CHE 1301

Basic Principles of Modern Chemistry I

Week 10

Hi! Thanks for checking out the weekly resources for Chemistry 1301! This resource covers topics typically taught by professors during the 10^{th} week of classes.

Visit our website, https://baylor.edu/tutoring, to sign up for appointments and check out additional resources for your course! You'll find helpful links with the following titles:

- "Online Study Guide Resources" – The pace of your course may vary slightly from what's shown in this document. If you don't see the topics you're learning right now, use this link to find the weekly resources for the rest of the semester.
- "How to Participate in Group Tutoring" - See if there is a Chemistry 1301 group tutoring session being hosted this semester. These are weekly question/answer sessions taught by our master tutors!
- "View tutoring times for your course" or "Schedule a private 30-minute appointment!"

You can also give us a call at (254)710-4135, or drop in! Our hours are Monday-Thursday 9 am – 8 pm on class days.

KEY WORDS: Limiting Reactants, Electrolytes/Nonelectrolytes, Molarity/Preparing Solutions

TOPIC OF THE WEEK: Limiting Reactant/Reagent Problems

A chemical equation shows the exact ratio of one reagent that is needed to react with the others. For example, in this reaction,

2H2+O2→2H2O

There are 2 molecules of hydrogen gas needed to react with one molecule of oxygen gas.

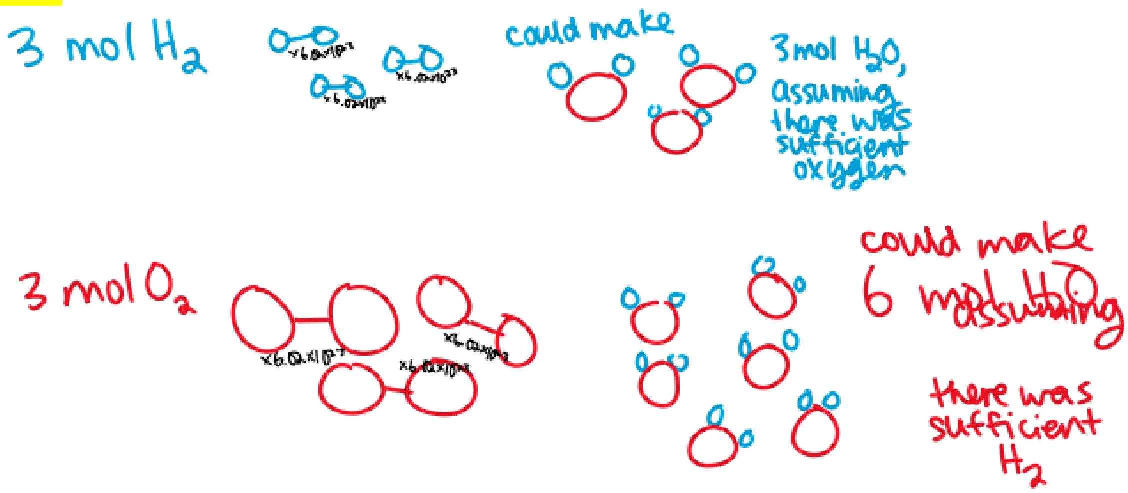
If given the masses of hydrogen and oxygen used in a reaction, we can use molar mass to convert them into moles. The ratio of **moles of one reagent** to **moles of another reagent** is the same as the ratio of **molecules of one reagent** to **molecules of the other**. See last week's resource for more review on this!

In a reaction, there is pretty much always a little more of one reagent than is needed to react with the other. The reagent(s) leftover at the end are said to be "in excess." The other reagent is the "limiting reagent" because the reaction is limited by it; it has to stop when this reagent is gone.

Here is a good analogy: Say that you have 24 tires, 3 steering wheels, and 5 car bodies. How many cars can you make? Just 3, right? You don't have enough steering wheels to make any more, and you need 1 steering wheel for every car that you make. Steering wheels are the limiting reagent. Tires and car bodies are in excess. And after you make your 3 cars, you'll still have 12 tires and 2 car bodies left.

Here are the questions that you'll generally be asked concerning limiting reagents:

Which reagent is limiting? It's easy to think at first that it's the reagent of which you have less molecules. But that's not always true—it's whichever one would form less product if completely reacted. Here's the difference—



Amount of excess reagent left: **Excess reagent(s)** do not react completely, because there was not enough limiting reagent to react with them. To find the amount of excess reagent left:

1. Find the amount of excess reagent that should have reacted (exactly enough to react with however much limiting reagent there was) *see table below!
2. (starting amount of excess reagent) minus (amount of excess reagent that reacted) = amount of excess reagent leftover

Amount of product formed:

The amount of product formed depends on how much limiting reagent there was. Don't consider amounts of excess reagents when making these calculations!

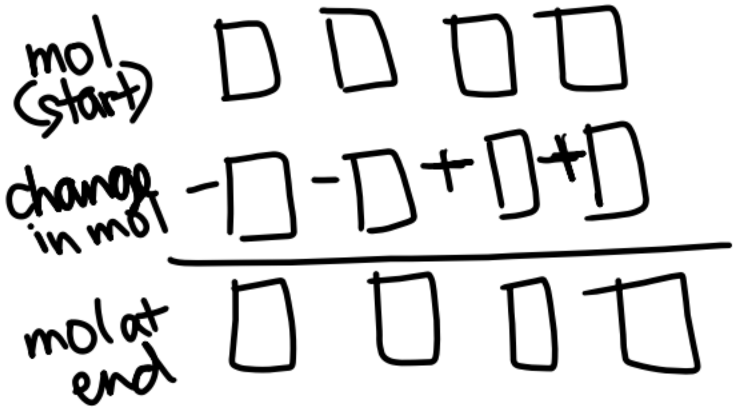
In general:

Known: amounts & formulas of each reagent at the beginning, formula of product

Find: amounts of reagents and products present at the end

How to: This table helps with visualization:

$$A + B \rightarrow C + D$$



Equation: Make sure the equation is balanced!

Row 1: Calculate moles of starting material: divide mass of starting material by its molecular mass.

Row 2: Figure out which reactant is limiting! Try this step assuming each reactant is limiting, and whichever one **does not** result in any **negative Row 3** values is limiting.

Pick one reactant. Assume that it's limiting. This means that its "change in mol," or Row 2, will be equal to its "mol (start)," or Row 1. Any other reagents' "change in mol" will be equal to

$$\frac{coefficient\ of\ reagent\ in\ question}{coefficient\ of\ limiting\ reagent} * mol\ of\ limiting\ reagent$$

On the left side, all changes will be negative. On the right side, they will be positive.

Row 3: Is based on whichever reactant was limiting, i.e., whichever did not give this row any negative values.

Highlight 1: Solutions Vocab

We'll start with some helpful vocab:

Dissociation: ions have strong enough interactions with water that the water is able to break apart their crystal lattice structure

Solubility: how well something dissolves

[of ionic compounds]: if they dissociate

[of nonpolar molecules]: if a dipole moment can be induced

Electrolytes: ions soluble in water

Strong electrolytes: dissociate completely

Weak electrolytes: dissociate partially

Nonelectrolytes: non-ions soluble in water, non-ions insoluble in water, or ions insoluble in waste

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Highlight 2: Electrolytes and Non-Electrolytes

You'll be asked to identify strong and weak electrolytes.

[STRONG ELECTROLYTES]:

Here's how you can tell—a strong electrolyte is something that will become a cation and an anion in water. This includes all strong acids and strong bases:

Strong acids are very good at donating protons (hydrogen atoms minus their electrons). A proton has a positive charge, and when it is transferred, the molecule that once had it becomes more negative (its charge drops by 1). The molecule to which it is transferred becomes more positive (its charge increases by 1). Here is a list of strong acids to memorize, and a video if you're curious as to why these acids are strong! https://www.youtube.com/watch?v=3IbUsvicRTk

Sulfuric acid (H_2SO_4)
Hydrochloric acid (HCl)
Hydrobromic acid (HBr)
Perchloric acid ($HClO_4$)
Chloric acid ($HClO_3$)
Hydroiodic acid (HI)
Nitric acid (HNO_3)

Here's how the equation looks:

$HA + H_2O \rightarrow A^- + H_3O^+$

Strong bases, similarly, are very good at taking protons. Their charge increases when they do so, and whatever they took a proton from loses some positive charge.

$LiOH$
$NaOH$
KOH
$RbOH$
$CaOH$
$Ca(OH)_2$
$Sr(OH)_2$
$Ba(OH)_2$

Ions that dissociate are also strong electrolytes.

[WEAK ELECTROLYTES] are weak acids and bases.

Weak acids:

HF
$HC_2H_3O_2$

Weak bases:

NH3 and other nitrogen-containing bases

[NON-ELECTROLYTES]:

Everything else

https://www.khanacademy.org/science/physics/discoveries/batteries/v/electrolyte-strong-acid-test

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Highlight 3: Molarity

Say that the ions did dissociate (are electrolytes), or that there were molecular compounds that were soluble in water (nonelectrolytes).

Molarity tells us how concentrated the solution is. In other words, how much solute does it have per volume of solvent?

Here's the formula: $M = \frac{moles\ of\ solute}{volume\ of\ solvent\ in\ L}$

You'll be given two of these values and asked to solve for the third.

Problem Type 1: Sometimes, one of these will be mass—and to get from mass to moles, you'll have to divide by molecular mass (see Week 3/8 on Stoichiometry).

Problem Type 2: Sometimes, instead of moles of solute, you will be given moles of one of the dissociated ions. This can be converted into moles of solute as follows: moles of solute = moles of ion / # of molecules of ion in one molecule of solute

For example, if given the sodium concentration for sodium sulfate, you can calculate the sodium sulfate concentration: moles of sodium sulfate = moles of sodium / 2 (Review nomenclature, Week 5).

Problem Type 3: Dilution

Given the molarity of one solution, how much of it would you want to dilute in order to change it to some volume of a new molarity?

Well, you only know the molarity of the new solution, right? How can you find the volume if you're missing the number of moles? Luckily, you know one other thing. The number of moles will stay the same for both molarities—only volume is changing! So, you can say,

$$Molarity = \frac{moles}{volume} \rightarrow moles = molarity * volume$$

$$also, moles_1 = moles_2$$

$.so, molarity_1 volume_1 = molarity_2 volume_2$

Now, you can plug in each concentration (molarity) and the desired volume (volume 2). To prepare the solution, you'd put [volume 1] of the first solution in a volumetric flask, then fill it with DI water to the line.

https://www.khanacademy.org/science/chemistry/states-of-matter-and-intermolecular-forces/mixtures-and-solutions/a/molarity

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Check Your Learning

1. You have 100 g of CO_2 and 50 g H_2O. How many moles of glucose can you make?
2. Explain the difference between "electrolyte" and "soluble"
3. Is acetic acid a strong electrolyte, weak electrolyte, or non-electrolyte?
4. What is the molarity of 30 g of NaCl in 1 L of solution?
5. How much volume would be required to dilute 10 M concentrated HCl to 1 L of 1 M solution?

Things You May Struggle With

- "Limiting reactant" and "limiting reagent" are the same thing! Both words refer to the chemicals that are inputted into a reaction.
- Just because something is a non-electrolyte doesn't necessarily mean that it won't dissolve in water. The difference is that electrolytes dissociate--this is what makes the solution conductive.

That's all this week! Please reach out if you have any questions and don't forget to visit the Tutoring Center website for further information at www.baylor.edu/tutoring. Answers to Check Your Learning are below.

1. Convert to moles. 2.27 mol of CO_2 and 2.77 mol of H_2O. If 2.27 mol were to be the "change in mol," no values would end up negative…so CO_2 is limiting. It can then be converted to moles of glucose (2.27/6 mol) = 0.37 mol
2. An electrolyte will always be soluble, but a non-electrolyte can either be soluble or insoluble. "Electrolyte" refers only to charged particle formation.
3. Weak electrolyte (weak acid)
4. 0.51 M or 0.61 mol/L
5. 0.1 L