

CHM 1025 Exam 2 Review

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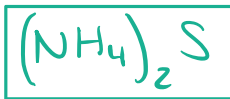
Academic Resources Reminders

- ▶ 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

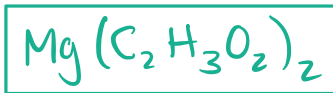
Ionic Compound Nomenclature

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

- ▶ Ammonium Sulfide



- ▶ Magnesium acetate



- ▶ $\text{Pb}(\text{NO}_3)_2$



- ▶ Li_3PO_4

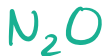


Molecular Compound Nomenclature

- ▶ 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. CO₂ 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



- ▶ Phosphorous pentafluoride



- ▶ 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
hydrochloric acid

- ▶ Examples: H_2S
hydrosulfuric acid

- ▶ Examples: HBr
hydrobromic acid

- ▶ Examples: HF
hydrofluoric acid

- ▶ Case 2: anion ends in "-ate"

- ▶ Replace "-ate" with "-ic", no prefix!

- ▶ Examples: HNO_3
nitric acid

- ▶ Examples: H_2SO_4
sulfuric acid

- ▶ Examples: H_3PO_4
phosphoric acid

- ▶ Examples: $HClO_3$
chloric acid

- ▶ Examples: $HClO_4$
perchloric acid

- ▶ Case 3: anion ends in "-ite"

- ▶ Replace "-ite" with "-ous", no prefix!

- ▶ Examples: $HClO$
hypochlorous acid

- ▶ Examples: $HClO_2$
chlorous acid

- ▶ Examples: H_2SO_3
sulfurous acid

- ▶ Examples: H_3PO_3
phosphorous acid

Percent Composition

- ▶ % composition of atom X in compound XYZ:

- ▶ $\frac{\text{mass of X}}{\text{mass of XYZ}} \times 100\%$

- ▶ What is the % by mass of fluorine in carbon tetrafluoride?

Assume 1 mol

$$\text{CF}_4 \rightarrow \text{MM} = 88.003 \text{ g/mol} \quad \frac{12.011 \text{ g}}{88.003 \text{ g}} \times 100\% = \boxed{13.6\%}$$

$$\text{C} \rightarrow \text{MM} = 12.011 \text{ g/mol}$$

- ▶ What is the % by mass of oxygen in glucose ($\text{C}_6\text{H}_{12}\text{O}_6$)?

Assume 1 mol

$$\text{C}_6\text{H}_{12}\text{O}_6 \rightarrow \text{MM} = 180.1536 \text{ g/mol}$$

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

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

Moles and Avogadro's Number

- ▶ Avogadro's number: 6.022×10^{23} (anything you want)/mol

- ▶ How many O atoms are in 4.5 moles of O_2 ?

$$4.5 \text{ mol } O_2 \cdot \frac{2 \text{ mol } O}{1 \text{ mol } O_2} \cdot \frac{6.022 \times 10^{23} \text{ atoms } O}{1 \text{ mol } O} = 5.4 \times 10^{24} \text{ atoms } O$$

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

$$MgF_2 \quad 7 \text{ mol } MgF_2 \cdot \frac{2 \text{ mol } F}{1 \text{ mol } MgF_2} \cdot \frac{6.022 \times 10^{23} \text{ atoms } F}{1 \text{ mol } F} = 8.4 \times 10^{24} \text{ atoms } F$$

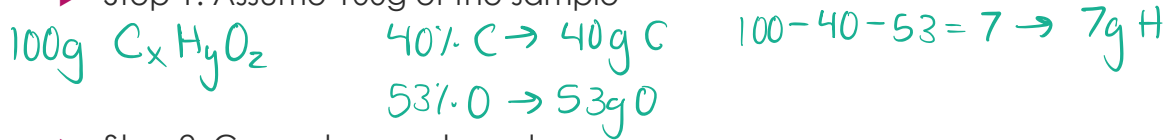
- ▶ How many CO_2 molecules are in 5.2 grams of carbon dioxide?

$$5.2 \text{ g } CO_2 \cdot \frac{1 \text{ mol } CO_2}{44.009 \text{ g } CO_2} \cdot \frac{6.022 \times 10^{23} \text{ molecules } CO_2}{1 \text{ mol } CO_2} = 7.1 \times 10^{22} \text{ molecules } CO_2$$

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



- ▶ Step 2: Convert grams to moles

$$\frac{40\text{g C}}{12.011\text{g/mol}} = 3.33\text{ mol C} \quad \frac{53\text{g O}}{15.999\text{g/mol}} = 3.31\text{ mol O} \quad \frac{7\text{g H}}{1.0078\text{g/mol}} = 6.95\text{ mol H}$$

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

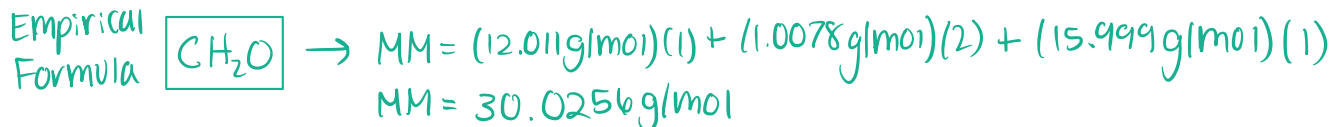
$$\text{C: } \frac{3.33}{3.31} = 1.006 \quad \text{O: } \frac{3.31}{3.31} = 1 \quad \text{H: } \frac{6.95}{3.31} = 2.099$$

Empirical/Molecular Formulas cont.

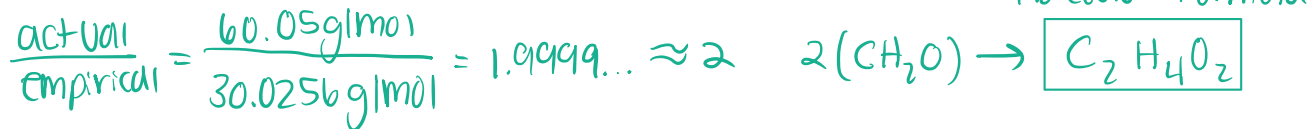
- ▶ Step 4: Multiply/divide to get integers



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



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



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?

$$\frac{\text{mass NaCl}}{\text{total mass}} \times 100\% = 2.7 \text{ mol NaCl} \cdot \frac{58.443 \text{ g}}{1 \text{ mol NaCl}} = 157.7961 \text{ g NaCl} \quad 50 \text{ mL} = 50 \text{ g H}_2\text{O} \quad \frac{157.8 \text{ g}}{157.8 \text{ g} + 50 \text{ g}} \times 100\% = 76\% \text{ NaCl by mass}$$

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

$$\frac{\text{mass Na}^+}{\text{total mass}} \times 100\% = 2.7 \text{ mol NaCl} \cdot \frac{1 \text{ mol Na}^+}{1 \text{ mol NaCl}} \cdot \frac{22.99 \text{ g}}{1 \text{ mol Na}^+} = 62.073 \text{ g Na}^+ \quad 50 \text{ mL} = 50 \text{ g H}_2\text{O} \quad \frac{62.073 \text{ g}}{157.8 \text{ g} + 50 \text{ g}} \times 100\% = 30\% \text{ Na}^+ \text{ by mass}$$

- ▶ 43 mg of lithium perchlorate are dissolved in 2.0 L of water.

- ▶ What is the molarity of lithium perchlorate in this solution?

$$M = \frac{\text{mol solute}}{\text{L solution}} = 43 \text{ mg LiClO}_4 \cdot \frac{1 \text{ g}}{1000 \text{ mg}} \cdot \frac{1 \text{ mol LiClO}_4}{106.39 \text{ g}} = 4.042 \times 10^{-4} \text{ mol LiClO}_4 \quad M = \frac{4.042 \times 10^{-4} \text{ mol}}{2 \text{ L}} = 2.0 \times 10^{-4} \text{ M}$$

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?

$$M_1 = 0.60 \text{ M} \quad V_2 = 22 \text{ mL} + 3 \text{ mL} = 25 \text{ mL}$$
$$V_1 = 3 \text{ mL} \quad M_1V_1 = M_2V_2$$
$$M_2 = ? \quad \frac{M_1V_1}{V_2} = M_2$$

$$M_2 = \frac{(0.60 \text{ M})(3 \text{ mL})}{25 \text{ mL}} = \boxed{0.072 \text{ M}}$$

- ▶ 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?

$$V_1 = 10 \text{ mL} \quad M_1V_1 = M_2V_2$$
$$M_1 = 1.3 \text{ M} \quad \frac{M_1V_1}{M_2} = V_2$$
$$M_2 = 1.0 \text{ M}$$
$$V_2 = ?$$

$$V_2 = \frac{(1.3 \text{ M})(10 \text{ mL})}{1.0 \text{ M}}$$
$$V_2 = 13 \text{ mL}$$

$$\text{Volume added} = 13 \text{ mL} - 10 \text{ mL} = \boxed{3 \text{ mL}}$$

↑ ↑
final initial
volume volume

Types of Chemical Reactions

▶ Decomposition

- ▶ One reactant, multiple products

- ▶ Ex. $\text{ZnCO}_3 \rightarrow \text{ZnO} + \text{CO}_2$

▶ Combination

- ▶ Multiple reactants, one product

- ▶ $\text{SO}_3 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_4$

▶ Single Displacement

- ▶ An ion (cation or anion) goes from one compound to another

- ▶ Cation replacement: $\text{Zn} + \text{CuCl}_2 \rightarrow \text{ZnCl}_2 + \text{Cu}$

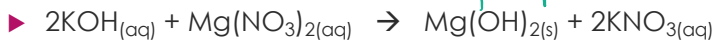
- ▶ Anion replacement: $\text{Br}_2 + 2\text{KI} \rightarrow 2\text{KBr} + \text{I}_2$

Chemical Reactions cont.

▶ Double Displacement

▶ 2 ionic compounds switch cations and anions

▶ Look for precipitates!



↙ precipitate

▶ Combustion

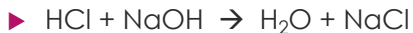
▶ Hydrocarbon reacts with O_2 and forms CO_2 and H_2O



▶ Acid-base neutralization

▶ Same as double displacement but the reactants are one acid and one base

▶ Products are water and an ionic compound



Balancing Chemical Reactions

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



- ▶ $Na_3PO_4 + 3KOH \rightarrow 3NaOH + K_3PO_4$

- ▶ $N_2 + 3H_2 \rightarrow 2NH_3$

- ▶ $2P_2O_3 \rightarrow P_4 + 3O_2$

- ▶ $2NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$

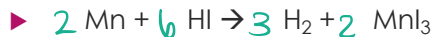
Stoichiometry

- ▶ For the following **unbalanced** chemical reaction, how many grams of aluminum can be produced from 10.0 g of AlBr_3 ?



$$10 \text{ g AlBr}_3 \cdot \frac{1 \text{ mol AlBr}_3}{266.694 \text{ g AlBr}_3} \cdot \frac{1 \text{ mol Al}}{1 \text{ mol AlBr}_3} \cdot \frac{26.982 \text{ g Al}}{1 \text{ mol Al}} = \boxed{1.01 \text{ g Al}}$$

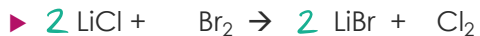
- ▶ For the following **unbalanced** chemical reaction, how many moles of hydroiodic acid are needed to produce 10.0 g of manganese (III) iodide?



$$10.0 \text{ g MnI}_3 \cdot \frac{1 \text{ mol MnI}_3}{435.638 \text{ g MnI}_3} \cdot \frac{6 \text{ mol HI}}{2 \text{ mol MnI}_3} \cdot \frac{127.9078 \text{ g HI}}{1 \text{ mol HI}} = \boxed{8.81 \text{ g HI}}$$

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 Br₂?

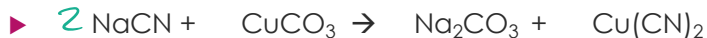


$$10.0 \text{ g LiCl} \cdot \frac{1 \text{ mol LiCl}}{42.394 \text{ g LiCl}} \cdot \frac{1 \text{ mol Br}_2}{2 \text{ mol LiCl}} \cdot \frac{159.808 \text{ g Br}_2}{1 \text{ mol Br}_2} = 18.8 \text{ g Br}_2$$

$$7.0 \text{ g Br}_2 \cdot \frac{1 \text{ mol Br}_2}{159.808 \text{ g Br}_2} \cdot \frac{2 \text{ mol LiCl}}{1 \text{ mol Br}_2} \cdot \frac{42.394 \text{ g LiCl}}{1 \text{ mol LiCl}} = 3.7 \text{ g LiCl}$$

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

- ▶ 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 CuCO₃?



$$9.0 \text{ g NaCN} \cdot \frac{1 \text{ mol NaCN}}{49.008 \text{ g NaCN}} \cdot \frac{1 \text{ mol Na}_2\text{CO}_3}{2 \text{ mol NaCN}} \cdot \frac{105.998 \text{ g Na}_2\text{CO}_3}{1 \text{ mol Na}_2\text{CO}_3} = \boxed{9.7 \text{ g Na}_2\text{CO}_3}$$

$$15.0 \text{ g CuCO}_3 \cdot \frac{1 \text{ mol CuCO}_3}{123.554 \text{ g CuCO}_3} \cdot \frac{1 \text{ mol Na}_2\text{CO}_3}{1 \text{ mol CuCO}_3} \cdot \frac{105.998 \text{ g Na}_2\text{CO}_3}{1 \text{ mol Na}_2\text{CO}_3} = 13 \text{ g Na}_2\text{CO}_3$$

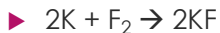
★ NaCN is the limiting reactant because $9.7 < 13$

Percent Yield

▶ Percent yield = $\frac{\text{actual yield}}{\text{theoretical yield}} \times 100\%$

limiting

▶ 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 F₂ and 7.80 g of K?



↓

$$3.30 \text{ g F}_2 \cdot \frac{1 \text{ mol F}_2}{37.996 \text{ g F}_2} \cdot \frac{2 \text{ mol KF}}{1 \text{ mol F}_2} \cdot \frac{58.096 \text{ g KF}}{1 \text{ mol KF}} = 10.091 \text{ g KF}$$

↑
excess

$$7.80 \text{ g K} \cdot \frac{1 \text{ mol K}}{39.098 \text{ g K}} \cdot \frac{2 \text{ mol KF}}{2 \text{ mol K}} \cdot \frac{58.096 \text{ g KF}}{1 \text{ mol KF}} = 11.59 \text{ g KF}$$

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

$10.09 < 11.59 \rightarrow \text{F}_2$ 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), ΔT =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?

$$q = mc\Delta T$$

$$q = +209.1 \text{ J}$$

$$m = 12.50 \text{ g}$$

$$c = ?$$

$$\Delta T = 311.6 \text{ K} - 298 \text{ K} = 13.6 \text{ K}$$

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

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

$$c = 1.23 \text{ J/g K}$$

$q=mc\Delta T$ 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?

$$m_{\text{Pb}} = 10.0 \text{ g}$$

$$C_{\text{Pb}} = 0.128 \text{ J/g}^\circ\text{C}$$

$$\Delta T_{\text{Pb}} = 25.0^\circ\text{C} - 98.2^\circ\text{C} = -73.2^\circ\text{C}$$

$$m_{\text{W}} = ?$$

$$C_{\text{W}} = 4.184 \text{ J/g}^\circ\text{C}$$

$$\Delta T_{\text{W}} = 27.0^\circ\text{C} - 25.0^\circ\text{C} = 2.0^\circ\text{C}$$

$$0 = q_{\text{Pb}} + q_{\text{W}}$$

$$-q_{\text{Pb}} = q_{\text{W}}$$

$$\downarrow q = mc\Delta T$$

$$-m_{\text{Pb}} C_{\text{Pb}} \Delta T_{\text{Pb}} = m_{\text{W}} C_{\text{W}} \Delta T_{\text{W}}$$

$$m_{\text{W}} = - \frac{m_{\text{Pb}} C_{\text{Pb}} \Delta T_{\text{Pb}}}{C_{\text{W}} \Delta T_{\text{W}}}$$

$$m_{\text{W}} = - \frac{(10.0 \text{ g})(0.128 \text{ J/g}^\circ\text{C})(-73.2^\circ\text{C})}{4.184 \text{ J/g}^\circ\text{C}(2.0^\circ\text{C})} = 11.2 \text{ g}$$

$q = mc\Delta T$ and ΔH

▶ ΔH : change in enthalpy

▶ For a reaction or process, $\Delta H = \frac{q}{\text{moles}}$

▶ 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 ΔH , in kJ/mol, of the dissolution of NaCl in water? ($C_{\text{water}} = 4.184 \text{ J/g K}$)

$$m_{\text{NaCl}} = 4.30 \text{ g}$$

$$0 = q_{\text{rxn}} + q_{\text{w}}$$

$$q_{\text{rxn}} = -q_{\text{w}}$$

$$m_{\text{w}} = 20.0 \text{ g}$$

$$q_{\text{rxn}} = -(20.0 \text{ g})(4.184 \text{ J/g}^\circ\text{C})(-2.3^\circ\text{C})$$

$$C_{\text{w}} = 4.184 \text{ J/g}^\circ\text{C}$$

$$q_{\text{rxn}} = 192.464 \text{ J}$$

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

$$\Delta T_{\text{w}} = 25.8^\circ\text{C} - 28.1^\circ\text{C} = -2.3^\circ\text{C}$$

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

$$\Delta H = 2620 \text{ J/mol}$$

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

$$n_{\text{NaCl}} = 0.07356 \text{ mol}$$

$$\Delta H = 2.62 \text{ kJ/mol}$$

Questions?