Chapter one

1. Consider the following reactions:

   (a) $CO(g) + \frac{1}{2}O_2(g) \rightarrow CO_2(g)$

   (b) $C(s) + \frac{1}{2}O_2(g) \rightarrow CO(g)$

   (c) $H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$

   (d) $C(s) + \frac{1}{2}O_2(g) + 2H_2(g) \rightarrow CH_3OH(l)$

   At constant pressure, in which of the reactions is work done by the system on the surrounding? By the surrounding on the system? In which of them no work is done?

2. A gas expands in volume from 2L to 7L at constant temperature. Calculate the work done (in joules) if the gas expands (a) against a vacuum, (b) against a constant pressure of 2.4 atm?

3. Consider the reaction

   $$H_2(g) + Cl_2(g) \rightarrow 2HCl(g) \qquad \Delta H = -184.6 kJ/mol$$

   If 3 moles of H_2 react with 3 moles of Cl_2 to form HCl, calculate the work done (in joules) against a pressure of 1 atm at 40 °C. What is ΔE for this reaction? Assume the reaction goes to completion.

4. A piece of gold of mass 372 g has a heat capacity of 48.0 J/°C. What is the specific heat of gold?

5. Glycine, $C_2H_5O_2N$, is important for biological energy. The combustion reaction of glycine is given by the equation:

   $4C_2H_5O_2N(s) + 9O_2(g) \rightarrow 8CO_2(g) + 10H_2O(l) + 2N_2(g)$

   $\Delta H_{rxn} = -3857$ kJ.

   Given that $\Delta H^\circ_f [CO_2(g)] = -393.5$ kJ/mol and $\Delta H^\circ_f [H_2O(l)] = -285.8$ kJ/mol, calculate the enthalpy of formation of glycine.

6. From the following heats of combustion,

$$CH_3OH(l) + \frac{3}{2}O_2(g) \rightarrow CO_2(g) + 2H_2O(l) \qquad \Delta H^\circ_{rxn} = -726.4kJ/mol$$

$$C(graphite) + O_2(g) \rightarrow CO_2(g) \qquad \Delta H^\circ_{rxn} = -393.5kJ/mol$$

$$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l) \qquad \Delta H^\circ_{rxn} = -285.8kJ/mol$$

Calculate the enthalpy of formation of methanol (CH_3OH) from its elements:

$$C(garaphite) + 2H_2(g) + \frac{1}{2}O_2(g) \rightarrow CH_3OH(l)$$

7. Calculate the enthalpy of reaction for $H_2(g) + C_2H_4(g) \rightarrow C_2H_6(g)$.
[$\Delta H_f°(C_2H_4(g))$ = 52.3 kJ/mol; $\Delta H_f°$ ($C_2H_6(g)$) = -84.7 kJ/mol]

8. A 6.22 g piece of copper metal is heated from 32.5 °C to 450 °C. Calculate the heat absorbed (in kJ) by the metal? (specific heat of copper is 0.385 J/g.°C).

9. Determine the amount of heat (in kJ) given off when 83.65 g of NO_2 are produced according to the equation

$$2NO(g) + O_2(g) \rightarrow 2NO_2(g) \qquad \Delta H = -114.6 kJ/mol$$