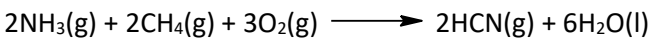
SURREY SUPPLEMENT: THERMOCHEMISTRY

1) Given the following reaction:



$$2NH_3(g) + 2CH_4(g) + 3O_2(g) \longrightarrow 2HCN(g) + 6H_2O(l)$$

a) Calculate $\Delta H°$ using the following enthalpies of formation:

Compound	$\Delta H°_f$ (kJ/mol)
$NH_3(g)$	-46.19 kJ/mol
$CH_4(g)$	-74.86 kJ/mol
HCN(g)	+130.5 kJ/mol
$H_2O(l)$	-285.9 kJ/mol

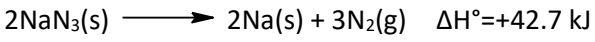
[-1212.3 kJ]

b) Calculate $\Delta H°$ using the following bond energies. You will also need to know that $\Delta H°_{vap}$ for water is +44 kJ/mol.

Bond	Bond energy (kJ/mol)
N-H	389
C-H	414
O=O	494
C≡N	879
O-H	463

[-1278 kJ]

2) Given the thermochemical equation



$$2NaN_3(s) \longrightarrow 2Na(s) + 3N_2(g) \quad \Delta H°=+42.7 \text{ kJ}$$

a) Calculate $\Delta E°_{298}$ for the above reaction. **[+35.3 kJ/mol]**
b) Calculate $\Delta H°_{f,298}$ for $NaN_3(s)$. Give your answer in kJ/mol. **[-21.35 kJ/mol]**

3) A 2.30 g sample of quinone, $C_6H_4O_2$, was burned in excess oxygen in a bomb calorimeter. The calorimeter (specific heat capacity 3.27 kJ/°C) was immersed in 1000 g of water (specific heat capacity 4.184 j/g·°C). The temperature of the calorimeter and contents increased from 19.22°C to 27.07°C. What quantity of heat would be liberated by the combustion of one mole of quinone under these conditions? **[-2747.6 kJ]**

4) Given the following reactions:

$OSCl_2(l) + H_2O(l) \longrightarrow SO_2(g) + 2HCl(l)$ $\Delta H° = +10.3$ kJ
$PCl_3(l) + \frac{1}{2}O_2(g) \longrightarrow OPCl_3(l)$ $\Delta H° = -325.1$ kJ
$P(s) + 1.5Cl_2(g) \longrightarrow PCl_3(l)$ $\Delta H° = -306.7$ kJ
$4HCl(g) + O_2(g) \longrightarrow 2Cl_2(g) + 2H_2O(l)$ $\Delta H° = -202.6$ kJ

Calculate $\Delta H°$ for the reaction:

$2P(s) + 2SO_2(g) + 5Cl_2(g) \longrightarrow 2OSCl_2(l) + 2OPCl_3(l)$ **[-1081.6 kJ]**

5) The combustion of 1.000 g of cyclohexane, $C_6H_{12}(l)$, in a bomb calorimeter, evolves 46.86 kJ of heat at 25°C. The products of combustion are carbon dioxide gas and liquid water. The molar mass of cylcohexane is 84.16 g.

   a) Calculate $\Delta E°$ for the combustion of one mole of cyclohexane. **[-3911.8 kJ]**
   b) Write the chemical equation for the combustion reaction and calculate $\Delta H°$ for the reaction. **[-3919.2 kJ]**
   c) Calculate the enthalpy of formation of cylcohexane from your calculated value of $\Delta H°$ and the molar enthalpies of formation of $CO_2(g)$ and $H_2O(l)$ (available in your text and/or on line). **[-157.2 kJ/mol]**

6) A balloonist is preparing to make a trip in a helium-filled balloon. The trip begins in the early morning when the temperature is 15°C. By mid-afternoon, the temperature has increased to 30°C. Assuming the pressure remains constant at 1.00 bar, for each mole of helium, calculate:

   a) the initial and final volumes **[23.96 L and 25.21 L]**
   b) the change in internal energy, ΔE [Hint: Helium behaves like an ideal gas, so $E = 3/2nRT$] **[187 J]**
   c) the work (w) done by the helium (in J) **[-125 J]**
   d) the heat (q) transferred (in J) **[312 J]**
   e) ΔH for the process (in J) **[312 J]**
   f) Explain the relationship between the answers to (d) and (e)