PHYSICAL SCIENCE STANDARD 1 - SCIENTIFIC INQUIRY

HYPOTHESIS - reasonable explanation of an observation or experiment that can be tested.

- May or may not be supported by the experimental results.
- The experimental results support or do not support the hypothesis.
- Valuable information is gained even when the hypothesis is not supported by the results
- Use **CREDIBLE** (trustworthy), **ACCURATE** (correct), and **RELEVANT** (related) sources of scientific information when creating a hypothesis.

DESIGNING A SCIENTIFIC INVESTIGATION:

- Stating the purpose or ask a question
- Researching information
- Stating the hypothesis
- Describing the experimental process
    - Planning for independent and dependent variables with repeated trials
    - Planning for factors that should be held constant (controlled variables)
    - Setting up the sequence of steps to be followed
    - Listing materials
- Recording, organizing and analyzing data
- Planning for a conclusion statement that will support or not support the hypothesis

INDEPENDENT VARIABLE - variable that the experimenter deliberately changes or manipulates.
Independent variable is the "cause" in the "cause-effect" relationship.
DEPENDENT VARIABLE - variable that changes in an investigation in response to the independent variable.
Dependent variable is the "effect" in the "cause-effect" relationship.
CONSTANT (CONTROLLED VARIABLES) - variables which are held constant.
All the other possible variables in the investigation should be held constant so that only one variable (the independent) is tested at a time.
CONTROL GROUP - a basis of comparison to test whether the effects on the dependent variable came from the independent variable.

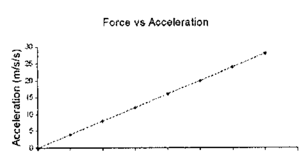
PRECISION - degree to which measurements made in the same way agree with one another.
ACCURACY - degree to which the experimental value agrees with the true or accepted value.

- It is possible to have a high degree of precision with poor accuracy.

ORANIZE DATA INTO GRAPHS

- DRY MIX (Dependent Responding Y-axis - Manipulating Independent X-axis)
- There should be two data points more than is needed on the vertical axis.
- The horizontal axis should be long enough for all of the data points to fit.
- The intervals on each axis should be marked in equal increments.
- Label each axis with the name of the variable and the unit of measure. Title the graph.

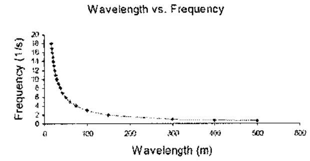
LINE GRAPH is used for continuous quantitative (number) data.
BAR GRAPH is used for non-continuous data which is usually categorical.
CIRCLE GRAPH shows a relationship among parts of a whole. Circle graphs often involve percentage data.



DIRECT VARIATION (PROPORTIONAL) As one variable increases, the other increases OR as one variable decreases the other decreases.

- A straight line with a positive slope indicates a <u>direct</u> relationship that changes at a constant rate.
- A greater slope indicates an increased rate of change.

INVERSE VARIATION (DISPROPORTIONAL) As one variable increases, the other decreases.



SCIENTIFIC MODEL an idea that allows us to create explanations of how we think some part of the world works.
MODELS are used to represent a concept or system so that it may be more easily understood.

TECHNOLOGY (tools/machines) can be used to develop better understanding of the science concepts studied.

- As technology improves, science concepts are studied more completely and more accurately.

SCIENTIFIC INVESTIGATION - Followed to determine the relationship between independent and dependent variables.

- The results of investigations can advance science knowledge.

TECHNOLOGICAL DESIGN - Followed to design products or processes to meet specified needs.

- The results of technological designs can advance standard of living in societies.

SCIENTIFIC INVESTIGATION	TECHNOLOGICAL DESIGN
Identifies a problem - asks a question and do research	Identifies a problem or need and do research
Designs an investigation or experiment	Designs a process or a product
Conducts the investigation - repeated trials	Implements the design - repeated testing
Analyzes the results	Analyzes the results
Evaluates the conclusion - did the results refute or verify	Evaluates the process or product - did it meet the criteria
Communicates the findings	Communicates the product or process

CHEMISTRY MATERIALS/APPARATUSES	PHYSICS MATERIALS/APPARATUSES
Balances, triple beam or electronic	Ammeters and voltmeters
Pipettes / droppers	Motion carts (or toy cars)
Beakers	Compasses
pH paper / pH meters / Litmus paper	Motors, simple electric
Bunsen Burners	Diffraction grating
flint strikers	Protractors
Chemical scoop	Dry cells (or other voltage source)
Stirring rods	Resistors
Conductivity apparatus (light bulb)	Electroscopes
Stoppers - rubber, cork	Slinky springs
Erlenmeyer flasks	Flashlights
Test tubes, holder, and rack	Spectroscope
Evaporating dishes	Generators (hand-held)
Test tube brushes	Spring scales
Filter paper	Hand lenses (magnifiers)
Thermometers (alcohol, digital)	Switches, knife
Forceps	Lenses (convex and concave)
Tongs (crucible, beaker)	Timers
Funnels	Light bulb and holders
Watch glasses	Tuning forks
Graduated cylinders	Magnets
Wire gauze with ceramic centers	Weights
Hot plates	Mirrors, plane rectangular
Wood splints	Wire, insulated copper

REQUIREMENTS FOR TECHNOLOGICAL DESIGNS:

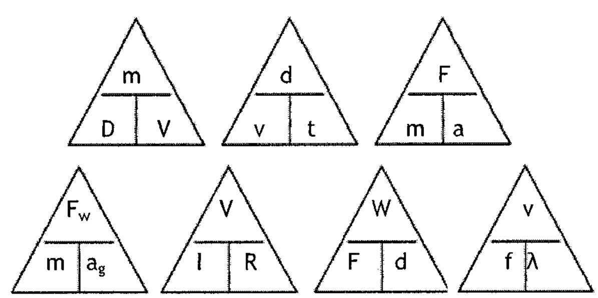
- Cost effectiveness
- Time effectiveness
- Materials that meet specific criteria, such as:
    - Solves the problem
    - Reasonably priced
    - Availability
    - Durability
    - Not harmful to users or to the environment
    - Qualities matching requirements for product or solution
    - Manufacturing process matches characteristics of the material

QUANTITY MEASURED	SYMBOL	SI UNIT
Density	D	g/cm^3
Mass	M	Gram, g
Volume	V	cm^3, mL, cc
Velocity or average speed	v	m/s
Distance	d	Meter, m
Time	t	Second, s
Acceleration	a	m/s/s, m/s^2
Force	F	Newton, N (kgm/s^2)
Mass	m	Kilogram, kg
Weight (Force of weight)	F_w or w	Newtons, N
Gravitational Acceleration	a_g or g	9.8 m/s/s
Voltage (potential)	V	volt, V
Current	I	Ampere, A
Resistance	R	Ohm, Ω
Work	W	Joule, J (Nm or kgm^2/s^2)
Frequency	f	Hertz, Hz (1/sec)
Wavelength	λ	Meter, m

METRIC SYSTEM

	Kilo	Hecto	Deca	UNIT	Deci	Centi	Milli
Meter	km	hm	dam	m	dm	cm	mm
Liter	kL	hL	daL	L	dL	cL	mL
Gram	kg	hg	dag	g	dg	cg	mg

EQUATION TRIANGLES



STANDARD 3 - PROPERTIES & CLASSIFICATION OF MATTER

THE KINETIC THEORY:

- All matter is composed of small particles (molecules, atoms, and ions).
- The particles are in constant, random motion.
- The particles are colliding with each other and the wall of their container.

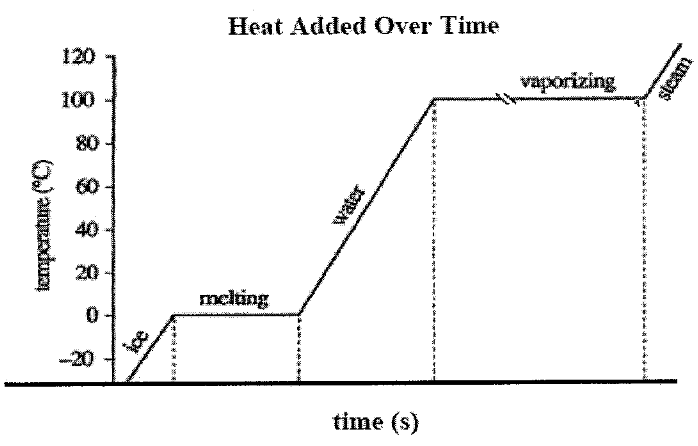
SOLIDS	• The particles of solids are closely packed together. • The particles of solids are constantly vibrating, but they do not readily slip past one another. • A solid has a definite shape.
LIQUIDS	• The particles of liquids are in contact with each other. • The particles of liquids have enough energy to partially overcome the attractive force of the surrounding particles. • Liquid particles can slip past surrounding particles and slide over one another. • Because the particles slip past one another, a liquid does not have a definite shape and so takes the shape of the container. A sample of a liquid can be poured.
GASES	• The particles of gases are not in contact with each other because they have enough energy to completely overcome the attractive force between or among the particles. • The particles of gases are moving randomly, in straight lines until they bump into other particles or into the wall of the container. When a particle hits another particle or the container, it bounces off and continues to move. • Because gas particles move independently, the particles move throughout the entire container. The forces between the particles are not strong enough to prevent the particles from spreading to fill the container in which the gas is located.
PLASMA	• Plasma is matter consisting of positively and negatively charged particles. • A substance is converted to the plasma phase at very high temperatures, such as those in stars (such as the sun). High temperature means that the particles of a substance are moving at high speeds. At these speeds, collisions between particles result in electrons being stripped from atoms. • Plasma is the most common state of matter in the universe, found not only in stars, but also in lightning bolts, neon and fluorescent light tubes and auroras.

TEMPERATURE - the average kinetic energy of the particles in a substance.

- At higher temperatures, more of the particles are moving fast and at lower temperatures, more of the particles are moving slowly.

PHASES CHANGE - due to *changing* the freedom of movement of the particles by the addition of energy.

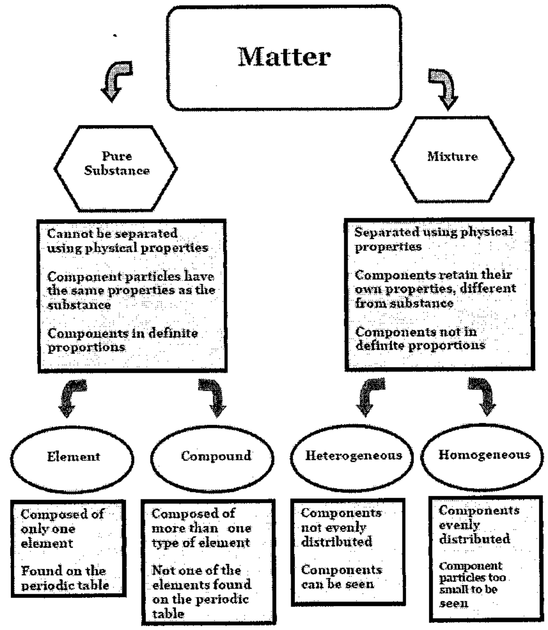
- **FREEZING/MELTING POINT** - temperature where a phase change occurs at both the liquid and solid phase.
  - If heat energy is being added at this temperature, a solid will melt.
  - If heat energy is being taken away, a liquid will freeze at this temperature.
- **BOILING POINT** - temperature where a liquid is changing to a gas throughout the liquid.
- **VAPORIZATION** - changing a liquid into a gas. There are 2 forms of vaporization:
  - **EVAPORATION** - occurs at the surface of a liquid can occur at any temperature.
  - **BOILING** - vapors are formed throughout the sample and rise to the top and escapes at which point the sample is said to be boiling.
- **SUBLIMATION** - changing directly from a solid to a gas. Ex: dry ice (solid carbon dioxide)



ELEMENTS - composed of only one type of atom; all elements are listed on the periodic table.
ATOM - smallest unit of an element that can be involved in a chemical reaction.
MOLECULES - composed of two or more atoms covalently bonded together. Molecules are the smallest particle of a molecular substance that can exist and still have the composition and chemical properties of the substance.

PURE SUBSTANCES - substances that have unique, identifying properties. There are 2 types of pure substances:

- **ELEMENT** - composed of only one type of atom.
- **COMPOUND** - composed of more than one type of element. Compounds have identifying properties which are different from the properties of the elements which compose them.
  - Compounds can be decomposed into elements only by chemical reactions; they can not be separated into elements by physical means.
  - Compounds have a definite chemical composition identified by a chemical formula.
  - MOLECULAR SUBSTANCES and IONIC SUBTANCES are types of compounds



MIXTURE - matter composed of two or more component substances which retain their own identifying properties. Mixtures do not have a definite composition.

- **HETEROGENEOUS MIXTURES** - Different components are often easy to see in a heterogeneous mixture.
- **HOMOGENEOUS MIXTURES** - Have components evenly distributed all the way down to the particles, whether atoms, molecules, or ions. Ex: SOLUTION.

MIXTURES CAN OCCUR BETWEEN:

- Gas/gas (air)
- Gas/liquid (oxygen in water)
- Liquid/liquid (alcohol in water)
- Solid/liquid (sugar in water)
- Solid/solid (alloy such as steel)

HOW TO SEPARATE A MIXTURE:

- Dissolving
- Filtering
- Evaporating
- Decanting
- Magnetic separation
- Chromatography
- Separating by particle size (screening)

WHAT AFFECTS THE RATE OF DISSOLVING?

- **TEMPERATURE -** The higher the temperature, the faster the rate of dissolving.
  - At higher temperatures more of the solvent molecules are moving faster and collisions with the surface of the solute occur more often carrying off particles of the solute so dissolving occurs more rapidly.
- **PARTIAL SIZE** - The smaller the size of the pieces of solute, the faster they dissolve.
  - The smaller the size of the individual pieces, the more surface area the sample will have to be in contact with the water molecules. With more surface area in contact the water molecules, the water will have more opportunities to pull the solute molecules away from the solute's surface, thereby, dissolving it faster.
- **AGITATION** - The more the solution is agitated, the faster the rate of dissolving for a solid in a liquid.
  - When a solution is agitated, the water particles collide with the surface of the solute more frequently and the dissolving process occurs faster.
- If a substance is soluble in water, it will eventually dissolve even if the size of the sample pieces of solute are large, the temperature is low and there is no agitation.

PROCESS OF DISSOLVING (sugar in water):

- The sugar molecules pull away from each other by the water molecules.
- The sugar molecules on the surface of the crystal are the only ones to dissolve because they are the ones in contact with the water molecules.
- As surface sugar molecules dissolve, they expose the ones beneath to the water.
- Because the dissolved sugar molecules are surrounded by water molecules, they are not attracted to each other (the water molecules block the attractive force).
- The sugar molecules are distributed throughout the water.
- The water can be removed by boiling the water or allowing it to evaporate. When the water boils or evaporates away, the sugar molecules will once again be attracted to each other and sugar crystals will reform.

PHYSICAL PROPERTY - can be observed directly without changing the composition of the substance.

DENSITY - the mass of a substance per unit volume.

- Density changes with phase change (solid to liquid to gas) because the volume of a particular substance is dependent upon phase.
- Density measured as the ration of mass to volume. D = m/v and the SI units are g/cm^3
- Density is a Physical Property!

SOLUBILITY - the maximum amount of a solute (substance being dissolved) that can dissolve in a given volume of solvent (the dissolving medium) at a particular temperature and pressure.

- Solubility is a Physical Property!

VISCOSITY - a measure of the material's resistance to flow.

- Viscosity is a property of fluids. High-viscosity fluids take longer to pour than low-viscosity fluids.
- Viscosity may change with temperature. (Increase temperature decreases the viscosity)
- Viscosity is a Physical Property!

ELECTRICAL CONDUCTIVITY - the ability of a solid to act as an electrical conductor or an electrical insulator.

- Materials (such as metals) with high conductivity are called electrical conductors because they allow current to flow easily.
- Materials with low conductivity are called electrical insulators because they do not allow current to flow. Most non-metals are insulators.
- Some solutions can conduct electric current. Solutes that dissolve in water that result in solutions that allow electric current to flow are called **ELECTROLYTES**. Electrolyte solutions contain *ions*.
- Electrical Conductivity is a Physical Property!

CHEMICAL PROPERTY - a characteristic of a substance that indicates whether it can or cannot undergo a certain chemical change. Chemical properties include but are not limited to:

- *Combustibility or flammability*, such as carbon reacting with oxygen to form carbon dioxide. (ex: burning)
- *Ability to oxidize*, such as iron reacting with oxygen to form iron(III) oxide. (iron rusting)
- *Ability to corrode*, such as silver reacting with sulfur to form silver sulfide. (silver tarnishing)
- *Ability to decompose*, such as hydrogen peroxide decomposing into water and hydrogen gas.
- *Ability to react with acids*, such as zinc reacting with hydrochloric acid to form zinc chloride and hydrogen gas.
- *Ability to not react*, such as gold being used in jewelry because it does not readily react.

PHYSICAL CHANGES - a change in matter from one form or appearance to another but does <u>not</u> involve a change in the identity of a substance.

- When physical changes occur a new substance is NOT produced.
- Change in size *(being broken into smaller pieces)*
- Change in shape *(such as being bent or stretched)*
- Expand or contract due to a temperature change
- Color change *(When different colors of paint, crayon, or food coloring are mixed together)*
- Phase changes *(freezing, melting, evaporation, sublimation, etc.)*

CHEMICAL CHANGES - occurs when there is a change in the arrangement of the atoms involved so a <u>different</u> substance with <u>different</u> properties is produced.

- When a chemical reaction takes place some type of evidence can be observed.
- Formation of a new gas.
- The reaction of a substance with an acid.
- Acids react with bases to form water and a salt (neutralization reaction).
- Color change.
- Metal tarnishing and changing color.

ORGANIC SUBSTANCES - compounds that contain carbon

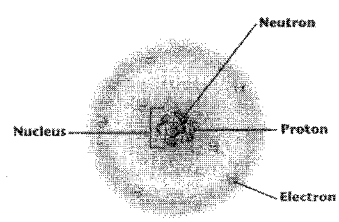
ORGANIC BIOLOGICAL MOLECULES INCLUDE:
- **PROTEINS** - long chains of small units (amino acid monomers) that are arranged in various configurations so they can form a wide variety of molecules. Proteins serve many varied functions in living organisms such as catalysts (enzymes) and tissue building.
- **CARBOHYDRATES** - (sugars and starches) provide organisms with energy when they break down into smaller molecules.
- **LIPIDS** (fats and oils) - good sources of stored energy because lipids produce more energy per gram than carbohydrates.

HYDROCARBONS - organic molecules composed of the elements *carbon* and *hydrogen*.
- Carbon and hydrogen can combine to make thousands of different hydrocarbon compounds.
- Hydrocarbons are <u>combustible</u> so they are used for fuel, including gasoline, kerosene, jet fuel, and diesel oil.
- Hydrocarbons form long chain molecules called **POLYMERS** so they are used to make <u>plastics</u>.

INORGANIC SUBSTANCES - elements or compounds that do not contain carbon. Examples and uses include:
- Copper is ductile and conducts electricity, so it is used in wiring.
- Aluminum has a low density compared to substances with similar strength, so it is used in making airplanes.
- Water is a good solvent for many compounds, so it is used to wash clothes.
- Argon is an inert/stable gas that will not react with the filament, so it is used in light bulbs.

STANDARD 2 - STRUCTURES & PROPERTIES OF ATOMS

ATOM - composed of subatomic particles (protons, neutrons, and electrons)



PROTONS: + charge; mass = 1 amu
NEUTRONS: neutral charge; mass = 1 amu
ELECTRONS: - change; negligible mass

NEUCLEUS - tiny center of the atom where protons and neutrons are tightly bound; has a positive charge.
ELECTRON CLOUD - surrounds the nucleus; electrons move in complicated patterns in this space.
- The volume of the 'electron cloud' determines the volume of the atom.

ENERGY LEVELS - levels of energy within the electron cloud
- Electrons with more energy occupy higher energy levels further from the nucleus
- 2 electrons can occupy the 1st energy level
- 8 electrons can occupy higher energy levels

IDENTITY OF THE ATOM:
- The number of protons determines the identity of an atom (an element).
- An atom of an element may lose/gain electrons or neutrons yet it still is the same element.

MASS OF THE ATOM:
- Total number of protons & neutrons within its nucleus.

REACTIVITY OF THE ATOM:
- Chemical reactions occur because the electrons around the atoms are exchanged or shared.
- The number of protons and neutrons <u>does not</u> change in a chemical reaction.
- The number of electrons in the outer energy level determines how the atom will react chemically.

ATOMIC NUMBER - equal to the number of <u>protons</u>, equal to the number of <u>electrons</u>.
- The atomic number never changes and be found as the whole number on the periodic table.

MASS NUMBER - Sum of the atom's protons and neutrons.
- The mass number <u>cannot</u> be found on the periodic table.
- The mass number must be given through words or an isotope symbol
- MASS NUMBER = PROTONS + NEUTRONS [# of NEUTRONS = MASS NUMBER - ATOMIC NUMBER]

ATOMIC MASS - The weighted average of the masses of the naturally occurring isotopes of an element.

- The atomic mass of an element can be found on the periodic table.
- Since the atomic mass of an element is an *average*, it is not a whole number

ISOTOPES - Atoms of the same element with different numbers of neutrons; therefore have different masses.
ISOTOPE SYMBOLS:

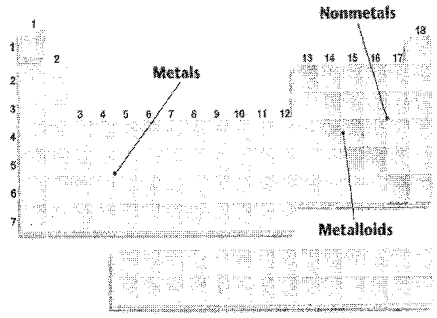
$$\text{MASS \# } \rightarrow \quad {}^{27}_{13}Al \quad \text{or} \quad \text{Al-27} \quad \swarrow \text{MASS \#}$$
$$\text{ATOMIC \# } \rightarrow$$

PERIORIC TABLE

PERIOD - horizontal row on the periodic table.
GROUP (FAMILY) - vertical column on the periodic table.

METALS - elements that tend to lose electrons. Located on the left-side of the periodic table's staircase.

- Reflect light (luster)
- Can be hammered into a sheet (malleable)
- Can be drawn into a wire (ductile)



NONMETALS - elements that tend to gain electrons. Located on the right-side of the periodic table's staircase.

- Not malleable or ductile
- Do not conduct electricity or heat well
- Not shiny

METALLOIDS - elements that have some characteristics of metals and some of nonmetals; they border the line between metals and nonmetals on the periodic table.

TRENDS OF THE PERIODIC TABLE

- PERIOD NUMBER tells you how many energy levels an atom has. (Ex: Period 2 elements have 2 energy levels)
- GROUP NUMBER tells you how many valence electrons an atom has. (Ex: Group 16 elements have 6 valence e-)

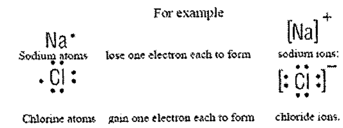
Group (Family) Number	Name of Group (Family)	# of Valence Electrons (# of outer energy level e-)	Oxidation Number (# of e- an atom gains/loses)
1	Alkali Metals	1	1+ (loses 1 e-)
2	Alkaline Earth Metals	2	2+ (loses 2 e-)
Skip the Transition Metals			
13	Boron Group	3	3+ (loses 3 e-)
14	Carbon Group	4	4+/- (mostly shares)
15	Nitrogen Group	5	3- (gains 3 e-)
16	Oxygen Group	6	2- (gains 2 e-)
17	Halogens	7	1- (gains 1 e-)
18	Noble Gases (Chemically stable atoms!)	8 (except He which has 2)	0 (does not lose or gain any e-)

STANDARD 4 - CHEMICAL BONDING AND REACTIONS

NOBLE GAS ELECTRON CONFIGURATION (an outside energy level with 2 or 8 electrons) is chemically *stable.*

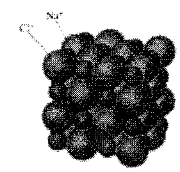
- When forming compounds, atoms gain, lose, or share electrons to reach an electron situation equal or similar to one of the noble gases.
- Atoms bond chemically to become more stable.
- Having the outside energy level full or "complete", like the noble gases, is chemically stable.

TYPES OF CHEMICAL BONDS



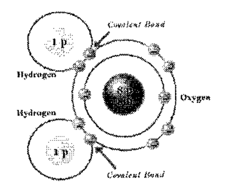
IONIC BONDING - electrons in the outer energy level are transferred (either gained or lost)

- Usually happens between a positively charged metals and negatively charged nonmetals.
- **ION** - Charged particle; atom with different number of e-. Ions form chemically stable atoms.
- Ionic bonds form **IONIC CRYSTALS.**



IONIC CRYSTALS - consist of metals bonded to nonmetals.

- These positive and negatively charged ions pack together as closely as possible in a crystal lattice to form an ionic crystal.
- Examples of ionic crystals may include: sodium chloride (NaCl), sodium hydroxide (NaOH), calcium fluoride (CaF_2), and potassium iodide (KI).



Bohr Model of H_2O

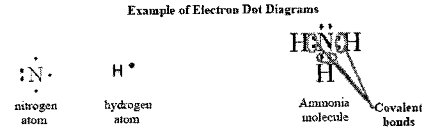
COVALENT BONDING - electrons in the outer energy level are shared.

- Usually happens between nonmetals.
- Multiple bonds can form when more than one pair of electrons are shared. (ex: double (2 covalent bonds) or triple (2 covalent bonds)) *You do not need to know how to draw or recognize multiple bonds!*
- **MOLECULES** are formed in covalent bonds.

MOLECULAR SUBSTANCES - often consist of nonmetals.

- Examples of molecular substances may include: hydrogen gas (H_2), carbon dioxide (CO_2), water (H_2O), and sugar ($C_6H_{12}O_6$).

Example of Electron Dot Diagrams



CHEMICAL FORMULA - indicates the ratio of atoms in a molecule or an ionic compound.

- The formula tells what elements are in the substance using symbols.
- The formula indicates the number of atoms of each element in a unit of the substance using subscripts (number written below).
- **BINARY IONIC COMPOUNDS** (two different elements bonded together)

HOW TO WRITE A CHEMICAL FORMULA (CRISSCROSS METHOD)

1. Determine the oxidation #s for both elements.
2. Write the chemical symbol and its positive oxidation # for the **metal** first.
3. Write the chemical symbol and its negative oxidation # for the **nonmetal** next.
4. Crisscross the **numbers** only and write the oxidation # of one element as the subscript of the other element.
5. Determine if the numbers are in simplest form (divide by common denominator if not).
6. Check by adding charges to equal 0.

CHEMICAL EQUATION - uses chemical formulas and symbols to show the **REACTANTS** and the **PRODUCTS** in a chemical reaction.

- **BALANCED CHEMICAL EQUATION** represents the process of a chemical reaction where atoms are rearranged but not created or destroyed. Atoms on both sides of the equation are equal.
- **LAW OF CONSERVATION OF MASS** states that the mass of all substances that are present before a chemical change equals the mass of all the substances that are remaining after a chemical change.
- **SUBSCRIPTS** indicate the number of atoms or ions in one chemical unit of that substance.
- **COEFFICIENTS** indicate the number of units of each material that is involved in a reaction.

TYPES OF CHEMICAL REACTIONS

- **SYNTHESIS REACTION** - two or more reactants combine to form one product
  - Ex: <u>4</u> Al + <u>3</u> O_2 → <u>2</u> Al_2O_3 ; A + B → AB
- **DECOMPOSITON REACTION** - a single reactant is broken apart into two or more products
  - Ex: <u>2</u> NaCl →<u>2</u> Na + Cl_2 ; AB → A + B
- **SINGLE DISPLACEMENT (REPLACEMENT)** - a reaction in which one element takes the place of another element in a compound
  - Ex: Zn + <u>2</u> HCl → $ZnCl_2$ + H_2 ; A + BC → AC + B
- **DOUBLE DISPLACEMENT (REPLACEMENT)** - a reaction in which there is an apparent exchange of atoms or ions between two compounds
  - Ex: FeS + <u>2</u> HCl → H_2S + $FeCl_2$; AB + CD → AD + CB

EXOTHERMIC REACTION - heat is given off.

- This type of reaction releases heat to the area around the reaction, so this area will become <u>warmer</u>.

ENDOTHERMIC REACTION -heat is absorbed.

- This type of reaction takes heat from the surrounding area, so the area around the reaction becomes <u>cooler</u>.

STEPS FOR BALANCING CHEMICAL EQUATIONS

Step 1: Write the chemical equation for the reactions using formulas and symbols
Step 2: Check the equation for atom balance
Step 3: Choose coefficients that balance the equation (remember coefficients are multipliers and can only be place in the FRONT of a compound!)
Step 4: Recheck the numbers of each atom on each side of the equation and adjust coefficients again if necessary

EVIDENCE A CHEMICAL REACTION HAS OCCURRED:

- FORMATION OF BUBBLES
- FORMATION OF A PRECIPITATE (insoluble solid)
- HEAT, LIGHT or FLAME IS PRODUCED (Exothermic change)
- CHANGE IN TEMPERATURE (Endothermic change)
- CHANGE IN COLOR
- ODOR

FACTORS THAT AFFECT CHEMICAL REACTION RATES:

TEMPERATURE	• When the temperature <u>increases</u>, the rate of a chemical reaction <u>increases</u>. • The kinetic energy of the molecules increases with increased temperatures and a greater number of the molecules will be moving faster. • Since more of the particles are moving faster, there will be more **total collisions** between particles and more collisions can a mean faster reaction rate.
CONCENTRATION	• When reactants are more <u>concentrated</u>, the rate of a chemical reaction can <u>increase</u>. • When reactants are more concentrated, it means there are more particles per unit volume. • Because there are more particles in a given volume, there is a greater chance that reactant particles will collide.
SURFACE AREA	• When the surface area of reactants <u>increases</u>, the reaction rate <u>increases</u>. • Only the particles at the surface of a sample of reactant can collide with particles of other reactants. • If the same mass of reactants is broken into smaller pieces, there is greater surface area. With many more particles on the surface, there is a greater chance for collisions to occur.
CATALYST	• When a catalyst is <u>added</u>, the reaction rate <u>increases</u>. • A *catalyst* is a substance that speeds up a reaction without being permanently changed itself. • Catalysts can lower the amount of energy needed to start a reaction (activation energy). • Since the energy needed for successful collisions is less, there will be more successful collisions.

ACID - a chemical that releases hydrogen ions (H+) in solution
BASE - a chemical which releases hydroxide ions (OH-) in solution.
pH SCALE - a way to measure the concentration of hydrogen ions(H+) in solution. It measures how acidic or how basic a solution is.

- The pH of a solution can be measured using pH paper, litmus paper, or pH meters.
- The pH range of many solutions falls between 0 and 14.
- The pH of pure water is 7. Any solution with a pH of 7 contains equal concentrations of H+ and OH- and is considered a **NEUTRAL SOLUTION.** It is not an acidic or a basic solution.

ACIDS	BASES
The pH is less than 7.	The pH is greater than 7.
It contains more H+ than OH-. A lower number indicates more hydrogen ions.	It contains less H+ than OH-. A higher number indicates more OH- ions.
Conduct electricity (are electrolytes).	Conduct electricity (are electrolytes)
Have a tart or sour taste	Have a slippery feel
Turns litmus paper red	Turns litmus paper turns
Acids react with active metals such as zinc and magnesium.	
HCl Hydrochloric acid (stomach acid) H_2SO_4 Sulfuric Acid (common industrial acid)	NaOH Sodium Hydroxide (drain cleaner) $Ca(OH)_2$ Calcium Hydroxide (hydrated lime - fertilizer)

NEUTRALIZATION REACTION- Acids and bases react to form water and a salt.

- An acid is used to neutralize a base; a base is used to neutralize an acid.
- Ex: HCl + NaOH → HOH (water) + NaCl (salt)

DIFFERENCE BETWEEN CHEMICAL REACTIONS AND NUCLEAR REACTIONS

NUCLEAR REACTIONS - involves protons and neutrons in the nucleus of the atom and involves LOTS of energy!
CHEMICAL REACTIONS - involve the electrons in an atom located in the electron cloud. e- will be transferred / shared.

ISOTOPES WITH UNSTABLE NUCLEI:

- In order for a nucleus to be stable, a correct ratio of neutrons and protons should be present in the nucleus.
- An isotope with an unstable nucleus is **RADIOACTIVE**.
- Due to the unstable condition of the nucleus, radioactive isotopes undergo nuclear decay.

NUCLEAR DECAY - a nuclear reaction that involves emission of energy and/or particles from the nucleus.

- Nuclear decay occurs naturally in many elements that are common on earth and there is always some radiation present in every environment.

RADIATION - particles and/or energy that are emitted during nuclear decay.

- Three types are alpha and beta particles, and gamma rays.

NUCLEAR FISSION - occurs when a heavy nucleus, such as the U-235 nucleus, splits into two or more parts and a large amount of energy is released.

- **CHAIN REACTION** - If one or more ejected neutrons strike another U-235 nucleus, another fission reaction may occur and so on.
- There must be a certain amount of mass, called a **CRITICAL MASS**, in close proximity for a chain reaction to occur.
- Understand that the mass of the products of a fission reaction is less than the mass of the reactants.
    - This lost mass (m) is converted into energy (E). The equation $E = mc^2$ shows the relationship of this "lost mass" to the energy released.
- Fission occurs in nuclear power plants, atomic bombs, nuclear-powered submarines and satellites.

NUCLEAR FUSION - occurs when light nuclei (such as hydrogen) fuse, or combine, to form a larger single nucleus (such as helium).

- In fusion reactions the mass of the products is less than the mass of the reactants and the "lost mass" is converted to energy.
- Fusion is the type of nuclear reaction that occurs on the sun (and other stars).
- A hydrogen bomb, *also called a thermonuclear bomb*, utilizes nuclear fusion.

NUCLEAR MEDICINE

BENEFITS	DRAWBACKS
Using radiation that results from the decay of certain isotopes to destroy targeted cells, such as cancer cells.	Waste from nuclear medicine must be stored in a special way until it is no longer radioactive.
Using the radiation that results from the decay of certain isotopes as a way of mapping the path of various substances through targeted organ systems.	Radiation treatment directed at cancerous cells will also cause some damage to healthy tissue.
Most substances that naturally pass through specific body systems can be "tagged" with radioactive samples of the same substances so the natural functioning of the body system can be observed.	

NUCLEAR WEAPONS

BENEFITS	DRAWBACKS
Some people believe that nuclear weapons are a deterrent to war.	Specialized technology is required to refine the fuel and to produce the weapons.
	Tremendous amounts of energy available from small amounts of fuel so smuggling is possible.
	The potential for a tremendous amount of destruction, both material and biological.
	Contamination of the environment with fission-product isotopes, many of which are radioactive and remain so for very long periods of time.
	Waste from the production of nuclear weapons must be stored in a special way until it is no longer radioactive, which can be a very long time
	Improper handling of nuclear materials and possible leakage can cause radioactive isotopes to contaminate the environment, causing long-term radioactive decay problems.

NUCLEAR-POWER REACTORS - PROCESS OF PRODUCING ELECTRICITY:

- Energy from controlled nuclear fission is used to heat water into steam,
- The steam expands turning a turbine which spins a huge magnet within a coil of metal wire
- The moving magnetic field forces electrons to flow in the metal wire.
  - The difference between a coal-powered plant and a nuclear-powered plant is the method of heating water; the other processes are the same in both types of power plants.

BENEFITS	DRAWBACKS
Tremendous amounts of energy available from small amounts of fuel	Requires specialized technology to refine the fuel.
No greenhouse gas or other air pollution from the burning of fossil fuels	Can cause thermal pollution to water systems.
Can be used anywhere (as opposed to wind power, solar power, hydroelectric power, etc)	Waste from nuclear fission reactors must be stored in a special way until it is no longer radioactive, which can be a very long time.
Abundance of fuel - Non-reliance on fossil fuel	Exposure of workers in nuclear facilities to radiation. Accidents in poorly designed or poorly maintained facilities, such as Chernobyl or Three Mile Island.

STANDARD 5 - FORCES AND MOTION

DISTANCE is a measure of how far an object has moved and is independent of direction.
DISPLACEMENT has both magnitude (measure of the distance) and direction. It is a change of position in a particular direction. For example: 40m east is a displacement.

TOTAL OR FINAL DISPLACEMENT refers to both the distance and direction of an object's change in position from the starting point or origin.

- Displacement only depends on the starting and stopping point.
- Displacement does not depend on the path taken.

SPEED is how fast something is going. It is a measure of the distance covered per unit of time and is always measured in units of distance divided by units of time. (The term "per" means "divided by")

- Speed is a *rate* as it is a change (change in distance) over a certain period of time
- Speed is independent of direction.

INSTANTANEOUS SPEED is "the speed at a specific instant".

- *Initial speed* and *final speed* are examples of instantaneous speed.
- A speedometer measures instantaneous speed.

AVERAGE SPEED is "the total distance covered in a particular time period"

VELOCITY refers to both the speed of an object and the direction of its motion.

- A velocity value should have both speed units and direction units, such as: m/sec north, km/h south, cm/s left, or km/min down.
- The velocity of an object can be changed in two ways:
  - The speed of the object can change (it can slow down or speed up).
  - The direction of an object can change.

Students must understand the meaning of the values on the chart in terms changing velocity.

	v_i	v_f
1st s	0.0 m/s	9.8 m/s
2nd s	9.8 m/s	19.6 m/s
3rd s	19.6 m/s	29.4 m/s
4th s	29.4 m/s	39.2 m/s
5th s	39.2 m/s	49.0 m/s

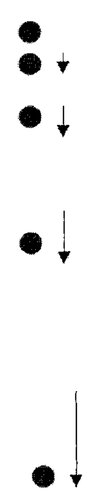
INSTANTANEOUS VELOCITY is the velocity at a specific instant.

- *Initial velocity* and *final velocity* are examples of instantaneous velocity.

AVERAGE VELOCITY is the total (final) displacement in a particular time.

ACCELERATION is a measure of the change in velocity (final velocity - initial velocity) per unit of time.

- When the velocity of an object is changing, it is accelerating.
- **NEGATIVE ACCELERATION** - object slows down
- **POSITIVE ACCELERATION** - object speeds up
- Acceleration is always measured in m/s/s or m/s^2



An object can accelerate in two ways:

- The speed can increase or decrease
- The direction can change.

GRAVITY

- All objects accelerate as they fall because Earth continually exerts a force (gravitational force) on them.
- An object will accelerate at a constant rate of **$9.8 m/s^2$** or m/s/s.
  - The value, 9.8m/s/s, is called the **ACCELERATION OF GRAVITY** and has the symbol a_g.
- The acceleration is in the *direction* of the force, so the direction of the acceleration is downward.
- Since the object is accelerating because of the gravitational force that is attracting Earth and the object, the velocity of the object continues to increase in speed and continues to fall in a downward direction until it hits the ground.

TABLES AND DIAGRAMS REPRESENTING ACCELERATION

CONSTANT VELOCITY OR ZERO ACCELERATION:

Below is a data table which shows an example of what instantaneous velocities might be if measured at equal time intervals for **zero acceleration.** Notice the velocity is the same each time.

Time	Instantaneous velocity
Initial time	15 m/s to the right
After one second	15 m/s to the right
After two seconds	15m/s to the right
After three seconds	15m/s to the right
After four seconds	15m/s to the right

The acceleration in the diagram below is **zero** because the velocity does not change.

CONSTANT POSITIVE ACCELERATION (SPEEDING UP):

Below is a data table which shows an example of what instantaneous velocities might be if measured at equal time intervals for **positive acceleration.** Notice the velocity is greater each time.

Time	Instantaneous Velocity
Initial time	0 m/s to the right
After one second	5 m/s to the right
After two seconds	10 m/s to the right
After three seconds	15 m/s to the right
After four seconds	20 m/s to the right

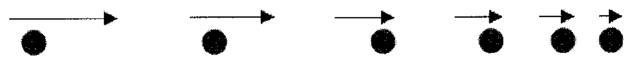
The acceleration in the diagram below is positive because the object is speeding up.

CONSTANT NEGATIVE ACCELERATION (SLOWING DOWN):

Below is a data table which shows an example of what instantaneous velocities might be if measured at equal time intervals for **negative acceleration.** Notice the velocity is smaller each time.

Time	Instantaneous Velocity
Initial time	20 m/s to the right
After one second	15 m/s to the right
After two seconds	10 m/s to the right
After three seconds	5 m/s to the right
After four seconds	0 m/s to the right

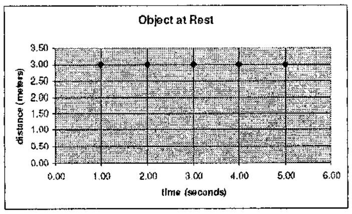
The acceleration in the diagram below is negative because the object is slowing down.



GRAPHING SPEED AND ACCELERATION

an object at rest

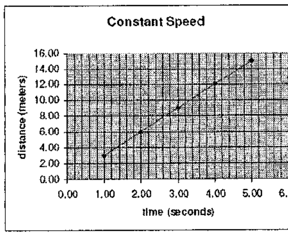
Elapsed Time (sec)	Total Distance Traveled (meters)
1.00	3.00
2.00	3.00
3.00	3.00
4.00	3.00
5.00	3.00



The shape of the graph is flat because between the 1st and 6th second no distance is covered.

an object with constant speed

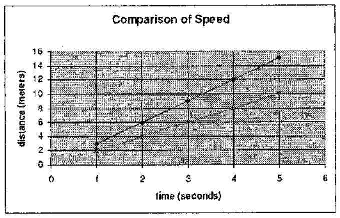
Elapsed Time (sec)	Total Distance Traveled (meters)
1.00	3.00
2.00	6.00
3.00	9.00
4.00	12.00
5.00	15.00



The shape of the graph is a diagonal straight line. The object covers the same amount of distance in each time period. As the time increases, the distance increases at a constant rate.

a comparison of two objects traveling at different speeds

Elapsed Time (sec)	Total Distance Traveled (meters) Object 1	Total Distance Traveled (meters) Object 2
1.00	3.00	2.00
2.00	6.00	4.00
3.00	9.00	6.00
4.00	12.00	8.00
5.00	15.00	10.00

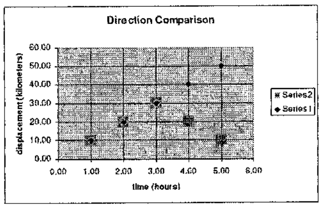


Both objects are traveling at a constant speed but the object represented by the top line is traveling faster than the lower one. You can tell this because the amount that the graph goes up each second (which represents the amount of distance traveled) is more for the top line than for the bottom one.

a comparison of two objects traveling in different directions at a constant speed

(to show this, a displacement-time graph is required)

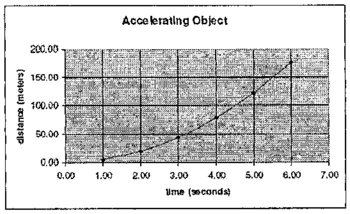
Elapsed Time (sec)	Total Displacement (meters) Object 1	Total Displacement (meters) Object 2
1.00	10.00 km W	10.00 km W
2.00	20.00 km W	20.00 km W
3.00	30.00 km W	30.00 km W
4.00	40.00 km W	20.00 km W
5.00	50.00 km W	10.00 km W



This is a displacement-time graph so it shows how far each object is from the starting point after each second. The series 1 object gets farther and farther away. At the 3rd hour, the series 2 object turns around and comes back toward the start. The speed of each object is the same.

an accelerating object — positive acceleration (speeding up)

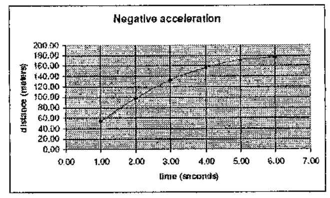
Elapsed Time (sec)	Total Distance Traveled (meters)
1.00	4.90
2.00	19.60
3.00	44.10
4.00	78.40
5.00	122.50
6.00	176.40



The shape of the graph is a curve getting steeper because as time goes by, the object covers more distance each second than it did in the previous second so the amount that the graph goes up each second gets more and more.

an accelerating object — negative acceleration (slowing down)

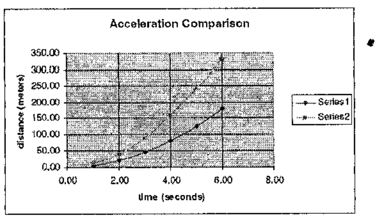
Elapsed Time (sec)	Total Distance Traveled (meters)
1.00	53.90
2.00	98.00
3.00	132.30
4.00	156.80
5.00	171.50
6.00	176.40



The shape of the graph is a curve getting flatter because as time goes by, the object covers less distance each second than it did in the previous second, so the amount that the graph goes up each second gets less and less.

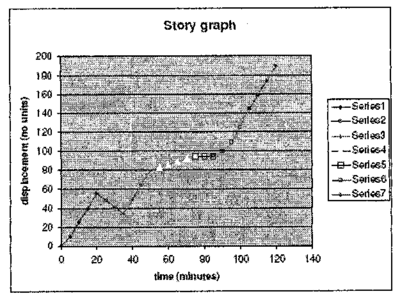
a comparison of two objects accelerating at different rates

Total elapsed Time (seconds)	Total distance traveled (meters) Object 1	Total distance traveled (meters) Object 2
1.00	5.00	10.00
2.00	20.00	40.00
3.00	45.00	90.00
4.00	80.00	160.00
5.00	125.00	240.00
6.00	180.00	330.00



Both of the objects are accelerating but the Series 2 object (bottom curve) is accelerating at a greater rate than the Series 1 object. Both objects cover more distance each second than they did during the previous second, but the amount of increase for the pink object is more than the amount of increase for the blue object.

infer a possible story given a graph



FORCE - a push or pull that one body exerts on another. (measured in Newtons)

BALANCED FORCES - forces on an object that are equal in size and opposite in direction

UNBALANCED FORCES - forces on an object that are NOT equal in size

- A **NET FORCE** is an unbalanced force.

The **WEIGHT** of an object is the force that gravity exerts on that object.

- The weight of an object depends on its mass.
- Given the mass of an object, its weight can be calculated using Newton's Second Law (F=ma).
- The force called weight is equal to an object's mass times the acceleration due to gravity.

NEWTON'S FIRST LAW states that the velocity of an object will remain constant unless a net force acts on it.

- This law is often called the **LAW OF INERTIA**.
- If an object is moving, it will continue moving with a constant velocity (in a straight line and with a constant speed) unless a net force acts on it.
- If an object is at rest, it will stay at rest unless a net force acts on it.

INERTIA - the tendency of the motion of an object to remain constant in terms of both speed and direction.

- That the amount of inertia that an object has is dependent on the object's mass.
  - The more mass an object has the more inertia it has.
- That if an object has a large amount of inertia (due to a large mass):
  - It will be hard to slow it down or speed it up if it is moving.
  - It will be hard to make it start moving if it is at rest.
  - It will be hard to make it change direction.
- That inertia does NOT depend on gravitational force.
  - Objects would still have inertia even if there were no gravitational force acting on them.

FRICTION - a net force that slows or stops a variety of everyday objects.

- If a ball were thrown in distant outer space away from forces, such as friction, it would continue to move at a constant velocity until an outside force acts on it.

NEWTON'S SECOND LAW OF MOTION - "When a net force acts on an object the object will accelerate in the direction of the net force".

- The larger the net force, the greater the acceleration.
- The larger the mass of the object, the smaller the acceleration.
- In mathematical terms, Newton's Second Law states that the net force equals the mass times the resulting acceleration. (F = ma)

THE EFFECTS OF FORCE:

- If the force is applied to an object at rest, the object will accelerate in the direction of the force.
- If the force is applied to a moving object in the same direction that the object is moving, the object will accelerate so its speed will increase to a greater speed and continue to travel in the same direction.
- If the force is applied to a moving object in a direction opposite to the direction that the object is moving, the object will have negative acceleration and slow down from its speed before the force was applied to a slower speed. It will either continue at the slower speed, stop, or begin to move in the opposite direction, depending on the magnitude of the force.

THE EFFECT OF MASS:

- If the same net force is applied to two different objects, the object with the smaller mass will have a greater acceleration in the direction of the applied force.

NEWTON'S THIRD LAW - states when one object exerts a force on a second object, the second one exerts a force on the first that is equal in magnitude and opposite in direction. (For every action there is an equal opposite reaction.)

- This law is sometimes called the *"Law of Action and Reaction"*.
- Even though the forces are equal in magnitude and opposite in direction, they do not cancel each other. This law addresses **two** objects, each with only **one** force exerted on it.
    - Each object is exerting one force on the other object.
    - Each object is experiencing only one force.

NEWTON'S LAW OF UNIVERSAL GRAVITATION - states that there is a force of attraction between all objects in the universe.

- The Law of Universal Gravitation applies to all objects.
- Gravitational force depends on:
    - Mass of both objects - the greater the mass, the greater the force.
    - Distance between objects - the closer the objects, the greater the force.
- The moon has less mass than Earth, so the moon has less attraction for objects on its surface than Earth does. (Objects on the surface of the moon weigh less than on Earth because the gravitational force between the object and the moon is less than the gravitational force between the object and the Earth.)

STANDARD 6 - CONSERVATION & TRANSFORMATION OF ENERGY

LAW OF CONSERVATION OF ENERGY - states that energy cannot be created or destroyed.

- Energy can be transformed from one form to another, but the total amount of energy never changes.

ENERGY - the property of an object or a system that enables it to do work.
WORK - is done when a force is applied to an object, and the object moves some distance in response to the force in the direction of the force.

- Work is the product of the force applied to an object and the distance the object is moved in the direction of the force (displacement).

DIFFERENT KINDS OF ENERGY

- **MECHANICAL ENERGY** is energy due to the position of something or the movement of something.
    - Mechanical energy can be potential, kinetic, or the sum of the two.
- **CHEMICAL ENERGY** is a type of energy associated with atoms, ions, and molecules and the bonds they form.
    - Chemical energy will change to another form of energy when a chemical reaction occurs.
- **ELECTRICAL ENERGY** is energy associated with current and voltage.
- **THERMAL ENERGY** is the energy associated with the random motion and arrangement of the particles of a material.
- **LIGHT ENERGY** is energy that associated with electromagnetic waves.
- **SOUND ENERGY** is energy associated longitudinal mechanical waves.

ENERGY TRANSFORMATION EXAMPLES:

- Electric circuit with a battery and a light bulb burning:
  - *Chemical energy changes to electrical energy.*
  - *The electrical energy flows through the light bulb and turns electrical energy to light and thermal energy.*
  - *The total of the energy from the chemical reaction in the battery is equal to the total energy that it transforms into.*
- A baseball is thrown to another ball player:
  - *A ballplayer converts chemical energy from the food he/she has eaten to mechanical energy when he/she moves his/her arm to throw the ball.*
  - *The work done on the ball converts the energy of the arm movement to kinetic mechanical energy of the moving ball.*
  - *As the ball moves through the air, it has both kinetic and potential mechanical energy.*
  - *When a second player catches the ball, the ball does work on the player's hand and glove giving them some mechanical energy.*
  - *The ball also moves the molecules in the glove moving them faster and thus heating the glove.*
  - *The player that catches the ball absorbs the energy of the ball, and this energy turns to heat.*
  - *The total heat produced is equal to the energy used to throw the ball.*

Most energy transformations are not 100% efficient. When energy changes from one form to another, some of the original energy dissipates in the form of energy that is not usable. Usually it dissipates as heat.

POTENTIAL ENERGY - energy that is stored due to position.
GRAVITATIONAL POTENTIAL ENERGY - stored energy above the Earth's surface.

- Factors that affect gravitational potential energy are <u>height</u> and <u>weight</u>
  - GPE is <u>greater</u> when the <u>height</u> of an object is <u>greater</u>.
  - GPE is <u>greater</u> when the <u>weight</u> of the object is <u>greater</u>.
- Gravitational potential energy of an object at some height is equal to the work required to lift the object to that height. Work is equal to force times distance; $W = Fd$.

KINETIC ENERGY - energy of motion.

- Factors that affect kinetic energy are <u>mass</u> and <u>speed</u>.
  - KE is <u>greater</u> when the <u>speed</u> of an object is <u>greater</u>.
  - KE is <u>greater</u> when the <u>mass</u> of a moving object is <u>greater</u>.

TRANSFORMATIONS BETWEEN GPE AND KE

- Lifting an object and dropping it
  - *An object is on the ground. It has zero potential energy with respect to the ground.*
  - *It is lifted to some height. It now has potential energy equal to the work it took to lift it to that height. Its potential energy depends on its weight and height above the ground.*
  - *When the object is dropped, it is attracted by gravity and begins to speed up. Some of the energy turns to kinetic.*
  - *On the way down some of the energy is kinetic and some is potential, but the total remains the same.*
  - *Just before the object hits the ground most of the energy has turned to kinetic. It loses its potential energy because its height has gone to zero.*
  - *When the object hits the ground some of the energy turns to sound and some turns to heat because it speeds up molecules when it hits the ground.*
- A swinging pendulum
  - *When a mass on a pendulum swings, it has mechanical energy. At the top of the swing all of its mechanical energy is potential energy that depends on its height and weight of the pendulum mass.*
  - *The kinetic energy is greatest at the bottom of the swing because the speed of the mass is greatest. Potential energy is zero at the bottom of the swing because the height of the mass is zero.*
  - *Between the top of the swing and the bottom of the swing the mass has both potential and kinetic energy because it has both height and movement (velocity).*
  - *Eventually the pendulum will stop. It stops because of friction.*
  - *The friction transforms the energy that was originally mechanical energy in the swinging pendulum into heat.*

WORK - the product of the force applied to an object and the distance the object is moved in the direction of the force (displacement).

- In order to do work on an object these conditions must apply:
  - A force is applied to the object.
  - The object must move in the direction of the force.
- When work is done on an object, *energy is transferred* to that object.
- Work is equal to change in energy.
- The unit of measure for work and energy is the j*oule (N·m).*

STATIC ELECTRIC CHARGE is the result of transfer of electrons.

- The electrons in the atoms can be removed from the atom and moved onto something else.
- When an object loses electrons, it will have more protons than electrons and will have a net positive charge.
- When an object gains electrons, it will have more electrons than protons and will have a net negative charge.
- Like charges repel each other and opposite charges attract.

CHARGING OBJECTS (CREATING A CHARGE)

FRICTION - when one object is rubbed against another, sometimes electrons leave one object and stick to the other leaving both objects charged.

- The object that loses electrons will get or have a net positive charge, and the object that gains electrons will get or have a net negative charge.

CONDUCTION - electrons can be transferred from one object to another by touching.

- When a charged object touches another object some charge will transfer to the other object.
  - If the charged object is negative, some of the electrons will leave the negatively charged object and travel to the neutral object leaving both objects with a negative charge.
  - If the charged object is positive, some of the electrons will leave the neutral object and travel to the positively charged object leaving both objects with a positive charge.
- Only the electrons are transferred in solid objects.
- Objects charged by conduction will have the same charge as the object charging it and therefore will repel it.

INDUCTION - objects can be charged by bringing a charged object near a neutral object.

- If a charged object is brought near a neutral object the charged object will attract unlike charges in the neutral object and repel like charges in the neutral object.
- Electrons will move in the neutral object and leave the side nearest the charged object charged with a charge that is opposite the charging object. (Only electrons can move in a solid object.)
- If the charged object is negative, the electrons in the neutral object will be repelled leaving the side nearest the charged object with a positive charge. If the neutral object is grounded, electrons are repelled into the ground. If the ground is removed the previously neutral object will be left with a residual positive charge.
- If the charged object is positive, the electrons in the neutral object will be attracted and move towards the positive charge leaving the side nearest the charged object with a negative charge. If the neutral object is grounded electrons are pulled from the ground. If the ground is removed, the previously neutral object will be left with a residual negative charge.
- After an object is charged by induction, it will have the opposite charge of the charging object and will attract it.

VOLTAGE - electric potential energy per charge. It provides the energy that pushes and pulls electrons through the circuit.

- Voltage is measured in *volts*. The symbol is (V).
- Voltage is created by:
  - **Chemical cell** (battery) when it changes *chemical energy* to *electrical energy.*
  - **Generator** when it changes *mechanical energy* to *electrical energy.*
  - **Solar cell** when it changes *light energy* to *electrical energy.*
- When a wire connects the terminals of a battery or generators, then the *voltage* will **push** and **pull** electrons through a conductor.
- One terminal has extra electrons thus a negative charge. The other terminal has a deficit of electrons and thus a positive charge.
- Electrons in the wire are pushed by the negative terminal and pulled by the positive terminal through the wire.

ELECTRIC CURRENT - the flow of charge through a conductor.

- The electric current in a wire is the flow of electrons.
- Electric current is measured in *amperes* or amps. The symbol is (A).

RESISTANCE - opposes the flow of charge through a conductor.

- All conductors have some resistance to an electric current.
  - In wires, resistance occurs when the electrons flowing through the wire continually run into metal atoms and bounce around. These collisions block the flow of the electric current and change some of the electrical energy to thermal and/or light energy.
- Resistance is measured in *ohms*. The symbol is (Ω).
- Resistance will <u>reduce</u> the flow of current because it is harder for the current to get through the conductor.
- When an electric current encounters resistance <u>heat</u> is produced.
- Sources of resistance are resistors, light bulb filaments, and other electric devices.

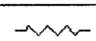
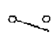
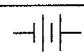
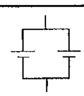
WHAT AFFECTS RESISTANCE IN A WIRE?

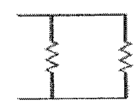
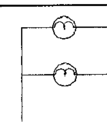
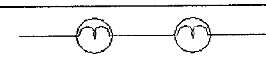
- Larger diameter = less resistance.
- Longer wires = greater resistance.
- Increase in temperature = increase resistance

OHMS LAW - describes the relationship between voltage, current, and resistance.

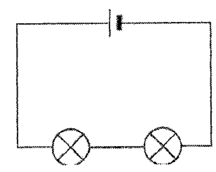
- The voltage (V) is the product of the current (I) and resistance (R). ($V = I R$)
- If the voltage increases and the resistance remains the same, the current will increase.
- If the voltage stays the same and the resistance increases, then the current will decrease.

CIRCUIT SYMBOLS

Wires	
Resistors	
Light bulbs	
Switches	
Chemical cell	
Battery circuit with 2 cells wired in series	
Battery circuit with 2 cells wired in parallel.	

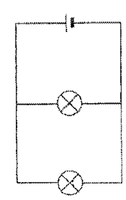
AC source (generator)	
Resistors in parallel	
Resistors in series	
Light bulbs in parallel	
Light bulbs in series	

SERIES CIRCUITS - there is a single path for electrons.



- When another resistor is wired in series with the resistors in a circuit, the total resistance increases because all of the current must go through each resistor and encounters the resistance of each.
- The current in the circuit decreases when additional resistors are added.
- When another light bulb is added to lights wired in series, the lights will dim.
- The current will be the same in each resistor.
- When light bulbs are wired in series and one is removed or burns out all of the lights in the circuit go out. When the light bulb is removed from the circuit, it opens the circuit and current cannot flow.

PARALLEL CIRCUITS - there is more than one path that the electrons can travel.



- The voltage in each path is the same.
- When another resistor is wired in parallel, then the total resistance is reduced.
- The total current in the circuit will increase when another path is added.
- If light bulbs are wired in parallel and one bulb burns out or is removed, the other bulbs keep burning because the circuit is still complete.

BATTERIES IN SERIES AND PARALLEL

- Batteries wired in series will increase the voltage of the battery.
- Batteries wired in parallel do not change the voltage of the battery; it makes the battery last longer.

ELECTROMAGNETS

- Electric currents in wires produce magnetic fields around the wire.
- The magnetic field can be strengthened in several ways:
  - Wrapping the *wire* in a coil with a greater number of turns.
  - Adding a larger *core* (like iron).
  - Increasing the *current* in the coil.

MOTORS - change electrical energy to mechanical energy.

- Motors contain an electromagnet called an *armature*.
  - When an electric current runs through the wire in the armature it becomes magnetized.
  - The armature spins because other magnets in the motor push and pull the armature and cause it to spin.
- Motors use the magnetic force from magnets to spin an armature (magnetized by an electric current) and thus change electric energy to mechanical energy.

GENERATORS - changes mechanical energy into electric energy.

- Generators use **ELECTROMAGNETIC INDUCTION** to produce an electric current.
- **ELECTROMAGNETIC INDUCTION** produces an electric current when a wire or a coil of wire moves relative to a magnetic field.
- In a generator at a power plant some other type of energy such as the energy in stream is used to turn a turbine which spins a magnet in a generator. The magnet spins past a coil of wire. This moving magnetic field pushes electrons through the wire.
- Generators produce AC current.

DIRECT CURRENT (DC) - current flows in one direction.

- DC current can be produced using a solar cell or a chemical cell (battery).
- Electrons are repelled by the negative terminal of a battery and attracted to the positive terminal of a battery. When a circuit is connected to the terminals the electrons will move from the negative terminal to the positive terminal.

ALTERNATING CURRENT (AC) - current moves back and forth.

- The electric current that comes out of the outlets in our homes and schools is AC current.
- AC current can be produced by a generator using the principle of *electromagnetic induction*.
- The current is produced when a magnet moves relative to a coil of wire.
  - In a generator the magnet (or coil) spins causing the terminals of the generator to alternate between positive and negative.
  - Since the terminals are continually changing from positive to negative the current continually changes direction.

STANDARD 7 - NATURE AND PROPERTIES OF WAVES

WAVE -repeating disturbance that transfers energy through matter or space.

- Wave motion transfers energy, not matter from one place to another.
- When a wave moves through matter, the matter is disturbed so that it moves back and forth, but after the wave passes, the matter will be in about the same position that it was before the wave passed.

TWO TYPES OF WAVES

MECHANICAL WAVES must have a medium through which to move.

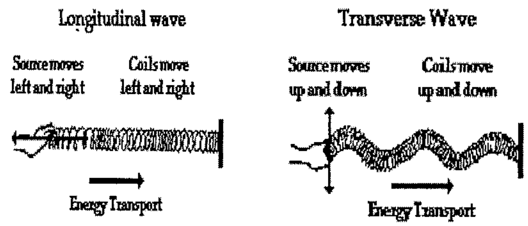
- Mechanical waves transfer energy through the particles of a medium.
- The particles of the medium move back and forth, but the wave (energy) itself are transmitted progressively from one place to another.

ELECTROMAGNETIC WAVES may travel through a medium but do not need a medium for transmission.

- Electromagnetic waves transfer energy through a medium or space.

TRANSVERSE WAVE - as the wave (energy) moves through the medium, the direction of the back and forth motion of the particles is perpendicular to the direction that the wave is moving.

- Examples of transverse, mechanical waves might include: Some "slinky" spring waves, secondary earthquake waves, and waves in the string of stringed instruments such as a guitar.
- The point of maximum displacement of the particles in a medium from the equilibrium position is called a *crest* or *trough*.



LONGITUDINAL WAVE (COMPRESSIONAL) - as the wave (energy) moves through the medium, the direction of the back and forth motion of the particles is parallel to the direction that the wave is moving.

- Examples of longitudinal mechanical waves might include: Some "slinky" spring waves, sound waves, primary earthquake waves, shock waves from a sonic boom or explosion, and ultrasonic waves.
- The particles of the medium are pushed closer together to form a high pressure area called a *compression* and spread out to form a lower pressure area with fewer particles called a *rarefaction*.

Some waves cannot be classified as transverse or longitudinal waves

- The motion of the particles in some waves can be described as circular. Surface water waves fall into this category.
- In torsion waves the motion of the particles is a twisting motion.

CHARACTERISTICS OF WAVES

AMPLITUDE - the greatest displacement of the particles in a wave from their equilibrium (rest) position.

- In a transverse wave amplitude is measured from the equilibrium or rest position of the medium to a crest or trough.

DISPLACEMENT - the displacement of the particles in the medium.

- This quantity has magnitude and direction.
- It is the distance of a vibrating particle from the midpoint of its vibration. (Displacement is used in discussing amplitude and interference of mechanical waves.)

FREQUENCY - the number of complete cycles (or vibrations) the particles go through per second or the number of waves that pass a point per second.

- The unit for frequency is *Hertz,* which is (one vibration/second) or (one cycle/second) or (one wave/second).
- The frequency and the wavelength are inversely related. When the frequency gets higher the wavelength gets shorter.

PERIOD - time for one cycle (or vibration) or the time for one complete wave to pass a point.

- The period is usually measured in seconds.
- The period and the frequency are inversely related. An increase in frequency would result in a decrease in period.

WAVELENGTH - distance between a point in a wave and the next similar (in phase) point.

- In a transverse wave the wavelength can be measured from a crest to the next crest or from a trough to the next trough.
- In a longitudinal wave the wavelength can be measured from point in the compression to a similar point in the next compression or from a rarefaction to a similar point in the next rarefaction.

VELOCITY/SPEED - a function of the medium and the type of wave and will not change unless the characteristics of the medium or type of wave changes.

- Changes in frequency or wavelength do not affect the velocity/speed (of mechanical waves).
- When the medium changes, the speed of waves changes.
- Examples may include:
  - Sound travels faster in steel than in air.
  - Sound travels faster in warm air than cooler air.
  - Light travels faster in air than in glass.
  - Transverse waves travel slower in a heavy rope than in a light rope.

"SLINKY" WAVES - transverse and/or longitudinal. A wave in a "slinky" spring illustrates a mechanical disturbance caused by a force displacing one of the spring coils.

- The energy of a wave in a "slinky" spring will pass from the point on the spring where a coil has been displaced to the end of the slinky.
- The medium consists of the slinky coils.
- The coils either move back and forth parallel to the length of the spring, or back and forth perpendicular to the length of the spring
- After the wave passes, the coils return to approximately the position where they were before the wave passed.

SOUND WAVES - a longitudinal, mechanical disturbance caused by a force displacing molecules in the medium through which it passes.

- The particles of the medium move back and forth, parallel to the direction of the wave.
- When a sound wave passes, the particles of the medium continue moving in approximately the same area where they were before the wave passed.

DOPPLER EFFECT - an apparent frequency shift due to the relative motion of an observer and a wave source.

- A Doppler shift occurs when a wave source is moving toward an observer or away from the observer.
- A Doppler shift also occurs when the observer is moving toward or away from the wave source.
- There is no shift when the source and observer are not moving toward or away from each other.

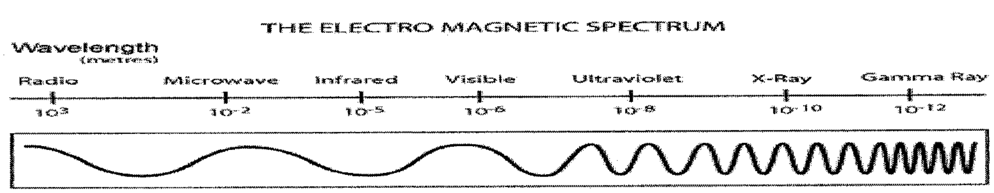
- When the wave source approaches the observer or the observer approaches the wave source:
  - The observer perceives a **higher** frequency, a **higher** pitch and a **shorter** wavelength.
- When the wave source moves away from the observer or the observer moves away from the wave source:
  - The observer perceives a **lower** frequency, a **lower** pitch and a **longer** wavelength.

LIGHT WAVES - are energy that can be transmitted without mechanical disturbance of the particles of a medium

- Light waves are transverse waves.
- Light waves do not need a medium through which to travel.
- Light waves (and other electromagnetic waves) travel in straight lines in all directions from the source of the light as long as the medium does not change.
- Light waves can transmit energy through empty space as from the Sun or stars.
- The energy of the light wave travels from one place to another, but the particles of the medium, if there is one, remain in approximately the same area where they were before the wave passed.

ELECTROMAGNETIC SPECTRUM - range of frequencies of electromagnetic waves.

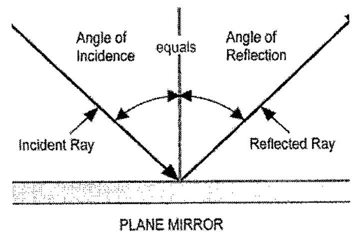
- From lowest frequency to highest frequency:
  - Radio waves
  - Microwaves
  - Infrared radiation
  - Visible light (red, orange, yellow, green, blue, violet)
  - Vltraviolet (UV)
  - X-rays
  - Gamma rays.
- The energy of electromagnetic waves is directly proportional to the frequency. (As frequency increases the amount of the wave carries energy increases.)
- Electromagnetic waves with higher frequencies than visible light can burn your skin and cause tissues damage.
- The higher frequency electromagnetic waves have shorter wavelengths.
  - Wavelengths vary greatly from very long wavelengths (many meters) to very short wavelengths (the size of atomic nuclei).
- Electromagnetic waves travel in space with no medium or may travel through a transparent medium.
  - All types of electromagnetic waves travel at the same speed in a vacuum.
- Electromagnetic waves slow down when they move from a vacuum to a transparent medium.



BEHAVIOR OF WAVES

REFLECTION IN LIGHT

- When light rays reflect they obey the "**LAW OF REFLECTION**". It states that the *angle of incidence* is equal to the *angle of reflection.*
- Light waves **REFLECT IN PLAIN MIRRORS** to produce images:
  - The image appears as far behind the mirror as the object is in front of it.
  - The image and the object appear to be same size.
  - The image is upright.



REFLECTION IN SOUND - sound bounces off a surface it cannot go through) - this produces echoes

CONSTRUCTIVE INTERFERENCE

- A crest will interfere with another crest constructively to produce a larger crest.
- A trough will interfere with another trough to produce a larger trough.
- Compressions interfere with other compressions to produce a more dense compression.
- Rarefactions interfere with other rarefactions to produce a less dense rarefaction.

DESTRUCTIVE INTERFERENCE

- A crest will interfere with a trough to lessen or cancel the displacement of each.
- Compressions interfere with rarefactions to lessen or cancel the displacement of each
- The individual waves are not affected by the interference and will continue on as if nothing has happened.

INTERFERENCE IN LIGHT WAVES

- Constructive Interference produces brighter light.
- Destructive Interference products darker light.
- Color = no interference; No color = destructive interference
- Light waves can reflect off the bottom and top surfaces of thin film, such as oil on water or bubbles, and produce a color pattern due to interference.
- Light wave can diffract through small slits or around lines to produce light and dark patterns or color patterns due to the interference of light waves.

INTERFERENCE IN SOUND WAVES

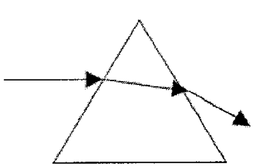
- Constructive interference makes sounds louder.
- Destructive interference makes sounds quieter
  - This is because amplitude of a wave is what is affected by interference and a sound wave's amplitude is heard as loudness.

DIFFRACTION - the bending of a wave around a barrier or around the edges of an opening.

- Waves with a longer wavelength diffract more readily.
- In order to observe light diffraction the barriers or openings must be small.
- When light waves diffract interference patterns can often be observed.

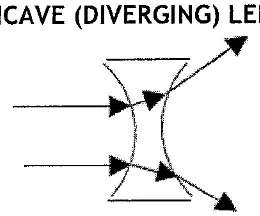
REFRACTION - Waves refract when they change direction upon entering another medium.

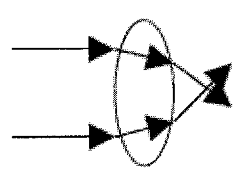
- In order to refract the wave must:
  - Change speed when it hits the new medium
  - The wave must strike the new medium at an angle other than perpendicular.



- When white light enters another medium such as a **PRISM** and refracts the colors may spread out.
  - This is because the violet end of the spectrum slows down more than the red end and therefore bends more.

CONCAVE (DIVERGING) LENS OR CONVEX (CONVERGING) LENS.





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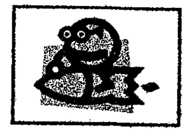


Name: ______________________ Class: ________ Date: __________

Scientific Method

1. Identify the Problem
2. Research the problem
3. Form a hypothesis
4. Test the hypothesis (experimentation)
5. Observe and record your results
6. Arrive at a conclusion

Mass, Length, and Volume

Kilo- (k)	hecto- (h)	deca- (da)	Basic Unit	deci- (d)	centi- ©	milli- (m)
1000	100	10	gram (g)	.1	.01	.001
			meter (m)			
10^3	10^2	10^1	liter (L)	10^{-1}	10^{-2}	10^{-3}

Scientific Notation and Significant Figures

Scientific notation takes the form of M x 10n where $1 \leq M < 10$ and "n" represents the number of places the decimal was moved from standard form. Positive "n" indicates the standard form is larger than zero, whereas negative "n" indicates a number smaller than zero.

Example: $1{,}500{,}000 = 1.5 \times 10^6$ Example: $0.00025 = 2.5 \times 10^{-4}$

Multiplication and Scientific Notation
When multiplying numbers in scientific notation, multiply the first parts of the numbers and add the exponents.

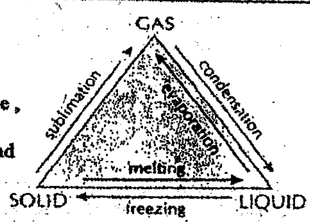
Example: $(3.0 \times 10^2)(2.5 \times 10^6) = (3.0 \times 2.5) \times 10^{(2+6)} = 7.5 \times 10^8$

Division and Scientific Notation
When dividing numbers in scientific notation, divide the first parts of the numbers and subtract the exponents.

$$\frac{(9.0 \times 10^6)}{(4.5 \times 10^2)} = \frac{9.0}{4.5} \times 10^{(6-2)} = 2.0 \times 10^4$$

Matter and Its Properties

Matter has mass and takes up space.
It exists in one of three states:
SOLID - Matter which has a definite shape and volume
LIQUID – Matter which has no definite shape, but a definite volume
GAS – Matter which has no definite shape and no definite volume

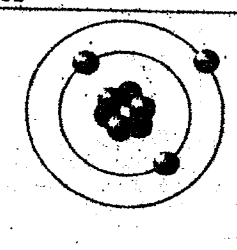


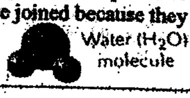
PHYSICAL PROPERTIES – These can be observed with the senses and can be determined without destroying the object:
- color - length -state -mass - shape

CHEMICAL PROPERTIES – These indicate how a substance reacts with something. The end result is a substance which is different from the original.

Atoms and Molecules

ATOM – The smallest amount of an element that has all the characteristics of that element. The nucleus of an atom consists of particles called protons (+) and neutrons (neutral). The nucleus is orbited by particles called electrons (-)
MOLECULE – The smallest unit in a compound; composed of two or more atoms that are joined because they share electrons





Masses of Atoms

The mass of an atom is equal to the number of protons and neutrons in the nucleus (mass of electron is too small to matter)
1 proton = 1 amu ; 1 neutron = 1 amu
ATOMIC NUMBER – the number of protons in an atom
MASS NUMBER – the number of protons and neutrons in an atom

Periodic Table

- The first table was organized by Dmitri Mendeleev
- Modern table is organized by increasing atomic number

PERIODS – Horizontal rows of the Periodic Table; the period # an element is in is the same as the # of energy levels it uses for its electrons
GROUPS (families) – Vertical columns of Periodic Table; all elements in the same group have the same # of outer (valence) electrons

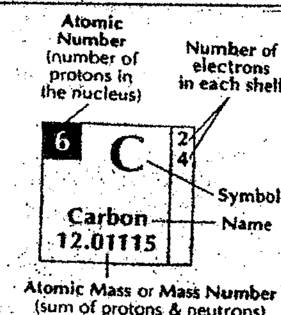
METALS – found to the left of the "zig-zag" line
- solid at room temp., shiny, malleable, ductile
- most reactive metals are found in the bottom left of table

NONMETALS – found to the right of the "zig-zag" line
- gases at room temp. or brittle solids

METALLOIDS – found along "zig-zag" line
- have properties of metals and nonmetals

Elements and Compounds

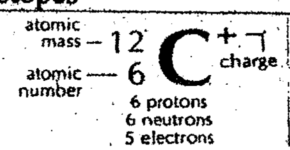
ELEMENT – A pure substance that is made up of only one kind of atom and cannot be broken down into other substances by electricity, heat, or light



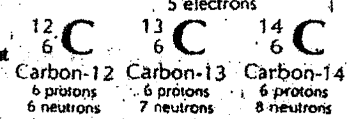
COMPOUND – A substance made up of two or more chemically bound elements.
EXAMPLE: Table salt is made up of the elements sodium and chlorine.

Ions and Isotopes

ION – An atom is generally electrically neutral. If an atom loses one or more electrons, it becomes a positive ion. If an atom gains one or more electrons, it becomes a negative ion



ISOTOPE - Atoms of the same element with different numbers of neutrons



Ionic and Covalent Bonds

IONIC – Chemical bond that results when one or more electrons are transferred from atom to atom. Because metals prefer to give away electrons and nonmetals prefer to pull them in, ionic bonds are typically metal-nonmetal.

COVALENT – Chemical bond that results when two or more atoms share a pair of electrons. Covalent bonds are typically nonmetal – nonmetal.

Balancing Chemical Equation

The Laws of Conservation of Mass and Energy state that matter and energy are neither created nor destroyed in a chemical reaction. Based on these laws, the total mass of all the reactants in an equation must equal the total mass of all the products, and the same number of atoms of each element must appear on both sides of the equation

4 2 4 2
EX: $2H_2 + O_2 \rightarrow 2H_2O$
(reactants) (product)

Classification of Chemical Reactions

Synthesis – Chemical reaction in which two or more elements, compounds, or both, join to make a new compound.

$4Al + 3O_2 \rightarrow 2Al_2O_3$

Single Replacement – Chemical reaction in which one element replaces another element in a compound.

$CaCl_2 + F_2 \rightarrow CaF_2 + Cl_2$

Decomposition – Chemical reaction in which one substance breaks down into simpler substances.

$2NaCl \rightarrow 2Na + Cl_2$

Double Replacement - Chemical reaction in which the elements of two compounds switch places. Typically results in the formation of a precipitate

$AgNO_2 + KCl \rightarrow AgCl + KNO_2$

Exothermic Reaction – heat is released during reaction
Endothermic Reaction – heat is required during reaction

Nuclear Reactions

NUCLEAR FUSION – process of fusing together two atomic nuclei with low masses to form one nucleus with a larger mass.
- These reactions take place on the sun

NUCLEAR FISSION – process of splitting a large atomic nucleus into two nuclei with smaller masses
- These reactions take place in nuclear reactors

Acids, Bases, Salts, and the pH Scale

ACID
- Produces hydrogen ions (H^+) when in solution with water
- Chemical formula begins with H
- Turns blue litmus paper red
- Characteristically sour-tasting

BASE
- Produces hydroxide ions (OH^-) when in solution with water
- Chemical formula ends with OH
- Turns red litmus paper blue
- Characteristically bitter-tasting

pH SCALE – Used to measure the concentration of H^+ and OH^- ions in a solution to determine whether it is acidic, basic, or neutral (having equal amounts of H^+ and OH^- ions). The lower the number on the pH scale, the more acidic a solution; the higher the number, the more basic a solution.

Higher concentration of H^+ ions ←→ Higher concentration of OH^- ions

1 2 3 4 5 6 7 8 9 10 11 12 13 14

acidic — neutral — basic

NEUTRALIZATION – chemical reaction that occurs when the $H3O^+$ ions from an acid react with the OH^- ions from a base to produce water molecules and a salt

$HCl + NaOH \rightarrow H_2O + NaCl$

Solutions

SOLUTION – mixture that appears to have the same composition, color, density, and taste throughout

SOLUTE – the substance being dissolved in a solution
SOLVENT – the substance in which the solute is dissolved

SOLUBILITY – maximum amount of a solute that can be dissolved in a given amount of solvent at a given temperature
- if a solution can hold more solute = unsaturated solution
- if a solution contains all the solute it can hold = saturated solution
- if a solution contains more solute than normal = supersaturated solution

There are 3 ways to increase the dissolving rate of a solid in a liquid
1. stir the solution
2. heat the solution
3. Grind the solute (increase the surface area of the solute)

Motion and Forces

VELOCITY – The measure of how fast an object is moving in a specific direction

velocity = distance/time

ACCELERATION – The change in velocity per unit of time

acceleration = (final velocity – initial velocity) / time

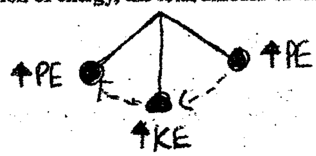
3 ways the accelerate:
1. speed up 2. slow down 3. change direction

NEWTONS LAWS OF MOTION:
1st Law – an object in motion will stay in constant motion and an object at rest will remain at rest unless an unbalanced force acts on it
2nd Law – Force = mass x acceleration
3rd Law – for every action, there is an equal and opposite reaction

FORCE – the amount of push or pull on an object; measured in Newtons (N)

Energy

ENERGY – the ability to do work; expressed in joules (J)
- kinetic energy – energy in the form of motion
- potential energy – stored energy due to position (gravitational, chemical, elastic)
- mechanical energy – total amount of energy in a system; according to the law of conservation of energy, the total amount of energy never changes



Electricity

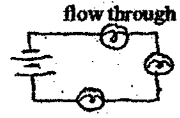
STATIC ELECTRICITY – Electricity generated when more of one type of charge is on an object; typically the abundance of electrons
- objects can acquire a static charge through friction, induction, and conduction

ELECTRIC CURRENT – The flow of an electric charge through matter. A current may differ based on voltage and resistance.

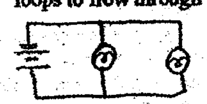
current = voltage/resistance

CIRCUIT – Closed conducting loop through which current can flow

series circuit – only one loop to flow through



parallel circuit – two or more loops to flow through

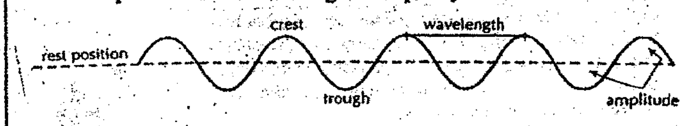


ELECTROMAGNET – temporary magnet made by looping a current-carrying wire around a piece of iron.
-The strength of an electromagnet can be increased by increasing the voltage or increasing the number of loops of wire

Waves

Waves carry energy from place to place. Matter does not move with the waves. Frequency is the number of wavelengths that pass a fixed point in one second

speed of wave = wavelength x frequency



REFLECTION – bouncing of a wave off an object (EX echo)
INTERFERENCE- 2 or more waves combine
REFRACTION- bending of wave caused by change of wave speed
DIFFRACTION – bending of waves around an object

★ Memorize the units! They will help with word problems!!!

Physical Science Reference Tables

MOTION AND ENERGY

$\bar{v} = \frac{\Delta d}{\Delta t}$

$a = \frac{v_f - v_i}{\Delta t}$

$F = ma$

$F_g = mg$

$p = mv$

$W = F\Delta d$

$P = \frac{W}{\Delta t}$

$PE_g = mgh = F_g h$

$KE = \frac{1}{2}mv^2$

$IMA = \frac{d_E}{d_R}$

$AMA = \frac{F_R}{F_E}$

$Efficiency = \frac{W_{out}}{W_{in}} \times 100$

$v_w = f\lambda$

v = velocity (m/s)

d = position (m)

t = time (s)

a = uniform acceleration (m/s² or m/s/s)

F = force (N)

m = mass (kg)

F_g = weight (N)

g = acceleration due to gravity on Earth = 9.8 m/s/s

p = momentum (kg·m/s)

W = work (J)

P = power (watt)

PE_g = gravitational potential energy (J)

h = height (m)

KE = kinetic energy (J)

IMA = ideal mechanical advantage (none)

AMA = actual mechanical advantage (none)

R = resistance (N)

E = effort (N)

v_w = wave velocity (m/s)

f = frequency (Hz)

λ = wavelength (m)

ELECTRICITY

$V = IR$

$P = VI$

V = electrical potential difference (V)

I = current (A or amp)

R = resistance (Ω or ohm)

P = power (watt)

DENSITY

$D = \frac{m}{V}$

D = density (g/cm³)

m = mass (kg) or (g)

V = volume (mL or cm³)

Bottom # = valence electrons   Side # = energy levels
Top # = oxidation/charge

PERIODIC TABLE

	1 IA	2 IIA	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8 VIIIB	9 VIIIB
Top #	+1	+2	Cannot be determined from table						
Bottom #	1	2	Cannot be determined from table						
1	1 **H** Hydrogen 1.008								
2	3 **Li** Lithium 6.941	4 **Be** Beryllium 9.012							
3	11 **Na** Sodium 22.99	12 **Mg** Magnesium 24.31							
4	19 **K** Potassium 39.10	20 **Ca** Calcium 40.08	21 **Sc** Scandium 44.96	22 **Ti** Titanium 47.88	23 **V** Vanadium 50.94	24 **Cr** Chromium 51.99	25 **Mn** Manganese 54.94	26 **Fe** Iron 55.85	27 **Co** Cobalt 58.93
5	37 **Rb** Rubidium 85.47	38 **Sr** Strontium 87.62	39 **Y** Yttrium 88.91	40 **Zr** Zirconium 91.22	41 **Nb** Niobium 92.91	42 **Mo** Molybdenum 95.94	43 **Tc** Technetium (98)	44 **Ru** Ruthenium 101.07	45 **Rh** Rhodium 102.91
6	55 **Cs** Cesium 132.91	56 **Ba** Barium 137.38	57 **La** Lanthanum 138.91	72 **Hf** Hafnium 178.49	73 **Ta** Tantalum 180.95	74 **W** Tungsten 183.84	75 **Re** Rhenium 186.21	76 **Os** Osmium 190.23	77 **Ir** Iridium 192.22
7	87 **Fr** Francium (223)	88 **Ra** Radium (226)	89 **Ac** Actinium (227)	104 **Rf** Rutherfordium (261)	105 **Db** Dubnium (262)	106 **Sg** Seaborgium (263)	107 **Bh** Bohrium (264)	108 **Hs** Hassium (269)	109 **Mt** Meitnerium (268)

58 **Ce** Cerium 140.12	59 **Pr** Praseodymium 140.91	60 **Nd** Neodymium 144.24	61 **Pm** Promethium (145)	62 **Sm** Samarium 150.36	63 **Eu** Europium 151.96	64 **Gd** Gadolinium 157.25
90 **Th** Thorium 232.04	91 **Pa** Protactinium 231.04	92 **U** Uranium 238.04	93 **Np** Neptunium (237)	94 **Pu** Plutonium (244)	95 **Am** Americium (243)	96 **Cm** Curium (247)

★Memorize valence, oxidation/charge, + energy level patterns!

OF THE ELEMENTS

			+3 3	+/- 4 4	-3 5	-2 6	-1 7	0 8
								18 VIIIA
			13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	2 **He** Helium 4.003
			5 **B** Boron 10.81	6 **C** Carbon 12.01	7 **N** Nitrogen 14.01	8 **O** Oxygen 16.00	9 **F** Fluorine 19.00	10 **Ne** Neon 20.18
10 VIIIB	11 IB	12 IIB	13 **Al** Aluminum 26.98	14 **Si** Silicon 28.09	15 **P** Phosphorus 30.97	16 **S** Sulfur 32.07	17 **Cl** Chlorine 35.45	18 **Ar** Argon 39.95
28 **Ni** Nickel 58.69	29 **Cu** Copper 63.55	30 **Zn** Zinc 65.39	31 **Ga** Gallium 69.72	32 **Ge** Germanium 72.61	33 **As** Arsenic 74.92	34 **Se** Selenium 78.96	35 **Br** Bromine 79.90	36 **Kr** Krypton 83.80
46 **Pd** Palladium 106.42	47 **Ag** Silver 107.87	48 **Cd** Cadmium 112.41	49 **In** Indium 114.82	50 **Sn** Tin 118.71	51 **Sb** Antimony 121.76	52 **Te** Tellurium 127.60	53 **I** Iodine 126.90	54 **Xe** Xenon 131.29
78 **Pt** Platinum 195.08	79 **Au** Gold 196.97	80 **Hg** Mercury 200.59	81 **Tl** Thallium 204.38	82 **Pb** Lead 207.20	83 **Bi** Bismuth 208.98	84 **Po** Polonium (209)	85 **At** Astatine (210)	86 **Rn** Radon (222)
110 **Ds** Darmstadtium (271)	111 **Rg** Roentgenium (272)	112 **Cn** Copernicium (285)						

65 **Tb** Terbium 158.93	66 **Dy** Dysprosium 162.50	67 **Ho** Holmium 164.93	68 **Er** Erbium 167.26	69 **Tm** Thulium 168.93	70 **Yb** Ytterbium 173.04	71 **Lu** Lutetium 174.97
97 **Bk** Berkelium (247)	98 **Cf** Californium (251)	99 **Es** Einsteinium (252)	100 **Fm** Fermium (257)	101 **Md** Mendelevium (258)	102 **No** Nobelium (254)	103 **Lr** Lawrencium (262)