

GHSGT Science Domain 4: Energy Transformations (approximately 16% of the test)

Overview of the Domain

- Students understand radioactivity.
 - Students describe half-lives of elements.
- Students examine the phases of matter and the related atomic and molecular motion.
- Students analyze energy transformations and the flow of energy in systems.
 - Students understand molecular motion involved in thermal energy changes due to conduction, convection, and radiation.

Energy Transformations *Students of physical science must understand the various forms in which energy exists and how it may be transformed from one form to another. Assessment in this domain focuses on students' knowledge of the phases of matter. Students also compare and contrast the atomic and molecular motion of solids, liquids, gases, and plasmas. Students identify and analyze energy transformations and thermal energy changes as well as radioactive decay. Questions assess conceptual understanding of energy transformation*

Associated Concepts and Skills

Assessment of this domain focuses on the following:

- describing the process of radioactive decay in which the unstable nucleus of a radioactive isotope spontaneously decays
- calculating the amount of a radioactive substance that will remain after one half-life
- analyzing graphs, tables, and other displays of data to determine the length of a half-life or the amount of material remaining after one half-life
- understanding that as temperature increases, the motion of the atoms increases
- describing a solid as a composition of particles closely situated in position giving a definite shape and definite volume and that little motion occurs between particles as compared to other phases of matter
- describing a liquid as a composition of particles free to move, giving a definite volume but not a definite shape and that particles have a greater range of motion as compared to solids
- describing a gas as a composition of particles that move more than the particles of either a solid or a liquid, giving no definite volume or shape, and colliding more randomly than the particles of solids and liquids
- understanding that phase changes require a gain or loss of energy
- describing the two forms of energy encountered during a given single energy transformation, including chemical, heat, light, electrical, and mechanical
- identifying the processes of conduction, convection, and radiation that occur during thermal energy changes

Energy can exist in nature as two main forms – Kinetic and Potential.

- Potential NRG = stored energy; ex – elastic, gravitational, chemical, nuclear
- Kinetic NRG = energy in motion; ex – electromagnetic (radiant), thermal, electrical, motion, sound

According to the first law of thermodynamics (aka Law of Conservation of Energy and Mass), energy and mass can never be created or destroyed. But, it can only change forms. Many times it commonly changes forms between a potential and kinetic energy:

Examples of energy transformations:

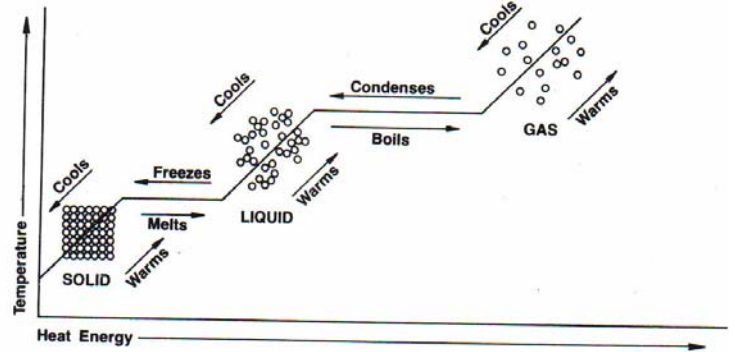
- Battery – Chemical potential energy → Electrical (kinetic) energy
- Food – Chemical potential energy → Motion (kinetic) energy
- Hydropower dam – Gravitational potential energy → Motion (kinetic) energy → Electromagnetic energy → Electrical energy

Kinetic Theory of Matter

- All matter is made of atoms and molecules that act like tiny particles.
- 2. These tiny particles are always in motion. The higher the temperature, the faster the particles move → (The higher the temperature, the more KE due to speed at which the particles move)
- 3. At the same temperature, more massive (heavier) particles move slower than less massive (lighter) particles. (Mass and Velocity of particle movement are inversely proportional. If temp remains the same, mass will have to increase if velocity decreases and vice versa)

Phase Changes

- The First Law of Thermodynamics, commonly known as the Law of Conservation of Matter/Energy, states that matter/energy cannot be created nor can it be destroyed. The quantity of matter/energy remains the same. It can change from solid to liquid to gas to plasma and back again, but the total amount of matter/energy in the universe remains constant.¹
- Phase changes occur as a result of energy being added to or taken away from matter.
- Add energy
 - Solid → Liquid → Gas → Plasma
- Take away energy
 - Plasma → Gas → Liquid → Solid

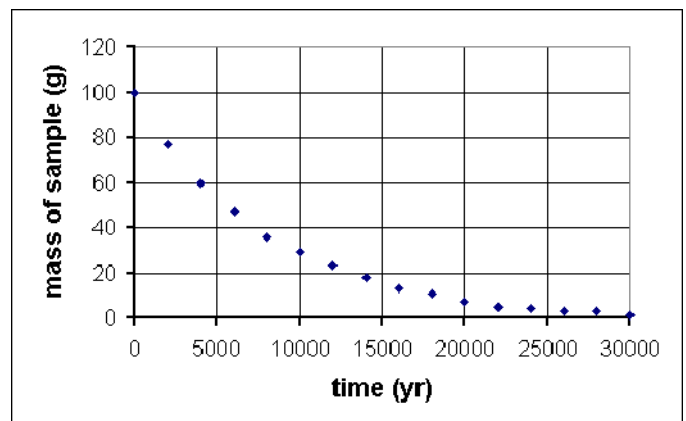


Methods of Energy Transfer

- The energy transfer as heat from a hot object can occur in 3 ways.
 - 1. conduction – objects must be in contact for energy to transfer (ex. Teapot on stove)
 - 2. convection – moving fluids (ex. Steam rising from boiling water in teapot on stove, air conditioner and/or heat pump)
 - 3. radiation – only type of radiation that can occur in a vacuum (ex. Heat and light from sun)
- Energy transfer can occur between transformations of any type of energy. For instance, conduction can occur with thermal and electrical energy. Radiation can occur with thermal and electromagnetic radiation.
- Naturally, energy flow follows the 2nd Law of Thermodynamics where energy will flow from a high energy state to a low energy state. Therefore, thermal energy will naturally flow from hot to cold; electrical energy (current) will naturally flow from a high voltage to low voltage etc.
- In order for energy to flow, there must be a difference in energy state. For example, there must be a change in temperature (ΔT) if thermal energy is to naturally flow.

Nuclear Energy

- Furthermore, nuclear changes also occur because of the 2nd Law of Thermodynamics. The unstable nuclei of isotopes will try to reach a state in which they are most stable. This is the process of radioactive decay in which the unstable nucleus of a radioactive isotope spontaneously decays.
- The three main types of radioactive decay
 - Alpha particles – least effective and can be stopped with paper, largest particle, produces ${}^4_2\text{He}$
 - Beta particles – can be stopped with Al foil, produces ${}^0_{-1}\text{e}$
 - Gamma rays – most damaging and produces electromagnetic gamma radiation – can be stopped with Pb
- Half – Life - measure of how quickly a substance decays; different radioactive isotopes have different half-lives
- When half – life is displayed using a graph, it should always take on a logarithmic form and never completely reach a mass of 0g.



¹ <http://www.allaboutscience.org/second-law-of-thermodynamics.htm>. February 28, 2007