

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.

$$\begin{aligned}\text{Boron average mass} &= (0.199 \times 10.0129 \text{ amu}) + (0.801 \times 11.0093 \text{ amu}) \\ &= 1.99 \text{ amu} + 8.82 \text{ amu} \\ &= 10.81 \text{ amu}\end{aligned}$$

3. Determine (mass) percent composition from chemical formulas.

(Hint: think of fractions, $\% = \frac{\text{portion}}{\text{total mass}} \times 100\% = \text{---}\%$)

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

$$\% \text{C} = \frac{12}{16} \times 100\% = 75\% \text{ C}$$

$$\% \text{H} = \frac{4}{16} \times 100\% = 25\% \text{ H}$$

Mass percent composition: Example below is for glucose, $\text{C}_6\text{H}_{12}\text{O}_6$.

$$\text{Percent} = \frac{\text{part}}{\text{whole}} \times 100\%$$

$$\text{Mass \% of C} = \frac{6(12.01 \text{ g})}{180.16 \text{ g}} \times 100\% = 39.9978 = \mathbf{40.0\%}$$

$$\text{Mass \% of H} = \frac{12(1.01 \text{ g})}{180.16 \text{ g}} \times 100\% = 6.72735 = \mathbf{6.73\%}$$

$$\text{Mass \% of O} = \frac{6(16.0 \text{ g})}{180.16 \text{ g}} \times 100\% = 53.286 = \mathbf{53.3\%}$$

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 $1 \text{ nm} = 1.00 \times 10^{-9} \text{ m}$

a) Convert 453 nm to meter (m)

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

b) Convert $6.58 \times 10^{-7} \text{ m}$ to nm.

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

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.

$$205 \text{ g C}_2\text{F}_4 \left(\frac{1 \text{ mol C}_2\text{F}_4}{100.0 \text{ g C}_2\text{F}_4} \right) \left(\frac{6.022 \times 10^{23} \text{ units C}_2\text{F}_4}{1 \text{ mol C}_2\text{F}_4} \right) = 1.23 \times 10^{24} \text{ units C}_2\text{F}_4$$

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

$$205 \text{ g C}_2\text{F}_4 \left(\frac{1 \text{ mol C}_2\text{F}_4}{100.0 \text{ g C}_2\text{F}_4} \right) \left(\frac{2 \text{ mol C}}{1 \text{ mol C}_2\text{F}_4} \right) \left(\frac{6.022 \times 10^{23} \text{ atoms C}}{1 \text{ mol C}} \right) = 2.55 \times 10^{24} \text{ atoms C}$$

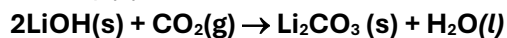
(c) How many moles of fluorine are in 205 g of Teflon?

$$205 \text{ g C}_2\text{F}_4 \left(\frac{1 \text{ mol C}_2\text{F}_4}{100.0 \text{ g C}_2\text{F}_4} \right) \left(\frac{4 \text{ mol F}}{1 \text{ mol C}_2\text{F}_4} \right) = 8.20 \text{ mol F}$$

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

$$205 \text{ g C}_2\text{F}_4 \left(\frac{1 \text{ mol C}_2\text{F}_4}{100.0 \text{ g C}_2\text{F}_4} \right) \left(\frac{4 \text{ mol F}}{1 \text{ mol C}_2\text{F}_4} \right) \left(\frac{6.022 \times 10^{23} \text{ atoms F}}{1 \text{ mol F}} \right) = 4.94 \times 10^{24} \text{ atoms F}$$

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) **incorrect**?

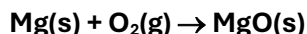


$$1.00 \times 10^3 \text{ g LiOH} \left(\frac{1 \text{ mol LiOH}}{23.95 \text{ g LiOH}} \right) \left(\frac{2 \text{ mol LiOH}}{1 \text{ mol CO}_2} \right) \left(\frac{1 \text{ mol CO}_2}{44.01 \text{ g CO}_2} \right)$$

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 .



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

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

$$10.0 \text{ g O}_2 \left(\frac{1 \text{ mol O}_2}{32.0 \text{ g O}_2} \right) \left(\frac{2 \text{ mol MgO}}{1 \text{ mol O}_2} \right) \left(\frac{40.31 \text{ g MgO}}{1 \text{ mol MgO}} \right) = 25.2 \text{ g MgO}$$

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: $2\text{Fe} + 3\text{Cl}_2 \rightarrow 2\text{FeCl}_3$. 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), $\text{Mg(NO}_3)_2$ (magnesium nitrate),

$\text{Al(NO}_3)_3$ (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 ₂ O ₄ – dinitrogen tetroxide	PCl ₅ – phosphorus pentachloride
P ₄ O ₁₀ – tetraphosphorus decoxide	IF ₇ – iodine heptafluoride
- **Binary Acids**

HF – hydrofluoric acid	HCl – hydrochloric acid
HBr – hydrobromic acids	H ₂ S – hydrosulfuric acid
- **Oxyacids**

H ₂ SO ₄ – sulfuric acid	H ₂ SO ₃ – sulfurous acid
H ₂ CO ₃ – carbonic acid	HClO ₄ – perchloric acid
HNO ₃ – nitric acid	CH ₃ COOH – acetic acid
- **Ionic Compound hydrates**
 - Pb(ClO₄)₂•3H₂O – lead(II) perchlorate trihydrate
 - Ba(OH)₂•8H₂O – barium hydroxide octahydrate
 - CuCl₂•2H₂O – copper(II) chloride dihydrate

Name the following compounds.

NaF _____

CaCl₂ _____

K₂O _____

Fe(NO₃)₃ _____

I₂F₇ _____

SO₃ _____

SnBr₂•2H₂O _____

Ni(NO₃)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: ${}^1_6\text{C}$, ${}^{13}_6\text{C}$, and ${}^{14}_6\text{C}$ or ${}^{12}\text{C}$, ${}^{13}\text{C}$, ${}^{14}\text{C}$

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

i. <u>isotope</u>	<u>Mass #</u>	<u># neutrons</u>	<u># protons</u>	<u>#electrons</u>
${}^{12}\text{C}$				
${}^{13}\text{C}$				
${}^{58}\text{Ni}$				
${}^{61}\text{Ni}$				
${}^{64}\text{Ni}$				