Name: _____
AP Chemistry
Chapter 5 Practice Problems

Multiple Choice
Identify the letter of the choice that best completes the statement or answers the question. Since these are "legacy" AP Chem questions, you may use your calculator for these MC!

____ 1. Consider the following information.

Reaction	Enthalpy of reaction
$3C(s) + 4\ H_2(g) \rightarrow C_3H_8(g)$	x
$C(s) + O_2(g) \rightarrow CO_2(g)$	y
$H_2(g) + \frac{1}{2}\ O_2(g) \rightarrow H_2O(\ell)$	z

Based on the information above, which expression gives the heat of combustion, ΔH^o_{comb}, for propane, C_3H_8?

$C_3H_8\,(g) + 5\ O_2(g) \rightarrow 3\ CO_2(g) + 4\ H_2O(\ell)$

a. x - (y + z)
b. (y + z) + x
c. x + (3y + 4z)
d. x - (3y + 4z)
e. (3y + 4z) - x

____ 2. Determine ΔH^o_{rxn} for the following reaction,

$N_2(g) + 3\ H_2(g) \rightarrow 2\ NH_3(g)$

given the thermochemical equations below.

$N_2(g) + O_2(g) \rightarrow 2\ NO(g)$ $\quad \Delta H = +180.8$ kJ
$4\ NH_3(g) + 5\ O_2(g) \rightarrow 4\ NO(g) + 6\ H_2O(g)$ $\quad \Delta H = -906.2$ kJ
$2\ H_2(g) + O_2(g) \rightarrow 2\ H_2O(g)$ $\quad \Delta H = -483.6$ kJ

a. -1209.0 kJ
b. -1189.0 kJ
c. -756.5 kJ
d. -91.5 kJ

____ 3.

$$3\ C_2H_{2(g)} \rightarrow C_6H_{6(g)}$$

What is the standard enthalpy change, ΔH^o_{rxn}, for the reaction represented above?

(ΔH^o_f of $C_2H_{2(g)}$ is 230 kJ mol^{-1}; ΔH^o_f of $C_6H_{6(g)}$ is 83 kJ mol^{-1}.)

a. -607 kJ
b. -147 kJ
c. -19 kJ
d. + 19 kJ

$CH_{4(g)} + 2\ O_{2(g)} \rightarrow CO_{2(g)} + 2\ H_2O_{(\ell)}$ $\Delta H^o_{rxn} = -889.1$ kJ

ΔH_f $H_2O_{(l)} = -285.8$ kJ/mol
ΔH_f $CO_{2(g)} = -393.3$ kJ/mol

___4. What is the standard heat of formation of methane, $CH_{4(g)}$, as calculated from the data above?

a. –210.0 kJ/mole
b. –107.5 kJ/mole
c. –75.8 kJ/mole
d. 75.8 kJ/mole

____ 5. Calculate ΔH^o_{rxn} for the combustion of gaseous ethanol,

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

using standard molar enthalpies of formation.

molecule	ΔH^o_f (kJ/mol)
$C_2H_5OH(g)$	-235.3
$CO_2(g)$	-393.5
$H_2O(g)$	-241.8

a. -1747.7 kJ
b. -1277.1 kJ
c. -793.5 kJ
d. -400.0 kJ

____ 6. When 27.0 g of an unknown metal at 88.4 °C is placed in 115 g H_2O at 21.0 °C, the final temperature of the water is 23.7 °C. What is the specific heat capacity of the metal? The specific heat capacity of water is 4.184 J/g·K.

a. 0.34 J/g·K
b. 0.51 J/g·K
c. 0.74 J/g·K
d. 0.94 J/g·K

____ 7. The thermochemical equation for the combustion of hexane is shown below.

$C_6H_{14}(g) + \frac{19}{2}\ O_2(g) \rightarrow 6\ CO_2(g) + 7\ H_2O(g)$ $\Delta H^o_{rxn} = -4163$ kJ

What is the enthalpy change for the combustion of 2.50 g C_6H_{14}?

a. -121 kJ
b. -1.66×10^3 kJ
c. -1.04×10^4 kJ
d. -1.43×10^5 kJ

____ 8. Which of the following chemical equations corresponds to the standard molar enthalpy of formation of N_2O?

a. $NO(g) + 1/2\ N_2(g) \rightarrow N_2O(g)$
b. $N_2(g) + 1/2\ O_2(g) \rightarrow N_2O(g)$
c. $2N(g) + O(g) \rightarrow N_2O(g)$
d. $N_2(g) + O(g) \rightarrow N_2O(g)$

____ 9. The heat of vaporization of benzene, C_6H_6, is 30.8 kJ/mol at its boiling point of 80.1 °C. How much heat is required to vaporize 128 g benzene at its boiling point?

a. 4.04 kJ
b. 18.8 kJ
c. 19.3 kJ
d. 50.5 kJ

Problem

10. **2002 D**

$H^+_{(aq)} + OH^-_{(aq)} \rightarrow H_2O_{(\ell\ l)}$

A student is asked to determine the molar enthalpy of neutralization, ΔH_{neut}, for the reaction represented above. The student combines equal volumes of 1.0 *M* HCl and 1.0 *M* NaOH in an open polystyrene cup calorimeter. The heat released by the reaction is determined by using the equation $q = mc\Delta T$.

Assume the following.

- Both solutions are at the same temperature before they are combined.
- The densities of all the solutions are the same as that of water.
- Any heat lost to the calorimeter or to the air is negligible.
- The specific heat capacity of the combined solutions is the same as that of water.

(a) Give appropriate units for each of the terms in the equation $q = mc\Delta T$. (2 pts)

(b) List the measurements that must be made in order to obtain the value of q. (2 pts)

(c) Explain how to calculate each of the following.

(i) The number of moles of water formed during the experiment (1 pt)

(ii) The value of the molar enthalpy of neutralization, ΔH_{neut}, for the reaction between $HCl_{(aq)}$ and $NaOH_{(aq)}$ (2 pts)

(d) The student repeats the experiment with the same equal volumes as before, but this time uses 2.0 *M* HCl and 2.0 *M* NaOH.

(i) Indicate whether the value of q increases, decreases, or stays the same when compared to the first experiment. Justify your prediction. (1 pt)

(ii) Indicate whether the value of the molar enthalpy of neutralization, ΔH_{neut}, increases, decreases, or stays the same when compared to the first experiment. Justify your prediction. (1 pt)

(e) Suppose that a significant amount of heat were lost to the air during the experiment. What effect would this have on the calculated value of the molar enthalpy of neutralization, ΔH_{neut}? Justify your answer. (1 pt)

.

11. Hydrogen gas burns in air according to the equation below. (2011A, 4 points total)

$$2\ H_2(g) + O_2(g) \rightarrow 2\ H_2O(\ell)$$

a) Calculate the standard enthalpy change, ΔH^o_{rxn}, for the reaction represented by the equation above. (The molar enthalpy of formation, ΔH^o_f, for $H_2O(\ell)$ is -285.8 kJ/mol at 298 K.

b) Calculate the amount of heat, in kJ, that is released when 10.0 g of $H_2(g)$ is burned in air.

c). Given that the molar enthalpy of vaporization, ΔH^o_{vap} , for $H_2O(\ell)$ is 44.0 kJ/mol at 298 K, what is the standard enthalpy change, ΔH^o_{rxn}, for the reaction $2H_2(g) + O_2(g) \rightarrow 2\ H_2O(g)$?

.

12. 2003 B

In another experiment, liquid heptane, $C_7H_{16}(\ell)$, is completely combusted to produce $CO_2(g)$ and $H_2O(\ell)$, as represented by the following equation.

$$C_7H_{16}(\ell) + 11\ O_2(g) \rightarrow 7\ CO_2(g) + 8\ H_2O(\ell)$$

The heat of combustion, ΔH^o_{comb}, for one mole of $C_7H_{16}(\ell)$ is -4.85×10^3 kJ.

a) Using the information in the table below, calculate the value of ΔH^o_f for $C_7H_{16}(\ell)$ in kJ mol^{-1}. (2 pts)

Compound	ΔH^o_f (kJ mol^{-1})
$CO_2(g)$	-393.5
$H_2O(\ell)$	-285.8

b) A 0.0108 mol sample of $C_7H_{16}(\ell)$ is combusted in a bomb calorimeter.

i) Calculate the amount of heat released to the calorimeter. (1 pt)

ii) Given that the total heat capacity of the calorimeter is 9.273 kJ $^oC^{-1}$, calculate the temperature change of the calorimeter. (1 pt)

.

13. 1995 B

Propane, C_3H_8, is a hydrocarbon that is commonly used as fuel for cooking.

(a) Write a balanced equation for the complete combustion of propane gas, which yields $CO_{2(g)}$ and $H_2O_{(l)}$.

(b) The heat of combustion of propane is -2,220.1 kJ/mol. Calculate the enthalpy of formation, ΔH_f^o, of propane given that ΔH_f^o of $H_2O_{(\ell)}$ = -285.3 kJ/mol and ΔH_f^o of $CO_{2(g)}$ = -393.5 kJ/mol.

(c) Assuming that all of the heat evolved in burning 30.0 grams of propane is transferred to 8.00 kilograms of water (specific heat = 4.18 J/g·K), calculate the increase in temperature of water.

Chapter 5 Practice Problems
Answer Section

MULTIPLE CHOICE

1. ANS: E PTS: 1
2. ANS: D PTS: 1 OBJ: 6.7 Hess's Law
3. ANS: A PTS: 1
4. ANS: C PTS: 1
5. ANS: B PTS: 1 OBJ: 6.8 Standard Enthalpies of Formation
6. ANS: C PTS: 1 OBJ: 6.2 Specific Heat Capacity and Heat Transfer
7. ANS: A PTS: 1 OBJ: 6.5 Enthalpy Changes for Chemical Reactions
8. ANS: B PTS: 1 OBJ: 6.8 Standard Enthalpies of Formation
9. ANS: D PTS: 1 OBJ: 6.3 Energy and Changes of State

PROBLEM

10. ANS:

q in J, m in grams, C in J/g°C, T in °C

(b) mass or volume of each solution

starting temperature of each reagent

ending temperature of mixture

(c) (i) both are 1 M acid and base and react on a 1:1 basis

volume × × = mol of H^+

$H^+ + OH^- \rightarrow H_2O$

(ii)

(d) (i) increases. Twice as much water is produced so it is twice the energy released in the same volume of solution

(ii) same. = same result

(e) smaller. heat lost to the air gives a smaller amount of temperature change in the solution, which leads to a smaller measured heat release

PTS: 1

11. ANS:

a) $\Delta H^\circ_{298} = [2(-285.8)] - [2(0) + 1(0)] = -571.6\ \text{kJ mol}^{-1}$ (1 pt)

b) $$q = 10\ \text{g}\ H_2 \times \frac{1\ \text{mol}\ H_2}{2.016\ \text{g}\ H_2} \times \frac{285.8\ \text{kJ}}{1\ \text{mol}\ H_2} = 1.42 \times 10^3\ \text{kJ}$$ (1 pt for setup, 1 pt for answer

$$2\,H_2(g) + O_2(g) \rightarrow 2\,H_2O(l) \qquad -571.6\ kJ$$

$$2\,H_2O(l) \rightarrow 2\,H_2O(g) \qquad +2(44.0)\ kJ$$

$$2\,H_2(g) + O_2(g) \rightarrow 2\,H_2O(g) \qquad -483.6\ kJ$$

c) 1 pt for answer

PTS: 1

12. ANS:
a) -191 kJ/mol
b) 52.4 kJ released
c) +5.65 oC

PTS: 1

13. ANS:
(a) $C_3H_8 + 5\ O_2 \rightarrow 3\ CO_2 + 4\ H_2O$

(b) 10.0 g $C_3H_8 \times 1$ mol C_3H_8/44.0 g $\times$ 5 mol O_2/1 mol C_3H_8) = 1.14 mol O_2

$$V_{O_2} = \frac{nRT}{P} = \frac{(1.14\ mol)\left(0.0821\ \frac{L\cdot atm}{mol\cdot K}\right)(303\ K)}{1.00\ atm}$$

= 28.3 L O_2 ; f(28.3 L,21.0%) = 135 L of air

(c) $\Delta H^\circ_{comb} = [\Delta H^\circ_{f(CO_2)} + \Delta H^\circ_{f(H_2O)}] - [\Delta H^\circ_{f(C_3H_8)} + \Delta H^\circ_{f(O_2)}]$

-2220.1 = [3(-393.5) + 4(-285.3)] - [X+ 0]

$X = \Delta H°_{comb}$) = -101.6 kJ/mol

(d) q = 30.0 g $C_3H_8 \times$ 1 mol/44.0 g $\times$ 2220.1 kJ/1 mol = 1514 kJ

$q = (m)(C_p)(\Delta T)$

1514 kJ = (8.00 kg)(4.184 J/g·K)(ΔT)

$\Delta T = 45.2°$

PTS: 1