Chemistry 101 Laboratory
Fall 2005 - 2006

Lecture 9

Solubility as a Function of Temperature

Purpose

- To determine the solubility of oxalic acid ($H_2C_2O_4$) in water at three different temperatures by titrating saturated solutions of the acid with a ***standard*** solution of NaOH.

Equation Involved and Calculations

$$H_2C_2O_{4(aq)} + 2NaOH_{(aq)} \longrightarrow Na_2C_2O_{4(aq)} + 2H_2O_{(l)}$$

Moles of $H_2C_2O_4$ = moles of NaOH / 2

Moles of $H_2C_2O_4$ = (M x V) NaOH / 2

Mass of $H_2C_2O_4$ = mol $H_2C_2O_4$ x 90.04 g/mol

$$\textbf{Solubility of oxalic acid (g/100 mL)} = \frac{\textbf{g oxalic acid}}{\textbf{mL oxalic acid}} x\,100$$

Solubility

- The maximum amount of solute that can be dissolved in a given quantity of solvent at a specific temperature.

  Therefore it is the concentration of solute in a saturated solution.

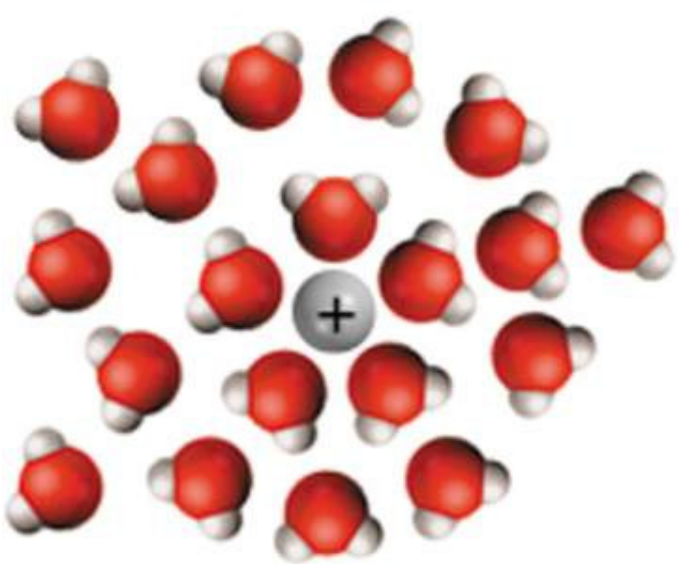
- ***Units:*** ***g/100 mL*** (g of solute/100 mL of solution

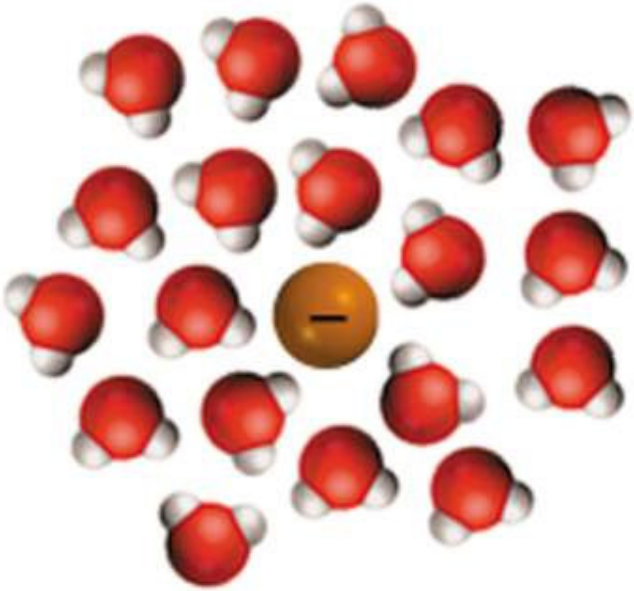
  moles/L (moles of solute/liter of solution)

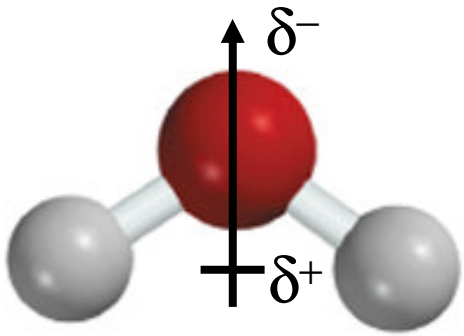
Hydration

Example: $NaCl_{(s)} \xrightarrow{H_2O} Na^+_{(aq)} + Cl^-_{(aq)}$

Hydration is the process in which an ion is surrounded by water molecules arranged in a specific manner.







H_2O

Heat of solution: $\Delta H_{(sol)}$

- Heat of solution, $\Delta H_{(sol)}$, is the heat generated or absorbed when a certain amount of solute dissolves in a certain amount of solvent.

- $\Delta H_{(sol)}$ is positive for endothermic (heat absorbing) processes and negative for exothermic (heat generating) processes.

Heat of solution: $\Delta H_{(sol)}$(cont'd)

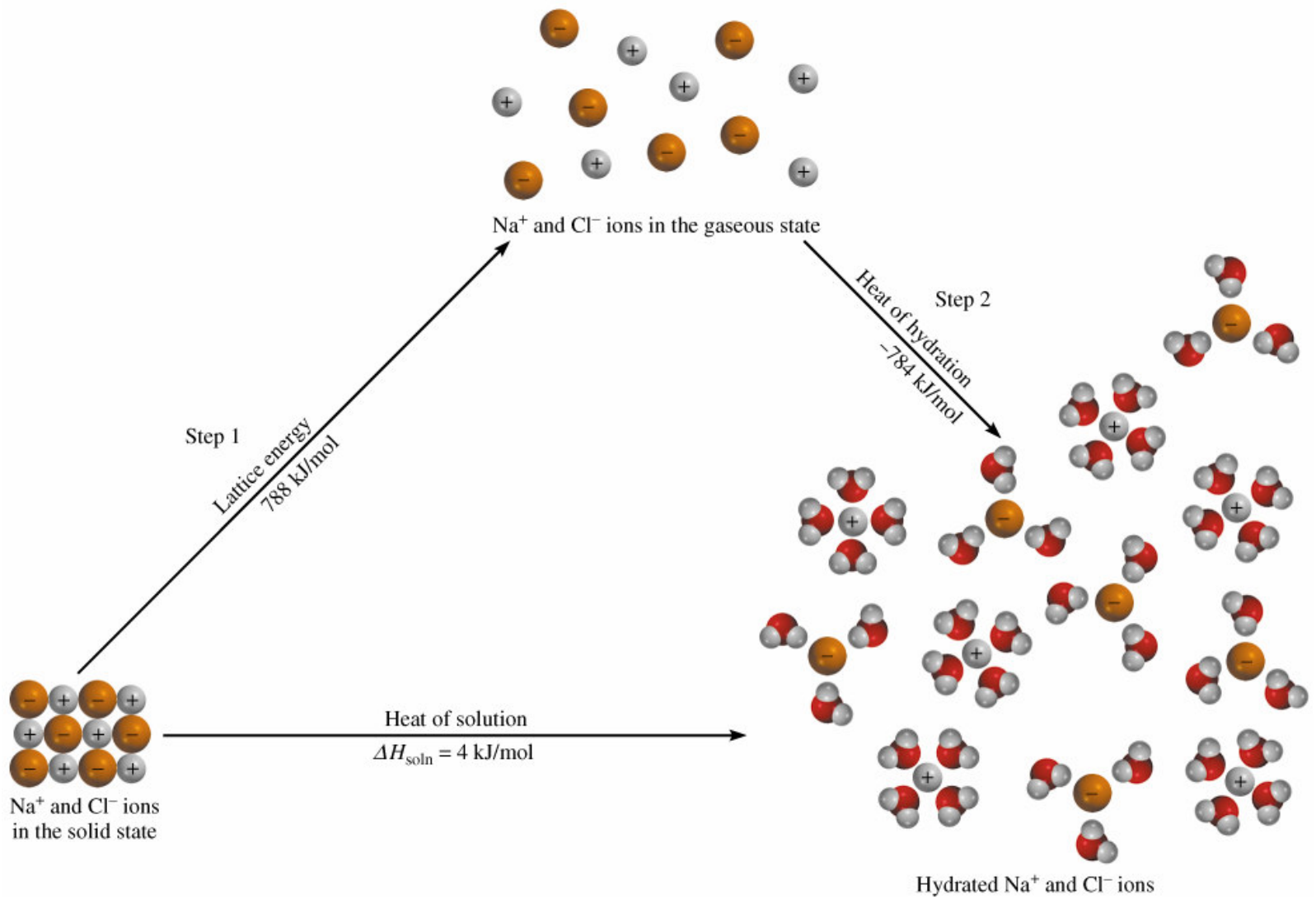
$\Delta H_{(sol)}$ = lattice energy + hydration energy

$\Delta H(sol) = L.E + H.E$

- ***Lattice energy (L.E)*: energy needed to separate one mole of a solid ionic compound into gaseous ions.**

- ***Hydration energy (H.E):*** energy released when an ion is surrounded by water molecules in a specific manner.

The Solution Process for NaCl



ΔHsoln = Step 1 + Step 2 = 788 – 784 = 4 kJ/mol

Conclusion

$$\Delta H(sol) = L.E + H.E$$

- **If H.E is greater than L.E**, energy is **released** and the solution process is exothermic.

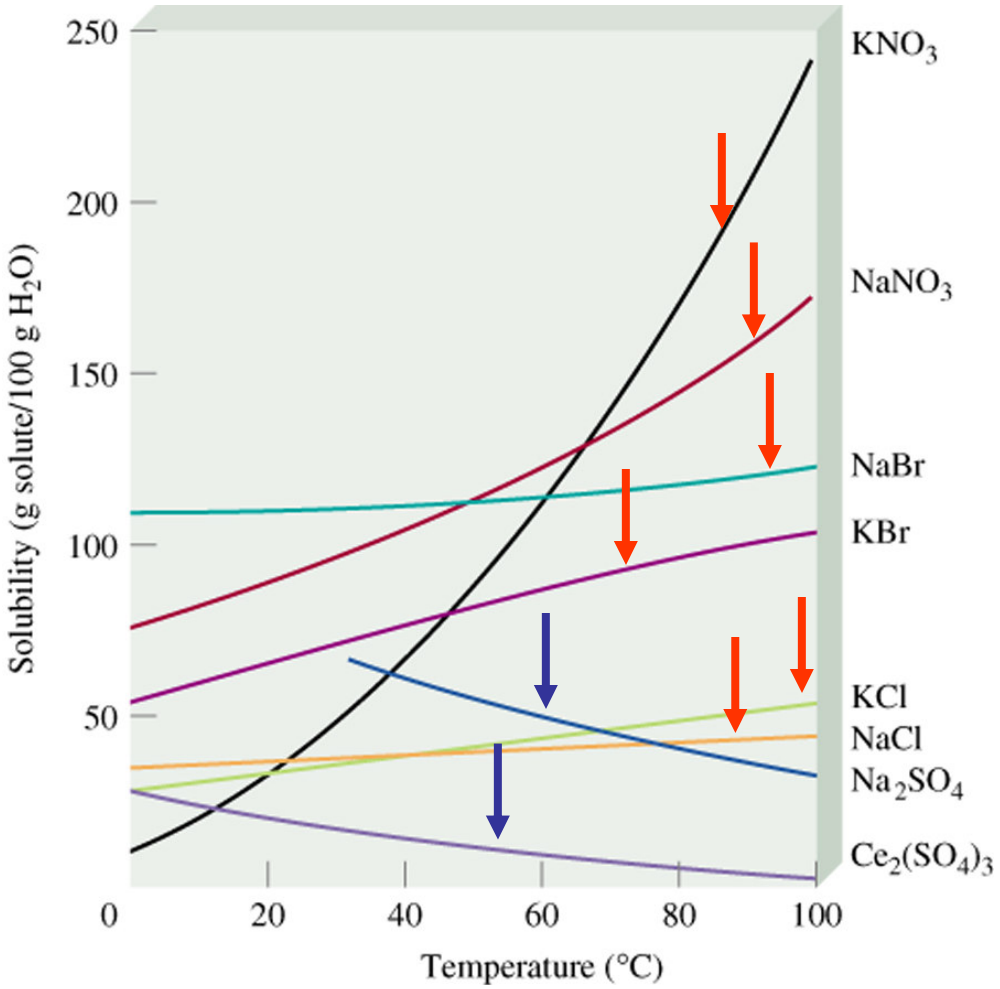
  Therefore solubility decreases with an increase in temperature.

- **If L.E is greater than H.E**, energy is **absorbed** and the solution process is endothermic.

  Therefore solubility increases with an increase in temperature.

Temperature and Solubility

Solid solubility and temperature



solubility decreases with increasing temperature

Experiment

- Find the solubility of oxalic acid (g/100mL) at three different temperatures.

- A saturated solution of oxalic acid at room temperature will be provided.

a- Solubility at room temperature

- Get 20 mL of the saturated oxalic acid solution.
- Measure the temperature.
- Pipet 10 mL of the above solution into an Erlenmeyer flask and titrate against NaOH using phenolphthalein indicator

b- Solubility at 0˚C

i - Preparation of a saturated solution at 0˚C:

- Transfer to a large test tube 20 mL of the provided saturated oxalic acid solution and 10 mL of distilled water.
- Cool the test tube in 400 mL beaker containing ice.
- Stir and wait.
- Measure the temperature (should be around 0˚C).

ii -Titration:

- Pipet 10 mL of the above saturated solution carefully (leaving the solid behind) into an Erlenmeyer flask.
- Add 2 drops of phenolphthalein and titrate against NaOH.

c- Solubility at 40˚C

i- preparation of a saturated solution at 40˚C:

- Prepare water bath at 50˚C using 400 mL beaker.
- Transfer 30 mL of the sat. oxalic acid to the large test tube.
- Place the test tube in the water bath.
- Add solid oxalic acid while stirring till no more dissolves.
- Maintain the temperature around 40˚C (add cold water).
- Measure the temperature.
- Decant 10 mL into a graduated cylinder, add 30 mL of water and homogenize.

ii- Titration:

- Pipet 10 mL of the above homogenized solution and titrate against NaOH using phenolphthalein indicator.
- Read the volume of NaOH and multiply by 4.