Semesters 1 & 2 Study Guide

Characteristics of Science

What Students Should Know:

- Safety rules must be followed in order to create a safe learning environment.
- Safety materials are located in the lab area in designated areas.
- The names of all equipment used.
- Equipment must be used safely.
- The Scientific Process is a process of checking conclusions against nature. After observing something, a scientist tries to explain what has been seen.
- Qualitative observations describe in words the characteristics or qualities of an object.
- Quantitative observations provide information about quantity.
- An inference is a statement that attempts to interpret or explain a set of observation.
- Predictions are reasoned statements based on what we observe and the mental models we have constructed to explain what we observe.
- A controlled variable is a variable that stays the same for all groups in an experiment.
- An independent variable is a variable which is manipulated or changed for different groups.
- Dependent variables are affected by the changes made to the independent variable.
- An operational definition of a variable describes what is observed and how the variable will be measured.
- The metric units for length, temperature, mass, volume and force.
- A valid conclusion must be supported with multiple experimental trials.
- Procedures must be used to obtain, record, and organize information from an experiment.
- Different types of graphs should be used depending on the type of information being presented.
- Technology can be used to produce tables and graphs.
- Technology can be used to develop and test experimental models.
- Disparities could exist between estimated and calculated answers to problems.
- Measurement errors can be estimated.
- There is a distinction between accuracy and precision.
- Numbers can be expressed in scientific notation.
- Scientific investigations must be presented in coherent report format.
- Scientific arguments and presentations must be supported by evidentiary data.
- Group discussions are integral parts of scientific investigations and issues.
- Certain basic principles and laws apply throughout the entire universe.
- Principles are developed using scientific processes.
- The body of scientific knowledge typically is revised slowly over time through experimentation and observation.
- Occasionally major shifts in scientific views occur due to new observations or interpretation.
- Hypotheses are used to develop new experiments and clarify seek answers.

- Scientific theories are constantly being tested and revised.
- The control of experimental conditions is necessary to produce valuable data.
- Thorough investigation of sources of bias is important in scientific investigation.
- Scientists share results of investigations to ensure integrity.
- Density is a physical property of matter that establishes the relationship between mass and volume.
- The SI unit of mass is grams and volume is liters. Volume can also be expressed in cm^3 ($1cm^3$=1mL).
- Density of a substance can be determined by measuring its volume and mass

What Students Should Be Able To Do:

- Follow safety rules.
- Locate and use safety materials.
- Identify and use lab equipment safely.
- Distinguish between qualitative and quantitative observations.
- Plan and conduct investigations in which objects are classified and arranged according to characteristics.
- Select the appropriate metric unit for measuring any property.
- Measure temperature, length, volume, mass, or force to the correct number of significant figures.
- Given an object or event, construct a set of inferences from your observations about that object or event.
- Distinguish among observation, inference, and prediction.
- Make predictions using graphed data.
- Identify the variables in a statement or description of an investigation as dependent, independent, and control variables.
- Construct a table of data when given a written description of the measurements made during an investigation.
- Recognize patterns in data.
- Use data to create a reasonable explanation for the results of an investigation.
- Determine the slope of a line graph.
- Use the slope of a graph to describe the relationship between the variables.
- Describe the relationship between variables on a graph.
- Design an experiment or redesign an experiment based on results.
- Identify the hypothesis being tested when supplied with a description of an investigation.
- Construct operational definitions for variables.
- Obtain and organize laboratory data and/or results in an appropriate format.
- Use computer spreadsheet and other computer-based software to develop tables and graphs from experimental data and/or results.
- Use computer software to develop, test and revise an experimental or mathematical model.
- Derive mathematical calculations from analyzed data.
- Differentiate between accuracy and precision.
- Convert numbers into scientific notation.
- Write and present clear and coherent lab reports.

- Compose a summary of the data and use the data to generate arguments and discussions based on the data.
- Debate current scientific issues using current data to support or refute a scientific issue
- Identify appropriate units for physical properties of substances (density, mass, and volume).
- Calculate density given mass and volume.
- Find volume using water displacement method and through mathematical computations.
- Identify an unknown substance based on its density.
- Predict the density of various materials when placed in water.
- Convert from various SI units of mass and volume.

Atomic Structure & The Periodic Table

What Students Should Know:

- Proton is a positively charged particles found in the nucleus of the atom with a mass of 1 atomic mass unit (amu).
- Neutron is a neutral particles found in the nucleus with a mass of 1 amu.
- Electrons are negatively charged particles found in the electron cloud (outside the nucleus) with negligible mass.
- Atomic number is the number of protons and electrons found in an element at the ground state and is measured in amu.
- Isotopes are atoms of the same element with different number of neutrons.
- The identity of an element depends on the number of protons.
- The Periodic Table was organized by Mendeleev according to reactivity of elements.
- The Periodic Table is organized by atomic number that reveals trends among elements.
- A period is a row on the periodic table and a group or family is a column.
- The arrangement of electrons within an atom determines its position in the Periodic Table.
- Valence electrons are the electrons in the outmost energy level that are involved in chemical interactions.
- The group number indicates the number of valence electrons (excluding transition metals) and ionic charge.
- In general, metals form cations and nonmetals form anions.
- Hydrogen has properties of both group 1 and group 17.
- Metalloids form a boundary between metals and nonmetals.
- The common name for Group 1 is Alkali Metals, Group 2 is Alkaline-earth Metals, Groups 3-12 is Transition Metals, Group 17 is Halogens, and Group 18 is Noble Gases
- Groups 1 & 17 are the most reactive and Group 18 is inert.
- At room temperature, elements are either solid, liquid, or gas.
  These phases can change with changes in temperature.

What Students Should Be Able To Do:

- Draw and label the parts of an atom.
- List the subatomic particles including the location, charge, and mass.
- Identify and explain the basis of different isotopes of the same element.
- Name an element given the atomic number.
- Given an element, identify atomic number, group number, and period number, number of valence electrons, ionic charge, and phase at room temperature.
- Write the electron configuration for a representative element.
- Locate the metals, metalloids and nonmetals on a periodic table.
- Locate Alkali Metals, Alkaline-earth Metals, Transition Metals, Halogens, and Noble Gases
- Compare representative elements on the basis of reactivity, atomic radius, and electronegativity.
- Using the Periodic Table, name elements given the chemical symbol and write symbol when given the element name.
- Draw models showing differences in the molecular motion between solid, liquids, and gases.
- Predict the effect of changing temperature, volume, or pressure on the behavior of a gas.
- Compare and contrast solutes, solvents, and solutions.
- Predict the approximate rate of solution given the physical conditions of the solution.
- Explain how concentration changes when more solute or solvent is added to a solution.
- Predict whether a compound will be an electrolyte or non-electrolyte.
- Demonstrate how to increase the rate of solubility.
- Construct and interpret a solubility curve that relates temperature to solubility for a variety of solutes.
- Use a solubility curve to make predictions about the amount of a solute within a solution.
- Prepare saturated, unsaturated, and supersaturated solutions.
- Give an example of a solid, liquid, or gas solution.

Chemical Reactions

What Students Should Know:

- A chemical bond is the attractive force produced by the interaction of subatomic particles that holds atoms together.
- There are two types of chemical bonds: ionic and covalent.
- Ionic bonds result from a transfer of electrons. Atoms that gain electrons are negatively charged. Atoms that lose electrons are positively charged. Oppositely charged ions attract.
- Covalent bonds result when electrons are shared between atoms. Atoms can share electrons equally (nonpolar) or unequally (polar).
- Each element has its own unique name and symbol.
- Ions are formed from losing or gaining of electrons.
- Chemical compounds are formed by the joining of two or more atoms to achieve chemical stability.
- Ionic compounds form when a positive ion and negative ion bond.
- The charges carried by anions and cations combine in equivalent proportions to produce a neutral ionic compound. The proportional combinations of the charges determine the formula for the compound.
- In a neutral ionic compound the total charge for the cation is equal to the total charge for the anion.
- Covalent compounds share electrons to form a neutral compound.
- IUPAC system ensures that all scientists are naming and writing formulas consistently.
- The Law of Conservation of Matter is: matter cannot be created nor destroyed
- Chemical equations need to be balanced to obey the law of conservation of matter.
- The indicators of a chemical reaction are: evolution of a gas, formation of a precipitate, temperature or energy change, color change, odor
- A synthesis reaction creates a new, complex compound from two or more substances.
- Decomposition is the breakdown of a compound into two or more simpler substances.
- Single replacement is one element replacing another element in a compound.
- Double replacement is when two elements or groups from two different compounds switch places resulting in the formation of two new compounds.
- All matter is in constant motion whether it is a solid, liquids, gas, or plasma.
- Molecular motion increases in this order: solids, liquids, gases, and plasma.
- In gases, temperature and pressure are directly related, temperature and volume are directly related, and pressure and volume are inversely related.
- Solutes are substances dissolved in solvents.
- The universal solvent is water.
- Concentration is defined as amount of solute per solvent.
- The ability of how well a solution conducts electricity depends on its degree of polarity.
- Electrolyte is a solution that conducts electricity.
- The rate of solubility depends on physical factors such as surface area, temperature, motion, and nature of the solvent.

- Saturated solutions contain a maximum amount of solute at given temperature, unsaturated solutions contain less solute at given temperature, and supersaturated solution contains more than the maximum solute at room temperature.
- Solutions can be made with liquids, solids, or gases.
- An acid is a substance that donates hydrogen ions, H^+, to form a hydronium ion, H_3O^+, when dissolved in water.
- Acids have particular physical properties such as, sour taste, corrosiveness, conductivity,
- A base is a substance that either contains hydroxide ions, OH^-, or reacts with water to form hydroxide ions.
- Common properties of bases include, bitter taste, feels slippery, can cause indicators to change colors such as red litmus paper turns blue, basic solutions can conduct electricity, ph range is 7.1 to 14, and neutralize acids.
- Certain indicators, such as litmus paper can be used to estimate the degree of acidity or basicity.
- The pH of a solution is used to determine whether the solution is acidic, basic, or neutral. The pH scale ranges from 0 to 14.
- A pH that is less than 7 indicates acid, more than 7 indicates base, and 7 is neutral.
- When combined, an acid and base of equivalent concentrations will produce a neutralization reaction, where the products are water and a salt.

What Students Should Be Able To Do:

- Classify, compare and contrast the movement of electrons in ionic and covalent bonds.
- Describe the two types of covalent bonds.
- Recognize the structural difference between positive and negative ions.
- Predict formulas for balanced chemical reactions, using IUPAC nomenclature.
- Name and write the formula for binary ionic compounds using the IUPAC system.
- Name and write the formula for binary covalent compounds using the IUPAC system.
- Identify and count all atoms involved in a chemical reaction or compound.
- Balance a variety of chemical reactions.
- Recognize balanced chemical equations.
- Demonstrate the Law of Conservation of Matter by comparing the mass of reactants to the mass of products of a reaction.
- Explain that a chemical reaction has taken place based on indicators of change (e.g. color change, formation of a gas, formation of a precipitate, release of energy – heat or light).
- Identify a chemical reaction equation as a synthesis, decomposition, single replacement or double replacement reaction.
- Identify the appropriate chemical formula for a binary ionic compound, given the oxidative state of the individual ions of that compound.
- Compare and contrast the physical and chemical properties of acids and bases.
- Identify common household solutions as acidic, basic, or neutral using an indicator.
- Given an unknown solution determine if it is acidic, basic, or neutral.
- Conduct a neutralization experiment and test pH of the products.

Radiation & Nuclear Power

What Students Should Know:

- Isotopes are atoms of the same element with different number of neutrons.
- Alpha radiation is a positively charged particle that consists of two protons and two neutrons (helium nucleus).
- Beta particle is an electron emitted from and unstable nucleus.
- Gamma rays are high-energy electromagnetic radiation.
- Fission is the process by which a nucleus splits into two or more smaller fragments releasing neutrons and energy.
- Fusion is the process in which light nuclei combine at extremely high temperatures, forming heavier nuclei and releasing energy.
- Half-life is the time required for half the sample of radioactive nuclei to decay to produce a more stable substance.
- Nuclear reactions can be harnessed to produce massive amounts of energy.
- Problems encountered with using nuclear energy include the danger of uncontrolled reactions and hazardous waste.

What Students Should Be Able To Do:

- Compare and contrast different radiation emissions.
- Illustrate how fission and fusion are different.
- Explain how half-life and radioactive decay results in the formation of a stable substance.
- Solve problems involving half-life calculations.
- List and support the pros and cons of nuclear energy.

Speed, Acceleration, & Newton's Laws

What Students Should Know:

- Objects fall towards each other due to gravitational attraction.
- Acceleration due to the gravitational pull of the Earth on an object is $9.8 m/s^2$
- The strength of the gravitational force between two objects depends on the masses of the objects and the distance separating the objects.
- Mass is the amount of space occupied by matter whereas weight is amount of pull of gravity on an object.
- Free fall is the motion of a body when only the force of gravity is acting on it.
- Terminal velocity is the maximum velocity reached by a falling object that occurs when the resistance of the medium is equal to the force due to gravity.
- Air resistance is an opposing force due to air on a moving object.
- Newton's first law states that an object in motion will stay in motion unless an outside force acts upon it or a body at rest will remain at rest unless acted upon by an outside force. This is inertia.

- Newton's second law states that force is mass of an object times the acceleration of the object.
- Newton's third law states that for every action there is an equal and opposite reaction.

What Students Should Be Able To Do:

- Distinguish the relationships and differences between velocity and acceleration using graphical representation.
- Calculate velocity of an object, given the displacement and time of measurement for that object.
- Calculate the acceleration of an object, given the change in velocity and time for that object.
- Measure and analyze the effects of balanced and unbalanced forces on an object in motion.
- Define inertia and recognize common examples of inertia.
- Solve application problems involving force, mass or acceleration of an object demonstrating an understanding of Newton's second law.
- Demonstrate an understanding of Newton's third law by solving application problems demonstrating balanced and unbalanced forces.
- Contrast mass and weight.
- Calculate weight of an object given its mass.
- Relate falling objects to gravitational force.
- Predict the outcome when two objects of different masses, dropped from the same height at the same time will reach the floor at the same time.

Simple Machines

What Students Should Know:

- Work is done when force is applied to an object to move it through a distance.
- No work is done when the applied force is perpendicular to the object's motion.
- Simple machines incline plane, screw, wheel and axle, wedge, lever, and pulley.
- Mechanical advantage is output force divided by input force
- Mechanical advantage is input distance divided by output distance.
- Energy is the ability to do work.

What Students Should Be Able To Do:

- Identify and explain real life examples of simple machines.
- Calculate amounts of work and mechanical advantage when using a simple machine.
- Calculate work provided the force and the distance moved.
- Distinguish between simple and compound machines.
- Determine the work done given various scenarios.
- Calculate the benefits of using simple machines in performing work (e.g. calculate mechanical advantage).

Energy & Heat

What Students Should Know:

- Energy is the ability to do work.
- Law of conservation of energy states that energy cannot be created or destroyed but can be transformed from one form to another.
- In a closed system, the total energy remains constant.
- When energy flows in or out of a system, it is an open system.
- Energy comes in many interchangeable forms: sound, chemical, light, mechanical (kinetic and potential), nuclear, thermal, electrical, magnetic, etc.
- The sun is the primary source of energy on Earth.
- Heat energy is transferred in three different ways: conduction (via direct contact between/within solids) convection (via indirect means between/within different phases of matter), and radiation (via electromagnetic waves).
- The method of energy transfer depends on the nature of the molecular motion involved: gases move rapidly, liquids move slowly, and solids vibrate.
- Different materials, or forms of matter, have specific capacities for heat retention and or release. This is the specific heat measure.
- Specific heat is the amount of energy required to raise one gram of a substance one degree.
- Insulators are substances that restrict the flow of heat and conductors encourage the flow of heat.
- Temperature is the measurement of kinetic energy of the particles in an object.
- Heat is the energy that flows from one object to another because if a difference in their temperature.
- A phase diagram shows the phases transformations of matter relative to changes in temperature.
- The different phase changes are melting, evaporating/boiling, sublimation, condensing, and freezing.
- Absolute zero is a temperature where it is predicted that all molecular motion will cease (O Kelvin).
- The equation for heat capacity. Energy change = mass * specific heat * change in temperature

What Students Should Be Able To Do:

- Identify a system as open or closed in terms of energy flow.
- Identify the types, sources, and uses of energy (mechanical, chemical, thermal, nuclear, light, electrical, and electromagnetic).
- Apply the law of conservation of energy to a variety of situations.
- Trace the transformation of energy within a given system.
- Analyze the transfer of heat through the processes of conduction, convection, and radiation.
- Recognize the role of insulators and conductors in the transfer of heat.
- Relate molecular motion to the thermal energy changes in conduction, convection, and radiation.
- Explain how energy and temperature affect the phase of matter.
- Describe the difference between temperature and heat.
- List common temperatures in Celsius and Kelvin.
- Describe absolute zero in terms of molecular motion.
- Calculate heat lost or gained by a system given mass, specific heat, and temperature change.
- Using a phase diagram, explain the changes within a system, as it relates to pressure and temperature.

Electricity & Magnetism

What Students Should Know:

- An object's electric charge depends on the imbalance of its protons and electrons and often produces static electricity.
- Friction is the resistance produced when two objects rub/slide against to each other.
- Friction can cause static electricity.
- Induction is the production of charges in an object by bringing a charged object close to but not touching.
- The flow of electrons through an object by direct contact is called conduction.
- A conductor is a material in which electrons are able to flow.
- An insulator is a material with a high resistance which restricts the flow of electrons.
- Current (unit is ampere – A or amp) is a rate of flow of electrons (charged particles) through a conductor from high potential to low potential as measured by voltage.
- In an alternating current, the direction and magnitude of the current changes cyclically.
- In a direct current, the electron charges always flow in the same direction.
- Voltage (unit is Volts – V) is the difference in electric potential between two points in a current.
- Resistance (unit is Ohm – Ω) is a measure of the degree to which an electrical component opposes the flow of current.
- The mathematical relationship between resistance, current, and voltage: $V = I \times R$
- An electrical circuit is a closed path in which a current can flow..
- In a series circuit, the electrical current flows in one continuous path.
- In a parallel circuit, the electrical current flows in two or more separate paths.
- A magnetic field is produced by moving electric charges that exert a force on other moving charges.
- An electromagnet is a magnet in which the magnetic field is induced by the flow of an electric current.
- A permanent magnet is any material that produces a magnetic field and does not rely on outside forces to generate the field.
- An electric motor converts electrical energy into mechanical motion.

What Students Should Be Able To Do:

- Investigate static electricity in terms of friction, conduction, and induction.
- Explain the flow of electrons in terms of alternating and direct current.
- Explain the relationships between voltage, resistance and current.
- Explain the flow of electrons in various levels of voltage, resistance, and current.
- Distinguish between parallel and series circuits.
- Explain the flow of electrons in parallel and series circuits
- Calculate current, voltage, or resistance using the equation $V = I \times R$

Waves & Light

What Students Should Know:

- All types of waves transfer energy.
- Waves are characterized by their frequencies and wavelengths.
- An electromagnetic wave is a wave that does not require a medium. (e.g. Light)
- A mechanical wave is a wave that requires a medium. (e.g. Sound)
- A transverse mechanical wave is one in which the medium vibrates perpendicular to the direction of the wave.
- A longitudinal wave is a mechanical wave in which the medium vibrates parallel to the direction of the wave.
- Frequency is the number of complete oscillations made by a wave in a given period of time.
- Wavelength is the distance between two consecutive (identical) parts of a wave.
- The energy of an electromagnetic wave depends on its wavelength and frequency.
- The speed of mechanical waves depends on the medium
- Reflections occur when a wave hits an object that it cannot pass through and bounces back.
- Refraction occurs when a wave passes from one medium to another and bends due to the change in speed of the wave.
- Diffraction occurs when a wave passes through an opening and spreads out or bends around a barrier.
- Interference occurs when two or more waves combine to make a bigger or smaller wave.
- Sound travels fastest in a solid and slowest in a gas.
- The speed of sound within a medium is directly related to the temperature of the medium.
- The Doppler Effect is the observed change in the frequency of a wave when the source or observer is moving relative to each other.

What Students Should Be Able To Do:

- Recognize that all waves transfer energy.
- Use the electromagnetic spectrum to determine the energy and frequency relationships of waves.
- Recognize the relationship between frequency and wavelength, and between amplitude and energy of a mechanical wave.
- Relate color to the wavelength and/or frequency of light.
- Discuss the wave-particle duality of light wave behavior.
- Identify common electromagnetic and mechanical waves.
- Compare and contrast electromagnetic waves and mechanical waves.
- Relate frequency and wavelength on the electromagnetic spectrum to technological