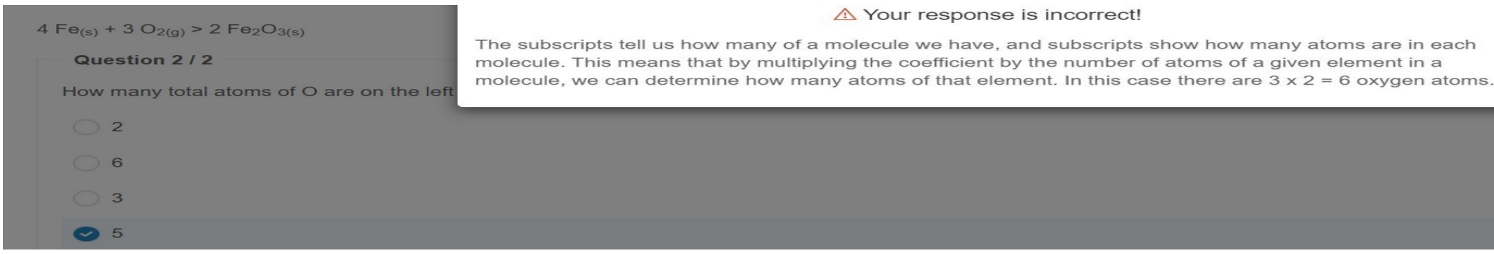
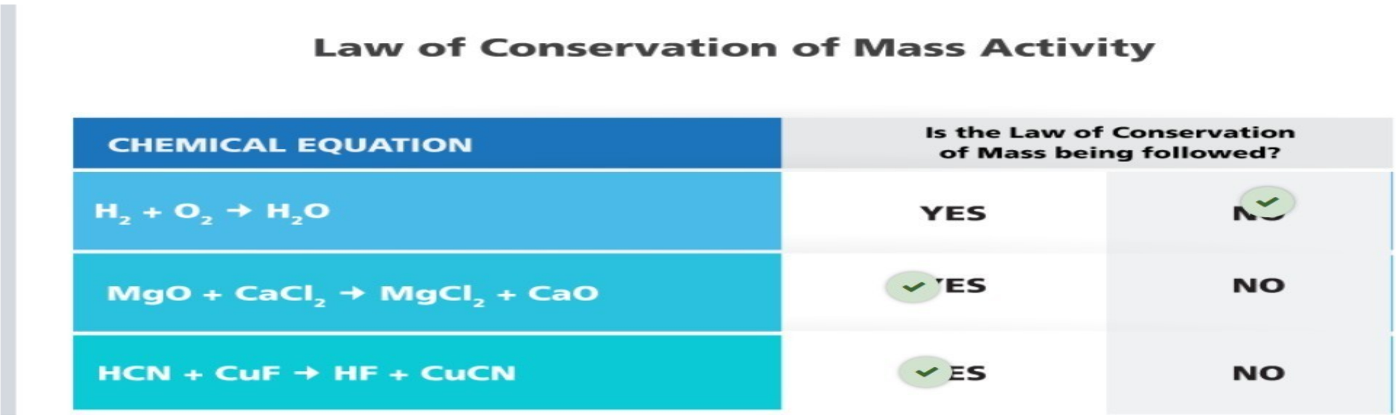
Edapt Notes Chem 120

Balancing Chemical Equations

- Balanced chemical equations have the same number of each atom on each side of the arrow. This equation is correct: $2\ NaBr + CaCl_2 \rightarrow 2\ NaCl + CaBr_2$
- Subscripts tell you how many of an atom you have in a chemical formula.
- Check each chemical reaction to determine the one that does not have the same number of each atom on each side of the chemical reaction. If a chemical equation violates the Law of Conservation of Mass, the atoms will not equal out on both sides. The correct answer is $2\ H_2 + N2 \rightarrow 2\ NH_3$. There are four atoms of H on the left, or reactant side while there are six atoms of H on the right, or products side. As matter cannot be created or destroyed in a chemical reaction, these are not this choice violates the Law of Conservation of Mass.
- The coefficients represent the number of molecules. The subscripts in a formula represent the number of atoms.
- In the equation *4 Fe(s) + 3 O2(g) > 2 Fe2O3(s)*, how many molecules of O2 are in the chemical?
  - Coefficients show us how many molecules of a given compound are in a chemical equation. In this case there are *3 O_2 molecules*.





Law of Conservation of Mass Activity

CHEMICAL EQUATION	Is the Law of Conservation of Mass being followed?	
$H_2 + O_2 \rightarrow H_2O$	YES	NO
$MgO + CaCl_2 \rightarrow MgCl_2 + CaO$	YES	NO
$HCN + CuF \rightarrow HF + CuCN$	YES	NO

- Chemical equations have **reactants** and **products**. Reactants are on the left side of the arrow, and products are on the right side of the arrow. For example, in the reaction below, HCl and NaOH are called reactants, and H_2O and NaCl are called products.
- The coefficients show the number of molecules of a given compound. This equation is $2\ H_{2(g)} + 1\ O_{2(g)} > 2\ H_2O_{(g)}$

Reactants Products

$Mg(OH)_2 + 2\ HCl \longrightarrow MgCl_2 + 2\ H_2O$

1	Mg	1
2	O	2
4	H	4
2	Cl	2

$Ca(OH)_2 + 2\ HBr \rightarrow CaBr_2 + 2\ H_2O$

Reactant Side	Atom	Product Side
1	Ca	1
2	O	2
4	H	4
2	Br	2

$3\ MgSO_4 + 2\ Al(NO_3)_3 > 3\ Mg(NO_3)_2 + Al_2(SO$

Reactant Side	Atom	Product Side
3	Mg	3
3	S	3
7	O	18
2	Al	2
6	N	6

3	Mg	3
3	S	3
30	O	30
2	Al	2
6	N	6

2 H_2 + **1** $O_2 \rightarrow$ **2** H_2O

1 $FeCl_{2(s)}$ + **1** $H_2O_{(l)} \rightarrow$ **1** $FeO_{(s)}$ + **2** $HCl_{(aq)}$

1 $C_4H_{8(g)}$ + **6** $O_{2(g)} \rightarrow$ **4** $CO_{2(g)}$ + **4** $H_2O_{(l)}$

2 $NaHCO_{3(s)} \rightarrow$ **1** Na_2CO_3 + **1** $CO_{2(g)}$ + **1** $H_2O_{(g)}$

2 $NaOH_{(aq)}$ + **1** $MgCl_{2(aq)} \rightarrow$ **2** $NaCl_{(aq)}$ + **1** $Mg(OH)_{2(s)}$

Balanced as written

$H_2 + O_2 > H_2O_2$

$Na + Cl > NaCl$

Not balanced as written

$H_2 + O_2 > H_2O$

$K + O_2 > K_2O$

- The symbols after the molecule indicate the state of matter
  (aq) indicates aqueous compounds, so $AgNO_3$, NaCl, and $NaNO_3$ are all dissolved in water.
- Be sure to count up every atom on both the product and reactant side. A balanced equation is **1** $S_{8(g)}$ + **12** $O_{2(g)} \longrightarrow$ **8** $SO_{3(g)}$

Select all examples where the Law of Conservation of Mass is not being followed.

- [ ] $H_2SO_4 + 2\ NaOH \rightarrow Na_2SO_4 + 2\ H_2O$
- [x] $Mg_3N_{2(s)} + 3\ H_2O_{(l)} \rightarrow NH_{3(g)} + 3\ Mg(OH)_{2(s)}$
- [ ] $2\ NaCl + MgBr_2 \rightarrow 2\ NaBr + MgCl_2$
- [x] $S_{8(g)} + Ag_{(s)} \rightarrow 8\ AgS$

Balance the chemical equation:

1 C_5H_{12} + 8 $O_2 \rightarrow$ 6 H_2O + 5 CO_2.

Stoichiometry

- Just like following a recipe, we can know how many of an ingredient (reactant) we need to make a specified amount of product according to a recipe (balanced chemical equation). You produce 3 molecules of $Li_2O_{(s)}$ by using 6 atoms of $Li_{(s)}$.

Avogadro's Number and the Mole

- **Avogadro's number: 6.022×10^{23}**. This is the number of atoms in 12 grams of the isotope carbon-12

Just as 12 of a substance is a dozen, 6.022×10^{23} of a substance is a mole. For example:

- One mole of aluminum atoms is 6.022×10^{23} atoms of aluminum.
- If you have 1 mole of cookies, you have 6.022×10^{23} cookies
- 1 mole of H_2O is equal to 6.022×10^{23} molecules of H_2O

It is important to note that a mole of a substance does not have the same mass of a mole of another substance, just as a dozen eggs would have a much smaller mass than a dozen cars.

Atomic Mass & Molar Mass

- The units you use here for atomic mass will be: g/mol (grams per mole). As you can see, the atomic mass of an atom of aluminum can be expressed as 26.98 g/mol. If you were to somehow count out exactly 1 mole (Avogadro's number, 6.022×10^{23}) atoms of Al and put them on a scale, the mass of this sample would 26.98 grams. In other words, an atomic mass is the number of grams of that atom per mole of that atom.

- As you see from the formula H_2O, we have two atoms of H and one atom of O in each molecule. We can add these up to get the molecular mass of H_2O:
- H: 2 x 1.01 g/mol + O: 1 x 16.00 g/mol = 18.02 g/mol
- This means that there are 18.02 grams of H_2O in one mole of H_2O. As an important note: the units of molecular mass are g/mol,

Use g/mol as the unit for molecular mass

$MgCl_2$	
Number of Mg atoms	1
Number of Cl atoms	2
Molecular Mass of $MgCl_2$	95.21 g/mole
$Ca(OH)_2$	
Number of Ca atoms	1
Number of O atoms	2
Number of H atoms	2
Molecular Mass of $Ca(OH)_2$	74.1 g/mol
$(NH_4)_2S$	
Number of N atoms	2
Number of H atoms	8
Number of S atoms	1
Molecular Mass of $(NH_4)_2S$	68.17 g/mol

32.00 g O_2 / 1 mole O_2

82.98 g Na_3N / 1 mole Na_3N

132.1 g $Ca(NO_2)_2$ / 1 mole $Ca(NO_2)_2$

157.9 g P_2O_6/ 1 mole P_2O_6

Converting Between Grams & Moles

- As you have likely noticed, molecular masses are in units of g/mol. This means that molecular masses give us the relationship between grams and moles. For example, for the molecule O_2, with a molecular mass of 32 g/mol, 32.0 grams of O_2 = 1 mole O_2. As you see, molecular masses are a relationship between grams and moles.

- You can use the relationship between grams and moles from molecular weight as a conversion factor. Specifically, you can use molecular masses to convert from grams to moles or moles to grams. Using the example above for O_2, use the molecular mass (32.0 g/mol) to determine how many moles you would have in 92.0 grams of O_2.

$$\frac{92.0\ \cancel{grams\ O_2}}{} \left| \frac{1\ mol\ O_2}{32.0\ \cancel{grams\ O_2}} \right| \frac{2.9\ moles\ O2}{}$$

- This is the same method we used for dimensional analysis earlier this session. As you see, you can arrange the equation so that the unit you do not want cancels (*grams O_2*) and you have the unit you want on top (*moles O_2*). Molecular mass allows you to quickly convert between grams and moles. This is an important skill in chemistry as you cannot measure out moles of substance on a balance, but can easily measure out grams.

As a take home from this part of the lesson, remember: The way to convert from g to mol OR mole to grams of a molecule is to use the molar mass of that molecule.

Convert 3.8 grams of H_2O into moles (Molar mass of H_2O is 18.02 g/mol)		
3.8 g H_2O	1 mol H_2O	0.21 moles H_2O
	18.02 g H_2O	

Convert 9.6 moles of NaOH into grams (Molar mass of NaOH is 40.0 g/mol)		
9.6 mol NaOH	40.0 g NaOH	384 g NaOH
	1 mol NaOH	

The units of molar mass from the periodic table are [grams per mole (g/mol)] and can relate what is measured in lab to balanced chemical equations. The units of mass are [grams (g)], which can be measured using a balance. The units of [mole] are used in balanced chemical equations, and represents 6.022×10^{23} molecules.

- 500 grams of water, divided by 18.0 g/mol is 27.8 moles of water.
- Molecular weight has units of g/mol. Mass has units of grams. The balanced chemical equation has units of moles.

Chemical Recipes