CHEMISTRY 11 AP – ENTHALPY CHANGES WORKSHEET

1) The complete decomposition of NOCl gas into its elements occurs by the following reaction:

$$2\ NOCl_{(g)} \rightarrow N_{2\,(g)} + O_{2\,(g)} + Cl_{2\,(g)}$$

Use the following two reactions and their enthalpy changes to determine the enthalpy change for the decomposition reaction.

$\frac{1}{2}\ N_{2\,(g)} + \frac{1}{2}\ O_{2\,(g)} \rightarrow NO_{\,(g)}$	$\Delta H_f = +\ 90.3$ kJ/mol
$NO_{\,(g)} + \frac{1}{2}\ Cl_{2\,(g)} \rightarrow NOCl_{\,(g)}$	$\Delta H_{rxn} = -\ 38.6$ kJ/mol

2) Polyvinyl chloride is commonly referred to as PVC. It is a polymer produced from a monomer formed by the addition of ethylene and chlorine gas. Use the following reactions and their enthalpy changes to determine the overall enthalpy change for the PVC monomer reaction:

$H_{2\,(g)} + Cl_{2\,(g)} \rightarrow 2\ HCl_{\,(g)}$	$\Delta H°_f = -\ 184.6$ kJ/mol
$C_2H_{4\,(g)} + HCl_{\,(g)} \rightarrow C_2H_5Cl_{\,(l)}$	$\Delta H°_{rxn} = -\ 65.0$ kJ/mol
$C_2H_3Cl_{\,(g)} + H_{2\,(g)} \rightarrow C_2H_5Cl_{\,(l)}$	$\Delta H°_{rxn} = -\ 138.9$ kJ/mol
$C_2H_{4\,(g)} + Cl_{2\,(g)} \rightarrow C_2H_3Cl_{\,(l)} + HCl_{\,(g)}$	$\Delta H°_f = ?$

3) Given the following data (all species are gases):

$2\ O_3 \rightarrow 3\ O_2$	$\Delta H°_{diss} = -\ 427$ kJ/mol
$O_2 \rightarrow 2\ O$	$\Delta H°_{diss} = +\ 495$ kJ/mol
$NO + O_3 \rightarrow NO_2 + O_2$	$\Delta H°_{rxn} = -\ 199$ kJ/mol

Calculate the enthalpy change for the following reaction: $NO + O \rightarrow NO_2$

4) Determine the enthalpy change for the following reaction:

$$CH_{4\,(g)} + 4\ Cl_{2\,(g)} \rightarrow CCl_{4\,(l)} + 4\ HCl_{\,(g)}$$

Using the following information:

$C_{\,(s)} + 2\ H_{2\,(g)} \rightarrow CH_{4\,(g)}$	$\Delta H°_f = -\ 74.6$ kJ/mol
$C_{\,(s)} + 2\ Cl_{2\,(g)} \rightarrow CCl_{4\,(g)}$	$\Delta H°_f = -\ 95.7$ kJ/mol
$H_{2\,(g)} + Cl_{2\,(g)} \rightarrow 2\ HCl_{\,(g)}$	$\Delta H°_f = -\ 92.3$ kJ/mol

5) Use the values for Heats of Formation on Page 30 of your notes to determine the enthalpy change for each of the following reactions:

(a) $2\ H_2S_{\,(g)} + 3\ O_{2\,(g)} \rightarrow 2\ SO_{2\,(g)} + 2\ H_2O_{\,(l)}$

(b) The Ostwald process for making nitric acid involves multiple steps, beginning with ammonia reacting with oxygen, forming nitrogen monoxide and water.

(c) 

6) Chlorine gas can react in a substitution reaction with the gaseous monomer mentioned in question 2 as follows:

$$C_2H_5Cl_{(g)} + Cl_{2(g)} \rightarrow C_2H_4Cl_{2(g)} + HCl_{(g)}$$

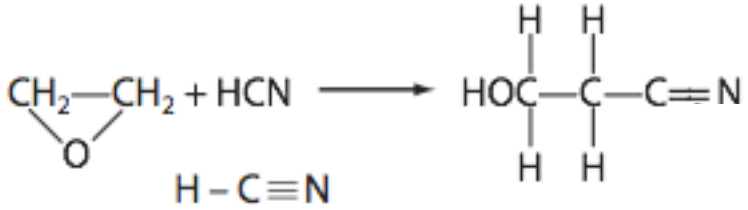
(a) Calculate the $\Delta H°$ for the reaction above, using values from Page 31 of your notes.

(b) Repeat the calculation done in part (a) using $\Delta H°_f$ values from Page 30 of your notes.

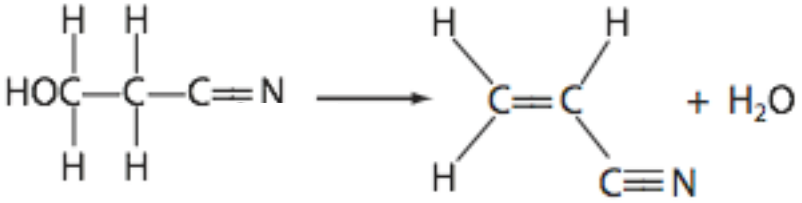
(c) Compare the answer to part (a) with part (b). Comment on the comparison.

7) Use a highlighter or some other method to indicate the bonds that break on the reactant side and form on the product side of this reaction. If a bond remains intact there is no need to break and reform it. Calculate the enthalpy change using the bond energy values on Page 31 of your notes.

(a)



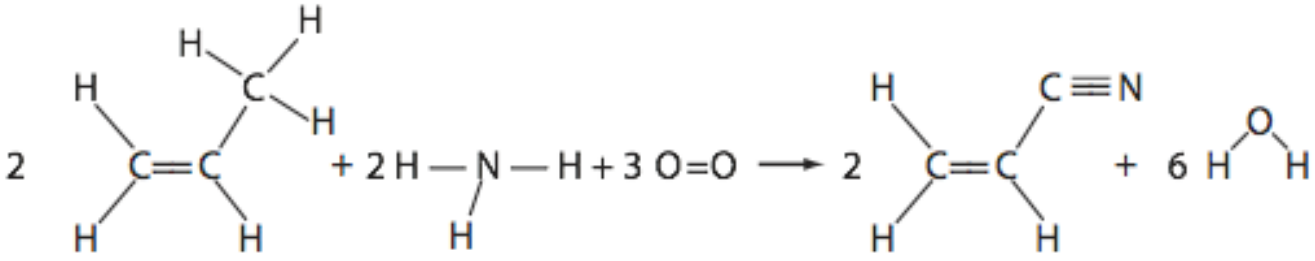
(b)



(c) Combine (a) and (b) into one reaction and calculate the overall enthalpy change.

8) The following shows the structural formulas for the reaction:

$$2\ CH_2CHCH_{3(g)} + 2\ NH_{3(g)} + 3\ O_{2(g)} \rightarrow 2\ CH_2CHCN_{(g)} + 6\ H_2O_{(g)}$$



Use the bond energy on Page 31 of your notes to calculate $\Delta H°_{rxn}$ for the given reaction.