—/42 =

Name:_____

TEST #2

THERMODYNAMICS

$\Delta H = -Q$ $\Delta H = +$ (A)

1. Each of the following examples involves a change in enthalpy. If the change in enthalpy is positive, label with an A. If the change in enthalpy is negative, label with a B. Do not guess! For every two wrong answers, one mark will be subtracted. $\Delta H = -$ (B)

a) (A) The lake thaws slowly in the spring.

b) (B) When two particular solutions are mixed together the average temperature increases

c) (B) In a fission reaction , the total mass of the products is significantly less than the total mass of the reactants. $E = mc^2$ $E = Q$

(5)

d) (B) Sulphuric acid is dissolved in water.

e) (B) The products of a reaction have greater attractive forces than the reactants.

f) (B) After a reaction, the forces of attraction between the atoms involved has undergone a net increase.

g) (B) The condensation of any liquid.

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h) (A) $H_2O(g) + C(s) = CO(g) + H_2(g)$ $\Delta H = 31.4$ kcal

i) (A) Photosynthesis

j) (B) The formation of water from its elements at 25 C and 1 atmosphere pressure.

The following questions will be graded according to presentation for a total of ten marks!!!! You should have adequate time to consider your approach to presentation.

—/10

—/20

2. Use heats of formation directly (i.e. not Hess Law) to calculate the heat of reaction for:

$$3CuO(s) + 2NH_3(aq) \Longrightarrow 3Cu(s) + 3H_2O(l) + N_2(g)$$

Use your answer to determine:
a) the heat released if 500 g of Cu(s) is recoverd
b) 1.5 L of nitrogen gas is recoverd at S.T.P. (22.414 L of gas = 1 mol of gas)

(5)

$$\Delta H = [3\Delta H^\circ_{Cu(s)} + 3\Delta H^\circ_{H_2O(l)} + \Delta H^\circ_{N_2(g)}] - [3\Delta H^\circ_{CuO(s)} + 2\Delta H^\circ_{NH_3(aq)}]$$

$$\Delta H = [3(0) + 3(-68.3\,kcal) + (0)] - [3(-37.1\,kcal) + 2(-19.3\,kcal)]$$

$$\Delta H = -55.0\,kcal$$

$$Q = -\Delta H$$

$$Q = 55.0\,kcal, \text{ (for the reaction as written)}$$

a) $$500g \times \frac{1\,mol\,Cu}{63.55g} \times \frac{55.0\,kcal}{3\,mol\,Cu} = 144.2\,kcal$$

b) $$1.5L \times \frac{1\,mol\,N_2}{22.414L} \times \frac{55.0\,kcal}{1\,mol\,N_2} = 3.68\,kcal$$

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↙ kcal

3. 30 L of water in a bomb calorimeter is warmed from 20.00 °C to 23.94 °C when 10 g of butane (C_4H_{10}) is reacted with sufficient oxygen to allow complete combustion. Use this information plus appropriate heats of formation (i.e. values for carbon dioxide, water and oxygen) to derive the heat of formation for the compound butane. Check this answer with the heat of formation value for butane found in the table to see if the information in the question is correct.

(5)

$Q = mc\Delta T$

$Q = 30000_g \times 1.000 cal \times (23.94 - 20.00)°C$

$Q = 118200\ cal$

$Q = 118.2\ kcal$

$$\frac{118.2\ kcal}{10_g\ C_4H_{10}} \times \frac{58.14_g\ C_4H_{10}}{1\ mol\ C_4H_{10}} = 687.2\ kcal/mol$$

$\Delta H = -Q$

$\Delta H = -687.2\ kcal$

$\therefore C_4H_{10(g)} + \frac{13}{2}O_{2(g)} \rightarrow 4CO_{2(g)} + 5H_2O_{(g)} \quad \Delta H = -687.2\ kcal$

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

$-687.2kcal = [4(-94.0kcal) + 5(-68.3kcal)] - [\Delta H^\circ_{C_4H_{10}(g)} + \frac{13}{2}(0)]$

$\Delta H^\circ_{C_4H_{10}} = -30.3kcal$

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4. Use Hess' Law to determine the heat of formation of p-nitrotoluene ($C_7H_7O_2N$) given:

(5)

① $C_7H_8(l) + HNO_3(l) \Longrightarrow C_7H_7O_2N(l) + H_2O(l)$ $\Delta H = -47.25$ kcal

② $C_7H_8(l) + 9O_2(g) \Longrightarrow 7CO_2(g) + 4H_2O(l)$ $\Delta H = -943.1$ kcal

③ $NO_2(g) + H_2O(l) \Longrightarrow HNO_3(l) + \frac{1}{2}H_2(g)$ $\Delta H = 18.8$ kcal

Table values for the formation reactions of $CO_2(g)$, $H_2O(l)$ and $NO_2(g)$

④ $C(s) + O_2(g) \rightarrow CO_2(g)$ $\Delta H = -94.0$ kcal

⑤ $H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)$ $\Delta H = -68.3$ kcal

⑥ $\frac{1}{2}N_2(g) + O_2(g) \rightarrow NO_2(g)$ $\Delta H = +8.1$ kcal

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Find $7C(s) + \frac{7}{2}H_2(g) + O_2(g) + \frac{1}{2}N_2(g) \rightarrow C_7H_7O_2N(l)$ $\Delta H = ?$

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① ~~$C_7H_8(l)$~~ + ~~$HNO_3(l)$~~ $\rightarrow C_7H_7O_2N(l)$ + ~~$H_2O(l)$~~ $\Delta H = -47.25$ kcal

rev ② ~~$7CO_2(g)$~~ + ~~$4H_2O(l)$~~ $\rightarrow$ ~~$C_7H_8(l)$~~ + ~~$9O_2(g)$~~ $\Delta H = 943.1$ kcal

③ ~~$NO_2(g)$~~ + ~~$H_2O(l)$~~ $\rightarrow$ ~~$HNO_3(l)$~~ + ~~$\frac{1}{2}H_2(g)$~~ $\Delta H = 18.8$ kcal

7 × ④ $7C(s) + 7O_2(g) \rightarrow 7CO_2(g)$ $\Delta H = -658.0$ kcal

4 × ⑤ ~~$\frac{7}{2}H_2(g)$~~ + ~~$2O_2(g)$~~ $\rightarrow 4H_2O(l)$ $\Delta H = -273.2$ kcal

⑥ $\frac{1}{2}N_2(g) + O_2(g) \rightarrow$ ~~$NO_2(g)$~~ $\Delta H = +8.1$ kcal

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$7C(s) + \frac{7}{2}H_2(g) + O_2(g) + \frac{1}{2}N_2(g) \rightarrow C_7H_7O_2N(l)$

$\Delta H = -8.45$ kcal