IDX G10 Chemistry H
Study Guide Issue S1M2
By TaeYun Kang, Edited by Edward Chen

Contents:

Aqueous Solutions

Precipitation Reactions

- Definition – a pair of oppositely charged ions attract each other so strongly that they form an insoluble ionic solid
- Complete ionic equation – equation with all strong electrolytes split into ions
- Net ionic equation – equation showing only the ions and molecules reacting
- Spectator ions – ions which do not participate in the reaction
- E.g.:
    - Molecular Formula: $Pb(NO_3)_2(aq) + 2KI(aq) \rightarrow PbI_2(s) + 2KNO_3(aq)$
    - Complete Ionic Equation: $Pb^{2+}(aq) + 2NO_3^-(aq) + 2K^+(aq) + 2I^-(aq) \rightarrow PbI_2(s) + 2K^+(aq) + 2NO_3^-(aq)$
    - Net Ionic Equation: $Pb^{2+}(aq) + 2I^-(aq) \rightarrow PbI_2(s)$
    - Spectator Ions: K^+, NO_3^-
- Precipitation reactions are a type of exchange/metathesis/double replacement reaction:
    - $AX + BY \rightarrow BX + AY$

Acid, Bases, and Neutralization Reactions

- Acids – substances that dissociate in H_2O to produce H^+
    - H^+ – proton with no surrounding valence electrons
- Common Acids:
    - Monoprotic Acids: HCl, HNO_3, $HC_2H_3O_2$
    - Diprotic Acids: H_2SO_4, H_2CO_3
    - Triprotic Acids: H_3PO_4
    - Strong Acids: HCl, HI, HBr, HNO_3, $HClO_3$, $HClO_4$, H_2SO_4
- H^+ is written for simplicity, but H_3O^+ is more accurate
    - $H^+ + H_2O \rightarrow H_3O^+$ (hydronium ion)
    - $HCl(g) + H_2O(l) \rightarrow Cl^-(aq) + H_3O^+(aq)$

- Base – substance that dissociates in H_2O to produce OH^- ions or accepts H^+ ions
- Common Bases:
    - NaOH, KOH
    - $NH_3 + H^+ \rightarrow NH_4^+$
    - Strong Bases: LiOH, NaOH, KOH, RbOH, CsOH, $Ca(OH)_2$, $Sr(OH)_2$, $Ba(OH)_2$
- Strong acids and bases completely dissociate in water
- Weak acids and bases partially dissociate into ions in aqueous solutions
- Typical Weak Acids and Bases:
    - Small organic molecules
    - COOH group
- (Acid-Base) Neutralization Reaction: exchange reaction which always produces salt & water
- Salt: ionic compound formed from cation of base and anion of acid
    - E.g., $NaOH(aq) + HCl\ (aq) \rightarrow NaCl\ (aq) + H_2O(l)$
    - Net ionic equation (when no precipitates form): $OH^-(aq) + H^+(aq) \rightarrow H_2O(l)$

Single Replacement (Displacement Reaction)

- $A + BX \rightarrow AX + B$
    - E.g., $Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$

- Activity Series (metal): Used to predict if a certain metal can be replaced by an H^+ ion in an acid or by another metal ion in a particular salt
    - Reactivity Series of Metals (will be given in the test)
    - K > Na > Ca > Mg > Al > Zn > Fe > Sn > Pb > H > Cu > Hg > Ag > Au
- Activity Series (halogen reactivity): F > Cl > Br > I
    - Halides – ions of halogens
        - E.g., F^-, Cl^-, Br^-, I^-

Review: Reactions

- Combination: A + B → AB
- Decomposition: AB → A + B
- Combustion: $C_xH_y + O_2 \rightarrow CO_2 + H_2O$
    - Incomplete: $C_xH_y + O_2 \rightarrow CO + H_2O$ or $C_xH_y + O_2 \rightarrow C + H_2O$
- Single-replacement: A + BX → AX + B
- Double-replacement: AX + BY → AY + BX
    - Driving force: force to make it "more stable"
        - Precipitate
        - Gas
            - Common Gas produced:
                - CO_2, SO_2, H_2S, NH_3
        - Water
- Acid-Base Neutralization Reaction: Base + Acid → Salt + Water
- Solubility rule (will be given in test)

Soluble Ionic Compounds	Exceptions
NO_3^-	None
CH_3COO^-	None
Cl^-	Ag^+, Hg_2^{2+}, Pb^{2+}
Br^-	Ag^+, Hg_2^{2+}, Pb^{2+}
I^-	Ag^+, Hg_2^{2+}, Pb^{2+}

SO_4^{2-}	Sr^{2+}, Ba^{2+}, Hg_2^{2+}, Pb^{2+}
Insoluble Ionic Compounds	Exceptions
S^{2-}	NH_4^+, alkali metal cations, Ca^{2+}, Sr^{2+}, Ba^{2+}
CO_3^{2-}	NH_4^+, alkali metal cations
PO_4^{3-}	NH_4^+, alkali metal cations
OH^-	NH_4^+, alkali metal cations, Ca^{2+}, Sr^{2+}, Ba^{2+}

Gases

- Gaseous elements:
  - He, Ne, Ar, Kr, Xe
  - H_2, N_2, O_2, F_2, Cl_2
- Properties:
  - Gas expands spontaneously to fill its container
  - Highly compressible
  - 2+ gases form a homogenous mixture

Pressure

- Pressure (P): force acting on a given area
  - $P = \frac{F}{A}$ (solid)
    - F: force (N)
    - A: area (m^2)
  - $P = \rho g h$ (liquid)
    - ρ: density of fluid (kg/m^3)
    - g: gravitational acceleration (m/s^2)
    - h: depth below surface (m)
- SI unit: Pascal (Pa)
- 1 atm = 760. mmHg = 760. torr = 1.01325×10^5 Pa = 101.325 kPa = 1.01325 bar
- Barometer: device used to measure atmospheric pressure
- Manometer: device used to measure the difference in pressure between atmospheric pressure and that of a gas in a vessel

- $P_{gas} = P_{atm} \pm P_{Hg}$ (open end)
    - Add P_{Hg} if mercury is lower on the closed gas side, subtract if higher on the closed gas side
- $P_{gas} = P_{Hg}$ (closed end); mercury is always higher on the vacuum side

- Standard atmospheric pressure: pressure at sea level, pressure sufficient to support column of mercury 760mm high

Gas Laws

- Boyle's Law
    - n, T constant
    - $P \propto \frac{1}{v}$; PV = constant
- Charles' Law
    - n, P constant
    - $V \propto T$; $\frac{V}{T}$ = constant
- Avogadro's Law
    - P, T constant
    - $V \propto n$; $\frac{V}{n}$ = constant
- V: volume
- P: pressure
- n: # of moles
- T: temperature (K)