Predicting Products of Chemical Reactions

This worksheet is designed to help you predict products of simple reactions of the four basic reaction types (synthesis, decomposition, single replacement, and double replacement) and combustion reactions.

For the first few reactions, the type of reaction is listed, you should predict the products, then balance. Further questions just have the reactants listed and you should decide on the type of reaction, as well as the correct products. Many of these reactions fall into the category of redox reactions, though do not let that confuse you...each can be described in terms of the four basic reaction types (except the combustion reactions).

Although states (s, l, g, aq) of the reactants and products are very important in a chemical reaction, don't worry about determining those for these problems. Rather, focus on what products might result from the reactants given. Pay particular attention to the ionic charge of species that you know form ions with only one possible charge (*e.g.*, alkali metals, alkaline earth metals, halogens, etc.)

a. Combustion: C_6H_{12} + O_2 →

b. Combustion: C_4H_6 + O_2 →

c. Combustion: $C_6H_{10}O_3$ + O_2 →

1. Synthesis: Mg + I_2 →

2. Double displacement: $CuCl_2$ + H_2S →

3. Double displacement: NaOH + $HClO_4$ →

4. Decomposition: $ZnCO_3$ + heat →

5. Single replacement: HCl + Zn →

6. _____ Na + $MgCl_2$ →

7. _____ $CaCl_2$ + K_2CO_3 →

8. _____ K + Cl_2 →

9. _____ $BaCl_2$ + K_3PO_4 →

10. _____ H_2SO_4 + KOH →

11. _____ $Al_2(CO_3)_3$ + heat →

12. _____ Al + O_2 →

13. _____ $Pb(NO_3)_2$ + KOH →

14. _____ H_2SO_4 + $BaCl_2$ →

15. _____ Ca + AgCl →

16. _____ H_3PO_4 + $FeBr_3$ →

17. _____ Li + N_2 →

18. _____ HCl + $Mg(OH)_2$ →

19. _____ $Mg(OH)_2$ + heat →

20. _____ $Fe(OH)_3$ + heat →

Answers for Predicting Products of Chemical Reactions

For all combustion reactions of hydrocarbons or hydrogen-carbon-oxygen molecules, the products will always be CO_2 and H_2O (assuming a complete reaction).

a. Combustion: $C_6H_{12} + 9O_2 \rightarrow 6CO_2 + 6H_2O$

b. Combustion: $2C_4H_6 + 11O_2 \rightarrow 8CO_2 + 6H_2O$

c. Combustion: $C_6H_{10}O_3 + 7O_2 \rightarrow 6CO_2 + 5H_2O$

1. Synthesis: $Mg + I_2 \rightarrow MgI_2$
Note that Mg can only form Mg^{2+} and I can only form I^-, so the product will must have a 1:2 cation:anion ratio.

2. Double displacement: $CuCl_2 + H_2S \rightarrow CuS + 2HCl$
Note that the product is **not** H_2Cl_2. It is important to recognize that $CuCl_2$ is made of three ions, Cu^{2+} and two Cl^-.

3. Double displacement: $NaOH + HClO_4 \rightarrow NaClO_4 + H_2O$
In this question, you must recognize that perchlorate, ClO_4^-, and hydroxide, OH^-, are polyatomic ions and will not break apart. Also, this is an acid-base reaction, so the products should be salt and water.

4. Decomposition: $ZnCO_3 + heat \rightarrow ZnO + CO_2$
When reactions have heat as a reactant, it is very likely that they will involve decompositions. Carbonate compounds usually decompose to CO_2 and a metal oxide.

5. Single replacement: $2HCl + Zn \rightarrow ZnCl_2 + H_2$
Note that one reactant is in its elemental form; if a single replacement reaction is going to occur, the species NOT in its elemental form in the reactants (H^+ in this case), will end up in its elemental form in the products (H_2) and the species that IS in its elemental form (Zn) will end up ionized (Zn^{2+}). Note that zinc can *only* form a Zn^{2+} ion, so it will have two chloride ions. Note also that hydrogen in its elemental form is H_2, not H.

6. Single replacement: $2Na + MgCl_2 \rightarrow 2NaCl + Mg$
Again notice that one species is in its elemental form (Na). The magnesium in $MgCl_2$ is an ion (Mg^{2+}), but is transformed into its elemental state (Mg), while the Na is converted into an ion (Na^+, sodium *only* forms a +1 ion).

7. Double replacement: $CaCl_2 + K_2CO_3 \rightarrow CaCO_3 + 2KCl$
Recognize that carbonate is a polyatomic ion (CO_3^{2-}) and that the cations are already stable ions (Ca^{2+} and K^+).

8. Synthesis: $2K + Cl_2 \rightarrow 2KCl$
Note that both materials are elemental species, so the only result could be a synthesis reaction. In the product, K^+ and Cl^- are formed. Note that we would NOT write the product as K_2Cl_2. Ionic compounds are written in their simplest forms.

9. Double replacement: $3BaCl_2 + 2K_3PO_4 \rightarrow Ba_3(PO_4)_2 + 6KCl$
Note that phosphate (PO_4^{3-}) is a polyatomic ion and will not break apart. Since barium is a +2 ion, the barium phosphate will have a 3:2 ratio of $Ba:PO_4$ in order to balance the charge.

10. Double replacement: $H_2SO_4 + 2KOH \rightarrow 2H_2O + K_2SO_4$
Notice that sulfate (SO_4^{2-}) is a polyatomic ion and that potassium exists as a +1 ion (K^+). Also, this is an acid-base reaction, so the products should be salt and water.

11. Decomposition: $Al_2(CO_3)_3 + heat \rightarrow Al_2O_3 + 3CO_2$
Another decomposition that will generate CO_2 and a metal oxide (note that Al forms a +3 ion, Al^{3+}, and monatomic oxygen will have a –2 charge, O^{2-}).

12. Synthesis $4Al + 3O_2 \rightarrow 2Al_2O_3$

Each species is in its elemental form, so a synthesis reaction is expected. Since the most stable ionic form of aluminum is Al^{3+} and oxygen is O^{2-}, Al_2O_3 will form (positive and negative charges must cancel out). Note that the elemental oxygen (O_2) is diatomic, but in the product, you no longer have elemental oxygen, since it is now an ion.

13. Double replacement $Pb(NO_3)_2 + 2KOH \rightarrow Pb(OH)_2 + 2KNO_3$

Note that there are two polyatomic ions present in the question: nitrate (NO_3^-) and hydroxide (OH^-). The lead has a +2 charge so it will require two negative ions to make a neutral salt ($Pb(OH)_2$). Note that potassium only has a +1 charge (K^+), so when it forms a compound with nitrate, it must occur with a 1:1 ratio (KNO_3).

14. Double replacement $H_2SO_4 + BaCl_2 \rightarrow BaSO_4 + 2HCl$

Notice that the $BaCl_2$ is made of three ions (Ba^{2+} and two Cl^-). $BaCl_2$ ***does not represent*** a barium ion and elemental chlorine. As a result, the chlorine in the product will not be Cl_2.

15. Single replacement $Ca + 2AgCl \rightarrow CaCl_2 + 2Ag$

With one species in its elemental form (Ca), this will be a single replacement reaction. Note that calcium can only form a +2 ion (Ca^{2+}) and that the chlorine can only have a –1 charge (Cl^-), so the salt produced must be $CaCl_2$.

16. Double replacement $H_3PO_4 + FeBr_3 \rightarrow FePO_4 + 3HBr$

Note that phosphate has a –3 charge (PO_4^{3-}) and that the iron has a +3 charge (Fe^{3+}).

17. Synthesis $6Li + N_2 \rightarrow 2Li_3N$

Recall that the monatomic charge for lithium is +1 (Li+) and nitrogen is –3 (N^{3-}). To form a neutral compound, there must be three +1 charges to match the one –3 charge.

18. Double replacement $2HCl + Mg(OH)_2 \rightarrow MgCl_2 + 2H_2O$

This one should have been easy by now.... (Plus, this is an acid-base reaction, so the products should be salt and water.)

19. Decomposition $Mg(OH)_2 + heat \rightarrow MgO + H_2O$

Hydroxides will often decompose with heat to yield water and an oxide. When you get to the Chemistry of Copper lab, you will see a dramatic change involving copper(II) hydroxide becoming copper(II) oxide.

20. Decomposition $2Fe(OH)_3 + heat \rightarrow Fe_2O_3 + 3H_2O$

Similar to the question above. Notice that the metal retains its ionic charge, it is Fe^{3+} in both the reactants and products.

If you have QUESTIONS about these, PLEASE ASK!!!!!!!!! I guarantee you will see questions similar to these on tests (including the final exam) and quizzes in class. It's important stuff!