A chemical reaction is like a recipe...

1 cup sugar + 2 cups flour + 1 stick butter + 2 cups water + 2 eggs = 24 cookies

A chemical reaction describes the proper amount of materials (chemical species) that participate in a chemical reaction.

In order for a chemical reaction to be useful (in a quantitative sense), it must be balanced...

i.e. If the recipe did not contain the amounts of the substances used, we would make rather awful cookies and we would have no idea how to predict how many cookies we would make.

The nuts and bolts of chemical reactions:

A balanced chemical reaction can help us do the following (quantitatively)...

- Predict if minerals should (and how much will) dissolve or precipitate
- Decipher the temperature and pressure a metamorphic rock experienced (great for plate tectonic applications)
- Predict the order of crystallization of minerals from a magma
- Interpret ore deposits (and other hydrothermal processes)
- Decipher the weathering history of a rock
- Interpret changes to seawater chemistry
- Interpret processes that result in natural contamination
- Predict the role of microbes in geochemical processes

The list goes on...

An unbalanced chemical reaction is only useful for qualitative purposes

I don’t find unbalanced reactions particularly useful...

You can’t accurately predict if the reaction will actually take place. (more on this later)
Chemical reactions are balanced using the quantity (amount) of substances used in the chemical reaction

Why not use mass as the quantity? (we will see)

What is a dozen? Will a dozen ping pong balls have the same mass as a dozen donuts?

Yet, a dozen is the same amount of something regardless of the mass... why not use this idea to help us with chemical reactions?

Since atoms are really small, a dozen is not a good number to use as a reference...

We need something that will result in a mass that is more reasonable (and measurable)...  

The Mole

A mole is $6.022 \times 10^{23}$ things (atoms, molecules, cats) (just like a dozen is 12 things)

$6.022 \times 10^{23}$ is Avagadro's number. It is defined as the number of atoms in 0.012 kg (or 12 grams) of carbon-12, where the carbon-12 atoms are unbound, at rest and in their ground state. (The current best estimate of this number is $6.022 \, 1415 \pm 0.000 \, 0010 \times 10^{23} \, \text{mol}^{-1}$)

So...

A mole of Ca is $6.022 \times 10^{23}$ atoms of Ca

A mole of CO$_2$ is $6.022 \times 10^{23}$ molecules of CO$_2$

A mole of Dougs is $6.022 \times 10^{23}$ Dougs

The mole is useful in chemistry because it allows different substances to be measured in a comparable way.

Since each substance described above has a different mass, a mole of one substance will have a different mass than another substance but will always contain the same number.
Moles make balancing and using chemical reactions easier:

Ca=40 grams, C=12 grams, O=16 grams

56CaO + 48CO₂ = 104CaCO₃ (balanced on mass)
(I can’t even think this through)

1CaO + 1CO₂ = 1CaCO₃ (balanced on moles)...much easier

Now we just need to figure out the mass of each mole of substance (the molar mass)

The molar mass indicates how much mass is contained in a mole of substance.

1 mole of Ca = 40.08 grams
1 mole of Fe = 55.85 grams

1 mole of SiO₂ is composed of 1 mole of Si and 2 moles of O...therefore the molar mass = 1*(28.09 grams) + 2*(16.00 grams) = 60.09 grams

The units of molar mass are grams/mole

My rule of sig figs when using molar masses...

Always use the full extent of the reported molar mass when doing a calculation...

i.e. If the PT reports Ca as having a molar mass of 40.078...use 40.078...not 40.08
(I will take short cuts during class...do not take short cuts in your homework)

At the conclusion of your calculation, report your results to the least number of decimal points experienced during the entire calculation...this is not the "proper" definition of sig figs but it will serve us just fine for our needs.

(keep in mind that quantities (like moles) do not change sig figs...)
Fun things about the “mol”…from Wikipedia

Given that the volume of a grain of sand is approximately $10^{-12} \text{ m}^3$, and given that the area of the US is about $10^{13} \text{ m}^2$, it therefore follows that a mole of sand grains would cover the United States in approximately one cm of sand.

A human body contains very roughly one hundred trillion cells; there are roughly six billion people on Earth; so the total number of human cells on the planet is approximately $100 \times 10^{12} \times 6 \times 10^9 = 6 \times 10^{23}$, which is very close to one mole.

Since the Earth has a radius of about 6400 km, its volume is approximately $10^{21} \text{ m}^3$. Since about 500 large grapefruit will fit in one cubic meter, it therefore follows that a mole of grapefruit would have approximately the same volume as the Earth.

Stoichiometry: The amounts of reactants and products in a balanced reaction

Also…The amounts of atoms in a unit cell for a mineral formula

By convention: for every chemical reaction…

Reactants (species on the left)
Products (species on the right)
The reaction:

A reaction with uncharged species is relatively straightforward... CaO + H2O = Ca(OH)2

How about a reaction containing charged species?

All natural substances (water, magma, minerals etc.) are electrically neutral...

Na+ + KAlSi3O8 = NaAlSi3O8 + K+
NaOH + Cl— = NaCl + OH—

Or NaCl + KAlSi3O8 = NaAlSi3O8 + K+ + Cl—

Electroneutrality is achieved by having the same number of charges on both sides of the reaction or by having opposite charges that cancel on the same side or a combination of both

Any balanced reaction is valid!!!!

It may not occur the way in which it is written (more on this later) but if you can write it and it is balanced it is a valid reaction

CaO + CO2 = CaCO3
CaO + H+ + HCO3— = CaCO3 + H2O

As long as all components of a reaction are in equilibrium, all reactions must be true (AT THE SAME TIME)