Unit 7

On completion of the unit you should be able to:

1. interpret balanced equations in terms of moles, mass units and number of particles.
2. given the number of moles (or mass or number of particles) of one substance calculate the number of moles (or mass or number of particles) of another substance in the balanced equation.
3. define limiting and excess reactants.

CALCULATIONS INVOLVING CHEMICAL REACTIONS

7.1 **Coefficients of a chemical reaction**

Today's focus.

Reading: Hebden – page 123-124

7.2 **Calculations based on chemical equations**

- **Mole-mole calculation**
- **Mass-mass calculation**
- **Mass-mole calculation**
- **Limiting reagent calculation**
- **Calculations involving neutralization reactions**

Reading: Hebden – page 125-133

PROBLEMS:
Practice Calculations

Coefficients

Coefficients

Coefficients are numbers written in front of each substance in a balanced chemical reaction.
If nothing is written in front, the default value is 1.

$$2\ H_2\ (g) + O_2\ (g) \rightarrow 2H_2O\ (l)$$

What type of reaction is this?

With nothing written here, the value is 1.

In the synthesis of water, two molecules H_2 (g) and one molecule of O_2 (g) form two molecules of H_2O (l).

SCALE UP

In the synthesis of water, two moles H_2 (g) and one mole of O_2 (g) form two moles of H_2O (l).

Ratio is always $H_2 : O_2 : H_2O$

2 : 1 : 2

a. the ratio between H_2 : O_2
b. the ratio between H_2 : H_20
c. the ratio between O_2 : H_20

Calculations based on Chemical equations

Continuation of the same question.

UNIT 7 - CALCULATIONS INVOLVING CHEMICAL REACTIONS

1. Calculations involving neutralization reactions

Calculate the volume of a 0.200 M KOH solution that is needed to neutralize 25.00 mL of a 0.115 M HCl solution.

2. Mole-mole calculation

How many moles of oxygen gas is required to burn 3.60 moles of ethyl alcohol, C_2H_5OH?

3. Mass-mass calculation

How many grams of oxygen gas is required to burn 20.5 grams of ethyl alcohol, C_2H_5OH?

4. Mass-mole calculation

How many moles of carbon dioxide gas is produced when 20.5 grams of ethyl alcohol, C_2H_5OH, is burned?

5. Limiting reagent calculation

(a) How many grams of carbon dioxide gas is produced when 20.5 grams of ethyl alcohol, C_2H_5OH, burns with 100.0 grams of oxygen, O_2?

(b) Identify the limiting reagent and how much of the other reactant is left over?

Calculations based on Chemical equations

- synthesis
- decomposition
- combustion
- single-replacement
- double-replacement
- neutralization

1. **Calculations involving neutralization reactions**
   (http://nobel.scas.bcit.ca/wiki/index.php/Calculations_involving_neutralization_reactions)

Calculate the volume of a 0.200 M KOH solution that is needed to neutralize 25.00 mL of a 0.115 M HCl solution.

Let's spend some time to fully understand this question.

1. What type of reaction is this question asking? Acid Base neutralization reaction

2. What is the balanced chemical reaction? $KOH\ (aq) + HCl\ (aq) \rightarrow KCl\ (aq) + H_2O\ (l)$

3. What is the mole ratio of KOH : HCl? 1:1 (i.e. If there is 1 mole of KOH, I need 1 mole of HCl to neutralize the KOH.)

4. In this question, are we given moles of acid? Yes, indirectly.

"25.00 mL of a 0.115 M HCl solution"
is indirectly telling you the moles of HCl you are working with.

KEY POINT: Any time you are given the volume and concentration of a solution, you are given the mole quantity of the solution.

$$\mathbf{0.02500\ \cancel{L}\ HCl \times 0.115\ ^{moles}/_{\cancel{L}}\ HCl = 0.002875\ moles\ HCl}$$

Calculations based on Chemical equations

- synthesis
- decomposition
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- single-replacement
- double-replacement
- neutralization

1. **Calculations involving neutralization reactions**
   (http://nobel.scas.bcit.ca/wiki/index.php/Calculations_involving_neutralization_reactions)

Calculate the volume of a 0.200 M KOH solution that is needed to neutralize 25.00 mL of a 0.115 M HCl solution.

Let's spend some time to fully understand this question.

Balanced reaction: $KOH\ (aq) + HCl\ (aq) \rightarrow KCl\ (aq) + H_2O\ (l)$

KOH: HCl
1 : 1

We have 0.02500 ~~L~~ HCl x 0.115 $^{moles}/_{\cancel{L}}$ HCl = 0.002875 moles HCl

5. How much KOH is needed to neutralize **0.002875 moles HCl** ?

0.002875 moles KOH

6. The KOH solution has a concentration of 0.200 M. What volume of KOH is needed to give us 0.002875 moles KOH?

$$0.002875\ \cancel{\text{moles}}\ KOH \times \frac{1\ L}{0.200\ \cancel{\text{mole}}\ KOH} = 0.0144\ L\ KOH \text{ or } 14.4\ mL\ KOH$$

This neutralization reaction is carried out via a technique known as TITRATION!

Double-replacement reactions

$$AX + BY \rightarrow AY + BX$$

Neutralization Reactions

- Special double-replacement reactions
- Involves acids and bases

ACIDS	BASES
Common Properties:	**Common Properties:**
• taste sour. • stings on a open wound. • produce H_2 gas when reacted with metals.	• taste bitter. • give a slippery feel.
Common Examples:	**Common Examples:**
Lemons, oranges, vinegar, soft drink, urine, sulfuric acid, hydrochloric acid	Soap, toothpaste, bleach, cleaning agents, limewater, ammonia water, sodium hydroxide.
Other Chemical Properties:	**Other Chemical Properties:**
• In acidic solution, phenolphthalein (a colour indicator) stays colourless. • Acid solution turns blue litmus paper (a pH indicator) red. • Acid solutions have a pH < 7.	• In basic solution, phenolphthalein (a colour indicator) turns pink. • Basic solution turns red litmus paper (a pH indicator) blue. • Basic solutions have a pH > 7.

Calculations based on Chemical equations

1. **Calculations involving neutralization reactions**
   (http://nobel.scas.bcit.ca/wiki/index.php/Calculations_involving_neutralization_reactions)

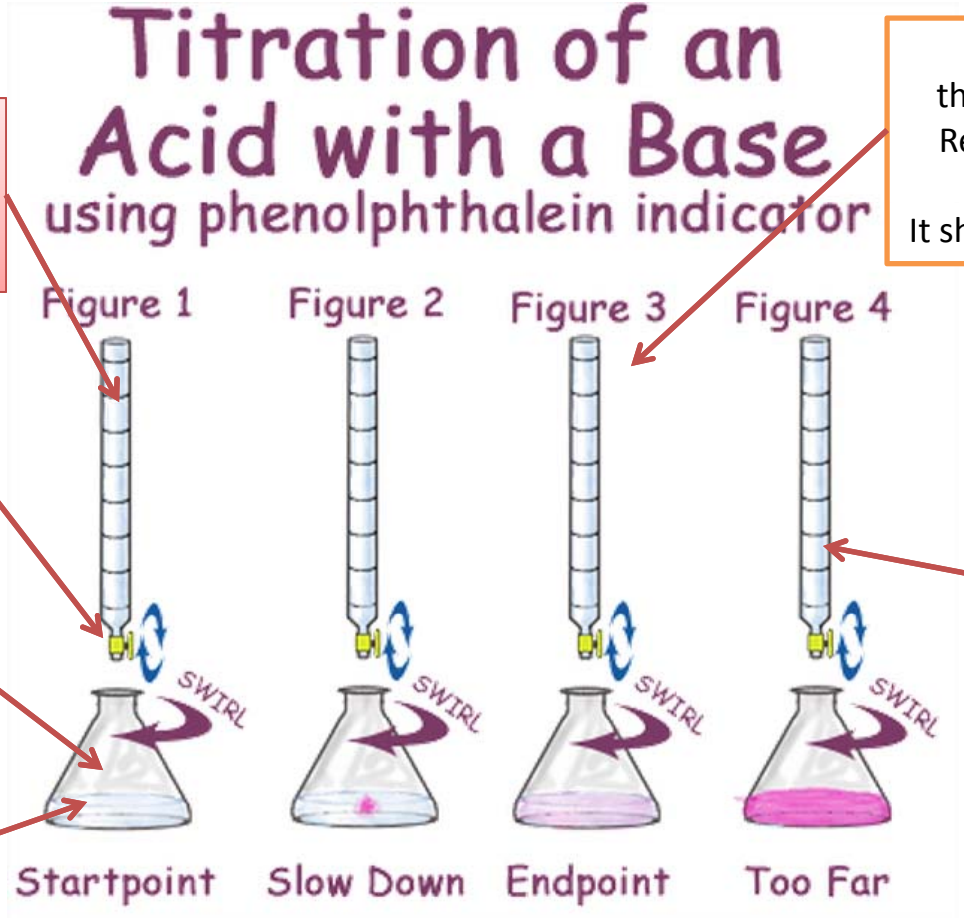
Calculate the volume of a 0.200 M KOH solution that is needed to neutralize 25.00 mL of a 0.115 M HCl solution.

Fill the buret with a 0.200 M KOH solution

Turn the valve to add KOH to the Erlenmeyer flask and swirl flask to mix.

Pipet 25.00 mL 0.115 M HCl

Add a few drops of Phenolpthalein



Endpoint is reached when the solution turns slightly pink. Read the burette to determine the volume of KOH added. It should be 14.4 mL + a drop KOH.

If you continue adding KOH passed the endpoint, the solution will turn bright pink. This is an indication that you have overshot the endpoint!

EXPECTION: Repeated titrations will result in $\pm$ 0.10 mL.

Image credit: http://2.bp.blogspot.com/_Red3kx4ddLw/THXg7KPCCKI/AAAAAAAAANo/DyCNzfO0Q0c/s1600/Titration.gif

Try some practice problems in Maple TA.

Use Dimensional Analysis in ALL your calculations!!