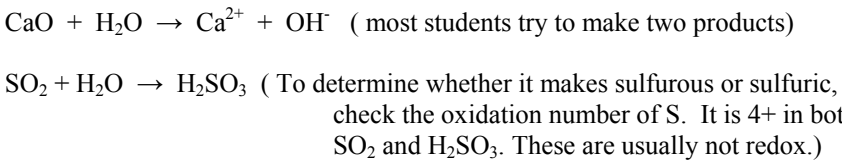
Cut to the Chase: Predicting Products of Chemical Reactions

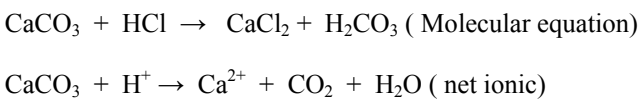
When trying to predict the products of a chemical reaction, remember that many of them will be first year equations and will fit into the neat categories: displacement, double displacement, synthesis, decomposition, and combustion. The key to success is realizing when the reaction is not one of the simple ones.
Below is a checklist you should use to determine if the reaction is not a simple first year reaction:

1. **Oxide + water** - Metal oxides make bases and nonmetal oxides make acids



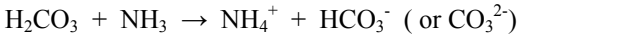
2. **Carbonate (or hydrogen carbonate) + acid**

This can be treated like a double displacement, but H_2CO_3 should be decomposed to CO_2 and H_2O.



3. **Nonmetal oxide bubbled through a solution**:

Carbon dioxide bubbled through an ammonia solution. The best way to handle this reaction is to first turn the nonmetal oxide into an acid since it is being bubbled through water and ammonia. CO_2 would then begin as H_2CO_3.



With polyprotic acids, the answer key will always show just one H being added or removed, thus the HCO_3^- in the answer. Removing all of the hydrogens is also an acceptable answer.

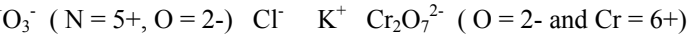
4. **Redox Reactions**

The key here is recognizing the reaction as a redox. Some key works will help you recognize them. If the problem specifies basic or acidic solution it is probably a redox. Certain polyatomic ions which contain metals with high oxidation numbers indicate a redox: MnO_4^-, $Cr_2O_7^{2-}$, and CrO_4^{2-}. To see others see the sheet titled : Things to Memorize for the AP Exam.

How to approach a redox:

Iron(II) Nitrate + Potassium dichromate in acidic solution

Step One: Identify the oxidation number of each element



Step Two: Choose one element that you think could go down in number. If are not sure, pick the element with the highest oxidation number.

Cr is the element. To decide what it will change to, see Things to Memorize for the AP Exam. In acidic solution: $Cr_2O_7^{2-} \rightarrow Cr^{3+}$ (This is memory).

Step Three: Chose an element to go up. In this case $Fe^{2+} \rightarrow Fe^{3+}$. Rather than memory, this is more common sense.

Step Four: Put the two equation together:

$Cr_2O_7^{2-} + Fe^{2+} + H^+ \rightarrow Cr^{3+} + Fe^{3+} + H_2O$

(notice that H^+ is added to the left because it is in an acidic solution. Water is added to the right side to counter the H. If in basic solution, add OH^- to the left and water to the right.)

4. **Complex Ions**

Very few complex ions are used on the AP Exam. Here are the most common.

A. When NH_3 is added to Ag^+ or Cu^{2+}, it produces: $Ag(NH_3)_2^+$ and $Cu(NH_3)_4^{2+}$. A rule of thumb is that the number of ligands (things attached to the metal) will be double the oxidation number of the metal.

B. When Concentrated OH^- is added to $Zn(OH)_2$, it will produce $Zn(OH)_4^{2-}$.

C. When SCN^- is added to Fe^{3+} it will form $Fe(SCN)_6^{3-}$

D. General Rule: Transition metals when reacted with OH^-, SCN^-, and NH_3 will often form complexes.

Worksheet Predicting Products of Chemical Reactions

1. **Displacement**
   Copper(II) Sulfate + Iron →

2. **Double Displacement**
   Hydrochloric Acid + Sodium Hydroxide →

3. **Combustion of a Hydrocarbon**
   Methane + Oxygen →

4. **Synthesis**
   Sodium + Chlorine →

5. **Decomposition**
   Water →
   Calcium Carbonate →
   Carbonic Acid →

6. **Acid + Carbonate or hydrogen carbonate**
   Calcium Carbonate + Hydrochloric Acid →
   Sodium Hydrogen Carbonate + Hydrochloric Acid →

7. **Metallic Oxides + Water**
   Calcium Oxide + water →
   Sodium Oxide + water →

8. **Nonmetallic Oxides + water**
   Sulfur dioxide + water →
   Cl_2O_7 + water →

9. **Redox Reactions**
Manganese Dioxide + Hydrochloric Acid (acidic) →
Iron(II) Nitrate + Potassium Permanganate(acidic)→

Key words to recognize in redox: in acid, in basic, permanganate, dichromate, Chromate.

10. **Nonmetallic oxide bubbled through water**
Carbon Dioxide is bubbled through an ammonia solution

11. **Complex Ions**
$Cu(NH_3)_4^+ + H^+ \rightarrow Cu^{2+} + NH_4^+$
$AgNH_3^+ + NH_3 \rightarrow Ag(NH_3)_2^+$
$Zn(OH)_2 + OH^- \rightarrow Zn(OH)_4^{2-}$

(often the number of ligands attached to the metal will be double the oxidation number of the metal)

Writing Chemical Reactions

Write net ionic equations. Balancing is not required. Points are given for reactants and products.

1. Sodium Sulfite is added to water
2. Potassium dichromate is added to lead(II) nitrate in an acidic solution
3. Calcium carbonate chips are added to excess nitric acid
4. Hydrogen sulfide gas is bubbled through a solution of cadmium nitrate
5. Solutions of acetic acid and sodium carbonate are mixed
6. Hydrogen chloride gas is bubbled through water
7. Solutions of carbon dioxide and ammonia are mixed
8. Solid lithium oxide is added to water
9. Sulfur trioxide gas is bubbled through a sodium hydroxide solution
10. A mixture of solid calcium oxide and solid tetraphosphorous decaoxide is heated
11. Solid magnesium carbonate is heated
12. Solid sodium cyanide is added to water
13. Gaseous boron trihydride is mixed with ammonia gas
14. Gaseous silane (SiH_4) is burned in excess oxygen
15. Magnesium ribbon is burned in pure nitrogen
16. Hydrogen peroxide is added to an acidified solution of potassium iodide
17. Potassium permanganate is added to an acidified solution of oxalic acid

18. Tin(II) acetate is added to an acidified solution of Potassium dichromate

19. Copper wire is added to dilute nitric acid

20. Sodium dichromate is added to acidified sodium iodide

21. Solid sodium hydride is added to water

22. Powdered iron is added to a solution of iron(III) sulfate

23. Chlorine gas is bubbled through a solution of potassium bromide

24. Solid sodium is added to water

25. Molten magnesium chloride is electrolyzed between platinum electrodes