1. Heat _____.

(A) is the thermal energy of an object
(B) is thermal energy transferred between objects
(C) is what a thermometer measures
(D) is carried by ultraviolet light

Hint: Heat is carried by infrared light.

Heat is thermal energy given off by an object and transferred to another object.

2. Temperature is a measure of _____.

(A) potential energy
(B) kinetic energy
(C) intramolecular movement
(D) intermolecular vibration

Hint: Kinetic energy includes translational, vibrational, and rotational movements.

3. Chill factor occurs because _____.

(A) windy air has more kinetic energy than still air and delivers more cold to our skin
(B) windy air absorbs more potential energy than still air
(C) windy air removes heat from our skin faster than still air
(D) our brains anticipate being colder in windy airr

Hint: Windy air cools off our skin more than still air and our brain senses the cooler skin as colder outdoor temperature.

4. Absolute zero is _____.

(A -273 degrees on the Celsius scale
(B) -100 degrees on the Celsius scale
(C) -459 degrees on the Celsius scale
(D) -459 degrees on the Kelvin scale

Hint: Absolute zero is unobtainable but is zero on the Kelvin scale.

273 degrees on the Kelvin scale is where water freezes, zero on the Celsius scale.

So, -273 degrees on the Celsius scale is the same as zero on the Kelvin scale.

5. Temperature correlates with _____.

(A) electron mobility
(B) potential energy
(C) arrangement of atoms
(D) molecular movement

Hint: Temperature is a measure of kinetic energy, which represents molecular movement.

6. List the following in order of best to worst insulator.

(A) outer space, moving air, still air, water
(B) outer space, still air, moving air, water
(C) still air, moving air, water, outer space
(D) water, still air, moving air, outer space

Hint: Heat transfer in non-metals occurs when moving molecules transfer some of their kinetic energy to neighboring molecules by bumping into them. The fewer molecules there are and the less they are moving, the better the insulator.

7. Which is a better insulator?

(A) water boiling at 100° C
(B) steam at 400 degrees Fahrenheit

Hint: While water molecules in hot steam have more kinetic energy than they do in boiling water, per cubic centimeter there are so many fewer water molecules in steam than water, even very hot steam cannot transfer as much heat energy as boiling water.

8. Which of the following is not an important way atoms and molecules conduct heat?

(A) causing intramolecular bonds to vibrate faster
(B) getting rapidly-moving molecules to bump into slower-moving molecules
(C) bombarding distant atoms with electrons
(D) vibrating atoms locked in a tight crystal lattice

Hint: Heat transfer occurs when atoms and molecules transfer their kinetic energy to neighboring atoms and molecules.

The least effective way to transfer kinetic energy is when a vibrating molecule is simply standing still and waving its atomic arms.

9. A glass of water sitting for two days in a 35 degree refrigerator is moved outside where it is also 35 degrees. However, outside there's a wind of 25mph. What happens to the temperature of the water?

(A) rises
(B) lowers
(C) remains the same

Hint: Moving air molecules may transfer heat away from a glass of water faster than still air, but when the glass of water finally reaches equilibrium with the surrounding air, its temperature will be the same as the surrounding air.

10. Hypothermia _____.

(A) indicates that an equilibrium has not been reached with the surrounding environment
(B) occurs faster in cool water than in a cold wind
(C) in humans, begins when the body's internal temperature reaches 90 degrees Fahrenheit, 32 degrees Celsius
(D) developing in 70 degree Fahrenheit water will continue to draw heat from the body and eventually result in a body temperature below 70 degrees Fahrenheit

Hint: The rate at which heat transfers depends on the temperature of the neighboring molecules and on how many molecules there are to transfer the heat.

The more molecules, the more rapid the heat transfer.

Eventually, at equilibrium, the temperature of an object and its surroundings will be the same.

11. Double-paned windows insulate by _____.

(A) blocking infrared radiation
(B) blocking the flow of air molecules
(C) removing all gas molecules
(D) trapping kinetic energy between the panes of glass

Hint: Single pane glass does a poor job at blocking infrared radiation (heat) and a very poor job at blocking visible electromagnetic radiation (visible light).

Trapping air molecules between two panes of glass greatly reduces the movement of the air molecules between the panes, reducing how often they bump into each other and thus limiting their ability to transfer kinetic energy.

12. The best insulators are _____(in order).

(A) gases, liquids, solids, vacuums
(B) vacuums, gases, liquids, solids
(C) solids, liquids, gases, vacuums
(D) liquids, gases, vacuums, solids

Hint: The more molecules there are per cubic millimeter, the more capacity for moving molecules to bump into each other and transfer their kinetic energy.

13. Trapped air is a better insulator than moving air because _____.

(A) trapped air is better able to absorb potential energy.
(B) trapped air is better able to absorb heat.
(C) trapped air has a lower specific heat capacity.
(D) trapped air transfers less kinetic energy.

Hint: A house furnace continually adds heat to a house. Double pane glass keeps that heat in the house. Trapped air between two panes of glass cannot transfer that furnace heat to the outdoors as effectively as a single pane of glass, because trapped air has so many fewer molecules per cubic millimeter than a cubic millimeter of single pane glass.

14. Specific heat capacity is the amount of _____.

(A) potential energy absorbed per gram
(B) both the potential and kinetic energy absorbed per gram
(C) the energy needed to raise the temperature of one gram one degree
(D) the energy needed to raise the potential and kinetic energy of one gram by one degree

Hint: Heat capacity is the energy need to increase the temperature of an object by one degree.

Specific heat capacity is the energy needed to increase one unit of a substance one degree.

15. The boiling point correlates best with the _____.

(A) strength of the intramolecular bonds
(B) strength of the intermolecular bonds
(C) degrees of freedom of movement
(D) density of the substance being heated

Hint: At the boiling point, molecules in a liquid finally have enough energy to pull apart and evaporate into the air.

Pulling apart requires breaking the intermolecular bonds that were causing molecules to stick to each other.

16. Which statement is untrue?

(A) A gas with twice as many molecules as another gas has twice the energy and is twice as hot
(B) During boiling, the temperature of the water remains at 100 degrees Celsius as heat is being absorbed by the intermolecular bonds
(C) There are no degrees in the denominator for either heat of vaporization or heat of fusion
(D) The specific heat capacity of ice is about the same as the specific heat capacity of steam

Hint: The temperature of an object depends on how much kinetic energy an average molecule has. Doubling the number of molecules does increase the total energy of all the molecules, but not their average kinetic energy.

During melting and boiling, the temperature remains constant because all the energy being added is being used to break the intermolecular bonds between molecules, not increase their kinetic energy. Heat energy added to ice is used primarily to increase the water molecules' kinetic energy, not break the intermolecular bonds, because the intermolecular bonds are locked up in frozen crystals of ice.

Likewise, heat added to steam also is only used to increase the molecules' kinetic energy, because in steam, there are no intermolecular bonds left to break.

17. Water's specific heat capacity is high because of all except _____.

(A) water has three atoms that move in three directions
(B) water's two hydrogen atoms can vibrate and scissor
(C) water molecules can spin in three directions
(D) water's unshared electrons increase its potential energy

Hint: The heat added to water molecules is used to increase their kinetic energy, meaning their translational, vibrational, and rotational movements.

Because vibrational and rotational movements do not contribute a molecules' translational movements, vibrational movements, and rotational movements do not raise the temperature of a thermometer.

Translational movements are the most effective movements for increasing water's temperature.

18. The reason canteens of water are covered with wet canvas is that _____.

(A) the sun infrared radiation warms the wet canvas instead of warming the water inside the canteen
(B) warm air molecules transfer their heat to the wet canvas instead of to water inside the canteen
(C) water evaporating from the canvas absorbs heat from the water inside the canteen
(D) the wet canvas traps air between the canvas and the metal canteen

Hint: Evaporating water requires a great deal of energy to break apart water's intermolecular bonds.

Evaporating from canvas is like sweating in that both absorb energy and use that energy to break water's intermolecular bonds.

19. The reason the temperature of boiling water does not rise above 100 degrees Celsius is _____.

(A) water becomes steam above 100 degrees Celsius
(B) the energy needed to get water above 100 degrees Celsius is diverted into increasing water's kinetic energy
(C) atmospheric pressure prevents water's temperature from rising above 100 degrees Celsius
(D) water's intramolecular bonds are stronger than its intermolecular hydrogen bonds

Hint: All the energy added to boiling water goes into breaking water's intermolecular bonds.

Breaking intermolecular bonds does not increase the kinetic energy of water molecules, and thus does not increase the temperature of the water.

Only when all the intermolecular bonds are broken will the energy being added go into increasing the kinetic energy of the water molecules.

The temperature of the steam can rise above 100° Celsius, but not the water.

20. For one gram of water molecules, the process that requires the most heat energy is _____.

(A) heating the gram of ice by one degree Celsius
(B) melting the gram of ice
(C) heating the gram of water by one degree Celsius
(D) evaporating the gram of water

Hint: The strength of water's intermolecular bonds is underscored by the large amount of energy needed to break them and get liquid water molecules to separate from each other and evaporate into the air.

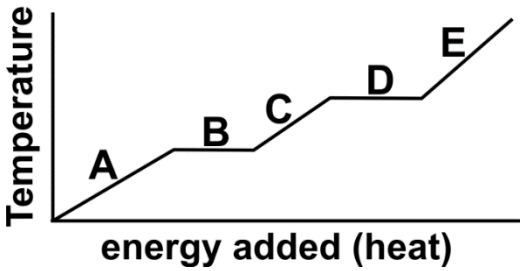
21. Orange growers spray their trees with water to protect the trees from frost. Why?

(A) The layer of water absorbs the cold before the leaves do.
(B) The water's freezing releases heat that warms the leaves and oranges
(C) The water on the leaves and oranges insulates the leaves and oranges
(D) The water's freezing absorbs heat which is then transferred

Hint: When enough heat is removed from liquid water, the water molecules are able to slow down enough to form stiff intermolecular bonds with other water molecules in the shape of a hexagon, in other words, ice crystals.

The heat leaving the water molecules during this process of freezing warms the surrounding environment immediately next to the freezing water. In this case, the immediate surrounding environment is tree leaves and oranges.

22. This graph depicts the temperature of ice as it is heated. In which sections of this graph is potential heat increasing?



(A) A, C, E
(B) A, B, C
(C) C, D, E
(D) B, D

Hint: When the temperature of water fails to rise even though the water is being heated, it means that the heat is not going into kinetic energy, but into potential energy.

Intermolecular bonds store potential energy because the energy stored in intermolecular bonds can be converted later into kinetic energy, just as stretching a spring stores potential energy that can later be converted into kinetic energy.