Chemical Equations, Ionic Equations, and Net Ionic Equations

The first part of this is going to be detailed step-by-step instructions on how to do chemical equations, ionic equations and net ionic equations with examples. The second part will be a few less detailed examples, and the third part will be problems for you to do. Good luck.

Part 1:

Terminology:

Balanced Chemical Equation:

$MgCl_{2(aq)} + \mathbf{2}AgNO_{3(aq)} \rightarrow Mg(NO_3)_{2(aq)} + \mathbf{2}AgCl_{(s)}$

Ionic Equation:

$Mg^{2+}_{(aq)} + 2Cl^{-}_{(aq)} + 2Ag^{+}_{(aq)} + 2NO_3^{-}{}_{(aq)} \rightarrow Mg^{2+}_{(aq)} + 2NO_3^{-}{}_{(aq)} + 2AgCl_{(s)}$

Net Ionic Equation:

$Cl^{-}_{(aq)} + Ag^{+}_{(aq)} \rightarrow AgCl_{(s)}$

Write a balanced chemical equation, an ionic equation and a net ionic equation for the following:

copper(II) carbonate + nitric acid → copper(II) nitrate + water + carbon dioxide

The first thing you need to do is translate the words into the chemical symbols. The easiest way to do this is to do one individual molecule at a time. Start with copper(II) carbonate. Copper(II) has a symbol of Cu and a charge of 2+ and carbonate is CO_3 with a 2- charge. Because the charges are equal, they cancel out and you only need one of each. Next you need to put (aq), (s), (l), or (g) as a subscript next to the compound to indicate if it is aqueous, solid, liquid or gas. Look on your solubility chart to find out if copper(II) carbonate is soluble. It is not; therefore an (s) needs to go next to the symbol. This is what the first part of the equation should look like:

$CuCO_{3(s)}$

Next is nitric acid. This is one you need to have memorized at some point. The symbol for it is HNO_3 and it is a strong acid and therefore needs an (aq) next to it. **All strong acids are soluble and will have an (aq) next to them**. This finishes the left side, so your equation now looks as follows:

$CuCO_{3(s)} + HNO_{3(aq)} \rightarrow$

Cooper(II) Nitrate is the first molecule in the right side of the equation. Again, copper is Cu and has a 2+ charge. Nitrate has the symbol NO_3 and has a -1 charge. Copper has two times the charge of nitrate, so you need two nitrates to make the molecule neutral. The 2 is added as a subscript because we are balancing charges within an individual molecule. Also, by looking at your solubility chart, you will see that copper(II) nitrate is soluble, and therefore needs an (aq) next to it. The equation now looks like this:

$CuCO_{3(s)} + HNO_{3(aq)} \rightarrow Cu(NO_3)_{2(aq)}$

NOTE: Because we are only balancing the charges in each individual molecule, we use subscripts next to the unit with the charge we need to have more of, which is why it is $Cu(NO_3)_2$ and not $Cu2(NO_3)$ or 2 $CuNO_3$.

Next add in the water and the carbon dioxide. Water is always a liquid and carbon dioxide is always a gas, so make sure to give them the appropriate subscript states (i.e. (l) and (g)). This gives us the final **un**balanced chemical equation of:

$CuCO_{3(s)} + HNO_{3(aq)} \rightarrow Cu(NO_3)_{2(aq)} + H_2O_{(l)} + CO_{2(g)}$

We now need to balance the chemical equation. You do this by putting numbers **in front** of the **molecule** in order to have the same number of each atom on each side of the arrow. You need to work slowly and check yourself as a mistake here will make everything after it wrong. For this reaction, a 2 needs to be place in front of the nitric acid to give the balanced chemical equation. The following is **exactly** what you need to write, and the form it needs to be written in, when asked for a balanced chemical reaction:

$CuCO_{3(s)} + \mathbf{2}HNO_{3(aq)} \rightarrow Cu(NO_3)_{2(aq)} + H_2O_{(l)} + CO_{2(g)}$

It is now fairly simple to write the ionic equation because all the information you need is in the balanced chemical equation. Look at the subscript state and do what it says. Molecules that have an (aq) subscript are broken up into ions, each ion having a charge and a state. Molecules that have an (s), (l) or (g) are **not** broken into ions. They also don't get charges, but they **do** still need a state. There is an (s) next to the $CuCO_3$, so it stays as a molecule in the ionic equation. The first part of the ionic equation looks exactly like the first part of the balanced chemical equation:

$$CuCO_{3(s)}$$

There is an (aq) next to the $2HNO_3$. Anything that has an (aq) next to it will break up into ions. Make sure that you have the right coefficient in front of **each** of the ions that the molecule breaks into. Because there is a 2 in front of the HNO_3, you must also put a 2 in front of both of the ions in the ionic equation:

$$CuCO_{3(s)} + \mathbf{2}H^+_{(aq)} + \mathbf{2}NO_3^-{}_{(aq)} \rightarrow$$

There is an (aq) next to the $Cu(NO_3)_2$ which means it too will break into ions. It will break into one copper ion and **two** nitrate ions because of the subscript. This gives us:

$$CuCO_{3(s)} + \mathbf{2}H^+_{(aq)} + \mathbf{2}NO_3^-{}_{(aq)} \rightarrow Cu^{2+}_{(aq)} + \mathbf{2}NO_3^-{}_{(aq)}$$

There is an (l) next to the water, so it stays water, and there is a (g) next to the carbon dioxide, so it stays CO_2. In fact, the only time you will split a molecule into ions is when it is (aq). The final ionic equation looks like this:

$$CuCO_{3(s)} + \mathbf{2}H^+_{(aq)} + \mathbf{2}NO_3^-{}_{(aq)} \rightarrow Cu^{2+}_{(aq)} + \mathbf{2}NO_3^-{}_{(aq)} + H_2O_{(l)} + CO_{2(g)}$$

This is **exactly** what you need to write, and the form it needs to be written in, when asked for am ionic equation!

Finally, you need a net ionic equation. This is found by simply crossing out everything that is **EXACTLY** the same on BOTH sides of the arrow:

$$CuCO_{3(s)} + \mathbf{2}H^+_{(aq)} + \cancel{\mathbf{2}NO_3^-{}_{(aq)}} \rightarrow Cu^{2+}_{(aq)} + \cancel{\mathbf{2}NO_3^-{}_{(aq)}} + H_2O_{(l)} + CO_{2(g)}$$

The net ionic equation consists of everything that HAS changed and is not crossed out, therefore, both of the $\mathbf{2}NO_3^-{}_{(aq)}$ drop out as spectator ions, and the net ionic equation is:

$$CuCO_{3(s)} + \mathbf{2}H^+_{(aq)} \rightarrow Cu^{2+}_{(aq)} + H_2O_{(l)} + CO_{2(g)}$$

Final Answer:

Balanced Chemical Equation: $CuCO_{3(s)} + \mathbf{2}HNO_{3(aq)} \rightarrow Cu(NO_3)_{2(aq)} + H_2O_{(l)} + CO_{2(g)}$

Ionic Equation: $CuCO_{3(s)} + \mathbf{2}H^+_{(aq)} + \mathbf{2}NO_3^-{}_{(aq)} \rightarrow Cu^{2+}_{(aq)} + \mathbf{2}NO_3^-{}_{(aq)} + H_2O_{(l)} + CO_{2(g)}$

Net Ionic Equation: $CuCO_{3(s)} + \mathbf{2}H^+_{(aq)} \rightarrow Cu^{2+}_{(aq)} + H_2O_{(l)} + CO_{2(g)}$

Part 2:

Write a balanced chemical equation, an ionic equation and a net ionic equation for the following:

1) magnesium nitrate + sodium phosphate → magnesium phosphate + sodium nitrate

Step one: Translate into symbols, making sure that each individual molecule is neutral and has its state shown:

$$Mg(NO_3)_{2(aq)} + Na_3PO_{4(aq)} \rightarrow Mg_3(PO_4)_{2(s)} + NaNO_{3(aq)}$$

Step two: Balance the equation:

$$\mathbf{3}Mg(NO_3)_{2(aq)} + \mathbf{2}Na_3PO_{4(aq)} \rightarrow Mg_3(PO_4)_{2(s)} + \mathbf{6}NaNO_{3(aq)}$$

Step three: Split all (aq) molecules into ions, showing charges and states to get the ionic equation. DO NOT slit (s), (l) or (g):

$$\mathbf{3}Mg^{2+}_{(aq)} + \mathbf{6}NO_3^-{}_{(aq)} + \mathbf{6}Na^+_{(aq)} + \mathbf{2}PO_4^{3-}{}_{(aq)} \rightarrow Mg_3(PO_4)_{2(s)} + \mathbf{6}Na^+_{(aq)} + \mathbf{6}NO_3^-{}_{(aq)}$$

Step four: Cross out everything that is **exactly** the same on both sides:

$$\mathbf{3}Mg^{2+}_{(aq)} + \cancel{\mathbf{6}NO_3^-_{(aq)}} + \cancel{\mathbf{6}Na^+_{(aq)}} + \mathbf{2}PO_4^{3-}_{(aq)} \rightarrow Mg_3(PO_4)_{2(s)} + \cancel{\mathbf{6}Na^+_{(aq)}} + \cancel{\mathbf{6}NO_3^-_{(aq)}}$$

Step five: Write everything that was not crossed out, **exactly** as it appears to get the net ionic equation:

$$\mathbf{3}Mg^{2+}_{(aq)} + \mathbf{2}PO_4^{3-}_{(aq)} \rightarrow Mg_3(PO_4)_{2(s)}$$

2) zinc + hydrochloric acid → zinc chloride + hydrogen

Step one: Translate into symbols, making sure that each individual molecule is neutral and has its state shown:

$$Zn_{(s)} + HCl_{(aq)} \rightarrow ZnCl_{2(aq)} + H_{2(g)}$$

Note: Because this is a single replacement reaction, you have to make sure it will actually happen. Look on your reactivity series to see which of the two positive ion forming elements is more reactive. The more reactive one will combine with the negative ion forming element. This step is only done for **single replacement reactions**, so learn to identify them. In this case, the two positive ion forming elements are zinc and hydrogen. By checking your reactivity series, you will see that zinc is **more** reactive than hydrogen and will therefore combine with the chloride.

Step two: Balance the equation:

$$Zn_{(s)} + \mathbf{2}HCl_{(aq)} \rightarrow ZnCl_{2(aq)} + H_{2(g)}$$

Step three: Split all (aq) molecules into ions, showing charges and states to get the ionic equation. DO NOT split (s), (l) or (g):

$$Zn^o_{(s)} + \mathbf{2}H^+_{(aq)} + \mathbf{2}Cl^-_{(aq)} \rightarrow Zn^{2+}_{(aq)} + \mathbf{2}Cl^-_{(aq)} + H_{2(g)}$$

Step four: Cross out everything that is **exactly** the same on both sides:

$$Zn^o_{(s)} + \mathbf{2}H^+_{(aq)} + \cancel{\mathbf{2}Cl^-_{(aq)}} \rightarrow Zn^{2+}_{(aq)} + \cancel{\mathbf{2}Cl^-_{(aq)}} + H_{2(g)}$$

Step five: Write everything that was not crossed out, **exactly** as it appears to get the net ionic equation:

$$Zn^o_{(s)} + \mathbf{2}H^+_{(aq)} \rightarrow Zn^{2+}_{(aq)} + H_{2(g)}$$

3) sodium acetate + calcium iodide → sodium iodide + calcium acetate

Step one: Translate into symbols, making sure that each individual molecule is neutral and has its state shown:

$$NaC_2H_3O_{2(aq)} + CaI_{2(aq)} \rightarrow NaI_{(aq)} + Ca(C_2H_3O_2)_{2\,(aq)}$$

Step two: Balance the equation:

$$\mathbf{2}NaC_2H_3O_{2(aq)} + CaI_{2(aq)} \rightarrow \mathbf{2}NaI_{(aq)} + Ca(C_2H_3O_2)_{2\,(aq)}$$

Step three: Split all (aq) molecules into ions, showing charges and states to get the ionic equation. DO NOT split (s), (l) or (g):

$$\mathbf{2}Na^+_{(aq)} + \mathbf{2}C_2H_3O_2^-_{(aq)} + Ca^{2+}_{(aq)} + \mathbf{2}I^-_{(aq)} \rightarrow \mathbf{2}Na^+_{(aq)} + \mathbf{2}I^-_{(aq)} + Ca^{2+}_{(aq)} + \mathbf{2}C_2H_3O_2^-_{(aq)}$$

Step four: Cross out everything that is **exactly** the same on both sides:

$$\cancel{\mathbf{2}Na^+_{(aq)}} + \cancel{\mathbf{2}C_2H_3O_2^-_{(aq)}} + \cancel{Ca^{2+}_{(aq)}} + \cancel{\mathbf{2}I^-_{(aq)}} \rightarrow \cancel{\mathbf{2}Na^+_{(aq)}} + \cancel{\mathbf{2}I^-_{(aq)}} + \cancel{Ca^{2+}_{(aq)}} + \cancel{\mathbf{2}C_2H_3O_2^-_{(aq)}}$$

Step five: Write everything that was not crossed out, **exactly** as it appears to get the net ionic equation:

Because everything in the ionic equation was exactly the same, and therefore crossed out, there is no net ionic equation, which implies **no reaction**.

Part 3:

Some problems for you to try:

A) Write the symbols for the following molecules. Make sure to show what state they are in.

1) EXAMPLE: lead(II) bromide
   Answer: $PbBr_{2(s)}$
2) barium sulfate
3) silver nitrate
4) lithium chromate
5) aluminum hydroxide
6) strontium chloride

B) Write a balanced chemical equation, an ionic equation, and a net ionic equation for each of the following:

1) ammonium carbonate + copper(II) nitrate → copper(II) carbonate + ammonium nitrate
2) lead(II) hydroxide + hydrochloric acid → lead(II) chloride + water
3) barium carbonate + hydrochloric acid → barium chloride + water + carbon dioxide
4) aluminum + tin(IV) sulfate → aluminum sulfate + tin
5) potassium + gold(III)chloride → potassium chloride + gold
6) ammonium phosphate + sodium nitrate → ammonium nitrate + sodium phosphate
7) silver nitrate + potassium iodide → silver iodide + potassium nitrate
8) magnesium sulfate + lithium bromide → magnesium bromide + lithium sulfate
9) strontium chloride + sodium carbonate → strontium carbonate + sodium chloride
10) nitric acid + calcium carbonate → calcium nitrate + water + carbon dioxide
11) zinc + barium bromide → barium + zinc bromide
12) ammonium chromate + barium chloride → ammonium chloride + barium chromate
13) copper(II) sulfate + sodium sulfide → copper(II) sulfide + sodium sulfate
14) iron (II) chloride + ammonium phosphate → iron(II) phosphate + ammonium chloride
15) potassium oxalate + calcium nitrate → potassium nitrate + calcium oxalate
16) silver nitrate + sodium carbonate → silver carbonate + sodium nitrate
17) sodium hydroxide + copper(II) nitrate → sodium nitrate + copper(II) hydroxide