**Worksheet 14A: Specific Heat, Latent Heat, Phase Change Graphs, and Calorimetry**

**Objective A: Caloric and Joule’s discovery**

**Questions:**

1. What was the caloric model?
2. How did it fail to explain the heating of drill bits when they got dull?

**Objective B: Specific Heat: Q = mCΔT**

Some specific heats

(in JoC-1kg-1)

H2O liquid 4186

H2O ice 2100

H2O steam 2010

Aluminum 900

Iron 450

Copper 390

Lead 130

**Questions:**

1. What is the specific heat of a substance? What does it mean?

**Problems:**

1. What heat is needed to raise 3.4 kg of lead from 23 oC to 58 oC? (1.5E4 J)
2. If 23.0 kg of copper at 21.0 oC absorbs 45.6 kJ of heat, what will be its final temperature? (26.1 oC)
3. If some aluminum at 57.0 oC, cools to 24.1 oC, and gives off 13.4 kJ of heat, what is its mass? (453 g)
4. A 35.0 g of a mystery substance absorbs 314 J of heat and raises its temperature by 2.14 oC. What is its specific heat? (4190 JoC-1kg-1)
5. A 125 Watt 100% efficient heater is immersed in a 503 ml container full of water. In what time will the heater heat the water from 21.0 oC to boiling? (1330 s)
6. Another 1250 Watt heater can raise 2.35 liters of water from 14.5 oC to 36.6 oC in three and a half minutes. What is its efficiency? (.828 or 82.8%)

**Objective C: Latent Heat: Q = mL**

**Questions:**

Some Latent heats (in Jkg-1)

 Fusion Vap.

H2O 3.33E5 22.6E5

Iron 2.89E5 63.40E5

Lead 0.25E5 8.70E5

1. What is the latent heat of a substance? What does it mean?
2. Why is the latent heat of vaporization almost always more?

**Problems:**

1. What heat does it take to melt 25 kg of solid iron already at the melting point? (7.2E6 J)
2. 2350 J of heat will melt how much lead? (94 g)
3. If it takes 45,120 J of heat to melt 172 g of a mystery substance, what is its latent heat of fusion? (2.62E5 J/kg)
4. A runner sweats away 3.5 kg of water through evaporation. What heat did they dissipate? (7.9E6 J)
5. What heat do you need to heat 2.15 Kg of ice at -34.0 oC to water at 75.0 oC? (1.54x106 J)
6. What heat do you need to heat 23.5 Kg of ice at -167.0 oC to water at 92.0 oC? (2.51x107 J)
7. What heat do you need to heat 3.61 Kg of water at 76.0 oC to steam at 142 oC? (8.83x106 J)

**Objective E: Calorimetry: Heat Lost = Heat Gained**

**Problems:**

1. 112. grams of a mystery liquid at 83.0 oC is mixed with 564 grams of water initially at 22.0 oC. The final temperature of the mixture is 33.0 oC. What is the specific heat of the mystery liquid? (Assuming no heat was lost to the surroundings) (4640 J kg-1 oC-1)
2. A piece of lead (c = 130 J/kg/oC) at 82.0 oC is mixed with 112 grams of water and an 87.5 g aluminum (c = 900. J/kg/oC) calorimeter cup initially at 25.0 oC. The final temperature of the system is 56.0 oC. What is the mass of the piece of lead? (Assuming no heat was lost to the surroundings) (5.02 kg)
3. 89.2 g of a mystery substance is at 99.20 oC, and it is placed in a 95.0 g iron container holding 216 ml of water both at 21.01 oC. The final temperature is 23.38 oC. What is the specific heat of the substance? (332 J/kg/oC)
4. A 347 g piece of copper at 98.0 oC is placed in a Styrofoam cup containing 259 ml of water at 18.0 oC. What will be the final temperature of equilibrium? (Ignore the Styrofoam) (26.9 oC)
5. A 13.5 g piece of aluminum at 93.9 oC is placed in an 82.0 g iron calorimeter containing 203 g of water both at 23.0 oC. What will be the final temperature? (24.0 oC)
6. If you drop a 16 g ice cube at 0.0 oC into a Styrofoam cup containing 241 ml of water at 20.0 oC what will be the final temperature? (13.8 oC)
7. You take an ice cube out of the freezer at -17.0 oC, and drop it into a 67.0 g aluminum cup containing 308 g of water at 23.0 oC. The final temperature is observed to be 12.7 oC. What is the mass of the ice cube? (33.0 g)

**Objective D: Phase change graphs**

Here is a phase change graph for 0.0160 kg of a substance that starts out as a solid at 0 oC:



1. Label the graph where the KE is increasing, and where the PE is increasing.
2. What is the melting point? What is the boiling point? (30. oC, 80. oC)
3. What is the specific heat of the solid, liquid and gas phase? (104 J/kg/oC, 188 J/kg/oC, 156 J/kg/oC)
4. What is the latent heat of fusion and vaporisation? (9380 J/kg, 15,600 J/kg)

Here is another phase change graph for 0.026 kg of a substance that starts out as a solid at 0 oC:



1. Label the graph where the KE is increasing, and where the PE is increasing.
2. What is the melting point? What is the boiling point? (40. oC, 80. oC)
3. What is the specific heat of the solid, liquid and gas phase? (48.1 J/kg/oC, 240. J/kg/oC, 76.9 J/kg/oC)
4. What is the latent heat of fusion and vaporisation? (7,690 J/kg, 11,500 J/kg)