Additional Material for Salts and Solubility

Calculations: Solubility and Solubility Product

$NaCl \rightleftarrows Na^+ + Cl-$

Solubility = S S

Number of Sodium ions at saturation = S, S = 180
Number of Chloride ions at saturation = S, S = 180

Volume of water in the container = $5x\ 10^{-23}$ L

Mol wt of NaCl = 58.5

Avogadro number = 6.02×10^{23}

Wt. of Avogadro number of molecules = Mol wt.

Amount of NaCl dissolved in the water container with 100 ml water =

$\{(180/6.023x10^{23} \times 58.5 \times 0.1)/(5.0x10^{-23})\}$ = 35 gms in 100 ml

Details of calculation of Molar solubility and Ksp for NaCl:

$180/\ 6.023x10^{23} = 2.988 \times 10^{-22}$
$2.988 \times 10^{-22} \times 58.5 = 1.748 \times 10^{-20}$
$1.748 \times 10\text{-}^{20} \times 0.1 = 1.748 \times 10^{-21}$
$1.748 \times 10^{-21} / 5.0x10^{-23} = 34.96$

Molar Solubility = (Wt. of the salt/Mol.wt) x (1000/Vol)

Molar Solubility = 35/58.5 x 1000/100 = 5.989 = 6 M

Solubility product of NaCl, $K_{sp} = S^2 = 6 \times 6 = 36$

Details of calculation of Molar solubility and K_{sp} for Strontium Phosphate:

$Sr_3(PO_4)_{2\,(s)}$ ⇄ $3Sr^{2+}_{(aq)} + 2PO_4^{3-}_{(aq)}$

Solubility = 3S 2S

Number of strontium ions at saturation (3S) = 45, S = 15

Number of Phosphate ions at Saturation (2S) = 30, S = 15

Volume of water in the container = $1x\ 10^{-16}$ L

Mol.wt of $Sr_3(PO_4)_2$ = 452.8
Avogadro number = 6.02×10^{23}

Amount of $Sr_3(PO_4)_2$ dissolved in the water container with 100 ml water =
$\{(15/6.023x10^{23} \times 452.8 \times 0.1)/(1x10^{-16})\} = 1.13 \times 10^{-5}$ gms in 100 ml

Details of calculation of Molar solubility and Ksp for $Sr_3(PO_4)_2$:

$15/\ 6.023x10^{23} = 2.49 \times 10^{-23}$
$2.49 \times 10^{-23} \times 452.8 = 1.127 \times 10^{-20}$
$1.127 \times 10\text{-}^{20} \times 0.1 = 1.127 \times 10^{-21}$
$1.127 \times 10^{-21} / 1.0x10^{-16} = 0.0000112 = 1.13 \times 10^{-5}$ grams in 100 mL

Molar Solubility (S) = (Wt. of the salt/Mol.wt) x (1000/Vol)

Molar Solubility (S) = $.13 \times 10^{-5}/452.8 \times 1000/100$
$=2.49 \times 10^{-7}$ M

Solubility Product of Strontium Phosphate = $\mathbf{108S^5}$
$= 108 \times (2.49 \times 10^{-7})^5$
$= 1.0 \times 10^{-31}$

Table 1.0

S. No	Name of the salt	Mol.Wt	No. of cations at saturation	No. of anions at saturation	Solubility in 100 mL	Solubility in moles/L
1	Sodium Chloride	58.44	180	180	35 gm	6 M

Table 1.1

S.No	Name of the salt	Solubility Product (K_{sp}) expression S is Solubility	Solubility in moles/L	Solubility Product (K_{sp})
1	Sodium Chloride	S^2	6	36

Table 2.0

S.No	Name of the salt	Mol.Wt	No. of cations at saturation	No. of anions at saturation	Solubility in 100 mL	Solubility in moles/L
1	Sodium Chloride NaCl	58.44	180	180	35 gm	6 M
2	Strontium Phosphate $Sr_3(PO_4)_2$	452.8	45	30	1.13×10^{-5}	2.5×10^{-7}

Table 2.1

S.No	Name of the salt	Solubility Product (K_{sp}) expression S is Solubility	Solubility (S) in moles/L	Solubility Product (K_{sp})
1	Sodium Chloride	S^2	6	36
2	Strontium Phosphate $Sr_3(PO_4)_2$	$(3S)^3(2S)^2 = 108S^5$	2.5×10^{-7}	1×10^{-31}

Table 2.2

S.No	Name of the salt	Solubility Product (K_{sp}) expression S is Solubility	Solubility (S) in moles/L	Solubility Product (K_{sp})
1	**Silver Bromide**			
2	**Thalium(I) Sulfide**			
3	**Copper(I) Iodide**			
4	**Silver Arsenate**			
5	**Mercury(II) Bromide**			

Le Chatelier’s principle:

Le Chatelier's principle states that change in any one of the parameters such as temperature, pressure, concentration of the reactants, will cause the equilibrium to shift in a direction to reduce the effect of the change. After the change is counteracted the equilibrium will be reestablished.

Suppose an equilibrium is established between four substances A, B, C and D.

$A + B \leftrightarrow C + D$

What would happen if we change the concentration of A or B?

According to Le Chatelier, the position of equilibrium will move in such a way as to counteract the change. That means that the position of equilibrium will move so that the concentration of A or B decreases as they react with each other and form C and D. The position of equilibrium moves to the right.

Also if formed C and D are more reactive than A and B, the reverse reaction will occur.

A very good example of a reversible reaction is formation of ammonia using Haber’s process.

$N_2 + 3H_2 \leftrightarrow 2NH_3$

The forward reaction is exothermic but it is difficult to start the reaction between nitrogen and hydrogen as nitrogen is an inert gas.

We apply **Le Chatelier's principle** for the manufacture of Ammonia. Increase in the concentration of Hydrogen gas and increase in pressure favours the forward reaction.