HEAT TRANSFER AND CALORIMETRY: GUIDED PROBLEMS Name:_____

Problem A) An 11.98-gram sample of zinc metal is placed in a hot water bath and warmed to 78.4°C. It is then removed and placed into a Styrofoam cup containing 50.0 mL of room temperature water (T=27.0°C; density = 1.00 g/mL, c=4.186 J/g°C). The water warms to a temperature of 28.1°C. Determine the specific heat capacity of the zinc. **Hint- use the density to determine the mass of the room temperature water**

H_2O: $m = 50.0\,g$, $c = 4.186\,J/g°C$, $\Delta T = 1.1°C$

Zinc: $m = 11.98\,g$, $c = ?$, $\Delta T = -50.3°C$

$Q_{H_2O} = -Q_{zinc}$

$mc\Delta T = -mc\Delta T$

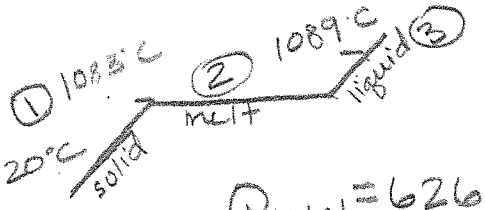
$(50)(4.186)(1.1) = -(11.98)(c)(-50.3)$

$\frac{230.23}{602.594} = \frac{602.594\,c}{602.594}$

$c = 0.382\,J/g°C$

Problem B) A copper penny has a mass of 0.00302 kg and a temperature of 20.°C. It has a melting point of 1083°C and a latent heat of fusion of 2.07×10^5 J/kg. How much heat must be added to the penny to melt it and raise the liquid penny to ~~40.~~ 1089°C?

$c = 0.385\,J/kg°C$



① $Q = mc\Delta T = (0.00302)(0.385)(1083 - 20) = 1.24\,J$

② $Q = mL = (0.00302)(2.07 \times 10^5) = 625.14\,J$

③ $Q = mc\Delta T = (0.00302)(0.385)(1089 - 1083) = 0.007\,J$

$Q_{total} = 626.387\,J$ → 630 J

$m = 0.00302\,kg = 3.02\,g$

Problem C) The latent heat of sublimation ($\Delta H_{sublimation}$) of dry ice (solid carbon dioxide) is 570 J/g. Determine the amount of heat required to turn a 5.0-pound bag of dry ice into gaseous carbon dioxide. (Given: 1.00 kg = 2.20 lb)

Q m L_{sub}

$Q = mL = (2272\,g)(570\,J/g) = 1{,}295{,}040\,J$

$5.0\,lb \left|\frac{1\,kg}{2.20\,lb}\right| \left|\frac{1000\,g}{1\,kg}\right| = 2272\,g$

1,300,000 J

$1.3 \times 10^6\,J$

HEAT TRANSFER AND CALORIMETRY PARTNER PRACTICE Name:_____

1. The temperature last night was 38° F. Convert this to the Celsius and to the Kelvin temperature scales. Be sure to label which temperature is which.

2. The melting point of lead is 327.3° C. Convert this measurement to Fahrenheit.

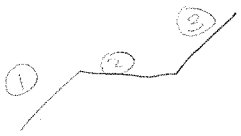
3. Oxygen changes from a gas to a liquid at -183° C. Convert this to Kelvin.

4. The specific heat of silver is 235 J/kg°C. How much heat must be added to a 0.25 kg piece of silver to raise its temperature from 25° C to 600° C?

$Q = (0.25)(235)(600-25)$

$= 33781.25\text{ J}$ 30,000 J

5. How much heat energy must be added to a 0.65 kg sample of water at 30° C to turn it into steam at 125° C? (The specific heat of steam is 2100 J/kg°C and the specific heat of water is 4186 J/kg°C. The boiling point of water is 100° C. The latent heat of vaporization for water is $2.26_E{}^6$ J/kg.)



① $Q = (0.65)(4186)(70) = 190463\text{ J}$

② $Q = (0.65)(2.26 \times 10^6) = 1469000\text{ J}$

③ $Q = (0.65)(2100)(25) = 34125\text{ J}$

$Q_{total} = 1693588\text{ J}$ 2000000 J

6. How much heat must be added to a 0.45 kg piece of lead with an initial temperature of 20° C to change it to molten (melted) lead? The specific heat of lead is 128 J/kg°C, the latent heat of fusion for lead is $2.32_E{}^4$ J/kg, and lead melts at 327° C.

① $Q = (0.45)(128)(327-20) = 17683.2\text{ J}$

② $Q = mL = (0.45)(2.32 \times 10^4) = 10440\text{ J}$

28123.2 J

7. A 1.2 kg sample of water has a temperature of 22° C. A 0.6 kg piece of copper at a temperature of 325° C is added to the sample. What is the final temperature of the water and copper? (The specific heat of copper is 385 J/kg °C and the specific heat of water is 4186 J/kg°C)

$Q_{H_2O} = -Q_{copper}$

$mc\Delta T = -mc\Delta T$

$(1.2)(4186)(T_f - 22) = -(0.6)(385)(T_f - 325)$

$5023.2(T_f - 22) = -231(T_f - 325)$

$5023.2T_f - 110510.4 = -231T_f + 75075$

$T = 25°C$

8. A 0.50 kg block of ice has a temperature of -20°C. How much heat must be added to this ice to change it to water at 70°C?

$L_{fusion} = 334000\ J/kg$ $c_{ice} = 2108\ J/kg°C$ $c_{water} = 4186\ J/kg°C$

① ② ③

① $Q = (0.5)(2108)(20) = 21080\ J$

② $Q = (.5)(334000) = 167000$

③ $Q = (.5)(4186)(70) = 146510$

$334590\ J$

$300000\ J$

9. A copper penny has a mass of 0.003 kg and a temperature of 20°C. It has a melting point of 1083°C and a latent heat of fusion of 2.07×10^5 J/kg. How much heat must be added to the penny to melt it?

① ②

① $Q = (0.003)(385)(1083 - 20) = 1227.765\ J$

② $Q = (0.003)(2.07 \times 10^5) = 621\ J$

$1848.765\ J$

$c_{copper} = 385\ J/kg°C$

$2000\ J$

10. A 0.30 kg piece of steel (c_{steel} = 452 J/kg*°C) at a temperature of 350°C is added to 10 kg of water at 20°C. Assuming no heat is lost to the surroundings and no water escapes, what is the final temperature of the water and steel?

$c_{water} = 4186\ J/kg°C$

$Q_{H_2O} = -Q_{steel}$

$mc(T_f - T_i) = -mc(T_f - T_i)$

$(10)(4184)(T_f - 20) = -(0.30)(452)(T_f - 350)$

$41840T_f - 836800 = -135.6 + 47460$

$41975T_f = 884260$

$T_f = 21.1°C$

$20°C$

11. A 0.38 kg glass container has 1 kg of water in it. The water and the container have an initial temperature of 25°C. One kg of water at 90°C is added to the container. What is the final temperature of the 2 kg of water and the container?

$Q_{water} = -Q_{hot\ water}$

$mc(T_f - T_i) = -mc(T_f - T_i)$

$(1)(4186)(T_f - 25) = -(1)(4186)(T_f - 90)$

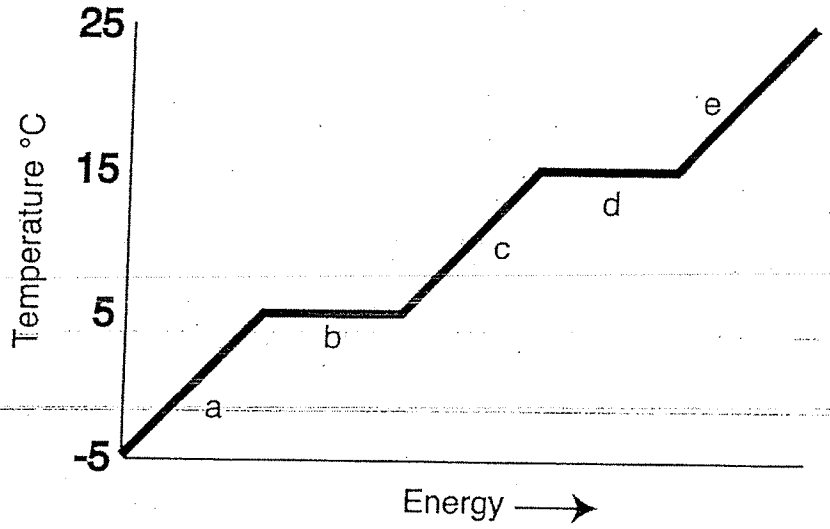
$T_f - 25 = -T_f + 90$

$2T_f = 115$

$T_f = 57.5°C$

FREEZING AND BOILING POINT GRAPH

Name _____



Answer the following questions using the chart above.

1. What is the freezing point of the substance? 5°C
2. What is the boiling point of the substance? 15°C
3. What is the melting point of the substance? 5°C
4. What letter represents the range where the solid is being warmed? a
5. What letter represents the range where the liquid is being warmed? c
6. What letter represents the range where the vapor is being warmed? e
7. What letter represents the melting of the solid? b
8. What letter represents the vaporization of the liquid? d
9. What letter(s) shows a change in potential energy? b, d
10. What letter(s) shows a change in kinetic energy? a, c, e
11. What letter represents condensation? d
12. What letter represents crystallization? b

Solve the following problems.

1. How many joules of heat are given off when 5.0 g of water cool from 75° C to 25° C? (Specific heat of water = 4.18 j/g° C)

$Q = (5)(4.18)(-50)$

$-1045\,J$

2. How many calories are given off by the water in Problem 1? (Specific heat of water = 1.0 cal/g° C)

$-250\,cal$

3. How many joules does it take to melt 35 g of ice at 0° C? (heat of fusion = 333 j/g)

$Q = (35)(333)$

$11655\,J$

4. How many calories are given off when 85 g of steam condense to liquid water? (heat of vaporization = 539.4 cal/g)

$Q = (85)(539.4)$

$45849\,cal$

5. How many joules of heat are necessary to raise the temperature of 25 g of water from 10° C to 60° C?

$Q = (25)(4.18)(50)$

$5225\,J$

6. How many calories are given off when 50 g of water at 0° freezes? (heat of fusion = 79.72 cal/g)

$Q = (50)(79.72)$

$3986\,cal$