Name: ***ANSWER KEY*** Pd: 3 Week 3 Distance Learning

Thermal Energy

Use the resources found on Mr. Hanna's website to help you respond to the following items.

VOCABULARY:

1) TEMPERATURE - *Measure of the AVERAGE kinetic energy in the particles of a substance, how fast the particles are moving*
2) THERMAL ENERGY - *Measure of the TOTAL amount of energy in ALL of the particles in an object or substance*
3) HEAT - *The movement of thermal energy from a substance with a higher temperature to a substance with a lower temperature*
4) CONDUCTION - *Energy is transferred by contact between particles*
5) CONDUCTOR - *Any material in which thermal energy is transferred quickly*
6) INSULATOR - *Any material in which thermal energy is transferred slowly*
7) CONVECTION - *Energy is transferred by the movement of CURRENTS within a fluid (liquid or gas)*
8) RADIATION - *Energy is transferred through electromagnetic waves*

SHORT ANSWER:

9) Explain the relationship between "thermal energy," "temperature," and "heat."
Temperature measures the AVERAGE kinetic energy of the particles in a substance; in other words, the speed of the particles. Thermal energy refers to the TOTAL energy of all of the particles in a substance. Therefore, the thermal energy of a substance depends on the amount, while the temperature does not. Heat is the transfer of thermal energy from one object/substance to another, which results in a temperature change.

10) Compare the three common temperature scales in the table below.

Temp. Scale	FAHRENHEIT	CELSIUS	KELVIN
Metric System? (Y or N)	*No*	*Yes*	*Yes*
Freezing Point of Water	*32°F*	*0°C*	*273 K*
Boiling Point of Water	*212°F*	*100°C*	*373 K*

11) How does the kinetic energy of the molecules in a substance relate to the temperature/phases?
When you measure the temperature of a substance, you are measuring its average kinetic energy. In other words, you're measuring how fast the particles are moving. As molecules move faster, the temperature increases; as they move slower, the temperature decreases. As the particles in the substance gain or lose enough energy, their physical state may transition from one phase to another.

12) Describe possible effects of adding thermal energy to a substance (*or removing it from the substance*)?
Adding (or removing) thermal energy to (or from) a substance can change its temperature (how fast the particles are moving) or its physical state/phase (solid, liquid, gas).

13) How is the energy required to raise the temperature of a substance related to the specific heat of the substance?
$Q=mc\Delta T$ is the equation to calculate the amount of energy necessary to raise the temperature of a substance. The variable, "c", in this equation represents the specific heat of the substance, which is unique for each substance. Therefore, the thermal energy required to heat a substance is a function of the mass of the substance, its specific heat, and the change in temperature that is desired. So a substance with a high specific heat value requires more thermal energy to raise its temperature, while a substance with a low specific heat value requires less thermal energy to raise its temperature.

14) The specific heat of water is 4.18 $^{J}/_{g^{o}C}$. If you are heating 500g of water from a temperature of 20°C to a temperature of 100°C, how many Joules of thermal energy will be required? (*show your work*)
$Q=mc\Delta T$ = 500g **x** *4.18 $^{J}/_{g^{o}C}$* **x** *(100°C-20°C) = 167,200 J*

15) Compare the three types of heat, convection, conduction, and radiation (*how they are similar/different*).
Convection, Conduction, and Radiation are three forms of heat, which is the transfer of thermal energy between objects. Convection transfers thermal energy within a fluid by means of the convection current which is caused by differences in density when the fluid is heated unevenly. Conduction transfers thermal energy through contact between objects, requiring the particles to bump into one another. Radiation transfers thermal energy by means of electromagnetic waves, or light (especially infrared light); it does not require matter to transmit thermal energy.

16) Differentiate conductors and insulators (*how they are different*). (*note – your answer should address density*)
Conductors are materials which allow the flow of thermal energy easily as a result of a high density. The closeness of the particles makes it easier for them to bump into each other and transmit energy through the substance. Insulators are materials which inhibit the flow of thermal energy because they have a lower density. Because their particles are farther apart, it is not as easy for them to bump into one another and transfer the energy.

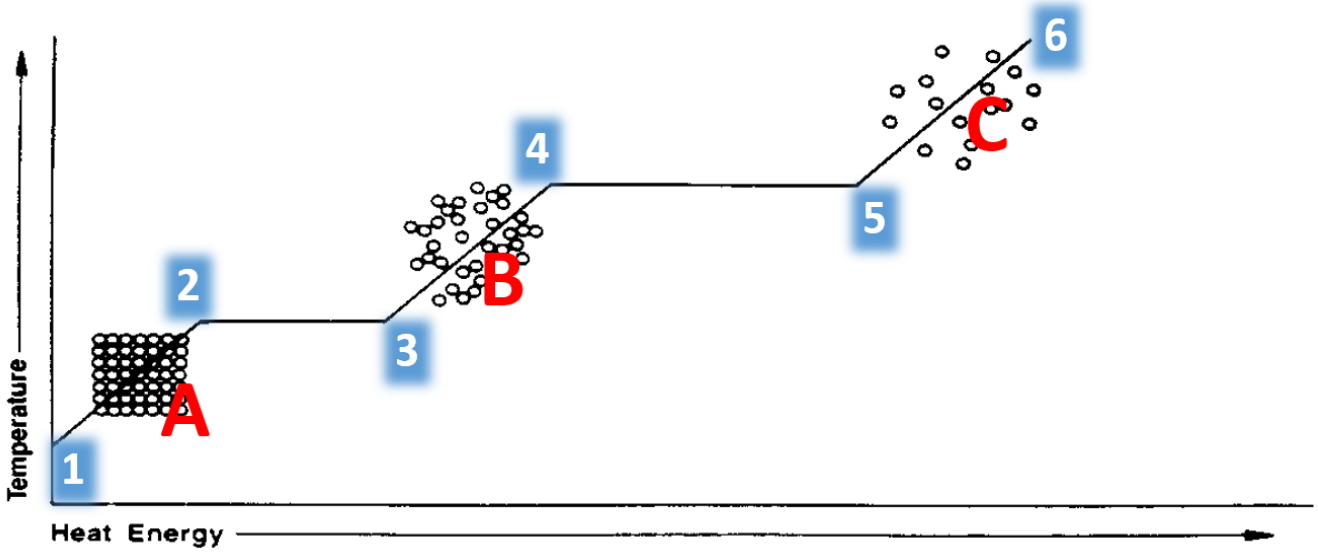
17) What causes a convection current? (*note – your answer should address density*)
Convection currents occur in a fluid when it is heated unevenly. The warmer fluid will float (or rise) because it is less dense, while the cooler fluid will sink because it is more dense. This cycle of warming and cooling fluid creates a current which transfers thermal energy throughout the substance.

18) What evidence do we have that radiation can transfer thermal energy through empty space?
The Earth receives thermal energy from the Sun in the form of infrared radiation. Because the sunlight traveled through the vacuum of space to reach Earth, we have evidence that thermal energy can be transferred by radiation without the presence of matter.

19) If I hand you a can of soda that I got from the refrigerator, explain why your hand would feel cold when you touch the can.
This is an example of conduction. Your hand is warmer than the soda can, so thermal energy will flow from your hand into the can. As energy exits your hand where it touches the soda can, your body perceives this loss of energy as "cold".

20) Explain the expression, "There's no such thing as cold."
What we feel as "hot" is thermal energy entering our body. When we feel "cold", it is thermal energy leaving our body. While thermal energy can flow from one object to another, there is no such thing as "cold" flowing between objects. Our perception of "cold" is simply an absence of thermal energy, much the same way that "dark" is simply the absence of light.

INTERPRETING A GRAPH: Use the phase change graph below to answer the following questions.



21) Label the state of matter present at each position below:

   A) *solid*

   B) *liquid*

   C) *gas*

22) What is happening to the substance during each interval below?

   A) Between positions 1 and 2 – *the solid is heating up (temperature is rising)*

   B) Between positions 2 and 3 – *the solid is melting into a liqid*

   C) Between positions 3 and 4 – *the liquid is heating up*

   D) Between positions 4 and 5 – *the liquid is boiling into a gas*

   E) Between positions 5 and 6 – *the gas is heating up*

23) Is thermal energy being added to this substance or removed from this substance between positions 1 and 6? What evidence do you have?
Thermal energy is being added to this substance, as you can infer based on the temperature of the substance increasing over time. In order to raise the temperature of a substance, thermal energy must be added.

24) Which positions on this graph would you use the equation "$Q=mc\Delta T$" to determine how much thermal energy transfer is required?
"$Q=mc\Delta T$" is used when the temperature of a substance is changing, so we would use this equation where the graph has a positive (in this case) slope indicating a rise in temperature; between positions 1-2, 3-4, and 5-6.

25) Which positions on this graph would you use the equations "$Q=mL_f$" or "$Q=mL_v$" to determine how much thermal energy transfer is required?
"$Q=mL_f$" or "$Q=mL_v$" are used during a phase change, so we would use this equation where the graph has zero slope (a horizontal line) indicating the substance is changing its physical state; between positions 2-3 and 4-5.