# CHM 1025 Exam 2 Review

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# Academic Resources Reminders

- Chemistry Drop-in Tutoring in TUR1315
  - Mondays and Tuesdays: 1-5pm
  - Fridays: 1-3pm
- Private appointments via tutor trac
- CHM 1025 Exam 3 Review: 11/17 7-9pm
- CHM 1025 Final Exam Review: 12/8 time TBA

# Ionic Compound Nomenclature

- Cation first, anion second
- Metal + nonmetal = ionic compound
- Replace end of anion name with "-ide" if it's not a polyatomic ion
- Ammonium Sulfide

  $NH_4^+$ $S^{2-}$

  $\boxed{(NH_4)_2S}$

- Magnesium acetate

  $Mg^{2+}$ $C_2H_3O_2^-$

  $\boxed{Mg(C_2H_3O_2)_2}$

- $Pb(NO_3)_2$

  Lead II ← $Pb^{2+}$ $NO_3^-$ = nitrate

  $\boxed{\text{Lead (II) Nitrate}}$

- $Li_3PO_4$

  $Li^+$ $PO_4^{3-}$

  $\boxed{\text{Lithium phosphate}}$

# Molecular Compound Nomenclature

- More than one nonmetal/metalloid = molecular compound
- Name element farthest to the left first
- Second element ends in "-ide"
- Use prefixes to specify the number of atoms (exception: don't put mono on first atom, i.e. $CO_2$ is carbon dioxide NOT monocarbon dioxide)
  - Mono: 1
  - Di: 2
  - Tri: 3
  - Tetra: 4
  - Penta: 5
  - Hexa: 6
  - Hepta: 7
  - Octa: 8
  - Nona: 9
  - Deca: 10

# Molecular Compound Practice

- Dinitrogen monoxide $N_2O$
- Phosphorous pentafluoride $PF_5$
- $XeBr_4$ Xenon tetrabromide
- $SO_2$ Sulfur dioxide

# Acid Nomenclature

- Acid: anion with one or more $H^+$ (number of $H^+$ depends on charge of anion)
- Case 1: anion ends in "-ide"
  - Replace "-ide" with "-ic" and add "hydro-" to the beginning
  - Examples:

| | | | |
|---|---|---|---|
| $HCl$ | $H_2S$ | $HBr$ | $HF$ |
| hydrochloric acid | hydrosulfuric acid | hydrobromic acid | hydrofluoric acid |

- Case 2: anion ends in "-ate"
  - Replace "-ate" with "-ic", no prefix!
  - Examples:

| | | | | |
|---|---|---|---|---|
| $HNO_3$ | $H_2SO_4$ | $H_3PO_4$ | $HClO_3$ | $HClO_4$ |
| nitric acid | sulfuric acid | phosphoric acid | chloric acid | perchloric acid |

- Case 3: anion ends in "-ite"
  - Reaplce "-ite" with "-ous", no prefix!
  - Examples:

| | | | |
|---|---|---|---|
| $HClO$ | $HClO_2$ | $H_2SO_3$ | $H_3PO_3$ |
| hypochlorous acid | chlorous acid | sulfurous acid | phosphorous acid |

# Percent Composition

- % composition of atom X in compound XYZ:
  - $\frac{mass\ of\ X}{mass\ of\ XYZ} x100\%$
- What is the % by mass of fluorine in carbon tetrafluoride?

Assume 1mol

$CF_4 \rightarrow MM = 88.003\ g/mol$

$C \rightarrow MM = 12.011\ g/mol$

$$\frac{12.011\ g}{88.003\ g} \times 100\% = \boxed{13.6\%}$$

- What is the % by mass of oxygen in glucose ($C_6H_{12}O_6$)?

Assume 1 mol

$C_6H_{12}O_6 \rightarrow MM = 180.1536\ g/mol$

$6C \rightarrow mass = (6mol)(12.011g/mol) = 72.066\ g$

$$\frac{72.066g}{180.1536g} \times 100\% = \boxed{40.0\%}$$

# Moles and Avogadro's Number

- Avogadro's number: $6.022 \times 10^{23}$ (anything you want)/mol
  - How many O atoms are in 4.5 moles of $O_2$?

$$4.5\,\text{mol}\,O_2 \cdot \frac{2\,\text{mol O}}{1\,\text{mol}\,O_2} \cdot \frac{6.022\times10^{23}\,\text{atoms O}}{1\,\text{mol O}} = \boxed{5.4\times10^{24}\,\text{atoms O}}$$

  - How many fluorine atoms are in 7 moles of magnesium fluoride?

$MgF_2$

$$7\,\text{mol}\,MgF_2 \cdot \frac{2\,\text{mol F}}{1\,\text{mol}\,MgF_2} \cdot \frac{6.022\times10^{23}\,\text{atoms F}}{1\,\text{mol F}} = \boxed{8.4\times10^{24}\,\text{atoms F}}$$

  - How many $CO_2$ molecules are in 5.2 ~~grams~~ grams of carbon dioxide?

$$5.2\,g\,CO_2 \cdot \frac{1\,\text{mol}\,CO_2}{44.009\,g\,CO_2} \cdot \frac{6.022\times10^{23}\,\text{molecules}\,CO_2}{1\,\text{mol}\,CO_2} = \boxed{7.1\times10^{22}\,\text{molecules}\,CO_2}$$

# Determining Empirical and Molecular Formulas

- A sample of a compound was found to be 40% carbon by mass, 53% oxygen by mass, and the rest hydrogen. If the molar mass of the compound is known to be 60.05 g/mol, what are the empirical and molecular formulas for this compound?
- Step 1: Assume 100g of the sample

100g $C_xH_yO_z$

40% C → 40g C

53% O → 53g O

$100-40-53=7 \rightarrow$ 7g H

- Step 2: Convert grams to moles

$\frac{40g\,C}{12.011 g/mol} = 3.33$ mol C

$\frac{53g\,O}{15.999 g/mol} = 3.31$ mol O

↑ smallest

$\frac{7g\,H}{1.0078 g/mol} = 6.95$ mol H

- Step 3: Divide all by the smallest number of moles

C: $\frac{3.33}{3.31} = 1.006$

O: $\frac{3.31}{3.31} = 1$

H: $\frac{6.95}{3.31} = 2.099$

# Empirical/Molecular Formulas cont.

- Step 4: Multiply/divide to get integers

C: $1.006 \sim 1$    O: $1$    H: $2.099 \sim 2$

- Step 5: Write the empirical formula and determine the molar mass of the empirical formula

Empirical Formula $\boxed{CH_2O} \rightarrow MM = (12.011\,g/mol)(1) + (1.0078\,g/mol)(2) + (15.999\,g/mol)(1)$

$MM = 30.0256\,g/mol$

- Step 6: Divide the actual molar mass by the empirical formula molar mass and multiply all subscripts by that number

Molecular Formula

$$\frac{\text{actual}}{\text{empirical}} = \frac{60.05\,g/mol}{30.0256\,g/mol} = 1.9999\ldots \approx 2 \qquad 2(CH_2O) \rightarrow \boxed{C_2H_4O_2}$$

# Chemical Composition of Solutions

- 2.7 moles of sodium chloride are dissolved in 50 mL of water (d=1 g/mL).
  - What is the % by mass of sodium chloride in this solution?

$\frac{\text{mass NaCl}}{\text{total mass}} \times 100\%$ $\quad 2.7\text{mol NaCl} \cdot \frac{58.443\text{g}}{1\text{mol NaCl}} = 157.7961\text{g NaCl}$ $\quad 50\text{mL} = 50\text{g } H_2O$ $\quad \frac{157.8\text{ g}}{157.8\text{g}+50\text{g}} \times 100\% = \boxed{76\%\ \text{NaCl by mass}}$

  - What is the % by mass of sodium ions in this solution?

$\frac{\text{mass Na}^+}{\text{total mass}} \times 100\%$ $\quad 2.7\text{mol NaCl} \cdot \frac{1\text{mol Na}^+}{1\text{mol NaCl}} \cdot \frac{22.99\text{g}}{1\text{mol Na}^+} = 62.073\text{g Na}^+$ $\quad 50\text{mL} = 50\text{g } H_2O$ $\quad \frac{62.073\text{g}}{\underset{\text{NaCl}}{\underset{\uparrow}{157.8\text{g}}} + \underset{H_2O}{\underset{\uparrow}{50\text{g}}}} \times 100\% = \boxed{30\%\ \text{Na}^+\ \text{by mass}}$

- 43 mg of lithium perchlorate are dissolved in 2.0 L of water.
  - What is the molarity of lithium perchlorate in this solution?

$M = \frac{\text{mol solute}}{\text{L solution}}$ $\quad 43\text{ mg } LiClO_4 \cdot \frac{1\text{ g}}{1000\text{ mg}} \cdot \frac{1\text{mol } LiClO_4}{106.39\text{g}} = 4.042\times10^{-4}\text{mol } LiClO_4$ $\quad M = \frac{4.042\times10^{-4}\text{mol}}{2\text{ L}} = \boxed{2.0\times10^{-4}\text{M}}$

# Dilutions

- Dilution equation: $M_1V_1=M_2V_2$
- 3.0 mL of a stock solution that is 0.60 M in glucose is diluted with 22 mL of water. What is the concentration (in M) of the diluted solution?

$M_1 = 0.6M$ $\quad V_2 = 22ml + 3mL = 25mL$

$V_1 = 3mL$

$M_2 = ?$

$$M_1V_1 = M_2V_2$$

$$\frac{M_1V_1}{V_2} = M_2$$

$$M_2 = \frac{(0.6M)(3\cancel{mL})}{25\cancel{mL}} = \boxed{0.072M}$$

- You have 10.0 mL of a stock solution that is 1.3 M in sodium acetate. What volume of water (in mL) must be added to the 10.0 mL stock solution to create a final solution that is 1.0 M in sodium acetate?

$V_1 = 10mL$

$M_1 = 1.3M$

$M_2 = 1.0M$

$V_2 = ?$

$$M_1V_1 = M_2V_2$$

$$\frac{M_1V_1}{M_2} = V_2$$

$$V_2 = \frac{(1.3\cancel{M})(10mL)}{1.0\cancel{M}}$$

$$V_2 = 13mL$$

$$\text{Volume added} = \underset{\substack{\uparrow \\ \text{final} \\ \text{volume}}}{13mL} - \underset{\substack{\uparrow \\ \text{initial} \\ \text{volume}}}{10mL} = \boxed{3mL}$$

# Types of Chemical Reactions

- Decompisition
  - One reactant, multiple products
  - Ex. $ZnCO_3 \rightarrow ZnO + CO_2$
- Combination
  - Multiple reactants, one product
  - $SO_3 + H_2O \rightarrow H_2SO_4$
- Single Displacement
  - An ion (cation or anion) goes from one compound to another
  - Cation replacement: $Zn + CuCl_2 \rightarrow ZnCl_2 + Cu$
  - Anion replacement: $Br_2 + 2KI \rightarrow 2KBr + I_2$

# Chemical Reactions cont.

- Double Displacement
  - 2 ionic compounds switch cations and anions
  - Look for precipitates!
  - $2KOH_{(aq)} + Mg(NO_3)_{2(aq)} \rightarrow \overset{\text{precipitate}}{Mg(OH)_{2(s)}} + 2KNO_{3(aq)}$
- Combustion
  - Hydrocarbon reacts with $O_2$ and forms $CO_2$ and $H_2O$
  - $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$
- Acid-base neutralization
  - Same as double displacement but the reactants are one acid and one base
  - Products are water and an ionic compound
  - $HCl + NaOH \rightarrow H_2O + NaCl$

# Balancing Chemical Reactions

- Write a balanced chemical reaction for the combustion of benzene ($C_6H_6$).

  $2C_6H_6 + 15O_2 \longrightarrow 12CO_2 + 6H_2O$

- $Na_3PO_4 + 3\ KOH \rightarrow 3\ NaOH + K_3PO_4$
- $N_2 + 3\ H_2 \rightarrow 2\ NH_3$
- $2\ P_2O_3 \rightarrow P_4 + 3\ O_2$
- $2\ NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$

# Stoichiometry

- For the following **unbalanced** chemical reaction, how many grams of aluminum can be produced from 10.0 g of $AlBr_3$?
  - $AlBr_3 + 3\ K \rightarrow 3\ KBr + Al$

$$10g\ AlBr_3 \cdot \frac{1\ mol\ AlBr_3}{266.694\ g\ AlBr_3} \cdot \frac{1\ mol\ Al}{1\ mol\ AlBr_3} \cdot \frac{26.982 g\ Al}{1\ mol\ Al} = \boxed{1.01\ g\ Al}$$

- For the following **unbalanced** chemical reaction, how many moles of hydroiodic acid are needed to produce10.0 g of manganese (III) iodide?
  - $2\ Mn + 6\ HI \rightarrow 3\ H_2 + 2\ MnI_3$

$$10.0g\ MnI_3 \cdot \frac{1\ mol\ MnI_3}{435.638\ g\ MnI_3} \cdot \frac{6\ mol\ HI}{2\ mol\ MnI_3} \cdot \frac{127.9078 g\ HI}{1\ mol\ HI} = \boxed{8.81\ g\ HI}$$

# Limiting Reactants

- Consider the following **unbalanced** reaction. What mass (in g) of the excess reactant are left over if 10.0g of LiCl are allowed to react with 7.0g of $Br_2$?
  - 2 LiCl + $Br_2$ → 2 LiBr + $Cl_2$

$$10.0\text{g LiCl} \cdot \frac{1\text{ mol LiCl}}{42.394\text{g LiCl}} \cdot \frac{1\text{ mol }Br_2}{2\text{ mol LiCl}} \cdot \frac{159.808\text{g }Br_2}{1\text{ mol }Br_2} = 18.8\text{g }Br_2$$

$$7.0\text{g }Br_2 \cdot \frac{1\text{ mol }Br_2}{159.808\text{g }Br_2} \cdot \frac{2\text{ mol LiCl}}{1\text{ mol }Br_2} \cdot \frac{42.394\text{g LiCl}}{1\text{ mol LiCl}} = 3.7\text{ g LiCl}$$

$$10.0\text{g LiCl} - 3.7\text{ gLiCl} = \boxed{6.3\text{g LiCl left over}}$$

- Consider the following **unbalanced** reaction. What mass (in g) of sodium carbonate can be produced if 9.0g of NaCN are allowed to react with 15.0g of of $CuCO_3$?
  - 2 NaCN + $CuCO_3$ → $Na_2CO_3$ + $Cu(CN)_2$

$$9.0\text{g NaCN} \cdot \frac{1\text{ mol NaCN}}{49.008\text{g NaCN}} \cdot \frac{1\text{ mol }Na_2CO_3}{2\text{ mol NaCN}} \cdot \frac{105.998\text{g }Na_2CO_3}{1\text{ mol }Na_2CO_3} = \boxed{9.7\text{g }Na_2CO_3}$$

$$15.0\text{g }CuCO_3 \cdot \frac{1\text{ mol }CuCO_3}{123.554\text{g }CuCO_3} \cdot \frac{1\text{ mol }Na_2CO_3}{1\text{ mol }CuCO_3} \cdot \frac{105.998\text{g }Na_2CO_3}{1\text{ mol }Na_2CO_3} = 13\text{g }Na_2CO_3$$

✱ NaCN is the limiting reactant because 9.7 < 13

# Percent Yield

- Percent yield = $\frac{actual\ yield}{theoretical\ yield} x100\%$
- Consider the following balanced reaction. What is the percent yield if 8.00 g of KF are produced from the reaction of 3.30 g of $F_2$ and 7.80 g of K?
  - $2K + F_2 \rightarrow 2KF$

limiting

↓

$3.3\text{g}F_2 \cdot \frac{1\text{mol }F_2}{37.996\text{g}F_2} \cdot \frac{2\text{mol KF}}{1\text{mol}F_2} \cdot \frac{58.096\text{g KF}}{1\text{mol KF}} = 10.091\text{g KF}$

$\frac{8.00\text{ g}}{10.09\text{g}} \times 100\% = 79.3\%$

$7.8\text{g K} \cdot \frac{1\text{mol K}}{39.098\text{g K}} \cdot \frac{2\text{mol KF}}{2\text{mol K}} \cdot \frac{58.096\text{g KF}}{1\text{mol KF}} = 11.59\text{g KF}$

↑

excess

$10.09 < 11.59 \rightarrow F_2$ is limiting and 10.09g is the theoretical yield

# $q=mc\Delta T$

- $q$=heat (J or kJ), $m$=mass (g), $c$=specific heat capacity(J/mol K), $\Delta T$=change in temperature (K or C)
- A 12.50 g sample of an unknown liquid absorbs 209.1 J of heat and the temperature rises from 298.0 K to 311.6 K. What is the specific heat capacity of the liquid?

$q=mc\Delta T$

$q=+209.1\,J$

$m=12.50\,g$

$c=?$

$\Delta T=311.6K-298K=13.6K$

$$c=\frac{q}{m\Delta T}$$

$$c=\frac{209.1\,J}{(12.50g)(13.6K)}$$

$$\boxed{c=1.23\,J/gK}$$

# q=mcΔT cont.

- A 10.0 g cube of hot lead (c=0.128 J/g C) with in initial temperature of 98.2 C is placed in a calorimeter filled with an unknown amount of water (c=4.184 J/g C) at 25.0 C and the temperature of the water and lead rises to 27.0 C. What mass of water (in g) is in the calorimeter?

$m_{Pb} = 10.0g$

$C_{Pb} = 0.128\ J/g°C$

$\Delta T_{Pb} = 25°C - 98.2°C = -73.2°C$

$m_W = ?$

$C_W = 4.184\ J/g°C$

$\Delta T_W = 27.0°C - 25.0°C = 2.0°C$

$0 = q_{Pb} + q_W$

$-q_{Pb} = q_W$

$\downarrow q = mc\Delta T$

$-m_{Pb} C_{Pb} \Delta T_{Pb} = m_W C_W \Delta T_W$

$$m_W = -\frac{m_{Pb} C_{Pb} \Delta T_{Pb}}{C_W \Delta T_W}$$

$$m_W = -\frac{(10.0g)(0.128J/g°C)(-73.2°C)}{.184J/\ °C)(2.0°C)} = \boxed{11.2g}$$

# $q=mc\Delta T$ and $\Delta H$

- $\Delta H$: change in enthalpy
  - For a reaction or process, $\Delta H = \frac{q}{moles}$
- 4.30 g of NaCl are dissolved in 20.0 g of water and the temperature of the water drops from 25.8 C to 28.1 C. What is $\Delta H$, in kJ/mol, of the dissolution of NaCl in water? ($C_{water}$=4.184 J/g K)

$m_{NaCl} = 4.30g$

$m_W = 20.0g$

$C_W = 4.184 J/g°C$

$\Delta T_W = 25.8°C - 28.1°C = -2.3°C$

$$\Delta H_{rxn} = \frac{q_{rxn}}{n_{NaCl}}$$

$0 = q_{rxn} + q_w$

$q_{rxn} = -q_w$

$q_{rxn} = -(20.0g)(4.184 J/g°C)(-2.3°C)$

$q_{rxn} = 192.464 J$

$$n_{NaCl} = \frac{4.30g}{58.443 g/mol}$$

$n_{NaCl} = 0.07356 mol$

$$\Delta H = \frac{192.464 J}{0.07356 mol}$$

$\Delta H = 2620 J/mol$

$\boxed{\Delta H = 2.62 KJ/mol}$

# Questions?