

Chemistry 141 Samuel A. Abrash
Chemical Reactions Lab Lecture
9/5/2011

Q: Before we start discussing this week's lab, can we talk about our lab notebooks?

Sure.

Q: What makes a lab notebook a good notebook?

The notebook needs to be a complete record of your experimental procedure and all measurements that you make. It needs to be sufficiently detailed that you or someone else could pick up your lab notebook a year from now, and do the experiment exactly as you originally did.

Q: I don't like it when my notebook looks messy. Can I write down my data and observations somewhere else and copy them into my notebook?

All data, procedural information and observations should be written directly into your notebook, not written on another piece of paper and copied in later.

Q: Can I write my entries in pencil? That way if I make a mistake I can erase it.

No. All entries must be in ink.

Q: In ink? What happens if I make a mistake?

If you make an incorrect entry, strike it out with a single line (so that it remains legible) and write a brief note explaining the reason for the change.

Q: My lab partner and I are working together. Can we just keep one lab notebook between the two of us?

Every student needs to keep their own notebook record. There are several reasons for this. One is that notebook keeping is skill that we want to teach you, and you learn it better if you do it each week. It also means that you aren't dependent on your partners when it's time to write your lab report.

Q: Can we talk about this week's experiment now?

Sure.

Q: What's this experiment about?

The purpose of today's lab is for you to observe the changes that occur when various solutions are mixed, and to figure out the net ionic equation that accounts for your observations.

Q: What do we mix them in?

Small test tubes.

Q: What kinds of changes will we see?

In some cases these changes will be the formation of a precipitate. In others there may be a color change, or evolution of gas as evidenced by the formation of bubbles. In some cases the evidence of a reaction occurring will be a change in temperature or a change in smells. In some cases no reaction will occur at all.

Q: So whenever we mix two solutions, one reaction occurs?

In some cases you may have two reactions occurring – one in solution and one in the vapor phase above the solution. In some cases the mixture will not result in any reaction.

Q: Do the reactions all occur immediately?

Different chemical reactions occur at different rates. Therefore some processes will occur immediately and some gradually. This means that you will need to take special care in your observations, and make your observations at more than one time. You should make these observations before you mix your reagents, so you have a clear basis for comparison, immediately after mixing, and one minute later. It can be useful to check once again after 5 minutes, since some changes intensify after additional time has passed.

Q: Will we be using these observations again, or will this week's lab report be the only time?

You will need these careful observations in order to do your bottle experiment next week, in which you'll have an unknown that you'll have to identify by its reactive properties.

Therefore in addition to noting whether a precipitate has formed, you should note when it forms (quickly or slowly), changes in odor (look for the odor of ammonia or vinegar), changes in temperature, whether a gas is evolved (as evidenced by formation of bubbles) and the colors of the substances you're working with.

Q: Can I write my observations directly onto the report sheet.

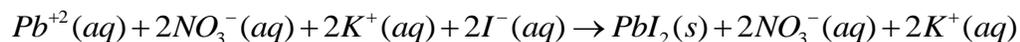
No, all observations need to be recorded directly into your laboratory notebooks.

Q: So all we do is make observations of the changes that occur and write them in our notebooks?

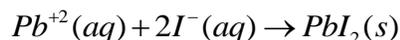
Sorry, no. After you do these reactions and make these observations you need to write down balanced net ionic equations for each reaction. In those cases where your observations indicate that more than one reaction has occurred, you should write equations for each reaction.

Q: What's a net ionic equation?

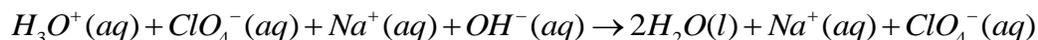
The concept here is fairly simple. In many ionic reactions, there are species that react, and species that are unchanged. For example in the reaction between lead nitrate and sodium iodide, a complete equation would be



Note that in this complete equation the nitrate ion and the potassium ions remain unchanged. In a net ionic equation those species that remain unchanged are eliminated, in this case resulting in the equation:



Another example is the neutralization of perchloric acid by sodium hydroxide. The full equation is



In this case the net ionic equation is:



Q: I see that you don't just have the reactants and products listed, but the phases as well. Do I have to do this too?

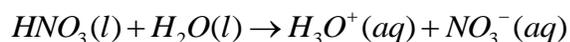
Note that in order to be correct you need to indicate the phase of each species. Species dissolved in water are designated (aq) for aqueous, gases are designated (g), liquids by (l), solids by (s). Sometimes when a precipitate is formed in a reaction a downward arrow is used instead of the (s), and sometimes when a gas is evolved an upward arrow will replace the (g).

Q: Is there anything I need to be careful about in writing these net ionic equations?

All of your equations must be balanced. This means that you must maintain the same number of each type of atom in the reactant side of the equation and in the product side of the equation. Note that this requirement is satisfied in both of our examples.

Q: I notice that you have to be able to write the full equation before you can write a net ionic equation, and in order to write the full equation, you need to know how a molecule dissociates when it dissolves. How can we tell? I mean I know it's easy if the molecule is NaCl(s), but what about K₂Cr₂O₇?

In addition to atomic ions, such as Na^+ and Cl^- , some species contain groups of atoms which, when the molecule dissolves in water, remain bonded to each other. An example that you may be familiar with is the solvation of nitric acid,



Note that in this process the NO_3^- does not break up into its constituent atoms, but remains as a single species. These species are called polyatomic ions and are very common. A list of many important polyatomic ions can be found in your manual on page 9 of the appendix. It is important that you be aware if one of these polyatomic ions is involved in one of your reactions or you will not be able to write the net ionic equation correctly.

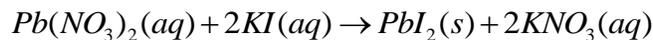
Q: The lab manual says we're doing 31 reactions. Is there anything they have in common, or are they all different?

There are several common classes of chemical reactions that you'll see in this experiment. While you will not be required to identify which of these classes of reaction you are observing, being aware of these classes will help you in identifying the reactions that are occurring in this experiment.

The types of reaction are double replacement, single replacement (also called oxidation-reduction), neutralization, and combination reactions. Some types of reactions can be found on page 8 of the Appendix.

Q: What's a double replacement reaction?

The reaction we just looked at between lead nitrate and potassium iodide is an example of a double replacement. It is easier to see this if we write the reaction as follows:

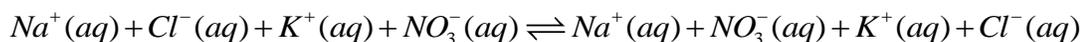


Note that in each of the molecules we start with one ion is replaced by another. It is important to realize that unless a precipitate is formed, no reaction has occurred. In many cases you'll know immediately from your observations that a reaction has

occurred but not which of the species has reacted. In those cases, referring to the solubility charts on pages 10-12 in the appendix will help a great deal. In addition, there are common solubility rules on page 8 of the appendix. If one pair of species forms a precipitate and the remaining species do not, then the ones that form the precipitate are the ones that have reacted. Because in many cases a double replacement reaction results in the form of a precipitate, these reactions are sometimes called precipitation reactions.

Q: How does a table of solubilities help us determine whether a reaction has occurred?

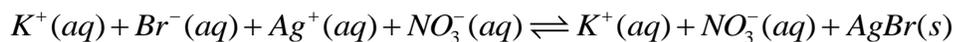
Your reactants all start as dissolved solids. If the products of a double replacement reaction are soluble as well, then all product and reactant ions cancel in the net ionic equation, and therefore no reaction occurs. For example consider what happens when you mix solutions of NaCl(aq) and KNO₃(aq). A double replacement would predict KCl(aq) and NaNO₃(aq) as the products, since the solubility table tells us that both KCl and NaNO₃ are highly soluble. The complete equation is:



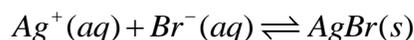
Since none of the ions are changed, all cancel out, and our net ionic equation becomes:

N.R.

In contrast, consider what happens when KBr(aq) is mixed with AgNO₃(aq). Our table of solubilities tells us that KNO₃ is highly soluble, but AgBr is insoluble. Therefore the AgBr forms a solid precipitate. The complete equation is:

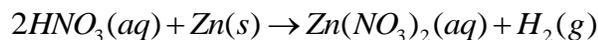


Canceling the ions which are unchanged yields the net ionic equation:



Q: What's a single replacement reaction?

An example of a single replacement reaction is the reaction between nitric acid and Zn:

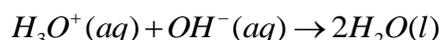


Notice that in this type of reaction only one ion, the nitrate ion, NO₃⁻, is transferred from the H to the Zn. Notice also that the oxidation state of the H goes from +1 to

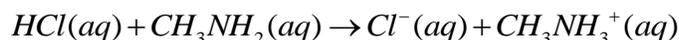
0, while the oxidation state of the Zn goes from 0 to +2. This change in oxidation states is something that all single replacements have in common – therefore all single replacement reactions are also oxidation-reduction reactions.

Q: I know we talked about neutralization reactions before, but could you refresh my memory?

A neutralization reaction is a reaction between an acid and a base which produces water as one of its products. It is one kind of double replacement reaction, but is given its own name because of its ubiquity. The most common neutralization reaction is the one we mentioned before:

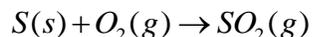


Neutralization reactions typically take place between an acid and a hydroxide containing base. Neutralization reactions are special cases of acid-base reactions. The most common types of acid base reactions involve the transfer of a proton from an acid to a base. An example of this is the reaction between hydrochloric acid and methylamine,



Q: Well that's three out of four. What's a combination reaction?

A combination reaction is one in which two compounds combine to make a single new compound. For example, the reaction with sulfur with oxygen to form sulfur dioxide,



is an important reaction in the chemistry of air pollution. The opposite of a combination reaction is a decomposition reaction. An important reaction in this class is the decomposition of carbonic acid into water and carbon dioxide, which often follows immediately on reactions of acids with metal carbonates:



Q: Any other hints?

Of course!

Wear your safety glasses throughout this experiment.

Smell the solutions by wafting the odors toward your nose. Do not inhale deeply.

Label one of your beakers as a waste beaker and then deposit the contents in the waste container at the end of the session. Do not put any chemicals down the sink. Rinse out your test tubes and dispose of them in the glass waste bins.

Q: What do we have to turn in as our lab reports?

Today you'll need to turn in the carbon copies of your notebook pages.

Next week you'll write molecular and net ionic equations for reactions 1-4, 6, 8, 10, 16-19, 24, and 27-30. There is an extra credit opportunity. Choose up to 10 of the remaining reactions, and write balanced equations for each. There is an extra report sheet for these extra credit reactions.

Q: What are we allowed to do with our partners and what do we need to do on our own?

All activities for the experiment, including working out the reactions and equations, can be done as a team, although each team member still has to hand in his/her own report. Please note, however, that the only person that you can work with is your lab partner.