$\overline{47}$ = 2

Name:_______________

SCHOA1 UNIT TEST
THERMODYNAMICS

1. Determine whether the following circumstances are endothermic or exothermic and label as endo or exo. Do not guess, one half mark deduced for each incorrect response.

a) endo ice-cream slowly melts

b) endo protein molecules from a medium rare steak are digested to form amino acids

c) endo the smell of frying mushrooms fills a room

d) exo in the nuclear power reaction used to generate the energy needed to cook the frying mushrooms the mass of uranium fuel becomes less during the reaction

/10

e) endo vegetables such as potatoes and corn are produced through the process known as photosynthesis

f) exo the energy one gets after digesting a good meal is due to the abundance of glucose available for the process known as cellular respiration

(2)

g) exo the beautiful smell associated with garlic is thought to form through the rapid combination of two separate molecules once the garlic cells are disturbed

h) exo the condensation of steam to form water droplets when pasta is cooking is a sure sign that dinner is almost ready

i) exo the freshness of many different vegetables such as peas and corn can be preserve through rapid freezing

j) endo when baking a cake sodium bicarbonate (baking soda) is frequently used to cause the cake to rise due to its spontaneous decomposition in the presence of an acid to form carbon dioxide gas thus making the cake light and fluffy! MMMMMMMM!

2. Using the table of values in the back of the text book, determine the heat of combustion of ethyl alcohol. The formula of ethyl alcohol is $C_2H_5OH(l)$. This is not a Hess' law.

(2)

/3

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

$$\Delta H = [2\Delta H^0_{CO_2(g)} + 3\Delta H^0_{H_2O(l)}] - [\Delta H^0_{C_2H_5OH(l)} + 3\Delta H^0_{O_2(g)}]$$

$$\Delta H = [2(-94.0kcal) + 3(-68.3kcal)] - [(-66.4kcal) + 3(0)]$$

$$\Delta H = -326.5 kcal$$

/13

3. Using Hess' Law find the heat of formation of toluene, $C_7H_8(l)$ given:

$C_6H_6(l) + 6H_2(g)$	$\rightarrow$	$3C_2H_6(g)$	$\Delta H° = -336.393$ kJ
$C_2H_6(g) + Cl_2(g)$	$\rightarrow$	$2CH_3Cl(g)$	$\Delta H° = -79.496$ kJ
$C_7H_8(l) + HCl$	$\rightarrow$	$C_6H_6(l) + CH_3Cl(g)$	$\Delta H° = -48.953$ kJ

The heat of formation of ethane, $C_2H_6(g)$ is -84.517 kJ

The heat of formation of HCl(g) is -92.048 kJ

If I haven't made a mistake you should be able to check your answer using the tables in the back of the text. Don't forget the conversion to kcal!!!

Find: $7C(s) + 4H_2(g) \rightarrow C_7H_8(l)$ $\Delta H = ?$ ✓

✓ ① $C_6H_6(l) + 6H_2(g) \rightarrow 3C_2H_6(g)$ $\Delta H = -336.393$ kJ

✓ ② $C_2H_6(g) + Cl_2(g) \rightarrow 2CH_3Cl(g)$ $\Delta H = -79.496$ kJ

✓ ③ $C_7H_8(l) + HCl(g) \rightarrow C_6H_6(l) + CH_3Cl(g)$ $\Delta H = -48.953$ kJ

④ $2C(s) + 3H_2(g) \rightarrow C_2H_6(g)$ $\Delta H = -84.517$ kJ ✓

✓ ⑤ $\frac{1}{2}H_2(g) + \frac{1}{2}Cl_2(g) \rightarrow HCl(g)$ $\Delta H = -92.048$ kJ ✓

rev ③ $\cancel{C_6H_6(l)} + \cancel{CH_3Cl}(g) \rightarrow C_7H_8(l) + \cancel{HCl(g)}$ $\Delta H = 48.953$ kJ

rev ① $\cancel{3C_2H_6}(g) \rightarrow \cancel{C_6H_6(l)} + 6\cancel{H_2}(g)$ $\Delta H = 336.393$ kJ

½ × ② $\cancel{\frac{1}{2}C_2H_6}(g) + \cancel{\frac{1}{2}Cl_2}(g) \rightarrow \cancel{CH_3Cl}(g)$ $\Delta H = -39.748$ kJ

rev ⑤ $\cancel{HCl}(g) \rightarrow \frac{1}{2}H_2(g) + \cancel{\frac{1}{2}Cl_2}(g)$ $\Delta H = 92.048$ kJ

$\frac{7}{2}$ × ④ $7C(s) + \cancel{\frac{21}{2}}\,4\,H_2(g) \rightarrow \cancel{\frac{7}{2}C_2H_6}(g)$ $\Delta H = -295.810$ kJ

$7C(s) + 4H_2(g) \rightarrow C_7H_8(l)$ $\Delta H = +141.837$ kJ

(2)

4. Determine the heat of combustion of methyl alcohol, $CH_3OH(l)$ given the following information:
   - mass of methyl alcohol combusted = 5.000 g
   - volume of water in bomb calorimeter = 2.000 L
   - initial temperature of water = 15.00 °C
   - final temperature of water = 28.541 °C

$CH_3OH(l) + \frac{3}{2}O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$

$Q = mc\Delta T$

$Q = 2000 g \times 1.000 cal/g°C \times (28.541°C - 15.00°C)$ $\Delta H = -173.60 kcal$

4 $Q = 27082$ cal

$Q = 27.082$ kcal

$1 mol\ CH_3OH \times \frac{32.05 g}{1 mol} \times \frac{27.082 kcal}{5.000 g} = 173.60 kcal$

$\Delta H = -Q$ $\therefore \Delta H = -173.60$ kcal

4. Determine the change in temperature in 50.00 L of water when warmed by the combustion of 25.00 g of butane, $C_4H_{10}(g)$.

$C_4H_{10}(g) + \frac{13}{2}O_2(g) \rightarrow 4CO_2(g) + 5H_2O(l)$

$\Delta H = [4\Delta H°_{CO_2(g)} + 5\Delta H°_{H_2O(l)}] - [\Delta H_{C_4H_{10}(g)} + \frac{13}{2}\Delta H°_{O_2(g)}]$

$\Delta H = [4(-94.0 kcal) + 5(-68.3 kcal)] - [(-29.8 kcal) + \frac{13}{2}(0)]$

$\Delta H = -687.7$ kcal

7 $Q = -\Delta H$ ✓

$Q = 687.7$ kcal

$25.00 g\ C_4H_{10} \times \frac{1 mol\ C_4H_{10}}{58.14 g\ C_4H_{10}} \times \frac{687.7 kcal}{1 mol\ C_4H_{10}} = 295.71 k$

$Q = mc\Delta T$ $\Delta T = 5.914°C$ ✓

$\Delta T = \frac{Q}{mc}$

$\Delta T = \frac{295710 kcal}{50000 g \times 1.000 cal/g°C}$

11

$^{15}_{7}N$

5. Find the binding energy in MeV for Nitrogen-15 given its mass of 15.00011 u.

$$B.E. = \frac{\text{expected mass} - \text{actual mass}}{\text{Mass Number}} \times \frac{934\ MeV}{u}$$

3

$$B.E. = \frac{(7\times 1.007276 + 7\times 0.000549 + 8\times 1.008665) - 15.00011}{15} \times \frac{934\ MeV}{u}$$

$$B.E. = 7.72\ MeV$$ ✓

6. Calculate the heat released by 125 g of Uranium-238 (238.0508 u) when it undergoes fission to form Thorium-234 (234.0436 u) plus helium-4 (4.00260 u) ✓

$$^{238}_{92}U \rightarrow ^{234}_{90}Th + ^{4}_{2}He$$ ✓

$$\Delta m = (m_f - m_i)$$

$$\Delta m = [(234.0436u + 4.00260u) - (238.0508u)]$$

$$\Delta m = 0.0046u$$ ✓

$$\Delta m = 0.0046\ g$$ 1000

$$\Delta m = 4.6\times 10^{-6}\ kg$$ ✓

7

$$E = mc^2$$ ✓

$$E = 4.6\times 10^{-6}\ kg \times (3\times 10^{8}\ m/s)^2$$

$$E = 4.14\times 10^{11}\ J$$ ✓

$$E = 4.14\times 10^{8}\ kJ$$

$$125g\ ^{238}U \times \frac{1 mol\ ^{238}U}{238.05g\ ^{238}U} \times \frac{4.14\times 10^{8}\ kJ}{1 mol\ ^{238}U} = 2.17\times 10^{8}\ kJ$$ ✓ ✓

10

7. Calculate the total amount of heat energy released when 50 g of water vapour at 240 °C is gradually cooled, condensed to water, cooled further, solidified to ice and cooled to a final temperature of -60 °C. Use the following information:

- specific heat capacity of ice = 1.845 J/g°C
- specific heat capacity of water = 4.184 J/g°C
- specific heat capacity of steam = 1.966 J/g°C
- latent heat of vaporization of water = 2343 J/g
- latent heat of fusion of water = 335.4 J/g

(2)

Steam @ 240°C to Steam @ 100°C

$Q_1 = mc\Delta T$

$Q_1 = 50g \times 1.966\ J/g°C \times 140°C$

$Q_1 = 13762\ J$

8/8

Steam @ 100°C to Water @ 100°C

$Q_2 = L_v m$

$Q_2 = 2343\ J/g \times 50g$

$Q_2 = 117150\ J$

Water @ 100°C to Water @ 0°C

$Q_3 = mc\Delta T$

$Q_3 = 50g \times 4.184\ J/g°C \times 100°C$

$Q_3 = 20920\ J$

Water @ 0°C to Ice @ 0°C

$Q_4 = L_F m$

$Q_4 = 335.4\ J/g \times 50g$

$Q_4 = 16770\ J$

Ice @ 0°C to Ice @ -60°C

$Q_5 = mc\Delta T$

$Q_5 = 50g \times 1.845\ J/g°C \times 60°C$

$Q_5 = 5535\ J$

$Q_T = Q_1 + Q_2 + Q_3 + Q_4 + Q_5$

$Q_T = 174137\ J$

8