NOTES #16/CALORIMETRY/AP CHEMISTRY

I. **Calorimetry** - the EXPERIMENTAL measurement of ____________ (enthalpy) transfers in physical and chemical processes.

** In calorimetry experiments, the amount of heat transferred is represented by the symbol,_____.

EX. (An easy example) How much heat (q) is absorbed when you heat 50.0 grams of water from 25.0°C to 35.0°C?
** *There are three factors that must be taken into account:*

<u>Sp. heat of common substances (J/g°C):</u>
Water: 4.184
Ethanol: 2.46
Iron: 0.444
Copper: 0.385
Lead: 0.159

1. **SPECIFIC HEAT (c)
- the amount of heat required to raise the temperature of 1.0 gram of substance 1.0°C. Units: ____________________

- Specific heat is a PHYSICAL property of a substance
- like density, specific heat is an _________________________________

** EX: What heats up faster on the stove, the pot or the water? Why?

2. **MASS OF SUBSTANCE (m)
- Since you have 50.0 grams of water, it's going to take ____________ as much energy to raise the temp of the entire amount of water 1.0°C.

_________________ x 4.184 J/g.°C = __________________
- This quantity represents the HEAT CAPACITY (C) - the amount of heat needed to:

____

C =

** EX: Which has a higher heat capacity, a bucket of water or a cup of water? ___________________________

- Heat capacity IS dependent on mass, so it's an ____.
3. CHANGE IN TEMPERATURE ΔT ....which is always ___________________.

For every one-degree temperature increase,____________________J are absorbed. How much energy for a temperature change from 25.0°C to 35.0°C?

* FINAL CONCLUSION - _________________________ J of heat must be absorbed to raise the temp of 50.0 grams of water from 25.0°C to 35.0°C.

II. Put 1,2,and 3 together and you have an expression for calculating q (amount of heat released or absorbed)

q = ______________ (in terms of spec. heat) or **q** = _______________ (in terms of heat capacity)

EX 1: What is the specific heat of lead if the temperature of a 425 g block increases 7.28 °C when it absorbs 492 J of heat? What is the heat capacity of the block of lead?

** Now, we can look at how calorimetry experiments are actually set up. There are two major types of calorimetry experiments:

1. Constant-pressure calorimetry (what we will do in lab with coffee cups)
2. Constant-volume calorimetry (or bomb calorimetry) mucho $$$$

CONSTANT-PRESSURE CALORIMETRY:
- This type of calorimetry is normally used to determine the heat transfers occurring in reactions taking place_______________________________ (_________________________ & _______________________ rxns are really common) or to determine the specific heat/ heat capacity of different solids (metals in particular).

- Basic set-up? Two nested Styrofoam cups with a lid - through which a thermometer can be inserted. A rxn or process takes place in the water. (Notice, the pressure is constant; it is equal to ____________________________.)

1. If the process is ENDO, heat will be ____________________ from the water. A ____________________ in the H_2O temp will be noted.
2. If the process is EXO, heat will be _____________________ by the water. An_____________________ in the H_2O temp will be noted.

From the temperature change of the water, the amount of heat released or absorbed by the process can be determined.

- The Basic Premise: The heat given off (or absorbed) during a process will be absorbed (or lost) by the_________________________and _________________________. ΔT of the water and calorimeter assembly can be measured. The big idea is that the heat gained or lost by the system as a whole is assumed to be zero, thus.....

HEAT GAINED (by the water & calorimeter) = $^{-}$**HEAT GIVEN OFF** (by the rxn)

Demo Lab: Experimentally, determine the specific heat and heat capacity of a large lead sinker.

EX: A 44.00 g sample of an unknown metal at 99.00°C was placed in a constant-pressure calorimeter containing 80.00 g of water at 24.00°C. The final temperature of the system was found to be 28.40°C. Calculate the specific heat of the metal. The heat capacity of the calorimeter is 12.40 J/$_{o}$C.

CONSTANT-VOLUME CALORIMETRY

- Involves a "Bomb" calorimeter. A bomb calorimeter is used to measure the heat evolved in ______________________ rxns usually involving foods and fuels. (This is how they figure out the amount of Calories in food (1 Cal = 4184 J))
- What's the set-up? A stainless steel "bomb" is loaded with a small amount of substance and _________ at HIGH pressure (around 30 atm....now, do you see why it's called a "bomb") and immersed in a ________________ of water.

****Note: because bomb calorimeters are really massive (to contain the force of the explosive combustion) they often do not need to contain water. If there is no water, assume the heat of the reaction is simply absorbed by the calorimeter itself.

- How's it work? The heat evolved during the combustion reaction will be absorbed by the _________________ and ____________________****. ΔT of the water and calorimeter assembly can be measured. The big idea is that:

HEAT GAINED (by the water & calorimeter) = $^{-}$**HEAT GIVEN OFF** (by the rxn)

$q_{rxn} = -(q_{bomb} + q_{water})$

EX 1: 0.5521 g of pentane (C_5H_{12}) was combusted in a bomb calorimeter filled with 1000 g of water and an excess of O_2 according to the following equation:

$$C_5H_{12} (l) + 8\ O_2 (g) \text{ -------> } 5\ CO_2 (g) + 6\ H_2O (g)$$

a) If the heat capacity of the calorimeter was 1,800. J/°C, and the temperature of the calorimeter and water rose from 21.22 °C to 25.70 °C, what is the heat of combustion per gram of pentane?

b) What is the heat of combustion per mole (ΔH_o) of pentane used?

EX 2: The combustion of benzoic acid is often used as a standard source of heat for calibrating combustion bomb calorimeters. The heat of combustion of benzoic acid has been accurately determined to be 26.42 kJ/g. When 0.8000g of benzoic acid was burned in a calorimeter containing 950. g of water, a temperature rise of 4.08 °C was observed. What is the heat capacity (C) of the bomb calorimeter?