B.Sc. (Honours) Part-I
Paper-IA
Topic: Common Ion Effect
UG
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Common Ion Effect

- The common-ion effect is used to describe the effect on an equilibrium involving a substance that adds an ion that is a part of the equilibrium. Adding a common ion prevents the weak acid or weak base from ionizing as much as it would without the added common ion. LeChatelier's Principle states that if an equilibrium gets out of balance it will shift to restore the balance. If a common ion is added to a weak acid or weak base equilibrium, then the equilibrium will shift towards the reactants, in this case the weak acid or base.
- Whenever a solution of an ionic substance comes into contact with another ionic compound with a common ion, the solubility of the ionic substance decreases significantly. For example, this would be like trying to dissolve solid table salt (NaCl) in a solution where the chloride ion (Cl^-) is already present. The amount of NaCl that could dissolve to reach the saturation point would be lowered. This phenomenon is the common ion effect and plays important roles in pharmaceutical and environmental areas. The common ion effect can be explained by Le Chatelier's principle of chemical equilibrium:
- The solubility products K_{sp}'s are equilibrium constants in hetergeneous equilibria (i.e., between two different phases). If several salts are present in a system, they all ionize in the solution. If the salts contain a common cation or anion, these salts contribute to the concentration of the common ion. Contributions from all salts must be included in the calculation of concentration of the common ion. For example, a solution containing sodium chloride and potassium chloride will have the following relationship:

$$[Na+]+[K+]=[Cl-](1)(1)[Na+]+[K+]=[Cl-]$$

Consideration of charge balance or mass balance or both leads to the same conclusion.

Common Ions

When NaCl and KCl are dissolved in the same solution, the $Cl^-$$Cl^-$ ions are *common* to both salts. In a system containing NaCl and KCl, the $Cl^-$$Cl^-$ ions are common ions.

$$NaCl \rightleftharpoons Na^+ + Cl^- NaCl \rightleftharpoons Na^+ + Cl^-$$
$$KCl \rightleftharpoons K^+ + Cl^- KCl \rightleftharpoons K^+ + Cl^-$$
$$CaCl_2 \rightleftharpoons Ca^{2+} + 2Cl^- CaCl_2 \rightleftharpoons Ca^{2+} + 2Cl^-$$
$$AlCl_3 \rightleftharpoons Al^{3+} + 3Cl^- AlCl_3 \rightleftharpoons Al^{3+} + 3Cl^-$$
$$AgCl \rightleftharpoons Ag^+ + Cl^- AgCl \rightleftharpoons Ag^+ + Cl^-$$

For example, when AgCl is dissolved into a solution already containing NaCl (actually Na^+Na+ and $Cl^-$$Cl^-$ ions), the $Cl^-$$Cl^-$ ions come from the ionization of both AgCl and NaCl. Thus, $[Cl^-][Cl^-]$ differs from $[Ag^+][Ag^+]$. The following examples show how the concentration of the common ion is calculated.

Effect Common Ion:

- The role that the common ion effect plays in solutions is mostly visible in the decrease of solubility of solids. Through the addition of common ions, the solubility of a compound generally decreases due to a shift in equilibrium.
- The common ion effect also plays a role in the regulation of buffers. Buffering solutions contain either an acid or base, accompanied by its conjugate counterpart. Addition of more like conjugate ions will ultimately shift the pH of the solution.
- The common ion effect must be taken into consideration when determining solution equilibrium upon addition of ions that are already present in the solution.
- The common ion effect can be used to obtain drinking water from aquifers (underground layer of water mixed with permeable rocks or other unconsolidated materials) containing chalk or limestone.

Sodium carbonate (chemical formula Na_2CO_3) is added to the water in order to decrease the hardness of the water.

- In the treatment of water, the common ion effect is used to precipitate out the calcium carbonate (which is sparingly soluble) from the water via the addition of sodium carbonate, which is highly soluble.
- A finely divided calcium carbonate precipitate of a very pure composition is obtained from this addition of sodium carbonate. The $CaCO_3$ precipitate is, therefore, a valuable by-product which can be used in the process of manufacturing toothpaste.
- Since soaps are the sodium salts of carboxylic acids containing a long aliphatic chain (fatty acids), the common ion effect can be observed in the salting-out process which is used in the manufacturing of soaps. The soaps are precipitated out by adding sodium chloride to the soap solution in order to reduce its solubility.