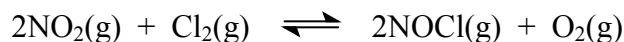


Calculate the partial pressure equilibrium constant,  $K_p$ , at 35 °C for the reaction:



**Marks**

7

**In the reaction, 3 moles of gas react to form 3 moles of gas – there is no change in the number of moles of gas and so  $\Delta n = 0$ .  $K_c$  was calculated in the previous question (2005-N-5) to be  $1.00 \times 10^{-4}$**

$$\begin{aligned} K_p &= K_c (RT)^{\Delta n} \\ &= K_c (RT)^0 = K_c = 1.00 \times 10^{-4} \end{aligned}$$

$$K_p = 1.00 \times 10^{-4}$$

What is the standard free energy change,  $\Delta G^\circ$ , for the forward reaction (in  $\text{kJ mol}^{-1}$ ) at 35 °C?

**Using  $\Delta G^\circ = -RT \ln K_p$ ,**

$$\begin{aligned} \Delta G^\circ &= -(8.314 \text{ J K}^{-1} \text{ mol}^{-1}) \times ((35 + 273) \text{ K}) \times \ln(1.00 \times 10^{-4}) \\ &= -23600 \text{ J mol}^{-1} = -23.6 \text{ kJ mol}^{-1} \end{aligned}$$

$$\Delta G^\circ = -23.6 \text{ kJ mol}^{-1}$$

If 0.150 mol of  $\text{O}_2(\text{g})$  and  $3.00 \times 10^{-4}$  mol of  $\text{NO}_2(\text{g})$  are added to the 1.00 L flask, determine the free energy change,  $\Delta G$ , (in  $\text{kJ mol}^{-1}$ ) as the system moves to its new equilibrium point.

**From the previous question (2005-N-5), the initial concentrations of  $[\text{NOCl}]$  and  $[\text{Cl}_2]$  are both equal to 0.0102 M. The concentrations of  $\text{O}_2(\text{g})$  and  $\text{NO}_2(\text{g})$  are equal to 0.150 M and  $3.00 \times 10^{-4}$  M as the flask has a volume of 1.00 L.**

The reaction quotient,  $Q$ , for this reaction is  $Q = \frac{[\text{NOCl}(\text{g})]^2 [\text{O}_2(\text{g})]}{[\text{NO}_2(\text{g})]^2 [\text{Cl}_2(\text{g})]}$ . Hence:

$$Q = \frac{(0.0102)^2 (0.150)}{(3.00 \times 10^{-4})^2 (0.0102)} = 17000 \text{ and}$$

$$\begin{aligned} \Delta G &= \Delta G^\circ + RT \ln Q = (-23.6 \times 10^3 \text{ J mol}^{-1}) + (8.314 \text{ J K}^{-1} \text{ mol}^{-1}) \times ((35 + 273) \text{ K}) \times \ln(17000) \\ &= +1.4 \text{ kJ mol}^{-1} \end{aligned}$$

$$\Delta G = +1.4 \text{ kJ mol}^{-1}$$

Will the amount of  $\text{NO}_2(\text{g})$  in the flask increase or decrease as the system moves to its new equilibrium position? Explain.

**As  $Q > K_c$ , the system will move to decrease  $Q$ . This occurs by reducing the concentration of the products and increasing the concentration of reactants.  $[\text{NO}_2(\text{g})]$  will thus increase.**