Heat of Fusion & Heat of Vaporization Name Mr. Sudbury – Key Date____ Block____

When an object changes from gas to liquid or liquid to solid, or back, we call it a *change of phase*. The heat required to change 1 g of a substance from solid to liquid is the *Heat of Fusion.* The heat required to change 1 g of a substance from liquid to gas is the *Heat of Vaporization.* Both of these are called *Latent Heats.* The heats of Fusion and Vaporization are also the same when the process is going back the other way (i.e. changing from a gas to a liquid and changing from a liquid to a solid.) ***It is important to remember that when a substance goes through the heat of fusion and heat of vaporization, the phase changes but the temperature of the substance does not change.*** The heat added (or subtracted) depends upon the Latent Heat and the mass of the substance and can be found using the following formulas:

$$Q = mH_f \qquad Q = mH_v$$

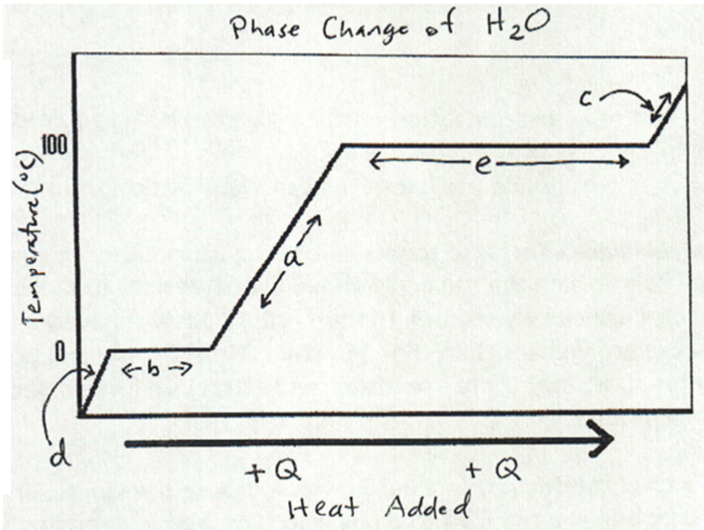
Substance	Heat of Fusion (H_f)	Heat of Vaporization (H_v)
Water	334 J/g	2260 J/g

Matching: Tell whether the phase change goes through the H_f or H_v.

1. Solid → Liquid H_f
2. Gas → Liquid $-H_v$
3. Liquid → Solid $-H_f$
4. Liquid → Gas H_v

Graphing Phase Changes: Label each line segment on the graph below.

5. a) Liquid
6. b) H_f
7. c) Gas
8. d) Solid
9. e) H_v



Word Bank:
Solid
Liquid
Gas
H_v
H_f

Problems: Solve the following problems, make sure and G.U.E.S.S.

10. How much energy is needed to melt 48.5 grams of ice at 0°C?

$Q = mH_f$

$= 48.5\,g \times 334\,J/g = 16{,}199\,J$

11. How much energy is released to condense 200 g of water vapor at 100 °C into 200 g of 100 °C liquid water?

$Q = m \cdot -H_V = 200g \times -2{,}260\ J/g = -452{,}000\ J$

12. How much energy does it take to turn 1.25 kg (convert to g) of 100 °C liquid water into steam (AKA water vapor)?

1,250 g

$Q = m \cdot H_V$ $Q = 1{,}250g \times 2{,}260\ J/g = 2{,}825{,}000\ J$

13. After you have gone through the H_V in #12 above and converted the water into steam, what is the temperature of the steam?

100 °C

14. You have an 89 g cup of water at 0 °C. How much heat must be released (or removed) from the water to freeze it into ice at 0 °C.

$Q = m \cdot -H_f = 89g \times -334\ J/g = -29{,}726\ J$

15. 400 grams of steam at 100 °C condenses into 400 grams of water also at 100 °C. How much heat was released during this phase change?

$Q = m \cdot -H_V$ $Q = 400g \times -2{,}260\ J/g = -904{,}000\ J$

Q: Why are the values for H_f and H_v so different?

A: Because…

The latent heat of fusion and vaporization both involve the heat required to change the state of a substance without a change in temperature. In the case of the latent heat of fusion it is the heat required to change a substance from a solid (ice) to a liquid (water) or vice versa while the latent heat of vaporization from a liquid (water) to a gas (steam) or vice versa.

In solids, the molecules are very close together and the attraction between the molecules is great. This causes a substance to have a structure in which the molecules have little freedom to move, as you would see in the case of ice. In the case of a liquid, the molecules are closely spaced, though not as closely spaced as a solid, they have more freedom to move and the intermolecular forces are weaker than that of a solid. Thus a liquid can flow, unlike a solid. Now in a gas, the molecules are sufficiently far apart that there are little to no attractive forces. Because of this a gas can easily be compressed and take the shape of the container.

Now as you heat a solid turning it into a liquid, you increase the kinetic energy of its molecules, moving them further apart until the forces of attraction are reduced to allow it to flow freely. Keep in mind the forces of attraction still exist. Now as you heat a liquid, turning it into a gas, the kinetic energy of the molecules is increased to a point where there are no forces of attraction between the molecules.

The energy required to completely separate the molecules, moving from liquid to gas, is much greater that if you were just to reduce their separation, solid to liquid. Hence the reason why the latent heat of vaporization is greater that the latent heat of fusion.