CHEMISTRY 12
STOICHIOMETRY review and RATES OF REACTIONS Calculations

A quick recap of what you learned in Chemistry 11:

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.

Consider:

Copper (II) sulphate reacts with Aluminum.

You should 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 metal** .

Write the balanced equation.

$$3CuSO_{4\,(aq)} + 2Al_{(s)} \rightarrow Al_2(SO_4)_{3\,(aq)} + 3Cu_{(s)}$$

1 molecule forms

3 molecules react — *2 atoms react* — *3 atoms are formed*

A more realistic scenario is **NOT** to think in individual atoms and molecules:

$$3CuSO_4 + 2Al \rightarrow Al_2(SO_4)_3 + 3Cu$$

3 moles

2 moles — *1 mole* — *3 moles*

And consider that moles represents a large number of atoms / molecules:

$3CuSO_4 + 2Al \rightarrow Al_2(SO_4)_3 + 3Cu$

3 moles
x 6.02×10^{23} molecules / mole

2 moles
x 6.02×10^{23}
ATOMS / mole

1 mole
x 6.02×10^{23}
MOLECULES / mole

3 moles
x 6.02×10^{23}
ATOMS / mole

In Chemistry 12, we study the RATE of reaction. This means that our Stoichiometry calculations include the time it takes for all of the reactant to be used up, or for all of the product to be made. It depends on what you are actually OBSERVING, to measure the rate of reaction.

A student carries out the chemical reaction 3 separate times.
The table below shows the data they collected each time, in order to determine the reaction rate:

	$3CuSO_4$	$+ 2Al$	$\rightarrow Al_2(SO_4)_3$	$+ 3Cu$
a)		5.00 moles completely reacts in 45 sec		
b)			1.75 moles forms in 30 seconds	
c)				Yield is 155 g. Reaction is complete in 21 seconds

In Chemistry 12, at this point, you should be thinking about what the experimenter would actually observe (see) to be able to monitor that reactant being used up, or that product being formed. Will they see a colour change? Gas forming? Volume difference? Mass change?
What number will they be writing down (for example every 5 seconds or 10 seconds), to keep track of how fast the reaction is occurring? *Refer to your notes for this.*

ANSWERS: Note the significant figures in each calculation!

	$3CuSO_4$	+ $2Al$	→ $Al_2(SO_4)_3$	+ $3Cu$
a)	7.50 moles	5.00 moles	2.50 moles	7.50 moles
	7.50 moles 45 seconds **= 0.17 moles/s**	5.00 moles 45 seconds **= 0.11 moles/s**	2.50 moles 45 seconds **= 0.056 moles/ s**	7.50 moles 45 seconds **= 0.17 moles / s**
b)	5.25 moles 30 seconds **= 0.2 moles/s**	3.50 moles 30 seconds **= 0.1 moles /s**	1.75 moles 30 seconds **= 0.06 moles/s**	5.25 moles 30 seconds **= 0.2 moles /s**

For question c) 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.

$155\ g \times \frac{1\ mole}{63.5\ g\ Cu} = 2.44$ moles of Cu

	$3CuSO_{4\ (aq)}$	+ $2Al\ (s)$	→ $Al_2(SO_4)_{3\ (aq)}$	+ $3Cu\ (s)$
c)	2.44 moles 21 seconds **= 0.12 moles / s**	1.63 moles 21 seconds **= 0.078 moles / s** X $\frac{27.0\ g}{1\ mole}$ **= 2.10 g /s**	0.813 moles 21 seconds **= 0.039 moles / s**	2.44 moles 21 seconds **= 0.12 moles / s** X $\frac{63.5\ g}{1\ mole}$ **= 7.38 g /s**

It makes sense to convert the rate for the two solid species into grams / second.

SAMPLE QUESTION 2

6.00 L of oxygen gas at RTP reacts with nitrogen gas to produce NO_2 (g).
Find the VOLUME of all chemicals.

$2\ O_2\ (g) + N_2\ (g) \rightarrow 2\ NO_2\ (g)$

Notice in this case it told you the product, since this particular product may not have been that predictable for you (yet)

6.00 L

$\times\ \frac{1\ mole}{24.5\ L}$

$= 0.245\ mol$ $0.122\ mol$ $0245\ mol$

$\times\ \frac{24.5\ L}{1\ mole}$ $\times\ \frac{24.5\ L}{1\ mole}$

$= 3.00\ L$ $= 6.00\ L$

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 relate the volumes of the gases directly.

Now consider that the 6.00 L of oxygen gas at RTP completely reacts (is consumed) after 46.3 seconds.

State the rate of reaction for every chemical (in L / s)

$2\ O_2\ (g)$	**+**	**$N_2\ (g)$**	**→ $2\ NO_2\ (g)$**
6.00 L		*3.00 L*	*6.00 L*
46.3 s		46.3 s	46.3 s
= 0.130 L / s		= 0.0650 L / s	= 0.130 L / s

CHEMISTRY 12 RATES OF REACTION PRACTICE QUIZ

1) Find the reaction rate of all chemical species if you start with 1.20 moles of hydrochloric acid and react it with tin (IV) oxide, to form water and tin (IV) chloride. The reaction occurs in 25 seconds.

2) 425 L of ammonia gas combusts at RTP. The reaction What is the reaction rate in moles per minute of each substance involved in the reaction? The reaction occurs in 1.35 minutes.

3) Lead (II) Oxide + Sulphur → Lead (IV) Sulphide + Oxygen
510 g of sulphur is consumed in 96 seconds. What is the rate of reaction in g / s for each reactant and product?

4) 80.0 g of methane gas is produced in the Combination (Synthesis) reaction between Carbon and hydrogen. It took 320 seconds for the products to form. What is the rate of reaction in g / s for each species in this reaction?

ANSWER KEY CHEMISTRY 12
RATES OF REACTION PRACTICE QUIZ

1) $4HCl + SnO_2 \rightarrow 2H_2O + SnCl_4$

$4HCl$	SnO_2	$2H_2O$	$SnCl_4$
$\frac{1.20\text{ mol}}{25\text{ s}}$	$\frac{0.300\text{ mol}}{25\text{ s}}$	$\frac{0.600\text{ mol}}{25\text{ s}}$	$\frac{0.300\text{ mol}}{25\text{ s}}$
= 0.048 moles / s	**= 0.012 moles / s**	**= 0.024 moles / s**	**= 0.012 moles / s**

2) $2NH_3 + 7/2\ O_2 \rightarrow 2NO_2 + 3H_2O$

425 L

$X \frac{1 mol}{24.5 L}$

=17.3 mol

$2NH_3$	$7/2\ O_2$	$2NO_2$	$3H_2O$
$\frac{17.3\text{ mol}}{1.35\text{ min}}$	$\frac{30.3\text{ mol}}{1.35\text{ min}}$	$\frac{17.3\text{ mol}}{1.35\text{ min}}$	$\frac{26.0\text{ mol}}{1.35\text{ min}}$
= 12.8 mol/ min	**= 22.4 mol/ min**	**= 12.8 mol/ min**	**= 19.3 mol/ min**

3) $4PbO$	+ S_8	$\rightarrow$ $4PbS_2$	+ $2O_2$
	510 g X $\frac{1mol}{256.8g}$ = 1.99 =2.0 mol		
8.0 mol X 223.2 g/mol = 1800 g (2 SF)		8.0 mol X 271.4 g/mol = 2200 g (2 SF)	4.0 mol X 32.0 g/mol = 130 g (2 SF)
$\frac{1800\text{ g}}{96\text{ s}}$ **= 19 g/s**	$\frac{510}{96\text{ s}}$ **= 5.3 g / s**	$\frac{2200\text{ g}}{96\text{ s}}$ **= 23 g/s**	$\frac{130\text{ g}}{96\text{ s}}$ **= 1.4 g/s**

4) $C + 2H_2 \rightarrow CH_4$

CH_4: 80.0g

X $\frac{1 mol}{16.04 g}$ =

5.00 mol

C	H_2	CH_4
5.00 mol	10.0 mol	
X $\frac{12.0 g}{1 mol}$	X $\frac{2.02 g}{1 mol}$	
= 60.0 g	= 20.2 g	
$\frac{60.0\ g}{320\ s}$	$\frac{20.2\ g}{320\ s}$	$\frac{80.0\ g}{320\ s}$
= 0.19 g/s	**= 0.063 g/s**	**= 0.25 g/s**