North Carolina Department of Public Instruction

PHYSICAL SCIENCE CURRICULUM SUPPORT DOCUMENT

This support document includes the NC Standard Course of Study goals and objectives along with objective weights, a detailed content explanation, a list of helpful resources and a collection of some suggested activities. Also included is a collection of Inquiry Support Labs and Activities.

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Acknowledgements

This document was developed in response to the expressed need of physical science teachers for materials designed to facilitate and enhance the teaching of the 1999 *North Carolina Standard Course of Study* for Physical Science. The materials provide a guide to translating the goals and objectives of the Physical Science curriculum into good instructional design.

A group of dedicated and talented Physical Science teachers led by Carolyn Elliott spent many hours developing these materials. The result is a resource that will facilitate the implementation of the North Carolina Science Curriculum.

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Physical Science Strands

The Physical Science curriculum is designed to continue the investigation of the concepts that guide inquiry in the practice of science begun in earlier grades. The Physical Science course will provide a rich knowledge base to provide a foundation for the continued study of science. The investigations should be approached in a qualitative manner in keeping with the mathematical skills of the students. The curriculum will integrate the following topics from both chemistry and physics:

- Structure of atoms
- Structure and properties of matter
- Motions and forces
- Conservation of energy, matter and charge

Strands: The strands are: Nature of Science, Science as Inquiry, Science and Technology, Science in Personal and Social Perspectives. They provide the context for teaching of the content Goals and Objectives.

Goal - Instructionally, these strands should be woven through the content goals and objectives of the course. Supplemental materials providing a more detailed explanation of the goals, objectives, and strands, with specific recommendations for classroom and/or laboratory implementation are available through the Department of Public Instruction's Publications Section.

Nature of Science

This strand is designed to help students understand the human dimensions of science, the nature of scientific thought, and the role of science in society. Physical science is particularly rich in examples of science as a human endeavor, its historical perspectives, and the development of scientific understanding.

Science as a Human Endeavor - Intellectual honesty and an ethical tradition are hallmarks of the practice of science. The practice is rooted in accurate data reporting, peer review, and making findings public. This aspect of the nature of science can be implemented by designing instruction that encourages students to work collaboratively in groups to design investigations, formulate hypotheses, collect data, reach conclusions, and present their findings to their classmates.

The content studied in physical science is an opportunity to present science as a basis for engineering, electronics, computer science, astronomy and the technical trades. The diversity of physical science content allows for looking at science as a vocation. Scientist, artist, and technician are just a few of the many careers in which a physical science background is necessary.

Perhaps the most important aspect of this strand is that science is an integral part of society and is therefore relevant to students' lives.

Historical Perspectives - Most scientific knowledge and technological advances develop incrementally from the labors of scientists and inventors. Although science history includes accounts of serendipitous scientific discoveries, most development of scientific concepts and technological innovation occurs in response to a specific problem or conflict. Both great advances and gradual knowledge building in science and technology have profound effects on society. Students should appreciate the scientific thought and effort of the individuals who contributed to these advances. Galileo's struggle to correct the misconceptions arising from Aristotle's explanation of the behavior of falling bodies led to Newton's deductive approach to motion in The Principia. Today, Newton's Law of Universal Gravitation and his laws of motion are used to predict the landing sites for NASA's space flights.

Nature of Scientific Knowledge - Much of what is understood about the nature of science must be explicitly addressed:

All scientific knowledge is tentative, although many ideas have stood the test of time and are reliable for our use.

Theories "explain" phenomena that we observe. They are never proved; rather, they represent the most logical explanation based on currently available evidence. Theories may become stronger as more supporting evidence is gathered. They provide a context for further research and give us a basis for prediction. For example, in physical science, atomic theory explains the behavior of matter based on the existence of tiny particles. And kinetic theory explains, among other things, the expansion and contraction of gases.

Laws are fundamentally different from theories. They are universal generalizations based on observations of the natural world, such as the nature of gravity, the relationship of forces and motion, and the nature of planetary movement. Scientists, in their quest for the best explanations of natural phenomena, employ rigorous methods. Scientific explanations must adhere to the rules of evidence, make predictions, be logical, and be consistent with observations and conclusions. "Explanations of how the natural world changes based on myths, personal beliefs, religious values, mystical inspiration, superstition, or authority may be personally useful and socially relevant, but they are not scientific." (National Science Education Standards, 1996, p. 201)

Science as Inquiry

Inquiry should be the central theme in physical science. It is an integral part of the learning experience and may be used in both traditional class problems and laboratory work. The essence of the inquiry process is to ask questions that stimulate students to think critically and to formulate their own questions. Observing, classifying, using numbers, plotting graphs, measuring, inferring, predicting, formulating models, interpreting data, hypothesizing, and experimenting help students to build knowledge and communicate what they have learned. Inquiry is the application of creative thinking to new and unfamiliar situations. Students should learn to design solutions to problems that

interest them. This may be accomplished in a variety of ways, but situations that present a discrepant event or ones that challenge students' intuitions have been most successful.

Classical experiments such measuring inertia and the speed of falling bodies need not be excluded. Rather, they should be a prelude to open-ended investigations in which the students have the chance to pose questions, design experiments, record and analyze data, and communicate their findings. For example, after measuring the relationships among force, mass, and acceleration of falling bodies, students might investigate the phenomenon of "weightlessness", or, after measuring physical properties, they might investigate the connection (if any) between the density of certain liquids and their boiling point.

Although original student research is often relegated to a yearly science fair project, continuing student involvement in research contributes immensely to their understanding of the process of science and to their problem-solving abilities. Physical science provides much potential for inquiries. "Does the aluminum baseball bat have an advantage over a wooden baseball bat?" "Why?" "Is one brand of golf ball better than another brand?" "Why?" The processes of inquiry, experimental design, investigation, and analysis are as important as finding the correct answer. Students will master much more than facts and acquisition of manipulative skills; they will learn to be critical thinkers.

Science and Technology

It is impossible to learn science without developing some appreciation of technology. Therefore, this strand has a dual purpose: (a) developing students' knowledge and skills in technological design, and (b) enhancing their understanding of science and technology.

The methods of scientific inquiry and technological design share many common elements - objectivity, clear definition of the problem, identification of goals, careful collection of observations and data, data analysis, replication of results, and peer review. Technological design differs from inquiry in that it must operate within the limitations of materials, scientific laws, economics, and the demands of society. Together, science and technology present many solutions to problems of survival and enhance the quality of life.

Technological design is important to building knowledge in physical science. Telescopes, lasers, transistors, graphing calculators, personal computers, and photogates, for example, have changed our lives, increased our knowledge of physical science, and improved our understanding of the universe.

Science in Personal and Social Perspectives

This strand helps students in making rational decisions in the use of scientific and technological knowledge.

"Understanding basic concepts and principles of science and technology should precede active debate about the economics, policies, politics, and ethics of various science and technology-related challenges. However, understanding science alone will not resolve local, national, or global challenges." …"Students should understand the appropriateness and value of basic questions - 'What can happen?' – 'What are the odds?' and 'How do scientists and engineers know what will happen?'" (National Science Education Standards, 1996, p. 199)

Students should understand the causes and extent of science-related challenges. They should become familiar with the advances that proper application of scientific principles and products have brought to environmental enhancement, better energy use, reduced vehicle emissions, and improved human health.

Competency Goal 1: The learner will construct an understanding of mechanics.

Total weight for Goal 1: 19%

Objective	Content	Demonstrations and Activities
1.01 Analyze uniform and accelerated motion (7%):		
Uniform motion is motion at a constant speed in a straight line. (Constant velocity)	All motion is determined by comparison to a background described as "stationary" to the observer. This background is the observer's frame of reference. The most commonly used reference frame is Earth's surface. Using the Earth as a frame of reference resulted in the long-held belief that the sun orbited the Earth. When people began using the background of stars as a reference frame, they realized that the Earth orbits the sun. Another example is the impression of motion in a video game. The character appears to "move" through the motion of the background. The playing character actually stays within several inches of the center of the screen. In this case, the video game screen is the frame of reference. v is used to represent velocity (speed with direction). $\bar{v}$ means average velocity. Δv means a change in velocity. Constant speed is the constant change in position in each unit of time. Average speed is found by dividing the total distance by the change in time of the trip. Average velocity is found by dividing change in displacement by the change in time of the trip. $\bar{v} = \frac{\Delta d}{\Delta t}$ Units: 1 m/s= 1 m/s Instantaneous velocity is the rate at which an object changes position for a given instant in time.	Speed, Distance, & Time Blood Drops in Motion (or Seed Trail)
The rate of change in velocity is acceleration.	*Acceleration* is the change in velocity for each unit of time. $\bar{a} = \frac{\Delta v}{\Delta t}$ Units: $1 m/s^2 = 1 (m/s)/s$ In each unit of time, the distance covered by an accelerating	Attach a strip of spark-timer tape to a falling object. The distance between dots will show a steady increase. Also, the acceleration due to gravity can be found using $a = 2d/t^2$ (Answer: $9.8 m/s^2$) (Note:

Competency Goal 1: The learner will construct an understanding of mechanics. Total weight for Goal 1: 19%		
Objective	**Content**	**Demonstrations and Activities**
	object increases. Acceleration due to gravity on the Earth is 9.8 m/s/s.	time is found by counting the dots and dividing by the number made per second - i.e. 30 dots = 0.5 seconds on a 60 dots-per-second spark timer.) Other forms of motion detectors as well as CBL's/ULI's might be used.
1.02 Analyze forces and their relationship to motion, Newton's Three Laws of Motion (6%)	A force is an interaction between two objects that can change the motion of those two objects [e.g. the force of gravity, friction (surface to surface or by fluids), air inside an inflated balloon, and buoyant force]. First law or the Law of Inertia states that a net force causes an object to accelerate. If the forces acting on an object cancel, no acceleration is caused, and the object may be at rest or have constant velocity. Second law state the acceleration (*a*) of an object depends on its mass (*m*) and the force applied to it. The net force or the sum of forces equals mass times acceleration. $F = ma$ Units: 1 N = (1 kg)(m/s/s) For example, a moving skateboard does not roll to a stop because the person stops pushing or exerting a force on the skateboard, but because the force of friction acts on it. Mass is the amount of matter in an object and does not change with location, but weight, which is the force of gravity on an object, varies depending on where the object is located (e.g. on a different planet). Forces also can cause a change in direction alone. An example is centripetal acceleration, such as the force toward the center of a curve on a car rounding a corner or a toy airplane spun in a circle by a string. Third law is that forces come in pairs, equal in size and acting	1) Using rolling carts, have students demonstrate Newton's Laws. 1st: When a vehicle comes to a stop, riders continue to move forward. Seatbelts keep the riders in place. Simulate this using a rolling cart hitting a pebble (at low speeds only). 2nd: A stronger pull gives a cart more acceleration; a larger student requires more of a pull to accelerate. 3rd: Start with two students, each on a cart. Neither can push nor pull on the other without being pushed or pulled back. 2) Place an effervescent tablet in a film container filled with water. Put on the lid. The lid and the canister will shoot apart in opposite directions.

Competency Goal 1: The learner will construct an understanding of mechanics. Total weight for Goal 1: 19%		
Objective	**Content**	**Demonstrations and Activities**
	in opposite directions on opposite objects. This law is also called the "action-reaction" law. Examples are as follows: the force of the exploding fuel on a rocket that it is in is a pair with the force of the rocket to expel exhausted fuel from its engines. The force of the air in a released balloon that propels it across a room is a pair with the force of the balloon that pushes air back out of the balloon's mouth. Momentum (not included in objectives) would be appropriate to mention here—the product of mass and speed. A collision results in equal forces on each object involved (3rd Law), but changes the speed of the lighter object the most. Total momentum is conserved because the amount of momentum lost by one object is equal and opposite to that gained by the other.	
1.03 Analyze the conservation of energy and work (6%):		
Work	Work is the amount of energy transferred from one place to another (and/or stored in a different way) through the action of a force (e.g. picking up an object, pushing trunk across the floor). $W = Fd$ Units: 1 *Joule = 1 J = 1 Nm Work is not done when the force is perpendicular to the direction moved. For example, no work done in holding a tray up while skating forward. The force is pushing up on the force on a tray when while the displacement that the tray moves is forward thus the force is perpendicular to the displacement. Simple machines make work easier. A trade-off always occurs—force is made less in exchange for traveling farther. The best possible machine cannot make "work out" equal to "work in":	*A Joule is defined as the energy (work) required to apply one Newton of force through a distance of 1 meter. Then the Joule can be expressed in the fundamental units of $kg(m^2)/(s^2)$. These fundamental units may be repositioned and maintain their equivalence to a Joule (for example, 1 Joule = 1 kg $(m/s)^2$ (usually used for Kinetic Energy) = 1 kg (m/s/s) m (usually used for Potential Energy)= 1 Nm (usually used for work).

Competency Goal 1: The learner will construct an understanding of mechanics. Total weight for Goal 1: 19%		
Objective	**Content**	**Demonstrations and Activities**
	Specific simple machines make good demonstrations, but are in the 8^{th} science curriculum. (4.02, 4.03)	
Power	Power is the rate of doing work (work done in a unit of time). $P = \frac{W}{t}$ Units: 1 Watt = 1W = 1 Nm/s (Another common unit is horsepower: 1 Hp = 746 Watts.) Watts are the power rating given to electrical appliances (e.g. 100 W light bulb). The units for electrical energy are traditionally measured in kilowatt-hours (kWh). This is calculated by multiplying the work and time (e.g. 1000 W light bulb used for 2 hours = 2000 watt-hours or 2 kilowatt-hours (kWh) of electrical energy used). These are the units of energy found on electric bills.	Running Stairs to Find Horsepower Review an electric bill; figure cost per kWh; look up wattage values for home appliances and calculate the cost of running them for an hour
Kinetic Energy	Kinetic energy is energy of motion. It is dependent on both mass and speed. $KE = \frac{1}{2}mv^2$ Units: 1 Joule = 1 kg $(m/s)^2$ Kinetic energy changes most in response to speed. An important example for students is that doubling the speed of a car actually quadruples its moving energy. The resulting energy makes it four times as difficult to stop.	
Potential Energy	Potential energy is stored energy (e.g. object on a ledge above a reference point, a compressed spring, a stretched rubber band). $PE = mgh$ Units: 1 Joule = 1 kg (m/s/s) m Gravitational potential is a property of the field and is equal to gh. It is the energy stored per kg of mass, and describes the ability of the field to store energy	

Competency Goal 1: The learner will construct an understanding of mechanics.

Total weight for Goal 1: 19%

Objective	Content	Demonstrations and Activities
	Gravitational potential energy is usually found as an increase or decrease in energy as an object's position changes. The calculation is identical to finding work needed to lift an object to a chosen height.	
Conservation of Mechanical Energy	Common forms of energy are as follows: kinetic, sound, gravitational potential, elastic potential, chemical, thermal, electrical, light, and magnetic. Energy may change form, but is never lost or created during any change (e.g. a falling ball loses gravitational potential energy, but gains an equal amount of kinetic energy and a compressed spring will loose elastic potential energy when released, but will jump to gain an equal amount of gravitational potential energy at peak height). Classic examples of energy conversion from gravitational potential energy to kinetic energy include a swinging pendulum "bob" and a roller coaster car.	Using a steel ball and a curved track, set up a "roller coaster." The ball will increase in speed (more KE) as it rolls from higher to lower points (less PE). The total KE+ PE should be constant throughout. The ball should be able to roll up a final hill to nearly its starting height. (All KE is then converted back into the original PE) The loss in height shows the amount of energy converted into heat through friction. A pendulum example might be an easier set up. Use "Newton's Cradle" (set of 4 or 5 pendulum balls hung by double strings and able to swing along a single line): Pull back one steel ball to a chosen height, storing a certain amount of gravitational PE, which converts into KE when released. This energy is passed through the other steel balls to the one on the far side, which will be hit and swung up to a height just less than the original height of the released ball. (The small "loss" of energy has actually been converted into heat energy in the collisions between the balls.)

Competency Goal 2: The learner will build an understanding of thermal energy.

Total weight for Goal 2: 9%

Objective	Content	Demonstrations and Activities
2.01 Assess molecular motion as it relates to temperature and phase changes. (4%) • Thermal energy • Expansion and contraction • Temperature • Phase change, heats of fusion and vaporization • Specific heat	Describe how the nature of thermal energy experiments by Count Rumford in 1790 and James Prescott Joule in the 1830's led scientists to believe that heat did not have fluid properties. Thermal energy is the energy associated with the random motion of the atoms and molecules that make up a substance. It can be transferred via conduction, radiation, and convection, and is called "heat" when it is in the process of being transferred. A substance or body capable of transferring thermal energy is called a conductor. Poor conductors are called insulators. Q = quantity of heat m = mass C_p = specific heat ΔT = temperature $Q = mC_p\Delta T$ Thermal energy, heat, and temperature are related, but they are not the same. Temperature is a measure of the average kinetic energy of the molecule of a substance, and thermal energy is the total kinetic energy of all the molecules of the substance. Thermal energy is mass dependent, but temperature is not; temperature can be measured directly, but thermal energy cannot. Temperature is measured with thermometers (temperature scales include Celsius, Fahrenheit, and Kelvin). $K = {}^{o}C + 273$ Heat is measured indirectly through changes in temperature. That is, an increase in temperature indicates an addition of thermal energy through heating, and a decrease in temperature indicates that thermal energy has transferred. Thermal energy is commonly measured in units of calories and joules. (1 calorie = 4.18605 joules.)	Heat samples of different metals (copper, aluminum, lead, iron) of the same mass to the same temperature. Set them on slabs of wax and see how much melts for each sample. Or put each in water and measure the temperature change of the water. (Also applies to objective 5.04.)

Competency Goal 2: The learner will build an understanding of thermal energy. Total weight for Goal 2: 9%		
Objective	**Content**	**Demonstrations and Activities**
	All substances have their own unique ability to absorb thermal energy. This is the specific heat capacity, which is determined by a substance's chemical structure. The increased molecular motion during heating causes expansion in solids, liquids and gases. If enough thermal energy is absorbed or removed from a substance it will change phase according to its heat of fusion and melting point or heat of vaporization and boiling point. The temperature remains constant during phase changes.	
2.02 Analyze the conservation of the total amount of energy, including heat energy, in a closed system; the First Law of Thermodynamics. (2%)	The first law of thermodynamics, also known as the law of conservation of energy, states that energy can never be created or destroyed. It can change forms, be stored in different ways, and transferred from one place to another. In a closed system, the internal energy can be changed only by (1) heat flowing into or out of the system or (2) the system doing work on an external system or having work done on it by an external system. The first law precludes the possibility of ever constructing a perpetual motion machine. In theory, a machine will produce only as much energy as is put into the machine. Due to friction, however, no machine can be 100% efficient because thermal energy is lost to the environment and cannot be converted into other forms of energy.	When stretched, a rubber band has the greatest potential energy. As the rubber band returns to its regular shape it converts its potential energy into kinetic energy. Fill a 16-oz. plastic bottle 1/3 full of sand. Take the temperature of the sand. Shake vigorously for 5-10 minutes. Take the temperature of the sand again.
2.03 Analyze the Second Law of Thermodynamics (3%) • Heat will not flow spontaneously from cold to hot body. • It is impossible to build a machine that does nothing but convert	Every time energy is converted from one from to another, some of the energy is lost as heat. No machine can be 100% efficient. Another way of stating the same thing is that entropy (the natural tendency for ever-increasing disorder) is always rising. Thermal energy is becoming more and more dissipated.	Hold a piece of ice in your hand. The heat from your hand moves to the ice and the ice melts.

Competency Goal 2: The learner will build an understanding of thermal energy. Total weight for Goal 2: 9%		
Objective	**Content**	**Demonstrations and Activities**
heat into useful work.	Another way of stating it is that over time, certain processes occur in one direction only (assuming no extra energy is added to a system). For example, heat flows from a hot body to a cold one, but not vice versa. Two gases can mix together, but will not spontaneously separate themselves back out. The direction in which processes occur spontaneously is the one in which entropy increases.	

Competency Goal 3: The learner will construct an understanding of electricity and magnetism.

Total weight for Goal 3: 14%

Objective	Content	Demonstrations and Activities
3.01 Analyze the nature of static electricity and the conservation of electrical charge (2%): • Positive and negative charges. • Opposite charges attract and like charges repel.	The electric force is a universal force that exists between any two charged objects. Opposite charges attract while like charges repel. The strength of the force is proportional to the charges, and as with gravitation, inversely proportional to the square of the distance between them. Between any two charged particles, electric force is vastly greater than gravitational force. Static electricity is the net accumulation of electric charges on an object. The presence of electric charges can be detected by an electroscope. Lightning is a large discharge of static electricity that occurs between positive and negative areas within a cloud, between clouds, or between a cloud and the ground. The electricity in lightning can have a potential of up to 100 million volts.	*Resources:* *Science Discovery: Static Electricity* *Interactive videodisc/CD-ROM*
3.02 Analyze the electrical charging of objects due to the transfer of electrons by friction, induction, or conduction. (3%)	Rubbing two objects together transfers electrons by friction (e.g. when you rub a balloon against a piece of cloth, the cloth loses electrons and the balloon gains electrons). Conduction involves the direct contact of objects: Electrons move from object to object. Materials that transfer electric charges easily, such as metals, are called conductors. Objects that do not transfer charges easily, such as glass and rubber, are called insulators. The third method of charging is induction, which involves the rearrangement of electric charges in a neutral object that comes close to a charged item. For example, a negatively charged rubber comb picks up tiny pieces of paper to pick them up. The electrons in the pieces of paper are rearranged by the approach of the charged comb.	Rubbing a balloon with a cloth (friction) to make it stick to a wall; using a charged comb to make little pieces of paper "dance" (induction) *Resources:* *Electric and Magnetic Interactions by Ruth Chabay and Bruce Sherwood, John Wiley and Sons, New York, 1995 (contains labs using transparent tape).* *Teaching About Electrostatics AAPT/PTRA-PLUS Workshop by Robert Morse, American Association of Physics Teachers, College park, Md, 1992.*
3.03 Analyze direct current electrical circuits (3%): • Electrical potential	Current is the rate of flow of electric charge through a wire or any conductive material. The electric charge is carried by moving electrons. Direct current (DC) occurs when the electrons flow in the same direction. The current in a	Build a Light Bulb Build Series and Parallel Circuits

Competency Goal 3: The learner will construct an understanding of electricity and magnetism.

Total weight for Goal 3: 14%

Objective	Content	Demonstrations and Activities
difference • Resistance • Ohm's Law • Simple direct current circuits • Series circuit • Parallel circuit	battery flows in one direction. Alternating current (AC) occurs when the electrons move back and forth, reversing directions regularly. A generator produces alternating current. The current in your house is alternating current. Current is measured by an ammeter in units called amperes (A). Electric potential is the amount of energy possessed by one Coulomb (or one unit) of electric charge at a particular location. This is the energy per unit charge. The size of the potential difference determines the current that will flow through a wire. Potential difference is measured in volts (V). Potential difference, often called voltage, is measured by a voltmeter. Resistance is the opposition to the flow of electric charges. Resistance is measured in ohms Ω. Resistance depends on the wire's material, thickness, and length. Copper wire has little resistance. A thick wire offers less resistance than a thin wire. Shorter wires offer less resistance than longer wires. As resistance of the circuit increases, the flow of current through the circuit decreases. Ohm's law states that the current in a wire (I) is equal to the voltage (V) divided by the resistance (R). $I = \frac{V}{R}$ A circuit is the path electricity follows. An electrical circuit consists of a source of energy, a load (lights or electrical devices that cause resistance), wire, and switch. In a closed circuit the switch is closed and the electrons make a complete path. In an open circuit the switch is open and the path is not complete. In an open circuit, charge flows	

Competency Goal 3: The learner will construct an understanding of electricity and magnetism.

Total weight for Goal 3: 14%

Objective	Content	Demonstrations and Activities
	for a very brief period of time until the accumulation of charge causes a buildup of electric potential that stops the flow. This brief period is called the transient period, and usually lasts for microseconds or less, after which there is no flow. A series circuit is a circuit with only one path for the current to follow. Decorative strings of tiny lights are often in series circuit. If one light goes out, all the lights go out. A parallel circuit has separate paths that allow the charge, as carried by electrons, to flow in more than one path. Each electrical device (light) has a separate path such standard wiring in the home.	
3.04 Analyze the practical applications of magnetism and its relationship to the movement of electrical charge. (4%)	Electricity and magnetism are two aspects of a single electromagnetic force. An electromagnet is made of a coil of wire around a soft iron core. Adding more turns of wire around the iron core and/or increasing the current passing through the wire can increase the strength of the magnetic field. A galvanometer uses an electromagnet to detect electric current. These effects help students to understand electric motors and generators.	Charting Magnetic Fields
3.05 Analyze permanent magnetism and the practical applications of the characteristics of permanent magnets. (2%)	Magnetism is a property of matter in which there is a force of repulsion and attraction between like and unlike poles. The magnetic forces are strongest at the poles, called north and south. The magnetic field is found in the area around the magnet and has the ability to exert forces on other magnets or moving charges. Magnets can become unmagnetized if heated or dropped. Heating causes an increase in the motion of the particles and they become unaligned.	Build an electromagnet with a low voltage dry-cell battery, a length of insulated wire, and a large iron nail or iron rod. Remove the insulation from the ends of the wire. Wrap the wire around the nail at least 25 times. Connect the ends to the battery. Use the wrapped nail to pick up paper clips.

Competency Goal 3: The learner will construct an understanding of electricity and magnetism. Total weight for Goal 3: 14%		
Objective	**Content**	**Demonstrations and Activities**
	Elements that are magnetic only when placed close to a magnet are iron, nickel, and cobalt. Materials that can be permanent magnets are steel, alnico (alloy of iron, aluminum, nickel and cobalt) and oxides of magnetic elements (such as the mineral magnetite). Magnets are found in electric clocks, motors, stereos, loudspeakers, television sets, and microwaves.	

Competency Goal 4: The learner will develop an understanding of wave motion and the wave nature of sound.

Total weight for Goal 4: 6%

Objective	Content	Demonstrations and Activities
4.01 Analyze the characteristics of waves (4%): • Wavelength • Frequency • Period • Amplitude	A wave is any periodic disturbance in a material that travels from one region to another. Two major types are mechanical which travels through a material (e.g. waves on a rope or spring, water waves, sound waves), and electromagnetic which may travel through a vacuum (e.g. radio, TV, radar, infrared, visible light, ultraviolet, X rays/gamma rays). Electromagnetic waves can move at the "speed of light"—a maximum speed of 300,000,000 meters/second or 186,000 miles/second in empty space. (They move more slowly through glass, water, or other materials.) The wavelength is the distance between two successive analogous points on a wave, usually measured in meters. In a sound wave (longitudinal or compressional wave), the material moves back and forth, making compressed and expanded regions: compression (high pressure area—crowded molecules) and rarefaction (low pressure area—spread out molecules). Wavelength is from compression to compression or from rarefaction to rarefaction. In waves traveling down a vibrated rope (transverse waves), the wavelength is the distance between two consecutive points on a wave, such as from high point (crest) to next high point or low point (trough) to low point. The frequency of a wave is based on both its wavelength and speed. Defined as the number of waves that pass a given location per second, it has a unit of Hertz (Hz). For example, if four water waves pass a buoy in one second, then the waves have a frequency of 4Hz. The perceived frequency of a sound wave is called its pitch.	Tie a Slinky © spring to the ceiling tile supports so that it hangs horizontally. (Use a string every 10 cm or so; a second Slinky may be attached to the first for better length.) Once hung, the Slinky can be shaken from side to side to demonstrate transverse waves. Point out wavelength, amplitude, and discuss speed. Gather about 6-10 links of the Slinky into your hand. Suddenly release them, and observe the compressional wave that results. Again, point out the wavelength, amplitude (your hand's release distance), and discuss speed. Making Waves with Sound

Competency Goal 4: The learner will develop an understanding of wave motion and the wave nature of sound. Total weight for Goal 4: 6%		
Objective	**Content**	**Demonstrations and Activities**
	Period is the mathematical inverse of frequency—it may be defined as the number of seconds required for one wavelength to pass a given point. The wave equation relates the speed at which a wave pattern moves through a material, its frequency, and its wavelength. It is usually expressed as follows: (v is velocity, f is frequency, and λ is wavelength) $v = f\lambda$ For example, 3 waves with wavelength of 2 meters pass a point in 1 second. What is the velocity of the wave? V = (3 Hz)(2 m) = 6 m/s. Amplitude is a measure of the maximum displacement of a material from its rest position. In a sound wave, the material actually moves back and forth, so the amplitude is measured by the movement of what generates the wave (i.e., how many millimeters did the speaker move in or out from rest to produce the sound). In a light wave, amplitude is measured as the maximum strength of the electric or magnetic field producing the waves. (These are just "measured" on a wave pattern as the distance from rest position up to the crest or down to the trough.) Amplitude is related to the quantity of energy a wave carries with it (e.g. a tall water wave can carry a surfer farther and faster).	
4.02 Analyze the phenomena of reflection, refraction, interference and diffraction. (1%)	All of these terms have to do with the response of a wave to an object or another wave in its path. Reflection is the partial return of a wave pattern off an object in its path (e.g. a string tied to a door knob will bounce back a wave pulse sent down the string; sound will echo off a distant wall; and light will reflect an image off a smooth surface). Law of Reflection: the angle at which a wave hits a surface will be equal to the angle at which it reflects from it. Reflection	1. Reflection: Hang a 3- or 4-foot-long mirror, and ask the students what they expect will happen to their reflection as they move away from a mirror. Most will say they will see more of themselves. Disprove this by having a student hold her hands in line with the region of her body visible in the mirror and then move

Competency Goal 4: The learner will develop an understanding of wave motion and the wave nature of sound. Total weight for Goal 4: 6%		
Objective	**Content**	**Demonstrations and Activities**
	only shows an image when the surface is sufficiently smooth to return the incoming waves in their original pattern, which is why you cannot see yourself in a piece of paper. Refraction is the bending of a wave pattern as it enters a new substance. For example, sound waves from an earthquake bend as they reach the center of Earth, which is one way geologists know the size of the core. Refraction is most obvious when light waves pass from air to water. Some examples include the apparent bending of a spoon in a glass of water, the "bending" of a swimmers legs hung under a pool's surface, or the false position observed for a fish swimming below an observer. (The fish is actually located behind where it appears to be.) Bending of light waves is color-dependent, so each color is bent a different amount on encountering a new substance. This is called dispersion (e.g. light going through a prism or through raindrops separates out into a rainbow of colors). Interference is the interaction between waves that are at the same place at the same time. Wave amplitudes at the same location simply add together, but their relative motion complicates this. Students should be able to describe both constructive (increasing amplitude) and destructive (reducing amplitude) interference. Important related concepts: 1. Standing wave patterns are made up of transmitted and reflected waves, which make a stationary pattern of "fixed" points (nodes) and "bouncing" points (antinodes) (e.g. steady shaking of a rope tied to a fixed point, the sound waves in wind instruments/organ pipes, or stringed instruments).	forward and back. (At home, you can often see more of yourself by moving back because the dresser top is obstructing part of the reflected image.) The shortest mirror in which you can see your entire body is half your height. It must be hung at about waist level. Why? 2. Refraction: Fill a glass beaker with water and place a pencil in it. It will appear bent. 3. Interference to produce standing waves: Use a stringed instrument (or slide whistle to show that shorter strings produce higher notes. Given a shorter distance in which to make a standing wave, the wavelength must be smaller. 4. Diffraction grating: Have students look at any light source through glasses with diffraction grating lenses (available at many science suppliers). Extension: demonstrate gas discharge tubes for several types of gas.

Competency Goal 4: The learner will develop an understanding of wave motion and the wave nature of sound.

Total weight for Goal 4: 6%

Objective	Content	Demonstrations and Activities
	2. "Dead spots" in an auditorium are caused by complete destructive interference between the waves from at least two source speakers on stage. Diffraction is defined as the bending of a wave around an obstacle. It is noticeable when the wavelength involved is nearly the same size as the object it encounters (e.g. the light/dark bands found on close observation of a shadow's edge or the bending and separating of colors by a diffraction grating).	
4.03 Compare and contrast the frequency and wavelength of sound produced by a fixed source of sound with a moving source of sound, the Doppler Effect. (1%)	The Doppler Effect is the difference in frequency between a sound produced from a source and that perceived by a listener, when the sound and the listener are moving relative to one another. A common example is the sudden drop in pitch of siren as an emergency vehicle passes a bystander. The cause of the Doppler shift in frequency is due to the source's "catching up" or "leaving behind" the waves it produces. A source moving towards an observer will sound higher than its actual sound at rest. A source moving away from an observer will sound lower than its actual sound at rest. The Doppler Effect can be understood as a decrease in the wavelength as a sounding object moves towards an observer, and an increase in wavelength as the object moves away	Tie any sound-producing object on a string and swing it overhead (a buzzer, beeper, or alarm clock). As the object approaches the observer the sound is of a higher pitch than it is when the object travels away.

Competency Goal 5: The learner will build an understanding of the structure and properties of matter.

Total weight of Goal 5: 20%

Objective	Content	Demonstrations and Activities
5.01 Analyze development of current atomic theory. (4%) • Dalton • J.J. Thomsom • Rutherford • Bohr	John Dalton (1766-1844) was an English chemist who organized several ideas into an atomic theory of matter: 1. All elements are composed of atoms, which are indivisible and indestructible. 2. All atoms of the same element are alike (all have the same mass). 3. Atoms of different elements are different (differ in mass). 4. Compounds are formed by joining of atoms of two or more elements in definite whole-number ratios (e.g. 1:1, 1:2, 3:2, ...) J.J. Thomson, another English scientist, studied cathode rays in gas discharge tubes in the late 1800's. (Cathode rays move from the negative end toward the positive in a sealed gas tube. Most of the gas is removed before a voltage is applied—similar to modern TV tubes.) He is credited for discovering that cathode rays are made up of negatively charged particles, called electrons. (1897) Lord Ernest Rutherford (1871-1937) was a British scientist known for his experiment demonstrating the existence of the nucleus. In the gold foil experiment, he used a radioactive alpha particle source and aimed the particles at a sheet of gold foil. Because alpha particles are fairly large (compared to electrons and protons), he expected most to past directly through. By studying a photosensitive film placed on the far side of the foil, he found most did pass through as expected. However, some alpha particles were deflected from their straight-line path; some even reflected directly back. He concluded: 1. The atom has a large positive nucleus. 2. Most of it is empty space.	

Competency Goal 5: The learner will build an understanding of the structure and properties of matter.

Total weight of Goal 5: 20%

Objective	Content	Demonstrations and Activities
	Niels Bohr, a Danish physicist, expanded on Rutherford's model of the atom in 1913. The electrons orbit the nucleus in definite orbits (similar to rungs on a ladder; there is no stepping between rungs). A key in his model is the idea of energy levels, which is an allowed orbit energy for a given electron. An electron must absorb a definite "jump" (a quanta of energy) to move up a level, and also releases a quanta (seen as a visible photon of light) when they drop a level. Students should know the total number of electrons permitted in each level: 1^{st}–2 2^{nd}—8 3^{rd}—18 4^{th}—32 The modern model is significantly different due to the wave nature of electrons. The speed and location of an electron in an atom cannot both be precisely known (Heisenberg Uncertainty Principle)—only the most probable region for its location within an atom.	
5.02 Examine the nature of atomic structure (4%): • Protons • Neutrons • Electrons • Atomic mass • Atomic number • Isotopes	Protons (discovered by Henry Moseley) are the positive particles found in the nucleus of an atom. Their mass is 1 atomic mass unit (amu) or 1/12 the mass of a Carbon-12 atom. Neutrons (discovered by James Chadwick) have no electrical charge (neutral), and are found in the nucleus of the atom. Their mass is just larger than 1 amu. Electrons (discovered by J.J. Thomson) are negatively charged particles found in the energy levels surrounding the nucleus. Their mass is $1/1837^{th}$ amu—much smaller	Visualizing the Atom

Objective	Content	Demonstrations and Activities
	than a proton. Atomic mass is the mass of an atom in atomic mass units. Atomic mass number (sometimes called simply mass number) is the sum of the protons and neutrons in an atom. These two numbers are approximately, but not exactly, equal. Atomic mass as given on the periodic table is a weighted average of all isotopes (see below) of an atom. When rounded, it is equal to the mass number of the most common isotope. Atomic number is equal to the number of protons in the nucleus of an atom. Each element has a unique atomic number, so these are used in sorting atoms on the periodic table. In a normal, electrically neutral atom, the number of protons and electrons are equal. (Electrons can be lost or gained during chemical reactions.) The symbol for the atomic number is *Z*. A simple formula relates this to the number of neutrons (*N*) and the mass number (*A*): **A = N + Z** For example, Carbon-14 has a mass number of 14 (A), and is known to have 6 protons (Z). As N = A - Z, it must have 14 - 6 = 8 neutrons. Isotopes are atoms of an element, which differ in their number of neutrons, resulting in different atomic masses. These atoms of differing masses are called isotopes of the element. Important isotopes to know are those of hydrogen [protium—0 neutrons (1 amu); deuterium—1 neutron (2 amu); and tritium—2 neutrons (3 amu)] and carbon [Carbon-12 is the most common with 6 neutrons, but carbon-14, used in carbon-dating, is a radioactive isotope with 8 neutrons.].	

Competency Goal 5: The learner will build an understanding of the structure and properties of matter.

Total weight of Goal 5: 20%

Objective	Content	Demonstrations and Activities
5.03 Describe radioactivity and its practical application as an alternative energy source (2%): • Alpha, Beta, and Gamma Decay • Fission • Fusion	Radioactivity is the spontaneous disintegration of the nuclei of certain elements to produce other elements. As this occurs, various types of energy and particles are released from the nucleus. Henri Becquerel, a French chemist in the late 1800's, discovered radiation. His assistant, Marie Curie, and later her husband Pierre made several breakthroughs in the study of radioactive elements. In 1903, the Curies shared a Nobel prize in physics with Becquerel for their discoveries. In 1911, Marie Curie received another Nobel prize in chemistry for her discovery of radium and polonium. Alpha decay is the release of alpha particles during radioactive decay. An alpha particle is a helium nucleus consisting of two proton and two neutrons. The result of alpha decay is to change the radioactive nucleus into one of a different element with an atomic number decreased by 2, and a mass number decreased by 4. For example, (#84) Polonium-212 is converted into (#82) Lead-208. Protection from alpha particles is least difficult. A single sheet of paper can stop them. Beta decay occurs when a radioactive nucleus releases a high-speed electron (beta particles are electrons). The result of beta decay is to increase the original atomic number by one, but leave the mass number of the new nucleus unchanged [e.g. (#43) Technetium-98 is converted into (#44) Rubidium-98]. Beta particles have more penetrating power, but can be blocked by a thin sheet of aluminum. Gamma decay occurs as strong electromagnetic waves (of short wavelength and high frequency) are produced. More	

Competency Goal 5: The learner will build an understanding of the structure and properties of matter.

Total weight of Goal 5: 20%

Objective	Content	Demonstrations and Activities
	penetrating than X-rays, gamma rays are dangerous and require several centimeters of lead to stop. Alpha, beta, and gamma rays can be separated out by passing them through a magnetic field: alpha rays have a positive charge, beta rays have a negative charge, and gamma rays are neutral. An understanding of half-life of a radioactive source is necessary to evaluate risks in using nuclear power. The half-life of a radioactive source is the time required for half of the original substance to decay. Half-life can vary from seconds to years depending on the element. Disposal of used nuclear materials must be studied from the standpoint of the time needed for radioactive products to convert into stable nuclei. Nuclear fission is the splitting of an atomic nucleus into fragments whose combined mass is slightly less than that of the original nucleus. The small loss of mass is converted into large amounts of energy according to Einstein's famous equation: $E = mc^2$. In a fission reactor, the splitting is controlled by slowing down the fast-moving neutrons, which are a product of the reaction. U-235 is a commonly used fuel with krypton and barium as products. Terms that are relevant parts of reactor: fuel, control rods, and moderator. A fission bomb is the result of an uncontrolled fission reaction in which the released neutrons spontaneously support continued reactions. A critical mass of the material is required and huge amounts of energy are released.	

Competency Goal 5: The learner will build an understanding of the structure and properties of matter.

Total weight of Goal 5: 20%

Objective	Content	Demonstrations and Activities
	Fusion is the joining of lighter nuclei to form a single nucleus of slightly less total mass. Again, the missing mass is converted into large amounts of energy. Fusion reactions occur only under extremely high temperatures, such as that found on the sun. The reaction that powers the sun can be broken down into the combining of four hydrogen nuclei into one helium nucleus, two electrons and energy. Scientists have not yet found a way to make fusion reactors successful on a large scale. If they could, fusion could supply our energy needs using low-cost, available fuel (hydrogen is the most abundant element in the universe) with fewer environmental problems than fossil fuel combustion or nuclear fission. Hydrogen bombs (fusion powered) have been developed, but require a fission bomb to be exploded within a sample of a hydrogen isotope to trigger the fusion reaction.	
5.04 Assess the use of physical properties in identifying substances (3%): • Density • Specific heat • Melting point • Boiling point	Before density can be understood, students must have a clear understanding of basic measurement of mass and volume. Mass is covered in objective 1.02. Volume is the amount of space a 3-D object takes up (sometimes described as the number of cubic units inside an object). Its units may be liters or cubic length units (cm^3 or m^3).Water displacement is used to measure volume of irregular objects. Density combines the two as "mass per unit of volume." $D = \frac{m}{V}$ The units are usually g/cm^3 or g/mL. Each state of matter has a given density. Water's density is significant (1 g/cm^3) for a few reasons: 1. Any object with a density larger than 1 g/cm^3 sinks in water while one with a density less than 1 g/cm^3	To find the calorie content of foods, a sample can be burned and used to heat water. The amount of calories produced to heat the water equals the calorie content of the food. Measurement and Density Graphing Density and Volume Phase Changes—Heating and Cooling Curve

Competency Goal 5: The learner will build an understanding of the structure and properties of matter. Total weight of Goal 5: 20%		
Objective	**Content**	**Demonstrations and Activities**
	will float. 2. Using the density of 1 g/cm^3, one finds that 1 liter (or 1000 cm^3) of water has a mass of 1 kg (or 1000 g). Knowing 1 cm^3 or 1 mL of volume equals 1 gram of mass can be useful in determining the mass of a sample of water. Specific heat is a measure of the amount of heat energy needed to raise the temperature of one gram of a substance by 1 degree Celsius. Specific heat varies from substance to substance. Water requires 4.18 Joules/g•C°. (4.18 Joules = 1 calorie, or 1/1000th of a food Calorie) $Q = mC_p\Delta T$ To find the calorie content of foods, a sample can be burned and used to heat water. The number of calories produced to heat the water equals the calorie content. During all phase changes (melting, freezing, boiling, condensing), temperature holds constant while the change occurs. The heat added (in melting) goes into converting the molecules from the solid to liquid phase rather than increasing their average kinetic energy. The heat removed (during freezing) comes from the liquid to solid phase conversion rather than in the loss of kinetic energy. The melting point of a substance is the temperature at which the solid form becomes a liquid. It occurs as vibrating particles within the solid gain enough energy to break into flowing motion to become particles within a liquid. The freezing point is an equal temperature (for water: 0° Celsius). A dissolved solid within a liquid usually causes the freezing/melting point to decrease (e.g. salt	

Objective	Content	Demonstrations and Activities
	sprinkled on icy roads causes them to melt or remain liquid at a lower temperature than usual). The boiling point of a substance is the temperature at which the liquid form becomes a gas. It occurs as flowing particles within a liquid gain enough energy to begin bouncing freely to become bubbles of gas (e.g. bubbles in boiling water). The point of condensation is an equal temperature (for water: 100°Celsius). Dissolving a solid in a liquid will usually cause its boiling point to increase (e.g. coolant contains dissolved solutes that keep radiator fluid from boiling at temperatures near 100 degrees Celsius). Air pressure also affects boiling point, which is decreased at low pressures. So at high altitudes, where air pressure is lower than at sea level, boiling occurs at a lower temperature.	
5.05 Analyze the formation of simple inorganic compounds from elements. (3%)	For a student to understand bonding, the key concept is the formation of a new substance through a chemical reaction. A new substance is formed by the bonding of atoms from the former substances in a new combination. The cause of bonding is the tendency of atoms to reach points of stability in energy and number of outer electrons. Most atoms are most stable with a full outer level of 8. This is referred to as the octet rule. In acquiring 8 outer electrons, atoms can lose, gain, or share their electrons. Metals usually lose electrons, becoming positively charged. Nonmetals usually gain electrons (becoming negatively charged) or share. Bonds formed when a positive atom (one that has lost electrons) is attracted to a negative atom (one that has gained electrons) are called ionic bonds. These usually form between metals	Ionic and Covalent Compounds

Competency Goal 5: The learner will build an understanding of the structure and properties of matter.

Total weight of Goal 5: 20%

Objective	Content	Demonstrations and Activities
	and nonmetals. Ionic bonds usually form crystalline solids, such as many minerals. Examples of ionic bonds are Sodium chloride (table salt) ($NaCl$), /Iron (III) oxide (Fe_2O_3), Magnesium oxide (MgO), and Sodium hydroxide ($NaOH$). Between nonmetals, covalent bonds form as they share pairs of electrons between them. Examples of covalent bonds are Water (H_2O), Carbon dioxide (CO_2), Carbon monoxide (CO), Ammonia (NH_3), Hydrochloric acid (HCl), and the diatomic elements (Br_2, I_2, O_2, N_2, F_2, H_2, and Cl_2). Metallic bonds, a third type, form among the atoms within a sample of a single metal. Electrons in such bonds are shared in a "sea" which flows freely between multiple atoms.	
5.06 Analyze the periodic trends in the physical and chemical properties of elements. (4%) • Symbols • Groups (families) • Periods	Symbols for elements as found on the periodic table primarily originated from Latin names, names of scientists, and names of places. Each begins with a capital letter. Any element name with a two letter abbreviation has the first capitalized and the second lower case. (Co is the symbol for the element cobalt; CO is the symbol for the compound carbon monoxide) A group (family) is any column of elements within the periodic table. Within any of the 18 groups, chemical and physical properties are similar but not identical. Excluding hydrogen (most similar to group 17), groups are indicated in the chart labeled element groups. A period is a row within the periodic table. Along each row, properties vary according to the columns. Periodic	

law states: The properties of elements are periodic functions of their atomic numbers.

Two significant periods (both metals) are placed below the periodic table and named after their first elements:

1. The Lanthanide Series contains “rare earth” elements #57 - #71.
2. The Actinide Series (#89-#103) contains elements, which all contain unstable nuclei, and so are radioactive. Element #93, and all above #95 are not found in nature, but are produced only in the laboratory.

Element Groups

Group Name	**Column Number**	**Characteristics**
Alkali metals	1 (except H)	Soft, gray, reactive metals with low density. Very reactive, tend to lose one electron
Alkaline earth metals	2	Dark metals with relatively low density. Reactive, tend to lose two electrons
Transition metals	3-12	Varied metals, tend to be high density. 1 or 2 outer electrons, brightly colored
Boron family	13	Boron metal, others tend to be lower density metals, tend to lose 3 electrons

Competency Goal 5: The learner will build an understanding of the structure and properties of matter. Total weight of Goal 5: 20%		
Objective	**Content**	**Demonstrations and Activities**

Carbon family	14	Dominated by C which shares electrons, mixed nonmetals, metalloids, and metals
Nitrogen family	15	Nitrogen: a most plentiful atmospheric gas, mixed nonmetals, metalloids, and metals
Oxygen family /Chalcogens	16	Primarily nonmetals, tend to gain two electrons or share in bonding, low density
Halogens	17	Very reactive nonmetal gases, tend to gain an electron in bonding (also hydrogen)
Noble gases	18	Non-reactive gases with full outer level, all very low density

Competency Goal 6: The learner will build an understanding of regularities in chemistry.

Total weight for Goal 6: 32%

Objective	Content	Demonstrations and Activities
6.01 Identify and classify the common chemical reactions that occur in our physical environment and in our bodies (3%): • Oxidation and reduction • Polymerization	Oxidation is a reaction in which the atoms or ions of an element lose one or more electrons and hence attain a more positive (or less negative) oxidation state. Reduction is a reaction in which the atoms or ions of an element gain one or more electrons and hence attain a more negative (or less positive) oxidation state. A redox reaction, or oxidation-reduction reaction, is a reaction that involves the transfer of electrons between reactants during a chemical change. Examples of oxidation reactions are the combustion of gasoline in a car engine, the burning of wood in a fireplace, and the "burning" of food in our bodies. Reduction usually means the loss of oxygen from a compound (e.g. iron oxide loses oxygen and is reduced to metallic iron). No oxidation occurs without reduction and no reduction occurs without oxidation. Cellular respiration is a redox reaction. Polymers are large molecules composed of many small molecules that are bonded together. The small units that make up the polymer are called monomers. A polymer may contain thousands of monomers. The two most common methods of joining monomers are addition polymerization and condensation polymerization. Many biological compounds in your body are polymers. These include proteins composed of amino acids and deoxyribonucleic acid (DNA) composed of nucleotides. There are also synthetic polymers, such as polyethylene, polyesters, PVC, dacron, and orlon.	1. Zinc wrapped around iron nail -iron reduced. Copper wrapped around iron nail - iron oxide. (Examples- environment- iron rust, cellular respiration body) 2. Place steel wool in a test tube and invert the tube in a beaker of water. The water level should be approximately one cm into the opening. Observe after a few days. Mix 5 ml of white glue in a small plastic cup. Add 1 ml of borax solution (4 g sodium borate in 96 ml of water) drop by drop as you stir. A sticky ball will be formed. Remove from the cup, rinse and form a ball. The borax cross-linked with the white glue to form a synthetic rubber.

Competency Goal 6: The learner will build an understanding of regularities in chemistry.

Total weight for Goal 6: 32%

Objective	Content	Demonstrations and Activities
6.02 Identify the reactants and products and balance simple equations of various types. (8%) • Single replacement • Double replacement • Decomposition • Synthesis • Combustion	Balancing an equation involves placing coefficients in front of the correct formulas of substances to result in an equal number of atoms of each element reacted and produced. Balancing is required for a realistic understanding of an equation according to the conservation of mass law: Matter (including conversion into energy) cannot be created or destroyed in any chemical reaction. Students often change subscripts within chemical formulas. This is not permissible, as it changes the identity of a substance. A single replacement reaction has the following form: $A + BX \rightarrow AX + B$ Example: $2Al + 3ZnCl_2 \rightarrow 2AlCl_3 + 3Zn$ As one type of atoms switches its bond from one element to another, an easy characteristic to look for is the single element left on both sides. A double replacement reaction has the following form: $AX + BY \rightarrow AY + BX$ Example: $BaCl_2 + H_2SO_4 \rightarrow BaSO_4 + 2HCl$ Both atoms switch the elements they bond with in this type of reaction. It is best identified by the pairs of elements found in both compounds on each side of the reaction. Common examples of double replacement reactions are acid-base neutralization reactions in which: Acid plus base yields water plus salt. (To better see the double replacement, water is best understood as HOH, or hydrogen bonded to the hydroxide ion.)	The Law of Conservation of Mass Four Types of Reactions Lab

Competency Goal 6: The learner will build an understanding of regularities in chemistry. Total weight for Goal 6: 32%		
Objective	**Content**	**Demonstrations and Activities**
	A decomposition reaction has the following form: $AX \rightarrow A + X$ Example: $2HgO \rightarrow 2Hg + O_2$ One reactant breaks into two or more products. Another common decomposition reaction is the breakdown of water to yield hydrogen gas plus oxygen gas. A synthesis reaction takes the following form: $A + X \rightarrow AX$ Example: $2CO + O_2 \rightarrow 2CO_2$ All reactants in a synthesis reaction combine to form a single product. One class of examples is the oxidation of metals: metal plus oxygen yields metal oxide. A combustion reaction takes the following form: hydrocarbon + oxygen → carbon dioxide + water Example: $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$ Combustion that is incomplete produces carbon monoxide, a poisonous gas. In an effort to make gasoline-burning cars safer, the permitted CO in the exhaust is regulated.	
6.03 Measure the temperature, pressure, and volume of gases and assess their interrelationship: (3%) • Boyle's Law • Charles' Law	Gases have neither definite shape nor definite volume. A gas will fill all of the available space in any container, and will expand without limit if not contained. Gases can be compressed. The addition of heat energy increases the kinetic energy of the gas molecules, and thus, causes expansion. A decrease in heat energy reduces kinetic energy and limits expansion. Boyle's law states that the volume of gas is inversely proportional to its pressure. This assumes fixed temperature and fixed amount of gas. When a gas at a fixed temperature is allowed to expand, its pressure will drop. When gas is forced into a smaller container, its pressure will increase.	

Competency Goal 6: The learner will build an understanding of regularities in chemistry. Total weight for Goal 6: 32%		
Objective	**Content**	**Demonstrations and Activities**
	Charles' law states that the volume of a gas varies directly with its temperature. This assumes fixed pressure and fixed amount of gas. When a gas at fixed pressure increases in temperature, it will expand. When the temperature decreases, the gas will contract.	
6.04 Analyze aqueous solutions and solubility. (8%) • Ionic Substances • Covalent Substances	A solution is a homogeneous mixture of two or more substances in a single state. All solutions are made of a solvent (that which does the dissolving) and a solute (that which gets dissolved). An aqueous solution is any solution in which water is the solvent. Solubility is the measure of a substance's ability to dissolve in a given solvent at a given temperature. A substance that cannot be dissolved in a given solvent is called insoluble. The solubility of most solids increases as solvent temperature increases. The solubility of gases decreases as solvent temperature increases. External pressure has little affect on the solubility of solids and liquids but greatly affects the solubility of gases. Increased external pressure increases the solubility of gases in a liquid and vice versa. The solubility of a substance can be represented in a graphical form called a solubility curve. Substances of similar bond types can form solution. Substances with different bond types will not form solution. This is called "like dissolve like".	
6.05 Assess the indicators of chemical change including: (6%) • Development of a gas • Formation of a precipitate • Change in color	A chemical reaction is the process by which physical and chemical properties of the original substances change as new substance is formed with different properties. Substances can be described as non-reactive, slightly reactive, reactive, and highly reactive. Metal, non-metals, and metalloids have varying chemical properties that are periodic to their atomic number.	Wear goggles! Place about 50 ml of a strong (at least 1 M) solution of HCL in a flask. Add several grams of zinc metal; cover immediately with a balloon. The reaction will produce hydrogen gas, which will blow up the balloon. When the reaction is finished, remove the balloon, tying it as quickly as possible. Tape the tied balloon to a ring stand or other non-flammable projecting surface.

Competency Goal 6: The learner will build an understanding of regularities in chemistry. Total weight for Goal 6: 32%		
Objective	**Content**	**Demonstrations and Activities**
	The key to determining if a change is chemical is locating a new substance, which has formed as a result of the reaction. Most reactions that produce bubbles as they occur are easily identified. A group of such reactions are the "eating" of metals by an acid. The gas most commonly produced is hydrogen, as with the following: hydrochloric acid plus zinc metal yields zinc chloride + hydrogen gas. Producing a gas should not be confused with a gas coming out of solution, such as carbon dioxide "fizz" produced when the cover is removed from a soft drink bottle. Carbon dioxide is already dissolved in the soda, and only appears as bubbles due to the sudden decrease in pressure. A precipitate is a solid that suddenly settles out of a liquid or gaseous mixture. If two or more chemicals in solution are mixed and a precipitate forms, it is identified as new substances because, unlike the original dissolved substances, it is insoluble. An example reaction is: $KCl + AgNO_3 \rightarrow KNO_3 + AgCl$ The precipitate formed is silver chloride, a white substance. The arrow indicates it settles out of solution. Color change is another indicator of the presence of a new substance. In this example, a reaction between two water solutions produces a bright yellow solution of lead chromate: $K_2CrO_4 + Pb(NO_3)_2 \rightarrow 2KNO_3 + PbCrO_4$ Although potassium chromate in solution has a faded yellow color, the lead chromate is boldly yellow, and has a precipitate, which settles to the bottom.	Tape a match to the end of a meter stick and light it. Bring it close to the balloon. It will burn suddenly. Make a water solution of potassium chloride and silver nitrate (salts). Add them together into a common beaker. The precipitate formed is silver chloride, a white substance. $KCl + AgNO_3 \rightarrow KNO_3 + AgCl$

Competency Goal 6: The learner will build an understanding of regularities in chemistry.

Total weight for Goal 6: 32%

Objective	Content	Demonstrations and Activities
6.06 Compare and contrast the composition of strong and weak solutions of acids or bases: (4%) • Degree of dissociation or ionization • Electrical conductivity • pH	Acids have a sour taste, contain hydrogen, react with metals to produce hydrogen gas, react with bases to produce salt and water, are corrosive and are electrolytes (e.g. vinegar, digestive juices in stomach, and hydrochloric acid.) Bases have a bitter taste, feel slippery to the skin, react with acids to produce salts and water, and are electrolytes (e.g. ammonia, drain cleaners and antacid tablets). Concentration of a solution is a measure of the amount of solute in an amount of solvent or solution. "Concentrated" means a large amount of solute in a solvent. "Dilute" means a small amount of solute in a solvent. For example, a small can of frozen "concentrated" orange juice is "diluted" with water to make a pitcher of orange juice. (Do not include percent by mass or molarity; leave this for chemistry.) The strength of an acid or base solution depends on how completely a compound is pulled apart to form ions when dissolved in water. This is called the degree of dissociation or ionization. A strong base or strong acid dissociates or ionizes completely in solution. (A 10% solution of hydrochloric acid is more concentrated than a 2% solution of hydrochloric acid, but hydrochloric acid in both solutions is still a strong acid.) Acids and bases are electrolytes. This property is due to the presence of ions in the solutions. Both acid and base solutions will conduct electricity. Acids produce H^+ ions and bases produce OH^- ions in solution.	Use a conductivity tester and test a number of substances. Both acidic and solutions will conduct electricity. Test orange juice, salt water, sugar, ammonia and other household items. Follow all safety rules. The pH Scale is Logarithmic Acids, Bases, and Indicators Lab

Competency Goal 6: The learner will build an understanding of regularities in chemistry. Total weight for Goal 6: 32%		
Objective	**Content**	**Demonstrations and Activities**
	The pH scale goes from 1 to 14, with one being the most acidic and 14 being the most basic (alkaline). Seven is neutral. Indicators that identify acids and bases are litmus paper, pH meter, pH paper, and phenolphthalein. Strong acids: hydrochloric, sulfuric, nitric Weak acids: acetic, carbonic, Strong bases: sodium hydroxide, potassium hydroxide Weak bases: ammonia, aluminum hydroxide, iron hydroxide	

Speed, Distance, and Time

This activity uses carts, ramps and photogates to study the relationship between speed, distance, and time. First distance is kept constant, then speed, and then time. Students enjoy working with photogates and pick up the basic relationship between distance and time in determining speed. Contributed by T. Brown, RHS, Durham

Standard Course of Study Goals and Objectives

1.01 Analyze uniform and accelerated motion:

- Uniform motion is motion at a constant speed in a straight line (constant velocity).
- The rate of change in velocity is acceleration.

Background

speed = distance/time

This formula can be better understood if we keep either speed, distance, or time at a constant value, and watch how the other variables change. The way we will study this is to roll a cart down a ramp.

Materials

cart with flag
ramp for the cart
stand to support ramp
photogate timing set
meter stick
marking pen

Procedure

Test 1: Keeping Distance Constant

- Set up the ramp so the cart can roll down smoothly. Do NOT make it too steep. Do tests from lowest to highest possible positions.
- Place the photogates on the lower part of the ramp at a distance of 40.0 cm apart.
- Test to make sure the flag on the cart cuts the beam of each photogate. Set the timer on “interval” with “A” and “B” lights on.
- Start the cart from 4 different heights and record the time for each height.

Data Table 1: Keeping **Distance** Constant:

Trial	Starting Height (cm)	Distance (cm)	Time (sec)	Speed (cm/sec)
1.		40.0		
2.		40.0		
3.		40.0		
4.		40.0		

Test 2: Keeping Speed Constant

- Now keeping the starting height constant, change the distance between photogates to the values shown in the chart.
- Start the cart from the *same height* for each trial, and record times.

Teacher Note: Students will observe that the speed changes slightly during the trial. The reason is that the increased distance down the ramp includes higher speed travel due to acceleration. The final speeds will be the same (constant), but the average speeds will not. An average speed over a short interval at the top of the ramp will be lower than an average speed over the length of the ramp (even for carts released from the same height). This can be avoided with a modified setup in which distances and times are measured on level track continuing from the base of the ramp.

Data Table 2: Keeping **Speed** Constant

Trial	Starting Height (cm)	Distance (cm)	Time (sec)	Speed (cm/sec)
1.		30.0		
2.		50.0		
3.		70.0		
4.		90.0		

Test 3: Keeping Time Constant

1. Now to keep the time constant, set the distance at the same values as we used in Test 2, but start the cart at *whatever height* necessary to get time to be constant. Begin with lowest height and go to the highest.
2. Do not spend too much time getting exactly the same value - to the nearest 0.03 seconds is close enough. (Example: A time of 0.5611 sec is O.K. for a goal time of 0.5321 seconds.)
3. Record starting height and times.

Data Table 3: Keeping **Time** Constant

Trial	Starting Height (cm)	Distance (cm)	Time (sec)	Speed (cm/sec)
1.		30.0		
2.		50.0		
3.		70.0		
4.		90.0		

Use a calculator to calculate the speed for each of the twelve trials.

Questions

1. In Test 1: the distance was kept the same. What happened to the times when the cart started with higher and higher speeds? Explain why this makes sense.
2. In Test 2: the speed was kept constant. What happened to the times when the cart went further and further distances? Explain why this makes sense.
3. In Test 3: the time was kept constant (if possible). What happened to the speed we needed to reach for the cart to travel further distances? Explain why this makes sense.
4. When was the cart moving the fastest—at the top or bottom? Explain how you could use this equipment to find its fastest speed.

“Blood Drops” in Motion (or Seed Trail)

In this activity, students measure the changing speed of a hypothetical student who is moving around the lab area with blood dripping from her finger. Place round stickers on the floor in the lab area to simulate the blood drops. Place them closer together when she is at a sink and farther apart when she is moving between sinks. (An alternate activity to the Blood Drops in Motion laboratory is to use a bag of seeds that has a hole in it. Because of the hole the seeds would be dropping on the ground as someone carried the bag.) In this activity, students will see that the slope of a velocity-time graph is speed. An excellent way to demonstrate this: Make two graph paper overheads. Plot Total Distance vs. Time on one and Speed vs. Time on the second one (use the same time scale). Lay one on top of the other. Steeply sloped areas on the Distance vs. Time graph should be aligned with high points on the Speed vs. Time. Shallow slopes will align with low speeds. Contributed by T. Brown, RHS, Durham.

Standard Course of Study Goals and Objectives

1.01 Analyze uniform and accelerated motion:
- Uniform motion is motion at a constant speed in a straight line. (constant velocity)
- The rate of change in velocity is acceleration.

Background

An unfortunate incident has occurred: In working with some glassware, a student has accidentally cut herself. She goes to the sink to clean her cut but finding the water is off, quickly moves on to the second sink to check there. Also no luck; she moves on to the third. As she finally reaches the last sink, she finds the water shut-off valve and a first aid kit right next to it. Turning it on, she finally gets the water she needs to clean up and bandage her cut.

However, in the meantime she has left a trail of blood drops as she passed each sink. Perhaps this part was imagined, but… as this occurred, she felt like she was moving in s-l-o-w motion. We will be looking at the evidence she has left, and assuming that her blood is dripping at the same rate as her heartbeat—once per second.

Recall that speed is the change in distance during each unit of time. We will be directly measuring distances, and finding her actual speed as she moved around the room.

Materials

accident scene (round stickers simulating the student’s path)
ruler/meter stick
graph paper

Procedure

1. Knowing that our series of points (the drops) were formed with a certain regularity (1 every second), measure the distance between each drop. Note: Also <u>number</u> the drops for easier reference. Place all information in the table provided.

2. Find the total distance back to the first drop by adding the intervals. Fill in this column in the data table.
3. Using these measurements, find her *speed* as she moved from one sink to the next. List these in the table as well.
4. From the data in the table, make the following 2 graphs:
   a. Total Distance from "Zero Drop" vs. Time
   b. Speed vs. Time

Questions

1. Two columns in your data table should be identical. Which two are they and why?
2. Describe the way in which she moved from your sink to the next one. Mention if she sped up, slowed down, or moved at about a constant speed for more than 2 seconds. Be specific with number values. (Ex: Her speed from seconds 10 to 14 was about 20 cm/sec.)
3. Using your data table, find the average speed for the entire trip. Show your work. Does it make sense? Why or why not?
4. Compare your two graphs. What is the meaning of the slope of your Total Distance vs. Time graph? How could you use it to make the Speed vs. Time graph?
5. Looking at your graphs, give at least one example of an observation about the person's motion that is easier to see using a graph than just a table of measurements.

Data Table: Blood Drops Distances and Times

Drop Number (sec)	Drop-Drop Distance (cm)	Total Distance (cm)	Speed (cm/sec)
0	---	0	0
(0.5)		---	
1	---		---
(1.5)		---	
2			
(2.5)			
3			
(3.5)			
4			
(4.5)			
5			
(5.5)			
6			
(6.5)			
7			
(7.5)			
8			
(8.5)			
9			
(9.5)			
10			
(10.5)			
11			
(11.5)			
12			
(12.5)			
13			
(13.5)			
14			
(14.5)			
15			
(15.5)			
16			
(16.5)			
17			
(17.5)			
18			
(18.5)			
19			
(19.5)			
20			….

Running Stairs to Find Horsepower

In this activity, students find a specific power for both their arms and legs as they lift weight. Some calculations are required, but they are broken down into steps. Concept R. Quackenbush RHS, Durham; adapted by J. Harris RHS, Durham

Standard Course of Study Goals and Objectives

1.03 Analyze the conservation of energy and work:
Work
Power
Kinetic Energy
Potential Energy
Conservation of Mechanical Energy

Background

Power is a measure of how fast work can be done on or by an object. During this lab, you will measure the amount of work required to do two different tasks and will time yourself as you do them. From this information, you can calculate the power you can provide using your arms or legs.

Materials
1 kg mass
stairs
meter stick
stopwatch

Procedure

Part I: Power of Your Arms
1. Stand while holding a 1 kg mass in your hand. Start with your arm held straight down by your side.
2. Lift the mass up to your shoulder, and have your partner measure the distance it travels upward. List this in the table.
3. Using the stopwatch, determine the time required to lift the 1 kg mass up (and back down) 25 times. Do this as fast as possible without hurting yourself. Be careful not to drop the mass.
4. Using half of the total time, fill in the data table.
5. How much work did your arm do? (Work = Force x Distance) Remember to use units!
6. How powerful is your arm? (Power = Work / Time) Remember to use units!
7. How much horsepower does your arm exert? (1 horsepower = 746 Watts)

Data Table: Power of Your Arms

Weight (N)	Height (m)	Number of times	Total distance (m)	Half time (sec)

Part II: Your Power (Legs Lifting You)

1. Locate a staircase near the classroom (outdoors if the weather is nice). Count the number of steps in the staircase. Record in the table below.
2. Measure the height of one step (<u>in meters</u>). Record in the table below.
3. Convert your weight from pounds (lbs) into Newtons. 1 lb = 4.45 Newtons
4. When your partner is ready with the stopwatch, run up the steps as quickly (and safely) as possible. Record the time in the data table.
5. How much work did your legs do? (Work = Force x Distance) Remember to use units!
6. 6. How much power do you have in your legs? (Power = Work /Time) Remember to use units!
7. How much horsepower do your legs have? (1 horsepower = 746 Watts)

Data Table: Legs Lifting You

Number of Steps	Height of step (m)	Your Weight (N) (lbs x 4.45 lbs/N)	Total vertical distance (m) (# of stairs x height)	Time up Steps (sec)

Questions

1. Why didn't we include the distance your arm moved back down from your shoulder? (Weren't you doing work then also?)
2. Why did we divide the time you lifted the weight in half?
3. Compare your arm's power to 1 HP. Does the answer surprise you?
4. Compare your (legs') power to 1 HP. Did you have 1 HP? Why or why not?

Build a Light Bulb

In this activity, students will build a simple light. The activity will demonstrate the relationship among voltage, current, and resistance. The students will observe the conversion of chemical, electrical, heat and light energy. The students can see how resistance varies in response to different properties—thickness of the wire (iron and steel wool, different thickness of the copper), length of wire (15 cm and 6 cm iron wire), and type of material (copper and iron). Contributed by C. Elliott, SIHS, Statesville

Standard Course of Study Goals and Objectives

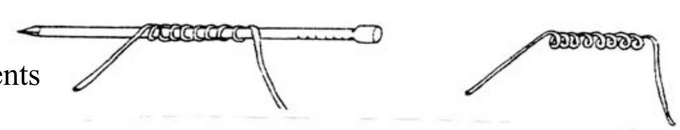
3.03 Analyze direct current electrical circuits:
- Electrical potential difference.
- Resistance.
- Ohm's Law.
- Simple direct current circuits.
- Series circuit.
- Parallel circuit.

Materials
(per group)
6 or 9-volt batteries
clay
glass jar
strands of wire (to act as filament)
- copper magnet wire (very small), 15 cm long
- copper wire (small), 15 cm long
- copper wire (larger), 15 cm long
- section of upbraided iron picture wire, 6 cm long
- section of upbraided iron picture wire, 15 cm long
- steel wool

birthday candle (removes oxygen)
small nail
2 -45 cm insulated pieces of wire (leads)
*Alternative: Allow students to choose which type of wire to use.

Procedure

Step 1: Make the Filaments

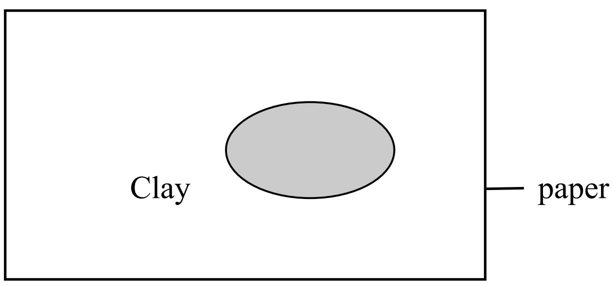


Start with the wires
15 cm copper magnet wire (very small)
15 cm copper wire (small)
15 cm copper wire (larger)
10 cm section of upbraided iron picture wire

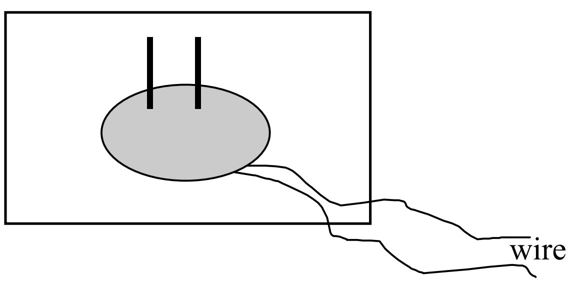
15 cm section of upbraided iron picture wire
steel wool

Wrap the wires around the nails to form a coiled filament. Each turn of wire should be close to the next, but not touching. Leave 2 cm of straight wire at each end.

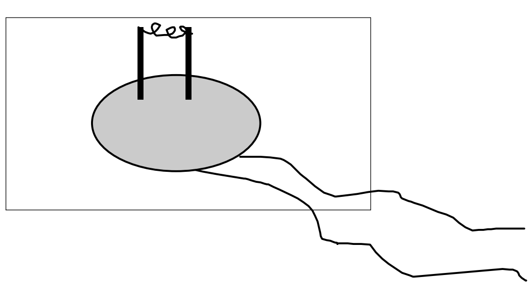
Step 2: Make the base
Flatten the clay on a piece of paper; make it larger than the jar opening.



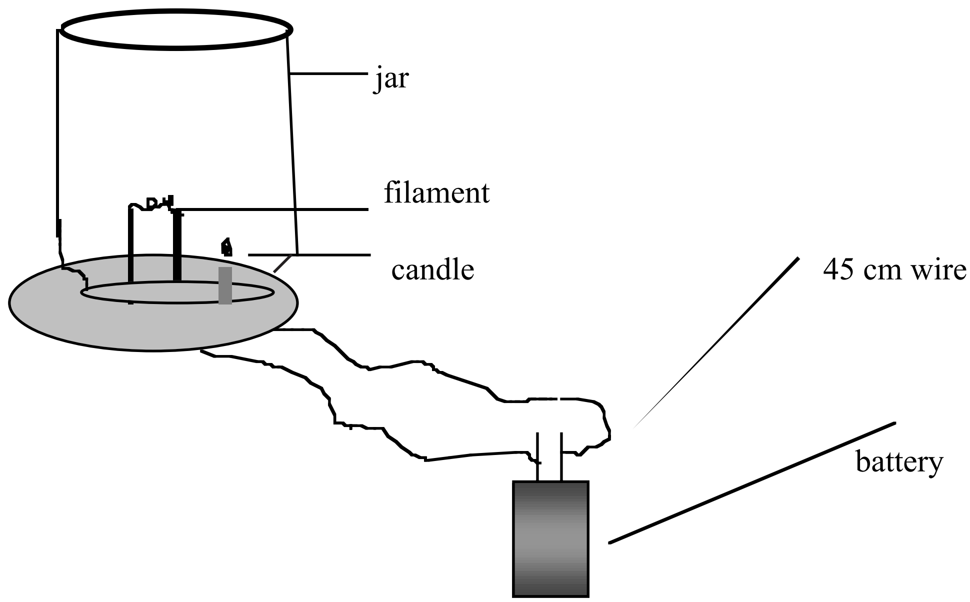
Stick the ends of the two wires through the clay near the center. The tops of the wires should be as far apart as the filament is long.



Step 3: Attach the filament
Attach the filament to the top of the two 45 cm insulated wires. Wrap the 2 cm of straight wire of the filament around the exposed part of the insulated wires.



Step 4: Complete the light bulb and test for brightness of light
Place the clear jar over the filament and press it to the base. Attach the free ends of the connecting wires or clips to the battery. Test each of the filament wires and compare the brightness of the light. (A birthday candle may be used to remove some of the oxygen. Place the candle in the jar and let it burn out before connecting to the batteries.)



Data Table

Wires	Brightness	Time to burn out
15 cm copper (very small)		
15 cm copper (small)		
15 cm copper (large)		
6 cm iron		
15 cm iron		
steel wool		

Questions
1. List the wires in the order that produced the brightest light to dullest light.
2. Does the thinness of the wire affect the brightness or resistance? Support your answer.
3. Does the length of the wire affect the brightness or resistance? Support your answer.
4. Does the type of wire affect the brightness or resistance? Support your answer.
5. If you were to design a light bulb, how would you ensure that it would burn brightly and last for a long time?
6. Describe the energy changes.

Build Series and Parallel Circuits

In this activity the students will design and build circuits and measure the current and voltages. Contributed by C. Elliott, SIHS, Statesville

Standard Course of Study Goals and Objectives

3.03 Analyze direct current electrical circuits:
- Electrical potential difference.
- Resistance.
- Ohm's Law.
- Simple direct current circuits.
- Series circuit.
- Parallel circuit.

Background

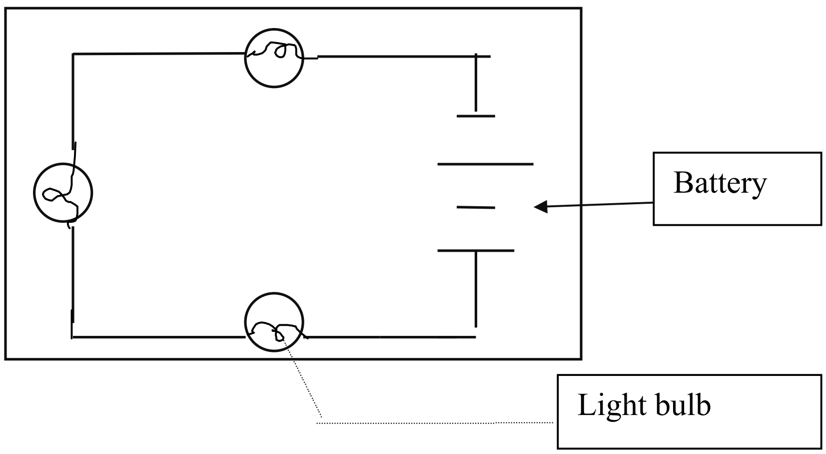
There are two types of electrical circuits. Series circuits have only one path for electrons to take. Parallel circuits have two paths for the electrons to take.

Materials
large sheet of heavy paper
aluminum foil or wire
tape
ornamental lights (3) with sockets (cut individual lights from set of ornamental lights)
battery (6-, 4-C in a packet, small 9-volt-with connectors)
pencil
ammeter
voltmeter

Procedure
1. On the large sheet of paper, draw a series circuit that contains three lights and one battery source. USE THE CORRECT SYMBOLS.
2. Construct the series circuit using the light, foil or wire, switch and battery. Test the setup.
3. Test for the amount of current and voltage. An ammeter measures electric current and should be connected in series with the circuit. A voltmeter measures potential difference across part of a circuit and should be connected in parallel across a part of the circuit.
4. Draw and construct a parallel circuit. Test the setup. Note the brightness of the lights. What happens with one bulb is removed?
5. Test for the amount of current and voltage.

Data Table

Circuit	Current	Brightness	Bulb Removed	Voltage
Series				
Parallel				



Charting Magnetic Fields

In this activity the students will chart the magnetic field of a bar magnet and a horseshoe magnet with a compass. Contributed by C. Elliott, SIHS, Statesville

Standard Course of Study Goals and Objectives
3.04 Analyze the practical applications of magnetism and its relationship to the movement of electrical charge.

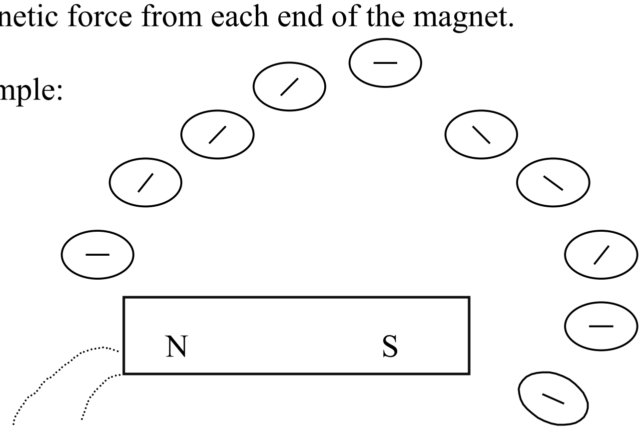
Background
A magnet exerts forces. In this activity the students will map the magnetic field around a magnet, two magnets, and a horseshoe magnet.

Materials
(each group)
2 bar magnets
small compass
pencil
horseshoe magnet
large sheet of paper

Procedure

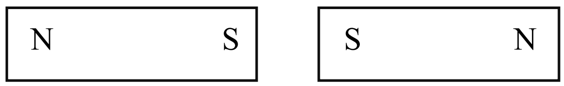
1. Center one bar magnet in the middle of the large sheet of paper. Draw around the magnet. Place the compass near the ends of the bar magnet. Place a dot to show the direction of the needle on the compass. Move the compass and line the compass needle with the dot. Continue until the line returns to the magnet or goes off the page. Connect the dots to show the magnetic field around the magnet. Draw at least 10 lines of magnetic force from each end of the magnet.

Example:

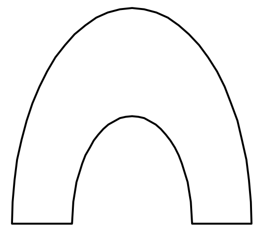


2. Repeat the procedure with two bar magnets, place the north and south poles about 3 centimeters apart.

3. Repeat the procedure with two bar magnets, place the south (north) and south (north) poles about 3 centimeters apart.



4. Repeat the procedure with horseshoe magnet.



Questions

1. Describe the lines of the magnetic field around a bar magnet, horseshoe magnet.
2. How does the magnetic field change when like poles were together? Opposite poles?
3. Where is the magnetic field the strongest? Explain the reasons based on your evidence.

Making Waves with Sound

This lab is designed to be done outside. Divide students into groups, then cycle from group to group, observing and checking several demonstrations at each stop. Supplies for this lab may often be purchased in a "Dollar Store." The items needed: Slinkies ®, slide whistles, rippled "sling" sound tubes, and noise tubes that have a weight inside that produces a sound as it falls slowly through the tube. Contributed by J. Whitehurst and T. Brown, RHS Durham

Standard Course of Study Goals and Objectives

4.01 Analyze the characteristics of waves:

- Wavelength.
- Frequency.
- Period.
- Amplitude.

Materials

(each group)
[what kind of timer, for measuring speed of sound?]
Slinky
slide whistle
rippled "sling" sound tube
noise tube ("Q" tube)

1. **Speed of Sound**

Calculate the speed of sound using an echo. Clap your hands 100 m from a building and time how long it takes for the echo to return.

Speed of sound = $\boldsymbol{v} = \dfrac{\textit{\textbf{distance sound wave travels}}}{\textit{\textbf{time}}} = \dfrac{\textbf{200 } \boldsymbol{m}}{\_\_\_\textbf{sec}} = \_\_\_\_\_\_\_$

2. **Demonstrate Longitudinal Wave with a Slinky**

Use a "slinky" to make a longitudinal wave: ____________ Teacher's initials.

3. **Demonstrate Transverse Waves with a Slinky**

a. With a partner, demonstrate a transverse wave with 2 cycles: _______ (initialed)

b. With a partner, demonstrate a transverse wave with 3 cycles: _______ (initialed)

c. With a partner, demonstrate a transverse wave with an amplitude = 15 cm: (Think total height = 30 cm) _______ (initialed)

d. With a partner, demonstrate a transverse wave with an amplitude = 30 cm: _______ (initialed)

4. **Sounds with a Slide Whistle**

Using a slide whistle, slide the rod up and down to change the sound you hear. Find points of high pitched and low pitched sound.

a. Demonstrate a low pitched sound: ____________ (initialed)
b. Demonstrate a medium pitched sound: ____________ (initialed)
c. Demonstrate a high pitched sound: ____________ (initialed)
d. Describe how far the rod is slid inside when comparing a high and low sound:

5. **Sounds with a "Sling" Sound Tube**

Using the rippled plastic tube, swing it over your head. *Make sure you have enough space around you before beginning to swing.* Depending how fast you swing it, you will hear different sounds.

a. Demonstrate a low pitched sound: ____________ (initialed)
b. Demonstrate a medium pitched sound: ____________ (initialed)
c. Demonstrate a high pitched sound: ____________ (initialed)
d. The faster you swing the pipe, the more waves you "pack" inside it. Does this make sense with the pitch (frequency) you hear? Explain why.

6. **Sounds with a "Q" Tube**

One of the tubes has a weight inside which will fall when the tube is turned over and back again.

a. Make both the high and low sounds as it falls each way: _________ (initialed)
b. Which direction is the weight inside going when it makes a high sound? (Toward or away from the open end?) Explain.

Visualizing the Atom

Students make models of different atoms using colored dots. Making the dots for each type of subatomic particle is best done using a hole punch and colored paper. Folding the paper to the maximum width the punch can accept speeds up punching. Place “holes” in envelopes by color. Contributed by T. Brown RHS, Durham

Standard Course of Study Goals and Objectives

5.02 Examine the nature of atomic structure:
- Protons
- Neutrons
- Electrons
- Atomic mass
- Atomic number
- Isotopes

Procedure
* Using the colored paper dots provided, construct models of the elements given.

Colors Key: Red - protons
Purple - neutrons
Yellow - electrons

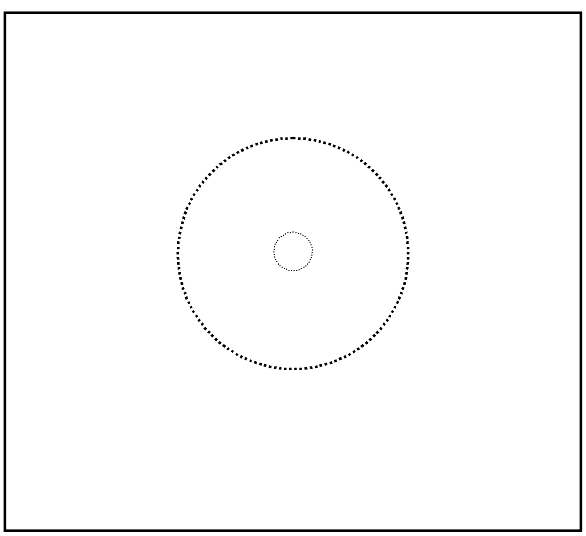
Elements Key:

20	Atomic Number
Ca	Chemical Symbol
40.08	Atomic Mass

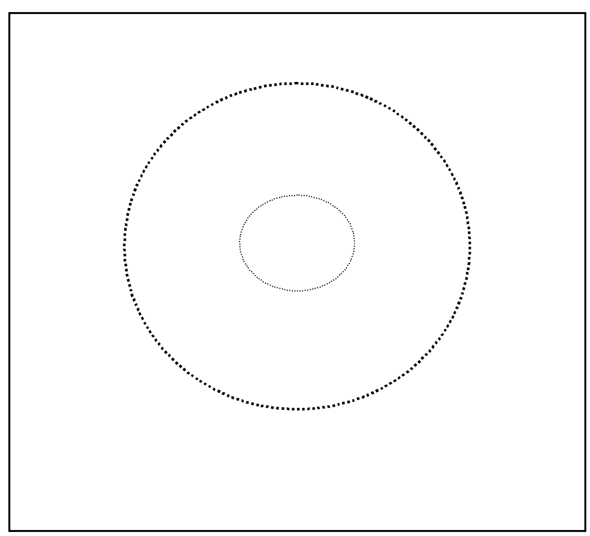
- An alternate way to write out the information for Calcium as above is: $^{40}_{20}Ca$ *
- The first electron energy level can hold **up to 2 electrons**, the second can hold **up to 8 electrons.**

Using the glue provided, *neatly* attach the dots given where needed:

$^{1}_{1}H$

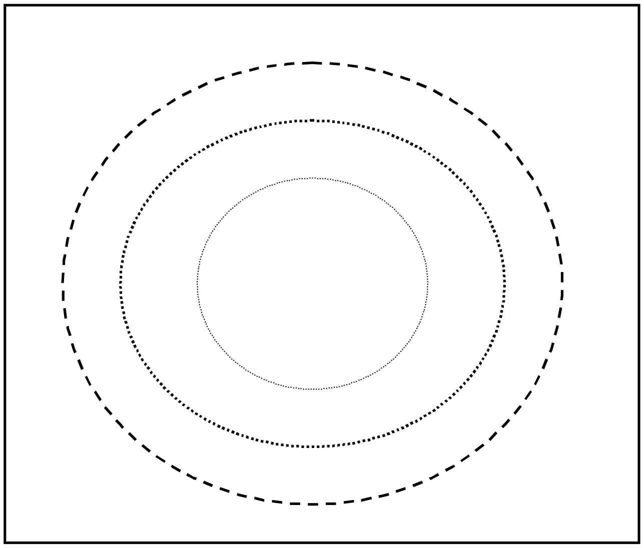


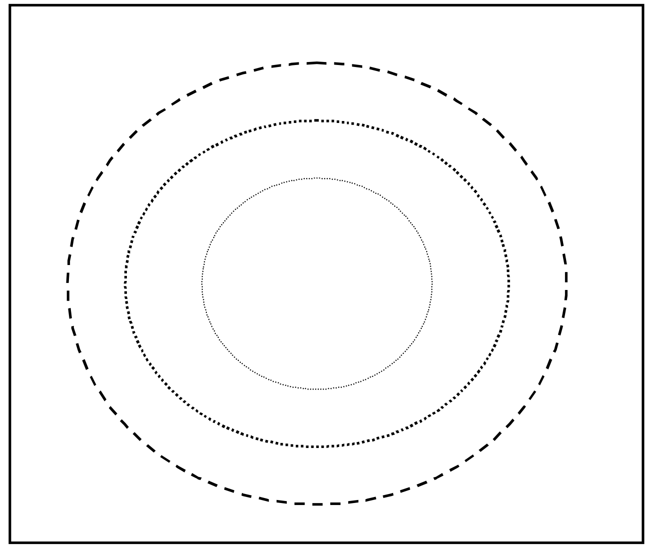
$^{4}_{2}He$



Isotopes of Carbon: Fill in each model with protons, neutrons, and electrons.

$^{14}_{6}C$ $^{12}_{6}C$





Questions

1. What does it mean in the model to have the protons and neutrons shown as larger paper dots than the electrons? (Are the electrons small enough?)
2. The symbols above each model's box are in a chemical symbol shorthand used in nuclear chemistry. Interpret each part of this symbol: $^{\text{Number A}}_{\text{Number B}}\textit{Chemical Symbol}$

   What does "Number A" mean?
   What does "Number B" mean?
3. What is an <u>isotope</u>? Use your models above or a glossary to explain:
4. Give at least one good way our models could be improved to make them more realistic:
5. What is special about "Carbon 14"?

Measurement and Density

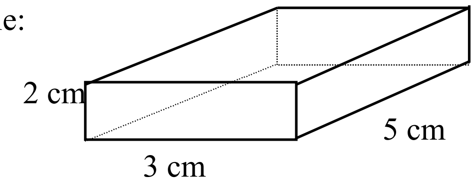
Sequenced by T. Brown, RHS, Durham

Standard Course of Study Goals and Objectives
5.04 Assess the use of physical properties in identifying substances:
- Density.
- Specific heat.
- Melting point.
- Boiling point.

Measurement and Density
The lesson begins by reviewing length, area and volume. Measurement of mass is briefly demonstrated, and then density is introduced to tie the ideas together.

Length:
    Draw a line on overhead/board and measure it
Area:
    Draw a box built on the line: recall formula for Area = Length* Width
    Find its area in cm^2.
Volume:
    Place a cube (wood suggested) on the overhead - How is it different?
    Trace around its base - What measurement is missing? (Height!)
    Recall formula for Volume = Length * Width * Height
    Units: $length^3$ OR Volume is "how many cubes fit in an object."
Fluid Units:
    Also can measure like fluid- gallons of milk or gasoline
    Metric - liters
    Use rectangular container marked with cm in each dimension
    Find volume: 10 cm x 10 cm x 10 cm = 1000 cm^3
    Mention: 1000 cm^3 = 1 liter (also = 1000 ml)
    Verify: (some don't believe it when they see it!)
        Pour a 1-liter bottle/graduated cylinder into a 1000 ml rectangular container
    Therefore: 1 cm^3 = 1 ml
Mass:
    Depending what it is made of, object has a certain mass.
    Use a balance and determine mass.
Density:
    Mass compared to volume - keep volume at 1 "unit"^3
    Requires "per volume unit."
    State the volume with units: D = M/V
    Check - does it float on water?

Example: Mass = 15 grams



1. **1.** Volume = 2 cm x 3 cm x 5 cm = 30 cm^3
2. **2.** Density = 15 grams/30 cm^3 = 0.5 g/cm^3 YES, it will float on water.

Graphing Density and Volume

The recommended objects for this lab are fairly standard metal density samples (cylinders). Any object may be substituted as long as it fits into your graduated cylinders (rocks, metal ball-bearings, etc.). The graphing portion of the lab is meant to give an example of direct and inversely proportional quantities. (Density is inversely proportional to volume, and directly proportional to mass.) Contributed by W. Whitmore RHS, Durham

Standard Course of Study Goals and Objectives

5.04 Assess the use of physical properties in identifying substances:

- Density.
- Specific heat.
- Melting point.
- Boiling point.

Background

Density is the amount of mass per unit of volume for a substance. As different substances have different densities, this can be used to identify a substance.

The formula for density, D = M/V, can be used to predict a graphical relationship between any two variables. If we use the quantity (1/V), there is a linear relationship between D and (1/V). The pattern is as follows:

$$y = mx + 0$$
$$D = M\,(1/V)$$

If we use samples of approximately the same mass, then the graph should have a slope equal to the average mass.

Materials

5 cylindrical metal samples
1 balance
1 graduated cylinder
spreadsheet with graphing ability
string
water

Procedure

1. Take the mass of each metal sample. Record in data table.

Data Table

Metal Sample	Mass (grams)	Original Water Level (ml)	Final Water Level (ml)	Volume (cm^3)	1/Volume ($1/cm^3$)
		40			

2. Fill your graduated cylinder to the 40 ml mark.
3. Tie a string onto a metal sample. Dip it into the graduated cylinder until it is totally submerged. Record the water level.
4. Make sure you have enough original water to submerge your object. You may need more than 40 ml. Subtract water levels to find the volume.
5. Using the network and Microsoft Works, enter the following data onto a spreadsheet:

Metal Sample Mass Volume Density 1/Volume

6. *U*se the spreadsheet to: a. Calculate Density from a formula.
   b. Graph Density vs. Volume.
7. Finally, use the spreadsheet to "straighten your graph." Use the "1/Volume" values and plot Density vs. 1/Volume.
8. On the printout of your final graph, draw a "best-fit" straight line and find its slope.

Comparison of Slope and Average Mass

Slope (g)	Average Mass (g)	% Difference

Questions

1. Discuss your density values. Were your measuring techniques accurate? Explain with examples.
2. Explain the shape of the first graph. What does it tell about the relationship between Density and Volume?
3. The final graph should be nearly a straight line. This comes from the y = mx relationship. (y-intercept = 0) Discuss your percent error. Were your masses similar enough to get a close value using average mass?

Phase Changes – Heating and Cooling Curve

In this activity, students measure, record, and graph the temperature of a cooling substance at regular intervals. The substance used is paradichlorobenzene (PDB), the scientific name for mothballs. PDB is easily melted in warm water, so it works well for phase changes. It is best to prepare the PDB in advance; about half a test tube full is needed. When the lab is done, cover each test tube with stretch tape to avoid evaporation. A fume hood is recommended.

Standard Course of Study Goals and Objectives

5.04 Assess the use of physical properties in identifying substances:
- Density.
- Specific heat.
- Melting point.
- Boiling point.

Background

Matter exists in three phases: solid, liquid, and gas. A <u>phase change</u> occurs when heat is added or removed from a substance. The <u>melting point</u> of a substance is the temperature at which the solid to liquid phase change takes place. The <u>freezing point</u> is the temperature at which the liquid to solid phase change takes place. The melting point is the same as the freezing point. At this temperature, the solid and liquid can exist together.

In part A, you will melt mothballs, and then observe what happens as they are cooled back into a solid, or frozen. The scientific name for mothballs is paradichlorobenzene (or PDB for short). In part B, the steps will be reversed to heat the PDB until it melts again. In both parts, you will record data that you will use to make a graph.

Materials (each group)
test tube with about 5 grams of paradichlorobenzene crystals
test tube clamp
test tube rack (shared between groups)
2 250 mL beakers
Celsius thermometer
hotplate
2 colored pencils
clock with second hand

Procedure

Note: Be careful with the glass beakers and test tubes; they are breakable. Do <u>not</u> touch the hot plate surface when it has been on; you could get burned.

Part A:

1. Make a data table with two columns, one labeled "time" and one labeled "temperature." Fill in the "time" column, beginning with 0 seconds and continuing in 30-second increments. Label the data table "Part A: Temperatures of PDB as it Cools."
2. Half-fill the two beakers with water.
3. Heat one on the hot plate on medium high until you see small bubbles forming on the bottom.
4. Pick up a test tube of PDB and remove any protective tape. Using the test tube clamp, hold the test tube in the hot water. Allow the PDB to melt completely.
5. As soon as it is melted, insert a thermometer in it and record the temperature. Record this temperature in the data table at time 0.
6. Turn off the hot plate.
7. Be ready to time the readings. (Use the second hand on the clock.) Remove the test tube from the beaker and place it in the beaker of cold water. Hold the thermometer in the PDB so that it does not touch the sides of the test tube. Stir the PDB using the thermometer.
8. Take a temperature reading every 30 seconds, and record it in your data table. Make a note in the table of when the liquid first starts to freeze (become solid), and a second note when it is totally solid.
9. Continue to record temperatures until the temperature drops below 40 C.
10. Observe what happens to the volume of the PDB as it turns into a solid.

Part B:

1. Make another data table, but this time label it "Part B: Temperatures of PDB as it Heats."
2. As long as the water is still fairly hot (65-70 C), place the test tube with the now solid PDB in the beaker of hot water. Take the temperature of the PDB as soon as you place it in the hot water. Record this temperature on the Part B data table at time 0.
3. Be ready to time the readings. Take a temperature reading every 30 seconds, and record it in the table. Make a note in the data table, of when the liquid first starts to melt (becomes liquid). Start to stir the PDB as soon as the thermometer is able to move.
4. Continue stirring and recording temperature readings until the temperature reaches 60 C. Note in your data table when the PDB is totally melted (liquid).

Clean up and Graphing

1. Remove the thermometer and wipe it clean with a paper towel. Remove the test tube from the hot water and allow it to cool in the test tube rack.
2. Graph your data on Graph 1. Use one color for the data from Table 1, and a second color for the data from Table 2. Use the starting high and low temperatures as the temperature at zero seconds. Make a key to indicate what each color represents.

Questions

1. At what temperature does the PDB become solid? (Include units in your answer.)
2. How does this compare to the temperature at which solid PDB becomes liquid?
3. Describe any similarities you see between your two graphs.
4. Are there any level sections of your graph? What is happening during these times?
5. What happened to the volume of the PDB as it became solid?
6. What does this tell about the density of the solid PDB as compared to liquid PDB?
7. As the PDB was melting, heat was added from the water, but the temperature did not rise. Where did the heat energy go?
8. What would the experiment be like if ice instead of PDB had been used? (Hint: think of freezing and melting temperature.)
9. Describe an experiment to determine which freezes more quickly - hot or cold water? Be sure to use the 7 steps of the scientific method. Number your steps on a separate sheet of lined paper.

Ionic and Covalent Compounds Lab

In this activity, students explore solubility in water, conductivity in solution, and melting point of sugar and salt. Due to the differences between ionic and covalent bonds, the two types of compounds show difference in properties. Adapted from Prentice-Hall's Exploring Physical Science, 1995.

Standard Course of Study Goals and Objectives

5.05 Analyze the formation of simple inorganic compounds from elements.

6.04 Analyze aqueous solutions and solubility:
- Ionic substances.
- Covalent substances.
-

Background

Ionic compounds involve atoms that transfer electrons and form ions. These ions then attract one another. Covalent compounds, on the other hand, involve atoms that make bonds by sharing pairs of electrons.

Different types of bonding should result in different characteristics in the final compounds. We will check solubility in water, conductivity in solution, and melting point.

Materials (each group)
2 beakers - 200 ml
spoon
stirring rod
water
hotplate
aluminum foil
sugar
salt
power supply
3 wires
light bulb

Procedure

Note: The power supply has been set at 3 V. DO NOT CHANGE THE SETTING.
Do not touch the hot plate surface when it has been on; you could get burned.

Part 1: Melting point:
1. Using the aluminum foil, construct two "wells" with folded up sides.

2. Add a pinch of salt to one "well," and a pinch of sugar to the other. *Make sure you know which is which!*
3. Place the foil on the hotplate and turn it on to the "medium-high" setting.
4. As the salt and sugar heat, continue with the lab. Watch to see if either melts.
5. Does the salt melt? Does the sugar melt? If both melt, comment on which melts faster:

<u>Part 2 - Solubility in water:</u>

1. Add about 150 ml of water to each beaker.
2. Add about half a teaspoon of salt to one beaker and half a teaspoon of sugar to the other.
3. Using the stirring rod, determine if each dissolves in water.
4. Does the salt dissolve in water? Does the sugar? Comment further if needed.
5. KEEP the solutions to use in part 3.

<u>Part 3: Conductivity of the Solution</u>

1. Your circuit should be set up as shown (power supply in place of the battery). If it is not, ask your teacher for help.
2. Take the two unconnected wire ends (red and black), and briefly touch them together. Your light bulb should light up. If it does not, ask for help.
3. Now for the test: Dip both the red and black wires in the salt-water solution.

Record what you observe: *(DO NOT touch the ends together while in the beaker)*

4. Next, dip both the red and black wires into the sugar-water solution.

Record what you observe: *(Do NOT touch the ends together while in the beaker)*

Data Table

Compound	Describe the Melting Point	Does it dissolve in water?	Does the solution conduct electricity?
1. SALT			
2. SUGAR			

Questions

1. Ionic bonds are strongly held by opposite charges, while covalent bonds are weaker as electrons are only shared. Explain how this makes sense with the melting points you saw:
2. Water is strongly "polar" - it has a positive end and a negative end in each H_20 molecule. This characteristic makes it a good solvent - it can dissolve many things. What evidence can you see for that in your lab?
3. Finally, when an ionic compound is dissolved, it breaks up into its positive and negative ions, while a covalent compound is just broken down into whole molecules. What evidence do you see which supports this?

The Law of Conservation of Mass

This lab can be used as an introduction to balancing chemical equations. Discovering the mass of a gas is a surprise to many students. Contributed by J. Harris RHS, Durham.

Standard Course of Study Goals and Objectives
6.02 Identify the reactants and products and balance simple equations of various types:
- Single replacement.
- Double replacement.
- Decomposition.
- Synthesis.
- Combustion.

Background

The law of conservation of mass states that the mass of the reactants in any chemical equation equals the mass of the products. The products of a chemical reaction usually look different from the reactants. If a gas is produced, for example, you may not see it. Yet its mass must be included as part of the total mass of the products. It also may show up as bubbles or affect the pressure in a closed container.

The law of conservation of mass is an important law of chemistry and holds true for *all* chemical reactions.

In this activity, you will confirm the law of conservation of mass. You will also determine the mass of the gas produced during the reaction.

Materials
bottle with cap
water
seltzer tablet
balance (accurate to less than a gram)

Procedure
1. Fill the bottle about 1/4 full of water. Keep the outside as dry as possible, or dry off before continuing.
2. Get an "Alka-Seltzer" tablet from your teacher.
3. Place both on the scale. Find and record their cumulative mass in the table.
4. Break the seltzer tablet in half <u>above the bottle</u>. Place it into the water, and <u>immediately</u> place the cover back on the bottle and screw it on <u>tightly</u>.
5. Swirl the water around and watch the reaction occur.
6. <u>Record</u> your observations of the reaction. Continue until the reaction ends and the water clears.
7. Take the bottle <u>with the cap on</u>, and place it back on the scale. Again, find and record the mass in the table.
8. Remove the cap so the gas escapes, and then put the cap back on the bottle. Again take the mass and record it in the table.

Data Table

Objects	Mass (g)
Mass of reactants (plus bottle): Bottle, water, cap and dry “Seltzer” tablet	
Mass of products (plus bottle): Bottle with water and Seltzer tablet inside and cap still tightly on	
Same as above, except that cap has been removed (to allow gas to escape) and then placed back on bottle	
Mass of gas produced	

Questions

1. What is the relationship between the mass of the reactants and the mass of the products in this experiment?
2. Does this experiment support the Law of Conservation of Mass? Why or why not?
3. What happened when you removed the cap? Why?
4. The seltzer table contains $NaHCO_3$. What gas do you guess could have been produced? (Hint: It was <u>not</u> hydrogen gas = H_2.)

Four Types of Reactions Lab

The reactions in this lab are fairly dramatic. Chemistry teachers commonly stock the materials. The tables are provided to organize observations for each reaction in a similar way. These reactions can be done as demonstrations or labs. Contributed by T. Brown, RHS, Durham

Standard Course of Study Goals and Objectives
6.02 Identify the reactants and products and balance simple equations of various types:

- Single replacement.
- Double replacement.
- Decomposition.
- Synthesis.
- Combustion.

Background

These four minilabs are best done as sets of two in a typical class period. Reactions #1 and #2 do not require the use of a Bunsen burner, while reactions #3 and #4 do. In each case the <u>unbalanced</u> reaction is given.

Goggles should be worn during all 4 lab activities.

Notes for Reaction #2:

The concentrations of the two solutions do not need to be exact. A weak solution of both is all that is needed to cause the reaction. (Test first if in doubt.)

When disposing of the product, use a funnel and filter paper to remove the yellow precipitate from each test tube. As it contains lead, it should not be washed down the drain. Dispose of the filter paper and PbI_2 with any other hazardous waste.

Notes on use of Bunsen burners:

Students should be instructed in how to properly light and adjust a Bunsen burner for the best flame. Students should not have loose clothing, unsecured long hair or any loose flammable materials near a flame. Announce the location of the fire extinguisher prior to the lab, and be prepared to shut off the room's gas valve in case of an emergency.

Often, the Bunsen burner will blow out a match during lighting. Use a spark lighter to light them more easily. If using spark lighters, matches are only necessary if a wooden splint needs to be lit and no Bunsen burner flame is already on.

Notes for Reaction #3:

Due to the densities of iron and sulfur, about twice the volume of sulfur is needed as iron. (Nearly equal masses react well.) It may be helpful to measure these ahead of time and place the iron in the expendable test tube.

Students should mix reactants well for best results. However, the reaction may give off sulfur vapors (rotten egg smell) and the room should be well ventilated. After the reaction has occurred, break the <u>cooled</u> test tubes to get at the product. Do this yourself

for each group using a weight or hammer, wrapping the test tube in a paper towel first. Dispose of broken glass separately from normal trash as it may tear the trash bags or cause injury to custodial staff.

Reaction #1: $Zn + HCl \quad ZnCl_2 + H_2$

Materials

6 M (or higher) HCl
zinc pieces
2 test tubes
matches
wooden splint
test tube clamp
test tube rack

Procedure

1. Observe reactants and describe in the table.
2. Stand a clean, dry test tube in a test tube rack. Add about 5 mL of 6M hydrochloric acid (HCl) to the tube. (Caution: This is a concentrated acid and should be handled with care. It can burn the skin.)
3. Carefully drop a small piece of zinc metal (Zn) into the test tube. Observe the reaction and record what happens in the table.
4. Using a test tube holder, invert a second test tube over the mouth of the test tube in which the reaction is taking place. Remove the inverted tube after about 30 seconds and quickly insert a burning wooden splint into the mouth of the tube. (A sharp "pop" sound indicates the presence of hydrogen gas.) Describe the visible (and invisible) products in the table.
5. Disposal: Rinse used acid down the sink with plenty of water. Catch and wash the zinc metal off with water and allow to dry on a paper towel. It will be used by the next class and should not be thrown away.

Data Table for Reaction 1

Characteristic	**Comments:**
1. Balanced Equation	
2. Type of Reaction	
3. Appearance of reactants	
4. Description of the reaction itself	
5. Appearance of products	
6. Evidence that a chemical change has taken place	
7. Anything unusual/ interesting observed?	

Reaction #2: $Pb(NO_3)_2 + KI \rightarrow PbI_2 + KNO_3$

Materials
2 mL of 1M $\mathbf{Pb(NO_3)_2}$ (lead nitrate)
2 mL of 1M **KI** (potassium iodide)
test tube
test tube rack
test tube clamp

Procedure
1. Observe reactants and describe in the table.
2. Add the 2 mL of lead nitrate to a clean, dry test tube.
3. Next, add the 2 mL of potassium iodide solution to the same test tube. Describe the reaction in the table.
4. Allow the new substances to settle for about 10 min. Describe the products (one is visible, the other is in the solution) in the table.
5. Disposal: The product will be disposed of by the teacher. Place the test tube in the beaker at the instructor's table.

Data Table for Reaction 2

Characteristic	Comments:
1. Balanced Equation	
2. Type of Reaction	
3. Appearance of reactants	
4. Description of the reaction itself	
5. Appearance of products	
6. Evidence that a chemical change has taken place	
7. Anything unusual/ interesting observed?	

Reaction #3: $\mathbf{Fe + S \rightarrow Fe_2S_3}$

Materials
iron powder
sulfur powder
2 test tubes (one of them expendable)
matches
Bunsen burner
test tube clamp
heat resistant test tube rack
magnet
paper towels
tweezers
stirring rod or blade

Procedure

1. Observe the appearance of both reactants. Bring the magnet to the <u>outside</u> of the test tubes and observe the response of both the iron and sulfur. Record in the table.
2. Mix both the iron and sulfur into the expendable test tube. Mix thoroughly.
3. Light the Bunsen burner. Pick up the test tube with the test tube clamp, and heat it directly over the flame. Tilt the test tube so it points away from everyone.
4. Continue heating the mixture until it glows a deep red. Once the reaction is complete, shut off the burner and place the test tube on a <u>heat resistant</u> test tube rack. Allow it to cool. Describe the reaction and product in the table.
5. Place the test tube inside a paper towel. Get your instructor to break open the test tube. Using your tweezers, remove a piece of the iron sulfide (product).
6. Is the product attracted by the magnet? Record any evidence of chemical change.
7. Dispose of the broken test tube and product as instructed by your teacher.

Data Table for Reaction 3

Characteristic	Comments:
1. Balanced Equation	
2. Type of Reaction	
3. Appearance of reactants	
4. Description of the reaction itself	
5. Appearance of products	
6. Evidence that a chemical change has taken place	
7. Anything unusual/ interesting observed?	

Reaction #4: $NaHCO_3 \rightarrow Na_2CO_3 + H_2O + CO_2$

Materials
sodium bicarbonate (baking soda)
2 test tubes
matches
stirring rod
tweezers
pH paper
pH scale
heat resistant test tube holder
spatula
test tube rack

Procedure
1. Observe the appearance of the reactant. Record in the table.
2. Using a spatula, place a small amount of sodium bicarbonate into each test tube. (about [?] inch deep in each) Place them in a test tube rack.
3. Light your Bunsen burner. Using a test tube holder, hold one of the test tubes over the flame, tilting it to point away from you and your lab partners.
4. After it's heated for about a minute, have your partner light a splint and insert it into the test tube as it heats. Note any observations in table. If the splint goes out, then carbon dioxide is present. If it goes out, then relights once inside the test tube, oxygen is present. If the splint goes out and there is a popping noise, then hydrogen gas has been produced.
5. During the next 2 minutes, make good observations of the reaction. Is there any condensation? Does the solid change color or consistency? Record observations in the table.
6. Turn off the burner. Place the test tube in the heat resistant test tube holder and allow it to cool completely.
7. Add about 10 mL of water to both of the test tubes. Using the stirring rod to mix each. Rinse between uses! Take a piece of pH paper and test both liquids. Make observations in table. Use the pH color scale to note the pH of each solution. Record one in the table under "reactants" and the other under "products."

Data Table for Reaction 4

Characteristic	Comments:
1. Balanced Equation	
2. Type of Reaction	
3. Appearance of reactants	
4. Description of the reaction itself	
5. Appearance of products	
6. Evidence that a chemical change has taken place	
7. Anything unusual/ interesting observed?	

The pH Scale is Logarithmic

This is a hands-on activity to illustrate that the pH scale is not linear, but logarithmic. The students will understand that pH 6 is 10 times more acidic than pH 7, or has 10 times more hydrogen or hydronium ion than pH 7. Depending on how much room you have, you might choose to use mm instead of cm. Or you can do the activity outside if you need more space. Adapted from *Acid Rain* Grades 6-12, A Sourcebook for Teaching A Major Environmental Problem, Volume II, by Edward W. Hessler and Harriet S. Stubbs (Sci-Link/Globe-Net Projects), published by Kendall/Hunt Publishing Co., Dubuque, Iowa, 1998.

Standard Course of Study Goals and Objectives

6.06 Compare and contrast the composition of strong and weak solutions of acids or bases:

- Degree of dissociation or ionization.
- Electrical conductivity.
- pH.
- Strength.
- Concentration.

Materials

ball of string or yarn
meter stick
metric ruler
pipe cleaners (about 6 cm-bright colors work best)

Procedure

1. Place the yarn on the floor and secure one end with tape.
2. Mark the end with a pipe cleaner. This represents pH 7.
3. Measure 10 cm from the pipe cleaner and mark with another pipe cleaner. This represents pH 6.
4. Measure 100 cm from the first pipe cleaner and place it on the string. This represents pH 5.
5. The next measurement is 1000 cm. This can be done in a hall or outdoors.
6. Continue until students understand or you run out of string.

Questions

1. Using the yarn as you did in this activity, what would be the distance between pH 3 and pH 5?
1. How many times more acidic is pH 3 than pH 5?
2. Using the yarn as you did in this activity, what would be the distance between pH 5 and pH 7?
3. How many times more acidic is pH 5 than pH 7?
4. Using the yarn as you did in this activity, what would be the distance between pH 1 and pH 5?
5. How many times more acidic is pH 1 than pH 5?
6. Place these solutions in order from the weakest acidity to the strongest acidity: vinegar (2.2), milk (6.6), lemon juice (2.0), bananas (5.2), water (7.0), and acid rain (4.0).

Activity: Acids, Bases, and Indicators Lab

This lab is an introduction to common acids and bases using pH paper, litmus paper, and phenolphthalein as indicators. Contributed by T. Brown, RHS, Durham.

Standard Course of Study Goals and Objectives

6.06 Compare and contrast the composition of strong and weak solutions of acids or bases:
- Degree of dissociation or ionization.
- Electrical conductivity.
- pH.
- Strength.
- Concentration.

Background

Acids, bases, and salts can be identified using several different substances. Some are compounds bound to paper strips (pH paper, litmus paper), while others are solutions (phenolphthalein, bromophenol blue, methyl orange). We will be testing seven substances using pH paper, litmus paper, and phenolphthalein.

Materials

pH paper
litmus paper
tweezers
dropper Plate
in dropper pipets:
NH_3 NaOH HCl NaCl $HC_2H_3O_2$ H_2SO_4 $NaHCO_3$ Phenolphthalein

Procedure

Wear protective eye gear throughout this activity.

1. Place the dropper plate on a piece of paper. Sketch out the pattern of wells, and label.
2. Place several drops of each of the test solutions (NOT phenolphthalein) into separate wells. As you place the solutions in the wells, label your sketch with their formulas.
3. Using the tweezers, place a piece of (yellow) pH paper into each well. Record your observations next to the correct solution name in the table. Use the pH color scale to find the number that most closely matches the color you see.
4. Remove the pH paper, and place it into the empty well near the pH paper. (waste)
5. Using the tweezers, now place a piece of litmus paper into each well. Again, record your observations next to the correct solution name in the table on the back.
6. Remove the used litmus paper, and place it with the used pH in the waste well.
7. Some solutions will now be slightly tinted due to reactions with the pH and litmus indicators. The coloring should not be a problem to our final step. Using the phenolphthalein dropper, add a small drop to each solution. Record your observations in the table.
8. Fill in the final column of the table using what you know about how acids and bases react with the indicators used.

Indicators Data Table

Substance Tested	pH Color…. Number		Litmus Final Color	Phenolph-thalein	Strong/Weak? and… Acid/Base/Salt?
NH_3 (Ammonia)					
NaOH (Sodium Hydroxide)					
HCl (Hydrochloric..)					
NaCl (Table …)					
$HC_2H_3O_2$ (Vinegar)					
H_2SO_4 (Sulfuric …)					
$NaHCO_3$ (Baking Soda)					

Questions

1. Were the indicators in good agreement with each other for each substance? Give an example showing why or why not.
2. Which was the best indicator? Explain why:
3. Which type of substance would have been the hardest to identify if the indicators were the only information you had? Explain.