THERMOCHEMISTRY (no calculator)

(All questions may be completed without the use of a calculator. Answers given were generated without a calculator.)

1) For the reaction:

   $2F_2(g) + 2H_2O(g) \rightleftharpoons 4HF(g) + O_2(g)$

   a) Use enthalpies of formation to calculate the value of ΔH° for the reaction.
      Enthalpies of formation: $H_2O(g)$ = -242 kJ/mol, HF(g) = -271 kJ/mol **[-600 kJ]**
   b) Use bond energies to calculate ΔH° for the reaction.
      F-F (158 kJ/mol); H-F (568 kJ/mol); O=O (494 kJ/mol); O-H (463 kJ/mol) **[-598 kJ]**

2) Given the thermochemical equation

   $2NaN_3(s) \rightleftharpoons 2Na(s) + 3N_2(g)$ ΔH° = + 42.7 kJ

   a) Calculate $\Delta H^\circ_{f,298}$ for $NaN_3(s)$. **[-21.35 kJ/mol]**
   b) Calculate ΔE°_{298} for the above reaction. **[about +35 kJ]**

3) A 20.0 millimole sample of an organic compound was burned in excess oxygen in a bomb calorimeter. The calorimeter contained 1000 g of water and the calorimeter itself had a heat capacity of 3.816 kJ/°C. The temperature of the calorimeter and its contents increased from 19.00°C to 27.00°C. What quantity of heat would be liberated by the combustion of one mole of this organic compound under these conditions? **[$\Delta E^\circ = q_v = -3.20 \times 10^3$ kJ]**

4) Given:

$OSCl_2(l) + H_2O(l) \rightleftharpoons SO_2(g) + 2HCl(aq)$	ΔH° = +10 kJ
$2PCl_3(l) + O_2(g) \rightleftharpoons 2\ OPCl_3(l)$	ΔH° = -650 kJ
$2P(s) + 3Cl_2(g) \rightleftharpoons 2PCl_3(l)$	ΔH° = -614 kJ
$4HCl(g) + O_2(g) \rightleftharpoons 2Cl_2(g) + 2H_2O(l)$	ΔH° = -203 kJ

   Calculate the value of ΔH° for the reaction

   $2P(s) + 2SO_2(g) + 5Cl_2(g) \rightleftharpoons 2OSCl_2(l) + 2OPCl_3(l)$
   [-1081 kJ]

5) The combustion of 10.0 millimoles of cyclohexane, $C_6H_{12}(l)$, in a bomb calorimeter evolves 39.12 kJ of heat. The products of the combustion are carbon dioxide gas and water liquid.
   a) Calculate ΔE° for the combustion of one mole of cyclohexane. **[-3912 kJ]**
   b) Write the chemical equation for the reaction above and calculate ΔH° for the combustion of cyclohexane. **[-3920 kJ/mol]**
   c) Calculate the enthalpy of formation of cyclohexane from your calculated value of ΔH° for the combustion of cyclohexane and the molar enthalpies of formation of CO_2 gas (-394 kJ/mol) and H_2O liquid (-286 kJ/mol). **[-160 kJ/mol]**

6) One mole of He gas initially at 0°C and 1.0 atm is warmed up to 27°C at a constant pressure of 1.0 atm, calculate:
   a) The ΔV for this process **[2.24 L]**
   b) The change in internal energy, ΔE, for this process *[Hint: He behaves like an ideal gas, so $E = 1.5nRT$]* **[3.4 x 10^2 J]**
   c) The work (w) done by the He **[about -225 J]**
   d) The heat (q) transfered **[about 5.65 x 10^2 J]**
   e) ΔH for the process **[$\Delta H = q_p \cong 5.65 \times 10^2$ J]**

7) Benzene (C_6H_6) and acetylene (C_2H_2) have the same empirical formula, CH. Which compound releases more energy per mole of CH? $\Delta H°_f$ of gaseous C_6H_6 = +83 kJ/mol and $\Delta H°_f$ of C_2H_2(g) = +227 kJ/mol)
   [C_2H_2(g) produces about 100 kJ/mol CH more than C_6H_6(g)]

8) A typical candy bar has a mass of about 60 g.
   a) Assuming that a candy bar is 100% sugar and that 1.0 g of sugar is equivalent to about 17 kJ of energy, calculate the energy in kJ contained in this typical candy bar. **[1.0 x 10^3 kJ]**
   b) If cycling at 23 kph requires 2.0 x 10^3 kJ/hr, approximately how many minutes of cycling would be needed to burn the energy produced from this candy bar? **[30]**