CB101: Experiment 3: Determination of equilibrium constant of a reaction by solubility method:

$$K=\frac{\left(C_2-C_1\right)\times C_0}{\left(C-\left(C_2-C_1\right)\right)\times C_1}$$

I- INTRODUCTION

When an excess of solid iodine is shaken with a solution of KI, one part combines with KI to form the complex KI_3, another part simply remains dissolved in water as free iodine and the third part remains as undissolved solid residue: $KI + I_2 \rightleftharpoons KI_3$

The equilibrium constant of this reaction is given by: $K=\frac{C_{KI_3}\times C_0}{C_{KI}\times C_{I_2}}$

<u>Objective:</u> Determine the equilibrium constant of this reaction

<u>To do so:</u>

1) Determine by iodometric titration the concentration C_1 of a saturated solution of iodine (I_2). This is the concentration of only free iodine.

2) Determine by iodometric titration the concentration C_2 of iodine in a saturated solution in the presence of KI potassium iodide with initial concentration C. It corresponds to the free iodine I_2 + the iodine transformed into KI_3 thanks to the presence of KI.

3) Calculating the equilibrium constant from those result :

$$K=\frac{\left(C_2-C_1\right)\times C_0}{\left(C-\left(C_2-C_1\right)\right)\times C_1}$$ and compare with theoritical value.

II- PRELIMINARY WORK

a) Read carefully the procedure, and make the preliminary calculation(s).

b) The equilibrium constant is given by: $K=\frac{C_{KI_3}\times C_0}{C_{KI}\times C_{I_2}}$.

Given : C_1 the saturated concentration of free iodine (I_2), and C_2 the saturated concentration of iodine in the form of I_2 and KI_3 , due to the presence of a solution KI of concentration C. C_0 is a normalization constant equal to 1 mol/L, so the constant K is unitless. Show that the equilibrium constant can be calculated from those three values with the relation:

III- PROCEDURE

<u>Chemicals required</u>:

- Solid iodine
- Solid potassiu  li 
- Sodium thiosulfate $Na_2S_2O_3$
- Starch solution

<u>Apparatus and laboratory glassware required:</u> See appended.

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To be prepared:

- Solution 1: 100 mL of a saturated solution of iodine I_2:

An excess of solid iodine (about 3 crystals) is crashed and taken in a reagent bottle. 100 mL of distilled water is added. This bottle is vigorously shaken for 30 min to attain saturation in iodine concentration. It has to remain undissolved solid iodine to make sure that the solution is saturated. It is then allowed to stand for 5 min to settle the undissolved solid iodine.

- Solution 2: 100 mL of saturated solution of iodine in presence of potassium iodide KI:

An excess of solid iodine (about 5 crystals) is crashed and taken in a reagent bottle. 100.0 mL of a 0.010 mol/L solution of KI is carefully prepared and added. This bottle is vigorously shaken for 30 min to attain equilibrium between dissolved I_2 and KI. It has to remain undissolved solid iodine to make sure that the solution is saturated. It is then allowed to stand for 5 min to settle the undissolved solid iodine.

Iodometric titration procedure to determine concentration of iodine of both solutions:

250.0 mL of sodium thiosulfate solution $Na_2S_2O_3$ 0.0050 mol.L^{-1} is carefully prepared.

10 mL of solution 1 is taken in a conical flask and titrated with a sodium thiosulfate solution $Na_2S_2O_3$ of concentration 0.0050 mol.L^{-1} with magnetic stirrer on. When the colour becomes very light yellow, just before the end point, few drops of starch solution (indicator) is added to have a significant blue colour (don't add too much!). At the end point the colour turns from blue to colourless.

Titration reactions: $I_2 + 2S_2O_3^{2-} \longrightarrow 2I^- + S_4O_6^{2-}$

and $I_3^- + 2S_2O_3^{2-} \longrightarrow 3I^- + S_4O_6^{2-}$

I_2 form a blue complex with starch solution. I^-, $S_2O_3^{2-}$ and $S_4O_6^{2-}$ are colourless.

- Calculate the concentration of iodine I_2 in solution 1 (C_1) and 2 (C_2). Calculate the constant of equilibrium K.

- Calculate the theoretical constant of equilibrium: K is related to the free Gibbs energy of the reaction with the relation: $K = e^{\frac{-\Delta_r G^o}{RT}}$

where T is the temperature in Kelvin, R is the gas constant (R=8.314 J.K^{-1}.mol^{-1}) and $\Delta_r G^o$ is obtained subtracting the sum of the free energy of reactants from the sum of the free energy of products.

Chemical specie	I_2	KI	KI_3
$\Delta_f G^O$ (kJ/mol)	16.40	-51.57	-51.4

APPENDED :

Apparatus and glassware required :

- glass watch
- Burette on stand
- 500 mL beaker
- 250 mL volumetric flask
- two 250 mL beakers
- funnel
- dropper
- mortar and pestle
- 100 mL Conical flask
- 100 mL volumetric flask
- spatula
- 2 stoppered bottles