Stoichiometry – a SIMPLE idea.

Stoichiometry – the process of relating one *quantity* of a chemical to another within a chemical reaction using *molar* *ratios* derived from the *coefficients of a balanced reaction*!

HOW TO DO STOICHIOMETRY:

1. START with a complete, balanced equation.
2. Take *whatever you know* in *whatever units you have* and convert to moles.
3. (is one reagent limiting? then choose that one to move forward.)
4. DO THE STOICHIOMETRY (IN UNITS OF MOLES)
5. Convert back from moles to *whatever units you need*.
6. (determine the theoretical yield, percent yield etc…)

Why does stoichiometry seem difficult?

Because of the conversions, not the chemistry!

What units could you be given/what units might you need?

1. moles – EASY; you’re already there!
2. mass – need molar mass.
3. volume (pure liquid) – you need the DENSITY of the liquid to find the mass, then see #2.
4. volume (solution) – need molar concentration.
5. pH (can find concentration of H+ or OH–) – but still need volume!
6. mixture (percent composition) – still need mass, molar mass, volume, pressure, temperature, etc.
7. volume (gas) – need pressure AND temperature!

NOW ADD THE FOLLOWING IDEAS:

* Limiting reactant (LR) – NOT the reactant with the fewer number of moles; rather the one with fewer “equivalents” in more concrete terms, the one that *generates less product!*
* Excess reactant (XS) – ALL the other reactants…
* Stoichiometric excess – the other (NON-LIMITING) reactant(s) left over at the end of the reaction
* Theoretical yield – the amount of product calculated using the LIMITING reactant
* Actual yield – the amount of product actually measured at the end of the reaction (imperfect world!)
* Percent yield = (Actual yield) / (Theoretical yield)

Analogy: movies in a new IKEA® bookshelf

180 DVDs total

7 shelves (18 DVDs per shelf)

34 pegs (4 pegs per shelf)

NOW, IN CHEMICAL TERMS…

1 shelf + 4 pegs + 18 DVDs 🡪 1 full shelf

**we have… 180 DVDs**

18 DVDs

7 shelves \* ---------------------- = 126 DVDs

1 shelf

18 DVDs

34 pegs \* ------------------------- = 153 DVDs

4 pegs

HOW MANY DVDs can we put away???

Which of the parts is limiting?

Which of the parts is in excess?

What is the theoretical yield (filled shelves of DVDs)?

What is the stoichiometric excess of DVDs?

(number started with – number put away)

180 – 126 = 54 DVDs (excess)

What is the stoichiometric excess of pegs?

(number of pegs – number actually used)

4 pegs

USED: 7 shelves \* ---------------------- = 28 pegs (used)

1 shelf

34 – 28 = 6 pegs (excess)

**WHEN YOU ACTUALLY put the DVDs on the shelf, you had some in odd-shaped boxes, and only 118 fit on the shelf.**

What is the actual yield?

What is the percent yield?

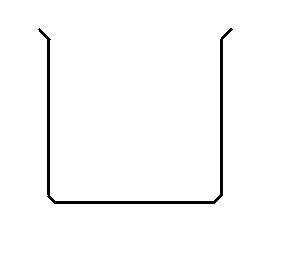
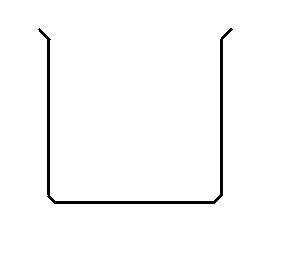
AN EXAMPLE OF LIMITING AND EXCESS REACTANTS

Pb2+ + 2 NO3– + 2 K+ + SO42– 🡪 PbSO4 (s) + 2 NO3– + 2 K+ (total ionic equation)

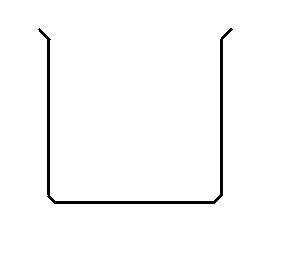
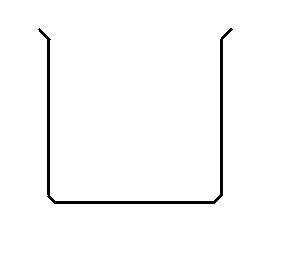
* 1. Start by adding 4X formula units of Pb(NO3)2 to a flask
  2. Add K2SO4 gradually, 2X formula units at a time
  3. Observe the progress of the reaction by conductivity

Pb2+: K+:

NO3–: SO42–:

**A B**

**C D**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **A** | **B** | **C** | **D** |
|  | Before reaction | Addition of 2 K2SO4 | Addition of 4 K2SO4 | Addition of 6 K2SO4 |
| K+ | 0 | 4 | 8 | 12 |
| SO42– | 0 | 0 | 0 | 2 |
| Pb2+ | 4 | 2 | 0 | 0 |
| NO3– | 8 | 8 | 8 | 8 |
| # of PbSO4 precipitates | 0 | 2 | 4 | 4 |
| # of ions still in solution | 12 | 14 | 16 | 22 |

Questions:

1. For which column is the reaction at stoichiometric equality?

(the “correct number” of reactants to products – equivalence point)

1. In column B, which reactant is limiting; which is in excess?
2. In column D, which reactant is limiting; which is in excess?

Percent Composition (in stoichiometry):

**MOST OF SOCIETY** IS UNFAMILLIAR WITH MOLES AND MOLARITY!

So they use percent composition instead –

you see this all over the place, especially in consumer goods, like toothpaste, bleach, etc.

THIS IS ALWAYS: the part divided by whole (MUST be in same units) \* 100%

This is often used for volumes (must have the same units!)

OR masses (yes – still the same units!)

…but it is ALWAYS specified (whether it is mass or volume).

*examples:*

In your car’s radiator, you will find a solution that contains approximately 600 mL of water and 800 mL of ethylene glycol, along with some other additives. What volume percent of the composition of the antifreeze is water?

A very explosive gas mixture contains 4.0 moles of propane and 20.0 moles of oxygen. What weight percent is the propane?

(C3H8 + 5 O2 🡪 4 H2O + 3 CO2)

The mineral chalcopyrite (CuFeS2) is the primary ore of copper, and contains 34.63% Cu by mass. How many grams of Cu can be refined from 5.11 x 103 kg of this mineral? What percent (by mass) Fe is in the ore? (NOTE: you can use the formula to find the MOLAR ratios…)