Marks
7

- Write the equation for the dissolution of lead(II) chloride, $PbCl_2$, in water.

$PbCl_2(s) \rightleftharpoons Pb^{2+}(aq) + 2Cl^-(aq)$

Write the expression for the solubility product constant, K_{sp}, for $PbCl_2$.

$K_{sp} = [Pb^{2+}(aq)][Cl^-(aq)]^2$

What $[Cl^-]$ is needed to reduce the $[Pb^{2+}]$ to the maximum safe level of 0.015 mg L^{-1}?
$K_{sp}(PbCl_2) = 1.6 \times 10^{-6}$

The molar mass of Pb is 207.2 g mol^{-1} so 0.015 mg corresponds to:

number of moles = mass / molar mass
= 0.015×10^{-3} g / 207.2 g mol^{-1} = 7.2×10^{-8} mol

The maximum safe value for $[Pb^{2+}(aq)] = 7.2 \times 10^{-8}$ mol L^{-1}. As $K_{sp} = 1.6 \times 10^{-6}$, the value of $[Cl^-(aq)]$ can be calculated:

$K_{sp} = [Pb^{2+}(aq)][Cl^-(aq)]^2 = (7.2 \times 10^{-8}) \times [Cl^-(aq)]^2 = 1.6 \times 10^{-6}$

$[Cl^-(aq)] = 4.7$ mol L^{-1}

$[Cl^-]$ = **4.7 mol L^{-1}**

The solubility of sodium chloride is 359 g L^{-1}. If a reservoir of 50,000 L is saturated with lead(II) chloride, can sodium chloride be used to reduce the $[Pb^{2+}]$ to a safe level? If so, what mass of sodium chloride (in kg) would be needed?

The molar mass of NaCl is:

molar mass = (22.99 (Na) + 35.45 (Cl)) g mol^{-1} = 58.44 g mol^{-1}

359 g corresponds to:

number of moles = mass / molar mass
= 359 g / 58.44 g mol^{-1} = 6.14 mol

The maximum concentration of $[Cl^-(aq)]$ from NaCl is therefore 6.14 mol L^{-1}. As this is greater than that required to keep the lead concentration at a safe level, it could be used.

The minimum concentration of $Cl^-(aq)$ needed is 4.7 mol L^{-1}. The number of moles required to achieve this concentration in 50,000 L is therefore:

number of moles = concentration × volume
= 4.7 mol L^{-1} × 50000 L = 24000 mol

ANSWER CONTINUES ON THE NEXT PAGE

The mass of NaCl that corresponds to this is:

mass = number of moles × molar mass
= 24000 mol × 58.44 g mol^{-1} = 1.4 × 10^{7} g = 14 tonnes

Answer: **1.4 × 10^{7} g or 14 tonnes**

Would the water in the reservoir be fit for drinking? Explain your answer.

It would be too salty to drink and is likely to exceed safe levels of Na^{+}(aq) and Cl^{-}(aq).