HONORS CHEMISTRY FINAL EXAM STUDY GUIDE – Fall 2024

1. Determine formula mass and number of atoms & molecules (use Avogadro's number)

2. Determine average atomic mass using isotopic mass and percent abundances.

For example, the element boron is composed of two isotopes: About 19.9% of all boron atoms are ^{10}B with a mass of 10.0129 amu, and the remaining 80.1% are ^{11}B with a mass of 11.0093 amu. The average atomic mass for boron is calculated to be:

$$\text{average mass} = \sum_i (\text{fractional abundance} \times \text{isotopic mass})_i$$

Hint: Need to convert percent (% abundance) into decimal notation.

Boron average mass = (0.199 × 10.0129 amu) + (0.801 × 11.0093 amu)
= 1.99 amu + 8.82 amu
= 10.81 amu

3. Determine (mass) percent composition from chemical formulas.
(Hint: think of fractions, % = $\frac{\text{portion}}{\text{total mass}}$ x 100% = ___%)

Example: what is theoretical percent composition of CH_4?
Get mass of C and mass of all H's from periodic table. Then, get total mass of CH_4

%C = $\frac{12}{16}$ x 100% = 75% C %H = $\frac{4}{16}$ x 100% = 25% H

Mass percent composition: Example below is for glucose, $C_6H_{12}O_6$.

Percent = $\frac{part}{whole}$ x 100 %

Mass % of C = $\frac{6(12.01\ g)}{180.16\ g}$ x 100 % = 39.9978 = **40.0 %**

Mass % of H = $\frac{12(1.01\ g)}{180.16\ g}$ x 100 % = 6.72735 = **6.73 %**

Mass % of O = $\frac{6(16.0\ g)}{180.16\ g}$ x 100 % = 53.286 = **53.3 %**

4. Five things you need to determine molecular formula:
1. Empirical formula
2. Mass from Empirical formula
3. Molar mass from Molecular formula
4. Ratio of Molar mass/Empirical mass
5. Molecular formula: Multiply the ratio found in Step 4 to the empirical formula (subscripts)

5. Determine the empirical formula that is 88.8% copper and 11.2% oxygen

6. Determine the molecular formula of caffeine (molar mass 194.19 g/mol), given that a sample contains 49.47 g carbon, 28.85 g nitrogen, 16.48 g oxygen, and 5.20 g hydrogen.

7. A compound with an empirical formula of C_2H_8N and a molar mass of 46.0 g/mol. What is the molecular formula of this compound?

8. Know how to use the density equation, $d = \frac{\text{mass}}{\text{volume}}$. What is the unit for density?

9. Know how to use dimensional analysis method to convert between units, for example, to convert nm to m or m to nm, etc. This method also applies to converting feet to yard, meter to cm, vice-versa and other forms of units, as well as converting between moles and grams and between moles and number of stuff using Avogadro's number.

Conversion factor 1 nm = 1.00 x 10^{-9} m

a) Convert 453 nm to meter (m)

$$453 \text{ nm} \left(\frac{1 \times 10^{-9} \text{ m}}{1 \text{ nm}}\right) = \mathbf{4.53 \times 10^{-7} \text{ m}}$$

b) Convert 6.58 x 10^{-7} m to nm.

$$6.58 \times 10^{-7} \text{ m} \left(\frac{1 \text{ nm}}{1.00 \times 10^{-9} \text{ m}}\right) = \mathbf{658 \text{ nm}}$$

Converting mole to grams

$$0.688 \text{ mol } CO_2 \left(\frac{44.01 \text{ g } CO_2}{\text{mol } CO_2}\right) = 30.3 \text{ g } CO_2$$

Converting grams to mole

$$16.0 \text{ g } CO_2 \left(\frac{1 \text{ mol } CO_2}{44.01 \text{ g } CO_2}\right) = 0.364 \text{ mol } CO_2$$

Practice: Teflon, C_2F_4 (polytetrafluoroethylene polymer)
molar mass of C_2F_4 unit = 100.00 g/mol

(a) Calculate the number of C_2F_4 units present in 205 g of Teflon.

$$205 \text{ g } C_2F_4 \left(\frac{1 \text{ mol } C_2F_4}{100.0 \text{ g } C_2F_4}\right)\left(\frac{6.022 \times 10^{23} \text{ units } C_2F_4}{1 \text{ mol } C_2F_4}\right) = 1.23 \times 10^{24} \text{ units } C_2F_4$$

(b) Determine the number of carbon atoms present in 205 g C_2F_4.

$$205 \text{ g } C_2F_4 \left(\frac{1 \text{ mol } C_2F_4}{100.0 \text{ g } C_2F_4}\right)\left(\frac{2 \text{ mol C}}{1 \text{ mol } C_2F_4}\right)\left(\frac{6.022 \times 10^{23} \text{ atoms C}}{1 \text{ mol C}}\right) = 2.55 \times 10^{24} \text{ atoms C}$$

(c) How many moles of fluorine are in 205 g of Teflon?

$$205 \text{ g } C_2F_4 \left(\frac{1 \text{ mol } C_2F_4}{100.0 \text{ g } C_2F_4}\right)\left(\frac{4 \text{ mol F}}{1 \text{ mol } C_2F_4}\right) = 8.20 \text{ mol F}$$

(d) How many fluorine atoms are in 205 g of Teflon?

$$205 \text{ g } C_2F_4 \left(\frac{1 \text{ mol } C_2F_4}{100.0 \text{ g } C_2F_4}\right)\left(\frac{4 \text{ mol F}}{1 \text{ mol } C_2F_4}\right)\left(\frac{6.022 \times 10^{23} \text{ atoms C}}{1 \text{ mol C}}\right) = 4.94 \times 10^{24} \text{ atoms F}$$

10. Solid lithium hydroxide has been used in space vehicles to remove exhaled carbon dioxide from the living environment. The products are solid lithium carbonate and liquid water. A student is trying to determine the mass of gaseous carbon dioxide that is needed to react with 1.00×10^3 g of lithium hydroxide absorb. Which step(s) in the student's work below is (are) **<u>incorrect</u>?**

$$\mathbf{2LiOH(s) + CO_2(g) \rightarrow Li_2CO_3\,(s) + H_2O}\boldsymbol{(l)}$$

$$1.00 \times 10^3 \text{ g LiOH} \left(\frac{1 \text{ mol LiOH}}{23.95 \text{ g LiOH}}\right)\left(\frac{2 \text{ mol LiOH}}{1 \text{ mol } CO_2}\right)\left(\frac{1 \text{ mol } CO_2}{44.01 \text{ g } CO_2}\right)$$

Step 1 Step 2 Step 3 Step 4

11. Limiting Reactant

Calculate the mass of magnesium oxide that could be produced if 2.40 g of Mg reacts with 10.0 g of O_2.

$$\mathbf{Mg(s) + O_2(g) \rightarrow MgO(s)}$$

Determine limiting reactant to get amount of product produced (theoretical yield).

$$2.40 \text{ g } \mathbf{Mg} \left(\frac{1 \text{ mol Mg}}{24.31 \text{ g Mg}}\right)\left(\frac{2 \text{ mol MgO}}{2 \text{ mol Mg}}\right)\left(\frac{40.31 \text{ g MgO}}{1 \text{ mol MgO}}\right) = 3.98 \text{ g MgO}$$

$$10.0 \text{ g } \mathbf{O_2} \left(\frac{1 \text{ mol } O_2}{32.0 \text{ g } O_2}\right)\left(\frac{2 \text{ mol MgO}}{1 \text{ mol g } O_2}\right)\left(\frac{40.31 \text{ g MgO}}{1 \text{ mol MgO}}\right) = 25.2 \text{ g MgO}$$

Based on the limiting reactant, the possible amount of MgO produced is 3.98 g. (**Limiting reactant is the reactant** that **produces the smaller product yield** [moles or grams])

12. Given the following reaction: $\mathbf{2\,Fe + 3\,Cl_2 \rightarrow 2FeCl_3}$. You wish to determine the limiting reactant for the formation of $FeCl_3$ from 2.30 g of Fe and 4.00 g of Cl_2.

a) How many moles of $FeCl_3$ can be produced from the given mass of Fe?

b) How many moles of $FeCl_3$ can be produced from the given mass of Cl_2?

c) Based on (a) and (b) above, which is the limiting reactant, Fe or Cl_2? _____

d) What is percent yield if the actual yield is 5.22 g of $FeCl_3$? (Hint: calculate theoretical yield from limiting reactant)

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

13. Be able to name compounds and write chemical formulas of compounds.

- **Group 1, 2 and 3 ionic compounds**:
  - NaCl (sodium chloride), $CaBr_2$ (calcium bromide)
  - KNO_3 (potassium nitrate), $Mg(NO_3)_2$ (magnesium nitrate),
  - $Al(NO_3)_3$ (aluminum nitrate)

- **Transition metal ionic compounds** (notice the use of **Roman Numerals**):
  - $CuCl$ – copper(I) chloride
  - $CuCl_2$ – copper(II) chloride
  - $Fe(OH)_2$ – iron(II) hydroxide
  - $Fe(OH)_3$ – iron(III) hydroxide
  - $Fe_2(CO_3)_3$ – iron(III) carbonate
  - $Ni_3(PO_4)_2$ – nickel(II) phosphate
- **Covalent compounds** (nonmetal and nonmetal) – use of **Greek prefixes**
  - CO – carbon monoxide
  - CO_2 – carbon dioxide
  - N_2O_4 – dinitrogen tetroxide
  - PCl_5 – phosphorus pentachloride
  - P_4O_{10} – tetraphosphorus decoxide
  - IF_7 – iodine heptafluoride
- **Binary Acids**
  - HF – hydrofluoric acid
  - HCl – hydrochloric acid
  - HBr – hydrobromic acids
  - H_2S – hydrosulfuric acid
- **Oxyacids**
  - H_2SO_4 – sulfuric acid
  - H_2SO_3 – sulfurous acid
  - H_2CO_3 – carbonic acid
  - $HClO_4$ – perchloric acid
  - HNO_3 – nitric acid
  - CH_3COOH – acetic acid
- **Ionic Compound hydrates**
  - $Pb(ClO_4)_2 \cdot 3H_2O$ – lead(II) perchlorate trihydrate
  - $Ba(OH)_2 \cdot 8H_2O$ – barium hydroxide octahydrate
  - $CuCl_2 \cdot 2H_2O$ – copper(II) chloride dihydrate

Name the following compounds.

NaF _____ $CaCl_2$ _____

K_2O _____ $Fe(NO_3)_3$ _____

I_2F_7 _____ SO_3 _____

$SnBr_2 \cdot 2H_2O$ _____ $Ni(NO_3)_2$ _____

Write the chemical formulas for the following compounds.

Lithium bromide _____ magnesium hydroxide _____

Calcium sulfide_____ ammonium carbonate _____

Sulfur hexafluoride_____ cobalt(III) sulfate _____

dinitrogen pentoxide _____ lead(IV) phosphate _____

14. Know isotope symbols. What is an isotope? For example: $^{12}_{6}C$, $^{13}_{6}C$, and $^{14}_{6}C$ or ^{12}C, ^{13}C, ^{14}C

Determine the mass number, number of protons, neutrons and electrons for the following isotopes.

i.

isotope	**Mass # # neutrons**	**# protons**	**#electrons**
^{12}C			
^{13}C			
^{58}Ni			
^{61}Ni			
^{64}Ni			