AP Chem Lab 2 Quiz #1 Calorimetry Name ________________________________

Conceptual Understanding. Write complete sentences to show your understanding.

Differentiate between kinetic energy and potential energy.

Energy may be transferred as _________ or __________.

Describe each of the above transfers of energy.

First Law of Thermodynamics. State the first law.

Justify the following statements using the First Law, also state the conditions that are required for this statement to be true.

$q_{\text{hot water}} + q_{\text{cold water}} + q_{\text{calorimeter}} = 0$

$\Delta E = q + w$

How does a calorimeter work to measure heat transfer. Include the equation for heat transfer. Address the first law of thermodynamics and the importance of the insulated walls.

Define internal energy.

Explain how a bomb calorimeter allows you to measure the change in internal energy. Address the significance of the constant volume.

Measuring the change in enthalpy is associated with constant ________________. Enthalpy essentially ignores energy transferred as ___________. How does enthalpy differ from internal energy?

How does bomb calorimeter differ from a stryofoam cup calorimeter? Include what is measured.

Calculations. Show all your work including equations and units.

75.0 mL of hot water at 67.2^{o}C is mixed with 75.0 mL of cold water at 18.6^{o}C already in a calorimeter. The final temperature of the mix is 42.5^{o}C. Calculate the heat capacity of the calorimeter.

The combustion of 1.048 g of benzene, $C_6H_{6\,(l)}$, in a bomb calorimeter compartment surrounded by 945 g of water raised the temperature of the water from 23.640^{o}C to 32.692^{o}C. The heat capacity of the calorimeter is 891 J/^{o}C. Calculate Δ*E* for the combustion reaction per mole of benzene burned (kJ/mol).

A 0.444-g sample of sucrose ($C_{12}H_{22}O_{11}$) is burned in a bomb calorimeter and the temperature increases from 20.00 °C to 22.06 °C. The calorimeter contains 748 g of water, and the bomb has a heat capacity of 420. J/°C. Calculate Δ*E* for the combustion reaction per mole of sucrose burned (kJ/mol).

AP Chem Lab 2 Quiz #1 Calorimetry Name ________________________________

Conceptual Understanding. Write complete sentences to show your understanding.

Differentiate between kinetic energy and potential energy.

Kinetic energy is the energy (or ability to work) due to the **MOTION** of the object or particle ($1/2\ mv^2$)

Potential energy is the energy stored due to the **POSITION** of the object or particle with respect to a force acting between it and another object or particle.

Energy may be transferred as ___work__ or ___heat___.

Describe each of the above transfers of energy.

Energy may be transferred as work or heat.

Energy transferred as **work** is the result of the movement of an object a distance. ($W = F \times d$)

Energy transferred as **heat** is due to the difference in temperature between two systems. ($q = mC\ \Delta T$)

First Law of Thermodynamics. State the first law.

First Law of Thermodynamics. **Energy is conserved. The energy in the universe remains constant.** A change in energy in one part of the universe is accompanied by a change in energy in another part of the universe. Thus there is no net change in energy. The challenge is accounting for all the energy transfers between parts of the universe. Since energy is transferred as either heat or work when we can account for these the change in energy will be zero.

Justify the following statements using the First Law, also state the conditions that are required for this statement to be true.

$$q_{\text{hot water}} + q_{\text{cold water}} + q_{\text{calorimeter}} = 0$$

In an isolated calorimeter (one that does not allow any transfer of heat beyond the walls of the calorimeter, the change in energy will be zero since energy is conserved within the calorimeter. Heat is transferred between the hot water, cold water and the walls of the calorimeter, so the sum of these must be zero as long as there is no heat exchange between the calorimeter and the surroundings.

$$\Delta E = q + w$$

Since energy is conserved, than the change in energy is the result of the energy transferred in (positive change) or out (negative change) as heat and/or work.

How does a calorimeter work to measure heat transfer. Include the equation for heat transfer. Address the first law of thermodynamics and the importance of the insulated walls.

A calorimeter works as an isolated system so that all the energy transfer happens within the calorimeter. The transfer of energy as heat is measured by measuring the mass of the water in calorimeter and the change in temperature of the water in calorimeter. The heat transfer to the water can then be calculated using the equation $q = mC\ \Delta T$.

Define internal energy.

Internal energy is the sum of the all the KE and PE of the particles. For example --KE of particles is due to the motion of the molecules, atoms, and sub atomic particles. For example -- PE of the particles is due to the position of molecules (intermolecular attractions acting between them – electrical force), atoms within the molecule (covalent bond acting between them – electrical force), electrons around the nucleus (electrical force between negative e- and protons within nucleus), protons and neutrons within nucleus (nuclear force acting between them)

Explain how a bomb calorimeter allows you to measure the change in internal energy. Address the significance of the constant volume.

A bomb calorimeter maintains a constant volume. Since the volume does not change, there is no distance and thus no work is done. So the change in energy is just due the heat transferred. A bomb calorimeter can be used to measure the change in internal energy by measuring the heat transfer.

Measuring the change in enthalpy is associated with constant ____pressure__. Enthalpy essentially ignores energy transferred as ___work____.

Enthalpy differs from internal energy since change in internal energy is a measure in the energy change whereas enthalpy is not. The work is ignored. Enthalpy is measured at constant pressure whereas internal energy is measured at constant volume.

How does bomb calorimeter differ from a stryofoam cup calorimeter? Include what is measured.

A Styrofoam cup calorimeter is used to measure the heat transfer at a constant pressure and thus the change in enthalpy (ΔH). The bomb calorimeter maintains constant volume and the measured change in heat transfer is a measure of the change in internal energy (ΔU).

Calculations. Show all your work including equations and units.

75.0 mL of hot water at 67.2^{o}C is mixed with 75.0 mL of cold water at 18.6^{o}C already in a calorimeter. The final temperature of the mix is 42.5^{o}C. Calculate the heat capacity of the calorimeter.

$$q_{\text{hot water}} + q_{\text{cold water}} + q_{\text{calorimeter}} = 0$$

$$m_{\text{hot water}} C_{\text{water}} \Delta T_{\text{hot water}} + m_{\text{cold water}} C_{\text{water}} \Delta T_{\text{cold water}} + q_{\text{calorimeter}} = 0$$

$$(75\text{ g})(4.184\text{J/g}^{o}\text{C})(42.5^{o}\text{C} - 67.2^{o}\text{C}) + (75\text{ g})(4.184\text{J/g}^{o}\text{C})(42.5^{o}\text{C} - 18.6^{o}\text{C}) + q_{\text{calorimeter}} = 0$$

$$q_{\text{calorimeter}} = 250.8\text{J}$$

This is the heat absorbed by the calorimeter.

The missing heat between heat lost by hot and gained by cold was gained by the calorimeter.

<u>Heat capacity of the calorimeter</u> is the heat absorbed by the calorimeter per each Kelvin or degree Celsius of change in calorimeter temperature.

$$\frac{250.8\text{ J}}{23.9\ ^{o}\text{C}} = 10.5\text{ J/}^{o}\text{C}$$

Show the equations used to calculation. Your work should be easy to follow.
Show the units in each number within your calculations.

The combustion of 1.048 g of benzene, $C_6H_{6\,(l)}$, in a bomb calorimeter compartment surrounded by 945 g of water raised the temperature of the water from 23.640^{o}C to 32.692^{o}C. The heat capacity of the calorimeter is 891 J/^{o}C.

$$q_{\text{water}} + q_{\text{calorimeter}} + q_{\text{reaction}} = 0$$

$$m_{\text{water}} C_{\text{water}} \Delta T_{\text{water}} + \text{heat capacity}_{\text{calorimeter}} \Delta T_{\text{calorimeter}} + q_{\text{reaction}} = 0$$

$$(945\text{ g})(4.184\text{J/g}^{o}\text{C})(32.692^{o}\text{C} - 23.640^{o}\text{C}) + (891\text{ J/}^{o}\text{C})(32.692^{o}\text{C} - 23.640^{o}\text{C}) + q_{\text{reaction}} = 0$$

35790.5 J + 8065.3 J + $q_{reaction}$ = 0 $q_{reaction}$ = 43855.8 J

This is the energy transferred by the combustion of 1.048 g of benzene. We need the ΔU in kJ/mol benzene.

– 43855.8 J	78.114 g benzene (C_6H_6)	1 kJ	– 3269 kJ/mol
1.048 g benzene (C_6H_6)	Mol benzene (C_6H_6)	1000 J	

A 0.444-g sample of sucrose ($C_{12}H_{22}O_{11}$) is burned in a bomb calorimeter and the temperature increases from 20.00 °C to 22.06 °C. The calorimeter contains 748 g of water, and the bomb has a heat capacity of 420. J/°C. Calculate Δ*E* for the combustion reaction per mole of sucrose burned (kJ/mol).

q_{water} + $q_{calorimeter}$ + $q_{reaction}$ = 0

$m_{water} C_{water} \Delta T_{water}$ + heat capacity$_{calorimeter}$ $\Delta T_{calorimeter}$ + $q_{reaction}$ = 0

$(748\text{ g})(4.184\text{J/g}^{o}\text{C})(22.06^{o}\text{C} - 20.00^{o}\text{C}) + (420\text{ J/}^{o}\text{C})(22.06^{o}\text{C} - 20.00^{o}\text{C}) + q_{reaction} = 0$

This is the energy transferred by the combustion of 0.444-g sample of sucrose ($C_{12}H_{22}O_{11}$).
We need the ΔU in kJ/mol sucrose.

– 7312 J	342.297 g $C_{12}H_{22}O_{11}$	1 kJ	– 5337 kJ/mol
0.444 g $C_{12}H_{22}O_{11}$	mol $C_{12}H_{22}O_{11}$	1000 J	