Marks 9

- In an experiment, NOCl (2.00 mol) was placed in a closed 1.00 L flask. After equilibrium was established at 25 °C, the concentration of NO(g) was 0.66 M. Calculate the value of K_c at 25 °C for the following reaction.

$$2NOCl(g) \rightleftharpoons 2NO(g) + Cl_2(g)$$

The initial concentration of NOCl is:

$$[NOCl(g)] = \frac{\text{number of moles}}{\text{volume}} = \frac{(2.00\,\text{mol})}{(1.00\,\text{L})} = 2.00\,\text{M}$$

The reaction table is:

	2NOCl(g)	$\rightleftharpoons$	**2NO(g)**	**Cl_2(g),**
initial	**2.00**		**0**	**0**
change	**-2x**		**+2x**	**+x**
equilibrium	**2.00-2x**		**2x**	**x**

As $[NO(g)]_{equilibrium}$ = 0.66 M, x = 0.33 M and so:

$[NOCl(g)]$ = (2.00 – 2x) M= 1.34 M and $[Cl_2(g)]_{equilibrium}$ = 0.33 M.

The equilibrium constant in terms of concentrations, K_c, is therefore:

$$K_c = \frac{[NO(g)]^2[Cl_2(g)]}{[NOCl(g)]^2} = \frac{(0.66)^2 \times (0.33)}{(1.34)^2} = 0.080$$

K_c = **0.080**

Calculate the value of K_p at 25 °C for the reaction above.

In the reaction, 2 mol of gas reacts to give (2 + 1) mol = 3 mol of gas.

Hence, Δn = +1.

Using, $K_p = K_c(RT)^{\Delta n}$:

$$K_p = 0.080 \times (0.08206 \times (25 + 273))^1 = 196$$

K_p = **196**

ANSWER CONTINUES ON THE NEXT PAGE

Given that $\Delta H_f°$ for NOCl(g) = 51.71 kJ mol^{-1} and $\Delta H_f°$ for NO(g) = 90.29 kJ mol^{-1} at 25 °C, calculate the value of $\Delta H°$ for the reaction above.

Using $\Delta_{rxn}H^{o} = \sum m\Delta_f H^{o}(\text{products}) - \sum n\Delta_f H^{o}(\text{reactants})$:

$$\Delta_{rxn}H^{o} = [2\Delta_f H^{o}(NO(g) + \Delta_f H^{o}(Cl_2(g)] - [2\Delta_f H^{o}(NOCl(g))]$$

$$= ([2 \times 90.29 + 0] - [2 \times 51.71]\,\text{kJ mol}^{-1}) = 77.16\ \text{kJ mol}^{-1}$$

$\Delta H°_{rxn}$ = **+77.16 kJ mol^{-1}**

What is the effect upon the [NOCl] of an equilibrium mixture if the temperature is increased?

As the reaction is endothermic, the forward reaction becomes more favourable when the temperature is increased. The amount of reactant (NOCl(g)) present at equilibrium therefore decreases.

In which direction will the equilibrium shift if the volume of the flask is reduced?

Reducing the volume of the flash acts to increase the pressure and the system responds to reduce it. The number of moles of gas increases in the reaction so reducing the volume favours reactants and the equilibrium shifts to the left.