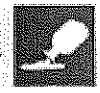
Safety and Scientific Method Cheat Sheet

SAFETY SYMBOLS	HAZARD	EXAMPLES	PRECAUTION	REMEDY
DISPOSAL 	Special disposal procedures need to be followed.	certain chemicals, living organisms	Do not dispose of these materials in the sink or trash can.	Dispose of wastes as directed by your teacher.
BIOLOGICAL 	Organisms or other biological materials that might be harmful to humans	bacteria, fungi, blood, unpreserved tissues, plant materials	Avoid skin contact with these materials. Wear mask or gloves.	Notify your teacher if you suspect contact with material. Wash hands thoroughly.
EXTREME TEMPERATURE 	Objects that can burn skin by being too cold or too hot	boiling liquids, hot plates, dry ice, liquid nitrogen	Use proper protection when handling.	Go to your teacher for first aid.
SHARP OBJECT 	Use of tools or glassware that can easily puncture or slice skin	razor blades, pins, scalpels, pointed tools, dissecting probes, broken glass	Practice common-sense behavior and follow guidelines for use of the tool.	Go to your teacher for first aid.
FUME 	Possible danger to respiratory tract from fumes	ammonia, acetone, nail polish remover, heated sulfur, moth balls	Make sure there is good ventilation. Never smell fumes directly. Wear a mask.	Leave foul area and notify your teacher immediately.
ELECTRICAL 	Possible danger from electrical shock or burn	improper grounding, liquid spills, short circuits, exposed wires	Double-check setup with teacher. Check condition of wires and apparatus. Use GFI-protected outlets.	Do not attempt to fix electrical problems. Notify your teacher immediately.
IRRITANT 	Substances that can irritate the skin or mucous membranes of the respiratory tract	pollen, moth balls, steel wool, fiberglass, potassium permanganate	Wear dust mask and gloves. Practice extra care when handling these materials.	Go to your teacher for first aid.
CHEMICAL 	Chemicals that can react with and destroy tissue and other materials	bleaches such as hydrogen peroxide; acids such as sulfuric acid, hydrochloric acid; bases such as ammonia, sodium hydroxide	Wear goggles, gloves, and an apron.	Immediately flush the affected area with water and notify your teacher.
TOXIC 	Substance may be poisonous if touched, inhaled, or swallowed.	mercury, many metal compounds, iodine, poinsettia plant parts	Follow your teacher's instructions.	Always wash hands thoroughly after use. Go to your teacher for first aid.
FLAMMABLE 	Open flame may ignite flammable chemicals, loose clothing, or hair.	alcohol, kerosene, potassium permanganate, hair, clothing	Avoid open flames and heat when using flammable chemicals.	Notify your teacher immediately. Use fire safety equipment if applicable.
OPEN FLAME 	Open flame in use, may cause fire.	hair, clothing, paper, synthetic materials	Tie back hair and loose clothing. Follow teacher's instructions on lighting and extinguishing flames.	Always wash hands thoroughly after use. Go to your teacher for first aid.

Eye Safety
Proper eye protection must be worn at all times by anyone performing or observing science activities.

Clothing Protection
This symbol appears when substances could stain or burn clothing.

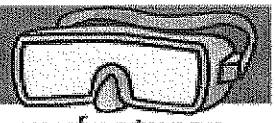
Animal Safety
This symbol appears when safety of animals and students must be ensured.

Radioactivity
This symbol appears when radioactive materials are used.

Handwashing
After the lab, wash hands with soap and water before removing goggles.

Scientific Process Skills

MATERIAL SAFETY DATA SHEET (MSDS)



The **MSDS** for a chemical is a document that lists the manufacturer, physical and chemical properties, health hazards, precautions for safe handling and use, exposure limits, first aid, and other hazard data.

Hazard	Possible Effects and Common Symbol
corrosive	damages tissues or surfaces on contact 
flammable	causes fires or ignition (burns or ignites easily)
radioactive	damages tissues by removing electrons or breaking bonds; increases risk of cancer; certain substances target specific organs (like radioactive iodine in thyroid) 
toxic	chemical or physical toxicants can damage or kill an organism or its parts by sufficient exposure via inhalation, dermal (skin) contact, or ingestion; "poisonous" 

EXPLANATIONS, DATA EVALUATION, AND REPRESENTATION

Evaluate scientific explanations using evidence, logic, and investigations. Extract and consider information from different sources, like scientific journals, news reports, and marketing materials.

hypothesis: educated guess about what might happen; must be able to be tested; can support a hypothesis using observations and repeated experiments with large sample sizes; results may change it

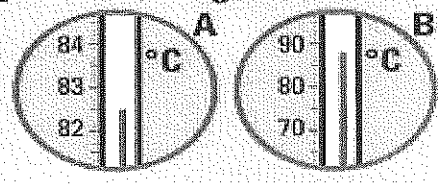
theory: well-established, reliable explanation that has been tested in many conditions by multiple people; new areas of science can change it

Example: Atomic theory evolved over time via the contributions of many scientists. The modern atomic theory accounts for all evidence acquired to date.

Term	Description
average or mean	sum of values divided by number of items
precision	closeness of values to each other (repeatability)
accuracy	closeness to "true" or "correct" value
percent error	$\left(\frac{\text{accepted value} - \text{experimental value}}{\text{accepted value}}\right)(100)$

Example: Two calorimeters are used to measure $\triangle H^0_f$ of H_2O. Calorimeter A's thermometer is more precise, so more significant digits are reported (3 versus 2). The true $\triangle H^0_f$ of H_2O is −241.8 kJ/mol, so Calorimeter B is more accurate.

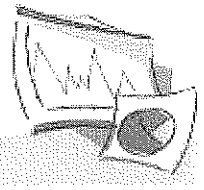
	T_{final} (°C)	$\triangle H^0_f$ (kJ/mol)
A	82.5	−229
B	88	−240



SCIENTIFIC METHOD

For an experimental investigation, use the **scientific method**:

1. Begin with a well-defined **question.**
2. Learn, research, and collect **information** about your question.
3. Make a **hypothesis**, an educated guess about what might happen. It is a statement (often *if/then*) that must be able to be tested (not just opinion).
4. Design and conduct an **experiment** to test your hypothesis. The **variable** is something that can be changed. Change only the variable that you are testing. The **control group** includes the samples that are kept at "normal" conditions. Compare the experiment's results to the results for the control group.



Variable	Description
independent	variable that is manipulated during the experiment; it is shown on the x-axis (horizontal axis)
dependent	variable that responds to changes in the independent variable; its value is measured; it is shown on the y-axis (vertical axis)
controlled	variable that is held constant during the experiment

5. Collect and organize **observations.** Probes, computers, and calculators can be used to record and analyze data. Observations can be **quantitative** (involves measurement, like mass of 2.3 g) or **qualitative** (uses descriptions, like describing a liquid's color as blue).
6. **Evaluate** the data and make inferences. Look for **patterns** and use models or mathematical approximations to describe the data.
7. Make a valid **conclusion.** Do the results support the hypothesis? Use reports, graphs, and drawings to communicate your conclusions.

SCIENTIFIC INVESTIGATION

Science includes the design and application of testable statements and predictions regarding natural phenomena. Many scientific questions can be explored through investigation.

Investigation	Example
descriptive	count the number of owls living in a forest
comparative	observe similarities and differences between the wings of a butterfly and the wings of a wasp
experimental	apply different amounts of fertilizer to two plants to explore how fertilizer levels affect plant growth

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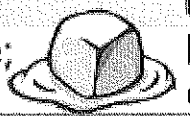
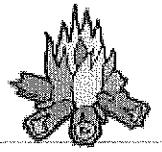
CHANGES AND PROPERTIES

Change	Description	Examples
physical	change in size, shape, or state; remains the same substance 	boiling water, chopping wood
chemical 	new substance is made; bonds between atoms are made or broken; often see a color change, temperature change, or the formation of gas or precipitate (solid)	electrolysis of water (to H_2, O_2), burning wood (makes H_2O, CO_2)

Property	Description	Examples
physical	can be observed without changing the substance into a different substance	boiling point, color, density, solubility
chemical	can be observed when a substance changes into a different substance	reactivity with O_2, flammability, toxicity

STATES OF MATTER AND PROPERTIES

Property	Solid	Liquid	Gas
compressible	essentially no	essentially no	yes
shape	fixed	container's shape	fills space
volume	constant	constant	can change
structure	forces keep particles in a rigid structure	intermolecular forces keep particles together but allow movement	particles move freely, virtually no forces

extensive property: dependent on sample size **Examples:** mass, $\triangle H$

intensive property: independent of sample size **Examples:** c_p, $\triangle H°$

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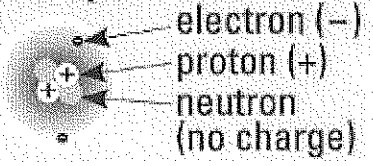
SUBSTANCES AND MIXTURES

atom: smallest complete part of an element

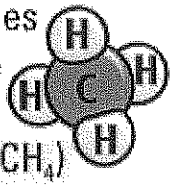
element: substance made of one kind of atom

compound: substance made of two or more different elements **Examples:** H_2O or NaCl

Example: Helium atom



substance: contains only one kind of matter; no two substances have identical chemical and physical properties; cannot be broken down into different parts using physical means



Examples: element like iron (Fe), compound like methane (CH_4)

mixture: combination of two or more substances in which each substance maintains its own properties; a mixture can be separated using physical means

Example: Salt water can be separated by boiling off the water, leaving only the salt. It is a homogenous mixture.

Example: In a famous story, Archimedes determined whether the king's crown was made of pure gold or a mixture of metals by calculating the crown's density, $D = \frac{m}{V}$. He knew that if it was <u>not</u> equal to that of gold (19.3 g/mL), then it was a mixture.

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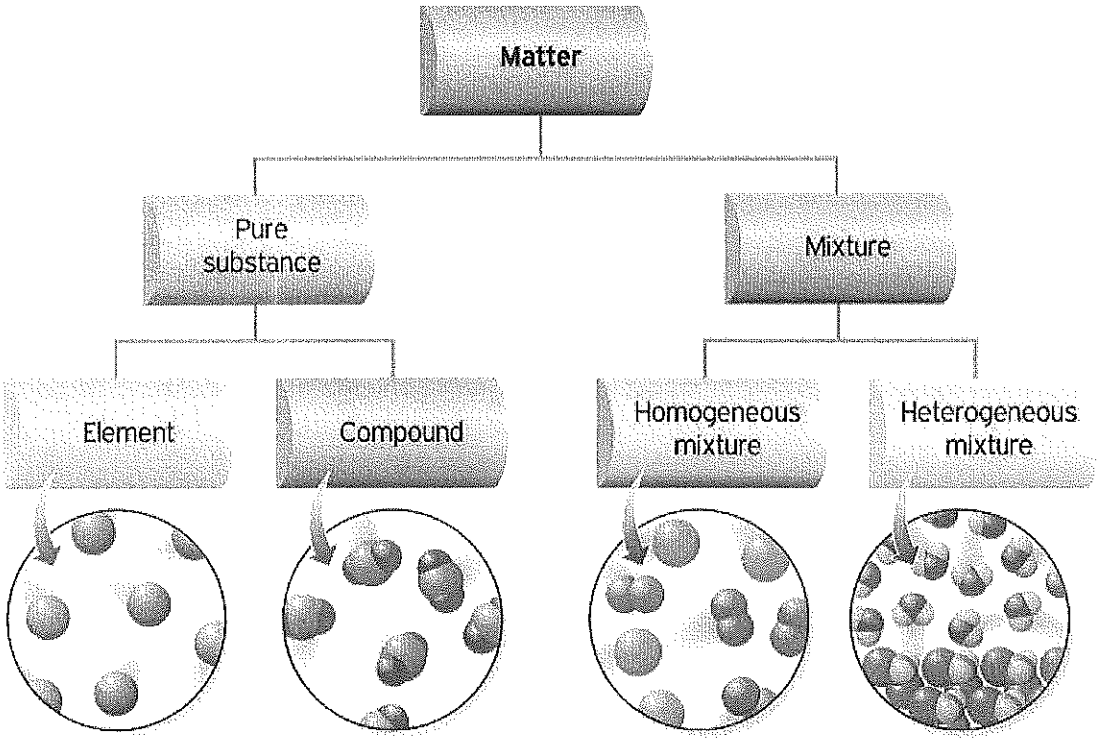

Homogeneous - is a mixture where the components that make up the mixture are uniformly distributed throughout the mixture. Example: air, blood, saturated sugar water

Heterogeneous - is a mixture where the components of the mixture are not uniform or have localized regions with different properties. Example: rocks, oil and water, soup, pizza