Marks 4

- The general formula for a nickel(II) chloride compound complexed with ammonia is $[Ni(NH_3)_x]Cl_2$. A 0.59 g sample of the salt was dissolved in water and the ammonia from it was titrated with 153 mL of 0.100 M HCl. What is the value of the coefficient *x*?

The molar mass of $[Ni(NH_3)_x]Cl_2$ is:

$$(58.69\ (Ni) + x\ (14.01\ (N) + 3 \times 1.008\ (H)) + 2 \times 35.45\ (Cl))\ g\ mol^{-1}$$

$$= (129.59 + 17.034x)\ g\ mol^{-1}$$

A 0.59 g sample therefore corresponds to:

$$\text{number of moles} = \frac{\text{mass}}{\text{molar mass}} = \frac{0.59}{(129.59 + 17.034x)}\ \text{mol} \qquad (1)$$

The number of moles in 153 mL of 0.100 M HCl is:

$$\text{number of moles} = \text{concentration} \times \text{volume}$$

$$= 0.100\ mol\ L^{-1} \times 0.153\ L = 0.0153\ mol$$

Ammonia reacts with HCl according to the reaction $NH_3 + HCl \rightleftharpoons NH_4Cl$ and so this is equal to the number of moles of NH_3 present. Each mol of $[Ni(NH_3)_x]Cl_2$ contains *x* mol of NH_3 so the number of moles of $[Ni(NH_3)_x]Cl_2$ is:

$$\text{number of moles} = 0.0153 / x\ \text{mol} \qquad (2)$$

The value of *x* is calculated by equating (1) and (2). This is easiest to achieve by trial and error.

x	(1) / mol	(2) / mol
1	0.0040	0.015
2	0.0036	0.0077
3	0.0033	0.0051
4	0.0030	0.0038
5	0.0027	0.0031
6	0.0026	0.0026
7	0.0024	0.0022

The best agreement is for *x* = 6 - a common coordination number for Ni(II).

Answer: **6**