

1: Experiments with Acids and Bases

Abnormal Psychology (SparkCharts), Accounting I (SparkCharts), Accounting II (SparkCharts), Adobe Photoshop CS2 (SparkCharts), African-American History.

This is an introductory course in the principles of general chemistry. Contemporary topics in chemistry as well as basic chemical principles will be the focus of this course. C is intended for students with little or no previous background in chemistry or need a review of basic chemical principles. However, I will assume that all students have a familiarity basic arithmetic and the use of a calculator. The text for the course will be: It is important for you to attend the lectures. Many concepts and ideas that are not readily found in the book are discussed during class. Do not hesitate to ask questions during lecture. Homework will be the odd numbered problems at the end of each chapter. Some additional problems during lecture may be assigned. Homework will be collected during the discussion section after we finish the chapter. No late homework will be accepted. All homework assignments must be submitted in the following manner for credit: The discussion section will be primarily used to go over class and homework material. Quizzes may be given. Students should come to these sessions prepared with questions that are derived from a serious attempt to understand these materials. Such a student will not understand the significance of the solution. There exists a homepage for the chemistry department [www](#). This homepage may contain the following features: The class should become familiar with the homepage and frequently check it as it will be used to relay messages during non class hours. I am in my office a high percentage of the time. It is not hard to find me. If you have any questions about the course come by and ask. You can even come to my office outside office hours, although I prefer you see me during office hours. The grade for the course will be determined by the usual factors: We will have four exams and a final. The best three of the four exams will be used towards the course grade. This policy means that a student can only miss one exam. Do not ask me if you can take a "make-up". The course grade will be determined in the following way: The following number system is used for the grades: The net course grade the actual grade you receive will differ slightly from the GCG by subjective factors such as improvement throughout the semester, willingness to contribute to the class, overall effort etc. These factors come into play when a student is near the border between grades. I cannot grant a withdraw if the withdraw deadline has passed. A grade of incomplete I can only be given under the following conditions all of which must be met:

2: DSpace@MIT: Chemistry Laboratory Techniques, January IAP

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Redox and Electrochemistry Oxidation-reduction redox reactions are another important type of reaction that you will see questions about on the SAT II Chemistry test. The test writers will expect you to be able to identify elements that are oxidized and reduced, know their oxidation numbers, identify half-cells, and balance redox reactions. The following is a brief overview of the basics. Oxidation-Reduction Oxidation-reduction reactions involve the transfer of electrons between substances. They take place simultaneously, which makes sense because if one substance loses electrons, another must gain them. For example, all single-replacement reactions are redox reactions. The study of the interchange of chemical and electrical energy. The loss of electrons. Since electrons are negative, this will appear as an increase in the charge e . The species that is reduced and thus causes oxidation. The gain of electrons. When an element gains electrons, the charge on the element appears to decrease, so we say it has a reduction of charge e . The species that is oxidized and thus causes reduction. The assigned charge on an atom. An equation that shows either oxidation or reduction alone. Rules for Assigning Oxidation States A reaction is considered a redox reaction if the oxidation numbers of the elements in the reaction change in the course of the reaction. We can determine which elements undergo a change in oxidation state by keeping track of the oxidation numbers as the reaction progresses. You can use the following rules to assign oxidation states to the components of oxidation-reduction reactions: The oxidation state of an element is zero, including all elemental forms of the elements e . The oxidation state of a monatomic ion is the same as its charge. In compounds, fluorine is always assigned an oxidation state of -1 . Oxygen is usually assigned an oxidation state of -2 in its covalent compounds. Exceptions to this rule include peroxides compounds containing the group O_2 , where each oxygen is assigned an oxidation state of -1 , as in hydrogen peroxide H_2O_2 . Metal hydrides are an exception: The sum of the oxidation states must be zero for an electrically neutral compound. For a polyatomic ion, the sum of the oxidation states must equal the charge of the ion. Now try applying these rules to a problem. Example Assign oxidation numbers to each element in the following: H_2S MgF_2 Explanation The sum of the oxidation numbers in this compound must be zero since the compound has no net charge. F is assigned an oxidation state of -1 according to rule 3, and there are two atoms of F , so this gives F a total charge of -2 . This time the net charge is equal to -3 the charge of the polyatomic ion according to rule 7. Oxygen is assigned a -2 oxidation state rule 4. Multiply the oxidation number by its subscript: Since there is only 1 phosphorus, just use those algebra skills: Example When powdered zinc metal is mixed with iodine crystals and a drop of water is added, the resulting reaction produces a great deal of energy. The mixture bursts into flames, and a purple smoke made up of I_2 vapor is produced from the excess iodine. Explanation Assign oxidation numbers to each species. Zn and I_2 are both assigned values of 0 rule 1. Evaluate the changes that are taking place. The half-reaction would look like this: This half-reaction would look like this: Here, zinc metal is the reducing agent it causes the reduction to take place by donating electrons while iodine solid is the oxidizing agent; iodine solid accepts electrons. Voltaic or Galvanic Cells Redox reactions release energy, and this energy can be used to do work if the reactions take place in a voltaic cell. In a voltaic cell sometimes called a galvanic cell, the transfer of electrons occurs through an external pathway instead of directly between the two elements. The figure below shows a typical voltaic cell this one contains the redox reaction between zinc and copper: Remember that electron flow always occurs from anode to cathode, through the wire that connects the two half-cells, and a voltmeter is used to measure the cell potential in volts. Batteries are cells that are connected in series; the potentials add to give a total voltage. One common example is the lead storage battery car battery, which has a Pb anode, a PbO_2 cathode, and H_2SO_4 electrolyte is their salt bridge. Standard Reduction Potentials The potential of a voltaic cell as a whole will depend on the half-cells that are involved. The cell potential is a measure of the difference between the two electrode potentials, and the potential at each electrode is calculated as the potential for reduction at the electrode. Here is the chart: On this reduction potential chart, the elements that have the most

positive reduction potentials are easily reduced and would be good oxidizing agents in general, the nonmetals, while the elements that have the least positive reduction potentials are easily oxidized and would be good reducing agents in general, metals. Example Which of the following elements would be most easily oxidized: Ca, Cu, Fe, Li, or Au? Explanation Use the reduction potential chart: Metals are at the bottom and are most easily oxidized. Example Which one of the following would be the best oxidizing agent: Ba, Na, Cl, F, or Br? Explanation Using the reduction potential chart and the fact that oxidizing agents are the elements that are most easily reduced, we determine fluorine is the best oxidizing agent. Electrolytic Cells While voltaic cells harness the energy from redox reactions, electrolytic cells can be used to drive nonspontaneous redox reactions, which are also called electrolysis reactions. These types of cells rely on a battery or any DC source—in other words, whereas the voltaic cell is a battery, the electrolytic cell needs a battery. Also unlike voltaic cells, which are made up of two containers, electrolytic cells have just one container. However, like in voltaic cells, in electrolytic cells electrons still flow from the anode to the cathode. An electrolytic cell is shown below.

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Some of them have acidic properties, others, basic properties. Bases are substances which free hydroxide ions OH⁻ when they are mixed with water. This freeing of ions is called dissociation in both cases. Free hydroxide ions react with the hydrogen ions producing water molecules: A solution rich in hydrogen ions is acidic, a solution poor in hydrogen ions is basic. Some acids dissociate only in part and they are called weak acids; others dissociate completely, freeing large amounts of hydrogen ions, and they are called strong acids. In the same way, the bases can be stronger or weaker. Diluted acids and bases are less concentrated and less aggressive in their actions. The acidic or basic degree of substances is measured in pH units. The scale used spans from 0 to 14. Substances with pH lower than 7 are considered acids, those with pH equal to 7 are considered neutral, and those with pH higher than 7 are considered bases. Substances with low pH are very acidic, while those with high pH are highly basic. Concentrated acidic and basic substances are very corrosive and dangerous. The following description is directed to high school students. As this concentration can extend over several orders of magnitude, it is convenient to express it by means of logarithms of base ten. As this concentration is always less than one, its logarithm always has the minus sign. To avoid having to always write the minus sign, it has been agreed to write this value with the positive sign. This is the same as using the logarithm of the reciprocal of the hydrogen ion concentration. So, the pH is the logarithm of the concentration of hydrogen ions, with the sign changed: Thus, when pH has low values, the concentration of hydrogen ions is high. So how it is possible that distilled water has free hydrogen ions? Immediately after, these ions recombine themselves, but other molecules dissociate themselves, thus keeping a constant equilibrium of a certain concentration of dissociated molecules. These substances are called pH indicators. Usually, they are used as dissolved substances, as for instance phenolphthalein and bromothymol blue. Often, to measure the pH, special papers which have been soaked with indicators are used. These papers change color when they are immersed in acidic or basic liquids. This is the case of the well-known litmus paper figure 3. More recently, it has become possible to measure the pH with electrical instruments like the pH meter figure 4. Litmus paper Litmus is a substance obtained from certain lichens. It has the property of changing its color to red with acidic substances and to blue with basic ones. On the packet of the litmus paper, there is a color scale which indicates the color assumed by the paper as a function of the pH figure 3. Using Litmus paper is simple. First of all, it is necessary to immerse an end of it in the liquid you wish to examine and to remove it immediately. The pH of the liquid is determined by comparing the color of the paper to the scale of colors which is printed on its packet figure 3. Figure 3 - Litmus Paper. High side, a strip dipped in a solution of baking soda. Bottom side, a strip dipped in vinegar. The pH meter is an electronic instrument supplied with a special bulb which is sensitive to the hydrogen ions which are present in the solution being tested. The signal produced by the bulb is amplified and sent to a liquid-crystal or an analog meter display. These instruments are much more precise and convenient to use than the indicating papers. Setting the pH meter. Before using it, the instrument has to be checked and possibly adjusted. For this purpose, the electrode of the meter is immersed in suitable buffer solutions with known pH. Usually, these solutions are supplied with the meter when you buy it, but they can also be bought separately or prepared for the purpose. Figure 4 - pH meter. In reference to the chemical reaction we described, with a litmus paper measure the pH of the saturated solution of baking soda, of the vinegar and of the solution which results from their reaction. If you have one, make the same measurement with the pH meter. This is the case with the juice of the red cabbage. This liquid has a blue-violet color, but when it comes in contact with acidic substances it becomes red, while in contact with basic substances it becomes green and even yellow. Figure 5 - Red cabbage. Figure 6 - Cut the cabbage into slices and put them in a pot. Figure 7 - Add water enough to cover the slices and boil for half an hour. Figure 8 - Pour the juice in a low container. During winter and spring, it is easy to find a red cabbage at the produce market or greengrocer. It is a cabbage which has a red-violet color figure 5. Buy one of them and cut it in little slices

figure 6. Put them in a pot and pour enough water to cover them figure 7. Boil for half an hour, then turn off the heat and let the temperature come down. Pour the blue-violet liquid you have obtained into a large, low container figure 8. The boiled cabbage slices are edible and you can use them in a recipe. Use of the red cabbage juice as an indicator in the liquid state. Pour some drops of this liquid on a white surface and observe its changes of color when it is mixed with vinegar or with baking soda. You will see that this liquid becomes red in contact with vinegar or lemon juice, while it becomes green in contact with baking soda figure 9. This behavior is unusual, and later on we will try to explain it. Pour one centimeter of the red cabbage juice indicator liquid into a transparent glass. Add water up to half of the glass. Now, pour vinegar into the glass and observe the color changes of the liquid. Repeat the experiment by adding, this time, a little baking soda instead of the vinegar. Also in this case, you will see color changes. Figure 9 - Red cabbage juice mixed with baking soda left and with vinegar right. On the top, a drop of unmixed juice. Preparing red cabbage pH papers. Cut some porous white paper or card sheets into rectangles and soak them in the juice so they will absorb it figure After about half an hour, remove the cards and put them away to dry figure To do it quicker, you can also dry them with a hairdryer. Cut the cards in strips figure Put away the red cabbage cards which are not used immediately: If you store them in a closed envelope to reduce their oxidization, they will last longer. Put the remaining juice in a bottle. To keep it longer, store it in a refrigerator. Figure 10 - Soaking cards Figure 11 - Drying the cards. Figure 12 - Cutting the strips. Figure 13 - Red cabbage paper in solution of lemon juice. Figure 14 - Red cabbage card in a saturated solution of baking soda. We will do this with litmus paper and with the pH meter if available. We will use also the red cabbage paper we prepared. In the following table, write the values of pH you determine for each substance, using litmus paper and the pH meter. By means of colored pencils, draw the corresponding color of the red cabbage paper.

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