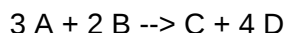


- **Make sure your chemical equation is balanced <---- Everything gets messed up if you don't pay attention to this little detail**
- Stoichiometry is a weird word. It sort of means "look at how the molecules must combine in the chemical reaction," like:



The stoichiometry is that three molecules of A react with two molecules of B to form a molecule of C and four molecules of D. Now, remember that molecules react with molecules <-- That is why you have to use moles to do chemical reactions. Moles are a unit of quantity. (1 mole = 6.02×10^{23} molecules)

We can't use grams because grams are a unit of mass and chemical equations aren't between masses, they are between molecules. You have to, have to, have to, HAVE TO be very good at converting between grams and moles.

$$\text{moles} = \frac{\text{grams}}{\text{molar mass}} \qquad \text{grams} = \text{moles} \cdot \text{molar mass}$$

- The central idea to chemical reaction stoichiometry is the mole ratio. If we know all the mole ratios and we know how much of one species gets used up or formed then you know how much of all species that get used up or formed.
- Mole ratios are just the ratios of stoichiometric coefficients.

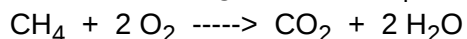
For example: $\frac{\text{moles A}}{\text{moles B}} = \frac{3}{2}$ etc.

Limiting Reactant Problems

Limiting reactant problems build on this idea of the mole ratio because the extent of the reaction is based upon the amount of one reactant that gets completely consumed (the limiting reactant).

To find which reactant is limiting just look at the moles of all the reactants present (convert from grams if necessary), and use mole ratios to see which reactant is limiting (used up first) and which are in excess. Excess reactants aren't completely consumed, so you have to remember to include the unconsumed part in the products. For example:

40 grams of O₂ reacts with 20 grams of CH₄ according to the reaction



Who is the limiting reactant?

moles CH₄ = 20g/16g/mol = 1.25 mol ---> To fully react would require 1.25 (2 /1) = 2.5 moles O₂

moles O₂ = 40g/32g/mol = 1.125 mol <---- There's not enough O₂ so it's the limiting reactant.

- You also need to know some terminology and definitions:

Theoretical yield = amount of products obtained if the reaction goes to completion

Actual yield = whatever you get from a specified extent of reaction

Percent yield = (actual yield/theoretical yield) x 100%

- **Percent composition** problems are ever-present on the AP. You have to know how to do them. The idea behind them is that if you can break a molecule apart and just look at the elements that compose it, you should be able to figure out, at the very least, the empirical formula of the thing. If you know how many moles your sample was or if you know the molecular weight of the molecule, you should also be able to determine the molecular formula.

Remember the difference between these two things: the empirical formula gives the lowest whole number ratio of all the elements in a molecule, and the molecular formula gives the actual makeup of the molecule. Okay, so this is how they usually proceed:

1. From some kind of a chemical analysis you will be given how much of each element there was in some molecule whose chemical formula you are supposed to figure out.
(Be careful about the information you are given because you can also get extra stuff, like, if something was burned in the air, there will be N_2 present because air is a mixture of oxygen, 21%, and nitrogen, 79%.)
2. What you do is find the moles (sometimes grams then moles) of each element in the analysis and then find the lowest integer ratio between them (by dividing through by the smallest number of moles). That ratio for each element will be the subscripts for the empirical formula.
3. If you're given the molecular mass you can divide it by the empirical formula weight to find the molecular formula; that is, how many empirical formulas do you need to make up the molecular formula.

All this is easier to show in an example than to describe:

A compound contains carbon, hydrogen and zinc. When burned in oxygen the products are 21.88 g of ZnO, 47.52 g of CO_2 and 24.3 g H_2O .

- (A) What is the empirical formula of the compound?
(B) If the molecular weight = 617, what is the molecular formula?

(A)

Element	Molecule	Mass of Molecule	Mass Fraction of Element	Mass Element	Moles Element	Lowest Integer Ratio	Emperical Formula
Zn	ZnO	21.98	.8	17.6	.27	1	ZnC ₄ H ₁₀
C	CO ₂	47.52	.27	13	1.1	4	
H	H ₂ O	24.3	.11	2.7	2.7	10	

1st key step. You have to figure out the mass of each element that was in the molecule

Convert to moles

Divide through by the smallest number of moles (.27)

(B)

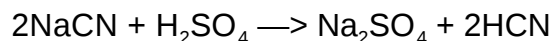
$$\text{Molecular formula: } \frac{617}{123.39} = 5 \quad \text{so it's } Zn_5C_{20}H_{50}$$

Student Packet: 3.4: Stoichiometry: AssessMe questions

- 1) If you wish to find the new volume of a gas which was at 20°C and 760 mm Hg pressure, and conditions were changed to 0°C and 700 mm Hg pressure, by what fractions would you multiply the original volume?
A) $(293 \times 760)/(273 \times 700)$
B) $(273 \times 700)/(293 \times 760)$
C) $(273 \times 760)/(293 \times 700)$
D) $(293 \times 700)/(273 \times 760)$
E) I'm clueless
- 2) A 27.0 g sample of an unknown hydrocarbon is burned in excess oxygen to form 88.0 g of carbon dioxide and 27.0 g of water. What is a possible molecular formula of the hydrocarbon?
A) CH₄ B) C₂H₂ C) C₄H₃ D) C₄H₆ E) I'm clueless
- 3) One mole of nitrogen, two moles of neon, and four moles of argon are sealed in a cylinder. The combined pressure of the gases is 1400 mm Hg. What is the partial pressure of nitrogen in the cylinder?
A) 100 mm Hg B) 200 mm Hg C) 400 mm Hg D) 500 mm Hg E) I'm clueless
- 4) The level of mercury inside a manometer is higher for the segment open to the atmosphere. The correct pressure inside the gas vessel would be found by performing what arithmetic operation on the difference in the height of mercury and atmospheric pressure?
A) subtracting
B) adding
C) dividing by 13.6
D) doing both C and A
E) I'm clueless
- 5) When 200 ml of a gas at constant pressure is heated, its volume:
A) increases
B) decreases
C) remains unchanged
D) oscillates
E) I'm clueless
- 6) 200 ml of a gas at constant pressure is heated from 0°C to 100°C. In order to determine the new volume, the initial volume must be multiplied by:
A) 0/100 B) 100/0 C) 273/373 D) 373/273 E) I'm clueless

Student Packet: 3.4: Stoichiometry: ShowMe questions

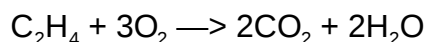
- 1) What is the percent yield of this reaction?



12 g of NaCN in excess H_2SO_4 yields 13.6 g Na_2SO_4

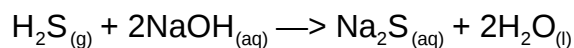
- 2) Boron sulfide, B_2S_3 , reacts with water to form H_3BO_3 and H_2S . How much boric acid is produced if 1.86 g of B_2S_3 is reacted with an excess amount of water?

- 3) Ethylene burns in the reaction:



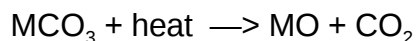
How many grams of CO_2 form if 2.8 g of C_2H_4 and 6 g of O_2 are combined and reacted?

- 4) Given the following reaction, how much Na_2S is generated if 3 g of $\text{H}_2\text{S}_{(\text{g})}$ is bubbled through a solution of NaOH assuming excess amount of NaOH?



Student Packet: 3.4: Stoichiometry: TestMe questions

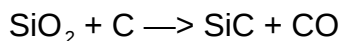
- 1) In an experiment, 1.915 g of metal carbonate is heated to give the metal oxide and 0.682 g of CO₂.



What is the metal?

- A) Ni B) Cu C) Fe D) Zn E) Ba
- 2) A mixture of CuSO₄ and CuSO₄·5H₂O has a mass of 1.82 g, but after heating to remove all water, the resulting mass is 1.26 g. What is the weight percent of CuSO₄ in the original mixture?
- A) 1.48% B) 5.62% C) 8.93% D) 11.45% E) 14.8%
- 3) Glass bottles (made up of Na₂SiO₃) can be dissolved in HF to yield H₂SiF₆, NaF, and H₂O. How much HF is needed to dissolve a glass test tube weighing 14.8 g?
- A) 16.8 g B) 19.4 g C) 23.3 g D) 46.2 g E) 50.0 g
- 4) The reaction $\text{C}_6\text{H}_6 + \text{Br}_2 \longrightarrow \text{C}_6\text{H}_5\text{Br} + \text{HBr}$ is known to have a 48% yield. How much C₆H₅Br is generated starting with 10 g of C₆H₆ and excess Br₂?
- A) 4.8 g B) 7.1 g C) 8.3 g D) 9.6 g E) 10.2 g

- 5) Silicon carbide is made in the following reaction:



Assuming the reaction goes to completion, starting with 5 g of starting reagent, how much excess reactant is left over?

- A) 1.00 g C
B) 2.01 g C
C) 0.58 g SiO₂
D) 0.23 g SiO₂
E) 1.28 g SiO₂