx 10^{-7}M$: $\quad \mathrm{pH} = -\log([\mathrm{x} + \mathrm{B}])$

$K_w = [H^+][OH^-] = [x][B + x] = 10^{-14}$

NaOH, KOH, Ca(OH)2, Ba(OH)2…

Question

A student prepares a solution by adding 2.0 mL of 0.010 M HCl to 998 mL of distilled water at 25°C. Part (a)What is the pH of the resulting solution?

A. 3.72
B. 4.70
C. 8.68
D. 6.70

The student performs a 1:100 dilution using 10 mL of the original solution under the same conditions.
(b) What is the pH of the resulting solution?

A. 5.45
B. 6.62
C. 6.80
D. 6.95

Weak Acids and Bases (aq)

Acid:

$HA(aq) + H_2O(l) \rightleftharpoons A^-(aq) + H_3O^+\ (aq)$

$$K_a = \frac{[A^-][H_3O^+]}{[HA]} < 1$$

$CH_3COOH(aq) + H_2O(l) \rightleftharpoons CH_3COO^-(aq) + H_3O^+\ (aq)$

Ka=1.8*10^{-5}, pKa=4.74 (25° C)

Base:

$B(aq) + H_2O(l) \rightleftharpoons HB^+(aq) + OH^-\ (aq)$

$$K_b = \frac{[OH^-][HB^+]}{[B]} < 1$$

$CH_3COO^-(aq) + H_2O(l) \rightleftharpoons CH_3COOH(aq) + OH^-(aq)$

Kb=5.5*10^{-10}, pKb=9.26 (25° C)

$2H_2O(l) \rightleftharpoons H_3O^+(aq) + OH^-(aq)$

$$K_a * K_b = K_w$$

$$\therefore pK_a + pK_b = 14$$

Question

A student prepares a 0.50 M solution of HF in water. The acid dissociation constant for HF at 25°C is:

$$K_a = 6.8\times10^{-4}$$

What is the solution's pH?

A. 1.0
B. 1.7
C. 2.3
D. 3.2

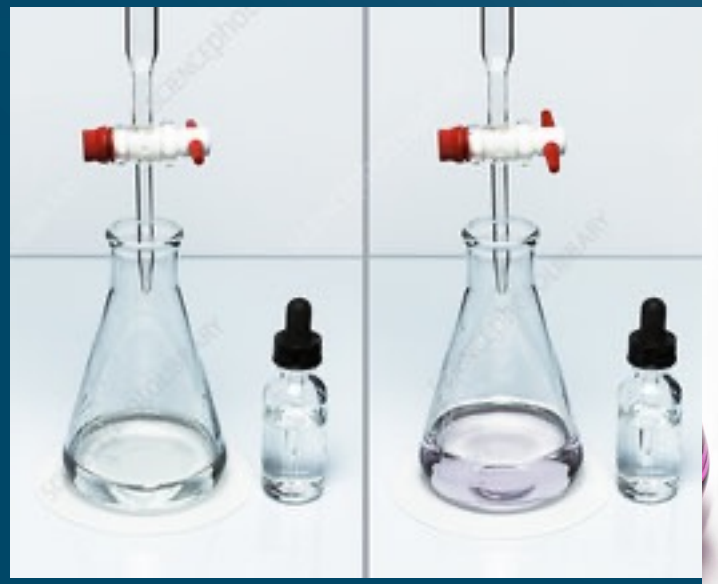
Neutralization

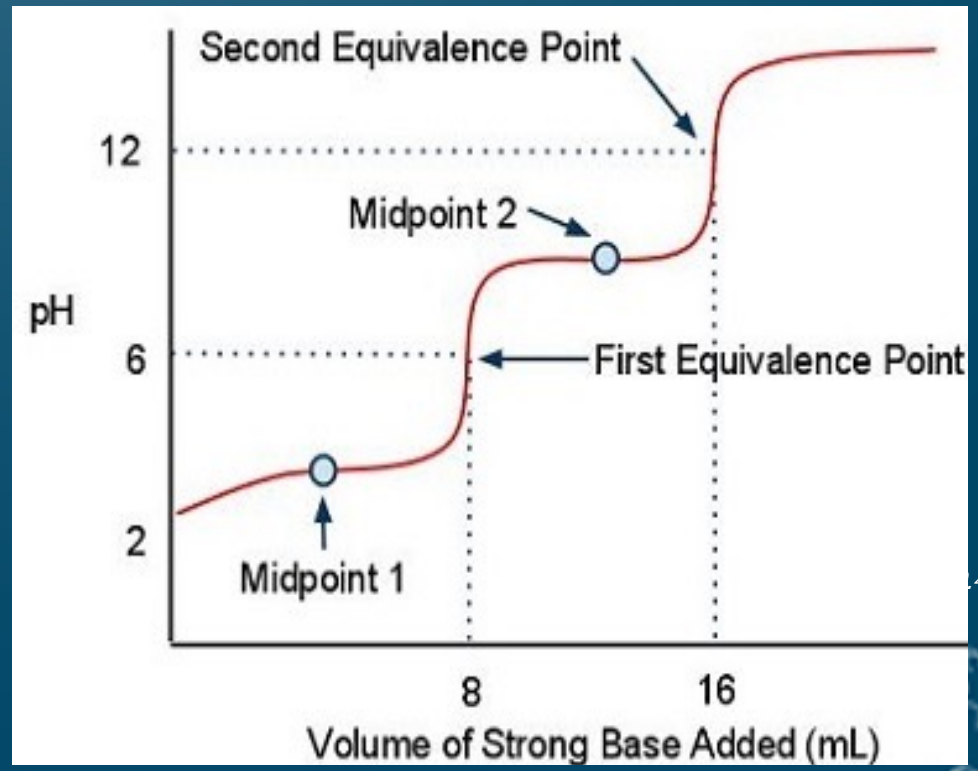
$$HA(aq) + BOH(aq) \rightarrow BA(s) + H_2O(l)$$

A strength	B strength	Product(s)	pH @ eq	E.g.
Strong	Strong	Salt+H2O	7	HCl(aq)+NaOH(aq)-> NaCl(aq)+H2O(l)
Strong	Weak	Salt	<7	HBr (aq)+NH3(aq)-> NH4Br(aq)
Weak	Strong	Salt+H2O	>7	HF(aq)+KOH(aq)->KF(aq)+H2O(l)
Weak	Weak	Salt	Idk	HCOOH(aq)+C5H5N(aq)->C5H5NH$^+$HCOO$^-$ (aq)

10.2: Properties

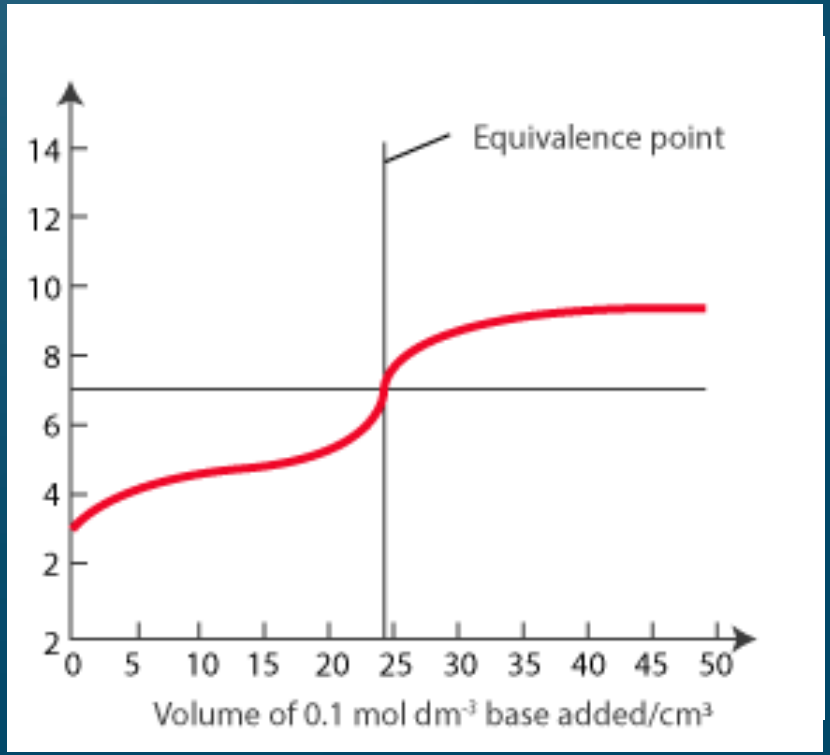
Acid-Base Titrations





Curves

A strength	B strength	pH @ eq
Strong	Strong	7
Strong	Weak	<7
Weak	Strong	>7
Weak	Weak	Idk



10.2: Titration and Buffers

Henderson-Hasselbalch Equation

$$pH = pK_a + \log\left[\frac{A^-}{HA}\right]$$

$$pOH = pK_b + \log\left[\frac{BH^{+-}}{B}\right]$$

Question

What is the pH of a solution made from 1 L of 0.05 *M* acetic acid (CH_3COOH, $K_a = 1.8 \times 10^{-5}$) mixed with 500 mL of 1 *M* acetate (CH_3COO^-)?

a. 3.9
b. 4.5
c. 5.2
d. 5.7

Question

A diprotic acid H_2Ahas:

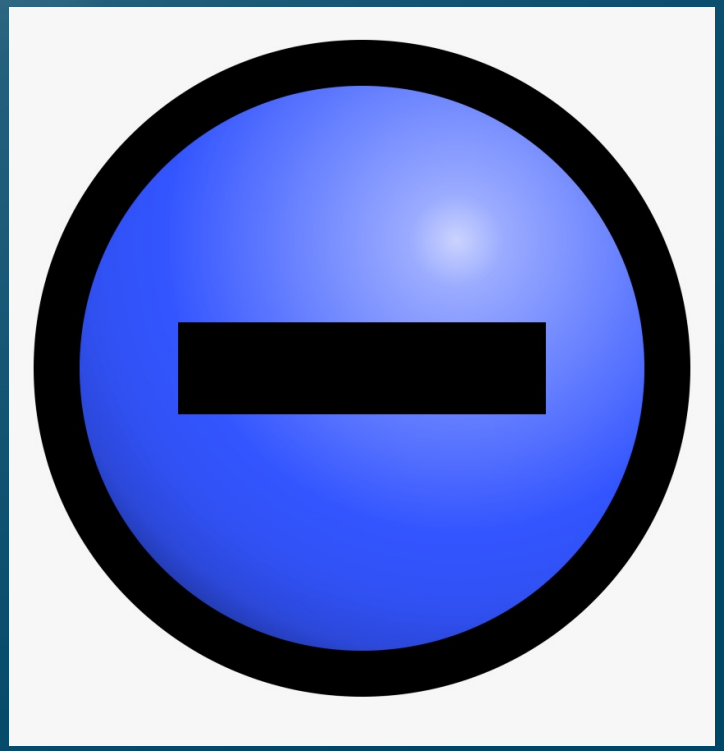
$$pK_{a1} = 3.0, pK_{a2} = 7.0$$

During titration with a strong base, the solution reaches the second equivalence point. Assume 25°C. What is the approximate pH at the second equivalence point?

A. 3.0
B. 5.0
C. 9.0
D. 11.0

General Chemistry Chapter 11

Redox Reactions



Redox Basics

$$RA^- + OA \rightarrow RA + OA^-$$

11.1 Oxidation-Reduction Rxns

Good OAs: O2, H2O2, X2, H2SO4, HNO3, NaClO, KMnO4, CrO3, NaCr2O7, PCC, NAD^+, FADH

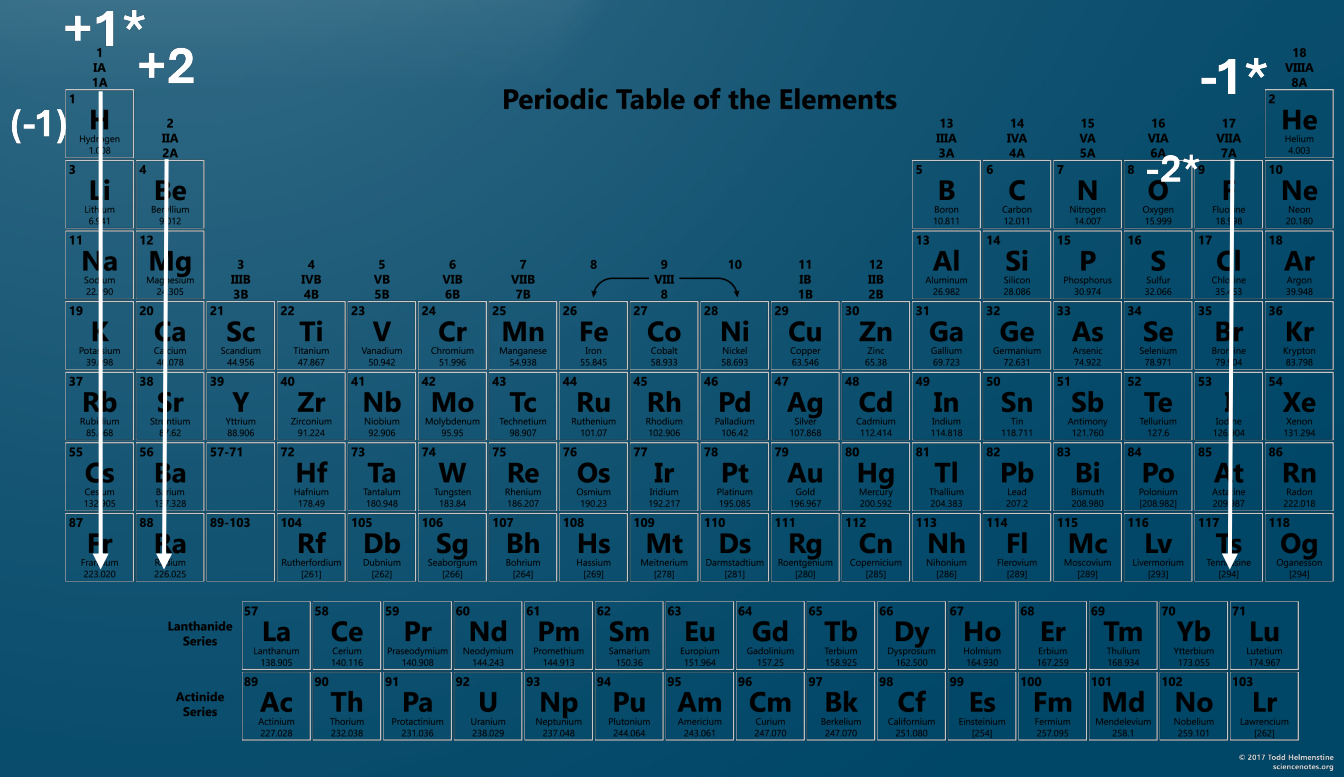
Good RAs: CO, C, B2H6, Sn2+, M^0s, hydrazine, ZnHg, Lindlar's cat., NABH4, LiAlH4, NADH, FADH2

Good OAs: O2, H2O2, X2, H2SO4, HNO3, NaClO, KMnO4, CrO3, NaCr2O7, PCC, NAD^+, FADH

Good RAs: CO, C, B2H6, Sn2+, M^0s, hydrazine, ZnHg, Lindlar's cat., NaBH4, LiAlH4, NADH, FADH2

Oxidation Number Rules

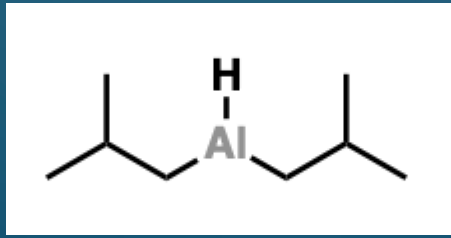
1. $Q_{net} = \sum O.N.$
2. Groups vs O.N. *



*Deviations due to relative electronegativity

Question

#X. The following molecule is often used in redox reactions. What is the most likely reason for this?



A. It is a reducing agent
B. It is an oxidizing agent
C. It can serve both as an electron acceptor or donor, catalyzing a redox reaction
D. It is a precursor to an oxidizing agent

Redox Half Reactions

1. Determine oxidation numbers

2. Split equations into half rxns

3. Balance all except H and O

4. Balance O and H per environment

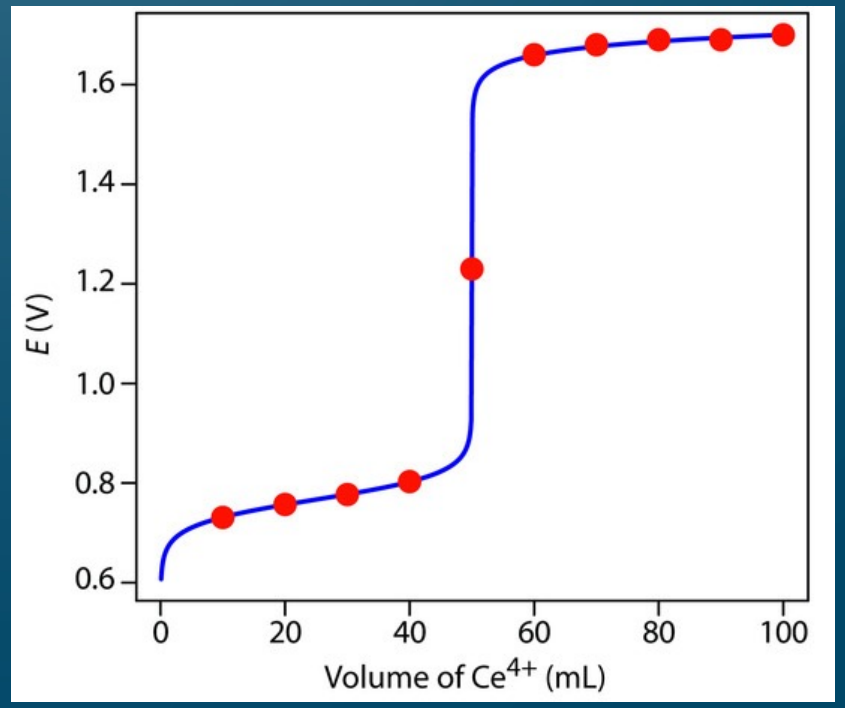
5. Balance e^-

Net Ionic Equations

For Redox:

1. Single Displacement
2. Combination
3. Decomposition
4. Combustion
5. Disproportionation

Redox Titrations



11.3: Titrations

Question

A 25.00 mL sample containing Fe^{2+} is titrated with 0.02000 M $KMnO_4$ in acidic solution to produce Fe^{3+} and Mn^{2+}. It requires 18.60 mL of the $KMnO_4$ solution to reach the endpoint.
The balanced reaction is:
What is the molarity of iron (II) in the sample in M?

a. 0.06700
b. 0.07440
c. 0.00850
d. 0.03260