Chemical equations and balancing reactions:

You need to be proficient in balancing reactions in order to be successful in chemistry. That is all good and well, but what does it mean to be a balanced chemical reaction? Essentially, it means that there is the SAME number of EACH atom on BOTH sides of the equation. No big deal right? It starts of pretty easy, but can get tough, so follow along with the examples, and try to understand what each step is doing and why it is being done. Some hints for you: Make a table listing all the elements for each side of the reaction. If polyatomic ions are present and are EXACTLY the same on both sides, then they can be balanced as one piece (see the examples below for… well. examples of this). Make on column for the reactants (right) side, and one column for the products (left) side. Make sure the elements or ions are listed in the same order in both columns, and ALWAYS make hydrogen next to last and oxygen last. It will always be easier to balance oxygen last. Here we go…

Examples:

a) Balance the chemical equation: $K_2SO_4 + Ba(NO_3)_2 \rightarrow KNO_3 + BaSO_4$

Start off by making a table of the elements and ions involved (because the nitrate and sulfate ions are on both sides of the equation, you can list them as the ions rather than sulfur, nitrogen and oxygen separately):

Initial equation: $K_2SO_4 + Ba(NO_3)_2 \rightarrow KNO_3 + BaSO_4$

Equation after trial 1: $K_2SO_4 + Ba(NO_3)_2 \rightarrow \mathbf{2}KNO_3 + BaSO_4$

Reactants			Products		
	Initial	Trial 1		Initial	Trial 1
K	2	2	K	1	2
SO_4	1	1	SO_4	1	1
NO_3	2	2	NO_3	1	2
Ba	1	1	Ba	1	1

In the initial column, compare the number of potassium atoms on the reactant side to the number of potassium atoms on the product side. There are two on the reactant and one on the product side. To fix this, put a 2 in front of the KNO_3 on the product side. This changes not only the number of potassium atoms on the product side, but also the number of nitrate ions. Putting the number in front of a molecule multiplies ALL the atoms in the molecule by that number. So putting a 2 in front of KNO_3 give you 2 K and 2 nitrates. Now that the columns on the reactant side and the product side are equal, the equation is balanced. The answer is: $K_2SO_4 + Ba(NO_3)_2 \rightarrow 2KNO_3 + BaSO_4$

b) Balance the equation: $Al(OH)_3 + HNO_3 \rightarrow Al(NO_3)_3 + H_2O$

Same steps as above, start off by making a table, then work your way through (nitrate is the same on both sides, so you can list it as the ion instead of nitrogen and oxygen separately. Hydroxide is NOT the same on both sides, so it needs to be listed as hydrogen and oxygen in the list).

Initial equation: $Al(OH)_3 + HNO_3 \rightarrow Al(NO_3)_3 + H_2O$

Multiply reactant side HNO_3 by 3 to get the same number of nitrates on both sides.

Equation after trial 1 $Al(OH)_3 + \mathbf{3}HNO_3 \rightarrow Al(NO_3)_3 + H_2O$

Multiply product side water by 3 to get the same number of H on both sides.

Equation after trial 2 $Al(OH)_3 + \mathbf{3}HNO_3 \rightarrow Al(NO_3)_3 + \mathbf{3}H_2O$

Reactants				Products			
Initial		Trial 1	Trial 2	Initial		Trial 1	Trial 2
Al	1	1	1	Al	1	1	1
NO_3	1	3	3	NO_3	3	3	3
H	4	6	6	H	2	2	6
O	3	6	6	O	2	2	6

After trial two, both the products and reactants had the same number of each atom and ion, so the equation is balanced. The final answer is $Al(OH)_3 + 3HNO_3 \rightarrow Al(NO_3)_3 + 3H_2O$

NOTE: The numbers in front of each molecule in the chemical equation, called coefficients, are used to find the mole to mole ratios that I spoke of earlier. Remember that any molecule in the equation that does not have a coefficient in front is assumed to be 1. So the equation in example b) can also be written $\mathbf{1}Al(OH)_3 + \mathbf{3}HNO_3 \rightarrow \mathbf{1}Al(NO_3)_3 + \mathbf{3}H_2O$. ***This can be read: 1 mole of aluminum hydroxide reacts with 3 moles of nitric acid to form 1 mole of aluminum nitrate and 3 moles of water. The mole to mole ratio of*** $Al(OH)_3$ ***to*** HNO_3 ***is 1/3.***

c) Balance the equation: $La_2O_3 + H_2O \rightarrow La(OH)_3$

Initial equation: $La_2O_3 + H_2O \rightarrow La(OH)_3$
Multiply product side $La(OH)_3$ by 2 to get same number of La on both sides.

Equation after trial 1: $La_2O_3 + H_2O \rightarrow \mathbf{2}La(OH)_3$
Multiply reactant side water bye 3 to get same number of H on both sides.

Equation after trial 2: $La_2O_3 + \mathbf{3}H_2O \rightarrow \mathbf{2}La(OH)_3$

	Reactants			Products	
Initial	Trial 1	Trial 2	Initial	Trial 1	Trial 2
La 2	2	2	La 1	2	2
H 2	2	6	H 3	6	6
O 4	4	6	O 3	6	6

d) Balance the equation for the combustion of isopropyl alcohol, C_3H_7OH

Initial equation: $C_3H_7OH_{(l)} + O_2 \rightarrow CO_{2(g)} + H_2O_{(g)}$
Multiply product side CO_2 by 3 to get same number of carbons on both sides (remember, start with everything that is NOT oxygen or hydrogen).

Equation after trial 1: $C_3H_7OH_{(l)} + O_2 \rightarrow \mathbf{3}CO_{2(g)} + H_2O_{(g)}$
Multiply product side water by 4 to balance the hydrogens.

Equation after trial 2: $C_3H_7OH_{(l)} + O_2 \rightarrow \mathbf{3}CO_{2(g)} + \mathbf{4}H_2O_{(g)}$
You know have a situation where you have the diatomic oxygen molecule in the equation and an odd number of oxygens on one side and an even number on the other. When this happens, double everything other than the diatomic element.

Equation after trial 3: $\mathbf{2}C_3H_7OH_{(l)} + O_2 \rightarrow \mathbf{6}CO_{2(g)} + \mathbf{8}H_2O_{(g)}$
You now need a total of 20 oxygens on the reactant side. There are 2 from the C_3H_7OH, so you need 18 more. Placing a 9 in front of the O_2 takes care of that and we are balanced!

Equation after trial 4: $\mathbf{2}C_3H_7OH_{(l)} + \mathbf{9}O_2 \rightarrow \mathbf{6}CO_{2(g)} + \mathbf{8}H_2O_{(g)}$

		Reactants					Products		
Initial	Trial 1	Trial 2	Trial 3	Trial 4	Initial	Trial 1	Trial 2	Trial 3	Trial 4
C 3	3	3	6	6	C 1	3	3	6	6
H 8	8	8	16	16	H 2	2	8	16	16
O 3	3	3	4	20	O 3	7	10	20	20

Okay here are LOTS of problems for you to try. Have fun!!
Balance the following reactions (you will have to complete some of them):

1) zinc sulfite reacts with cobalt (III) bromite
2) magnesium nitride reacts with water to form magnesium hydroxide and ammonia
3) nitrogen trichloride reacts with water to form hypochlorous acid and ammonia
4) dinitrogen pentaoxide and water react to form nitric acid (start with H)
5) iron (II) oxide and oxygen gas combine to make iron (III) oxide
6) iron (III) oxide and carbon monoxide react to form iron metal and carbon dioxide (start with O)
7) phosphorous pentachloride and water form phosphoric acid and hydrochloric acid
8) aluminum carbonate reacts with lithium nitrite
9) phosphorous trichloride and water form phosphorous acid and hydrochloric acid
10) diphosphorous pentaoxide and water react to form phosphoric acid
11) nickel (II) nitrate and sodium hydroxide are mixed together
12) ammonium dichromate decomposes into nitrogen gas chromium (III) oxide and water
13) sulfuric acid is added to bismuth (III) hydroxide
14) antimony (V) arsenate reacts with titanium (IV) oxide
15) octane (C_8H_{18}) is burned
16) hydrogen gas and nitrogen gas are combined to form ammonia

17) lead (II) oxide is reacted with ammonia to form lead metal nitrogen gas and water
18) iron metal reacts with chlorine gas. The product of this reaction is iron (III) chloride
19) copper (II) sulfate, sulfur dioxide, and water are the products of the reaction between copper metal and sulfuric acid.
20) diethyl either ($C_4H_{10}O$) is combusted
21) The **products** of a reaction are cadmium sulfide and sodium nitrate.
22) potassium perchlorate and potassium chloride are the decomposition products of potassium chlorate (start with oxygen)
23) acetic acid neutralizes calcium hydroxide
24) phosphoric acid and sodium carbonate react
25) arsenic acid is used to neutralize barium hydroxide