Thermochemistry WebQuest Student Worksheet

Student Name:________Key_____________________

Follow the WebQuest Process and answer the problems in each section.

Section A

1. Define energy:

2. List the five different types of energy listed in the video

   a. __Potential_____________

   b. __Kinetic______________

   c. __Light (radiant)________

   d. __Heat (thermal)________

   e. __Chemical_____________

Section B

1. Describe the direction in which heat energy flows .

Energy flows from hot to cold

2. Define a system.

   A specific part of the universe that is of interest

3. Define surroundings.

   The rest of the universe apart from the system

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4. Provide an example of system and surroundings.

A system could be a beaker and the surroundings would be the chemistry lab (counter top, fumehood, stool, sink, floor, etc.)

5. What happens to mass and energy in a/an

a. Open system
Mass and energy are freely exchanged with the surroundings

b. Closed system
Only energy is freely exchanged with the surroundings, not mass

c. Isolated system
An exchange of mass and energy does not occur.

Section C

1. Write the equation expression that represents the **first law of thermochemistry**. What do each of the three variables in this equation represent?

$\Delta U = q + w$

2. Solve the following problems:

a. Calculate the overall change in internal energy, ΔU, (in kilojoules) for a system that absorbs 1.24 x 10^4 kJ of heat and does 1.13 x 10^4 kJ of work on its surroundings.

$\Delta U = q + w$, thus in this problem
q represents the heat absorbed by the system and w represents the work done by the system on the surroundings
$\Delta U = 1.24 \times 10^4 + (-1.13 \times 10^4) = 1.10 \times 10^3$ kJ

b. Determine the work done (in joules) when a sample of gas expands from 432 mL to 726 mL at constant pressure.
$w = -P\Delta V$
$\Delta V = (726 \text{ mL} - 432 \text{ mL}) = 294$ mL and
using the conversion factor 1L·atm = 101.3J, therefore
$294\, ml \times \frac{1\, L}{1000\, mL} \times \frac{101.3\, J}{1L \cdot atm} = 29.7\, \frac{J}{atm}$ or
$-1.25 atm \times 29.7\, \frac{J}{atm} = -37.2$ J

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Section D

1. Write the equation defining the state function, enthalpy.

$H = U + PV$

2. Define **enthalpy of reaction** and provide the equation.

The difference between the enthalpies of the products and the enthalpies of the reactants.
$\Delta H = H(\text{products}) - H(\text{reactants})$

3. Solve the following problem:

Given the thermochemical equation for photosynthesis,

$6H_2O(l) + 6CO_2(g) \rightarrow C_6H_{12}O_6(s) + 6O_2(g)$ $\quad\quad \Delta H = +2803$ kJ/mole

Calculate the mass (in grams) of O_2 that is produced by photosynthesis when 3.26×10^4 kJ of solar energy is consumed.

If the reaction yields 2803 kJ/mole, than $3.26 \times 10^4 \text{ kJ} \times \frac{6 \text{ mole}}{2803 \text{ kJ}} = 69.8 \text{ moles}$

Therefore, $69.8 \text{ moles} \times \frac{32.00 \text{ g } O_2}{1 \text{ mole } O_2} = 2.23 \times 10^4 \text{ g } O_2$

Section E

1. Write the equation used to calculate the heat change of a substance in a calorimeter.

$q = ms\Delta T$ or $q = C\Delta T$,
where q is heat absorbed or released by the system; m is mass ; s is specific heat; T is temperature OR
where q is heat absorbed or released by the system; C is heat capacity; T is temperature

2. Solve the following problems:

a. Calculate the amount of heat (in kJ) required to heat 145 g of water from 26.3°C to 85.3°C.

Using: $q = ms\Delta T$
$145\, g \times 4.184 \frac{J}{g \cdot ^\circ C} \times (85.3^\circ C - 26.3^\circ C) \times \frac{1\, kJ}{10^3\, J} = 35.8 kJ$

b. A copper (Cu) pellet having a mass of 25.32g and an initial temperature of 83.54°C is dropped into a 156 g sample of water with an initial temperature of 22.5°C. What is the final temperature?

$q_{Cu} + q_{H2O} = 0$ OR $q_{Cu} = -q_{H2O}$ and $q = ms\Delta T$, thus

$(25.32g)\left(0.385\ \frac{J}{g\cdot°C}\right)(T_f - 83.54°C) = -(156g)(4.184\frac{J}{g\cdot°C})(T_f - 22.5°C)$ OR

$9.7482T_f - 814.36 = -652.70T_f + 14{,}686$, and solve for T_f

$662.45T_f = 15{,}500$ OR final temperature is 23.4°C

Section F

1. Write the equation for the **standard enthalpy of reaction**.

$\Delta H°_{rxn} = \Sigma n\Delta H°_f(products) - \Sigma m\Delta H°_f(reactants)$, where n and m represent stoichiometric coefficients and Σ is the sum of

2. Solve the following problems:

a. A thermite reaction involving aluminum and copper(I) oxide
$2Al(s) + 3CuO(s) \rightarrow Al_2O_3(s) + 3Cu(l)$
is exothermic and results in liquid copper used in cadwelding.

Calculate the heat released in kilojoules per gram of Al reacted with CuO. The standard enthalpy of formation, $\Delta H°_f$, for Cu(l) is 13.49 kJ/mole.
Use table to find other $\Delta H°_f$ values

$\Delta H°_{rxn} = [\Delta H°_f(Al_2O_3) + 3\Delta H°_f(Cu)] - [2\Delta H°_f(Al) + 3\Delta H°_f(CuO)$ or

$\Delta H°_{rxn} =$
$\left[\Delta H°_f\left(-1669\frac{kJ}{mole}\right) + 3\Delta H°_f\left(13.49\frac{kJ}{mole}\right)\right] - [2\Delta H°_f(0\frac{kJ}{mole}) + 3\Delta H°_f\left(-155.2\frac{kJ}{mole}\right)$

$\Delta H°_{rxn} = \left(-1628.5\frac{kJ}{mole}\right) - \left(-465.6\frac{kJ}{mole}\right)$

$\Delta H°_{rxn} = -1163\frac{kJ}{mole}$

b. Use the following data to calculate the standard enthalpy of formation, $\Delta H°_f$, for $CS_2(l)$:

$C(graphite) + O_2(g) \rightarrow CO_2(g)$ $\Delta H°_{rxn} = -393.5$ kJ/mole
$S(rhombic) + O_2(g) \rightarrow SO_2(g)$ $\Delta H°_{rxn} = -269.4$ kJ/mole
$CS_2(l) + 3O_2(g) \rightarrow CO_2(g) + 2SO_2(g)$ $\Delta H°_{rxn} = -1073.6$ kJ/mole

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First of all, we are looking for the formation of $CS_2(l)$, therefore reverse the third equation:

$CO_2(g) + 2SO_2(g) \rightarrow CS_2(l) + 3O_2(g)$ $\Delta H°_{rxn} = 1073.6$ kJ/mole

Next we need 2 moles of SO_2, thus

$2S(\text{rhombic}) + 2O_2(g) \rightarrow 2SO_2(g)$ $\Delta H°_{rxn} = 2(–269.4$ kJ/mole)
$= –538.8$ kJ/mole

Along with

$C(\text{graphite}) + O_2(g) \rightarrow CO_2(g)$ $\Delta H°_{rxn} = –393.5$ kJ/mole

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$C(\text{graphite}) + 2S(\text{rhombic}) \rightarrow CS_2(l)$ $\Delta H°_{rxn} = 141.3$ kJ/mole