CHAPTER 3
THERMOCHEMISTRY
CHAPTER OUTLINE

HW: Questions are below. Solutions are in separate file on the course web site.

Sect. **Material**

1. Conversion between ΔU and ΔH

2. Phase Transitions

3. Bond Enthalpies

4. Enthalpies of Combustion

5. Thermochemical Rules

6. Hess's Law

7, Enthalpy of Formation

8. Fuel Value

9. Food Metabolism

10. Temerature Dependence of Reaction Enthalpies
Note: This section is FYI only. You will not be tested on it

Chapter 3 - Homework

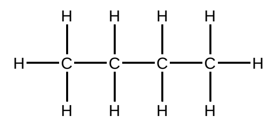
3.1 HydroFluorocarbons ($C_xH_yF_z$) are safer alternative refrigerants than are Chlorofluorocarbons ($C_xCl_yF_z$), which are a major source of ozone depletion in the upper atmosphere. A certain fluorocarbon liquid has an enthalpy of vaporization, $\Delta_{vap}H^o$ = 26.0 kJ/mol. Calculate q, w, ΔH, and ΔU when 1.50 mol of the compound is vaporized at -23 ^oC and 750 torr.

3.2 Use Bond Enthalpies (below) to estimate the enthalpy change for the hydrogenation of 1,3-butadiene to form butane:

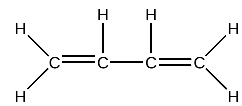
$C_4H_6(g) + 2\ H_2(g) \rightarrow C_4H_{10}(g)$

Bond	**BE**
H-H	436 kJ/mol
C-H	412
C-C	348
C=C	612

n-butane:



1,3-butadiene:



3.3 The enthalpy of formation of ethylbenzene [$C_6H_5(CH_2CH_3)$] is -12.6 kJ/mol. Calculate the enthalpy of combustion of ethylbenzene

Note: $\Delta_fH^o(CO_2)$ = -393.5 kJ/mol , $\Delta_fH^o(H_2O)$ = -285.8 kJ/mol

3.4 Consider the formation of liquid methyl methanoate, $CH_3C(O)OCH_3(l)$, from the elements at 25 ^oC :

$3\ C(s) + 3\ H_2(g) + O_2(g) \rightarrow CH_3C(O)OCH_3(l)$.

For this reaction, $\Delta H^o = \Delta_fH^o(CH_3C(O)OCH_3)$ = -442 kJ/mol

Calculate ΔU^o for this reaction at 25 ^oC.

3.5 The standard enthalpy of combustion of napthalene, $C_{10}H_8$, is -5157 kJ/mol. Calculate the enthalpy of formation of napthalene.

Note: $\Delta_fH^o(CO_2)$ = -393.5 kJ/mol , $\Delta_fH^o(H_2O)$ = -285.8 kJ/mol

3.6 The complete combustion of fumaric acid, HOOCCH$=$CHCOOH(s) [$C_4H_4O_4$], in a (constant volume) bomb calorimeter released 1333 kJ per mole of fumaric acid. The reaction is: HOOCCH=CHCOOH(s) + 3 O_2(g) $\rightarrow$ 4 CO_2(g) + 2 H_2O(l)

Calculate:

(a) The internal energy of combustion of fumaric acid at 25 ^oC.

(b) The enthalpy of combustion of fumaric acid at 25 ^oC.

(c) The enthalpy of formation of fumaric acid at 25 ^oC.

Note: $\Delta_f H^o(CO_2)$ = -393.5 kJ/mol , $\Delta_f H^o(H_2O)$ = -285.8 kJ/mol

3.7 Classify as endothermic or exothermic:

(a) a combustion reaction in which the enthalpy of combustion is -2020 kJ/mol
(b) a solution process for which Δ_{soln} = +4.0 kJ/mol
(c) vaporization
(d) fusion
(e) sublimation

3.8 Calculate the standard enthalpy of formation of N_2O_5 from the following data:
Hint: Start by writing the equation representing the formation of 1 mole of N_2O_5 from the elements in their standard states.

(1) $2\ NO + O_2 \rightarrow 2\ NO_2$ ΔH_1 = -114.1 kJ
(2) $4\ NO_2 + O_2 \rightarrow 2\ N_2O_5$ ΔH_2 = -110.2 kJ
(3) $N_2 + O_2 \rightarrow 2\ NO$ ΔH_3 = +180.5 kJ

3.9 From the following enthalpies of reaction,

$N_2 + O_2 \longrightarrow 2NO$ ΔH = +180.7 kJ

$4N_2 + 2O_2 \rightarrow 4N_2O$ ΔH = +326.2 kJ

Calculate ΔH for the reaction, $2N_2O + O_2 \longrightarrow 4NO$.

3.10 Use the enthalpy of formation data below to calculate the Fuel Value C_6H_6(l), in kJ/g

Compound	**$\Delta_f H^o$**
CO_2	-393.5 kJ/mol
H_2O	-285.8
C_6H_6(l)	+49.0

3.11 The Dietary Value of glycine, $C_2H_5NO_2$(s) [M=75 g/mol], is 13.0 kJ/g. Calculate the enthalpy of combustion of glycine, in kJ/mol.

3.12 When 210. grams of 1-propanol [$CH_3(OH)CH_2CH_3$, M = 60. g/mol] is combusted O_2(g) to form CO_2(g) + H_2O(l), the heat involved is $q = \Delta H = -7{,}070$ kJ

Calculate the Fuel Value (FV) of 1-propanol, in kJ/g.