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

Some specific heats (in $J^oC^{-1}kg^{-1}$)	
H2O liquid	4186
H2O ice	2100
H2O steam	2010
Aluminum	900
Iron	450
Copper	390
Lead	130

Problems:
4. What heat is needed to raise 3.4 kg of lead from 23 ^oC to 58 ^oC? (1.5E4 J)
5. 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)
6. 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)
7. 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 $J^oC^{-1}kg^{-1}$)
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 ^oC to boiling? (1330 s)
9. 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:
10. What is the latent heat of a substance? What does it mean?
11. Why is the latent heat of vaporization almost always more?

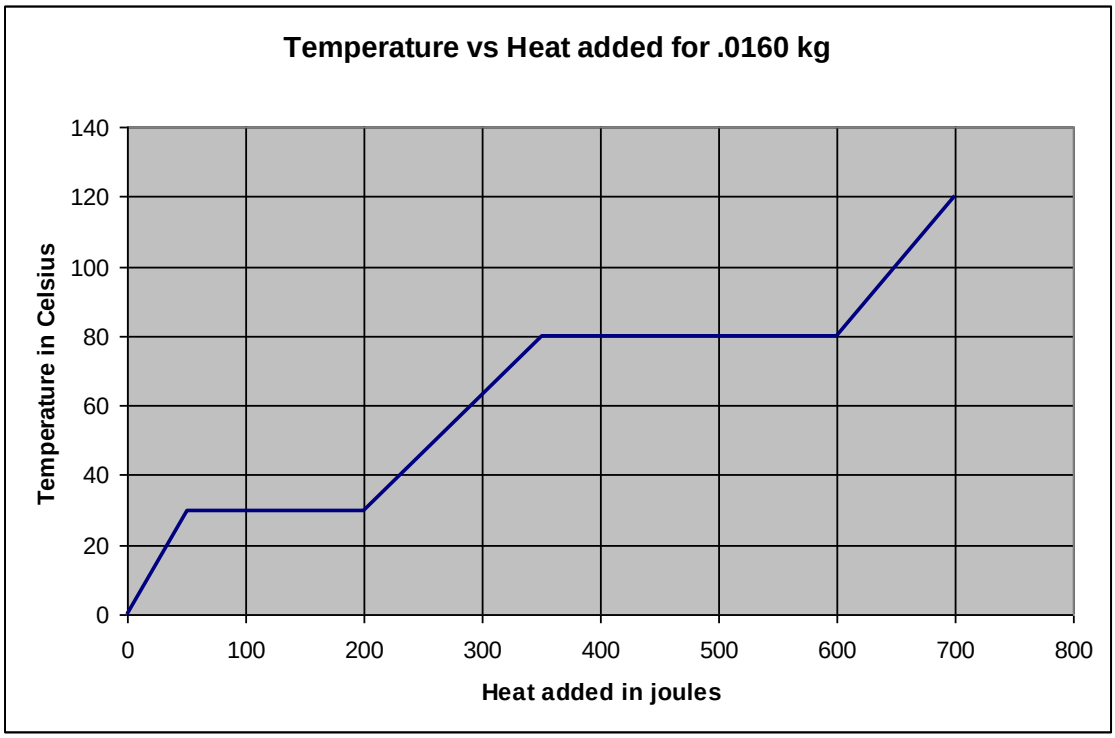
Some Latent heats (in Jkg^{-1})		
	Fusion	Vap.
H2O	3.33E5	22.6E5
Iron	2.89E5	63.40E5
Lead	0.25E5	8.70E5

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 ^oC to water at 75.0 ^oC? ($1.54x10^6$ J)
17. What heat do you need to heat 23.5 Kg of ice at -167.0 ^oC to water at 92.0 ^oC? ($2.51x10^7$ J)
18. What heat do you need to heat 3.61 Kg of water at 76.0 ^oC to steam at 142 ^oC? ($8.83x10^6$ J)

Objective E: Calorimetry: Heat Lost = Heat Gained
Problems:
19. 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} $^oC^{-1}$)
20. 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)
21. 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)
22. 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)
23. 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)
24. 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)
25. 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)

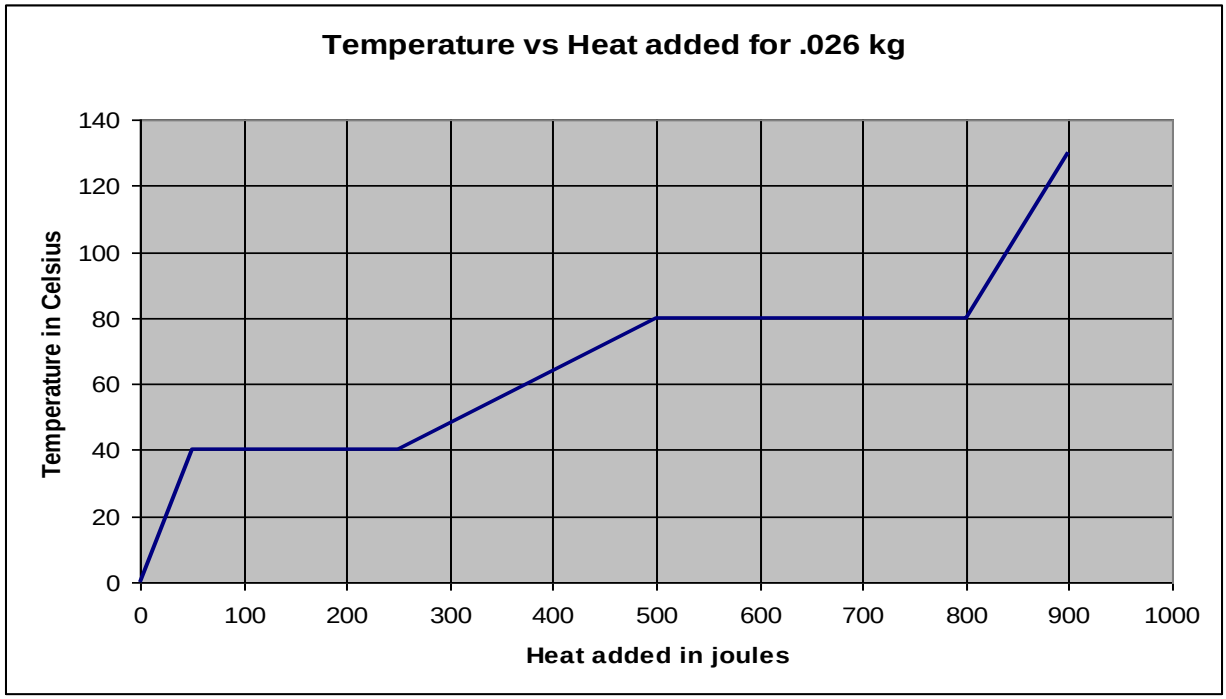
Objective D: Phase change graphs

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