

= 2
43

Name: _____

THERMODYNAMICS TEST

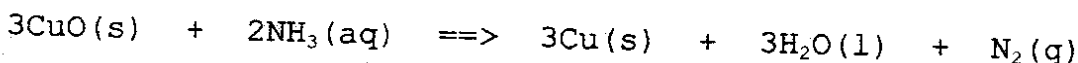
1. Each of the following examples involve a change in enthalpy. If the change in enthalpy is positive, label with an A. If the change in enthalpy is negative, label with a B. Do not guess! Wrong subtracted from right!

7

- 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 nuclear fission reaction, the total mass of the products is significantly less than the total mass of the reactants.
- 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.
- h) A $\text{H}_2\text{O}(\text{g}) + \text{C}(\text{s}) = \text{CO}(\text{g}) + \text{H}_2(\text{g}) \Delta\text{H} = 31.4 \text{ kcal}$
- i) A Photosynthesis
- j) B The formation of water from its elements at 25 °C and 1 atmosphere pressure.

10

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



7

Use your answer to determine:

- a) the heat released if 500 g of Cu(s) is recovered
- b) 1.5 L of nitrogen gas is recovered at S.T.P. (22.414 L of gas = 1 mol of gas)

$$\Delta\text{H} = [3\Delta\text{H}_{\text{Cu}(\text{s})}^\circ + 3\Delta\text{H}_{\text{H}_2\text{O}(\text{l})}^\circ + \Delta\text{H}_{\text{N}_2(\text{g})}^\circ] - [3\Delta\text{H}_{\text{CuO}(\text{s})}^\circ + 2\Delta\text{H}_{\text{NH}_3(\text{aq})}^\circ] \checkmark$$

$$\Delta\text{H} = [3(0) + 3(-68.3\text{kcal}) + 3(0)] - [3(-37.1\text{kcal}) + 2(-19.3\text{kcal})] \checkmark$$

$$\Delta\text{H} = -55.0\text{kcal} \checkmark \quad \therefore Q = -\Delta\text{H} \checkmark$$

$$Q = 55.0\text{kcal}$$

$$\text{a) } 500\text{g Cu} \times \frac{1\text{mol Cu}}{63.55\text{g Cu}} \times \frac{55.0\text{kcal}}{3\text{mol Cu}} = 144.24\text{kcal} \checkmark$$

$$\text{b) } 1.5\text{LN}_2 \times \frac{1\text{mol N}_2}{22.414\text{LN}_2} \times \frac{55.0\text{kcal}}{1\text{mol N}_2} = 3.68\text{kcal} \checkmark$$

8

18

3. 30 L of water in a bomb calorimeter is warmed from 20.00 °C to 23.94 °C when 10 g of butane (C₄H₁₀) 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.

7

$$Q = mc \Delta T$$

$$Q = 30000 \text{ g} \times 4.184 \text{ J/g}^\circ\text{C} \times 3.94^\circ\text{C}$$

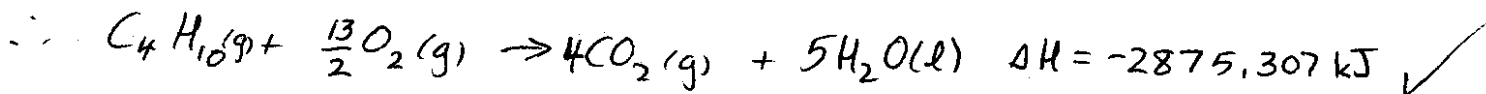
$$Q = 494549 \text{ J}$$

$$Q = 494.549 \text{ kJ}$$

$$\frac{494.549 \text{ kJ}}{10 \text{ g C}_4\text{H}_{10}} \times \frac{58.14 \text{ g C}_4\text{H}_{10}}{1 \text{ mol C}_4\text{H}_{10}} = 2875.307 \text{ kJ/mol C}_4\text{H}_{10}$$

$$\Delta H = -Q$$

$$\Delta H = -2875.307 \text{ kJ/mol C}_4\text{H}_{10}$$

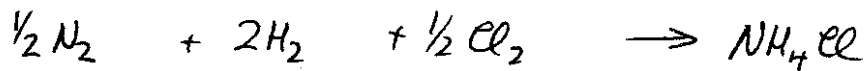


$$\Delta H = [4 \Delta H^\circ_{\text{CO}_2(\text{g})} + 5 \Delta H^\circ_{\text{H}_2\text{O}(\text{l})}] - [\Delta H^\circ_{\text{C}_4\text{H}_{10}} + \frac{13}{2} \Delta H^\circ_{\text{O}_2(\text{g})}]$$

$$-2875.307 \text{ kJ} = [4(-393.1 \text{ kJ}) + 5(-285.6 \text{ kJ})] - [\Delta H^\circ_{\text{C}_4\text{H}_{10}} + \frac{13}{2}(0)]$$

$$\Delta H^\circ_{\text{C}_4\text{H}_{10}} = -125.09 \text{ kJ} \Rightarrow -29.9 \text{ kcal}$$

9

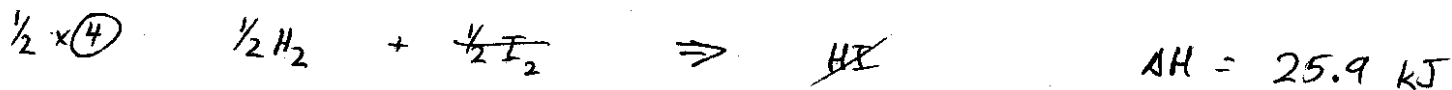
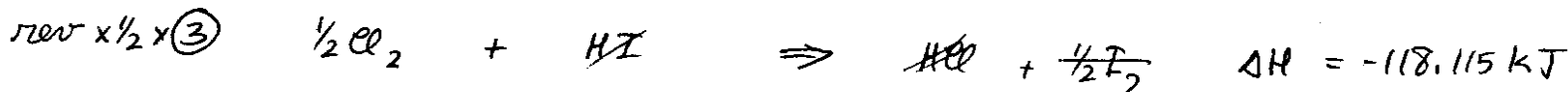
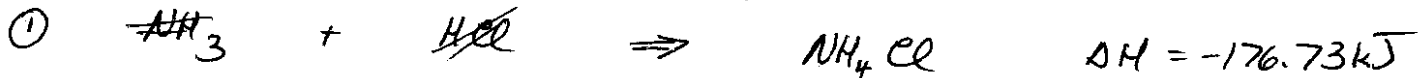


4. Calculate the heat of formation of NH_4Cl using the following equations and Hess' Law (ignore states).

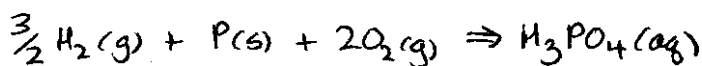
1. $NH_3 + HCl \rightleftharpoons NH_4Cl$ $\Delta H = -176.73 \text{ kJ}$
2. $N_2 + 3H_2 \rightleftharpoons 2NH_3$ $\Delta H = -92.30 \text{ kJ}$
3. $2HCl + I_2 \rightleftharpoons 2HI + Cl_2$ $\Delta H = 236.23 \text{ kJ}$
4. $H_2 + I_2 \rightleftharpoons 2HI$ $\Delta H = 51.80 \text{ kJ}$

7

15



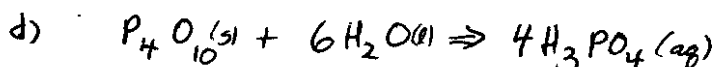
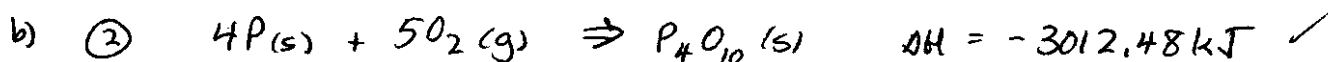
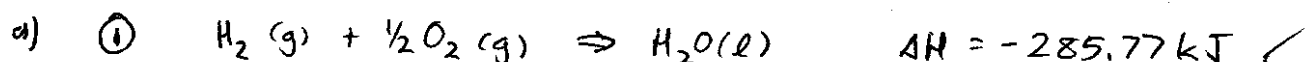
15



5. From the following information, calculate $\Delta H_{\text{H}_3\text{PO}_4(\text{aq})}$ in kJ

- a) $\Delta H_{\text{H}_2\text{O}(\text{l})} = -285.77 \text{ kJ}$
 b) $\Delta H_{\text{P}_4\text{O}_{10}(\text{s})} = -3012.48 \text{ kJ}$
 c) The natural form of phosphorus is P(s).
 d) 13.5 g of $\text{P}_4\text{O}_{10}(\text{s})$ is placed in exactly 1 L of water and an exothermic reaction proceeds in which $\text{H}_3\text{PO}_4(\text{aq})$ is the only product. The temperature is observed to increase from 15.03 °C to 19.93 °C
 e) The specific heat capacity of water is 4.184 J/g°C.
 f) The answer is $\Delta H_{\text{H}_3\text{PO}_4(\text{aq})} = -308.2 \text{ kcal}$

7



$$Q = mc\Delta T \checkmark$$

$$Q = 1000\text{g} \times 4.184\text{J/g}^\circ\text{C} \times (19.93 - 15.03)^\circ\text{C}$$

$$Q = 20501.6 \text{ J}$$

$$Q = 20.5016 \text{ kJ} \checkmark$$

$$\frac{20.5016 \text{ kJ}}{13.5 \text{ g P}_4\text{O}_{10}} \times \frac{283.88 \text{ g P}_4\text{O}_{10}}{1 \text{ mol P}_4\text{O}_{10}} = 431.111 \text{ kJ} \checkmark$$

$$\Delta H = -Q$$

$$\Delta H = -431.111 \text{ kJ} \checkmark$$

