<u>Grade 11 Notes May 4 - 8, 2020</u>

Start of another week. Hope you are well. Hopefully, you are keeping up with all your school work. Remember that even though we are not together you still need to learn grade 11 material for grade 12 classes.

This week we will be continuing our investigation of Thermal Energy (the energy of heat transfer) with the following notes

1. Principle of Heat Transfer

2. Latent Heat of Fusion and Vaporization

Remember to submit your assignment from last Thursday on Wednesday this week. I will send out the new assignment on May 7, 2020 this week. Questions email me.

Have a good week.

Miss Takken

1. The Principle of Heat Transfer

Whenever two substances at different temperatures are mixed together, the amount of heat transferred LOST from the HOT substance is equal to the amount of heat GAINED by the COLD substance. Which is just another example of the law of conservation of energy.

$$\therefore -E_{Lost} = E_{Gained} \text{ in an isolated system}$$

Thermal equilibrium is achieved when two systems in thermal contact with each other cease to transfer heat. Basically when the temperature at which no more heat is lost or gained and both original substances have **the same final temperature.**

Example: A hard boiled egg with a specific heat capacity of 2.4×10^3 J/kg°C and a mass of 50.0 g is cooled from 100°C by 1.0 L of water at 5.0°C. What will the final temperature of the water and the egg be after they have been allowed to reach thermal equilibrium?

Recall: Density = mass/ volume and the Density of water is 1.0 kg/L. Therefore 1.0 L of water = 1.0 kg of water. But only for water!!!!

Solution: First we must decide what is the losing substance and what is the gaining substance. In this case the egg gets colder so it is the loser and the water gets hotter so it is the gainer.

Loser (egg)	**Gainer (water)**
m = 0.050 kg	m = 1.0 kg
C = 2.4×10^3 J/kg°C	C = 4200 J/kg°C
T_i = 100°C	T_i = 5.0°C
T_f =?	T_f =?

$$-E_{lost} = E_{gained}$$

$$-mC(T_f - T_i) = mC(T_f - T_i)$$

$$-0.050(2.4 \times 10^3)(T_f - 100) = 1.0(4200)(T_f - 5.0)$$

$$-120(T_f - 100) = 4200(T_f - 5.0)$$

expand brackets

$$-120T_f + 12000 = 4200T_f - 21000$$

Collect like terms

$$12000 + 21000 = 4200T_f + 120T_f$$

$$33000 = 4320T_f$$

$$T_f = 7.6°C$$

Example: 750 g of hot water at 75°C is poured into a 300 g glass mug. If the final temperature of the glass mug and hot water is 70°C what was the initial temperature of the glass mug?

Solution: The gaining substance is the glass mug as it gets hotter and the losing substance is the hot water as it gets colder.

Loser (water)	**Gainer (glass)**
m = 0.75 kg	m = 0.3 kg
C = 4200 J/kg°C	C = 840 J/kg°C
T_i = 75°C	T_i = ?
T_f = 70°C	T_f = 70°C

$$-E_{lost} = E_{gained}$$

$$-mC(T_f - T_i) = mC(T_f - T_i)$$

$$-0.75(4200)(70 - 75) = 0.3(840)(70 - T_i)$$

$$15750 = 252(70 - T_i)$$

$$15750/252 = 70 - T_i$$

$$62.5 = 70 - T_i$$

$$T_i = 70 - 62.5$$

$$T_i = 7.5^\circ C$$

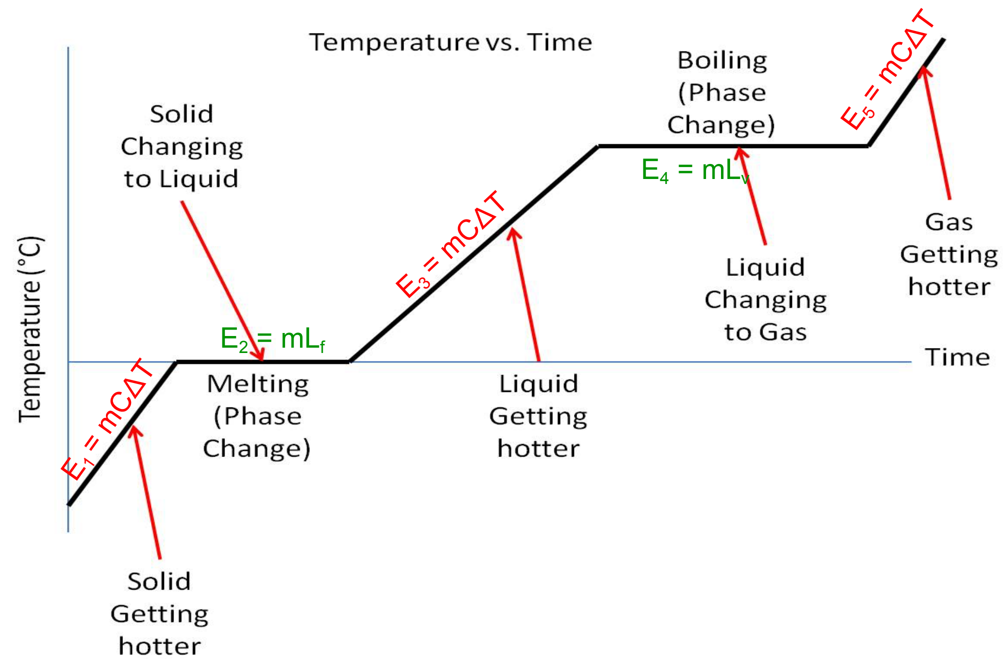
Now you try pg 276 # 30, 31, 32

2. <u>Latent Heat of Fusion and Vaporization</u>

So far when discussing thermal energy we have only heated substances that stay the same state (solid, liquid, gas, plasma). When you cross the boiling point or melting point temperature of a substance the energy goes into breaking the bonds between the molecules not changing the temperature. So you get a plateau. The energy needed to break the bonds is much more than the specific heat capacity. The second table on the Specific Heat Capacity chart handed out last week lists the values of latent heat needed to change the state of a substance from solid to liquid and liquid to vapour.

Latent Heat ~ The amount of heat that is required (or given off) when a substance changes from one state to another.i.e. it takes heat to turn solid iron into liquid iron

Note the temperature of melting and boiling point changes depending on the substance.



Specific Latent Heat of Fusion ~ The amount of heat required to melt or fuse 1 kg of a substance with no change in temperature. For water (ice) L_f=3.3 x 10^5 J/kg. Notice that temperature does not come into play since temperature is constant.

$$E_H = mL_f$$

Specific Latent Heat of Vaporization ~ The amount of heat required to vaporize 1 kg of a substance with no change in temperature.

$$E_H = mL_v$$

If you want to find the total energy to travel the whole curve then

$$E_H = E_1 + E_2 + E_3 + E_4 + E_5$$

Example: How much heat is required to melt 2.5 kg of ice cubes?

Note: Water melts at 0°C and this is the fusion point of water.

$E_H = mL_f$
$E_H = 2.5(3.3x10^5)$
E_H = 825000J of energy is needed from the surrounding air to melt the 2.5 kg of ice.

Example: How much heat is required to vaporize 0.5 kg of molten silver?

This is vaporization. So use EH = mL_v
$E_H = 0.5(2.3\ x10^6)$
$E_H = 1.15 \times 10^6$ J

Example: How much heat is required to take 1.0 kg of water from -10°C to 110°C?
The melting point of water is 0°C and the boiling point is 100°C. So we are going through three state of matter; solid, liquid, vapour.
Here we need to find the energy to heat the ice from -10°C to 0°C, melt the ice, heat the water from 0°C to 100°C, vaporize the water and then heat the steam from 100°C to 110°C. Being sure to use all the proper values from the charts.

$$E_H = E_1+E_2+E_3+E_4+E_5$$

$$E_H = mC_{ice}(T_f-T_i)+mL_f+mC_{water}(T_f-T_i)+mL_v+mC_{steam}(T_f-T_i)$$

$$E_H = 1.0(2116)(0-(-10))+1.0(3.3x10^5)+1.0(4200)(100-0)+1.0(2.3x10^6)+1.0(2020)(110-100)$$

$$E_H= 21160 + 3.3x10^5 +420000+ 2.3x10^6+20200$$

$$E_H = 3.09x10^6 \text{ J}$$

Now you try pg 277 # 34-36, 38