Marks 5

- A solution is prepared by dissolving lead(II) nitrate (33.12 g) in 1.00 L of water. Write the balanced ionic equation for this dissolution reaction.

$Pb(NO_3)_2(s) \rightarrow Pb^{2+}(aq) + 2NO_3^-(aq)$

When a 100.0 mL portion of this solution is mixed with a solution of potassium iodide (0.300 M, 150.0 mL), a bright yellow precipitate of lead(II) iodide forms. Write the balanced ionic equation for this precipitation reaction.

$Pb^{2+}(aq) + 2I^-(aq) \rightarrow PbI_2(s)$

What mass of lead(II) iodide is formed?

The formula mass of $Pb(NO_3)_2$ is:

formula mass = (207.2 (Pb) + 2 × 14.01 (N) + 6 × 16.00 (O)) g mol^{-1}
= 331.22 g mol^{-1}

The number of moles in 33.12 g is therefore:

$$\text{number of moles} = \frac{\text{mass}}{\text{formula mass}} = \frac{33.12\text{ g}}{331.22\text{ g mol}^{-1}} = 0.1000\text{ mol}$$

If this dissolved in 1.00 L and a 100.0 mL portion is taken, this will contain 0.01000 mol of $Pb^{2+}(aq)$.

150.0 mL of a 0.300 M solution of KI contains:

number of moles = concentration × volume
= 0.300 mol L^{-1} × 0.1500 L = 0.0450 mol

The precipitation reaction requires 2 mol of $I^-(aq)$ for every 1 mol of $Pb^{2+}(aq)$. The 0.01000 mol of $Pb^{2+}(aq)$ that is present requires 0.02000 mol of $I^-(aq)$. As there is more $I^-(aq)$ than this present, $I^-(aq)$ is in excess and $Pb^{2+}(aq)$ is the limiting reagent.

From the precipitation reaction, 1 mol of $Pb^{2+}(aq)$ will produce 1 mol of $PbI_2(s)$. Therefore 0.01000 mol of $Pb^{2+}(aq)$ will produce 0.01000 mol of $PbI_2(s)$.

The formula mass of PbI_2 is:

formula mass = (207.2 (Pb) + 2 × 126.9 (I)) g mol^{-1}
= 461.0 g mol^{-1}

The mass of 0.01000 mol is therefore:

mass = formula mass × number of moles = 461.0 g mol^{-1} × 0.01000 mol
= 4.61 g

Answer: **4.61 g**

ANSWER CONTINUES ON THE NEXT PAGE

What is the final concentration of I^-(aq) ions remaining in solution after the reaction is complete?

As described above reaction of 0.01000 mol of Pb^{2+}(aq) requires 0.02000 mol of I^-(aq). As 0.0450 mol are initially present, there are (0.0450 – 0.02000) mol = 0.0250 mol of I^-(aq) after the precipitation reaction.

After mixing the two solutions, the total volume becomes (100.0 + 150.0) mL = 250.0 mL. The final concentration of I^-(aq) is therefore:

$$\text{concentration} = \frac{\text{number of moles}}{\text{volume}} = \frac{0.0250\ \text{mol}}{0.2500\ \text{L}} = 0.100\ \text{mol L}^{-1} = 0.100\ \text{M}$$

Answer: **0.100 M**