Chem 20 Unit D - Quantitative Changes in Chemical Reactions

Gravimetric Stoichiometry

(subtle hint)

Nov 30-1:28 PM

Dr. Martyn Poliakoff
Proudly Presents:

The Periodic Table Movie of the Day!!!

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POS Checklist

- ☐ calculate the quantities of reactants and/or products involved in chemical reactions, using gravimetric, solution or gas stoichiometry.
- ☐ contrast quantitative and qualitative analysis

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Review: (page 285 # 3)

An acceptable method for the treatment of soluble lead waste is to precipitate the lead as a low solubility lead (II) silicate.

a) Write a net ionic equation for the reaction of aqueous lead (II) nitrate and aqueous sodium silicate.

b) What can we assume about the ambient conditions and the container that likely could be used?

c) Identify the spectator ions.

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Review (#5 pg 285)

a) One commercial example of the production of strontium compounds is the reaction of aqueous solutions of strontium nitrate and sodium carbonate. Write a net ionic equation for this reaction.

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b) Suggest another compound in solution that would react with the same net ionic reaction as the reaction in a).

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Gravimetric Stoichiometry

Recall from a previous class that one limitation to a chemical equation was that it did not tell us how much of a chemical product can be produced from an amount of reactant.

Take, for example, the decomposition of malachite:

(Read Investigation 7.1 on page 287)

$Cu(OH)_2CuCO_{3(s)}$ - malachite

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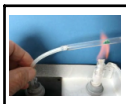

http://www.youtube.com/watch?v=JUzlVTGbH8U

$$Cu(OH)_2CuCO_{3(s)} \longrightarrow 2\ CuO_{(s)} + CO_{2(g)} + H_2O_{(g)}$$

If we heat 10 g of malachite, what mass of copper (II) oxide would we expect to get?

How can we work out the mass of the products given the mass of the reactant? The answer does not come from the chemical equation alone.

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$$1\,Cu(OH)_2CuCO_{3(s)} \longrightarrow 2\,CuO_{(s)} + 1\,CO_{2(g)} + 1\,H_2O_{(g)}$$

Recall that the coefficients tell us the ratio of the moles of reactants and products.

The process of using these molar ratios to determine the amount of one species in reaction is called stoichiometry.

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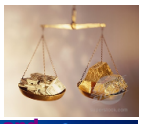
We have three types of stoich to study:



1. gravimetric: stoich dealing with masses.

2. gas: stoich dealing with pressure, volume and temperature.

3. solution: stoich dealing with volume and concentration.

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Now, let's solve this problem:

If we heat 10 g of malachite, what mass of copper (II) oxide would we expect to get?

Step 1: Write out the balanced equation.

$$Cu(OH)_2CuCO_{3(s)} \longrightarrow 2\ CuO_{(s)} + CO_{2(g)} + H_2O_{(g)}$$

Step 2: Write out information under the eqn.

$$Cu(OH)_2CuCO_{3(s)} \longrightarrow 2\ CuO_{(s)} + CO_{2(g)} + H_2O_{(g)}$$

m = 10 g	m = ?
M = 211.13 g/mol	M = 79.55 g/mol

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Step 3: Calculate the number of moles of the known chemical.

$$n_{malachite} = 10\text{ g} \times \frac{1\text{ mol}}{221.13\text{ g}} = 0.0452\text{ mol}$$

Step 4: Calculate the number of moles of the unknown using the ratio "unknown over known".

ratio of moles / ratio of coefficients

$$\frac{\text{unknown}}{\text{known}} = \frac{n_{CuO}}{0.0452\text{ mol}} = \frac{2}{1}$$

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Step 5: Solve the ratio.

$$\frac{n_{CuO}}{0.0452\ mol} = \frac{2}{1} \qquad n = 0.0904\ mol$$

Step 6: Convert this moles to mass.

$$0.0904\ mol \times \frac{79.55\ g}{1\ mol} = 7.9\ g$$

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ex) Elemental sulphur ($S_{8(s)}$) reacts with barium oxide to produce barium sulfide and oxygen gas. If 50 g of sulphur is used, how much barium sulfide is produced?

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Limiting and Excess Reagents

Problems up until now have only given you info about one of the reactants. But what if we know info about both reactants?

ex) 50 g of $CaCl_{2(s)}$ reacts with 50 g of $Na_{(s)}$. What is the mass of calcium metal produced?

How can we answer a question like this?

Dec 3-8:03 AM

ex) 50 g of $CaCl_{2(s)}$ reacts with 50 g of $Na_{(s)}$. What is the mass of calcium metal produced?

In this problem, you are given info about both reactants. We know both reactants have the same mass. But their number of moles is not the same!

$$n_{CaCl_{(s)}} = \frac{50\ g}{110.98\ g/mol} = 0.45\ mol$$

$$n_{Na_{(s)}} = \frac{50\ g}{22.99\ g/mol} = 2.17\ mol$$

There is much more sodium present!

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If these two chemical s were mixed together and started to react, the $CaCl_{(s)}$ would get used up first, as there is less of it. This is our limiting reagent.

The reactant that gets used up first is called the limiting reagent.

Even after all the $CaCl_{(s)}$ is used up, there is still $Na_{(s)}$ left over. Sodium is our excess reagent.

The reactant that is left over after reaction is called the excess reagent.

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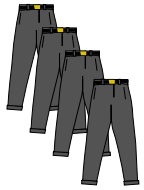
My beautiful chemistry-teacher fiancee explains it like this: If in your drawer you have:

3 shirts



4 pairs of pants

and only 2 pairs of socks

You can only dress for two days. The socks are your limiting reagent.

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Back to the question:

ex) 50 g of $CaCl_{2(s)}$ reacts with 50 g of $Na_{(s)}$. What is the mass of calcium metal produced?

$$CaCl_{2(s)} + 2\ Na_{(s)} \longrightarrow Ca_{(s)} + 2\ NaCl_{(s)}$$

n = 0.45 mol n = 2.17 mol

We have to use the moles of the limiting reagent in the ratio.

$$\frac{1}{1} = \frac{n}{0.45\ mol} = 0.45\ mol\ of\ Ca_{(s)} \times 40.08\ g/mol = \underline{\underline{18\ g}}$$

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HW: Read: Percent Yield page 292

Questions: 293 #1, 6, 7, 8, 10

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