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Experiments with

ACIDS and BASES

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CONTENTS

INTRODUCTION

This time, we will do some simple chemistry experiments to begin learning about acids and bases. We will see how the acidity of substances is measured; we will learn about some acid-base indicators; we will produce pH indicating papers; we will do a titration of vinegar; we will search for natural indicating substances and we will determine the color scale of them. In most cases, we will use household substances. We will use also some substances and devices bought especially for our experiments.

The experiments we will describe are suited to be performed not only in schools, but also at home and for your own personal interest. Their difficulty differs from one case to another, and it is up to the teacher or parent to choose the experiment to be performed and to adapt the explanations to the level of preparation of his or her students.

CAUTIONS

Never use dangerous substances. Do not use strong acids or bases. Do not put dangerous chemicals in containers for food use (i.e: cups, glasses, bottles) because they could be mistaken for beverages or foods. Never leave dangerous chemicals around the house; work instead in a room like a laboratory, a cellar, or a garage. At the end of the experiments, empty the beakers and wash them. Place the containers of the remaining substances which you want to preserve in suitable places, out of reach of children. Write on the containers their contents and dangerousness. While using ammonia, work in the open air or in an airy room with open windows. As soon as you have taken the amount of ammonia you need, close its container. Boys and girls should keep at least 2 m distant, and upwind. An adult must always be present during these experiments. In any case, we do not assume any liability. **As for the safety issues and the responsibilities involved, we recommend that you read our Warning page.**

You can buy the chemicals and the laboratory equipment for these experiments in stores which sell chemical laboratory items. Often, these stores are located near universities.

Be safe and have a good time!

A CHEMICAL REACTION

This first experiment serves to introduce the concept of chemical reaction and can be performed in an elementary school also. It is useful to help children understand how acid substances react with basic ones.

In half a glass of water, put a few teaspoons of baking soda and mix in order to obtain a quite concentrated solution. In the same glass, pour a spoon of vinegar. As you can see, there will be an abundant production of foam (figure 2). What happened? A chemical reaction occurred between the baking soda (a basic substance) and vinegar (an acid substance). These two substances reacted with each other, producing a salt, water, and carbon dioxide. That is the gas which produced the little bubbles you observed. In general, acid and basic substances react with each other, producing a salt and often other substances like water and carbon dioxide. If you want make the reaction more lively, use warm (not hot) water.

The salt produced by this reaction is sodium acetate: $CH_3COOH + NaHCO_3 = CH_3COONa + H_2O + CO_2$

CH_3COOH	$NaHCO_3$	CH_3COONa	H_2O	CO_2
Acetic acid	Baking soda	Sodium acetate	Water	Carbon dioxide

Figure 2 - Chemical reaction between vinegar and baking soda.

ACIDS, BASES AND pH

There are millions of chemical substances in the world. Some of them have acidic properties, others, basic properties. *Acids* are substances which free hydrogen ions (H^+), when they are mixed with water. *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: $H^+ + OH^- = H_2O$. in this way, bases diminish the concentration of hydrogen ions. 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.)

pH is the measure of the concentration of hydrogen ions in a solution. 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: $pH = - \log[H^+]$. Thus, when pH has low values, the concentration of hydrogen ions is high.

Distilled water has pH = 7. So how it is possible that distilled water has free hydrogen ions? Their presence is due to the casual dissociation of some water molecules because of the thermal agitation (H_2O ß à $H^+ + OH^-$). Immediately after, these ions recombine themselves, but other molecules dissociate themselves, thus keeping a constant equilibrium of a certain concentration of dissociated molecules.

MEASURING THE pH

There are substances which have the property of changing their color when they come in contact with an acidic or basic environment. 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.
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. In the market, it is easy to find pH meters which cost $30 US. 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. If the meter doesn't give the exact value, it can be adjusted by means of two potentiometers: one for the shift and the other for the gain. Usually, to adjust the instrument it is enough to use a buffer solution with pH = 7 and to adjust the shift trimmer only.

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.

RED CABBAGE JUICE

As we have seen, acids and bases have the property of modifying the color of certain substances. 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. Let's see how it is possible to use the juice of the red cabbage to measure the pH of various substances.

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.

Figure 9 - Red cabbage juice mixed with baking soda (left) and with vinegar (right). On the top, a drop of unmixed juice.

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.

Preparing red cabbage pH papers.
Cut some porous white paper or card sheets into rectangles and soak them in the juice so they well absorb it (figure 10). After about half an hour, remove the cards and put them away to dry (figure 11). To do it quicker, you can also dry them with a hairdryer. Cut the cards in strips (figure 12). Put away the red cabbage cards which are not used immediately: they will last some months. If you store them in a closed envelope to reduce their oxidization, they will last longer. Put the remaining juice in a bottle. After a few days, this juice goes bad and you have to throw it away. To keep it longer, store it in a refrigerator.

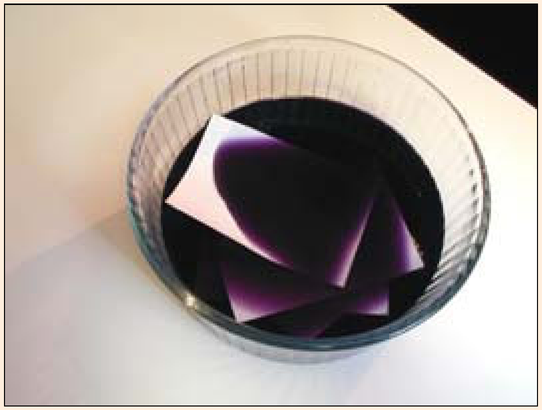

Figure 10 - Soaking cards with red cabbage juice.

Figure 11 - Drying the cards.

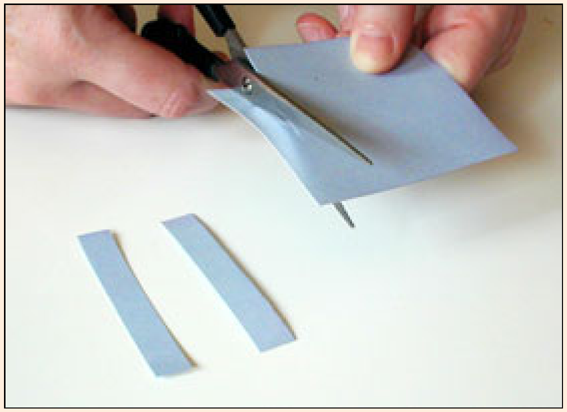

Figure 12 - Cutting the strips.

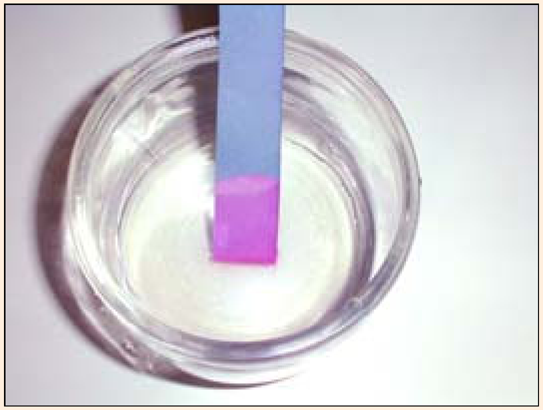

Figure 13 - Red cabbage paper in solution of lemon juice.

Figure 14 - Red cabbage card in a saturated solution of baking soda.

DETERMINE THE pH OF SOME SUBSTANCES

In this paragraph, we will measure the pH of some common substances. 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.

TABLE 1 - MEASURING THE pH OF SOME SUBSTANCES

SUBSTANCES	pH (litmus p.)	pH (pH meter)	COLOR (red cabbage paper)
distilled water			
tap water			
rain water			
soda water			
vinegar			
lemon juice			
wine			
beer			
Coca-Cola			
milk			
baking soda (saturated solution)			
ammonia (20% sol. about, to be diluted again with 3 parts of water). To be kept in a closed bottle.			
normal aspirin (1 tb in 20 ml of distilled water)			
buffered aspirin (1 tb in 20 ml of distilled water)			
shampoo			
soap			
other substances commonly used at home and not dangerous. Do not use strong acids or bases because they are dangerous. Do not use bleach.			

EQUIPMENTS	
pH meter	if available
litmus paper	a roll
red cabbage paper	strips
beakers or glass pots	20
glass or plastic rods	1

At the end of the measurements, compare the values supplied by the litmus paper and by the pH meter.
Observe the corresponding colors of the red cabbage paper.
Highlight the two more acidic substances.
Highlight the two more basic substances.

Observations:
Vinegar, lemon and Coca-Cola are acidic substances.
Baking soda and ammonia are basic substances.
Distilled water has a neutral pH.

THE COLOR SCALE OF RED CABBAGE

Let's see now how to determine the color scale of red cabbage papers (figure 15). The procedure consists in preparing solutions with whole number of pH and in taking pictures with a digital camera of the pH papers after they have been immersed in the solutions. With an image editing software, it will be easy to determine the color you have obtained. To do this experiment, it is necessary to obtain a pH meter.

TABLE 2 - SUBSTANCES AND EQUIPMENT TO DETERMINE THE COLOR CHART OF THE RED CABBAGE PAPER.	
tap water	
unripe lemon	
white wine vinegar	
ammonia (20% sol. about) in closed bottle.	
baking soda	
EQUIPMENTS	
pH meter	if available

buffer solution pH = 7 to set up the pH meter	
litmus paper	roll
red cabbage paper	strips
beakers or glass pots	20
glass or plastic rods	1
digital camera or scanner	1
computer with Excel or other electronic spreadsheet and an image editing program.	1

By means of the pH 7 buffer solution and a screwdriver, set up the pH meter.
Prepare a watery solution with pH = 2. For this purpose, use an unripe lemon (vinegar is not acidic enough). Dilute it with water until you obtain the right value of pH. Take out the pH meter and rinse it well with tap water.
Immerse a red cabbage paper strip in the pH = 2 solution, remove it and after a minute take a picture. Unlike the litmus paper, the red cabbage paper gets its color with a little delay.
Prepare a watery solution with pH = 3. For this purpose, you can use the same lemon juice or white vinegar. Dilute them with water until obtaining the right value of acidity. Rinse the pH meter.
Immerse a red cabbage paper strip in the pH = 3 solution, remove it and after a minute take a picture.
Continue in this way with the pH 4, 5, 6, 7 solutions.
As pH = 7 solution, you can use the buffer solution you used to set the pH meter, or even tap water provided you adjust its acidity by means of vinegar or baking soda, to obtain the right pH value.
By using diluted ammonia, prepare solutions with pH equal to 8, 9, 10 and 11 and continue to take pictures of the red cabbage strips immersed on them.
When you are using ammonia, keep in open air or in an airy room. Also, the ventilating hood of the kitchen could help you to avoid the irritating vapors of ammonia. Close the bottle immediately after you have drawn the necessary amount of ammonia. Do not try to do solutions with pH lower than 2 or higher than 11 because they are dangerous.

With an adjusted pH meter, check the pH of the solutions. Before passing from one solution to another, rinse the electrode of the instrument well with tap water. Once in a while, check the correct functioning of the instrument by means of the buffer solution.

Take the different pictures in the same conditions of light. To avoid problems due to a low color temperature (i.e.: the light of a lamp with filament) or due to discontinuities in the spectrum (certain fluorescent lamps), you should do these pictures under sunlight. Try to avoid reflections.

Another way to record the color of the papers consists in using a scanner. In this case, remember to well clean the glass of the scanner before you put the papers on it. In our case, we noticed our scanner did not have the same color fidelity as the digital camera.

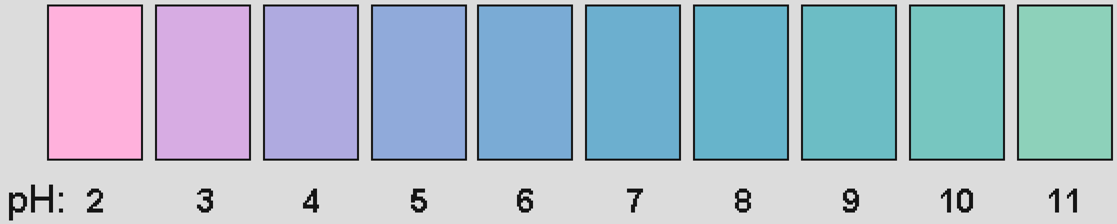

Figure 15 - Color scale of the red cabbage papers.

With image editing software, open a picture at a time and, with the dropper tool of the software, determine the color of the part of each paper which has been immersed in the solution. Express this color with the values of its three RGB components (Red, Green, Blue). They are three numbers which go from 0 to 255 each. Make a copy of figure 15 and give another name to it. With the image editing program, replace its colors with those which you have obtained. For this purpose, you will have to modify the palette of colors.

Very probably, you will obtain a color scale with rather irregular steps. To reduce this irregularity, for each paper it is necessary to do different measurements of the color to determine the mean value. Some programs allow you also to obtain the mean color of a 5x5 pixels square instead of checking a single pixel.

Unfortunately, the color scale you have obtained is valid for papers produced which are fresh; in fact, with the passing of time, these papers will fade and they will have a different color scale. If you want, at intervals of a month, you can determine the color scale of the paper in order to describe its changes by reference to the fresh one.

Determine the color scale of the Litmus paper. Compare it with the scale printed on its packet.

Why determine the color scale of the Litmus papers, since it is printed on its packet? We made it and we obtained a color scale quite different by reference to that of the packet. Perhaps, this is due to the fact that we bought it some years ago.

Why determine the color scale of the red cabbage papers, given that one is shown in figure 15? First of all because this is an interesting exercise, then because very likely your cabbage is of a different species or variety than ours.

Prepare pH papers with other vegetable substances. In summer, you can use the red mulberries and the berries of the elder. Determine the color scale of papers prepared with these substances and try to assess their stability.

Now, you have determined their color scale, utilize these papers to measure the pH of substances like those of the preceding experiment.

IS IT MAGIC?

In a beaker, pour about 100 ml of water and 3 drops of phenolphthalein. The phenolphthalein is an indicator which usually is colorless. You will obtain a colorless solution, just like water (figure 16).

Figure 16 - Add 3 drops of phenolphthalein to 100 ml of water. You will obtain a colorless solution.

With a dropper, add some drops of ammonia. To avoid its irritating vapours, make this experiment in the open air or in a ventilated room with windows open. People have to keep at least 2 meters distant, avoiding being downwind.

After some drops, you will see the solution suddenly become reddish purple (figure 17). This phenomenon is quite surprising because all the liquids we are using are colorless and transparent, like water.

Figure 17 - By adding ammonia, the solution becomes red.

Now, to the red-purple fluid you obtained, add some drops of vinegar. What it happens? The liquid becomes colorless again (figure 18)!

Figure 18 - By adding vinegar, the solution becomes again colorless. The picture illustrates the change in progress.

The fact that a colored liquid results from colorless liquids is already something strange, but to see it to become colorless again simply by adding a colorless fluid like the vinegar is something truly amazing. It is necessary to avoid to make boys and girls believe science is something magical. So, after some seconds of astonishment on the part of those who observe this experiment, the teacher has to explain them that what they have seen has nothing to do with magic, but that it is based on a precise chemical reason.

In particular, it is necessary to tell them that phenolphthalein has the property of becoming reddish- purple when the pH of the solution exceeds the value of 8.3. This value is that which you achieved by adding ammonia, when you saw the fluid take color. You can experimentally check this value with a litmus paper or better with the pH meter. More precisely, the molecule of phenolphthalein is colorless in its associated form, but when the pH attain a certain threshold the molecule dissociates and it takes its typical purple color.

Likewise, as you have seen in this experiment with the phenolphthalein, check if also the color variations of the red cabbage juice are reversible.

THE ACID-BASE INDICATORS

Indicators are fluids which change color with the pH.

Table 3 - Acid-Base Indicators

Indicator	Color change interval (pH)	Acid	Base
thymol blue	1.2 - 2.8	red	yellow
methyl orange	3.1 - 4.4	red	yellow
methyl red	4.4 - 6.2	red	yellow
chlorophenol red	5.4 - 6.8	yellow	red

bromothymol blue	6.2 -7.6	yellow	blue
phenol Red	6.4 - 8.0	yellow	red
thymol Blue	8.0 - 9.6	yellow	blue
phenolphthalein	8.0 - 10.0	colorless	red
alizarin yellow	10.0 -12.0	yellow	green
More indicators: http://chemistry.about.com/library/weekly/aa112201a.htm			

Usually, these substances are weak acids which have a color in the non dissociated form and another in the dissociated form. When a certain threshold of pH is exceeded, the molecules dissociate in ions. These indicators are often used to measure the acidity-basicity of a solution. In the pH papers, often some of these substances are used together. In fact, the color change of an indicator is not a point, but it is an intermediate value of an interval during which the indicator progressively change color. For example the phenolphthalein starts to change color at about pH = 8.3.

HOW ACID IS THAT VINEGAR?

As we will use a small amount of a corrosive substance and as we will take for granted some basic knowledge of chemistry, this experiment is suited to high-school boys and girls.

Table 4 - MATERIALS FOR THE TITRATION OF VINEGAR		
NaOH (sodium hydroxide)	50 ml	0.1 Molar solution. Buy the solution already prepared. This solution is not very dangerous, but it is necessary to make sure that it doesn't end up in the eyes or on the skin and it is not taken internally. DO NOT handle pure sodium hydroxide because it is very dangerous and can cause skin burns.
vinegar	50 ml	you can apply this procedure also to red vinegars, but it is better to use a white vinegar.
phenolphthalein	10 ml	1% solution in alcohol
distilled water	500 ml	
buret (graduated tube with a tap in the bottom)	1	capacity = 25 ml
sopport (base and pole)	1	
holdfast (clamp?) for buret	1	
beacker	1	capacity = 100 ml
glass rod	1	
graduated tube	1	capacity = 50 ml
graduated pipette	1	capacity = 5 ml
funnel	1	

safety glasses or shield	1 pair	
gloves	1 pair	
apron	1	

Vinegar is a substance whose acidity varies quite a bit because it can have from 4 to 6 % of acetic acid. The manufacturers of vinegar, and also of other substances, often need to precisely determine the acidity of their products. To titrate a vinegar means to determine its acetic acid content.
In this experiment, we will use a common procedure of titration of the vinegar.

In water, the sodium hydroxide dissociates as follows: NaOH à $Na^+ + OH^-$. As you know, the OH- ions combine with as many H+ ions if they are available. Essentially, to titrate vinegar you have **to add a solution of sodium hydroxide having a concentration known with precision** to the sample to be titrated, until you neutralize all the excess H^+ ions produced by the acetic acid. To know when the sample is neutralized, some drops of a suitable indicator are added to it. In this way, when the sample is neutralized suddenly it will change color. At this point, the number of moles of NaOH present in the titrant solution you have used will correspond exactly to the number of moles of the acetic acid present in the sample of vinegar to be titrated.

Add a few drops of phenolphthalein, an indicator suitable to this purpose, to the sample of vinegar. Then, drop the 0.1 M solution of sodium hydroxide into the liquid to be titrated. When the pH of the sample attains the point of equivalence, in which all the hydrogen ions (H^+) present in the sample are neutralized by as many OH^- ions present in the solution of sodium hydroxide, the phenolphthalein will suddenly become purple. So, as soon the sample of vinegar starts to change color, you have to note the amount of sodium hydroxide solution which has been used to neutralize it. Since we know the volume and the concentration of the sodium hydroxide solution added, with simple calculations we will be able to determine also the acid concentration of the vinegar.

Figure 19 - Apparatus to titrate the vinegar.

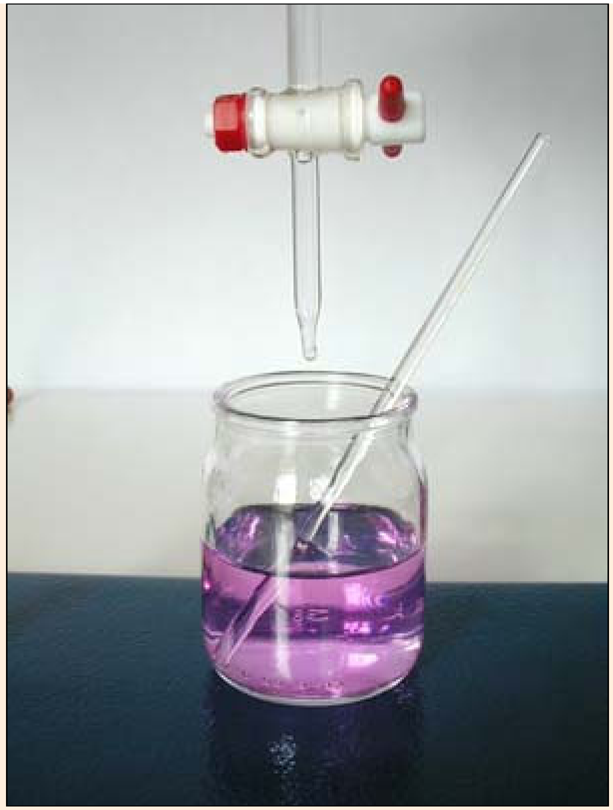

Figure 20 - As soon the liquid in the beacker changes color, stop the dropping.

Figure 21 - Notice the amount of titrating solution used.

PROCEDURE

- pour 1.5 ml of vinegar in a beaker;
- dilute with about 50 ml of distilled water;
- add 3 drops of phenolphthalein (at this point the solution is colorless);
- wear safety glasses for chemistry, an apron and a pair of gloves;
- fill a buret with a 0.1 M solution of sodium hydroxide;
- allow the liquid in the buret to come down to the zero mark and close the tap;
- put the solution to be titrated under the buret (figure 19);
- slowly drip the solution of sodium hydroxide into the solution to be titrated and mix with a glass rod;
- as soon the solution to be titrated becomes pink and keeps the color, close the tap of the buret (figure 20);
- note how much titrating solution you have used (figure 21).

At this point, all the acetic acid present in the sample to be titrated has been neutralized by the sodium hydroxide, according the reaction:

$$CH_3COOH + NaOH \rightarrow CH_3COONa + H_2O$$

However, remember that in water the acetic acid is dissociated in the CH_3COO^- and H+ ions and that the sodium hydroxide is dissociated in the Na+ and

OH^- ions.

CALCULATIONS

Imagine that to neutralize the sample of vinegar required 14.5 ml of titrating solution. Given that the number of molecules of NaOH used and the number of molecules of acid neutralized is the same, and the number of moles present in each solution is the same.

The volume of titrating solution used is 14.5 ml. As it was in 0.1 M concentration, the number of moles used is:

nM = 0.1 x 0.0145 (1ml = .001 litre)
nM = 0.00145

It is possible to obtain the same result solving the following proportion: V1 : M1 = V2 : nM
where:
V1 = volume of reference of NaOH (1 liter);
M1 = number of moles present in a liter of titrating solution (0.1);
V2 = volume of titrating solution used (14.5 ml = 0.0145 litres);
nM = Moles used (to be calculated).

The value we have obtained corresponds to the number of moles present in the titrating solution we have used and to the number of moles of acetic acid present in the solution to be titrated. To know the molar concentration of the vinegar (referred to a liter), we can set up the following proportion:

V1 : M1 = V2 : Mx
where:
V1 = volume of vinegar taken (1.5 ml = 0.0015 liters);
M1 = number of moles present in V1 (0.00145);
V2 = volume of reference (1 liter of vinegar);
Mx = number of moles in a liter of vinegar (to be calculated).

Mx = m1 x V2 / V1
Mx = 0.00145 x 1000 / 1.5
Mx = 0.97

If you want to know the concentration of acetic acid in terms of g/l, you have to multiply the number of moles found for the molecular mass of the acetic acid, which is 60.

Conc = number of moles x 60
Conc = 0.97 x 60
Conc = 58 g/l

Which in per cent terms correspond to a concentration of 5.8%.

The same procedure can be followed to titrate other acidic substances like wine, beer, etc. You can also use it to titrate a base of unknown concentration. In this case, in the buret you have to put an acid solution of concentration known with precision.

With a pH meter, measure the pH when the sample to be titrated change of color.

Someone can ask himself: "How come in this experiment we used an indicator which start to tack at pH = 8.3 instead of one which taks at pH = 7? The answer is that in the weak acids, like the acetic acid, the equivalence point is shifted toward high pH values. In the case of the acetic acid, the equivalence point is at about pH = 8.3.

We have used a titrating method we can call "volumetric", but you can also make titrations with balances. In this case you will follow a "gravimetric" method. http://www.woodrow.org/teachers/chemistry/institutes/1986/exp24.html Acid-base titration without burets.

THE pH OF SOAPS

Soap is produced by the reaction of fatty substances with sodium or potassium hydroxide. In chemistry, the fatty substances are named fatty acids, while the sodium hydroxide (NaOH) and the potassium hydroxide (KOH) are known to be very strong bases. The reaction of these substances produces a salt: the soap. Usually, soaps have a basic reaction. Particularly in winter, these soaps contribute to dry the skin of the hands, to chap it, to cause redness and even bleeding. Probably, this is also due to the fact the skin has an acidic pH, around 5.5. The frequent use of soap, and also of detergents, tends to increase the pH of the skin and to cause harm. To reduce this problem, neutral and even acid soaps are produced. If you are washing dishes, it is better to use protective gloves. To prevent problems to your hands, besides using suitable ointments, some drops of citron could be useful.

Check the pH of the soaps you have at home. For this purpose, put some drops of water on the soap to be tested. With a finger, scrape a little so as to put in solution a bit of soap and wet a litmus paper with it. If the soap is basic, the paper becomes blue, if the soap is acid, the paper becomes red. Check also the pH of the detergents you use to hand wash dishes, of shampoo, balsams, creams and other toiletries.

SEARCHING FOR NATURAL INDICATORS

Did you ever happen to see a herb tea to change color when you add some lemon? For example, the mallow tea should be clear blue (it depends also on the producer of the teabag you use). By adding some drops of lemon juice, it will become colorless and, with some other drops it will become pink.

Many vegetables, such as the herbs used in teas, have natural substances which have indicating properties. As we saw, this is the case of the red cabbage. Usually, these substances are anthocyanins, substances which often have a red-purplish or a violet color. They are present also in fruits like blueberries, grapes, mulberries and elder berries. Also flower petals can change color with pH, as red poppies and bluebottle do.

Look for natural substances having indicating properties and describe their characteristics. Try some of these as indicators. Check if the color of their solutions is reversible. If it is possible, obtain their color scale. Put some petals of rose in a dish with acid water and other petals in basic water. Try with petals of other flowers.

CONCLUSION

With these experiments, you saw that there are acid substances and basic substances. They react with each other, producing salts. The acid-basic degree is expressed in pH. To measure the acid-basic degree of a substance, you can use pH papers like litmus paper, indicators like phenolphthalein, and electronic pH meters. Many other natural substances of vegetable origin have the property to change color because of the acidity of the environment. We used the juice of the red cabbage as an indicator and we obtained pH papers. We determined the color scale of these papers. You saw how the phenolphthalein changed color when it gets over a pH threshold. We exploited the properties of this indicator to determine with precision the acidity of vinegar. You can continue with experiments of this kind, for example by titrating other liquids, by looking for natural indicators among herb teas, plants, flowers, fruits, berries, etc.

As you know, the aim with which we propose laboratory activities is not only to get amusement, but also to arouse curiosities which then stimulate a deeper study of the matters we touched. For this reason, we hope you do not limit yourself to the operational aspects of these experiments, but try also to take the occasion to study a text of inorganic chemistry to acquire its basic concepts. The knowledge you will gain will allow you also to continue with experiments like these, getting further amusement and knowledge. In fact, it is clear that you can benefit much more from activities of this type, when you have learned what are atoms, molecules, valence, the different types of solutions, electrolytic dissociation, and other basic concepts of chemistry. In the

Bibliography you will find sources to help advance your knowledge of the exciting subject of chemistry!

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