

CHEMISTRY 11

Introduction to STOICHIOMETRY

Balanced equations represent the **RATIO** in which substances combine.
The ratio comes from the **COEFFICIENTS** of the balanced equation.
The combining ratio of substances in any chemical reaction is called the **MOLE RATIO**.

This is **STOICHIOMETRY**.

Stoichiometry sample questions:

- 1) Consider a lab experiment where a student attempts to react aluminum sulphate with copper.

*It does not react since the copper is below aluminum on the reactivity series!
Nothing will happen!*

NOW TRY THIS:

Copper (II) sulphate reacts with Aluminum.

In this case, you should start to recognize that the copper (II) sulphate will be an **aqueous solution**.

Do you know what colour it will be? **Blue**

And the Aluminum will be a **solid**.

Write the balanced equation.



- a) You are told that ONE MOLECULE of aluminum sulphate forms.
Use the MOLE RATIO of the balanced equation, to find the # of molecules (or atoms) of each of the other chemicals in this reaction.



1 molecule

<i>3 molecules</i>	<i>2 atoms</i>	<i>3 atoms</i>
<i>react</i>	<i>react</i>	<i>are formed</i>

- b) A more realistic scenario:



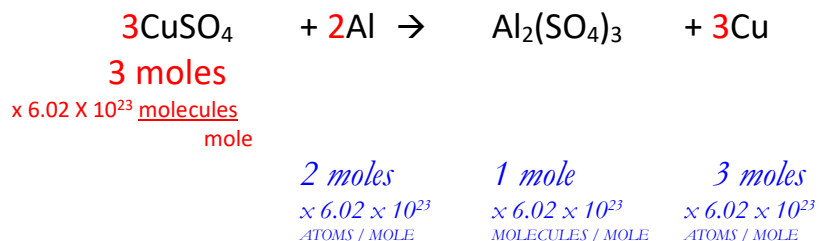
3 moles

2 moles

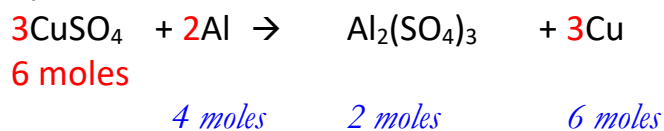
1 mole

3 moles

c) Now consider:



d) Now consider that we start with a different amount:



	3CuSO ₄	+ 2Al	→ Al ₂ (SO ₄) ₃	+ 3Cu
e)		5.00 moles		
f)				5.25 moles
g)			Goal is to make 279 g	

	3CuSO ₄	+ 2Al	→ Al ₂ (SO ₄) ₃	+ 3Cu
e)	7.50 moles	5.00 moles	2.50 moles	7.50 moles
f)	5.25 moles	3.50 moles	1.75 moles	5.25 moles
g)			Goal is to make 279 g	

For question g) it is EXTREMELY IMPORTANT that you understand that

YOU CAN ONLY DO RATIOS IN MOLES!!!!

Therefore, the first thing you must do is change any given data into moles.

$$\begin{array}{l}
 279 \text{ g X } \frac{1 \text{ mole}}{342.3 \text{ g Al}_2(\text{SO}_4)_3} \\
 = 0.815 \text{ moles}
 \end{array}$$

	3CuSO ₄	+ 2Al	→ Al ₂ (SO ₄) ₃	+ 3Cu
g)	2.445 moles	1.63 moles	0.815 moles	2.44 moles

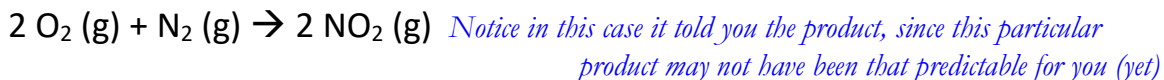
	X $\frac{159.6 \text{ g}}{1 \text{ mole}}$ = 389 g	X $\frac{27.0 \text{ g}}{1 \text{ mole}}$ = 44.0 g	279 g (given)	X $\frac{63.5 \text{ g}}{1 \text{ mole}}$ = 155 g
--	---	---	---------------	--

The **LAW of CONSERVATION of MASS** says that the
 MASS OF THE REACTANTS = MASS OF THE PRODUCTS

$$\begin{array}{rcl}
 \text{LS} & = & \text{RS} \\
 389 \text{ g} + 44.0 \text{ g} & = & 279 \text{ g} + 155 \text{ g} \\
 433 \text{ g} = & 434 \text{ g}
 \end{array}$$



2) 6.00 L of oxygen gas at RTP reacts with nitrogen gas to produce NO₂ (g). Find the **VOLUME** of all chemicals.



6.00 L

$$\text{X } \frac{1 \text{ mole}}{24.5 \text{ L}}$$

$$= 0.245 \text{ mol} \quad 0.122 \text{ mol} \quad 0.245 \text{ mol}$$

$$\begin{array}{cc}
 \times \frac{24.5 \text{ L}}{1 \text{ mole}} & \times \frac{24.5 \text{ L}}{1 \text{ mole}}
 \end{array}$$

$$= 3.00 \text{ L} \quad = 6.00 \text{ L}$$

WHAT DO YOU NOTICE?

AVOGADRO says that gases at the SAME TEMPERATURE and PRESSURE will contain the same number of moles and occupy the same volume.

THEREFORE, we used the RTP value (stating that 1 mole of gas at this temperature will occupy 24.5 L of space) to change the L into moles,
 BUT then we used the RTP value to change the moles back to volume...

...so we could have just used the mole ratio to change the volumes of the gases directly.

EQUATIONS AND STOICHIOMETRY

I. Predict the Products

II. Balance the Equation

III. Name the TYPE of reaction

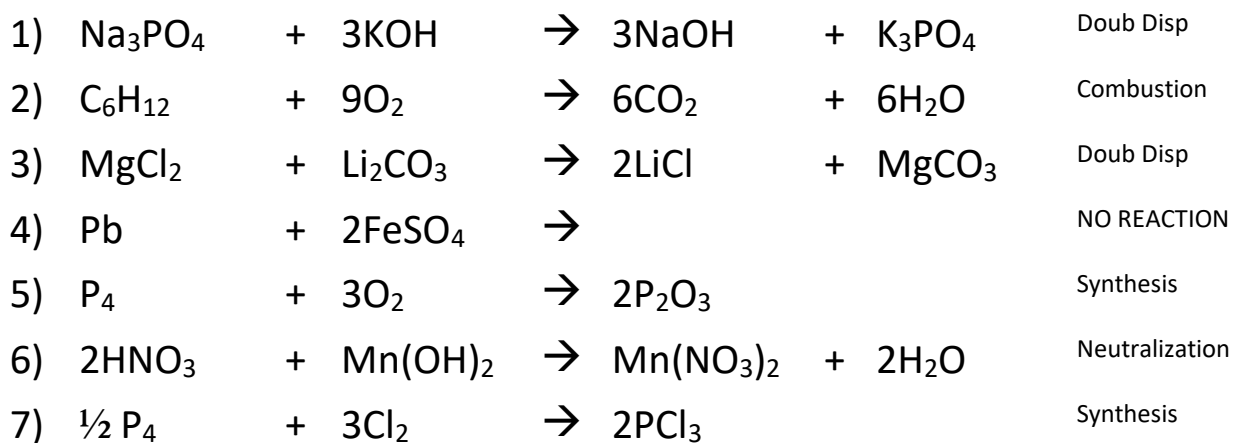
- a) $\text{Na}_3\text{PO}_4 + \text{KOH} \rightarrow$ _____
- b) $\text{C}_6\text{H}_{12} + \text{O}_2 \rightarrow$ _____
- c) $\text{MgCl}_2 + \text{Li}_2\text{CO}_3 \rightarrow$ _____
- d) $\text{Pb} + \text{FeSO}_4 \rightarrow$ _____
- e) $\text{P}_4 + \text{O}_2 \rightarrow$ _____
- f) $\text{HNO}_3 + \text{Mn}(\text{OH})_2 \rightarrow$ _____
- g) $\text{P}_4 + \text{Cl}_2 \rightarrow$ _____

- 1) Find the moles of each product if you start with 1.20 moles of hydrochloric acid and react it with tin (IV) oxide, to form water and tin (IV) chloride.

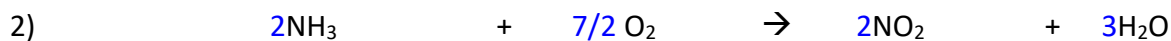
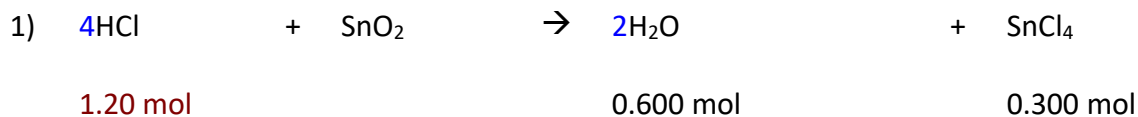
- 2) 425 L of ammonia gas combusts at RTP. How many moles of each substance is involved in the reaction?

- 3) Lead (II) Oxide + Sulphur \rightarrow Lead (IV) Sulphide + Oxygen
How many grams of each product would be produced if you start with 510 g of sulphur?

- 4) 80.0 g of methane gas is produced in the combination reaction between Carbon and hydrogen. What was the mass of all chemicals involved in this reaction. Show your check of the law of conservation of mass.



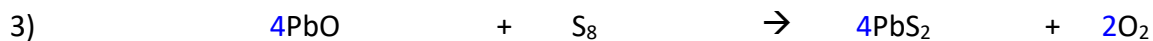
STOICHIOMETRY



given 425 L

Change to moles $\times \frac{1\text{mol}}{24.5\text{L}}$
=17.3 mol

Mole ratio		30.4 mol	17.3 mol	26.0 mol
------------	--	----------	----------	----------



given

510 g

Change to moles

$$\begin{aligned} &\times \frac{1\text{mol}}{256.8\text{g}} \\ &= 1.99 \\ &= 2.0\text{ mol (2SF)} \end{aligned}$$

Mole ratio

$$\begin{aligned} &8.0\text{ mol} \\ &\times 223.199\text{ g/mol} = \\ &1800\text{ g} \end{aligned}$$

$$\begin{aligned} &8.0\text{ mol} \\ &\times 217.332\text{ g/mol} \\ &= 2200\text{ g} \\ &(2\text{ SF}) \end{aligned}$$

$$\begin{aligned} &4.0\text{ mol} \\ &\times 31.998\text{ g/mol} \\ &= 130\text{ g} \end{aligned}$$

4)

C

+

2H_2

\rightarrow

CH_4

given

80.0g

Change to moles

$$\times \frac{1\text{mol}}{16.04\text{g}} = 4.99\text{ mol}$$

Mole ratio


4.99 mol

9.98 mol

Change to grams

$$\begin{aligned} &\times \frac{12.0\text{g}}{1\text{mol}} \\ &= 59.9\text{ g} \end{aligned}$$

$$\begin{aligned} &\times \frac{2.02\text{g}}{1\text{mol}} \\ &= 20.2\text{ g} \end{aligned}$$

Check: reactants: 59.9g + 20.2 g = 80.1 g  products: 80.0g

For all of the above questions, I could have easily calculated the moles and mass of each and every reactant and product (ie I could have filled in every single space), but the questions only asked for specific things, and those are what were shown here.