Name KEY Period

Thermochemistry Test Review Problems
(check the website for solutions to these problems)

1. An unknown metal sample with a mass of 10.0 grams is heated to a temperature of 74.0°C and is dropped into 100.0 grams of water with a temperature of 30.0°C. The final temperature of the system is 32.0°C. What is the specific heat of the unknown metal? Report your answer with 2 decimal places.

$$-q_{metal} = q_{H_2O}$$

$$-\left(\frac{10\text{ g}}{}\left|\frac{X\text{ J}}{g^\circ C}\right|\overset{-42^\circ C}{(32-74)^\circ C}\right) = \left(\frac{100\text{ g}}{}\left|\frac{4.184\text{ J}}{g^\circ C}\right|\overset{2^\circ C}{(32-30)^\circ C}\right)$$

$$X = 1.99\ \frac{J}{g^\circ C}$$

2. Methanol, $CH_3OH(l)$, burns in oxygen to produce $CO_2(g)$ and $H_2O(g)$.
$\Delta H^\circ_{comb} = -239$ kJ/mol rxn
   A. Write a balanced equation for the combustion of methanol.
   B. If 17.5 grams of methanol react with 10.0 liters of oxygen gas at STP, determine the limiting reactant and the amount of energy that will be released (report your answer with 2 decimal places).
   C. If the methanol combustion reaction is used to heat 250 mL of water at 30°C, what would the final temperature of the water be? Round your answer to have 3 significant figures.
   D. ~~How many grams of methanol would need to be burned with excess oxygen to produce 1060 kJ of heat? (3 sig figs)~~

(A) $2CH_3OH + 3O_2 \rightarrow 2CO_2 + 4H_2O$

(B) $\frac{17.5\text{ g } CH_3OH}{}\left|\frac{1\text{ mol } CH_3OH}{32.042\text{ g } CH_3OH}\right|\frac{1\text{ mol rxn}}{2\text{ mol } CH_3OH}\left|\frac{-239\text{ kJ}}{\text{mol rxn}}\right. = -65.27\text{ kJ}$

$\frac{10\text{ L } O_2}{}\left|\frac{1\text{ mol } O_2}{22.4\text{ L } O_2}\right|\frac{1\text{ mol rxn}}{3\text{ mol } O_2}\left|\frac{-239\text{ kJ}}{\text{mol rxn}}\right. = -35.57\text{ kJ}$

I was bad and didn't show work

(C) $q = mC\Delta T$

$35,570\text{ J} = \frac{250\text{ g}}{}\left|\frac{4.184\text{ J}}{g^\circ C}\right|(X-30)^\circ C$

$T_f = 64.0^\circ C$

LR = O_2, Energy released is −35.57 kJ

3. Write the balanced equation when a solution of calcium chloride has a piece of lithium added.
   a. When 10. g of lithium is mixed with an excess of calcium chloride, 15 joules of energy are absorbed. Calculate the enthalpy for the reaction in units of kJ per gram of Li. Report your answer with 2 sig figs.
   b. How much energy (in joules) is absorbed with 25 grams of lithium react? (2 sig figs)

$CaCl_2 + 2Li \rightarrow 2LiCl + Ca$

(a) $\frac{?\text{ kJ}}{g\text{ Li}} = \frac{15\text{ J}}{10\text{ g}}\left|\frac{1\text{ kJ}}{10^3\text{ J}}\right. = 0.0015\ \frac{kJ}{g}$

(b) $?\text{ J} = 25\text{ g Li}\left|\frac{0.0015\text{ kJ}}{g}\right|\frac{10^3\text{ J}}{1\text{ kJ}}$

$= 37.5 = 38\text{ g Li}$

4. What is the total amount of energy required to take a 4.2 gram piece of ice at -15.0°C and create 4.2 grams of water vapor at 110.0°C? Water's melting point is 0°C and it boils at 100°C. Round your answer to 2 decimal places.

ΔH_{fusion} = 6.01 kJ/mol
ΔH_{vap} = 40.7 kJ/mol
Specific heat capacity for ice = 2.08 J/g C
Specific heat capacity for liquid water = 4.184 J/g C
Specific heat capacity for steam = 1.70 J/g C

131.04
1402.33
1757.28
9496.67
71.40

5 q's!

$q_{warm\ ice} + q_{melt\ ice} + q_{warm\ water} + q_{vaporize\ water} + q_{warm\ gas}$

110
100
0
-15

$(4.2\text{ g})\left(\frac{2.08\text{ J}}{g^\circ C}\right)(0 - -15^\circ C) + (4.2\text{ g})\left(\frac{6.010\text{ J}}{\text{mol}}\right)\left(\frac{1\text{ mol}}{18\text{ g}}\right) + (4.2\text{ g})\left(\frac{4.184\text{ J}}{g^\circ C}\right)(100^\circ C - 0^\circ C) + \left(\frac{40,700\text{ J}}{\text{mol}}\right)\left|\frac{\text{mol}}{18\text{ g}}\right|4.2\text{ g}$

$+ (4.2\text{ g})\left(\frac{1.70\text{ J}}{g^\circ C}\right)(110^\circ C - 100^\circ C) = 12,858.72 = 12,860\text{ J}$

5. A student wants to determine the enthalpy for the reaction between magnesium and hydrochloric acid.
   A. Write the reaction for Mg and HCl. The ionic product is soluble and appears as a colorless solution. The second product is a colorless gas.

The students places a piece of magnesium (a silver metal) into 1.5 M hydrochloric acid. Hydrochloric acid is a colorless solution where a small amount of HCl is dissolved in a large amount of water. The student watches the change in temperature. The data is found below.

Mass of Mg	0.55 g
Volume of HCl	95.0 mL
Ti	22.5°C
Tf	84.2°C

   B. Is the reaction endo- or exothermic? How do you know?
   C. After the reaction, the student peaks in the cup and notices that is looks like a colorless solution. What is the limiting reactant?
   D. Use the data to calculate the enthalpy of the reaction in units of kJ/mol rxn. The density for the acid is the same as pure water. The solution's specific heat capacity is approximately the same as pure water and the mass can be found by adding the mass of the acid and the metal.

(A) $Mg + 2HCl \rightarrow MgCl_2 + H_2$

(B) exo, Temp of H_2O ↑

(C) Mg

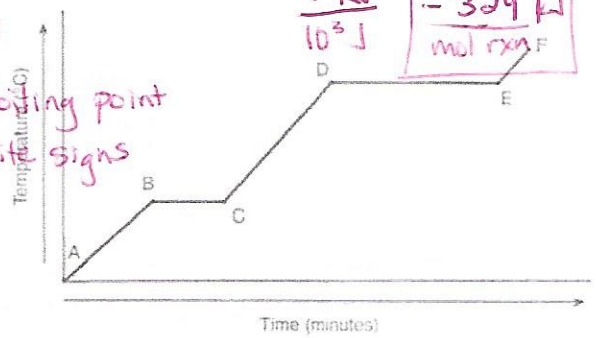
(D) $q_{soln} = mC\Delta T = (95.55g)(4.184 J/g°C)(41.1 - 22.5)°C$

$q_{soln} = 7435.9\ J \Rightarrow q_{rxn} = -7435.9$

$\frac{?\ kJ}{mol\ rxn} = \frac{-7435.9}{0.55\ g\ Mg} \left|\frac{24.305\ g\ Mg}{1\ mol\ Mg}\right| \frac{1\ mol}{1\ mol\ rxn}$

$\frac{1\ kJ}{10^3\ J}$ → $\boxed{-329\ kJ / mol\ rxn}$

6. Use the graph to answer the questions about a substance called X.
   a. What does line segment ~~CD~~ BC represent? melting
   b. Which line segments can be calculated using q=mCΔT? $\overline{AB}$ $\overline{CD}$ $\overline{EF}$
   c. Which line segments can be calculated using q=mΔH? $\overline{BC}$ $\overline{DE}$
   d. What would that temperature at point D be called for substance X? Boiling point
      What do we call the temperature at point B? melting point
   e. How would the enthalpy compare for B → C versus C → B? opposite signs
   f. What does the line segment DE represent? substance X vaporizing



8. A coffee cup calorimeter holding 50.0 grams of water has a temperature of 23.0°C. If 140.0 grams of aluminum metal heated to 141.0°C is dropped into the cup, what will the final temperature of the system be? ~~(heat capacity of calorimeter = 29.1 J/°C)~~ Report your answer with 3 significant figures.

$-q_{Al} = q_{H_2O}$

$-\left|140\ g\right|\frac{0.900\ J}{g°C}\left|(x - 141)°C\right| = \left|50\ g\right|\frac{4.184\ J}{g°C}\left|(x - 23)°C\right|$

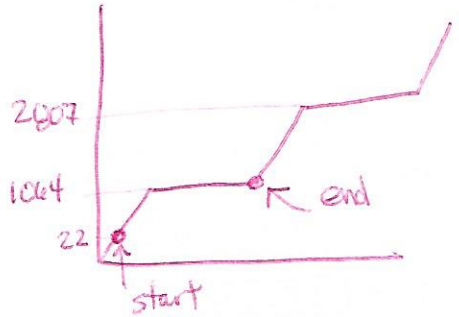
$-126x + 17766 = 209.2x - 4811.6$

$22577.6 = 335.2x$

$\boxed{67.4°C} = x$

7. A bitter divorcée wishes to have her gold wedding ring made into a bracelet charm in the shape of a skull and crossbones. Her ring has a mass of 5.323 grams. How many kJ of energy are required to melt her ring so it can be poured into the skull and crossbones mold if the ring is initially at room temperature (22°C)?

Substance	Chemical Formula	Melting point (°C)	ΔH_{fus} (kJ/mol)	Boiling point (°C)	ΔH_{vap} (kJ/mol)	Specific Heat (J/g°C)
Gold	Au	1064.18	12.550	2807.0	334.4	0.129



2 q's

$q = q_{warm\ metal} + q_{melt\ metal}$

$q = (5.323\ g)(0.129\ \frac{J}{g°C})\left(\frac{1\ kJ}{10^3\ J}\right)(1064.18 - 22) + \left(5.323\ g\left(\frac{1\ mol\ Au}{196.967\ g\ Au}\right)\left(12.55\ \frac{kJ}{mol}\right)\right.$

$= \boxed{1.05\ kJ}$