

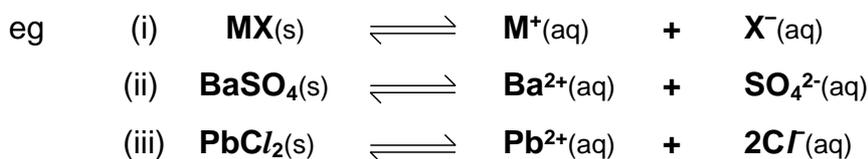
SOLUBILITY PRODUCT

- Solubility**
- ionic compounds tend to be **insoluble in non-polar solvents**
 - ionic compounds tend to be **soluble in water**
 - water is a polar solvent and stabilises the separated ions
 - some ionic compounds are very insoluble
 - even soluble ionic compounds have a limit as to how much solute dissolves

- Saturated solutions**
- a solution becomes saturated when solute no longer dissolves in the solvent
 - solubility varies with temperature
 - most solutes are more soluble at higher temperatures

Solubility product

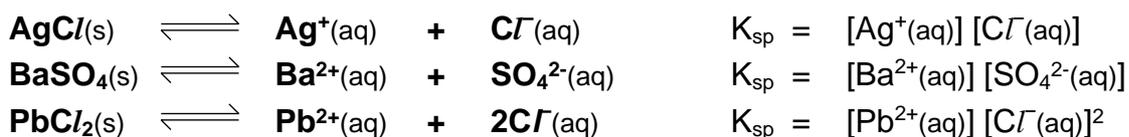
Even the most insoluble ionic compounds dissolve to a small extent. An equilibrium is set up between the undissolved solid and its aqueous ions;



Theory Applying the equilibrium law to (i) and assuming the concentration of MX(s) is constant in a saturated solution.
[] is the concentration in mol dm⁻³

$$[\text{M}^+(\text{aq})] [\text{X}^-(\text{aq})] = \text{a constant}$$

The constant is known as the **SOLUBILITY PRODUCT K_{sp}**



Units The value of K_{sp} **has units** and is **varies with temperature**

$$K_{sp} = [\text{Ag}^+(\text{aq})] [\text{Cl}^-(\text{aq})] \quad \text{units of} \quad \text{mol}^2 \text{ dm}^{-6}$$

$$K_{sp} = [\text{Pb}^{2+}(\text{aq})] [\text{Cl}^-(\text{aq})]^2 \quad \text{units of} \quad \text{mol}^3 \text{ dm}^{-9}$$

Q.1 Write expressions for K_{sp} for the following compounds; state the units of K_{sp}



Calculating solubility

Solubility products can be used to calculate the solubility of ionic compounds.

Example 1 At 25°C the solubility product of lead(II) sulphide, PbS is $4 \times 10^{-28} \text{ mol}^2 \text{ dm}^{-6}$. Calculate the solubility of lead(II) sulphide.

The equation for its solubility is $\text{PbS(s)} \rightleftharpoons \text{Pb}^{2+}(\text{aq}) + \text{S}^{2-}(\text{aq})$

The expression for the solubility product is $K_{\text{sp}} = [\text{Pb}^{2+}(\text{aq})][\text{S}^{2-}(\text{aq})]$

According to the equation you get one $\text{Pb}^{2+}(\text{aq})$ for every one $\text{S}^{2-}(\text{aq})$; the concentrations will be equal $[\text{Pb}^{2+}(\text{aq})] = [\text{S}^{2-}(\text{aq})]$

Substituting and rewriting the expression for K_{sp} $K_{\text{sp}} = [\text{Pb}^{2+}(\text{aq})]^2$

Re-arranging $[\text{Pb}^{2+}(\text{aq})] = \sqrt{K_{\text{sp}}} = \sqrt{4 \times 10^{-28}} = 2 \times 10^{-14} \text{ mol dm}^{-3}$

As you get one Pb^{2+} from one PbS, the solubility of PbS = $2 \times 10^{-14} \text{ mol dm}^{-3}$

M_r for PbS is 239; the solubility is $239 \times 2 \times 10^{-14} \text{ g dm}^{-3} = 4.78 \times 10^{-12} \text{ g dm}^{-3}$
[mass = moles x molar mass]

Example 2 The solubility of ionic compound MY at 25°C is $5 \times 10^{-10} \text{ g dm}^{-3}$. The relative mass of MY is 200. Calculate the solubility product of the salt MY at 25°C.

Solubility of MY $\frac{\text{solubility in g}}{\text{molar mass}} = \frac{5 \times 10^{-10}}{200} = 2.5 \times 10^{-12} \text{ mol dm}^{-3}$

The equation for its solubility is $\text{MY(s)} \rightleftharpoons \text{M}^+(\text{aq}) + \text{Y}^-(\text{aq})$

The expression for the solubility product is $K_{\text{sp}} = [\text{M}^+(\text{aq})][\text{Y}^-(\text{aq})]$

According to the equation; moles of $\text{M}^+(\text{aq})$ = moles of $\text{Y}^-(\text{aq})$
= moles of MY(s) which have dissolved

Substituting values $K_{\text{sp}} = [2.5 \times 10^{-12}][2.5 \times 10^{-12}]$

The value of the solubility product $K_{\text{sp}} = 6.25 \times 10^{-24} \text{ mol}^2 \text{ dm}^{-6}$

Q.2

a) Calculate the solubility of PbSO_4 in mol dm^{-3} ($K_{\text{sp}} = 1.6 \times 10^{-8} \text{ mol}^2 \text{ dm}^{-6}$).

b) The solubility of Ag_2CO_3 is $1.2 \times 10^{-4} \text{ mol dm}^{-3}$; calculate the K_{sp} value.

