Practice Test – Chapter 5 - Thermochemistry

Goal: I can give examples of different forms of energy. I can also state common units of energy and convert between these units.

1. Choose the correct type of energy for each of the following: Choices: potential energy, kinetic energy, thermal energy, internal energy, electrostatic potential energy

_____ a) The energy of motion.

_____ b) The energy of an object due to its relative position.

_____ c) The energy due to the attractions or repulsions of charged particles such as protons and electrons.

_____ d) The energy that a substance possess because of its temperature.

_____ e) The sum of all the PE and KE of a system.

2. Circle all of the following which are units of energy:

joule kilogram gram calorie Calorie kilojoule $kg \bullet m^2/s^2$ m^2/s^2

Goal: I can define the first law of thermodynamics and write the associated equation.

3. The First Law of Thermodynamics states that . . .

4. Which equation represents the First Law of Thermodynamics?
   a. $\Delta E = q + w$
   b. $\Delta H = q_p$
   c. $q = m \bullet C_p \bullet \Delta T$
   d. $KE = \frac{1}{2} mv^2$

Goal: I can describe how the change in internal energy of a system is related to the changes of heat and work between the system and its surroundings.

5. A positive "q" means that the system _____ heat. A positive "w" means that work is done _____ the system.

   a. loses, by b. loses, on c. gains, by d. gains, on

6. What is ΔE for a system when it does 230 kJ of work on its surroundings and 130 kJ of heat is removed from the system?
   a. +100 kJ b. -100 kJ c. +360 kJ d. -360 kJ

Goal: I can define enthalpy and relate the enthalpy change in a process to the heat added (endothermic) to or lost (exothermic) by the system during the process.

7. Enthalpy is the same thing as heat when measured at a constant _____ .
   a. volume b. temperature c. pressure d. elevation

8. A negative ΔH indicates that a reaction is . . .
   a. endothermic.
   b. absorbing heat.
   c. occuring spontaneously.
   d. nonspotaneous.
   e. losing heat.

9. Assume that a chemical reaction is occuring in a plastic bag and that you are holding the bag in your hands. If your hands feel cold it is because . . .
   a. the chemical reaction is exothermic and absorbing heat from your hands.
   b. the chemical reaction is endothermic and absorbing heat from your hands.
   c. the chemical reaction is exothermic and releasing heat into your hands.
   d. the chemical reaction is endothermic and releasing heat into your hands.

Goal: I can differentiate between exothermic and endothermic processes. I can also sketch an exothermic and endothermic energy diagram and label the various parts.

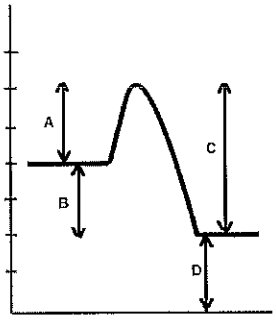
10. Which ONE statement concerning the following is correct?

$$N_2(g) + O_2(g) \rightarrow 2\,NO(g)\,;\quad \Delta H = +43.2\ kcal$$

   a. The reaction is exothermic.
   b. The products have an enthalpy loss.
   c. The sign of ΔH for the reaction is negative.
   d. PE of the products exceeds that of the reactants.
   e. The products have less enthalpy than the reactants.

11. Consider the following energy diagram:

$$A + B \rightarrow C + D$$



   a. Is the reaction exothermic or endothermic?

   b. Label the reactants and products

   c. What is the value of ΔH?

Goal: I can make stoichiometric calculations based upon a thermochemical equation.

12. Consider the following reaction:

$$2\,SO_2(g) + O_2(g) \rightarrow 2\,SO_3(g);\ \Delta H = -192.8\ kJ$$

Assume enough SO_2 and O_2 were reacted and 200. grams of SO_3 were produced. Calculate the corresponding amount of heat produced.

a. -3.86 kJ b. -15.1 kJ c. -75.5 kJ d. -241 kJ e. -521 kJ

13. Typical heat capacity units are _____ and specific heat capacity units are _____ .
a. J/°C, J/g•°C b. J/g•°C, J/°C, c. °C/J, °C•J/g d. °C•J/g, °C/J

Goal: I can solve problems using $q = m \bullet C_p \bullet \Delta T$; calculate any one of the quantities given the other three.

14. What is the final temperature of 30. g of Al if 540. J of heat is added to a sample at 25.0°C? (specific heat of Al = 0.90 J/g•°C)

a. 10°C b. 20°C c. 35°C d. 45°C d. 135°C

15. Assume that 100.0 g of water 30.0°C is mixed with 50.0 g of water at 0.0°C. What is the final temperature?

a. 40.0 °C b. 20.0 °C c. 15.0 °C d. 10.0 °C

16. How much heat is lost when 10.0 g of iron cools from 129°C to 79°C? (The specific heat of iron is 0.450 J/g°C).

a. 12.0 J b. 24 J c. 124 J d. 175 J e. 225 J

17. Consider the following specific heats of metals:

Metal	Specific Heat (J/g°C)
Lithium	3.56
Gallium	0.372
Nickel	0.444
Gold	0.129
Sodium	1.23

If the same amount of heat is added to 200 g samples of each of the metals, assume all metals are at the same temperature, which metal will attain the lowest temperature?

a. Lithium b. Gallium c. Nickel d. Gold e. Sodium

Goal. I can state Hess's law and use Hess's Law to solve problems.

18. State Hess's Law.

19. What is the heat of hydrogenation of acetylene, at 25°C and 1 atm,

$C_2H_2(g) + 2\,H_2(g) \rightarrow C_2H_6(g)$

given the following thermochemical equations:

$2\,C_2H_6(g) + 7\,O_2(g) \rightarrow 4\,CO_2(g) + 6\,H_2O(l)$ $\Delta H = -3{,}120$ kJ

$2\,C_2H_2(g) + 5\,O_2(g) \rightarrow 4\,CO_2(g) + 2\,H_2O(l)$ $\Delta H = -2{,}610$ kJ

$H_2(g) + \frac{1}{2}\,O_2(g) \rightarrow H_2O(l)$ $\Delta H = -290$ kJ

a. -325 kJ b. +325 kJ c. +1,610 kJ d. -1,610 kJ

Goal: I can define the terms *standard state and standard heat of formation.* I will also be to write a chemical reaction associated with the standard heat of formation.

20 Which of the following conditions represent standard states?

a. 1 atm & 0°C b. 2 atm & 0°C c. 2 atm & 273°C d. 1 atm & 25°C

21. Which equation represents ΔH_f° for NO_2?

a. $NO(g) + O(g) \rightarrow NO_2(g)$

b. $NO(g) + \frac{1}{2}\,O_2(g) \rightarrow NO_2(g)$

c. $2\,NO(g) + O_2(g) \rightarrow 2\,NO_2(g)$

d. $N_2(g) + 2\,O_2(g) \rightarrow 2\,NO_2(g)$

e. $\frac{1}{2}\,N_2(g) + O_2(g) \rightarrow NO_2(g)$

22. Choose the proper ΔH for each equation below. Place the correct ΔH on the provided blanks.

CHOICES: ΔH°_{fusion} ΔH°_{vap} ΔH°_f ΔH°_{comb}

_____ $H_2O(l) \rightarrow H_2O(s)$ _____ $CH_4 + 2\ O_2(g) \rightarrow 2\ H_2O(g) + CO_2(g)$

_____ $H_2O(l) \rightarrow H_2O(g)$ _____ $2\ H_2 + \frac{1}{2}\ O_2(g) + C(gr) \rightarrow CH_3OH(l)$

Goal: I can calculate the enthalpy change in a reaction when given the standard enthalpies of formations of each reactant and product.

23. What is ΔH_f° for one mole of $C_2H_5OH(l)$ given the following data at 25°C:

$C_2H_5OH(l) + 3\ O_2(g) \rightarrow 2\ CO_2(g) + 3\ H_2O(l)$

$\Delta H^\circ_{reaction} = -1{,}366$ kJ
ΔH°_f for $CO_2(g) = -393.5$ kJ/mol
ΔH°_f for $H_2O(l) = -285.8$ kJ/mol

a. +462.6 kJ b. +278.4 kJ c. -462.6 kJ d. -278.4 kJ

24. What is the heat of combustion for one mole of benzene at 25°C and 1 atm,

$2\ C_6H_6(l) + 15\ O_2(g) \rightarrow 12\ CO_2(g) + 6\ H_2O(l)$

given the following data:
ΔH°_f for $CO_2(g) = -393.5$ kJ/mol
ΔH°_f for $H_2O(l) = -285.8$ kJ/mol
ΔH°_f for $C_6H_6(l) = 49.0$ kJ/mol

a. +3,271 kJ b. -3,271 kJ c. -636 kJ d. +636 kJ

Part II: Free Response

Directions: Show all work, include units, and answer with the correct number of singificant figures.

1. An experiment is to be performed to determine the standard molar enthalpy of neutralization of a strong acid by a strong base. Standard school laboratory equipment and a supply of standardized 1.00 molar HCl and standard 1.00 molar NaOH are available.

    a) What equipment would be needed?

    b) What measurements should be taken?

    c) Without performing calculations, describe how the resulting data should be used to obtain the standard molar enthalpy of neutralization.

    d) When a class of students performed this experiment, the average of the results was -55.0 kilojoules per mole. The accepted value for the standard molar enthalpy of neutralization of a strong acid by a strong base -57.7 kilojoules per mole. Propose two likely sources of experimental error that could account for the result obtained by the class.

2. When iron is oxidized at standard conditions it forms iron (III) oxide.
    a) Write the reaction representing this reaction.

    b) What is oxidized and what is reduced?

    c) Assume that 16.0 grams of iron is oxidized. Calculate the amount of heat (kJ) produced. (ΔH_f° for iron III oxide solid is -824 kJ/mol).

3. How many grams of hot aluminum at a temperature of 180.0°C would have to be placed in 400.0 g of water to raise the temperature of the water from 18.0°C to 25.0°C? (C_p for Al = 0.941 J/g•°C and C_p for H_2O = 4.18 J/g•°C)

4. When a 1.000 gram sample of the rocket fuel hydrazine, N_2H_4, is burned in a bomb calorimeter which contains 1,200. grams of water, the temperature rises from 24.62°C to 28.16°C. If the heat capacity of the dry calorimeter is 840. J/°C, calculate the heat produced by the combustion of the one gram sample. (C_p for water is 4.18 J/g•°C)

5. **AP Chemistry 2013 FR Question 3 (9 points)**

$$MgO_{(s)} + 2H^{+}_{(aq)} \rightarrow Mg^{2+}_{(aq)} + H_2O_{(l)}$$

A student was assigned the task of determining the enthalpy changes for a reaction between solid MgO and aqueous HCl represented by the net-ionic equation above. The student uses a polystyrene cup calorimeter and performs four trials. Date for each trial are shown in the table below.

Trial	Volume of 1.0 M HCl (ml)	Mass of MgO (s) added (g)	Initial Temperature of solution (°C)	Final Temperature of solution (°C)
1	100.0	0.25	25.5	26.5
2	100.0	0.50	25.0	29.1
3	100.0	0.25	26.0	28.1
4	100.0	0.50	24.1	28.1

a) Which is the limiting reactant in all four trials, HCl or MgO? Justify your answer.

b) The date in one of the trials is inconsistent with the data of the other three trials. Indentify the trial with inconsistent data and draw a line through the data from the trail in the table above. Explain how you indentified the inconsistent data

For parts (c) and (d), use the data from one of the other three trials (i.e., not from the trial you identified in part (b) above). Assume the calorimeter has a negligible heat capacity and that the specific heat of contents of the calorimeter is 4.18 J/(g·°C). Assume that the density of the $HCl_{(aq)}$ is 1.0 g/mL.

c) Calculate the magnitude of q, the thermal energy change, when the MgO was added to the 1.0 M HCl (aq). Include units with your answer.

d) Determine the student's experimental value of $\Delta H°$ for the reaction between MgO and HCl in unites of kJ/mol_{rxn}.

e) Enthalpies of formation for substances involved in the reaction are shown in the table below. Using the information in the table, determine the accepted value of $\Delta H°$ for the reaction between $MgO_{(s)}$ and $HCl_{(aq)}$.

Substance	$\Delta H°_f$ (KJ/mol)
$MgO_{(s)}$	-602
$H_2O_{(l)}$	-286
$H^+_{(aq)}$	0
$Mg^{2+}_{(aq)}$	-467

f) The accepted value and the experimental value do not agree. If the calorimeter leaked heat energy to the environmental, would it help account for the discrepancy between the values? Explain