The Dangerous Book for Boys™

Classic CHEMISTRY

CHEMISTRY SET

WARNING — This set contains chemicals and parts that may be harmful if misused. Read cautions on individual containers and in the manual carefully. Not to be used by children except under adult supervision.

Thames & Kosmos

WHAT IS CHEMISTRY?

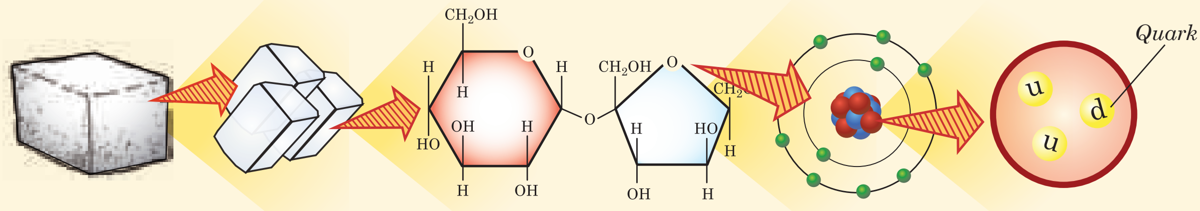
A dictionary would tell you that chemistry is the science of the composition, properties, structure, and reactions of matter. But what does that really mean? It means that **chemistry** is the organized study of all materials: what they are made of, how they are put together, how they come apart, why they behave the way they do, and why they are the way they are.

Everything — all the matter in the universe — is a chemical or is made of chemicals that can be studied in chemistry. That sounds like a lot, doesn't it? So how do the scientists who study chemistry, called **chemists**, keep it all straight? Well, they break things down into smaller and smaller categories, organizing them by their properties.

Take sugar for example. Regular table sugar is a material called sucrose. Sucrose is actually made of three other materials that you've probably heard of: hydrogen, carbon, and oxygen. These are called **elements**, and are categorized by their properties.

TABLE OF CONTENTS

FIG. 1: EXAMINING SUGAR



Sugar Cube *Sugar Crystal* *Sucrose Molecule* *Oxygen Atom* *Proton*

The smallest unit of an element is called an **atom**. An element consists of one atom or multiple atoms that are all exactly the same. You can't break an atom down any further without changing its properties. But atoms can be broken down into smaller components that do have different properties from each other: **protons**, **neutrons**, and **electrons**. However, all protons in the world are the same as each other, as are neutrons and electrons, no matter what atom they're a part of. It's as if you built houses out of blocks, and there were three types of blocks: blue, green, and red. Towns with only one house or many of the same houses represent elements, individual houses represent atoms, and the blue, green, and red blocks represent protons, neutrons, and electrons. Even protons and neutrons can theoretically be divided into smaller parts called quarks and leptons. And electrons are so small that they behave less like particles of matter and more like waves of energy. But we're getting ahead of ourselves.

At this time, there are only about 117 known elements. So everything you see is made of only these 117 elements. In fact, about 20 of these elements are not found naturally on Earth and have only been made artificially in a lab, so we're talking less than 100 different building blocks for everything on Earth!

How do so few parts come together to make so many different things, that interact in so different many ways? Answering this question is what chemistry is all about.

IS CHEMISTRY REALLY DANGEROUS?

Despite the name of this kit, chemistry is not inherently dangerous. In fact, when true chemists experiment with chemical reactions, they are controlled, precise, and deliberate. Before you begin with the experiments, please read the following safety advice carefully. Even though you are only working with relatively harmless materials and experiments in this kit, you should work safely at all times.

1. Read the instructions before beginning an experiment. Follow them and have them ready for reference. Pay special attention to the specified quantities of substances, and to the sequence of individual activities. Perform only the experiments described in this manual.

2. Keep small children, pets, and people without safety goggles away from the place of experimentation. Store your experiment kit out of reach of small children.

3. Always wear eye protection. If you wear glasses, you will need safety glasses designed for people who wear eyeglasses.

4. Wear appropriate protective clothing that covers your body and hands while performing experiments. This can be a smock or apron, and a pair of rubber gloves.

5. Clean all containers after use. Carefully close the chemical containers after use and put them back in their proper place in the experiment kit.

6. Wash your hands after finishing the experiments. If any chemicals get onto your skin by accident, immediately wash them off under running water.

7. Do not use any devices other than those supplied with the kit or specifically recommended for use with individual experiments.

8. Do not eat or drink at the place of experimentation. Do not use eating, drinking, or other kitchen utensils for your experiments, except when specifically called for and to fill bowls with the required amount of food or food products.

9. When investigating food or food products (like sugar, flour, kitchen salt, or vinegar), use your own clean kitchen utensils, and not the measuring spoon from this kit. Do not put food or food products back into the original container; dispose of them immediately into the garbage or down the drain.

10. Do not bring any chemicals in contact with eyes or mouth, and avoid skin contact.

11. Have a bucket of water or a box of sand ready to extinguish fires. If you are not able to put out a fire right away, call the fire department immediately (dial 911).

Setting Up Your Lab

Finding a good place to do your experiments is a big part of safety. Some experiments might damage a table top. So, you should choose an appropriate work surface, such as a sturdy old table or a discarded counter top. The work surface should be washable and heat resistant. Do not do experiments in the kitchen or dining room — near food, utensils, or where food is prepared. The workplace should also be brightly lit, easy to access, and well ventilated. You will need water for your experiments and cleaning, so you should have a sink nearby, and a bottle of water on hand. Also keep a rag handy for wiping up spills.

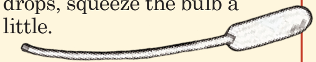

Fig. 3: A Fine Lab Space

TOOL TIPS

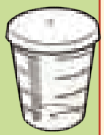
Measuring Spoon
The measuring spoon has two heads. When the instructions call for "one measuring spoon," use the larger head. When the instructions call for "one small measuring spoon," use the smaller head. "One spoon tip" means just a little on the tip of the small spoon.

Chemical Vials
The chemical vials are child-resistant. You need the lid opener to open them. To open, place the vial upright, on a table and hold with one hand, insert the lid opener into the red top of the vial, and pry upward. The lids are not twist-off.

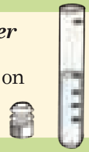
Pipette
To use the pipette, squeeze the bulb, insert the tip in a liquid and release the bulb to suck up the liquid. To release drops, squeeze the bulb a little.



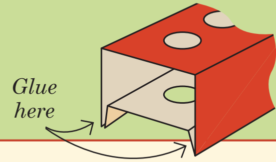
Measuring Beaker
The measuring beaker has lines on the side indicating volumes in milliliters.



Test Tube and Stopper
Follow the advice for marking the test tube on page 6.



Test Tube Rack
Fold the test tube rack and glue or tape it together, then insert it into your kit box.



THE ELEMENTS

You have already learned that all matter is composed of elements. Elements cannot be broken down into simpler substances without changing their properties (remember the building block towns with one or all the same houses). Scientists group elements by their properties. An element's phase of matter at room temperature is one important property (see the box to the right). Most elements are solids at room temperature. Examples include copper, iron, sulfur, and gold. Only a few elements are liquids at room temperature, such as mercury and bromine. A good number of elements are gases at room temperature, including hydrogen, helium, oxygen, and neon. Elements are also grouped by the ease with which they lose electrons and their ability to conduct electricity into three categories: **metals**, **metalloids**, and **nonmetals**.

Every element is in a particular phase of matter at room temperature. Nonmetal elements are solids, liquids, and gases at room temperature, but metals and metalloids are mostly solids. In fact, there are no metal or metalloid element gases at room temperature, no metalloid liquids at room temperature, and only one metal liquid at all — namely mercury. That's because the bonds of metals and metalloids are so strong that they only exist as solids; mercury is a special exception. However, elements can change phase when the temperature or pressure changes. For example, hydrogen is actually solid below -259 °C (-434 °F), liquid between that and -253 °C (-423 °F), and gas above that temperature.

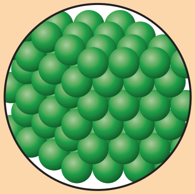
PHASES OF MATTER

There are three **phases of matter: solid**, **liquid**, and **gas**. (There are actually others, like plasma and Bose-Einstein condensate, but they're much less common.) This means that pretty much all the stuff you see in the world can be characterized as being in either a solid, liquid, or gas phase.

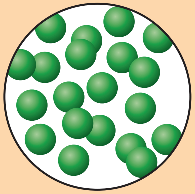
The atoms of solids are packed together densely and have fixed positions in space relative to each other (like bricks in a wall), which makes solids rigid.

Liquids have atoms that are packed less densely than are those of solids, and while solids form a rigid shape, liquids move freely. But when liquids are poured into a container, they must conform to the shape of the container, except for possibly one surface (like the surface of water in a fish tank).

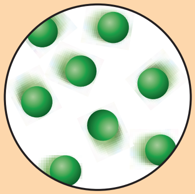
This is not the case for gases, which must conform to the shape of the container entirely (like water vapor in a fish tank, which would have no surface different from the walls of the tank). The atoms of gases are packed the least densely of all three phases, and are in relatively random motion. Gases have no definite shape or volume, can expand and contract greatly with changes in temperature and pressure, and spread easily to distribute themselves evenly throughout a container — hence their total conformity to the shapes of containers.



Solid



Liquid

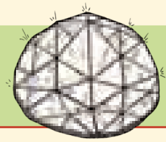


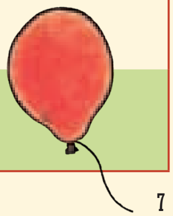
Gas

SOME ELEMENTS AND THEIR PHASES AT ROOM TEMPERATURE

	Solid	Liquid	Gas
Metal	Copper, Silver, Iron, Aluminum, Tin	Mercury	None
Metalloid	Boron, Silicon, Arsenic	None	None
Nonmetal	Carbon, Sulfur, Iodine	Bromine	Hydrogen, Helium, Nitrogen, Oxygen, Neon







SMOKY, SMELLY, SLIMY, AND SOAPY CHEMISTRY

Try saying that ten times fast! Now that you've labored through atomic structure and chemical reactions and noble gases and plastics, you're ready for your reward: the smelliest, slimiest chemistry of this entire kit. The following experiments bring together a lot of what you have already learned. Let's start with a smoke bomb.

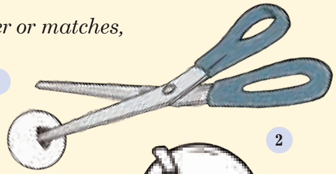
Experiment No. 28 — Smoke Bomb

WARNING

Only an adult can do this experiment. The adult should wear heavy duty work gloves when cutting and lighting the ping pong ball. This must be done outside. Use extreme caution when lighting the ball, as it is highly flammable. Noxious fumes and smoke are created. Do not breathe them. If you are unsure of your ability to do this experiment safely, do not attempt it. Do not throw this at anyone or near anyone. Do not attempt if it is windy.

Materials: ping pong ball, straw, *scissors, aluminum foil, lighter or matches, work gloves*

1



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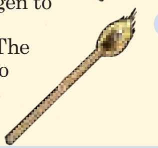


Procedure

1. Using the scissors, cut a hole the size of the straw in one side of the ping pong ball.
2. In the other side, cut a little strip that folds out from the ping pong ball as shown.
3. Put the straw in the hole of the first ping pong ball, and cut it off at a height of about 3 cm.
4. Wrap the entire ping pong ball in aluminum foil, with only the tip of the straw and the little strip of plastic from step 2 sticking out of the tin foil. Make sure the entire ball is covered with foil, and that there are absolutely no holes in the foil except for those where the straw and plastic strip protrude.
5. If you're not already outside, go outside to a location where there is open pavement (such as a driveway or parking lot) and no chance of igniting surrounding plants or objects. Do not attempt if it is windy.
6. Remember, an adult must do this: With the lighter or a match, light the little strip of plastic and immediately toss it on the pavement, away from people, pets, and objects that could ignite.
7. Stand back and no do not inhale any of the smoke or fumes from the burning ping pong ball.

Explanation

Ping pong balls are made of celluloid, one of the first plastics to be manufactured and molded into various products. It dates back to the 1850s! Celluloid is highly flammable and is not widely used today — except in ping pong balls and guitar picks. Celluloid is made from camphor, a naturally occurring solid hydrocarbon, and nitrocellulose, a compound made by adding nitrogen to organic cellulose, a polysaccharide. Nitrocellulose is flammable.

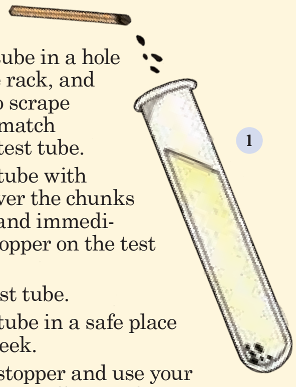
You already know that combustion (rapid oxidation) needs oxygen. The aluminum foil limits the amount of oxygen that can get to the reaction, so instead of burning quickly, the ball burns more slowly and produces a lot of smoke. The straw acts as a little chimney, letting the smoke out.

Exp. No. 29 — Stink Bomb

WARNING

An adult must do this experiment. Follow the safety precautions on the bottle of ammonia (e.g., don't breathe it in) and box of matches. **Ammonium sulfide** can be toxic and flammable. Work in a well-ventilated area. Keep away from heat and flames.

Materials: stopper, test tube, *20 matches, ammonia, dull knife*

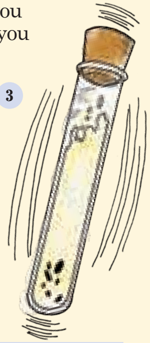


1

Procedure

1. Set the test tube in a hole in the test tube rack, and use the knife to scrape coating off the match heads into the test tube.
2. Fill the test tube with ammonia to cover the chunks of match head and immediately put the stopper on the test tube.
3. Shake the test tube.
4. Put the test tube in a safe place and wait one week.
5. Remove the stopper and use your hand to waft the smell towards you (don't smell it directly). What do you smell?

3



Explanation

That smells like rotten eggs! This is because the ammonia combines with the sulfur from the match heads to create ammonium sulfide, a compound that smells terrible and is toxic. Make sure to dispose of it properly in the sink with lots of water.