

Name: _____

50 = 2

SCH OA1
Thermodynamics Test

1. For each of the following, decide if the situation represents an increase in potential energy or a decrease in potential energy. Label the increases in potential energy with a "+" sign and the decreases in potential energy with a "-" sign. Proceed carefully. Wrong subtracted from right.

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- a) - the combustion of methane gas
- b) + the formation of diamond from coal or graphite deep within the earth's crust
- c) - formation of ice on a window pane through a sublimation process
- d) - or + formation of toluene from its constituent elements (1)
- e) + a reaction in which the reactants have greater forces or attraction than the products
- f) + evaporation of isopropyl alcohol
- g) + formation of an onion from all necessary raw materials
- h) + the conversion of ethyl alcohol to dimethyl ether
- i) - physical exertion
- f) + a tree grows in the forest

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2. For each of the following convert to a value to kJ per mol. show all conversion factors

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a) combustion of 20 mg of ethane yields 248 cal C_2H_6

$$\frac{248 \text{ cal}}{20 \text{ mg}} \times \frac{1000 \text{ mg}}{1 \text{ g}} \times \frac{30.08 \text{ g}}{1 \text{ mol}} \times \frac{4.184 \text{ J}}{1 \text{ cal}} \times \frac{1 \text{ kJ}}{1000 \text{ J}} = 1560.60 \text{ kJ/mol}$$

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b) ionization of chromium to Cr^{3+} requires approximately 19.44 meV per electron. (meV is a millielectronvolt) (1 eV = 1.6022×10^{-19} J)

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$$\frac{19.44 \text{ meV}}{1 \text{ e}^-} \times \frac{1 \text{ eV}}{1000 \text{ meV}} \times \frac{1.6022 \times 10^{-19} \text{ J}}{1 \text{ eV}} \times \frac{1 \text{ kJ}}{1000 \text{ J}} \times \frac{3 \text{ e}^-}{Cr^{3+} \text{ ion}} \times \frac{6.022 \times 10^{23} Cr^{3+} \text{ ions}}{1 \text{ mol } Cr^{3+}}$$

= 5.6263 kJ/mol

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3. From the following information determine the percent by mass of a 20 kg block of ice at -30°C that can be converted to water through the combustion of 130 g of octane (C_8H_{18}).

$$\Delta H_{\text{C}_8\text{H}_{18}(l)} = -250.1 \text{ kJ}$$

$$\Delta H_{\text{H}_2\text{O}(l)} = -285.8 \text{ kJ}$$

$$\Delta H_{\text{CO}_2(g)} = -393.5 \text{ kJ}$$

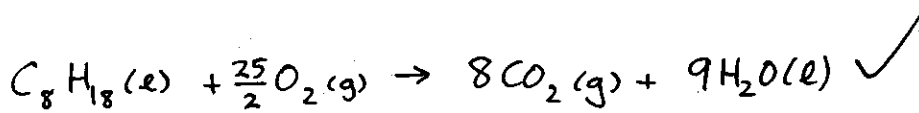
$$c_{\text{H}_2\text{O}(l)} = 4.184 \text{ J/g } ^{\circ}\text{C}$$

$$c_{\text{H}_2\text{O}(s)} = 2.010 \text{ J/g } ^{\circ}\text{C}$$

$$L_F \text{ H}_2\text{O} = 6.03 \text{ kJ/mol}$$

Note: do not use Hess' Law in your solution

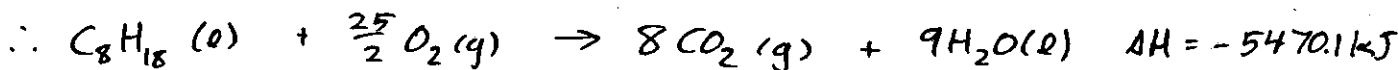
Hint: start this problem using the heat summation method to determine the $\Delta H_{\text{combustion}}$ for octane.



$$\Delta H = [8\Delta H^{\circ}_{\text{CO}_2(g)} + 9\Delta H^{\circ}_{\text{H}_2\text{O}(l)}] - [\Delta H^{\circ}_{\text{C}_8\text{H}_{18}(l)} + \frac{25}{2}\Delta H^{\circ}_{\text{O}_2(g)}] \checkmark$$

$$\Delta H = [8(-393.5 \text{ kJ}) + 9(-285.8 \text{ kJ})] - [(-250.1 \text{ kJ}) + \frac{25}{2}(0)]$$

$$\Delta H = -5470.1 \text{ kJ} \checkmark$$



$$Q = -\Delta H \checkmark$$

$$Q = 5470.1 \text{ kJ/mol C}_8\text{H}_{18}$$

$$130 \text{ g C}_8\text{H}_{18} \times \frac{1 \text{ mol C}_8\text{H}_{18}}{114.26 \text{ g}} \times \frac{5470.1 \text{ kJ}}{1 \text{ mol}} = 6223.6 \text{ kJ} \checkmark \checkmark$$

$$Q = mc\Delta T$$

$$Q = 20000 \text{ g} \times 2.010 \text{ J/g } ^{\circ}\text{C} \times 30^{\circ}\text{C}$$

$$Q = 1206000 \text{ J}$$

$$Q = 1206 \text{ kJ} \checkmark$$

$$\begin{array}{l} \text{heat available} \\ 6223.6 \text{ kJ} - 1206 \text{ kJ} \end{array}$$

$$= 5017.6 \text{ kJ} \checkmark$$

heat remaining to melt ice

$$Q = L_F m$$

$$m = \frac{Q}{L_F}$$

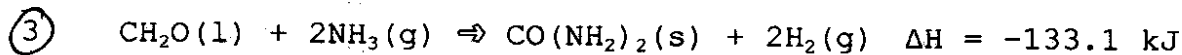
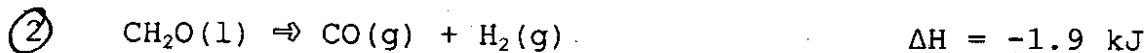
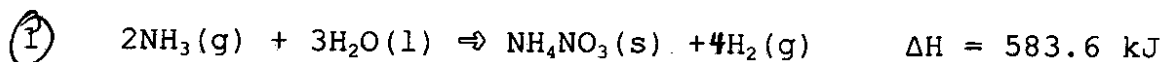
$$m = \frac{5017.6 \text{ kJ}}{\frac{6.03 \text{ kJ}}{1 \text{ mol}} \times \frac{1 \text{ mol}}{18.02 \text{ g}}}$$

$$m = 14995 \text{ g}$$

$$m = 15.0 \text{ kg ice will melt} \checkmark$$

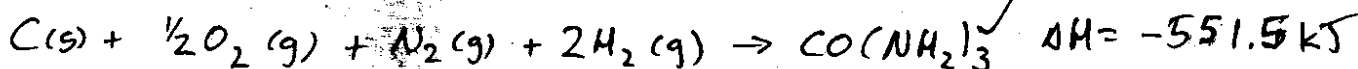
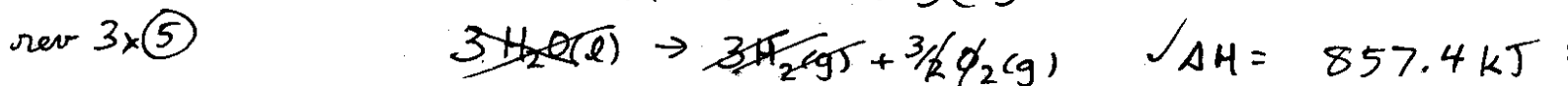
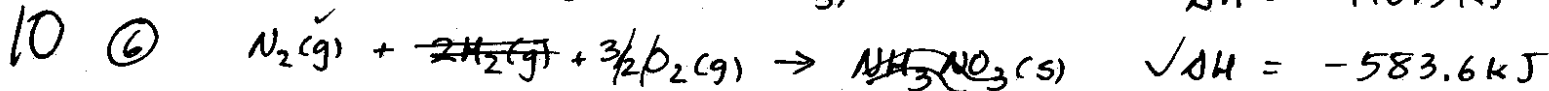
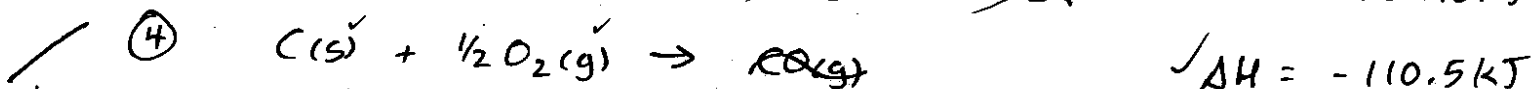
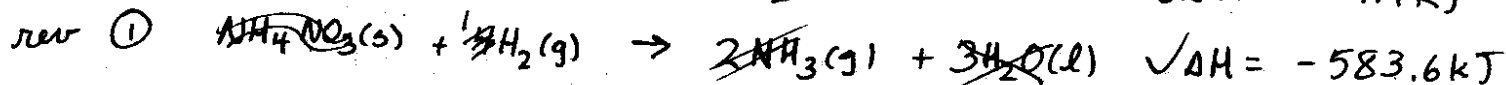
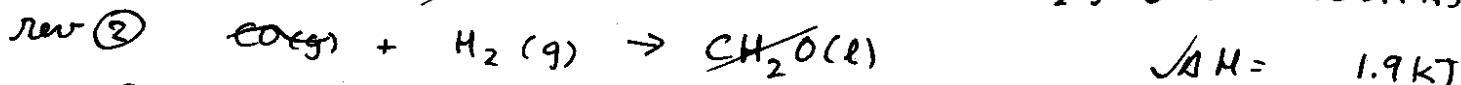
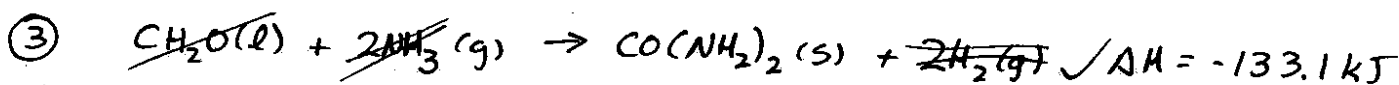
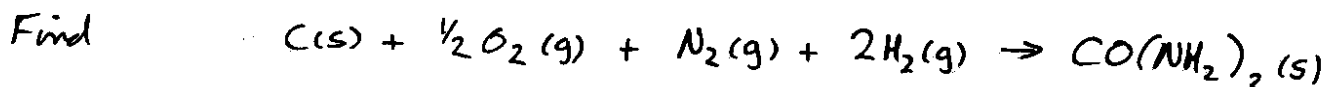
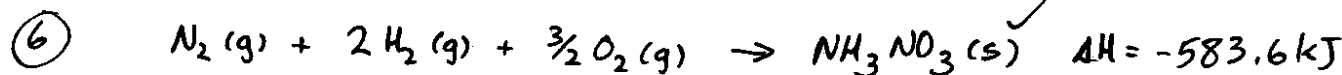
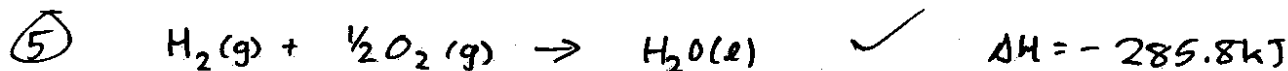
$$\frac{15.0 \text{ kg}}{20.0 \text{ kg}} \times 100\% = 75\% \text{ by mass} \checkmark$$

4. Determine the heat of formation of urea, $\text{CO}(\text{NH}_2)_2$ using Hess' law from the information given below.



④, ⑤ & ⑥ heats of formation of $\text{CO}(\text{g})$, $\text{H}_2\text{O}(\text{l})$ and $\text{NH}_4\text{NO}_3(\text{s})$ are ~~-293.5 kJ~~, -285.8 kJ and -583.6 kJ respectively
~~-110.5 kJ~~

If this question has been written correctly (i.e. Schlank didn't make a mistake, the answer should be ~~-325 kJ~~
~~-551.5~~



5. The combustion of 21.9 g of ethanol C_2H_5OH is able to warm 8.000 L of water from 20 °C to 40 °C, determine the heat of formation of ethanol. ($c_{H_2O(l)} = 4.184 \text{ J/g } ^\circ\text{C}$). Do not use Hess' Law in your solution. See question #3 for data

$$Q = mc\Delta T$$

$$Q = 8000 \text{ g} \times 4.184 \text{ J/g } ^\circ\text{C} \times 20 ^\circ\text{C}$$

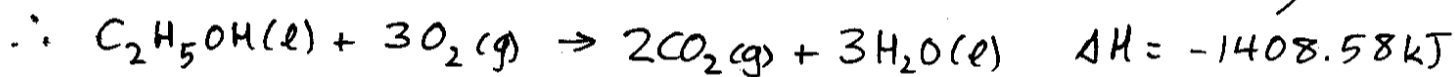
$$Q = 669440 \text{ J}$$

$$Q = 669.440 \text{ kJ}$$

$$\frac{669.440 \text{ kJ}}{21.9 \text{ g EtOH}} \times \frac{46.08 \text{ g EtOH}}{1 \text{ mol EtOH}} = 1408.58 \text{ kJ/mol}$$

$$\Delta H = -Q$$

$$\Delta H = -1408.58 \text{ kJ/mol}$$



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

$$-1408.58 \text{ kJ} = [2(-393.5 \text{ kJ}) + 3(-285.8 \text{ kJ})] - [\Delta H^\circ_{C_2H_5OH(l)} + 3(0)]$$

$$\Delta H^\circ_{C_2H_5OH(l)} = -235.82 \text{ kJ/mol}$$