Name _____ AP Chemistry ___/___/___

Chapter 6 Collected AP Exam Free Response Answers 1980 - 2010

1984 - #3

Substance	Standard Heat of Formation, $\Delta H_f°$, in kJ mol^{-1}
C(s)	0.00
$CO_2(g)$	-393.5
$H_2(g)$	0.00
$H_2O(l)$	-285.85
$O_2(g)$	0.00
$C_3H_7COOH(l)$	?

The enthalpy change for the combustion of butyric acid at 25°C, $\Delta H°_{comb}$, is -2,183.5 kilojoules per mole. The combustion reaction is:

$C_3H_7COOH(l) + 5\ O_2(g) <===> 4\ CO_2(g) + 4\ H_2O(l)$

(a) From the data above, calculate the standard heat of formation, $\Delta H_f°$, for butyric acid at 25 °C. **-533.8 kJ**

(b) Write a correctly balanced equation for the formation of butyric acid from its elements.

$4C(s) + 4H_2(g) + O_2(g) \rightarrow C_3H_7COOH$

1984 - #4c

Give a scientific explanation for the following observations. Use equations of diagrams if they are relevant.

(c) Perspiring is a mechanism for cooling the body.

Vaporization or evaporation of sweat from the skin.

These processes are endothermic and so cool the skin.

1995 - #2

(a) Write a balanced equation for the complete combustion of propane gas, which yields $CO_2(g)$ and $H_2O(l)$.

$C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$

(b) Calculate the volume of air at 30°C and 1.00 atmosphere that is needed to burn completely 10.0 grams of propane. Assume that air is 21.0 percent O_2 by volume. **134 L air**

(c) The heat of combustion of propane is -2,220.1 kJ/mol. Calculate the heat of formation, $\Delta H°_f$, of propane given that $\Delta H°_f$ of $H_2O(l)$ = -285.3 kJ/mol and $\Delta H°_f$ of $CO_2(g)$ = -393.5 kJ/mol. **-101.6 kJ = $\Delta H°_f$ (C_3H_8)**

(d) 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 the water. **45.1 K**

1998 - #3

$C_6H_5OH(s) + 7O_2(g) \rightarrow 6CO_2(g) + 3H_2O(l)$

When a 2.000-gram sample of pure phenol, $C_6H_5OH(s)$, is completely burned according to the equation above, 64.98 kilojoules of heat is released.

Use the information in the table below to answer the questions that follow.

Substance	Standard Heat of Formation, $\Delta H°_f$, at 25°C (kJ/mol)
C (graphite)	0.00
$CO_2(g)$	-395.5
$H_2(g)$	0.00
$H_2O(l)$	-285.85
$O_2(g)$	0.00
C_6H_5OH (s)	?

(a) Calculate the molar heat of combustion of phenol in kilojoules per mole at 25°C. **ΔH_{comb} = - 3,058 kJ/mol**

(b) Calculate the standard heat of formation, $\Delta H°_f$, of phenol in kilojoules per mole at 25°C. **$\Delta H°_f$ phenol = - 173 kJ**

(d) If the volume of the combustion container is 10.0 liters, calculate the final pressure in the container when the temperature is changed to 110°C. (Assume no oxygen remains unreacted and that all products are gaseous.)
0.601 atm

2000 - #6a

$O_3(g) + NO(g) \rightarrow O_2(g) + NO_2(g)$

Consider the reaction represented above.

(a) Referring to the data in the table below, calculate the standard enthalpy change, ΔH^o, for the reaction at 25ºC. Be sure to show your work.

	$O_3(g)$	$NO(g)$	$NO_2(g)$
Standard enthalpy of formation, ΔH_f^o, at 25ºC (kJ mol^{-1})	143	90.	33

ΔH° = 33 − (90. + 143) kJ = −200 kJ

2001 - #2a

$2\ NO(g) + O_2(g) \rightarrow 2\ NO_2(g)$ $\Delta H^\circ = -114.1$ kJ

The reaction represented above is one that contributes significantly to the formation of photochemical smog. Calculate the quantity of heat released when 73.1 g of $NO(g)$ is converted to $NO_2(g)$. **139 kJ of energy are released**

2002 - #3

Consider the hydrocarbon pentane, C_5H_{12} (molar mass 72.15 g).

(a) Write the balanced equation for the combustion of pentane to yield carbon dioxide and water.

$C_5H_{12} + 8O_2 \rightarrow 5CO_2 + 6H_2O$

(b) What volume of dry carbon dioxide, measured at 25°C and 785 mm Hg, will result from the complete combustion of 2.50 g of pentane? **4.11 L**

(c) The complete combustion of 5.00 g of pentane releases 243 kJ of heat. On the basis of this information, calculate the value of ΔH for the complete combustion of one mole of pentane. **$\Delta H = -3.50 \times 10^3$ kJ**

(d) Under identical conditions, a sample of an unknown gas effuses into a vacuum at twice the rate that a sample of pentane gas effuses. Calculate the molar mass of the unknown gas. **18.0 g/mol**

2003B - #3 c & d

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

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

The heat of combustion, ΔH_{comb}°, for one mole of $C_7H_{16}(l)$ is -4.85×10^3 kJ.

(c) Using the information in the table below, calculate the value of ΔH_f° for $C_7H_{16}(l)$ in kJ mol^{-1}. **-190 kJ/mol**

Compound	ΔH_f^o, at 25ºC (kJ mol^{-1})
$CO_2(g)$	–393.5
$H_2O(l)$	–285.8

(d) A 0.0108 mol sample of $C_7H_{16}(l)$ is combusted in a bomb calorimeter.

(i) Calculate the amount of heat released to the calorimeter. **52.4 kJ**

(ii) Given that the total heat capacity of the calorimeter is 9.273 kJ °C^{-1}, calculate the temperature change of the calorimeter. **5.65ºC**

2004 - #2e

$$2Fe(s) + \frac{3}{2} O_2(g) \rightarrow Fe_2O_3(s) \qquad \Delta H_f^o = -824 \text{ kJ mol}^{-1}$$

The reaction represented below also produces iron(III) oxide. The value of ΔH^o for the reaction is -280. kJ per mole of $Fe_2O_3(s)$ formed.

$$2FeO(s) + \frac{1}{2} O_2(g) \rightarrow Fe_2O_3(s)$$

Calculate the standard enthalpy of formation ΔH_f^o of FeO(s) **-272 kJ/mol**

2005B - #7

Substance	Combustion Reaction	Enthalpy of Combustion, ΔH°_{comb}, at 298 K (kJ mol^{-1})
$H_2(g)$	$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)$	–290
$C(s)$	$C(s) + O_2(g) \rightarrow CO_2(g)$	–390
$CH_3OH(l)$		–730

(a) In the empty box in the table above, write a balanced chemical equation for the complete combustion of one mole of $CH_3OH(l)$. Assume products are in their standard states at 298 K. Coefficients do not need to be whole numbers. **$CH_3OH + \frac{3}{2}O_2 \rightarrow CO_2 + 2H_2O$**

(b) On the basis of your answer to part (a) and the information in the table, determine the enthalpy change for the reaction $C(s) + H_2(g) + H_2O(l) \rightarrow CH_3OH(l)$. **50. kJ**

(c) Write the balanced chemical equation that shows the reaction that is used to determine the enthalpy of formation for <u>one</u> mole of $CH_3OH(l)$. **$C + ½O_2 + 2H_2 \rightarrow CH_3OH$**

2006 - #2a

$CO(g) + ½\ O_2(g) \rightarrow CO_2(g)$

The combustion of carbon monoxide is represented by the equation above.

(a) Determine the value of the standard enthalpy change, ΔH_{rxn}, for the combustion of $CO(g)$ at 298 K using the following information.

$C(s) + ½\ O_2(g) \rightarrow CO(g)$ $\Delta H_{298} = -110.5$ kJ mol^{-1}

$C(s) + O_2(g) \rightarrow CO_2(g)$ $\Delta H_{298} = -393.5$ kJ mol^{-1}

-283.0 kJ mol^{-1}

2006B - #3f

Reaction *X*: $½\ I_2(s) + ½\ Cl_2(g) \rightleftharpoons ICl(g)$ $\Delta H^\circ_f = 18$ kJ mol^{-1}

Reaction *Y*: $½\ I_2(s) + ½\ Br_2(l) \rightleftharpoons IBr(g)$ $\Delta H^\circ_f = 41$ kJ mol^{-1}

(f) For the vaporization of solid iodine, $I_2(s) \rightarrow I_2(g)$, the value of ΔH°_{298} is 62 kJ mol^{-1}. Using this information, calculate the value of ΔH_f for the reaction represented below.

$I_2(g) + Cl_2(g) \rightleftharpoons 2\ ICl(g)$

$\Delta H_f = -26$ kJ mol^{-1}

2007 - #2c

$N_2(g) + 3F_2(g) \rightarrow 2NF_3(g)$ $\Delta H^\circ_{298} = -264$ kJ mol^{-1}

(c) Calculate the standard enthalpy change, ΔH°, that occurs when a 0.256 mol sample of $NF_3(g)$ is formed from $N_2(g)$ and $F_2(g)$ at 1.00 atm and 298 K. **-33.8 kJ**