Thermochemistry

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Aim:- To determine the ΔG, ΔH and ΔS of the Pottassium nitrate (KNO_3) dissolving reaction by measuring the equilibrium Constant (ksp) at different temparatures and using vant Hoffs equation.

Procedure:-

1. About 30g of KNO_3 Salt is accurately weighed in a clean and dry boiling Testtube. Exactly 30ml of deionized water is added and heated in a water bath to dissolve the salt completely for a clear solution.

2. The solution is allowed to cool with smooth mixing and the temperature (T_1) at which fine crystals start to appear in solution is noted

3. Then exactly 2ml of water is added, mixed well and warmed to get clear solution. Allowed to cool with gentle mixing to find the temperature (T_2) at which the fine crystals start to appear. This process is repeated 4 times to get T_3, T_4, T_5 and T_6. The mass of KNO_3, temperature and volume data are tabulated.

4. The mass of KNO_3 taken remains constant whereas the volume varies from 30, 32, 34, 36, 38 and 40ml with respective saturation temperatures varying from $T_1, T_2, T_3, T_4, T_5, T_6$

5. The equal molar concentrations of $[K^+]$ and $[NO_3^-]$ are calculated as:

$$[K^+] = [NO_3^-] = \frac{\text{mass of } KNO_3}{101.1032} \times \frac{1000}{\text{Sol}^n \text{ volume}} \text{ mol/L}$$

6. Then the equilibrium constant is calculated as,

$$K_{sp} = [K^+][NO_3^-]$$

Observations and calculations:-

Mass of KNO_3 = 30.81g.

Solution Vol. mL	Saturation temp, T(K)	Molarity. M (mol/L)	Ksp	1/T
30	332	10.15826733	103.1903951	0.003012048
35	326	8.707086281	75.81335151	0.003067485
40	321	7.618700496	58.04459725	0.00315265
45	317	6.772178219	45.86239783	0.003154574
50	313	6.094960397	37.14854224	0.003194888
55	310	5.540873088	30.70127458	0.003225806

ln ksp
4.636575778
4.328274418
4.061211633
3.825645562
3.614924531
3.424304171

$\Delta H = -\text{Slope} \times R$

$\text{Slope} = (y_2 - y_1)/(x_2 - x_1)$

$$= \frac{(4.636 - 3.424)}{0.00301 - 0.00322}$$

$= -5.67123$

$\Delta H = -(-5.67123) \times 0.008314$

$\Delta H = 47.1$ KJ/mol

$\Delta S = -\text{intercept} \times R$

$= (4.636 - 3) \times 0.008314$

$= 1.36 \times 10^{-2}$ KJ/mol.

$$\Delta G = \Delta H - T\Delta S$$

$$= 47.1 - (273) \times (1.36 \times 10^{-2})$$

$$= 43.58 \text{ KJ/mol.}$$

Result:

The thermodynamic Parameters for dissolution of KNO_3 in water are; $\Delta H = 47.1$ KJ/mol, $\Delta S = 1.36 \times 10^{-2}$ KJ/mol, $\Delta G = 43.38$ KJ/mol

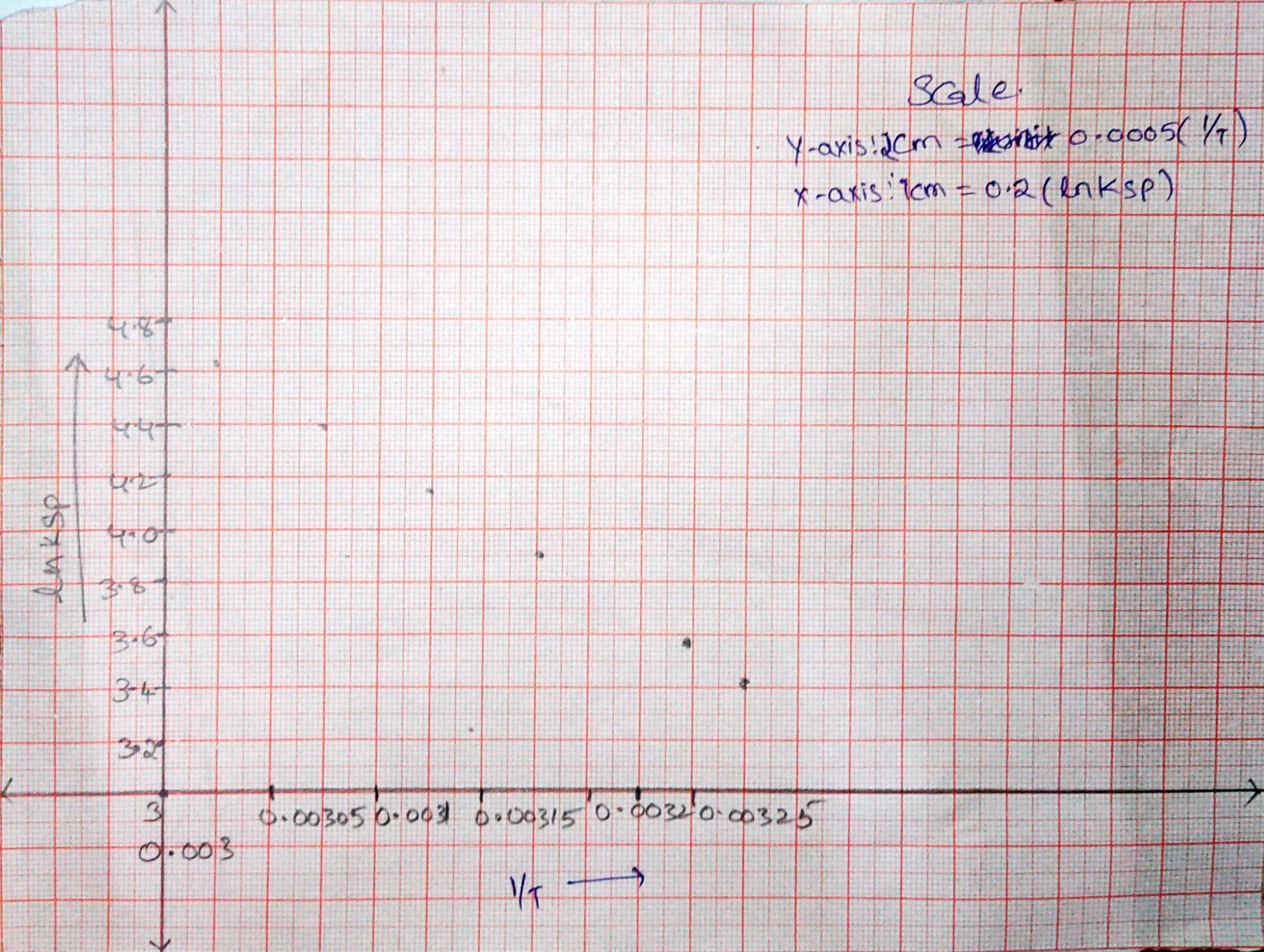
Questions:

1 (A) There is an entropy charge associated with formation of a Solution, an increase in entropy that thermodynamically favors the Solution over the two original States. If the other energetics of dissolution are favourable, this increase in entropy means that means the Condition for Solubility will always be met

2 (A) The entropy is decreased because a gas is becoming a liquid. The entropy is increasing because a gas is being proceded and the number of molecules is increasing. The entropy is decreasing because four total reactant molecules are forming two total product molecules

3 (A) The maximum Product of the ionic Concentrations or activities of an electrolyte that at one temperature can Continue in equillibrium with the undissolved Phase.

The greater the solubility product constant, the more soluble is the compound.


Scale.
Y-axis: 2cm = 0.0005 (1/T)
X-axis: 1cm = 0.2 (ln Ksp)
ln Ksp
4.8
4.6
4.4
4.2
4.0
3.8
3.6
3.4
3.2
3
0.003
0.00305
0.0031
0.00315
0.0032
0.00325
1/T