Nancy Larson®

Science 5

Booklet C

Investigating Matter and Its Interactions

Chemistry

Chemist _____

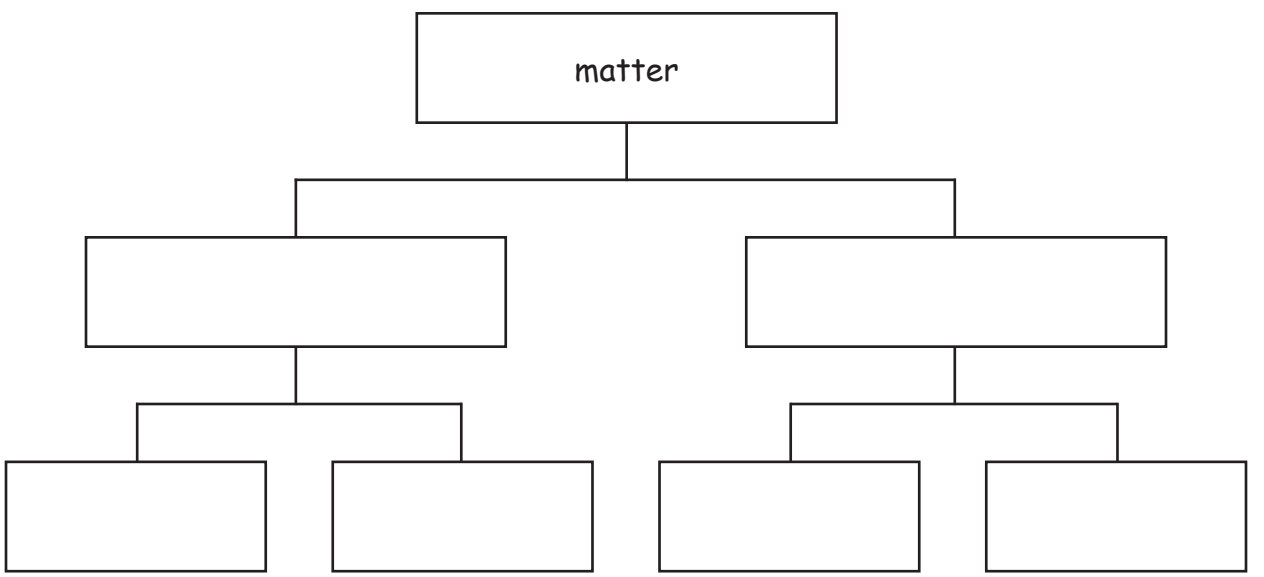
Classifying Matter

[1] Matter is classified as either a pure substance or a mixture. An element or a compound is a pure substance. Oxygen, gold, neon, table salt, water, quartz, and carbon dioxide are examples of pure substances. All minerals are pure substances.

[2] A mixture is a combination of two or more pure substances that do not chemically bond. Air, seawater, granite, pudding, and vinaigrette dressing are examples of mixtures. Most rocks are mixtures of minerals.

[3] A mixture with particles that are evenly spread out, or dispersed, is called a homogeneous mixture. Examples of homogeneous mixtures are air, brass, pudding, and seawater. Air is a mixture of nitrogen, oxygen, and other gases. Brass is a mixture of copper and zinc. Seawater is a mixture of water, sodium chloride, and other salts.

[4] A mixture with particles that are not evenly spread out, or dispersed, is called a heterogeneous mixture. Examples of heterogeneous mixtures are vinaigrette dressing, chicken noodle soup, trail mix, fruit salad, and granite. Granite is a mixture of the minerals feldspar, quartz, and mica.



Types of Mixtures

[1] A solution is a homogeneous mixture in which very small particles of one substance are dissolved completely in another substance. The substance that is dissolved is called the solute, and the substance it is dissolved in is called the solvent. The particles of the solute do not settle out upon standing. Seawater, air, brass, and steel are examples of solutions.

[2] A colloid is a mixture in which small particles of one substance are dispersed, but not dissolved, in particles of another substance. The particles of a colloid usually do not settle out upon standing. Paint, pudding, whipped cream, mayonnaise, gelatin, and fog are examples of colloids. Colloids can be either homogeneous or heterogeneous.

[3] A suspension is a heterogeneous mixture in which small particles larger than those in a solution or colloid are dispersed in a liquid or gas. The particles in a suspension do not mix completely and the particles settle out upon standing. Examples of suspensions are muddy water, dust in the air, and vinaigrette dressing.

Mixtures

Mixture	Type of Mixture	Substances that Combine
air		nitrogen, oxygen, other gases
seawater		water, sodium chloride, other salts
brass		copper, zinc
structural steel		iron, carbon
mayonnaise		oil, egg yolk, vinegar
fog		water droplets or ice crystals, air
vinaigrette dressing		oil, vinegar, herbs

States of Matter

1 Solid, liquid, gas, and plasma are four states, or phases, of matter. Most matter on Earth is in a solid, liquid, or gaseous state.

2 Matter that is a solid has a definite shape and volume. The atoms or molecules of solids vibrate rapidly but they do not move apart because they are so closely packed together.

3 Matter that is a liquid has a definite volume but not a definite shape. Atoms or molecules of liquids move faster and have more energy than atoms or molecules of solids. Atoms and molecules of liquids have room to slide past one another. The ability of the particles to slide past one another allows a liquid to flow and spread out to fill the bottom of its container.

4 Matter that is a gas does not have a definite shape or volume. Atoms or molecules of gases move very fast in all directions and are constantly bouncing off one another. The space between particles allows a gas to flow, change shape, and expand to fill its container.

5 Plasma, found in stars and lightning, is composed of ions and free electrons that move faster than atoms or molecules of gases. Plasma flows and spreads out in all directions. Plasma does not have a definite shape or volume.

Characteristics of Solids, Liquids, Gases, and Plasma

	Solid	Liquid	Gas	Plasma
Definite Volume				
Definite Shape				
Flows				

Changing States of Matter by Adding Heat

1 Matter can change state when heat is added. Different substances change state at different temperatures. When matter gains heat, the kinetic energy of the particles in the matter increases and they move more rapidly.

2 Adding heat to a solid causes the particles in the solid to move faster. If enough heat is added to a solid, the particles spread apart and begin to slide past one another so that the solid changes to a liquid. Changing from a solid to a liquid is called melting. An example of melting is ice changing to water when heat is added.

3 As heat is added to a liquid, the particles in the liquid move faster. If enough heat is added, the particles have enough energy to move even farther apart, and the liquid changes to a gas. Changing from a liquid to a gas is called vaporization. An example of vaporization is water changing to water vapor when heat is added. Boiling and evaporation are two types of vaporization.

4 Boiling occurs when a liquid reaches a temperature called its boiling point. At a liquid's boiling point, particles throughout the liquid change into a gas. At sea level, the boiling point of water is 100 degrees Celsius and 212 degrees Fahrenheit. Different substances have different boiling points.

5 Evaporation occurs at a temperature below the boiling point of the liquid and only occurs at the surface of the liquid. An example of evaporation is water in a puddle changing to water vapor.

6 Some solids can change to a gas without first becoming a liquid. Changing from a solid to a gas without becoming a liquid is called sublimation. Dry ice, which is frozen carbon dioxide, sublimates to a gas when heat is added.

7 When enough heat is added to a gas, the gas can change to plasma. Changing from a gas to plasma is called ionization. During ionization, electrons separate from the atoms or molecules in the gas, resulting in ions and free electrons.

Changing States of Matter by Removing Heat

1 Matter can change state when heat is removed. When matter loses heat, the kinetic energy of the particles in the matter decreases and they move more slowly.

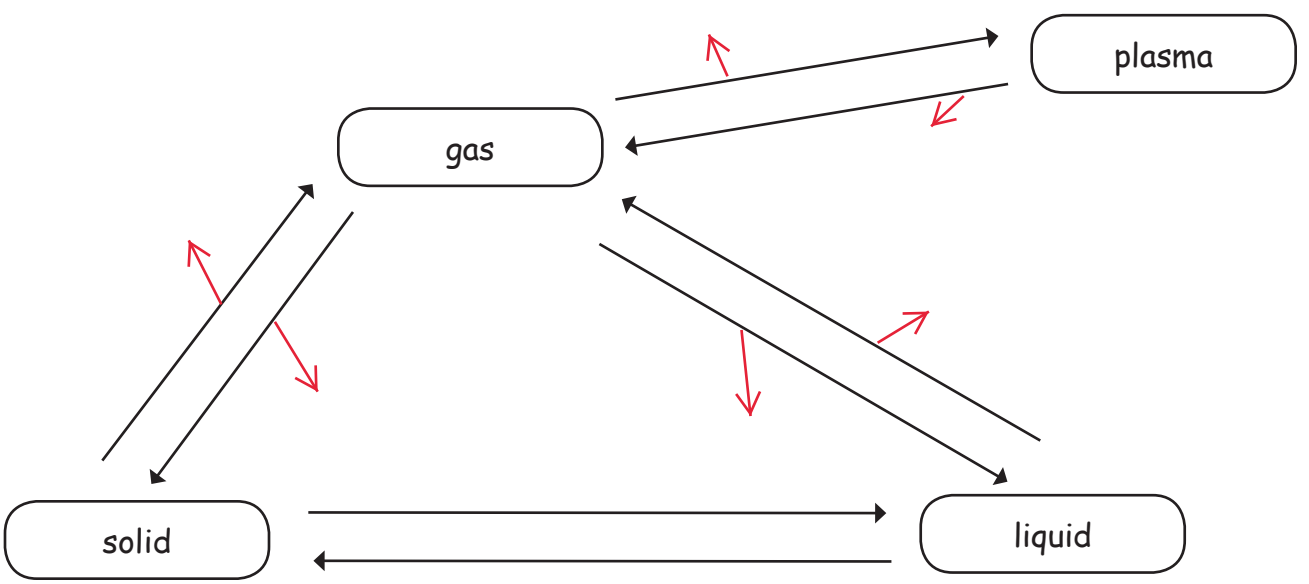
2 If enough heat is removed from a gas, the particles no longer have enough energy to move apart and the gas changes to a liquid. Changing from a gas to a liquid is called condensation. An example of condensation is water vapor changing to drops of water on a cold glass.

3 Removing heat from a liquid causes the particles in the liquid to move more slowly. If enough heat is removed from a liquid, the particles have only enough energy to vibrate in place and the liquid changes to a solid. Changing from a liquid to a solid is called freezing. An example of freezing is water changing to ice. The freezing point of water is 0 degrees Celsius and 32 degrees Fahrenheit.

4 Some gases can change to a solid without first becoming a liquid. Changing directly from a gas to a solid is called deposition. Frost—water vapor that has changed to ice crystals on surfaces—is an example of deposition.

5 Plasma changes to a gas when enough heat is removed. Changing from plasma to a gas is called deionization.

Phase Changes

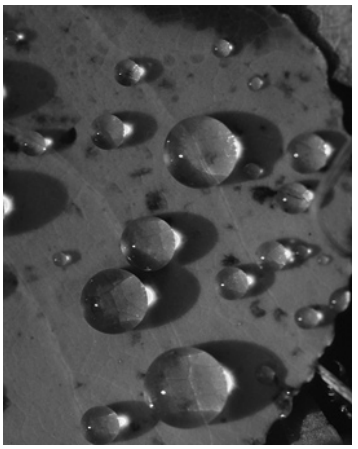


Cohesion, Surface Tension, Adhesion

[1] Molecules are attracted to one another because of their chemical structure. The attraction molecules of a substance have for one another is called cohesion. Cohesion is what causes the molecules of a liquid to stay connected and to form spherical drops.

[2] The molecules at the surface of a liquid are more attracted to one another than they are to the air above them. The strong attraction molecules at the surface of a liquid have for one another is called surface tension. Surface tension is what allows the surface of a liquid to support light objects.

[3] Sometimes molecules are more attracted to another substance than they are to each other. The attraction between molecules of different substances is called adhesion. Adhesion is what causes a liquid to stick to the surface of a solid.



Spherical water drops are an example of

_____.

A water strider can walk on water because of

_____.

Water drops are attracted to the spider web because of

_____.

Physical Changes

[1] A physical change occurs when matter changes state, changes shape, or changes size. During a physical change, the appearance of matter changes but the chemical formula of the matter does not change. Examples of physical changes are crushing a can, melting ice, shredding paper, sharpening a wood pencil, cracking an egg, mixing salt and water, and popping popcorn.

Physical Properties of Matter

A physical property of matter is a characteristic that can be observed or measured.

Property	Description		
State	Is it a solid, a liquid, a gas, or plasma?		
Color	What color is it?		
Transparency	Does it allow light to pass through?		transparent
			translucent
			opaque
Luster	Is it shiny or dull?		
Hardness	Is it hard or soft? Can it be scratched?		
Texture	Is it smooth or rough?		
Flexibility	Is it flexible? Can it be bent?		
Elasticity	Does it return to its original shape after being stretched or bent?		
Brittleness	Does it break or shatter easily?		
Magnetic	Is it attracted to a magnet?		
Fluidity	Is it a fluid? Does it flow?		
Viscosity	Does it have a high or low resistance to flowing?		
Temperature	How hot or cold is it?		
Mass	How much matter does it contain?		
Volume	How much space does it take up?		

Measuring Temperature

1 Temperature is a measure of the average kinetic energy of matter. Celsius, Fahrenheit, and Kelvin are three scales used to measure temperature. The Celsius scale, named after Swedish scientist Anders Celsius, is commonly used by scientists worldwide. The Fahrenheit scale, named after German scientist Daniel Fahrenheit, is in common use in the United States. The standard international unit of measure for temperature is the kelvin, named for Irish scientist Lord Kelvin. Kelvin temperatures do not include the degree symbol.

2 Zero on the Kelvin scale is called absolute zero and is the lowest possible temperature of matter. The Kelvin scale does not use negative numbers. Zero degrees Celsius is the same as 273.15 K and 100 °C is the same as 373.15 K. One kelvin equals one degree Celsius.

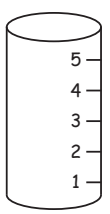
Measuring Mass

1 All matter has mass. Mass is the amount of matter a substance contains. Mass is measured in kilograms (kg) or grams (g). The mass of a solid or liquid can be found by using a balance.

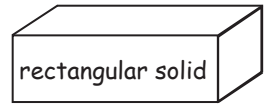
Measuring Volume

1 Volume is the amount of space matter takes up. Solids and liquids have a definite volume that can be measured. The volume of a liquid is measured in liters (L) or milliliters (mL). The volume of a solid is measured in cubic meters (m^3) or cubic centimeters (cm^3).

2 The volume of a liquid can be found by pouring the liquid into a graduated cylinder. The volume of a solid can be found by placing the solid in a container of water and measuring the amount of water it displaces. One milliliter of water is equal to one cubic centimeter.



water



Density of Solids and Liquids

[1] Density is a measure of how tightly the atoms or molecules in matter are packed together. The density of a substance is found by dividing the mass of the substance by its volume. Water has a density of 1 because one cubic centimeter of water has a mass of one gram.

[2] Density is also a measure of how much matter the atoms of a substance contain. The more protons and neutrons an atom contains, the greater its density. This is why lead has a greater density than aluminum.

[3] The density of matter determines whether it will sink or float in water. Substances with a density less than 1 are less dense than water and will float. Substances with a density greater than 1 are more dense than water and will sink.

[4] Objects or substances that float in water or in any other fluid are described as buoyant. Oil will float on water because it is less dense than water. Helium balloons are buoyant because helium gas is less dense than the gases that make up air.

Density of Metals

Metal	Mass (g)	Volume (cm^3)	Density = $\frac{\text{Mass}}{\text{Volume}}$
aluminum			
copper			
steel			
brass			

Chemical Changes

[1] A chemical change occurs when there is a chemical reaction. During a chemical reaction, one or more substances changes into one or more new substances. There is a transfer of energy to or from the surroundings during a chemical reaction. Examples of chemical reactions are burning a candle, baking a cake, a nail rusting, organic matter decomposing, fireworks exploding, and photosynthesis.

[2] In a chemical reaction, a substance that is being changed is called a reactant. A new substance formed by a chemical reaction is called a product. During photosynthesis, water and carbon dioxide are the reactants and glucose and oxygen are the products.

[3] A chemical reaction that absorbs, or gains, energy from the surroundings is called an endothermic reaction. During an endothermic reaction, the energy taken in is often in the form of heat. Baking a cake and photosynthesis are examples of endothermic reactions.

[4] A chemical reaction that gives off energy to the surroundings is called an exothermic reaction. The energy an exothermic reaction gives off can be in the form of heat, light, sound, motion, or electricity. Burning a candle, exploding fireworks, a nail rusting, and decomposing organic matter are examples of exothermic reactions.

[5] Four indicators of a chemical change are a change of temperature, the production of a gas, a change of color, or a change of odor.

Chemical Reactions

Hydrogen Peroxide + Yeast	Baking Soda + Vinegar
Indicators of chemical change	Indicators of chemical change
_____	_____
_____	_____
☐ Absorbs energy (feels cool) or ☐ Gives off energy (feels warm)	☐ Absorbs energy (feels cool) or ☐ Gives off energy (feels warm)
☐ Endothermic ☐ Exothermic	☐ Endothermic ☐ Exothermic

Four Types of Chemical Reactions

Chemical Reaction	Reactants	Products
Combustion	organic compound + oxygen	water + carbon dioxide
	$C_{31}H_{64} + 47O_2$	$32H_2O + 31CO_2$
Synthesis	2 or more elements or compounds	new compound
	$4Fe + 6H_2O + 3O_2$	$4Fe(OH)_3$
Decomposition	compound	2 or more elements or simpler compounds
	$2H_2O_2$	$2H_2O + O_2$
Neutralization	acid + base	salt + water
	$C_2H_4O_2 + NaHCO_3$	$NaC_2H_3O_2 + H_2O + CO_2$

Identifying Acids and Bases

[1] The pH of a substance indicates whether the matter is an acid or a base. The pH of a substance is measured on a scale from 0 to 14. A substance with a pH of 7 is called neutral. Pure water is a neutral substance. A substance with a pH less than 7 is called an acid. Examples of acids are vinegar, orange juice, cola, and sulfuric acid in car batteries. A substance with a pH greater than 7 is called a base. Examples of bases are bleach, baking soda, human blood, hydrogen peroxide, and ammonia.

pH Scale

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
hydrochloric acid	battery acid	vinegar	grapefruit juice	orange juice	coffee	milk	pure water	baking soda	liquid soap	antacids	ammonia	lime (calcium oxide)	liquid bleach	sodium hydroxide

stronger acid — weaker acid — neutral — weaker base — stronger base

cola—2.5 human blood—7.4 seawater—8.0

Designing an Experiment

[1] An experiment begins with a question. Based on prior knowledge and research, a hypothesis is made. A hypothesis is an educated prediction about the answer to the question.

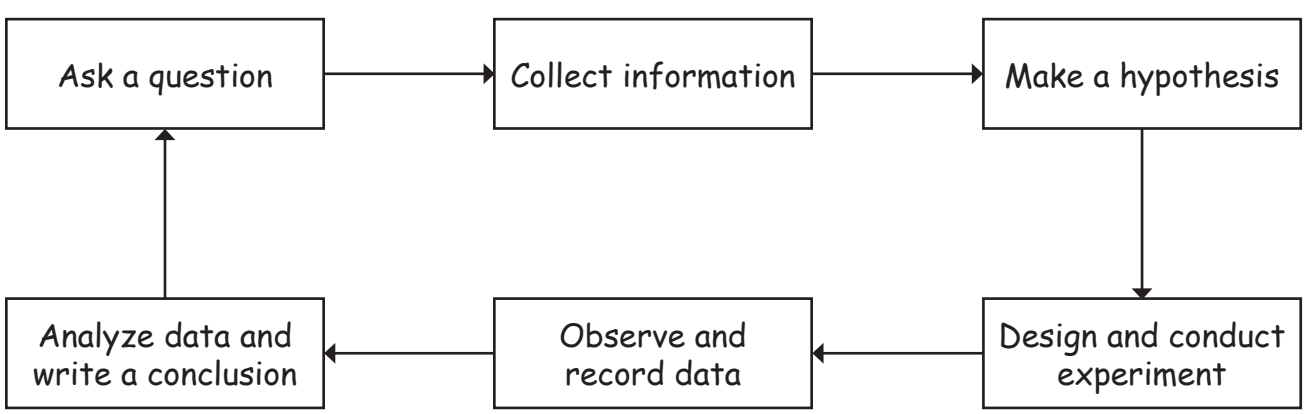
[2] An experiment is designed to test the hypothesis. The independent variable is what is being tested and the dependent variable is what is being measured. The control is what the independent variable is compared with. Conditions that remain the same throughout the experiment are called constants.

[3] The experiment should be conducted several times using the same materials and procedure. During the experiment, observations and measurements—called data—are recorded. After the data has been collected, it can be presented on a chart, diagram, or graph.

[4] The next step is to analyze the data by looking for patterns or trends. After the data has been analyzed, a conclusion is written to summarize the data and state whether or not the hypothesis was correct.

[5] When the experiment is completed, new questions can be investigated based on the results of the experiment.

Scientific Method



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