CH1011 Tutorial 6 Answers

1. Explain the term **enthalpy**. What is an **exothermic** reaction?

Enthalpy is a thermodynamic variable the change in energy associated with a chemical reaction $\Delta H = \Delta E + p\Delta V$ where ΔE is the internal energy and $p\Delta V$ is the work associated with pressure and volume change. Most reactions are carried out *at constant pressure conditions (1 atm) ΔH = heat of reaction* under these conditions. Enthalpy is generally quoted in kJ/mol at a specified temperature in K

An exothermic reaction is one where ΔH is negative (< 0 kJ) for the system being considered thus the products are more stable than the reactants.

2. Calculate the heat of combustion $\mathbf{\Delta H^o_c(_{C2H4(g)\ ,\ 298K})}$ when ethene (C_2H_4) is combusted to form $CO_2(g)$ and $H_2O(l)$

Balanced equation: $C_2H_4(g) + 3O_2(g) \rightarrow 2CO_2(g) + 2H_2O(l)$

$\Delta H^o_{c(\ C2H4(g)\ )}$ = products - reactans

$= [2 \times \Delta H^o_{f(\ CO2(g)\ )} + 2 \times \Delta H^o_{f(\ H2O(l)\ )}] - [\Delta H^o_{f(\ C2H4(g)\ )}]$

$= [(2 \times -394) + (2 \times -286)] - [53]$

$= -1413$ kJ

3. The oxidation of carbon (graphite) to carbon monoxide occurs spontaneously at 375K.
After reaction of the above system in a closed reaction vessel the equilibrium partial pressure of oxygen is 0.021 atm and that of carbon monoxide is 0.50 atm.
Write down the expression for K_p and determine the value of K_p in the above system.

Balanced equation: $2C(s) + O_2(g) \rightarrow 2CO(g)$

$Kp = p(CO)^2 / p(O_2) = (0.50)^2 / 0.021 = 11.91 = 12$

[or Balanced equation: $C(s) + \frac{1}{2} O_2(g) \rightarrow CO(g)$

$Kp = p(CO) / p(O_2)^{1/2} = 0.50 / \sqrt{0.021} = 3.45 = 3.5$]

4. $3O_2(g) \rightleftharpoons 2O_3(g)$ $\Delta H^o = 286$ kJ mol^{-1}

In an equilibrium reaction mixture of the above reaction how would $p(O_2)$ and K_p change if the temperature of the reaction vessel were raised? Explain your answer.

$p(O_2)$ would decrease. K_p would increase.
Le Chatalier's principle states that for an endothermic reaction external heating will result in an increase in the forward (endothermic) reaction to reduce the effect of the change. This will result in an increase in $p(O_3)$ and a decrease in $p(O_2)$ hence K_p will increase [$Kp = p(O_3)^2 / p(O_2)^3$].

5. 50.0 mL of water at 75.0^{o}C is added to a thermos flask containing 100.0 mL of water which is at 25.0^{o}C. Assuming that no heat is lost to the surroundings what is the final temperature of the water in the flask? (C_S H_2O 4.184 J K^{-1} g^{-1}, ρ H_2O 1.00 g cc^{-1})

100 g 25^{o}C $q = Cs \times g \times \Delta T = 4.184 \times 100 \times 25^oC = 10460$ J

50 g 75^{o}C $q = Cs \times g \times \Delta T = 4.184 \times 50 \times 75^oC = 15690$ J

$q_{system} = q_1 + q_2 = 26150$ J

$T_{system} = q_{system} / C_s \times g_{system} = 26150 / 4.184 \times 150\ g = 41.7\ ^oC$