Name _____ Date _____ Class _____

12–2 Practice Problems

1. How much heat will be released when 6.44 g of sulfur reacts with excess O_2 according to the following equation?

   $2S + 3O_2 \rightarrow 2SO_3$ $\quad \Delta H° = -791.4$ kJ

   $\frac{6.44\text{ g}}{1} \times \frac{1}{32.06} \times \frac{-791.4}{2} = -79.5\text{ kJ}$

2. How much heat will be released when 4.72 g of carbon reacts with excess O_2 according to the following equation?

   $C + O_2 \rightarrow CO_2$ $\quad \Delta H° = -393.5$ kJ

   $\frac{4.72\text{ g}}{1} \times \frac{1}{12.01} \times \frac{-393.5}{1} = -155\text{ kJ}$

3. How much heat will be absorbed when 38.2 g of bromine reacts with excess H_2 according to the following equation?

   $H_2 + Br_2 \rightarrow 2HBr$ $\quad \Delta H° = 72.80$ kJ

   $\frac{38.2\text{ g}}{1} \times \frac{1}{159.82} \times \frac{72.80}{1} = +17.4\text{ kJ}$

4. How much heat will be released when 1.48 g of chlorine reacts with excess phosphorus according to the following equation?

   $2P + 5Cl_2 \rightarrow 2PCl_5$ $\quad \Delta H° = -886$ kJ

   $\frac{1.48\text{ g}}{1} \times \frac{1}{70.9} \times \frac{-886}{5} = -3.70\text{ kJ}$

5. How much heat will be released when 4.77 g of ethanol (C_2H_5OH) reacts with excess O_2 according to the following equation?

   $C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$
   $\Delta H° = -1366.7$ kJ

   $\frac{4.77\text{ g}}{1} \times \frac{1}{46.08} \times \frac{-1366.7}{1} = -141\text{ kJ}$

6. How much heat will be absorbed when 13.7 g of nitrogen reacts with excess O_2 according to the following equation?

   $N_2 + O_2 \rightarrow 2NO$ $\quad \Delta H° = 180$ kJ

   $\frac{13.7\text{ g}}{1} \times \frac{1}{28.02} \times \frac{180}{1} = +88.0\text{ kJ}$

7. How much heat will be released when 11.8 g of iron reacts with excess O_2 according to the following equation?

   $3Fe + 2O_2 \rightarrow Fe_3O_4$ $\quad \Delta H° = -1120.48$ kJ

   $\frac{11.8\text{ g}}{1} \times \frac{1}{55.85} \times \frac{-1120.48}{3} = -78.9\text{ kJ}$

8. How much heat will be released when 18.6 g of hydrogen reacts with excess O_2 according to the following equation?

   $2H_2 + O_2 \rightarrow H_2O$ $\quad \Delta H° = -571.6$ kJ

   $\frac{18.6\text{ g}}{1} \times \frac{1}{2.02\text{ g}} \times \frac{-571.6}{2} = -2630\text{ kJ}$

9. How much heat will be transferred when 14.9 g of ammonia reacts with excess O_2 according to the following equation? Is this reaction endothermic or exothermic?

   $4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$
   $\Delta H° = -1170$ kJ

   $\frac{14.9\text{ g}}{1} \times \frac{1}{17.04} \times \frac{-1170}{4} = -256\text{ kJ}$

10. How much heat will be transferred when 5.81 g of graphite reacts with excess H_2 according to the following equation? Is this reaction endothermic or exothermic?

    $6C(\text{graphite}) + 3H_2 \rightarrow C_6H_6$
    $\Delta H° = 49.03$ kJ

    $\frac{5.81\text{ g}}{1} \times \frac{1}{12.01} \times \frac{49.03}{6} = +3.95\text{ kJ}$

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12–4 Practice Problems

÷ 74.55 = 0.171

1. When a 12.8-g sample of KCl dissolves in 75.0 g of water in a calorimeter, the temperature drops from 31.0°C to 21.6°C. Calculate ΔH for the process.

$KCl(s) \rightarrow K^+(aq) + Cl^-(aq)$ $\Delta H = ?$ kJ/mol

$Q = mc\Delta T$

$= (87.8)(4.184)(21.6 - 31)$

$Q_{rxn} = -3453.139$

$\frac{q_{soln}}{mol} = \frac{+3.453\ kJ}{0.171\ mol}$

$= 20.2\ kJ/mol$

2. What is the specific heat of aluminum if the temperature of a 28.4-g sample of aluminum is increased by 8.1 C° when 207 J of heat is added?

$207 = (28.4)(c)(8.1)$

$\frac{207}{230.04} = c$

$c = 0.8998\ J/g°C$

÷ 149.89 = 0.171 mol

3. When a 25.7-g sample of NaI dissolves in 80.0 g of water in a calorimeter, the temperature rises from 20.5°C to 24.4°C. Calculate ΔH for the process.

$NaI(s) \rightarrow Na^+(aq) + I^-(aq)$ $\Delta H = ?$ kJ/mol

$Q = (105.7)(4.184)(24.4 - 20.5)$

$Q_{soln} = 1724.77\ J$

$Q_{rxn} = -1.725\ kJ$

$= \frac{-1.725\ kJ}{0.171\ mol}$

$= -10.1\ kJ/mol$

4. What is the specific heat of silicon if the temperature of a 4.11-g sample of silicon is increased by 3.8 C° when 11.1 J of heat is added?

$11.1 = (4.11)(c)(3.8)$

$\frac{11.1}{15.618} = c$

$c = 0.7107\ J/g°C$

÷ 40 = 0.4225 mol

5. When a 16.9-g sample of NaOH dissolves in 70.0 g of water in a calorimeter, the temperature rises from 22.4°C to 86.6°C. Calculate ΔH for the process.

$NaOH(s) \rightarrow Na^+(aq) + OH^-(aq)$ $\Delta H = ?$

$Q = (86.9)(4.184)(64.2)$

$Q = 23342\ J$

$Q_{rxn} = -23.342\ kJ$

$\frac{-23.342\ kJ}{0.4225\ mol} = -55.2\ kJ/mol$

6. What is the specific heat of gold if the temperature of a 8.21-g sample of gold is increased by 6.2 C° when 6.51 J of heat is added?

$6.51 = (8.21)(c)(6.2)$

$\frac{6.51}{50.902} = c$

$0.1279 = c$

$c = 0.13\ J/g°C$

÷ 65.12 = 0.29

7. When a 19.2-g sample of KCN dissolves in 65.0 g of water in a calorimeter, the temperature drops from 28.1°C to 15.4°C. Calculate ΔH for the process.

$KCN(s) \rightarrow K^+(aq) + CN^-(aq)$ $\Delta H = ?$

$Q = (84.2)(4.184)(-12.7)$

$Q = -4474$

$Q_{rxn} = +4.474\ kJ / 0.29\ mol = +15.4\ kJ/mol$

8. What is the specific heat of silver if the temperature of a 15.4-g sample of silver is increased by 11.2 C° when 40.5 J of heat is added?

$40.5 = (15.4)(c)(11.2)$

$\frac{40.5}{172.48} = c$

$0.2348 = c$

$c = 0.235\ J/g°C$

÷ 166 = 0.173

9. When a 28.7-g sample of KI dissolves in 60.0 g of water in a calorimeter, the temperature drops from 27.2°C to 13.2°C. Calculate ΔH for the process.

$KI(s) \rightarrow K^+(aq) + I^-(aq)$ $\Delta H = ?$

$Q = (88.7)(4.184)(-14)$

$Q = -5195.6912\ J$

$Q_{rxn} = +5.196\ kJ / 0.173\ mol = 30.0\ kJ/mol$

10. What is the specific heat of titanium if the temperature of a 36.7-g sample of titanium is increased by 4.8 C° when 91.6 J of heat is added?

$q = mc\Delta T$

$c = \frac{q}{m\Delta T} = \frac{91.6}{(36.7)(4.8)}$

$= 0.52\ J/g°C$

Name _____ Date _____ Class _____

12–3 Practice Problems

1. From the following enthalpy changes,

same $C(s) + \frac{1}{2}O_2(g) \rightarrow CO(g)$ $\Delta H° = -110.5$ kJ

same $CO(g) + \frac{1}{2}O_2(g) \rightarrow CO_2(g)$ $\Delta H° = -283.0$ kJ

calculate the value of $\Delta H°$ for the reaction $C(s) + O_2(g) \rightarrow CO_2(g)$.

−393.5 kJ

2. From the following enthalpy changes,

flip ÷2 $2P(s) + 3Cl_2(g) \rightarrow 2PCl_3(l)$ $\Delta H° = -640$ kJ

÷2 $2P(s) + 5Cl_2(g) \rightarrow 2PCl_5(s)$ $\Delta H° = -886$ kJ

calculate the value of $\Delta H°$ for the reaction $PCl_3(l) + Cl_2(g) \rightarrow PCl_5(s)$.

+320
−443

−123 kJ

3. From the following enthalpy changes,

same $C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(g)$ $\Delta H° = -1234.7$ kJ

flip $CH_3OCH_3(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(g)$ $\Delta H° = -1328.3$ kJ

calculate the value of $\Delta H°$ for the reaction $C_2H_5OH(l) \rightarrow CH_3OCH_3(l)$.

−1234.7
+1328.3

93.6 kJ

4. From the following enthalpy changes,

flip $Cu(s) + Cl_2(g) \rightarrow CuCl_2(s)$ $\Delta H° = -206$ kJ

same $2Cu(s) + Cl_2(g) \rightarrow 2CuCl(s)$ $\Delta H° = -136$ kJ

calculate the value of $\Delta H°$ for the reaction $CuCl_2(s) + Cu(s) \rightarrow 2CuCl(s)$.

+206
−136

70 kJ

5. From the following enthalpy changes,

×2 $H_2(g) + F_2(g) \rightarrow 2HF(g)$ $\Delta H° = -542.2$ kJ

flip $2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$ $\Delta H° = -571.6$ kJ

calculate the value of $\Delta H°$ for the reaction $2F_2(g) + 2H_2O(l) \rightarrow 4HF(g) + O_2(g)$.

−1084.4
+571.6

−512.8 kJ

6. From the following enthalpy changes,

$Xe(g) + F_2(g) \rightarrow XeF_2(s)$ $\Delta H° = -123$ kJ flip

$Xe(g) + 2F_2(g) \rightarrow XeF_4(s)$ $\Delta H° = -262$ kJ same

calculate the value of $\Delta H°$ for the reaction $XeF_2(s) + F_2(g) \rightarrow XeF_4(s)$.

+123
−262

−139 kJ

7. From the following enthalpy changes,

$4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(l)$ $\Delta H° = -1170$ kJ ÷2

$4NH_3(g) + 3O_2(g) \rightarrow 2N_2(g) + 6H_2O(l)$ $\Delta H° = -1530$ kJ flip ÷2

calculate the value of $\Delta H°$ for the reaction $N_2(g) + O_2(g) \rightarrow 2NO(g)$.

−585
+765

+180 kJ

8. From the following enthalpy changes,

$2Al(s) + \frac{3}{2}O_2(g) \rightarrow Al_2O_3(s)$ $\Delta H° = -1601$ kJ same

$2Fe(s) + \frac{3}{2}O_2(g) \rightarrow Fe_2O_3(s)$ $\Delta H° = -821$ kJ flip

calculate the value of $\Delta H°$ for the reaction $2Al(s) + Fe_2O_3(s) \rightarrow 2Fe(s) + Al_2O_3(s)$.

−1601
+821

−780 kJ

9. From the following enthalpy changes,

$H_2O_2(l) \rightarrow H_2O(l) + \frac{1}{2}O_2(g)$ $\Delta H° = -94.6$ kJ same

$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)$ $\Delta H° = -286.0$ kJ same

calculate the value of $\Delta H°$ for the reaction $H_2(g) + H_2O_2(l) \rightarrow 2H_2O(l)$.

−380.6 kJ

10. From the following enthalpy changes,

$C(s) + O_2(g) \rightarrow CO_2(g)$ $\Delta H° = -393.5$ kJ ×2

$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)$ $\Delta H° = -285.8$ kJ same

$2C_2H_2(g) + 5O_2(g) \rightarrow 4CO_2(g) + 2H_2O(l)$ $\Delta H° = -2598.8$ kJ flip ÷2

calculate the value of $\Delta H°$ for the reaction $2C(s) + H_2(g) \rightarrow C_2H_2(g)$.

−787
−285.8
+1299.4

226.6 kJ

Name _____ Date _____ Class _____

12–3 *Review and Reinforcement (continued)*

Solve the following problems in the space provided. Show all your work.

7. The combustion of propene proceeds in two steps:

$CH_2CHCH_3(g) + H_2(g) \rightarrow CH_3CH_2CH_3(g)$ $\Delta H° = -124$ kJ

$CH_3CH_2CH_3(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(g)$ $\Delta H° = -2220$ kJ

Calculate the value of $\Delta H°$ for the combustion of 2.70 mol of propene into carbon dioxide and water.

2.7 × −124 = −334.8

2.7 × −2220 = + −5994

−6328.8 kJ

8. From the following enthalpy changes,

$2PbS(s) + 3O_2(g) \rightarrow 2PbO(s) + 2SO_2(g)$ $\Delta H° = -827.0$ kJ

$PbO(s) + C(s) \rightarrow Pb(s) + CO(g)$ $\Delta H° = +106.8$ kJ × 2 = +213.6

calculate the value of $\Delta H°$ when 1.55 mol of PbS reacts to form lead in the following reaction: $2PbS(s) + 3O_2(g) + 2C(s) \rightarrow 2Pb(s) + 2CO(g) + 2SO_2(g)$. Is the reaction endothermic or exothermic?

1.55 × −827 = −1281.85

1.55 × 213.6 = + 331.08

−950.77 kJ

exothermic

9. Determine the change in enthalpy for the following reaction:

$$C \text{ (graphite)} + 2H_2(g) \rightarrow CH_4(g)$$

Use these reaction equations:

$C \text{ (graphite)} + O_2(g) \rightarrow CO_2(g)$ $\Delta H° = -394$ kJ −394

$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)$ $\Delta H° = -286$ kJ × 2 = −572

$CO_2(g) + 2H_2O(l) \rightarrow CH_4(g) + 2O_2(g)$ $\Delta H° = +890.3$ kJ +890.3

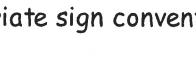
−75.7 kJ

NAME _____ PERIOD _____

BOND ENERGIES

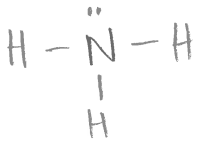
Calculate the amount of energy required or released in each of the following processes. Be sure to use the appropriate sign convention in your answer.

1. Breaking the bonds of water



464 × 2 = 928 kJ/mol

2. Forming the bonds of ammonia



−389 × 3 = −1167 kJ/mol

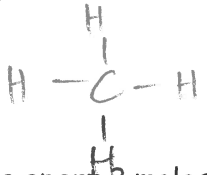
3. Breaking the bonds of carbon dioxide

743 × 2 = 1486 kJ/mol

4. Forming the bonds of oxygen

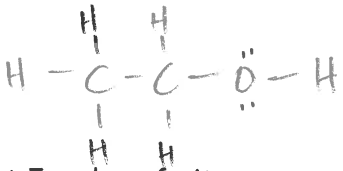
−498 kJ/mol

5. Forming 2 moles of methane



2(−414 × 4) = −3312 kJ

6. Breaking apart 3 moles of ethanol



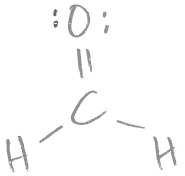
CH = 414 × 5
CC = 347
CO = 351
OH = 464

3 × 3232 = 9696 kJ

7. Breaking apart 5 moles of nitrogen

5(945) = 4725 kJ

8. Forming 4 moles of formaldehyde (CH_2O)



C=O = −743
CH = −414 × 2

4(−1571) = −6284 kJ

ENTHALPY OF REACTIONS

$$\Delta H_{rxn} = \Sigma H_p - \Sigma H_r$$

Use ENTHALPY OF FORMATION VALUES to calculate the amount of energy absorbed or released by each reaction. Then, identify each reaction as endothermic or exothermic.

1. $2\,H_2O\,(g) \rightarrow 2\,H_2\,(g) + O_2\,(g)$

$2(-241.82)$ 0 0

-483.64 0

$\Delta H_{rxn} = 0 - (-483.64) =$ 483.64 kJ endo

NOT STANDARD STATE!

2. $H_2\,(g) + I_2\,(g) \rightarrow 2\,HI\,(g)$

0 62.25 $2(25.94)$

51.88

$\Delta H_{rxn} = 51.88 - 62.25 =$ −10.37 kJ exo

3. $2\,C\,(s) + 2\,H_2\,(g) \rightarrow C_2H_4\,(g)$

0 0 52.30

$\Delta H_{rxn} = 52.30 - 0 =$ 52.30 kJ endo

4. $2\,H_2O_2\,(l) \rightarrow 2\,H_2O\,(l) + O_2\,(g)$

$2(-187.8)$ $2(-285.85)$ 0

-375.6 -571.7

$\Delta H_{rxn} = -571.7 - (-375.6) =$ −196.1 kJ exo

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

0 0 $2(-46.19)$

-92.38

$\Delta H_{rxn} = -92.38 - 0 =$ −92.38 kJ exo

6. $C\,(s) + O_2\,(g) \rightarrow CO_2\,(g)$

0 0 −393.5

$\Delta H_{rxn} = -393.5 - 0 =$ −393.5 kJ exo

7. $CH_4\,(g) + Cl_2\,(g) \rightarrow CH_3Cl\,(g) + HCl\,(g)$

−74.8 0 −103.18 −92.30

−74.8 −195.48

$\Delta H_{rxn} = -195.48 - (-74.8) =$ −120.68 exo

8. $CS_2\,(l) + 2\,H_2O\,(l) \rightarrow CO_2\,(g) + 2\,H_2S\,(g)$

89.41 $(-285.85)2$ −393.5 $(-20.17)2$

−482.29 −433.84

$\Delta H_{rxn} = -433.84 - (-482.29)$

$=$ 48.45 kJ endo

9. $C_2H_4\,(g) + 3\,O_2\,(g) \rightarrow 2\,CO_2\,(g) + 2\,H_2O\,(g)$

52.30 0 $2(-393.5)$ $(-241.82)2$

52.30 −1270.64

$\Delta H_{rxn} = -1270.64 - 52.30$

$=$ −1322.94 kJ exo