

## 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: $Q = mC\Delta T$

#### Questions:

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

#### Problems:

4. What heat is needed to raise 3.4 kg of lead from 23 °C to 58 °C? ( $1.5E4$  J)
5. If 23.0 kg of copper at 21.0 °C absorbs 45.6 kJ of heat, what will be its final temperature? (26.1 °C)
6. If some aluminum at 57.0 °C, cools to 24.1 °C, and gives off 13.4 kJ of heat, what is its mass? (453 g)
7. A 35.0 g of a mystery substance absorbs 314 J of heat and raises its temperature by 2.14 °C. What is its specific heat? ( $4190 \text{ J}^\circ\text{C}^{-1}\text{kg}^{-1}$ )
8. 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 °C to boiling? (1330 s)
9. Another 1250 Watt heater can raise 2.35 liters of water from 14.5 °C to 36.6 °C in three and a half minutes. What is its efficiency? (.828 or 82.8%)

Some specific heats  
(in  $\text{J}^\circ\text{C}^{-1}\text{kg}^{-1}$ )

|            |      |
|------------|------|
| H2O liquid | 4186 |
| H2O ice    | 2100 |
| H2O steam  | 2010 |
| Aluminum   | 900  |
| Iron       | 450  |
| Copper     | 390  |
| Lead       | 130  |

### Objective C: Latent Heat: $Q = mL$

#### Questions:

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

#### Problems:

12. What heat does it take to melt 25 kg of solid iron already at the melting point? ( $7.2E6$  J)
13. 2350 J of heat will melt how much lead? (94 g)
14. 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)
15. A runner sweats away 3.5 kg of water through evaporation. What heat did they dissipate? ( $7.9E6$  J)
16. What heat do you need to heat 2.15 Kg of ice at -34.0 °C to water at 75.0 °C? ( $1.54 \times 10^6$  J)
17. What heat do you need to heat 23.5 Kg of ice at -167.0 °C to water at 92.0 °C? ( $2.51 \times 10^7$  J)
18. What heat do you need to heat 3.61 Kg of water at 76.0 °C to steam at 142 °C? ( $8.83 \times 10^6$  J)

Some Latent heats (in  $\text{Jkg}^{-1}$ )

|      | Fusion | Vap.    |
|------|--------|---------|
| H2O  | 3.33E5 | 22.6E5  |
| Iron | 2.89E5 | 63.40E5 |
| Lead | 0.25E5 | 8.70E5  |

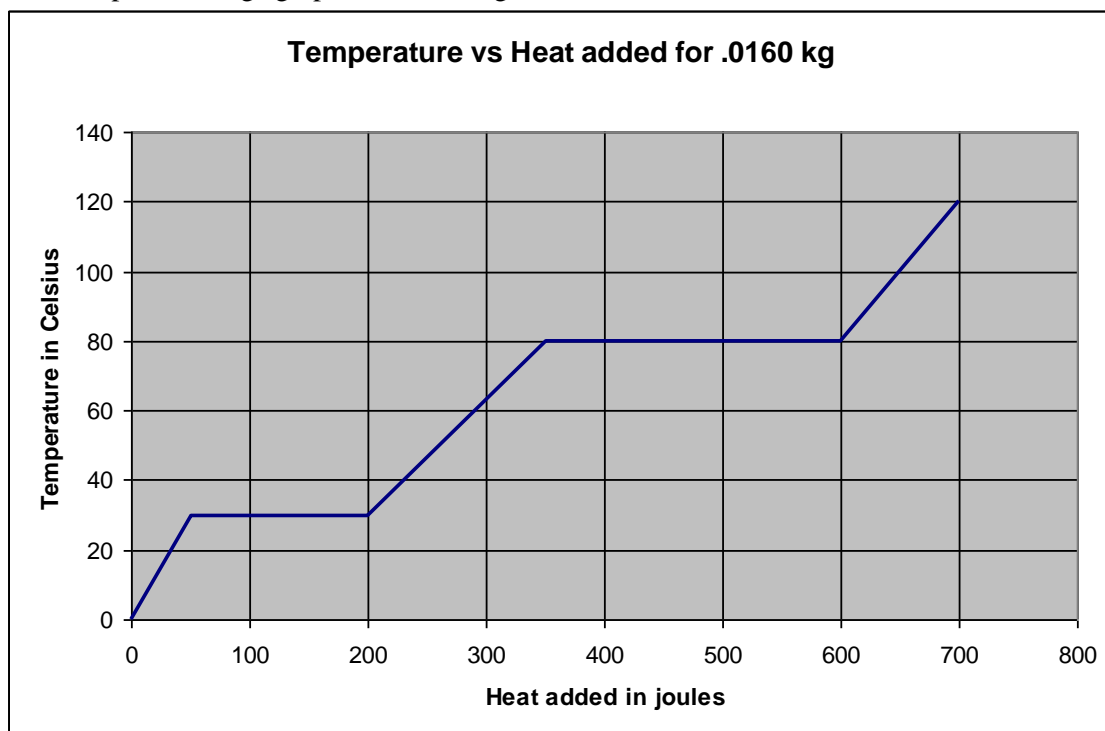
### Objective E: Calorimetry: Heat Lost = Heat Gained

#### Problems:

19. 112. grams of a mystery liquid at 83.0 °C is mixed with 564 grams of water initially at 22.0 °C. The final temperature of the mixture is 33.0 °C. What is the specific heat of the mystery liquid? (Assuming no heat was lost to the surroundings) ( $4640 \text{ J kg}^{-1}\text{ }^\circ\text{C}^{-1}$ )
20. A piece of lead ( $c = 130 \text{ J/kg}^\circ\text{C}$ ) at 82.0 °C is mixed with 112 grams of water and an 87.5 g aluminum ( $c = 900. \text{ J/kg}^\circ\text{C}$ ) calorimeter cup initially at 25.0 °C. The final temperature of the system is 56.0 °C. What is the mass of the piece of lead? (Assuming no heat was lost to the surroundings) (5.02 kg)
21. 89.2 g of a mystery substance is at 99.20 °C, and it is placed in a 95.0 g iron container holding 216 ml of water both at 21.01 °C. The final temperature is 23.38 °C. What is the specific heat of the substance? ( $332 \text{ J/kg}^\circ\text{C}$ )
22. A 347 g piece of copper at 98.0 °C is placed in a Styrofoam cup containing 259 ml of water at 18.0 °C. What will be the final temperature of equilibrium? (Ignore the Styrofoam) (26.9 °C)
23. A 13.5 g piece of aluminum at 93.9 °C is placed in an 82.0 g iron calorimeter containing 203 g of water both at 23.0 °C. What will be the final temperature? (24.0 °C)
24. If you drop a 16 g ice cube at 0.0 °C into a Styrofoam cup containing 241 ml of water at 20.0 °C what will be the final temperature? (13.8 °C)
25. You take an ice cube out of the freezer at -17.0 °C, and drop it into a 67.0 g aluminum cup containing 308 g of water at 23.0 °C. The final temperature is observed to be 12.7 °C. What is the mass of the ice cube? (33.0 g)

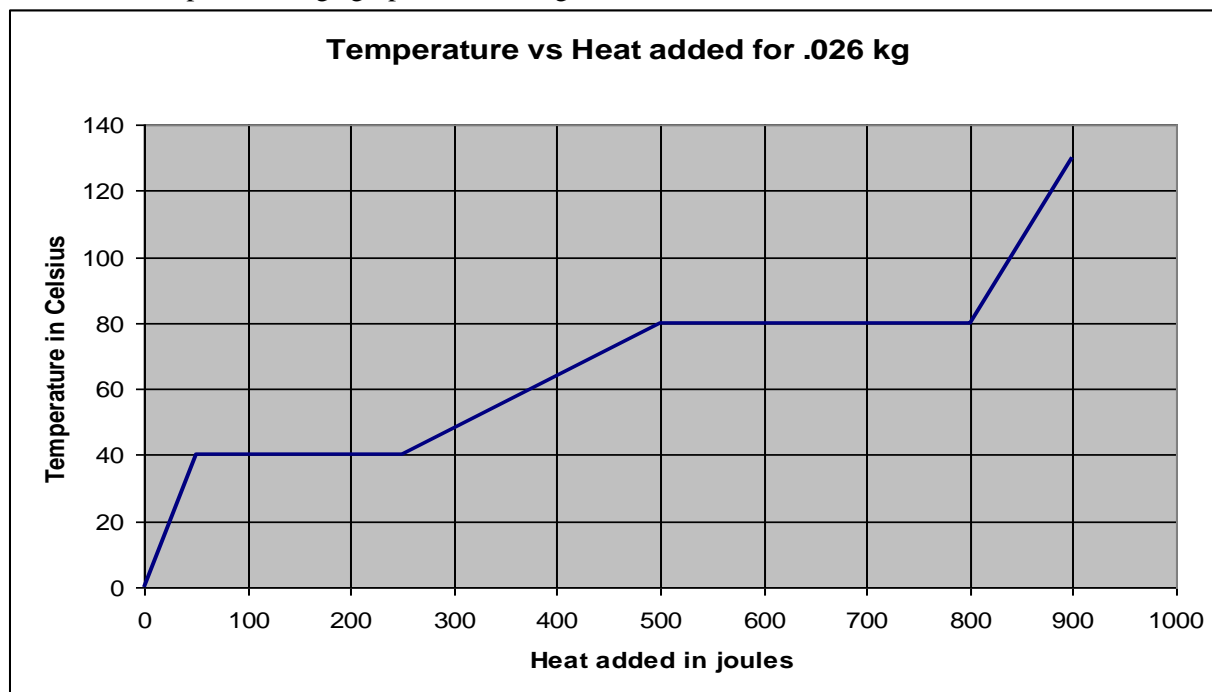
### Objective D: Phase change graphs

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



26. Label the graph where the KE is increasing, and where the PE is increasing.  
27. What is the melting point? What is the boiling point? (30. °C, 80. °C)  
28. What is the specific heat of the solid, liquid and gas phase? (104 J/kg/°C, 188 J/kg/°C, 156 J/kg/°C)  
29. 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 °C:



30. Label the graph where the KE is increasing, and where the PE is increasing.  
31. What is the melting point? What is the boiling point? (40. °C, 80. °C)  
32. What is the specific heat of the solid, liquid and gas phase? (48.1 J/kg/°C, 240. J/kg/°C, 76.9 J/kg/°C)  
33. What is the latent heat of fusion and vaporisation? (7,690 J/kg, 11,500 J/kg)