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Bite-size Information

Main features

Big Picture Science

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Chemistry Experiments

Help students fit experiments into their concept framework

When students understand and apply chemistry concepts, they are able to make accurate predictions. Chemistry experiments become more than a series of interesting but random experiences.

The purpose of having students do chemistry experiments is to allow them to personally experience matter and its properties and to see concepts in action. This is a vital part of their construction of chemistry knowledge.

Many chemistry experiment books are collections of interesting activities with no particular order. Experiments done in an order that follows a concept progression can help students achieve a greater understanding. There is no one "right" order to an experiment sequence, but there is a general direction to take. Before students can fully appreciate a chemical reaction, they need to be able describe the properties of the reactants, since these will change when a chemical reaction takes place. They should understand the difference between mixtures and pure substances, and know with which they are working. It can be difficult to determine the properties of substances in mixtures and therefore to follow the changes.

Start with the properties of matter, including solids, liquids and gases. Solids and liquids are good subjects for lower elementary and up. You can show the compressibility of air (see page 2) and compare gas densities at all levels. The gases you can easily generate and study are carbon dioxide (CO_2), oxygen (O_2), and hydrogen (H_2). You can show how with these gases affect burning. Does the gas support combustion (O_2), stop combustion (CO_2), or combust (H_2)? It is probably best to show the combustion-related properties as demonstrations until upper elementary level or later.

Separating mixtures is another fundamental chemical activity. These experiments can be grouped according to the property used for the separation (solubility, density, magnetism, etc.). Next come observations of chemical reactions. For beginning students, ask how the properties of the reactants have changed. Write a simple description (starch + iodine results in a dark purple color; iron + oxygen + water makes rust). For advanced students (usually at middle school level), help them write an equation for the reaction using chemical symbols and perhaps discuss what has happened with the electrons (i.e., iron lost electrons and oxygen gained them).

In the following pages I have listed categories and examples of experiments to build chemistry concepts. To save space, I have used a selection of experiment books (see page 6) to which I refer by letter.

Big Picture News

There are two new products from Big Picture Science this month. "Teacher's Guide to the Fungus Kingdom" is a nine-page booklet with a seven-page illustrated wall chart. It costs $9.

The second is the set, "Discovering the Periodic Table". It includes a seven-page teacher's booklet, 92 double-sided element cards, and 11 group cards. It costs $10. To order either item, see the enclosed order blank.

The American Chemical Society has an excellent experiment resource. It is a magazine called WonderScience. There is also a book, *The Best of WonderScience*. Call 1-800-209-0423 to order.

What topics would you like to see in future Big Picture Science News? Please send your ideas.

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Experiments to build chemistry concepts (Note: the letter refers to the books listed on page 6.)

Matter and its properties

Air is matter: See B) p. 12-15. F) p. 15 K) p. 14, 20, 22.
Comparing compressibility of liquids and gases. Use a large, clean syringe without a needle. Make sure it has not been used medically. The syringes sold for giving medicine to babies will work. Fill the syringe with air. Cap the end or hold your finger over it. Try to compress the air. You should be able to press the plunger down, since gases are compressible. The increased pressure will cause the plunger to spring back out. Next fill the syringe with water, completely excluding the air. Try to compress the water. Liquids do not compress, so you should not be able to press the plunger down at all.

Describing the properties of liquids

Make a collection of liquids for your students. Use sturdy glass bottles with leak-proof lids or large, screw-cap test tubes. Juice bottles with reclosable caps work well. Fill the container about 1/3 full to allow room to see how the liquid flows. Make the containers all the same. You may want to paint the lids to match. Label each lid with the name of the liquid. For some exercises, you may want to use code numbers and cover the labels on the containers. Always use liquids that are not hazardous if spilled! Avoid perishable liquids for this set or you may collect microorganisms you don't want. Below are properties, their definitions, and some liquids that can be used as examples.

- **Beginning properties**

Viscosity – a measure of the liquid's resistance to flow. Beginners can estimate this by the time it takes for the liquid to flow to the top of the bottle when it is tilted. For older students, see J) p. 18 for a more quantitative approach.

Highly viscous – corn syrup; concentrated sugar solutions; liquid starch; white glue
Medium to high viscosity – transparent, colorless shampoo; dishwashing liquid
Low viscosity – rubbing alcohol; water

Transparent, translucent, or opaque – a description of the amount and quality of light transmitted by the substance. Transparent substances transmit clear images. Translucent substances transmit light, but do not transmit the image. A cloudy fluid or wax paper is translucent. Opaque substances block light. Provide a white card with heavy black lines to hold behind the liquid. This will help the student judge whether the light or image is coming through the liquid. These terms apply to solids as well as liquids.

Transparent – water; rubbing alcohol
Translucent – concentrated salt water made with table salt (this has fine sand in it), clay in water
Opaque – some shampoos; tempera paint; white glue

Color – Use food color in water or rubbing alcohol to produce an array of colors and intensities.

Colored liquids – shampoos and detergents, tempera paints
Colorless liquid – pure water

Give the students cards with a complete description of a liquid and have them find the bottle. They may want to write some of these for their friends to guess. Example: an opaque, green liquid with medium viscosity or a transparent, colorless liquid with high viscosity.

- **Advanced properties**

Miscible or immiscible? – Do two liquids dissolve in each other or remain unmixed? Provide the two liquids and a container to combine and stir them. Color the water (or one of the liquids) to see what happens more clearly.

Immiscible – water and oil
Miscible – water and alcohol

Surface tension – a measure of the attraction of molecules in the liquid for each other. Will the liquid foam when shaken? How long does the foam last? Detergents and soaps lower the surface tension and allow the bubbles to last longer. Another test of surface tension is to fill a small container such as a medicine cup with the liquid and add more drops on top. If the liquid mounds up, it has high surface tension. If it overflows, it has low surface tension. See C) p. 13. Lastly, sprinkle pepper on the surface of the liquid. High surface tension liquids hold the pepper on the surface. It sinks in low surface tension ones.

High surface tension – water
Lower surface tension – dilute detergent or shampoo, oil, alcohol

Volatility – How easily does the liquid evaporate? Provide a container and a cotton swab for sampling of each test liquid. Have the student put a streak of the liquid on the back of her/his hand. Add streaks of the other liquids nearby on the same hand. The coldest streak is the most volatile liquid. Have the student predict which liquid will evaporate first. Have the student pour a small amount of the liquid into a shallow container and observe for a day or two to see if the prediction is correct. [NOTE: many fluids that evaporate very rapidly and feel very cold on the skin are organic solvents that are harmful to cell membranes and one's liver. Avoid things like nail polish remover on the skin.]

High volatility – rubbing alcohol (Make sure the students put only a small amount on their skin.)
Medium volatility – water
Low volatility – cooking oil

Acid, base, or neutral? – Use a plant pigment indicator or litmus paper. See B) p. 85 - 92, D) p.8, G) p.88, K) p. 190-200, J) p. 67. Explain that an indicator shows us something we cannot detect with only our senses. Although acids are sour, many of them would be harmful to taste. Almost all of our foods are a little bit acid, but we can't always taste that. Bases are bitter, but who likes bitter? This is a bad taste, perhaps because many poisons from plants are bitter.

Acids – vinegar; lemon juice; lightly colored fruit juice or Gatorade-type drinks
Bases (alkalis) – ammonia water; a solution of baking soda; solution of automatic dishwashing detergent; wood ashes in water. Strong bases are irritating to the skin, so use caution.

Is it a solvent for table salt? – Try to dissolve table salt (sodium chloride) in the liquid. Use about ½ teaspoon (2.5 ml) of salt and about 50 ml of the liquid. Solvents that dissolve table salt and other ionic compounds are polar solvents. Those that do not are non-polar solvents. See H) p.43.

Good solvent for table salt, polar solvent – water
Poor solvent for table salt, non-polar solvent – oil
Rubbing alcohol will dissolve some, but not all of the salt. See B) p. 45

Density. See B) p. 23 for a good method to compare the densities of liquids. Make a hydrometer to measure liquid densities. See J) p.126. Older students can measure the grams per milliliter.

Low density – oil
High density – corn syrup

<u>Describing the properties of solids</u>

Does a magnet attract it or not? Is it a good conductor of electricity? How well does it conduct heat? See J) p. 189 for a heat conduction experiment. Is it brittle or ductile?

Density. Weigh an object, and then use a graduated cylinder to find its volume. Sinking objects displace their volume. Find the density in grams per ml. Obviously this method will not work for water-soluble solids. If the solid floats, note that it is less dense than water.

Deformable or rigid? Can you press on the solid and have it change shape? Does it return to its previous shape or not? For a fun demonstration of an effect of these properties, use the "Happy and Unhappy Balls" from Edmunds Scientific Company (609)573-6250.

Color, texture, form. Sample questions include "Is it a powder?" and "Does it have a shiny or a matte surface?"

Solubility. Does the solid dissolve in water? In rubbing alcohol? If you have a well-ventilated work area, older students can see if a small amount of nail polish remover on a cotton swab will dissolve the solid. Supervise this activity.

Volume of a solid versus a gas. Demonstrate this with dry ice. Use a one liter graduated cylinder or a gallon jar with a three-inch layer of bubble solution in the bottom. Place the jar or cylinder in a sink or large pan. Select a piece of dry ice about golf ball size. Ask students to predict the volume of gas that this solid carbon dioxide will become. Explain that the bubbles will trap the gas and allow us to estimate the volume. Drop the dry ice in the container. The bubbles climb up and overflow the container, showing that the volume of a gas is many times the volume of the same amount of matter as a solid.

Mixtures and their separation

Separations based on the magnetic properties of the matter

- Separate a mix of small steel washers and brass washers. This example allows students to clearly see what they will be doing with smaller particles in later activities.
- Separate iron fillings from sand. Some sands have naturally occurring magnetite, a magnetic mineral.
- Separate iron fillings from sulfur powder. This mixture can be heated to show that the properties change after a chemical reaction. When the iron reacts with the sulfur, it is no longer magnetic. See Eyewitness Science Chemistry, p. 20-21.
- Separate iron particles from breakfast cereal. See H) p. 80

Separations based on the density of matter.

- Separate sand and sawdust. Just add water. Use washed sand for this and other experiments that use water.

Separations based on the solubility of matter.

- Separate sand and salt. Dissolve the salt with water, filter the mixture to remove the sand and let the water evaporate to recrystallize the salt. See B) p. 54
- Use chromatography to separate inks. See A) p. 124, C) p.17, J) p.97
- Separate iodine from water by dissolving it in mineral oil. See L) p. 13

For advanced students – use fractional distillation to separate mixtures of water and alcohol based on their differing boiling points. You will need a distillation apparatus with a thermometer to measure the temperature of the vapors.

Chemical reactions

Observe chemical and physical properties and use them to identify a substance – Experiments with white powders – Use salt (sodium chloride; try to get some without silicon dioxide or other additives), sugar (sucrose), baking soda (sodium bicarbonate), corn starch, cream of tartar (potassium tartrate), and unflavored gelatin. Start beginning students with the first four and add more for advanced students. Have students test the properties of these substances one at a time and record their results in a table. Then give them a set of "unknowns" that are labeled only with letters. See B) p. 56-60, L) p. 97.

- Test with vinegar (acetic acid) – Acids release a gas (CO_2) from baking soda.
- Test with heat – Carbon-based molecules (sugar, starch, and gelatin) turn brown or black. See L) p. 18, 71
- Test with iodine – Starch and iodine together produce a dark purple color. Use tincture of iodine (make sure it is not "decolorized") and dilute it about 1 part to 3 parts water. It should be a golden color, not dark brown.
- Test of solubility in water – Try cold water first, then hot water. Does the solubility change? If you get a transparent solution, the solute is an ionic compound or a small molecule. A cloudy suspension means that there are particles large enough to reflect light. Gravity will eventually cause the particles to settle. Gelatin is in-between. It forms a colloidal dispersion. It looks clear, but if you shine a beam of light through it in a darkened room, the large molecules reflect the light and you can see the beam. You can't see the light beam shining through a true solution.

If the substance dissolves, do the following tests:

- Test of crystal shape – Recrystallize the solute from solution and observe the shape of the crystals. Place some of the solution in a jar lid or other shallow container and allow the water to evaporate.
- Test of pH (See "Acid or base?") – baking soda is alkaline, cream of tartar is basic.

An extra challenge: Can you do tests to find if there is something in powdered sugar other than sugar?

Chemical reactions that involve oxidation (combining with oxygen)

Rusting of steel wool. Use 0000 grade steel wool from the hardware store (not soap pads). Have students describe its properties. Remind them that the properties will change after a chemical reaction. Compare a piece of dry steel wool with a piece that has been wet for a day. Ask students to determine if a chemical reaction has taken place. Has the electrical conductivity, magnetic properties, color, or form changed?

- After the students have established that a chemical reaction has taken place, ask what could have combined with the steel wool. When they conclude it is something from the air or water, try to find what it is. See B) p. 105, F) p. 55, and J) p. 21 for experiments in which steel wool is placed in a tall jar that is then inverted in a pan of water. See D) p. 12 for an experiment to determine if air is required. In this experiment, you lower the oxygen in water by boiling it. Place the iron sample in a jar and fill it totally with the boiled water, capping it tightly to exclude air.
- After students see that oxygen and water are needed for rusting, do experiments to see if you can change the rate of the reaction. See B) p. 101, J) p. 162.
- Slow combination with oxygen is corrosion (rusting in the case of iron), but rapid combination is combustion or burning. Will steel wool burn? Do this as a demonstration over a non-flammable surface. Try it before you do it in class. You will need an alcohol burner and a loose, fluffed-out piece of steel wool. Use a pair of tongs to hold the steel wool. It will burn and oxidize the surface of the fibers. Note that the result will not look like rust until the oxidized iron is wet. It will then rust rapidly. Rust is hydrated iron oxide (iron oxide with water associated).
- Other metals combine with oxygen and tarnish. For experiments with copper pennies, see G) p. 80, J) p. 163. To remove tarnish from aluminum, see L) p. 65. For silver tarnish, see A) p. 95.

Browning of fruit. An acid such as lemon juice or vitamin C can prevent this complex reaction. See K) p. 80.

Chemical reactions that release a gas. Identify the gas by its chemical properties.

- Acids with baking soda release carbon dioxide – See A) p. 13 for a gas collection apparatus.
  Testing for carbon dioxide – See A) p. 14, B) p.75, F) p. 61, J) p. 165, L) p.87, 90
  You can also show a physical property of this gas. Float soap bubbles on carbon dioxide to show that it is denser than air. Use a stoppered sink or empty aquarium. Make carbon dioxide with vinegar and baking soda or allow dry ice to sublime. Gently blow soap bubbles over the container. They should float on the denser gas.
- Hydrogen peroxide and yeast or other catalyst release oxygen – Use caution when testing for oxygen. Wooden splints from a science supply work well for this test. See B) p. 116, J) p.159, L) p.104
- Acids or bases and a metal – These reactions require care because they release hydrogen, which is flammable. Do them in small volumes as demonstrations only. See Usborne Introduction to Chemistry by Chisholm and Johnson, p. 29. You can mix the reactants in a flask and add a loose cover. Pull off the cover and quickly bring a lighted match near. Acids and zinc or strong bases and aluminum will release hydrogen. It is lighter than air and burns with a pop when you ignite it. If you make a solution of lye (sodium hydroxide, $NaOH$), remember to dissolve only a small amount at a time. A lot of heat is released when $NaOH$ dissolves. The solution is very caustic, so be careful.
- Decompose water – electrolysis of water releases hydrogen and oxygen. See A) p. 61, J) p. 94, and L) p. 101. Many experiments tell you to use table salt in the water to increase conductivity. This causes small amounts of chlorine to be released. See I) p. 33. It is safer to use washing soda (sodium carbonate).

Chemical indicators – See "Acid, base, or neutral?" above for pH indicators. For experiments on neutralizing acids and bases – See B) p. 95

- Iodine shows the presence of starch – See A) p. 131, K) p. 104-106 L) p. 27-34
- Hydrogen peroxide reveals iodine in iodized salt – See I) p. 53

Precipitation reactions – mixing two solutions results in an insoluble solid being formed. Have students describe the color of the solutions and the precipitant (the solid that comes out of solution).

- Iron tannin from iron sulfate or acetate and tea – This has a color change. See A) p. 54, I) p. 57, L) p. 74.
- Magnesium hydroxide from Epsom salt and ammonia – This forms a cloudy precipitant. See B) 78, K) p. 100.
- Iron hydroxide (which is green) from iron acetate and ammonia (which are colorless) – See B) p. 80, I) p.63, K) p. 102.
- Iron oxide (which is bluish green and will further oxidize to reddish brown) from iron acetate and hydrogen peroxide (which are colorless) – See I) p. 63.

Physical factors that affect the rate of chemical reactions – what do temperature and surface area do? See B) p. 68, F) p. 51, and G) p. 55

Heat in chemical reactions and dissolving. Endothermic reactions absorb heat and feel cool. Exothermic reactions give off heat and feel warm. There is energy involved with all chemical reactions, but often we do not notice the heat change unless we have a thermometer in the reactants or we are holding the reaction container. Sometimes the heat is so slight we cannot easily measure it.

- Dissolving Epsom salt absorbs heat – endothermic change. See F) p. 43.
- Exothermic reaction of iron oxidizing – See K) p. 182.
- Mixing yeast with hydrogen peroxide is also exothermic. See F) p.88.

Reactions with enzymes

- Gelatin and fresh pineapple juice or meat tenderizer – See F) p. 84 or J) p. 55. You can do further experiments with gelatin to find if detergents contain enzymes. This basic experiment scheme can be used to find the effects of concentration and temperature on an enzymatic reaction.
- Yeast and hydrogen peroxide – See F) p. 88.
- Laundry enzymes and egg protein – See J) p. 25 and L) p. 53.

Chemistry report forms – Provide a recording form for experiments. One of the hardest things to do is to record results when you are excited about seeing what will happen next. Students will record more data and observations with the help of a report form. Here are some items to include. 1) What question are you investigating? 2) A list of materials (which can be preprinted on the form) 3) A basic diagram or description of what you do. 4) Most importantly, have a space for the student to make a prediction about what s/he thinks will happen. 5) A place for results – a brief description of what happened. 6) Did what you predicted happen? What did you learn? 7) Basic kind of experiment – finding properties of matter, separating a mixture, identifying substances by their chemical properties, observing a change in properties after a chemical reaction, etc.

Chemistry Experiment Books (Dewey decimal cataloging at 540.78 and 507.8)

These books are in print as of Oct. 1998. LE = lower elementary, UE = upper elementary, MS = middle school.

A. Cobb, Vicki. 1985. ***Chemically Active! Experiments You Can Do at Home***. Harper Trophy: NY. ISBN 0-06-446101-7 [Good background information, uses common materials for apparatus. UE, MS]

B. Gardner, Robert. 1994. ***Science Projects About Chemistry***. Enslow Publishers, Inc., PO Box 699, Springfield, NJ 07081. ISBN 0-89490-531-7 [Well organized on a concept progression, good background information. UE, MS]

C. Gardner, Robert. 1992. ***Robert Gardner's Favorite Science Experiments***. Franklin Watts: NY. ISBN 0-531-11038-9 [Explains which experiments involve physical changes and which have chemical changes. UE, MS]

D. Lyon, Sue. 1989. ***Fun with Chemistry***, Science in Action series. Marshall Cavendish Corp.: NY. ISBN 0-86307-940-7. [Use extra caution should you decide to do the experiments that involve flame. UE, MS]

Mebane, Robert C. and Thomas R. Rybolt.

E. 1985. ***Adventures with Atoms and Molecules***. ISBN 0-89490-120-6
F. 1987. ***Adventures with Atoms and Molecules, vol. II***. ISBN 0-89490-164-8
G. 1991. ***Adventures with Atoms and Molecules, vol. III***. ISBN 0-89490-254-7
H. 1992. ***Adventures with Atoms and Molecules, vol. IV***. ISBN 0-89490-336-5
I. 1995. ***Adventures with Atoms and Molecules, vol. V***. ISBN 0-89490-606-2
Enslow Publishers, Inc., PO Box 699, Springfield, NJ 07081
[The experiments show mostly physical changes, but some have chemical changes. The levels are mixed and the order is random. LE, UE, MS]

J. Van Cleave, Janice. 1993. ***A+ Projects in Chemistry***. John Wiley & Sons: NY. ISBN 0-471-58631-5 [This book is deeper than most by this author. Good directions and explanations. UE, MS]

K. Van Cleave, Janice. 1989. ***Chemistry for Every Kid: 101 Experiments That Really Work***. John Wiley & Sons: NY. ISBN 0-471-62085-8 [Simple experiments for beginners, little background information. LE, UE]

L. Wood, Robert W. 1991. ***Science for Kids: 39 Easy Chemistry Experiments***. TAB Books: NY. ISBN 0-8306-7596-5 (hard-back) 0-8306-3596-3 (paperback) [Simple directions and explanations, but good experiments. LE, UE. If you add more background, many of these work for MS.]

Important safety, common sense, and operational guidelines

Always do the experiment yourself before your students do it. This allows you to spot hazards and make sure you have materials that will work. Read and follow the safety guidelines in the experiment books.

Provide lab aprons and goggles for protection of clothing and eyes. These contribute to a serious atmosphere and help students focus as well. The goggles do not need to be used for all experiments. Use your judgement, especially if the materials involved in the experiment are no more hazardous than salad dressing.

Make sure that students are prepared before using flames. Long hair and loose clothing needs to be out of the way and all flammable materials removed from the area. Students need a lesson on the safe use of the alcohol burner before using it. They need to know how to extinguish flames. Emphasize the importance of keeping a cool head.

Inform students of any chemical that could harm them. Show them where to wash spills off their skin. Establish a procedure in case of accidents. You can prevent many problems by using low hazard chemicals. Forbid tasting experiment materials and do not allow food in the laboratory area.

Make sure the experiment area is well ventilated, especially if you are using ammonia or other volatile substance.

Use small quantities of chemicals when possible. There is less waste, as well as less potential for hazards.

Your glassware can be "real" laboratory beakers and flasks or less expensive alternatives. Make sure it is sturdy and the glass is not scratched and hard to see through. If you have flasks, beakers, test tubes, etc., help the students learn the proper names of this apparatus.

Have a procedure for the disposal of the materials when the experiment is finished. Make sure nothing that can harm or clog plumbing gets poured down the sink.