Upper Elementary

Chemistry

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CHEMICAL	STORE	PRODUCT
Acetic acid	Supermarket	Vinegar
Acetone	Drug store/hardware	Fingernail polish remover/paint solvent
Alcohol Ethanol Isopropanol Methanol	 Hardware Drugstore Hardware/Auto supply	 Denatured alcohol Rubbing alcohol Paint thinner/Gas line antifreeze
Antacid tablets	Drugstore	Any antacid tablets
Aluminum	Hardware/Craft Store	Wire, siding nails, flashing
Bobby pins	Drugstore	Metal bobby pins
Butane lighter	Supermarket/Drugstore	Butane lighter
Citric acid	Supermarket	Gatorde/Crystal Light
Copper	Hardware/Craft Store	Wire/Strips
Cornstarch	Supermarket	Any brand
Corn Syrup	Supermarket	Any brand
Cream of tartar	Supermarket	Any brand
Dishwashing liquid	Supermarket	Any brand
Gelatin dessert	Supermarket	Jell-O (citric flavors)
Glycerin	Drugstore	By name
Guar gum	Health food store	Any brand
Hydrocholoric acid (HCl)	Hardware	Muriatic acid
Iodine	Drugstore	By name
Lead	Sporting Goods	Sinkers
Lighter fluid	Drugstore	By name
Magnesium	Sporting Goods	Light-weight frame Light-weight packframes
Oxalic acid	Auto supply	Radiator cleaner
Oils	Supermaket/Auto Supply/Drug-store	Cooking oils/Motor oils/Baby oil and Mineral oil
Paradicholorbenzene	Supermarket	Mothballs
pH indicator strips	Pet supply/Swimming pool supply	By name
Plaster of Paris	Hardware	By name
Powdered sugar	Supermarket	By name
Sodium Bicarbonate	Supermarket	Baking soda
Sodium Borate	Supermarket	Borax
Sodium Hydroxide	Supermarket	Drain cleaner
Sodium thiosulfate	Photography Store	Fixer, hypo
Sugar	Supermarket	By name
Waterless hand cleaner	Auto Supply	By name
White Glue	Craft Store/Supermarket	By name
Xylene	Hardware	Thinner/solvent
Zinc	Hardware	Hot-dipped galvanized nails

List of Notable Chemists

A

- Emil Abderhalden, (1877–1950), Swiss chemist
- Richard Abegg, (1869–1910), German chemist
- Peter Agre, (1949-), American chemist and doctor, 2003 Nobel Prize in Chemistry
- Arthur Aikin, (1773–1855), English chemist and mineralogist
- Johan August Arfwedson, (1792–1841), Swedish chemist
- Amedeo Avogadro,(1776–1856), Italian physicist

B

- Neil Bartlett, (born 1932), English/Canadian/American chemist
- Sir Derek Barton, (1918–1998), 1969 Nobel Prize in Chemistry
- Antoine Baum, (1728–1804), French chemist
- Claude Louis Berthollet, (1748–1822), French chemist
- Jöns Jakob Berzelius, (1779–1848), Swedish chemist
- Joseph Black, (1728–1799), chemist
- Dale L. Boger, (born 1953), American organic and medicinal chemist
- Carl Bosch, (1872–1940), German chemist
- Robert Boyle, (1627–1691), Irish pioneer of modern chemistry
- Johannes Nicolaus Brønsted, (1879–1947), Danish chemist
- Henri Braconnot, (1780–1855), French chemist and pharmacist
- Robert Wilhelm Bunsen, (1811–1899), German inventor, chemist
- Eduard Buchner, (1860–1917), 1907 Nobel Prize in Chemistry

C

- Melvin Calvin, (1911–1997), American chemist, winner of 1961 Nobel Prize in Chemistry
- Georg Ludwig Carius, (1829–1875), German chemist

- Heinrich Caro, (1834–1910), German chemist
- Wallace Carothers, (1896–1937), American chemist
- Henry Cavendish, (1731–1810), British scientist
- Yves Chauvin, (born 1930), 2005 Nobel Prize in Chemistry
- Elias James Corey, (born 1928), American organic chemist, winner of 1990 Nobel Prize in Chemistry
- Marie Curie, (1867–1934), Polish-born French radiation physicist, 1903 Nobel Prize in Physics
- Pierre Curie, (1859–1906), 1903 Nobel Prize in Physics
- Robert Curl, (born 1933), winner of 1996 Nobel Prize in Chemistry
- Theodor Curtius, (1857–1928), German chemist

D

- John Dalton, (1766–1844), physicist
- Carl Peter Henrik Dam, (1895–1976), Danish biochemist, winner of the 1943 Nobel Prize in Physiology or Medicine
- Humphry Davy, (1778–1829)
- Peter Debye, (1884–1966)
- Sir James Dewar, (1842–1923)
- François Diederich, (born 1952), Luxembourg chemist
- Otto Diels, (1876–1954), German chemist, winner of the 1950 Nobel Prize in Chemistry
- Edward Doisy, (born 1893), American biochemist, winner of the 1943 Nobel Prize in Physiology or Medicine
- Davorin Dolar, (1921-2005), chemist from Univ. of Ljubljana
- Emmanuel Dongala, Congolese chemist and novelist
- Jean Baptiste Dumas, (1800–1884), French chemist

E

- Paul Ehrlich, (1854–1915), German chemist, winner of the 1908 Nobel Prize in Physiology or Medicine
- Manfred Eigen, (born 1927), German chemist, winner of the 1967 Nobel Prize in Chemistry

- Arthur Eichengrün, (1867–1949)
- Emil Erlenmeyer, (1825–1909), German chemist
- Richard R. Ernst, (born 1933), 1991 Nobel Prize in Chemistry
- Hans von Euler-Chelpin, (1873–1964), Swedish chemist, winner of the 1929 Nobel Prize in Chemistry

F

- Michael Faraday (1791–1867), scientist
- Hermann Emil Fischer (1852–1919), 1902 Nobel Prize in Chemistry, not to be confused with:
- Franz Joseph Emil Fischer
- Ernst Gottfried Fischer (1754–1831), German chemist
- Hans Fischer (1881–1945), German organic chemist, 1930 Nobel Prize in Chemistry winner
- Nicolas Flamel, French alchemist
- Rosalind Franklin (1920–1958), British chemist and crystallographer
- Carl Remigius Fresenius (1818–1897), German chemist
- Wilhelm Fresenius (1913–2004), German chemist, great-grandson of Carl
- Alexander Naumovich Frumkin, (1895–1976), electrochemist

G

- Johan Gadolin, (1760–1852), Finnish chemist
- Merrill Garnett, (born 1930), American biochemist
- Victor Goldschmidt, (1888–1947) Father of Modern Geochemistry
- Ljubo Golic, (born 1932), chemist
- Thomas Graham, (1805–1869), not to be confused with:
- William Hardin Graham ???
- Francois Auguste Victor Grignard, (1871–1935), 1912 Nobel Prize in Chemistry corecipient
- Robert H. Grubbs, (born 1942), 2005 Nobel Prize in Chemistry

H

- Fritz Haber, (1868–1934) 1918 Nobel Prize in Chemistry
- Otto Hahn, (1879–1968) 1944 Nobel Prize in Chemistry
- John Haldane,(1860–1936), British biochemist
- Odd Hassel, (1897–1981), Norwegian chemist 1969 Nobel Prize in chemistry
- Charles Hatchett, (1765–1847), English chemist who discovered niobium
- Clayton Heathcock, American chemist
- Dudley R. Herschbach, (1932-), American chemist, 1986 Nobel Prize in Chemistry
- Charles Herty, American chemist
- Robert Havemann, (1910–1982), chemist.
- George de Hevesy, (1885–1966), chemist, recipient of the Nobel Prize in Chemistry 1943
- J. H. van ‘t Hoff, (1852–1911), Dutch physical chemist, 1901 Nobel Prize in Chemistry
- Friedrich Hoffmann, (1660–1742), physician and chemist
- Roald Hoffmann, (born 1937), Polish-born American chemist, 1981 Nobel Prize in Chemistry
- August Wilhelm von Hofmann, (1818–1892) German organic chemist
- Jaroslav Heyrovský, (1890–1967), Czech chemist, 1959 Nobel Prize in Chemistry
- Gerhard Herzberg, (1904–1999), German-Canadian chemist, 1971 Nobel Prize in Chemistry

I

- Sir Christopher Kelk Ingold (1893–1970), English chemist

J

- Frederic Joliot-Curie, (1900–1958), French chemist and physicist
- Irène Joliot-Curie, (1897–1956), French chemist and physicist

K

- Paul Karrer, (1889–1971), 1937 Nobel Prize in Chemistry

- Karl Wilhelm Gottlob Kastner, (1783–1857)
- Friedrich August Kekulé von Stradonitz, (1829–1896), German organic chemist
- Emil Knoevenagel, (1865–1921)
- Walter Kohn, (born 1923), 1998 Nobel Prize in Chemistry
- Adolph Wilhelm Hermann Kolbe, (1818–1884)
- Izaak Kolthoff, (1894–1993) the “Father of Analytical Chemistry”
- Aleksandra Kornhauser, (born 1926), chemist
- Harold Kroto, (born 1939), English chemist, 1996 Nobel Prize in Chemistry
- Richard Kuhn (1900–1967), 1938 Nobel Prize in Chemistry.

L

- Irving Langmuir, (1881–1957), chemist, physicist
- Antoine Lavoisier, (1743–1794), French pioneer chemist
- Eun Lee, (born 1946), Korean organic chemist
- Yuan T. Lee, (born 1936), winner of 1986 Nobel Prize in Chemistry
- Janez Levec, (born 1943), chemist
- Primo Levi, (1919–1987), resistance fighter, chemist and novelist
- Gilbert N. Lewis, (1875–1946), American chemist and first Dean of the Berkeley College of Chemistry
- Joseph Lister, 1st Baron Lister, (1827–1912), English surgeon
- Henri Louis le Chatelier, (1850–1936)
- Willard Libby ,(1908–1980), American chemist, winner of 1960 Nobel Prize in Chemistry
- Justus von Liebig, (1803–1873), German inventor
- H. Christopher Longuet-Higgins, British Chemist
- Martin Lowry, (1874–1936), British chemist

M

- Vladimir Vasilevich Markovnikov, (1838–1904)
- Lise Meitner, (1878–1968), physicist

- Dmitri Ivanovich Mendeleev, (1834–1907), chemist, creator of the Periodic Table of Elements
- John Mercer, (1791–1866), chemist and industrialist
- Robert Bruce Merrifield, (1921–2006), solid-phase chemist
- Lothar Meyer, (1830–1895)
- Viktor Meyer, (1848–1897), not to be confused with :
- Kurt Heinrich Meyer
- Stanley Miller (born 1930), American chemist, best known for the Miller-Urey experiment
- Luis E. Miramontes, (1925–2004), co-inventor of the combined oral contraceptive pill
- William A. Mitchell, (1911–2004), key inventor behind Pop Rocks, Tang, and Kool Whip
- Alexander Mitscherlic, (1836–1918), chemist
- Jacques Monod, (1910–1976), biochemist, winner of 1965 Nobel Prize in Physiology or Medicine
- Peter Moore, (born 1939), American biochemist, Sterling Professor of Chemistry at Yale University
- Henry Gwyn Jeffreys Moseley ,(1887-1915), English physicist, discovered Moseley's law.
- Robert S. Mulliken, (1896–1986), American physicist, chemist
-

N

- Robert Nalbandyan, (1937–2002), Armenian protein chemist
- Kyriacos Costa Nicolaou, American chemist
- Alfred Nobel, Swedish chemist

O

- George Andrew Olah, (born 1927), 1994 Nobel Prize in Chemistry
- Lars Onsager, (1903–1976), physical chemist, 1968 Nobel Prize in Chemistry
- Wilhelm Ostwald, (1853–1932), 1909 Nobel Prize in Chemistry

P

- Paracelsus, (1493–1541), alchemist
- Rudolph Pariser, (born 1923), theoretical and organic chemist

- Robert G. Parr, (born 1921), theoretical chemist
- Louis Pasteur, (1822–1895), French biochemist
- Linus Pauling, (1901–1994), Nobel Prizes in chemistry and peace
- William Perkin, (1838–1907) British organic chemist and inventor of mauveine (dye)
- John A. Pople, (1925–2004), theoretical chemist, 1998 Nobel Prize in Chemistry
- Roy J. Plunkett, (1910–1994), discoverer of Teflon
- Fritz Pregl, (1869–1930), chemist,1923 Nobel Prize in Chemistry
- Vladimir Prelog, (1906–1998), 1975 Nobel Prize in Chemistry
- Joseph Priestley, (1733–1804)
- Ilya Prigogine, (1917–2003), 1977 Nobel Prize in Chemistry
- John Charles Polanyi, (born 1929), Canadian chemist, 1986 Nobel Prize in Chemistry

Q

- Ğilem Qamay (1901–1970), Soviet chemist

R

- William Ramsay, (born 1852), Scottish chemist
- Henry Rapoport, American chemist, UC Berkeley
- Rhazes (Razi), (865–925)
- Julius Rebek, chemist
- Marij Rebek, chemist
- Henri Victor Regnault, (1810–1878), French chemist and physicist
- Tadeus Reichstein, (1897–1996), chemist, 1950 Nobel Prize in Physiology or Medicine
- Stuart A. Rice, (born 1932), physical chemist
- Ellen Swallow Richards, (1842–1911), industrial and environmental chemist
- Jeremias Benjamin Richter, (1762–1807), German chemist
- H. M. Rouell, (1718–1779)
- Leopold Ruzicka (Lavoslav Ružička) , (1887–1976), 1939 Nobel Prize in Chemistry

S

- Paul Sabatier, (1854–1941), 1912 Nobel Prize in Chemistry, corecipient
- Maks Samec, (1844–1889), Slovenian chemist.
- Carl Wilhelm Scheele, (1742–1786), Swedish 18th century chemist, discovered numerous elements
- Stuart L. Schreiber, (born 1956), American chemist, a pioneer in a field of chemical biology
- Richard R. Schrock, (born 1945), 2005 Nobel Prize in Chemistry
- Glenn T. Seaborg, (1912–1999), 1951 Nobel Prize in Chemistry
- Nils Gabriel Sefström, (1787–1845), chemist.
- Francesco Selmi, (1817–1881), Italian chemist
- Nikolay Nikolayevich Semyonov, (1896–1986), physicist and chemist, 1956 Nobel Prize in Chemistry
- Israel Shahak, (1933–2001)
- K. Barry Sharpless, (born 1941), 2001 Nobel Prize in Chemistry
- Patsy O. Sherman (born 1930), 12 US Patents
- Alexander Shulgin, (born 1925), Pioneer researcher in Psychopharmacology and Entheogens
- Peter Schultz, American chemist
- Oktay Sinanoglu, (born 1935), Turkish chemist
- S.P.L. Sørensen, (1868–1939), Danish chemist
- Frederick Soddy, (1877–1956), British chemist, 1921 Nobel Prize in Chemistry
- Wendell Meredith Stanley, (1904–1971), 1946 Nobel Prize in Chemistry
- Branko Stanovnik, (born 1938), chemist
- Hermann Staudinger, (1881–1965), polymer chemist, 1953 Nobel Prize in Chemistry
- Alfred Stock, (1876–1946)
- Fraser Stoddart, (born 1945), Scottish chemist, a pioneer in the field of the mechanical bond
- Theodor Svedberg, (1884–1971), 1926 Nobel Prize in Chemistry
- Gilbert Stork

T

- Richard Taylor, (1965-), Professor of Organic Chemistry, University of York.
- Henry Taube, (born 1915), 1983 Nobel Prize in Chemistry
- Miha Tisler, (born 1926), chemist.

U

- Harold Clayton Urey, (1893–1981), 1934 Nobel Prize in Chemistry.

V

- Lauri Vaska, (born 1925), Estonian/American chemist.
- Artturi Ilmari Virtanen, (1895–1973), chemist, Nobel Prize laureate
- Alessandro Volta, (1745–1827), electrochemist, Invented the Voltaic Cell

W

- Johannes Diderik van der Waals, (1837–1923)
- John E. Walker, (1941–), 1997 Nobel Prize in Chemistry
- Alfred Werner, (1866–1919), 1913 Nobel Prize in Chemistry
- George Whitesides, American chemist
- Heinrich Otto Wieland, (1877–1957) German chemist 1927 Nobel Prize in Chemistry
- Harvey W. Wiley, (1844–1930), US chemist, Pure food & drug advocate
- Sir Geoffrey Wilkinson, (1921–1996), 1973 Nobel Prize in Chemistry
- Friedrich Wöhler, (1800–1882), German chemist
- William Hyde Wollaston, (1766–1828), English chemist
- Robert B. Woodward (1917–1979), 1965 Nobel Prize in Chemistry
- Kurt Wüthrich, (born 1938), 2002 Nobel Prize in Chemistry
- Charles-Adolphe Wurtz, (1817–1884)

X

- Xiaoliang Sunney Xie, (born 1962), Chinese chemist at Harvard University. Famous for his pioneering work in Single Molecule Microscopy and CARS (Coherent Anti-Stokes Raman Spectroscopy) microscopy.

Y

- Sabir Yunusov, (1909–1995), Soviet chemist (alkaloids)

Z

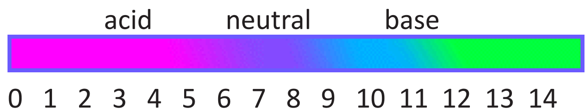
- Ahmed H. Zewail (born 1946), Egyptian, 1999 Nobel Prize in Chemistry for his work on femtochemistry.

Teacher’s Notes for Experiments on Acids and Bases

Upper Elementary

To Make Indicators

Cabbage Juice is an indicator of pH. Although it can’t be used to determine exact pH, it can distinguish between acid (pH of 0 to 6), neutral (pH near 7), and base (pH of 8 to 14).



- If the indicator turns the solution red or pink, the solution is an acid.
- A purple solution indicates that it is neutral, neither an acid nor a base.
- If the indicator turns the solution blue or green, the solution is a base.

1. CHOP one large red cabbage into small pieces. **Note:** Blackberries, red onions, or even hibiscus flowers can be used as a substitute.
2. SIMMER the cabbage pieces until the water turns a deep shade of purple.
3. ALLOW the water to cool.
4. REFRIGERATE when not in use.

Phenolphthalein Testing Solution, a clear solution, turns pink when added to a base. (Experiment #2)

1. Finely CRUSH a laxative such as Ex-Lax.
2. ADD laxative powder to rubbing alcohol in a sealable jar.
3. SHAKE vigorously.
4. LABEL the jar.

Mystery Solutions for Experiments #1 and #2

500 mL water	500 mL water + 500 mL sugar	500 mL water + 500 mL baking soda
500 mL vinegar	500 mL water + 50 mL milk of magnesia	250 mL lemon juice
500 mL water + 125 mL salt	500 mL of tonic water	

Mix up and label the mystery solutions so you know what they are. When the children are doing the experiment, pour quantities into **unmarked** containers.

Experiment #1

Students will understand the concepts of categorizing and sorting. This is essential in reinforcing the concepts of physical characteristics and chemical characteristics. Remember that the concept you want to have students understand is that physical changes allow the substance to maintain its original characteristics. However, chemical changes create a new substance that has new characteristics and sometimes new physical characteristics.

Experiment #2

The cabbage juice indicator will detect acids and bases, by turning pink with acids, remaining purple with neutrals, and blue or green with bases.

Experiment #3

pH paper is made from lichen, a plant material that is sensitive to acids. Acids when placed in water, give a pH of less than 7. The definition of an acid is a compound that donates a hydrogen ion to a base. PH stands for the French term *pouvoir hydrogene* which may be thought of in English as hydrogen power.

Experiment # 4

Since the “ink” is an acid, and dissolved in water, it “disappears” when dry, but “reappears” when sprayed with indicator.

Experiment #5

Soaps are alkaline so therefore work well with acidic particles. For this reason the water with the baking soda will work best, followed by the club soda. The bubbles in the club soda help to lift the stain but may not affect it at all. The vinegar will not help lift the stain at all.

Experiment #6

Often the name-brand products we buy are more expensive because of the cost of advertising. While different brands may yield different results, generally it is not more cost effective to buy the name-brand.

Experiment #7

Acid rain has been a problem for many years. It came to the forefront as a result of air pollution and it continues to be a problem especially when it comes to preserving artifacts that have been around since ancient times. Marble is especially vulnerable to acid rain. In ecological terms, many of the lakes and the life that lives in those lakes are particularly vulnerable to acid rain.

The lakes that contain carbonated rocks tend to have their acidity level changed less than those that contain non-carbonated rocks.

Although this experiment is designed to take place in the classroom, it can be taken outdoors and students can visit different lakes while they take samples and measure acidity levels.

The skills that you are trying to reinforce in this lab are observation, recording, and investigative learning. Try to get the students to observe what is around the lake and the land formations that make the lake. Many students will focus solely on the lake and ignore what is around them.

Since carbonate minerals such as limestone or marble will react with the acid rain, they will tend to neutralize it. On the other hand, lakes that do not have these minerals near them will be "flooded" with acid rain thus changing the acidity level of the water.

The reaction formula is as follows:

$$CaCO_{3\,(s)} + 2H^{+}_{(aq)} \rightarrow Ca^{2+(aq)} + H_2O + CO_{2(g)}$$

$CaCO_3$ which is readily found in marble or limestone will react with the Hydrogen in acid rain (H^+), this will result in calcium (Ca^{2+}), water (H_2O) and carbon dioxide (CO_2) which is a gas.

The picture on this lab sheet shows the results that acid rain has on the plants that surround a lake.

Experiment #8

The main purpose of this lab is to find out the color variations of different plant extracts under acidic or basic conditions.

For hundreds of years, chemists have used natural color indicators to determine acid or basic conditions. Long before litmus paper was invented plant extracts were used as indicators. Today we are mostly familiar with the red cabbage as a natural indicator. However, almost any highly-colored fruit or vegetable or flower will act as an acid-base indicator.

SAFETY NOTE:

Make sure your students have chemical splash goggles available. Ammonia and its vapors can irritate or damage the eyes. Use ammonia only in a well-ventilated area. Should contact with the eyes occur, rinse with water for 15 minutes and seek medical attention. If you have any students who wear contact lenses, make sure that they are taken off during the time work is performed with ammonia.

From the list below, decide which vegetables, fruits, or flowers you want to use in order to make your indicators. Squash or rip up berries, petals or stems and place them in a zip-lock bag. Add enough hot water so that your plant material is completely soaked. Seal the bag and knead it. Make sure you rub the contents together so that the plant dyes are released. Once that is completed, make a small opening in your bag so that the juice can come out, and pour it in a jar. Keep the plant material in the bag.

Roses, violets, primroses, hydrangeas, cherries, beets, blueberries, turnip skins, plum skins, radish skins, rhubarb skins, red grapes, red wine, or grape juice concentrate.

To make the baking soda solution, mix 1 tablespoon of baking soda to 1 cup of water. Stir the contents until they are completely dissolved.

Experiment #9

Having the right pH is very important in growing plants. Under normal conditions, soils have a pH between 4.5 and 8.5. On the lower end, only a few plants can tolerate acidic soils. Likewise, soils over 7.5 tend to be too alkaline or "sweet" for most plants. The majority of crops, gardens, and flower beds have a pH of around 6.5 to 7.

Your local hardware store or garden center has kits that measure pH levels of the soil. However, if you have litmus paper in your classroom, feel free to use that as well.

Preparation:

It is important that you remove the CO_2 from the water you will use in this experiment. If you do not do this, then the CO_2 that will be present will lower the pH level and the results you get will not be accurate. To do this take the distilled water and boil it. This removes the CO_2 gas which is in the solution. Once you have boiled the water, store it in a sealed container in order to keep out the CO_2.

Experiment #10

Acids react with carbonate compounds to produce salt, water, and carbon dioxide. How vigorously a reaction is depends on the intensity of the base and acid. In this experiment, your students will be using a rather mild acid such as the acetic acid found in vinegar. The acid will be reacting with the calcium carbonate, $CaCO_{3,}$ that is found in the egg shell.

The reaction looks as follows:

$$CaCo_{3(solid)} + 2HC_2H_3O_{2(aq)} \rightarrow Ca(C_2H_3O_2)_{2(aq)} + H_2O + CO_{2(gas)}$$

If this experiment is done correctly the egg shells will disappear and the egg will be left inside its membrane. Acetic acid is not strong enough to harm the egg membrane. The students can touch the eggs, but make sure they are careful not to break the membrane.

Experiment #11

SAFETY NOTE:

Make sure your students have chemical splash goggles available.

Alcohol vapors can catch on fire. Make sure your students do not breathe or have their face over the beaker they are heating.

Soap is made from fats and alkaline solutions. However, there are many kinds of fats, both animal and vegetable. Although animal fats tend to be solid at room temperature, most plant fat is liquid. When it comes to making soap though, any kind of fat will do!

Alkaline solutions all contain a metal and a hydroxide ion. The most common bases are those produced by the reaction of a group I metal plus water. These are water-soluble and can be used to make extremely strong solutions. Lye or drain cleaner is the most common alkali compounds that can be easily found and used.

Up until to about 100 years ago, most people made their own soap. To do this they often used household waste products such as solid animal fats that were left over from cooking. To this they would add a potash solution from wood ashes.

Making soap was long and hard work. First the fat had to be ***rendered***, that is melted and filtered to remove any non-fat solids. Then the potash solution was added to the hot fat. Since water and oil do not mix, this mixture had to be continuously stirred and heated sufficiently to keep the fat melted. Slowly a chemical reaction called ***soaponfication*** would take place between the fat and the hydroxide which resulted in a liquid soap. When the fat and water no longer separated, the mixture was allowed to cool. At this point, salt [sodium chloride] was added to separate the soap from the excess water. The soap came to the top, was skimmed off, and placed in wooden molds to cure. It was often aged many months to allow the reaction between the fat and hydroxide to run to completion. Poorly-made soap could contain excess alkali and could dry and chap people's skin.

Egg-samples of Acids

Materials

- Fresh large uncooked eggs
- 500 mL of vinegar
- Large clear container
- Bucket of water
- Clear plastic cups

Procedure

1. Show the students the eggs and the vinegar. Let them know that they will be observing the reaction that an acid such as the vinegar (acetic acid) will have on the calcium carbonate that is found in the eggshell. Inform them that the reaction is slow and it will take about 3 days.
2. Place 3 large eggs into the large clear container and cover them with vinegar. Place a fourth egg in a small plastic container and cover it with water. This will be your control.
3. Observe the containers several times during the day and note your observations.
4. At the end of the 3rd day, rinse your eggs in the bucket of water and gently rub them to remove the remaining shell.
5. Carefully touch the eggs without breaking the membrane.

Observation

Record your observation.

1. What happened to the eggs during the three days they were in the vinegar?
2. How do you know that a chemical reaction was taking place?

Cleaning Up

Materials

- Ring with ring stand and a screen
- Bunsen burner or Sterno
- Stirring rod
- Beaker
- Cooking oil, linseed oil or shortening (fat)
- Ethyl alcohol
- 6M sodium hydroxide solution
- Saturated salt solution

Procedure

1. Place 10 mL of fat in the beaker. If you are using shortening make sure that it is melted.
2. Add 10 mL of alcohol to the beaker.
3. Add 5 mL of sodium hydroxide solution to the beaker.
4. GENTLY heat the solution while you constantly stir. CAUTION: if your flame is too high, the alcohol fuel will ignite and then the cooking oil will ignite.
5. Continue heating and stirring until you can no longer see any oil drops on the surface. The mixture will begin to froth. If this happens, continue to mix to break up the bubbles so that the mixture does not overflow.
6. Allow the mixture to cool.
7. Once cool, add 20 mL of hot water to the beaker and stir.
8. Add 25 mL of salt solution. DO NOT STIR
9. Allow the beaker to stand for 5 minutes.
10. Skim the soap curds from the top of the liquid and place them in your hand and shape them into the shape of a soap bar.

Observation

Record your observation. (Allow the soap to harden overnight.)

- What is the smell of the soap?
- Can you wash your hands with the soap you have just made?
- Do you think it cleans your hands well enough?
- Read the ingredients on a bar of soap that you bought from the store. How do they compare to what you used?
- Do you think different kinds of fat make a difference in how well the soap works?

Acid, Base, or Neutral Solutions

Name of solution	Prediction acid, base, neutral	What happened to the paper? red / blue	Actual acid, base, neutral
1. ________			
2. ________			
3. ________			
4. ________			
5. ________			
6. ________			
7. ________			
8. ________			
9. ________			
10. ________			

Conclusion

Acid, Base, or Neutral Solutions

Name of solution	Prediction acid, base, neutral	What happened to the paper? red / blue	Actual acid, base, neutral
1. ________			
2. ________			
3. ________			
4. ________			
5. ________			
6. ________			
7. ________			
8. ________			
9. ________			
10. ________			

Conclusion

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Teacher's Notes for Experiments on Physical Changes

Upper Elementary

Experiment #1

Whether a material expands or contracts when it is warmed depends on its entropy. The entropy of a specific substance is a measurement of the "organization" of the molecules. When they are disordered, the entropy is high. Heating the rubber band causes middle sections of the molecules to become excited and "wiggle", much like a string of beads. If you wiggle the middle of the beads, the ends of the string come closer together. In this experiment the molecules of rubber become shorter as the rubber is heated, causing the stretched rubber band to contract.

Experiment #2

There is no chemical change since no bonds were broken or formed at a molecular level. The weight of the sugar and salt solutions should be identical. This is a physical change since the sugar or salt could be removed from the water by evaporation or boiling.

Experiment #3

The idea behind this experiment is to show the students that there was a chemical change that took place. Not only did the appearance of the substances changes but so do their chemical characteristics. The acid reacted with the iron found in the steel wool. Bonds were broken in order for the iron acetate to be formed. New bonds were formed when the green blob appears, once you add the ammonia.

Experiment #4

Matter can exist in three forms: solid, liquid, and gas. In this activity, we want the students to understand the relationship that exists among the atoms of each of these three forms.

In solids, the atoms are highly ordered and packed tightly next to each other. Solids maintain their form. Liquids have their atoms ordered, but are not held together as tightly as those of the solid. This is why liquids take the form of whatever container they are in. This is also the reason why liquids are able to flow. (An interesting sidebar to this is the concept that glass is a liquid even in its cooled state. Glass is capable of "flowing", however, it flows so slowly that that its movement is insignificant). Gases have no order in the way that their molecules move or exist.

This experiment is good introduction to the concept of melting point and boiling point. Students should discover that the melting point is the temperature at which a solid turns to liquid. On the other hand the temperature at which a liquid turns to vapor is called the boiling point.

When trying to discover these concepts, probe the students to make careful observations. A very interesting phenomenon occurs when changing states. The temperature will not rise until all of the substance from the initial state is in the new state. Therefore, when liquid water begins to boil (100 degrees Celsius) it will remain at that temperature until all of the water has changed to gas.

Experiment #5

Water appears dirty because of the particles that are found suspended in it. These particles can easily be removed from the water by the use of a filter. The key idea behind this experiment is for the students to understand that there is an order in the way that particles are removed. The largest particles are removed first, followed by the second largest, and so on.

In this experiment, it is important for the students to understand that all the changes which are taking place are physical changes. There are no chemical changes taking place here. Furthermore, this type of filtration does not remove chemical contaminants that are found in the water; neither will it remove microscopic particles which remain suspended.

NOTE: **Stress that no one under any circumstances should try to drink the water after it has been filtered.**

Experiment #6

Liquid starch and glue go through a chemical reaction and have as a result the creation of a totally different substance. What the students will observe here is indeed a chemical reaction. The new substance will not only have a different appearance but it will also have different chemical characteristics than either one of the two substances that created it.

Most students have experienced this type of goop creation. However, there is great mystery in this new substance. Chemists refer to goop as a "non-newtonian" liquid. The reason for this name is because this substance has qualities that are both liquid and solid. The suspended particles that are found in goop act one way when they are under stress or pressure and a different way when they are allowed to flow freely.

NOTE: Make sure that the liquid starch is added to the glue and water mixture very slowly. If the goop is too sticky or runny then add more starch and continue to mix.

Although the goop is nontoxic and is completely safe, students should refrain from eating it.

Experiment #7

The process that the students will be observing is definitely a chemical change. Copper is oxidized in the presence of air. This process is accelerated by the presence of an acid, in this case the vinegar. Oxidation is a process where one substance combines with oxygen. The most common form is the burning of something. Yet, another form of oxidation that everybody is familiar with is rust.

The chemical reaction that is going to be taking place in this experiment is described by the following formula:

$$\underset{\text{Copper}}{Cu_{(solid)}} + \underset{\text{Oxygen}}{O_{2(gas)}} \rightarrow \underset{\text{black copper oxide}}{CuO_{(solid)}}$$

The reaction that is shown here is not the one that produces the green color that copper usually has and we are familiar with. At first, Copper II oxide is black. The students should be able to see this within one hour after they have begun the experiment. Copper II oxide is not a stable compound, so it undergoes other reactions very easily. In this case, it will react with the vinegar which is an acid. It is this reaction that produces the green copper II hydroxide that will be visible on the penny.

Tips:

- ✓ Try placing the penny in different positions so that students can see the consistency of the experiment.
- ✓ Make sure that the cotton balls are wet all the way. This will cause the reaction to take place at a much faster rate.
- ✓ If you want to achieve a tight seal around the jar and the lid, place excess amounts of vinegar in the lid.
- ✓ Do not let any of the condensed vinegar that will be on the jar or any of the vinegar in the lid fall on the penny. The copper hydroxide is basic and the vinegar is an acid. If the vinegar comes in contact with the green copper hydroxide, it will neutralize it thus restoring the original shine on the penny.

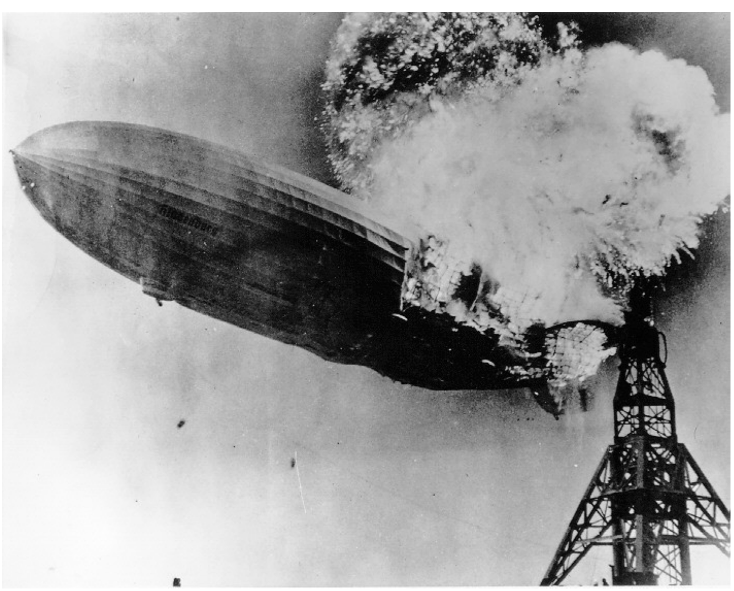
Experiment #8

This experiment is a decomposition reaction. The heat from the flame will provide the energy for the chemical decomposition of the baking soda. In a decomposition reaction, you start with one product and you end up with more. The chemical reaction for the decomposition of baking soda is as follows:

$$\underbrace{2NaHCO_{3(solid)}}_{\text{Baking soda}} \rightarrow \underbrace{CO_{2(gas)}}_{\text{carbon dioxide}} + \underbrace{Na_2CO_{3(solid)}}_{\text{sodium carbonate}} + \underbrace{H_2O_{(liquid)}}_{\text{water}}$$

The glowing splint that the students will be using is to determine the type of gas that is produced. There are three types of gases that they are testing for; hydrogen, oxygen, and carbon dioxide.

If the hydrogen is present, then a small popping sound will be heard as the burning splint ignites the gas. If oxygen is present, then the glowing splint should burst into flames and burn brightly. On the other hand, if carbon dioxide is present then the glow on the splint will immediately go out. In order to visualize these gases in the presence of fire, give your students examples of how they are used.



In 1937 the Hindenberg, a passenger-carrying dirigible, explodes. The picture to the left shows the explosion that took place at that time.

The aircrafts of that period were filled with helium. Helium is much lighter than air, therefore, it allowed the blimp to float. However, hydrogen is extremely flammable as they soon found out. Everyone in the Hindenberg accident was killed.

On January 27, 1967, the three astronauts who were to man the Apollo I mission, Gus Grissom, Edward Higgins White, and Roger Chaffee were killed in the capsule of the Apollo rocket. The cause was believed to be a spark, which ignited the pure oxygen atmosphere that was inside the capsule.

Many of the fire extinguishers that are available today are made from carbon dioxide. Carbon dioxide is heavier than air, therefore, it does not escape through the mouth of the test tube.

Experiment #9-10

Before modern chemistry, came alchemy. It was because of the research that alchemists conducted that much of our knowledge of chemistry was developed.

Alchemy began in Egypt, Persia, and Mesopotamia. Records indicate that in Alexandria around 300 B.C., many alchemists conducted their work and, from there, alchemy spread to India, China and the rest of Europe. Much of the equipment that we use today in the chemistry laboratory was developed by alchemists. In the Middle ages, alchemists were hired by kings and nobles in order to figure out a way to transmute common metals into gold. The reason behind this was to increase the wealth of those who sponsored them. As a result, many alchemists conducted their experiments in secret and kept careful records using secret symbols, for obvious reasons. It is because of this that many alchemists were often thought of as magicians, mystics, and frauds.

Teacher's Notes for Experiments on States of Matter

Upper Elementary

Introduction

Experiments 1,2,3

All of these experiments are to lead the children to the idea that chemistry is based on inference. Scientists are unable to see at the molecular level, so they must infer, based on cause and effect relationships.

States of Matter

Experiment 1

This experiment is demonstrating that not only changes in heat will modify solids, but also pressure. This is significant in rock formation as well.

Experiment 2

The molecules in a solid are tightly knit together. As the temperature changes in a solid to a liquid, those bonds begin to change, and the solid changes to a liquid. Not all substances have the same melting point.

Experiment 3

Solids take up less space than a liquid since the molecules are more tightly packed together.

Experiment 4

Water is unusual. As it freezes, the water expands and becomes less dense. In the case of water, the bonds between the molecules in the solid are less tightly packed than when it is a liquid. Therefore, it expands when it is a solid. This is why water pipes often crack in the winter, but the flow of water does not happen until the water begins to melt!

Experiment 5

This experiment introduces the children to the concept of a control. They will be comparing the freezing point of a pure substance (straight water) to various solutes of different strengths. This procedure is often used in laboratories to decide the appropriate strength needed, as in laundry detergents, insecticides, etc.

Experiment 6

The smaller the surface area, the quicker a solute will dissolve. For this reason, super fine sugar is often used to sweeten cold drinks.

Experiment 7

The boiling point of a liquid is different than the melting point. Since liquids can change states at any time depending on the conditions they are found in, it is important that students understand the difference between boiling point and melting point.

Once a liquid has reached its boiling point, students should realize that the temperature no longer continues to rise. It is interesting to use a graph to demonstrate how the temperature changes. Once boiling point has been reached, the students will see a flat line being reached in the graph and no matter how much longer they continue to boil the liquid, the line will stay the same.

Different liquids have different boiling points. One of the more interesting experiments is to add alcohol into the water and observe how the boiling temperature of the liquid changes.

Exercise caution when dealing with alcohol and open flames.

Experiment 8

Students will observe that just as solids have different densities so do liquids. The heavier liquids (or those whose molecules are closer together) will settle first and so on.

Although this experiment has the students add each layer carefully, allow the students to see what happens if they mix the liquids. Note that there will be a definite separation of the various liquids; however, some droplets of a lighter liquid might become trapped inside the heavier liquids. Build on that concept, but try to let the students understand the idea of density and what makes a substance denser than another.

Experiment 9

As the water temperature of water decreases the molecules begin to assume a position that will ultimately match that of its crystalline structure. Once water has reached 0 degrees Celsius, then water becomes ice and the water molecules have achieved a crystalline state. At that particular point, the molecules have a solid state. Students will come to realize that the lower the temperature the more difficult it is for the dye to move around the water because the water molecules do not move as fast. As the temperature of water rises so does the movement of the molecules, thus allowing the dye molecules to move faster and causing the water to assume the color faster.

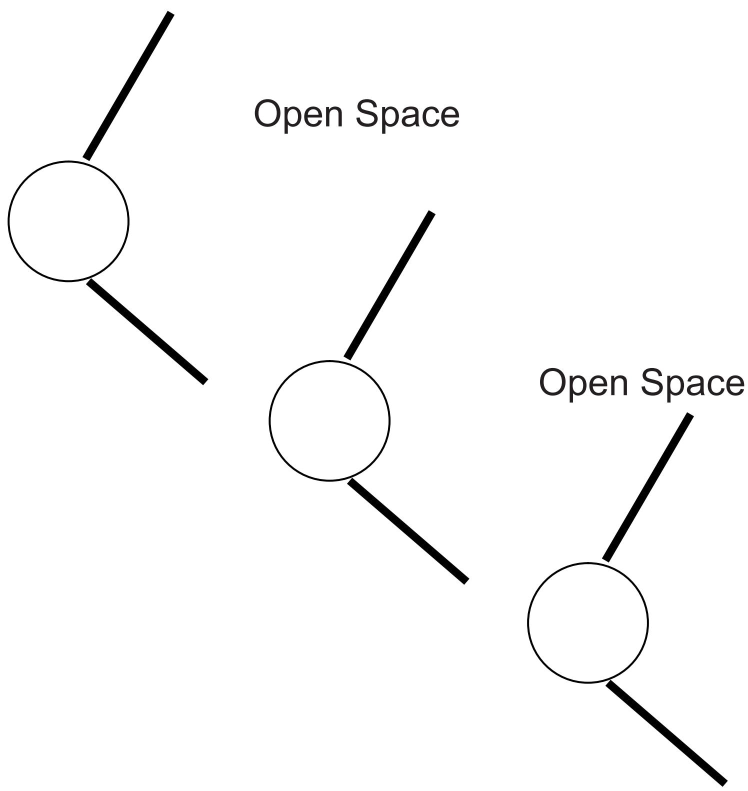
Experiment 10

The drops of colored ink will sink to the bottom and remain there for a while. When the students come back after 24 hours, the water will be completely infused with the ink and will have an even-colored look.

The atoms and molecules of substances are constantly in motion. As the ink droplets enter the water, they are quickly pushed to the bottom of the jar and retain their shape to a certain extent. However, given enough time the ink will be spread around the water because the water molecules themselves will begin pushing and moving the ink molecules.

Experiment 11

As the water molecules come together, they form pockets, or open spaces between them.



Because the alcohol molecules are smaller, they are able to fit inside the open spaces. Although you have added a total of 400 mL of liquid into the measuring jar, the combined volume of the two liquids will not be seen that way. The idea is to show students that liquids have molecules that move much more freely than solids do.

Experiment 12

Since molecules in a gas are further apart than they would be in liquid form or solid form, they are able to take up more space. One of the characteristics of gas is that the molecules will move around to occupy all of the space they are given.

In this experiment, you will be mixing bicarbonate of soda and vinegar, which will release carbon dioxide. Carbon dioxide is a gas and it will behave as a gas by having its molecules expand to fill all available space.

Experiment 13

During the 18th century, many scientists conducted numerous experiments in order to find out what it is that a flame needs in order to keep burning. The experiment here is a classic one and very much enjoyed by students.

You will need to affix the candle in the shallow bowl for the children. To do this simply light the candle and allow a few drops of hot wax to fall to the bottom of the plate. Once you have done that and the dropped wax is still hot place the bottom of the candle on the melted wax and allow it to solidify. This will keep the candle in place as the children begin their experiment. **Note. Hot wax can cause burns if it comes in contact with the skin. It is strongly advised that you oversee this procedure or actually perform it for the students.**

The idea behind this experiment is to show the students that fire needs oxygen in order to keep burning. As the candle burns it uses up the trapped oxygen that is found in the jar that is over it. Once the oxygen is entirely used up, the candle no longer burns.

You can also talk about what elements are formed as the candle melts and burns. In this case, as the candle wax melts it releases carbon and hydrogen. The hydrogen combines with remaining oxygen and soon there will be no more oxygen available in the jar and the flame goes out.

Experiment 14

The idea behind this experiment is to show kids that gases do have a mass. In this particular case the gas that is given off from the combination of bicarbonate of soda and vinegar is carbon dioxide. Carbon dioxide is heavier than air. A balloon that is filled with carbon dioxide will never rise.

Because CO_2 happens to be heavier than air it can actually be “poured” into the plastic bag and therefore will cause the balance to tilt.

Experiment 15

When fire extinguishers were first invented the theory behind them was to produce carbon dioxide. Since carbon dioxide is heavier than air which contains oxygen, when you would aim the fire extinguisher towards the base of the fire, the CO_2 would take the place of the oxygen displacing it further up.

The idea behind this experiment is to show kids that a fire needs oxygen in order to burn.

Experiment 16

As air molecules become heated their energy increases which in turn translates to the fact molecules begin to move faster. Because gas molecules will expand to take up all available space, they will in turn begin moving faster bumping into the walls of the bottle and the balloon. This, in turn, causes the balloon to inflate. Since hot air is lighter than cold air the number of molecules in the balloon will increase, as compared to those found in the bottle.

Modern-day hot air balloons are based on this theory. Heating the air in the balloon cause it to float into the air and thus rising. When the handler wants to bring the balloon back down to earth, they turn the fire off causing the air to cool down, and thus bring the balloon down.

Experiment 17

No two substances with mass can occupy the same space. Since the nozzle of the funnel is sealed around the bottle, it prevents air from entering or exiting the bottle. The only opening will be through the funnel. However, when the funnel is filled up with water, the air that is inside the bottle has no way of escaping. It in turn pushes up from the bottom. Furthermore, the water molecules at the entrance of the nozzle are held together by surface tension. Unless there is a break, the two substances will remain where they are.

The straw acts as this break. The minute that it breaks through the water it allows the air to exit through it. Since water is heavier than air, it will take its place inside the bottle. The air, in turn, will be displaced and exit through the straw.

Notes

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