

Chemistry 12 - Notes on Unit 1 - Reaction Kinetics

Reaction Kinetics <http://jchemed.chem.wisc.edu/JCESoft/CCA/CCA0/MOVIES/N3IOD.html>

- study of **rates** of rx. and the **factors** which affect the rates.

(note: "rx" = reaction(s))

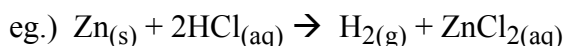
Expressing Rates

rate = $\frac{\text{quantity of a product formed}}{\text{unit time}}$

or **rate** = $\frac{\text{quantity of a reactant consumed}}{\text{unit time}}$

in general: **rate** = $\frac{\Delta \text{amount (a reactant or product)}}{\Delta \text{time}}$

Note: A **time unit** is always in the denominator of a rate equation.



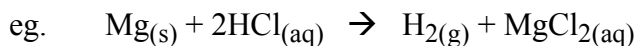
$$r = \frac{\Delta \text{ mass of Zn}}{\Delta \text{ time}}$$

$$r = \frac{\Delta [\text{HCl}]}{\Delta \text{ time}} \quad (\text{note: } [] = \text{molar concentration})$$

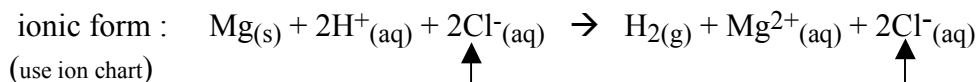
$$r = \frac{\Delta \text{ volume H}_2}{\Delta \text{ time}}$$

Note

- some rxs, when written in **ionic form** show that some ions don't change concentration.



NOTE: To write an equation in IONIC FORM, dissociate all the aqueous (aq) compounds:



[Cl⁻] does not change as rx. proceeds (spectator ion)

Write 4 possible equations which express rate.

Calculations Involving Reaction Rates

When doing calculations involving rate, amount (grams, moles, Litres etc.) use the general equation:

$$\text{Rate} = \frac{\Delta \text{ amount (g, mol, L)}}{\Delta \text{ time (s, min)}}$$

$$\text{or } \Delta \text{ amount} = \text{Rate} \times \Delta \text{ time}$$

$$\text{or } \Delta \text{ time} = \frac{\Delta \text{ amount}}{\text{Rate}}$$

WHEN YOU USE ONE OF THESE FORMULAS, MAKE SURE YOUR **UNITS** CAN CANCEL OUT PROPERLY!

to help solve for what you need.

ALWAYS use conversion factors to cancel units you don't want and replace them with ones you do want!

$$\text{Eg.) } 0.020 \frac{\text{mol}}{\text{min}} = ? \frac{\text{mol}}{\text{s}}$$

$$\text{Solution: } \frac{0.020 \text{ mol}}{1 \text{ min}} \times \frac{1 \text{ min}}{60 \text{ s}} = \frac{3.3 \times 10^{-4} \text{ mol}}{\text{s}}$$

The 60 in 60 s/1min is an exact number by definition. Therefore, we don't consider it using significant digits. The 0.020 has 2 sig. digs., therefore the answer has 2.

You also must use molar mass to go grams \leftrightarrow moles.

$$\text{Eg.) } \frac{0.26 \text{ mol Zn}}{\text{min}} = ? \frac{\text{g of Zn}}{\text{s}}$$

$$\text{Solution: } \frac{0.26 \text{ mol Zn}}{1 \text{ min}} \times \frac{65.4 \text{ g Zn}}{1 \text{ mol Zn}} \times \frac{1 \text{ min}}{60 \text{ s}} = \frac{0.28 \text{ g of Zn}}{\text{s}}$$

You would use 22.4 L for conversions moles \leftrightarrow L (STP) for gases.
1 mol

$$\text{eg.) } 0.030 \text{ mol O}_2/\text{s} = \text{_____ L/s (STP)}$$

$$\text{Solution: } \frac{0.030 \text{ mol O}_2}{1 \text{ s}} \times \frac{22.4 \text{ L}}{\text{mol}} = \frac{0.67 \text{ L O}_2}{\text{s}}$$

(The 0.030 has 2 sig digs so the answer must have 2 sig. digs.)

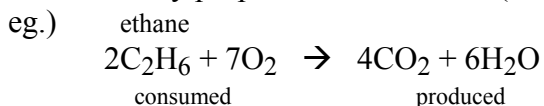
NOTE: This conversion is only used for **gases** at STP!

Try this problem:

The rate of a reaction is 0.034 g of Mg per second. Calculate the number of moles of Mg used up in 6.0 minutes.

Comparing rates using balanced equations

-use **coefficient ratios** - only proportional to mol/s (not to g/s)



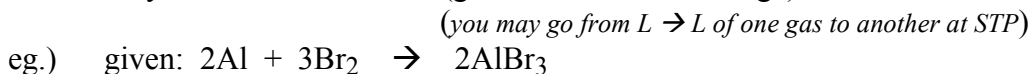
eg.) if ethane is consumed at a rate of 0.066 mol /s, calculate the rate of consumption of O₂ in mol /s

$$\text{Solution: } \frac{0.066 \text{ mol C}_2\text{H}_6}{\text{s}} \times \frac{7 \text{ mol O}_2}{2 \text{ mol C}_2\text{H}_6} = \frac{0.23 \text{ mol O}_2}{\text{s}}$$

if ethane is consumed at a rate of 0.066 mol /s calculate rate of production of CO₂

$$\text{Solution: } \frac{0.066 \text{ mol C}_2\text{H}_6}{\text{s}} \times \frac{4 \text{ mol CO}_2}{2 \text{ mol C}_2\text{H}_6} = \frac{0.13 \text{ mol CO}_2}{\text{s}}$$

- when other units used – you must use **moles** to (go over the “mole” bridge)



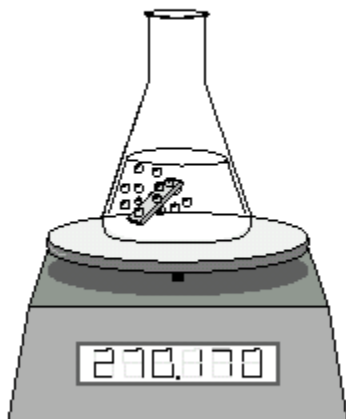
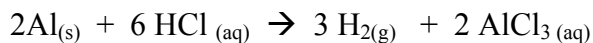
if 67.5 g of Al are consumed per second - calculate the rate of consumption of Br₂ in g/s.

$$\text{Solution: } \frac{67.5 \text{ g Al}}{\text{s}} \times \frac{1 \text{ mol Al}}{27.0 \text{ g Al}} \times \frac{3 \text{ mol Br}_2}{2 \text{ mol Al}} \times \frac{159.8 \text{ g Br}_2}{1 \text{ mol Br}_2} = \frac{599 \text{ g Br}_2}{\text{s}}$$

You may have to use a few conversions and the “rate equation” to arrive at an answer. As you did in Chem. 11, make a “plan” first and make sure your units all cancel the correct way!

Sample Problem:

An experiment is done to determine the rate of the following reaction:

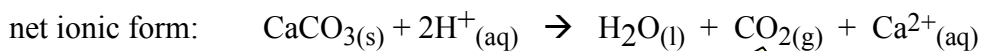
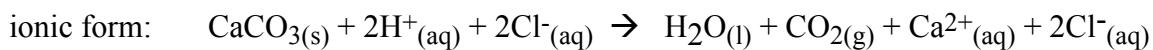
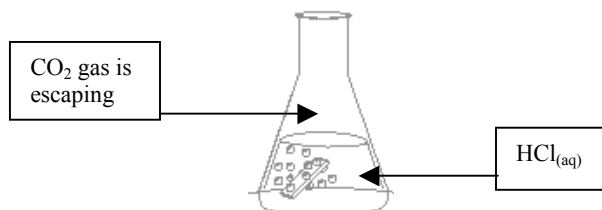
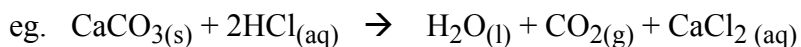


It is found that the rate of production of $\text{H}_{2(g)}$ is 0.060 g/s .

Calculate the mass of Aluminum reacted in 3.0 minutes.

Measuring Reaction Rates

- different methods for different reactions.
- must look at subscripts & use common sense.



in an open system $\text{CO}_{2(g)}$ escapes

- as CO₂ escapes, **mass** of the rest of the system will _____

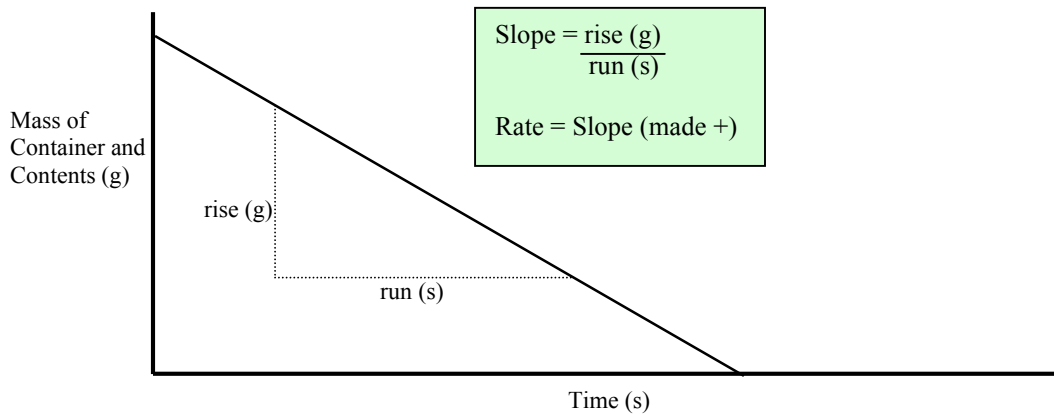
- so rate could be expressed as...

$$r = \frac{\Delta \text{ mass of container and contents}}{\Delta \text{ time}} \quad (\text{open system})$$

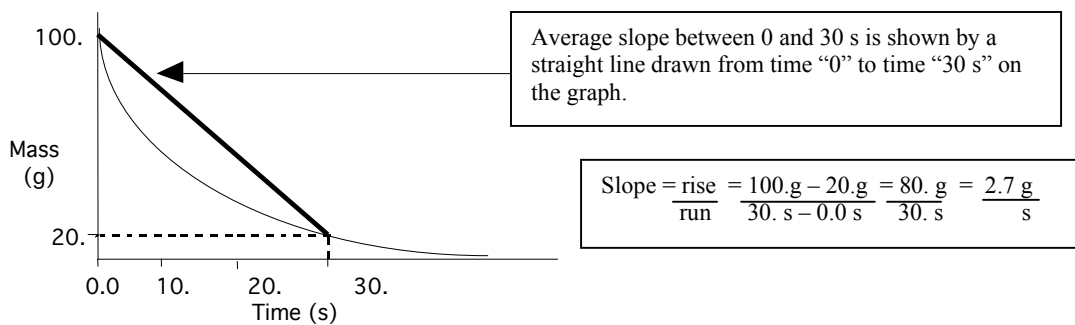
Note

rate = slope of amount. vs. time graph

(disregard sign of slope. Slope will be negative if something is being consumed and positive if something is being produced. Rate is just the Δ amount/ Δ time)



Note - for a changing rate (slope) –which is more realistic -rate could be expressed over a certain interval



or rate at a certain point in time is the slope of the tangent at that point.

