8th Grade Physical Science
Energy Unit: Section 1

TEST DATE: _____

Section 1 EQs:

1. **What is energy? (building on prior knowledge)**
2. **How is Potential Energy different from Kinetic Energy? (2b)**
3. **How is energy conserved during an energy transformation? (2a)**
4. **What are the different forms of energy? How can you identify them? (2c)**
5. **What is Mechanical Energy of motion? (2c)**
6. **What is heat? How is transferred from place to place? (2c, 2d)**

Standards: S8P2 Students will be familiar with forms and transformations of energy.

a. Explain energy transformations in terms of the Law of Conservation of Energy

b. Explain the relationship between potential and kinetic energy.

c. Compare and contrast the different forms of energy (heat, light, electricity, mechanical motion, and sound) and their characteristics.

d. Describe how heat can be transferred through matter by the collisions of atoms conduction, convection through currents, and radiation through space.

What is Energy?

Energy is all around you. For example, the light given off by a lamp or from the sun is a form of energy. The warmth from the Sun is energy too. When you run and jump or even talk, energy is present. Energy is stored in the foods you eat and helps you to carry out all of the functions needed to keep you alive.

Energy is different from matter because energy does not have any mass or weight. Energy also does not take up any space. So, energy is not considered matter. Like above, we said the light from a lamp or the sun is energy, but the objects, lamp and sun, are matter. They are matter because they have mass (like weight) and they take up space.

The scientific definition of **energy** is: "the ability to do work or cause change." There are many forms of energy each with its own characteristics. The Georgia Performance Standards name five types: heat, light, electricity, mechanical motion and sound. There are more than just these types. In our learning we will also extend to include the basics of chemical and nuclear energies.

Energy forms can be classified as potential or kinetic depending on if they are moving or being stored.

Potential Energy and Kinetic Energy

Potential energy is any type of energy that is stored and is not being used right now. **Kinetic energy** is the energy that is in motion and being used. Kinetic energy is determined by mass and velocity of the object. Gasoline in the tank of a car, food on your plate, and a light switch turned "off" are all examples of energy that is stored and is not being used as it is, but will be used in the future. Once this energy is in motion and is being used, then it is changed to kinetic. An energy transformation happens from potential energy to kinetic energy once motion has begun. Gasoline is potential chemical energy, but once the car is turned on and gasoline is pumping through the engine, then the energy is kinetic producing the mechanical motion of the car. Food on your plate has potential; however, once you have eaten the food and it is being digested and your body is using the nutrients to carry out your life processes, it is transforming into the kinetic energy of the mechanical motion of your body. A switch turned "off" is potential electrical energy, but once the light switch is turned "on" and you can see, then you have kinetic energy. Kinetic energy is moving energy that is being used right now.

Potential energy is stored energy to be used for later. Examples of common types of potential energy are 1) **chemical energy** stored in chemical bonds of foods and fuels, 2) **nuclear energy** stored in nuclei of atoms found in the elements of stars and in the chemicals used in nuclear power plants, 3) **gravitational energy** stored in the position of the object like a roller coaster at the top of a hill. GPE (gravitational potential energy) is calculated by multiplying the mass of the object by the object's height above the ground. You can use the formula : **PE=mxh** and 4) **elastic energy** when an object is stretched or compressed like a bow and arrow or spring.

Kinetic energy has common examples in 1) **electrical energy** flowing on a current, 2) **light energy** like visible light waves shining from the sun 3) **sound energy** vibrating through a medium 4) **mechanical motion** like flowing water, wind, machines or your body when you move and 5) **thermal energy** that is made from the kinetic energy of the moving particles with in an object.

Many times the potential and kinetic energy refer to the energy of an entire object, like a skier at the top of a hill or a diver on the top of a diving board. When this is the condition, you can calculate how much potential and kinetic energy the object has. Like potential, kinetic energy of an object can be calculated too. To find kinetic energy, you must half the mass and multiply it by the velocity squared. You can use the formula: **$KE=1/2 \times m \times v^2$.**

Heat/Thermal Energy

Heat itself is not energy. **Heat** is the transfer of thermal energy from one object to another. Matter is made up of tiny particles that are always in motion. **Thermal energy** is the total energy of the motion of these particles of matter. The amount of thermal energy within a substance is dependent on two factors: the temperature of the substance and the amount of the substance. Thermal energy is measured as an average of the kinetic energy of the particles within a substance. That average is recorded as the temperature of that substance. The temperature of a substance is divided by degrees. There are three temperature scales to measure thermal energy: Kelvin, Celsius and Fahrenheit.

The United States commonly uses the Fahrenheit scale. When we say it is 92 degrees out side, we are using degrees Fahrenheit. Most every other part of the world uses the Celsius scale and is the standard unit of temperature measurement. Celsius is also measured in degrees. Physical scientists are usually the only people to use the Kelvin scale**.** Kelvin scale is unique because it measures to the extent when all of the thermal energy available within an object is removed. That special temperature of an object when all thermal energy is removed is called "**absolute zero**".

Thermal energy can change without changing the identity of the substance. Heat transfers between objects with different temperatures. For example, think of a hot cup of coffee sitting by a cold milkshake. Heat will always move from the warmer object to the cooler object. This transfer will continue to happen until both objects reach the same temperature. That temperature is called **equilibrium**. So, when the milkshake and the coffee both reach the equilibrium temperature, heat will stop transferring.

More motion in the particles means there is more thermal energy and will have a higher temperature. This logic also applies to you. Your temperature rises when you move around more. But what about two substances with the same temperature? How can you decide which has more thermal energy? This is when you would determine the amount of that substance you have. Two coffee cups with the same temperature; one large, one small; the large cup will have more thermal energy because there is more coffee in the cup. Remember thermal energy is the total energy of the particles. If there are more particles, the total is higher. Temperature measures on average, not total.

Heat Transfers in 3 Ways!

Recall that all mater is made from particles that are always in motion. Even objects that are frozen have molecules that are vibrating. Because these particles are moving, they have kinetic energy. The total kinetic energy of the particles is also called the **thermal energy**. The thermal energy is measured on an average by finding the **temperature.**

When the motion of the particles changes, the temperature also changes. The more quickly particles move, the higher the temperature will be.

Heat is the transfer of thermal energy between objects in any state of matter. Heat always flows from the object with a higher temperature to the object with a lower temperature. Heat will continue to flow this way until all materials are at the same temperature. This point of equal temperatures is called **equilibrium**.

Heat can be transferred between objects in three ways: radiation, conduction and convection.

Radiation is the transfer of heat without matter. Because no matter is needed, radiation can transfer heat through a vacuum or empty space. Radiant heat energy travels in waves and does not require any particles to touch. A microwave transfers heat energy to your food through the use of radiation. The heat from the Sun travels to Earth by way of radiation.

Conduction is the process where the particles of the objects have to touch each other to transfer heat. If you touch something hot, then heat is conducted into your hand.

Heat transfers in fluids a little differently. A fluid is something that flows like liquids and gases. Tiny Individual particles in fluids flow around each other. Depending on the temperature of the fluid, the particles act differently. At any given time a large amount of fluid has an uneven temperature. At hotter places, the particles are spread out and moving faster. At cooler places, particles are closer and moving slower. Hotter particles will rise away from the point of heat while the colder particles move in to fill their spot. The hotter fluid moves away, only to cool and move back again. This repeating pattern of movement of the particles makes what is called **convection current**.

This works in small spaces, like your living room and in large spaces like the atmosphere and ocean. In large masses of fluid, the entire fluid never reaches the same temperature, so this cycle of currents continue without end.

An insulated coffee mug will keep your warm drink warm for a longer period of time.

Thermal Energy and Materials

Materials are generally constructed to resist heat transfers or to encourage them.

Conductors are made to allow heat to travel through them easily with little resistance. Items like metal pots and pans are made from materials so heat can be easily transferred from the stove into the food within the pan. Metals are generally good conductors of heat.

Items that want to resist heat from flowing in or out are called **insulators**. Things like coolers and insulated coffee cups are made from insulating materials to keep the items inside hot or cold. Materials that make good insulation are glass, plastics, air and even wood.

Electricity/ Electrical Energy

Electrical Energy is the energy resulting from moving charges. Electrical devices use electricity to work.

Electricity can be static where it builds up and discharges only once, like a static shock or a lightning bolt. Electricity can also be continuous and flow as a current on a circuit. Depending on whether the charges are moving or stored, electricity can be kinetic or potential.

Chemical Energy

Chemical Energy is energy stored within the chemical bonds that hold chemical compounds together. Almost every kind of matter is made from compounds. A compound forms when two or more elements bond together. These have potential (stored) energy. Chemical bonds are generally in anything that is used as a fuel. Fuels could include gasoline, wood, a match tip, and even food. When the fuel is burned, these bonds break and energy is released. Potential chemical energy then turns into another type of energy.

Mechanical Motion/ Mechanical Energy

Mechanical energy is a form of energy associated with the position and the motion of an object as a whole. It does not refer to the particle motion inside the object. It can be calculated by adding the PE and the KE of a system. For example, bouncing a ball, riding a bike, or sharpening a pencil all show mechanical energy in motion. Wind blowing and a river flowing have mechanical energy because it involves movement of matter. The mechanical energy is calculated by adding the potential energy and the kinetic energy together.

Nuclear Energy

Nuclear energy is a form of energy stored in the center of an atom called the **nucleus**. The nucleus has strong nuclear forces that hold the nucleus together. Nuclear energy is released when there is a nuclear reaction. Nuclear power plants uses these forces in a controlled way to produce a nuclear reaction to make electricity. There are two kinds of nuclear reactions. One is nuclear fusion, where two nuclei are joined together. Nuclear fusion of hydrogen and helium atoms are a continuous reaction that fuels the sun. Nuclear fission is when a nucleus is split apart and energy is released. Nuclear power plants use the fission process to change nuclear energy into electricity.

Sound/ Sound Energy

Sound energy sometimes called acoustic energy is always made by a vibration within matter and always travels through matter called a medium. **Vibrations** are rapid, back-and-forth movements of particles. Sound can travel through solids, liquids and gases, but cannot travel in a vacuum of space. Sound energy travels through a medium as a sound wave.

We hear sound waves as our ears respond to the vibrations carried through the air. Our eardrum vibrates, sending the vibrations on through our middle and inner ear where the vibrations are turned into signals by our auditory nerve and sent to our brain.

Light Energy/ Solar Energy/ Radiant Energy

Light energy, sometimes called solar energy or radiant energy, travels as an electromagnetic wave at the speed of light: 300,000 m/s or 180,000 mi/s. Light travels so quickly that it is instant to our eyes. When we think about the speed of light, we must think of things that are farther away than the light bulb in our lamp. Think of the Sun, about 93 million miles from Earth. We can learn more about speed of light using this distance. It takes about 8 minutes for the light energy leaving the Sun to reach the Earth. So, you are really seeing the Sun as it was 8 minutes ago. We could say that the Sun is 8 light minutes from Earth. Our nearest stars are like Suns in distant solar systems and galaxies. The closest star to us is approximately 4.6 light years away. So, that means we are seeing light that left from that star 4 1/2 years ago. Hmmmm… like looking into the past. Interesting fact is that 4 1/2 light years away is our *closest* star. There are stars that are 20, 200 and even 700 million light years away.

Light does not need a medium in order to travel, but it ***can*** travel through different mediums if that medium is translucent or transparent. Translucent materials allow some scattered light to pass, while transparent objects are clear and allow most light to pass through. Light can only travel at the "speed of light" in a vacuum. When light changes mediums, it also changes speed and bends.

Visible light ranges in color from red to violet. When light is refracted through a prism, it is broken into all of the colors of the spectrum that make white light. We see this as a rainbow.

Because light is an electromagnetic wave, it has an electrical field wave and a magnetic field wave. The two waves are intertwined kind of like shoe laces.

Energy Transformations

Energy can change from one form of energy to another form. These are called **energy transformations**. When energy is transformed, the total energy is always there in the same amount. Scientists say that all energy is conserved which means saved during any energy transformation. Sometimes an energy transformation can be described as potential to kinetic. This means that the energy that was stored is now being used. Other times energy transformations are more specific. For example, the transformation of digesting food may be described as: you use mechanical energy to chew your food, as it is being digested the chemical energy held in the bonds of the food is being released and then you and your cells are changing that into back into mechanical energy to carry out life processes. Another example could be plants during photosynthesis: the sun gives off light energy, the plant uses the light energy to make its own food which is chemical energy. Yet another, a stove transforms electrical energy into thermal energy which transfers heat into raw food to cook food. The examples are endless in our day to day lives. To get really good at identifying the transformations, you must first get really good at identifying which types of energy apply to different situations.

Note:

Law of Conservation of Energy

Examples of energy show that energy can be found in many forms. Energy can also be transformed into other forms of energy. There is a scientific law about this. A law is a rule that is true every time in a certain situation.

The **law of conservation of energy** states that during any energy transformation, energy cannot be created or destroyed, it can only be transformed. All of the energy present in the beginning will also be present in the end. If you add up all of the types of energy before and after, all of the energy will be accounted for.

So, think of a rolling ball. You transfer your mechanical energy to the ball to make it roll. That mechanical energy transforms into kinetic energy of the ball rolling. Will that ball roll forever? No, of course not. It will eventually stop. What happens when the ball is rolling, it is experiencing friction, a force of contact between the ball and the ground. This rubbing together force of friction will transform some of the kinetic energy of the rolling ball into thermal energy at the points of friction.—So, energy is not destroyed, but is transformed.

The fact that friction transforms mechanical energy into thermal energy explains why no machine will ever be 100 percent efficient. Every machine with moving parts will experience friction at points of contact. A machine must use some of the input energy to make it work to overcome the force of friction.

Sometimes matter and energy can be conserved together. Albert Einstein published a famous theory in 1905. He stated that sometimes matter can be changed into energy. But the law of conservation is still true. If some of the matter is transformed into energy, the amount of the matter will be equivalent to the amount of energy produced.