Topic 5 Exercise 2 – Equilibrium Constants

1. State the three features of a dynamic equilibrium

2. For each of the following equilibria, write the expression for the equilibrium constant K_c and state its units:

i) $2NO_2(g) == N_2O_4(g)$
ii) $CH_3CH_2CO_2H(l) + CH_3CH_2OH(l) == CH_3CH_2CO_2CH_2CH_3(l) + H_2O(l)$
iii) $H_2(g) + I_2(g) == 2HI(g)$
iv) $2SO_2(g) + O_2(g) == 2SO_3(g)$
v) $N_2(g) + 3H_2(g) == 2NH_3(g)$

3. For the equilibrium $PCl_5(g) == PCl_3(g) + Cl_2(g)$
the equilibrium concentrations of PCl_5, PCl_3 and Cl_2 are 1.0, 0.205 and 0.205 moldm^{-3} respectively. Calculate the value of K_c.

4. For the equilibrium $2N_2O_5(g) == 2N_2O_4(g) + O_2(g)$
The equilibrium concentrations are $[N_2O_5]$ = 1.0 moldm^{-3}, $[N_2O_4]$ = 0.11 moldm^{-3}, $[O_2]$ = 0.11 moldm^{-3}.
Calculate the value of K_c.

5. The reaction for the formation of hydrogen iodide does not go to completion but reaches an equilibrium: $H_2(g) + I_2(g) == 2HI(g)$
A mixture of 1.9 mol of H_2 and 1.9 mol of I_2 was prepared and allowed to reach equilibrium in a closed vessel of 250 cm^3 capacity. The resulting equilibrium mixture was found to contain 3.0 mol of HI. Calculate the value of Kc.

6. Consider the equilibrium: $N_2O_4(g) == 2NO_2(g)$.
1 mol of dinitrogen tetroxide, N_2O_4, was introduced into a vessel of volume 10 dm^3. At equilibrium 50% had dissociated. Calculate Kc for the reaction.

7. In an experiment, 9.0 moles of nitrogen and 27 moles of hydrogen were placed into a vessel of volume 10 dm^3 and allowed to reach equilibrium. It was found that two thirds of the nitrogen and hydrogen were converted into ammonia. Calculate Kc for the reaction.
$N_2(g) + 3H_2(g) == 2NH_3(g)$

8. Hydrogen chloride can be oxidised to chlorine by the Deacon process:
$4HCl(g) + O_2(g) == 2Cl_2(g) + 2H_2O(g)$
0.800 mol of hydrogen chloride was mixed with 0.200 mol of oxygen in a vessel of volume 10 dm^3. At equilibrium it was found that the mixture contained 0.200 mol of hydrogen chloride. Calculate Kc for the reaction.

9. A 0.04 sample of SO_3 is introduced into a 3.04 litre vessel and allowed to reach equilibrium. The amount of SO_3 present at equilibrium is found to be 0.0284 mole. Calculate the value of K_c for the reaction $2SO_3(g) == 2SO_2(g) + O_2(g)$.

10. The reaction between carbon monoxide and hydrogen proceeds according to the equilibrium $CO(g) + 2H_2(g) == CH_3OH(g)$ A 1 litre flask maintained at 700K contains 0.1 mole of carbon monoxide. After 0.3 mole of hydrogen is added, 0.06 mol of ethanol are formed. Calculate the equilibrium constant K_c.

11. When 1.0 mole each of ethanoic acid and ethanol were allowed to reach equilibrium in a sealed vessel of volume 500 cm^3, the amount of ethanoic acid present at equilibrium was found to be 0.33 mole. Calculate the value of K_c for the reaction $CH_3COOH + CH_3CH_2OH == CH_3COOCH_2CH_3 + H_2O(l)$

12. At 723K, hydrogen and iodine react together and the following equilibrium is established: $H_2(g) + I_2(g) == 2HI(g)$
The value of K_c for this equilibrium is 64. In an experiment, equal amounts of hydrogen and iodine were mixed together, and the equilibrium mixture of the three gases in a container of volume 1 dm^3 at 723K was found to contain 1.5 moles of iodine. Calculate the concentration of hydrogen iodide in the mixture at 723K.