# Chapter 8. Cracolice, 2/e. Chemistry X11.

## Chapter 8

This is real chemistry: chemical reactions, and the equations that describe them. Emphasize Sect 1-4 as the most general. Most of the rest is examples. Work with the reactions as examples of interesting chemistry, and begin to see the types of reactions that chemicals undergo. The goals stated on p 200 are excellent; learn them by practice, not memorization.

## Balancing equations

Balancing chemical equations is largely a trial and error process. With experience, you begin to see "tricks", but there aren't good rules for how to proceed. (Don't get too bogged down with Cracolice's "procedure" on p 202; see the margin note.) A critical point is to keep separate the steps of

1) figuring out which chemicals are involved
2) balancing.

Step 1 involves knowing (figuring out) the chemicals, and their correct formulas; you may need to refer to Ch 6. Once you get to Step 2 -- balancing -- you must not change any chemical formula; you can only state "how many" by a coefficient in front of the formula. And then there is Step 3 -- very important: always check that your final equation really is balanced, by adding up the atoms in your proposed solution.

It is important that you learn to balance chemical equations. You do this by understanding the general idea, then doing lots of practice equations. There are plenty of them on pp 219-220. I suggest you do the first set ("Exercises", p 219 top) by doing one at a time, checking your own balancing, then checking the answer section. After that, work on the main set of problems (starting at middle of p 219); they involve figuring out reactions and then writing balanced equations. This is good practice, both with reactions and with chemical formulas -- especially since you can use the book to help you at this point. Refer to Ch 6 as needed to help you with the formulas. Do lots from the "unclassified" section.

If you have regular trouble balancing equations, let's do some together (I have tricks for helping people balance). Even if you're basically doing ok, you will occasionally find a particular equation that is hard to balance. Try to distinguish having trouble with a particular equation from not knowing how to balance.

### Notes about balancing

- Balanced equations are commonly written with small integer coefficients (e.g., p 202 step 4). This is a matter of convention and preference. More importantly, any set of coefficients that leads to the same number of each kind of atom on each side is balanced -- and is "correct". Once balanced, one can multiply through an entire equation by any constant, and achieve another balanced equation.

- Balanced equations must have the same number of each kind of atom on each side. They also must have the same charge (same number of electrons) on each side. If your equation involves ions, be sure ion charges are shown, and are balanced. (This point will be even more important in Ch 17.)

- In Section 2.9 you learned that mass is conserved in chemical reactions. Now we understand that the numbers of protons, electrons and neutrons are (each) conserved. This leads to the observed fact that mass is conserved.

State (phase) symbols

It's a good habit to routinely write the state (or "phase") symbol for each species in a reaction (Table 8.1), even though it does not directly affect balancing. It is useful information. (The terms state and phase are used more or less interchangeably in this context.)

Yes, there are some you don't know, but with a little practice you can figure out most of them. For example, almost all metal are solids. All (common) salts are solids in the pure state.

Be particularly careful to distinguish the states
- (l) = liquid
- (aq) = aqueous = in aqueous solution.

If you have a solution of NaCl, the NaCl is (aq), the water is (l).

**Predicting precipitation reactions**

In Section 8.9 you learn about precipitation reactions, as one type of double replacement reaction. Can you predict which product will precipitate? Yes, but we largely leave that until Ch 17.

For now, just a couple of very useful rules-of-thumb…
- All nitrates are soluble.
- All sodium salts are soluble. (Of course, if it is true for Na…)

**You should know** these two solubility rules at this point. They will get you started thinking about predicting precipitates; in fact, these are very common ions and the "rules" given here are very good (but not perfect) rules. (For those who want more at this point, peek ahead to Sect 17.6, including Tables 17.3 & 4.)

**Errata**

p 219. Answer to #22 shows one phase that is rather questionable. Can you improve on his answer?

**Further reading**

R Hoffman, Dobereiner's lighter. Amer Sci 86:326, 7/98. In this chapter you learn that Zn can displace the hydrogen from an acid, releasing hydrogen gas (a single replacement reaction). And you know that hydrogen gas burns. Platinum metal is a good catalyst for many reactions with $H_2$; it works because the $H_2$ adsorbs to the surface of the Pt. Under appropriate conditions, Pt can catalyze fire production -- from $H_2 + O_2$. So now we have a lamp.

K-A Hughes Kubatko et al, Stability of peroxide-containing uranyl minerals. Science 302:1191, 11/14/03. Peroxides tend to be unstable; they bring two O atoms, each highly electronegative (Ch 11), very close together. In fact, peroxides are rare among natural minerals. The only exceptions are two peroxides of uranium, such as studtite, a hydrated uranyl peroxide: $UO_2O_2(H_2O)_4$ (the uranyl ion is $UO_2^{2+}$). Here they show that the radioactive emissions from uranium can cause low levels of hydrogen peroxide in water, enough to stabilize the uranium peroxide minerals. They also suggest that this might be relevant to proposed methods for long term storage of nuclear wastes. This is an example of some rather exotic chemistry with a possible important implication.

S Kwok, The synthesis of organic and inorganic compounds in evolved stars. Nature 430:985, 8/26/04. We have noted that the atoms (heavier than He) were born in the stars, in nuclear reactions. Now it seems that chemical reactions are going on in the circumstellar regions. Here, Kwok reviews what is known on this subject.

P F McMillan, Geochemistry: A stranger in paradise. Science 310:1125, 11/18/05. News, about the geology of xenon. Xe is surprisingly rare in the atmosphere. Here they suggest that the reason is because it reacts with silicate minerals under the high P-high T conditions of the inner earth. I should emphasize that this suggestion needs confirmation; the work is indirect, and alternative explanations are possible.

D G DeWit, Predicting inorganic reaction products: A critical thinking exercise in general chemistry. J Chem Educ 83:1625, 11/06. A discussion of predicting chemical reactions, by recognizing reaction types. Includes a page of practice questions. Some of this is a little advanced for an "intro" chem course, but the ideas are good. Give it a try.

**Computer resources** (See web page for details and links.)

Check the book CD for this chapter. There are some video sequences showing a few reactions. There are also some interactive practice problems for balancing equations.

Physiology of Respiration. Describes how Lavoisier made the connection between ordinary combustion and burning our food.

There are a couple of resources for equation balancing. One is a "quiz"-type program, for practice. The other is a program that balances equations for you. Both of these can be of some use. But be careful… What is most important is that you learn the concept of what a balanced equation means. Further, you need to write proper equations, period. Both of the resources listed start with a proper chemical equation; they just deal with the balancing step. (Also, remember that you will not have the program on tests.)

The ION site (one of those noted above) also has some information about chemical reactions, and some include short videos; choose “Experiments”. For example, there is a nice video of a double replacement reaction, showing formation of a precipitate.

Other demos and videos of reactions are listed in the “Lab activities; demos; videos” section of the Intro Chem Internet Resources page.

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