

ENERGY TRANSFORMATIONS

Science Review

When studying for this portion of the test, be sure to review the following:

1. Understand radioactivity and describe the half-lives of elements
2. Examine the phases of matter and the related atomic and molecular motion
3. Analyze energy transformations and the flow of energy in systems
 - a. Understand molecular motion involved in thermal energy changes due to conduction, convection, and radiation.

Assessment will focus on the following:

1. Describing the process of radioactive decay in which the unstable nucleus of a radioactive isotope spontaneously decays.
2. Calculating the amount of a radioactive substance that will remain after one half-life.
3. Analyzing graphs, tables, and other displays of data to determine the length of half-life or the amount of materials remaining after one half-life.
4. Understanding that as temperature increases, the motion of molecules increases.
5. 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.
6. 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.
7. Describing gases as a composition of particles that move more than particles of either a solid or a liquid, giving no definite volume or shape, and colliding more randomly than particles of solids or liquids.
8. Understanding that a phase change requires a gain or loss in energy.
9. Describing the two forms of energy encountered during a single energy transformation, including chemical, heat, light, electrical, and mechanical.
10. Identifying the processes of conduction, convection, and radiation that occur during thermal energy changes.

Become Familiar with the following terms:

Alpha radiation
Beta radiation
Gamma radiation
Half-life
Solid
Liquid
Gas
Phase change

Melting
Freezing
Sublimation
Vaporization
Condensation
Conduction
Convection
Radiation

RADIOACTIVITY AND HALF-LIFE

HALF-LIFE

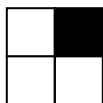
Each radioactive element breaks down after a certain amount of time to become stable. This time is measured in “half-life”. A half-life is the time required for one half of the substance’s atoms to break down and become stable. The half-life for a substance does not change. Some examples are carbon-14 (half-life of 5730 years) and uranium-238 (half-life of 4.5 billion years). When asked to work a half-life problem, draw the boxes, like the ones below, to help you answer the question.



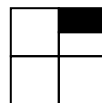
All atoms are radioactive



One half-life later, half are radioactive



Two half-lives later, ¼ are radioactive



Three half-lives later, 1/8 are radioactive

RADIATION

The unstable elements tend to break down spontaneously. They do not have enough “binding energy” in their nuclei to hold the protons and neutrons together. Most radioactive nuclei have too many neutrons compared to their protons. These elements are said to be radioactive. Radioactivity is where rays are spontaneously produced by the nucleus of an unstable atom. It can be particles, energy, or a mixture of both.

Types of Radioactive Decay:

- **Alpha Particle, α :** Has a +2 charge; the particle is composed of two protons and two neutrons; Is stopped by skin, tissue paper. These particles are not very energetic. The atomic number drops by two. It is sometimes written as a helium atom: ${}^4_2\text{He}$
Example: When uranium (atomic number 92) undergoes radioactive decay, it gives off an alpha particle. The atomic number drops by two and it becomes the element, thorium, with an atomic number of 90.
- **Beta Particle, β :** Has a –1 charge; comes from a neutron being given off – the neutron gives off a beta particle (negative) and a proton (positive); the beta particle leaves and the proton stays in the nucleus. Metal foil stops this particle. The atomic number increases by one.
Example: When bismuth (atomic number 83) undergoes radioactive decay, it gives off a beta particle. The atomic number increases by one and it becomes the element polonium, with an atomic number of 84.
- **Gamma Ray, γ :** Has no mass or charge because it is energy. It is high-powered electromagnetic radiation and it is stopped by lead, concrete.

Uses of Radioactivity

- **Medicine:** Radiation is used as a form of therapy for cancer. X-rays and gamma rays produced by cobalt-60 or cesium-137. Radioactive elements can be used as tracers that can follow certain chemical reactions inside living organisms.
- **Industry:** Food may be exposed to gamma rays in an effort to kill bacteria and other parasites in the food in hopes to limit the number of food poisoning cases.
- **Radiochemical Dating:** Radioactive isotopes are used to measure fossils and other artifacts. While an organism is alive, it takes in isotopes. Once the organism dies, the isotopes do not enter the body anymore. Scientists can estimate how much of the radioactive isotope was present in the body to begin with and then determine how much is currently left. Carbon-14 is a common isotope measured.
- Too much radiation can be lethal. You are exposed to radiation every day by watching television, standing in the sun, and even standing in your basement. The goal is to not get exposed to too much radiation. Too much radiation can result in cancer or other diseases. This happens when the radioactive substance causes damage to your DNA and chromosomes. This damage to the DNA is called mutations. This in turn causes changes in your cells.

- Fuel/Electrical Source: The energy produced in nuclear reactions can be used as a fuel source. Fusion is the result of nuclei combining and giving off huge amounts of energy. This occurs in the sun. Fission is the splitting of an atom into two and releasing energy at the same time.

STATES OF MATTER

SOLID

Solids have definite shape and definite volume. For the most part, solids can be carried around without the help of a special container. The molecules or atoms in a solid are densely packed together and vibrate back and forth in their own space. The atoms cannot change positions. Examples: rock, paper.

LIQUID

Liquids have no definite shape and a definite volume. They take on the shape of the container that they are in. The molecules or atoms in a liquid are packed together, but not as densely as a solid. They can slide around each other but cannot break apart. Examples: water, mercury.

GAS

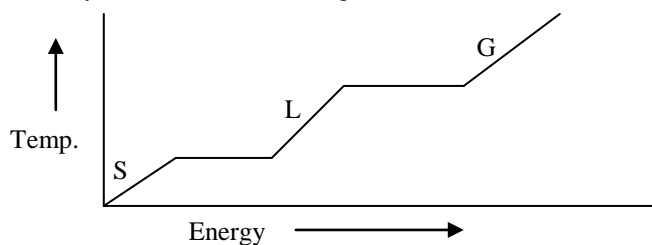
Gases have no definite shape and no definite volume. They expand to take on the shape and volume of the container they are in. A gas' molecules or atoms have more energy than a solid or liquid and they can go anywhere within their container. Examples: helium, air.

PHASE CHANGES

Each of the three main states of matter can change into another state by going through a phase change. Remember as a solid becomes a liquid becomes a gas, temperature is increasing and the molecules in the substance are moving faster. Substances are made to change phases by adding or taking away heat energy. There are six phase changes.

Melting	solid becomes liquid	absorbs heat	}	ENDOTHERMIC
Vaporization (boiling)	liquid becomes gas	absorbs heat		
Sublimation	solid becomes gas	absorbs heat		
Freezing	liquid becomes solid	loses heat	}	EXOTHERMIC
Condensation	gas becomes liquid	loses heat		
Deposition	gas becomes a solid	loses heat		

Be sure you understand a heating curve. See below:



Phase changes are physical changes. Physical changes do not produce a new substance. They produce the same substance with new physical properties. For instance, water may change from a solid to a liquid. Its volume and density will change, but it is still water. Examples of physical changes include melting, freezing, condensation, vaporization, sublimation, cutting, breaking, mixing, and dissolving.

Chemical properties cannot be observed unless the substance you are observing becomes something new. The particles of one substance undergo a chemical change and become something new. Chemical properties include such properties as flammability. You cannot observe this in paper unless the paper burns. Then, it is no longer paper.

There are several evidences of chemical changes. We also call these chemical reactions. These are:

- Formation of a new substance (solid precipitate, gas bubbles)
- The production of energy (heat or light)
- The absorption of energy
- Appearance of a new color or odor

Examples of chemical changes include combustion (burning), fermentation, metabolism, electrolysis, rusting – anything that involves a chemical reaction.

TRANSFORMING ENERGY

Energy is the ability to do work (work involves a change in movement). Energy is the ability to cause change. The units for energy are joule, J. All matter contains some form of energy because all matter has the ability to do work or cause change.

There are changes in forms of energy. This is where energy changes from one type to another. Energy cannot be created or destroyed, just converted from one form to another. When you rub your hands together, mechanical energy (moving your arms) turns into heat energy in your hands due to friction.

MECHANICAL	associated with motion. Ex. waterfall, sound, running.
HEAT	internal motion of particles of matter. The faster the particles move, the more heat energy is present Ex. rubbing hands together.
CHEMICAL	stored in bonds that hold atoms and ions together. Ex. fire, energy to move muscles
ELECTRICAL	moving electrical charges. Ex. lightning, radio
LIGHT	visible portion of the electromagnetic radiation

Examples of Changes from One Form of Energy to Another

Chemical to electrical	Flashlight battery
Electrical to heat	toaster
Electrical to sound	telephone, door bell
Electrical to chemical	human sight
Electrical to mechanical	turning on a ceiling fan
Chemical to mechanical	energy in food helping your arms move to throw a ball
Mechanical to electrical	water turning a turbine which then moves a magnet to generate electricity

HEAT TRANSFER

Heat is energy, sometimes called thermal energy. The heat of an object is the total kinetic energy of the random motion of its atoms and particles. When a substance is heated, its molecules move faster and further apart. Heat is always transferred from the hotter object to the cooler object. Dark colored objects absorb more heat than light colored objects. That is the reason tennis players wear white!

Conduction:

Heat is transferred from one object to another by direct contact. The two substances must be touching. An example of conduction is the hot chocolate heating the cup it was poured into. Substances that are conductors transfer heat very easily - iron, copper, and aluminum. Insulators slow down the conduction of heat - air and glass.

Convection:

Heat is transferred through currents of liquids and gases. As a fluid gets warmer, its molecules spread out and become less dense. This fluid will rise because it is now less dense than the fluid on top of it. As it rises, colder fluids fall. This cycle forms a current of warm rising fluid and cold falling fluids. This is called a convection current. Water circulating in the oceans or world wind currents are examples of this type of heat transfer.

Radiation:

This type of heat transfer requires no matter. Radiant heat is the transfer of energy by electromagnetic (infrared) waves. Examples of radiation are when you feel the heat from the fire or the sun's heat on your face.