ESS 100 Name: D 3/4

Physical Properties: Heat, States of Matter, and Cloud Formation

Temperature: the average kinetic energy of the molecules or atoms in a substance

Kinetic Energy: Energy of motion; think of it as the energy required to set something in motion at a given speed

Kinetic Energy Formula: $KE = \frac{1}{2} mv^2$ [m = mass, v = velocity]

States of Matter (a.k.a. phases of matter):

- **Solid phase:** Molecules (or individual atoms)are locked in place, touching one another, vibrating. Hotter solids vibrate more violently.
- **Liquid phase:** Molecules are touching one another, but sliding and bumping around and changing positions; flowing. Hotter liquid molecules slide and bump around faster.
- **Gas phase:** Molecules flying free, but occasionally bumping into one another. Hotter gas molecules fly faster.

1. Describe the relationship between temperature and molecular motion.

Higher temperature ⇒ faster molecules
Lower temp. ⇒ slower molecules

2. Suppose you inflate a balloon with air and tie off the balloon. Then you heat the balloon.

   a. What will happen to the air pressure in the balloon when you heat it?

Increase

   b. Why?

Faster molecules will push against the balloon with more force.

Heat: the transfer of thermal energy

Thermal Energy of a substance: the total kinetic energy of the molecules moving *within* the substance

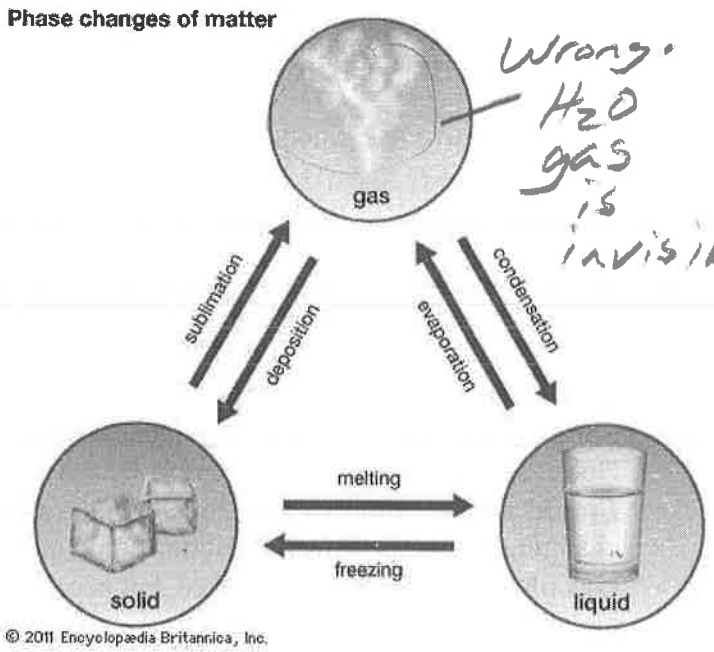
3. Which has more thermal energy, a hot cup of 150°F coffee, or a 70° swimming pool? Explain.

Swimming pool has way more molecules, so it's total thermal energy is greater, even though each molecule has less energy

Evaporate: turn from a liquid to a gas
Condense: turn from a gas to a liquid
Melt: turn from a solid to a liquid
Freeze: turn from a liquid to a solid

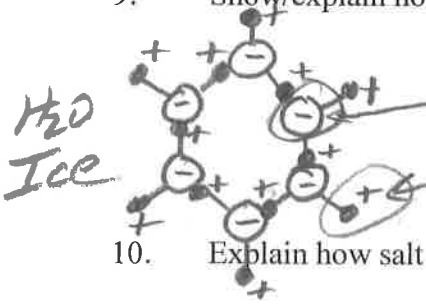
Latent Heat of Vaporization: the energy that must be added to a substance to allow it to turn from liquid to gas (and which must be removed in order for a gas to turn to a liquid). *Latent heat of vaporization does not change a substance's temperature; it only changes the substance's phase (see diagram).*

Latent Heat of Fusion: the energy that must be added to a substance to allow it to turn from solid to liquid (and which must be removed in order for a liquid to turn to a solid). *Latent heat of fusion does not change a substance's temperature; it only changes the substance's phase. (see diagram).*



Wrong. H_2O gas is invisible.

4. In order to turn from a liquid to a solid, a substance needs to lose energy.
5. In order to turn from a gas to a liquid, a substance needs to lose energy.
6. In order to turn from a solid to a liquid, a substance needs to gain energy.
7. In order to turn from a liquid to a gas, a substance needs to gain energy.
8. Why do humans sweat? to cool off.
   - Water is on our skin
   - water evaporates from our skin
   - In order to evaporate, water needs energy.
   - water takes that energy from our skin
9. Show/explain how salt melts ice:



NaCl pulls the ring of H_2O molecules apart, melting ice.

10. Explain how salt is used to make ice cream.

- Salt forces ice to melt.
- Ice needs heat in order to melt.
- Ice takes the heat from its surroundings.
- Surroundings (including cream) get cold.

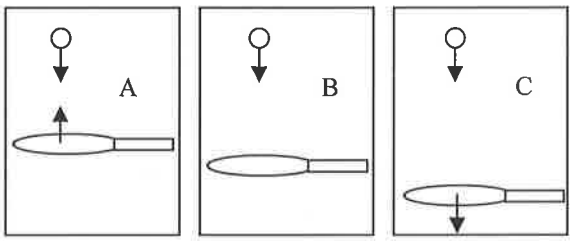
Conduction: heat transfer by touch; when hot object A touches cold object B, the rapidly moving molecules of object A bump into the molecules of object B, causing them to begin moving. The molecules of object A lose some energy in the process, thus cooling down.

Convection: heat transfer by the flow of warm fluid (e.g. currents of magma rising and sinking in Earth's mantle)

Radiation: heat transfer by photons in electromagnetic waves – no touch and no movement of fluid (e.g. a campfire warms you from a distance even though the air around you flows toward the fire, not toward you. Infrared radiation from the fire is what warms you.)

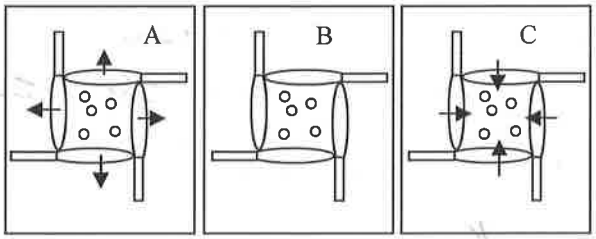
Temperature Changes due to Compression and Expansion

In the three pictures on the right, a "perfectly bouncy" ping pong ball is dropped onto a "perfectly bouncy" ping pong paddle.



11. In which situation will the ball speed up the most (and bounce highest) after being hit by the paddle? A
12. In which situation will the ball slow down the most (and bounce the least) after being hit by the paddle? C
13. In which situation will the ball's speed remain approximately the same after hitting the paddle? B

The three pictures on the right show "boxes" which have tennis rackets for walls. Inside the boxes, tennis balls are bouncing around. In one box, the walls are pushing inward against the balls. In another box, the rackets are relaxed, allowing the balls to push them out. In a third box the walls are held stationary.



14. In which "box" will the walls' behavior cause the balls to speed up? C
15. In which "box" will the walls behavior cause the balls to slow down? A
16. In which "box" will the walls behavior not affect the balls' speeds? B
17. What happens to the temperature of air when the air is rapidly compressed? Why?

It heats up. Compressing the air gives the molecules a push, causing them to move faster.

18. What happens to the temperature of air when the air is allowed to rapidly expand? Why?

It cools off.

The air molecules push the container walls. This takes their energy (makes them tired).

Make a cloud in a bottle

Complete these steps and then answer the questions that follow:

Get a clear 2-Liter bottle with a cap.

a. Get the inside of the bottle wet by putting water in it and shaking the water around. Then pour out the water.
b. Light a match and get it burning well. Blow it out as you place it in the bottle. The point is to get some smoke the bottle. Cap the bottle tightly before the smoke escapes.
c. Now squeeze the bottle as hard as you can for one second.
d. Stop squeezing and let the bottle expand for one second.
e. Squeeze again for another second, with all of your might. But don't jump on the bottle. This should be a steady squeeze.
f. Release your squeeze.
g. Squeeze again....
h. Keep repeating this until you see a cloud forming and disappearing. Pay close attention to when the cloud is appearing and when it is disappearing. Holding the bottle in a bright light with a dark background will make the cloud easier to see.

19. Do you see a cloud when you squeeze or when you release?

Release.

20. Explain why the cloud appears. Make sure you mention the effect of your action on the pressure and temperature inside the bottle, as well as the phase of the water.

- Squeezing heats up the air and water in the bottle.
- Heating causes water to evaporate.
- Releasing causes the air and water to cool down.
- Cooling causes the water in the air to condense into a liquid.

21. Do you think this would work without the smoke? Why or why not?

No.
Water needs to condense on a surface. Smoke provides surfaces in the air for water to condense upon.

22. What kind of air current will produce cloudy skies, rising air or sinking air? Explain.

Rising air. As air rises, it encounters lower air pressure, so the air expands. Expansion causes air to cool. Cooling causes water vapor in the air to condense into a liquid.