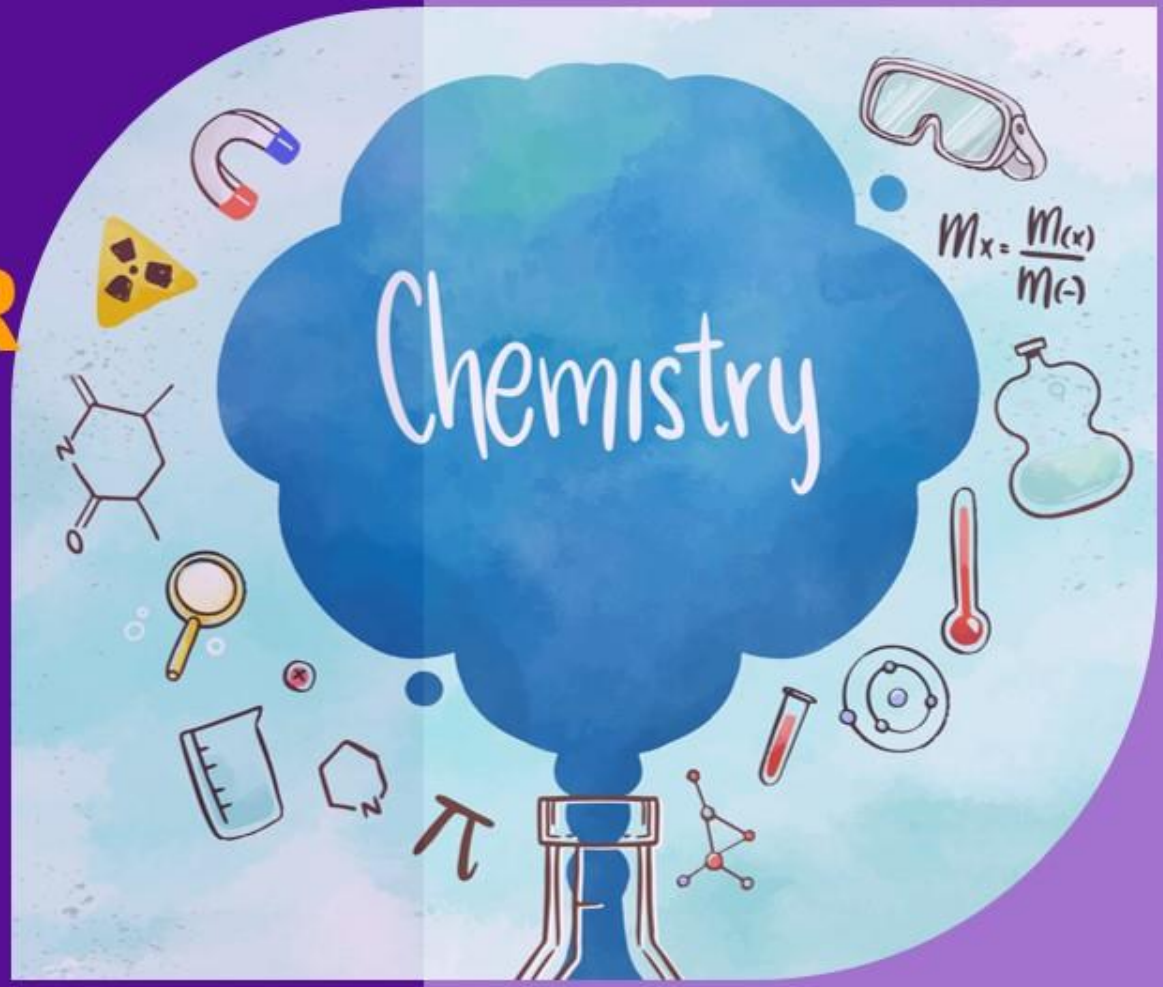
CLASS 11 ACADEMIC PROGRAM 2020

CHEMISTRY 1ST PAPER

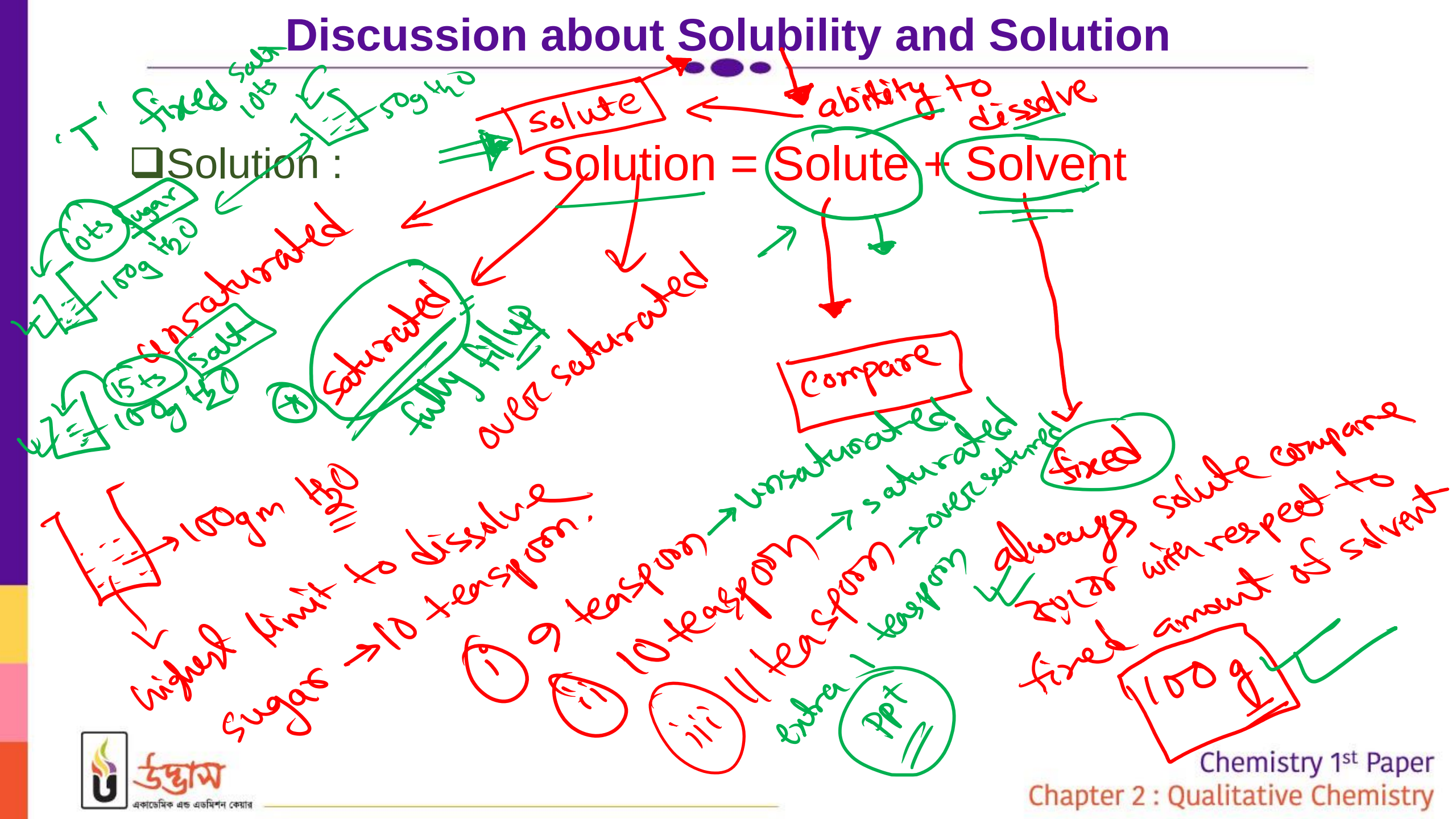
LECTURE : C-05

CHAPTER 2 : QUALITATIVE CHEMISTRY



Discussion about Solubility and Solution

- Solution :



Discussion about Solubility and Solution

- **Solubility:**

  In a saturated solution, the concentration of the solute is called the solubility of that solute.

  Or, the maximum amount of solute that can be dissolved in 100g solvent at a particular temperature to give saturated solution that amount is called the solubility of the solute in that solvent at that temperature.

Solution → saturated
solvent → 100g T' fixed
solute = solubility

at 25°c, solubility of NaCl is 40.

solute = 40g
solvent = 100g
∴ solution = (100+40)g
= 140g

at 30°c, solubility of KCl is 30.
↳ solute = 30 g
solvent = 100 g
solution = 130g

Poll question-01

- If solubility of a compound is 60 then what is the amount of solute and solution ?

(a) Solute 60 g & solution 160 g

(b) Solute 50 g & solution 250 g

(c) Solute 50 g & solution 150 g

(d) Solute 60 g & solution 150 g

solute = 60g

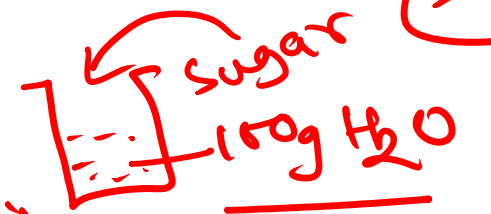
solvent = 100g

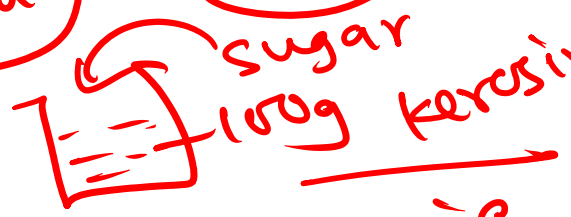
∴ solution = 160g

Dependency of Solubility

i. The Nature of the Solute →

ii. Nature of Solvent





like dissolves like → organic → organic
inorganic → inorganic

iii. Temperature ↘ next slide

iv. Stress → Co Cola → sealed → Pressure ↑↑ → more CO_2 is dissolved

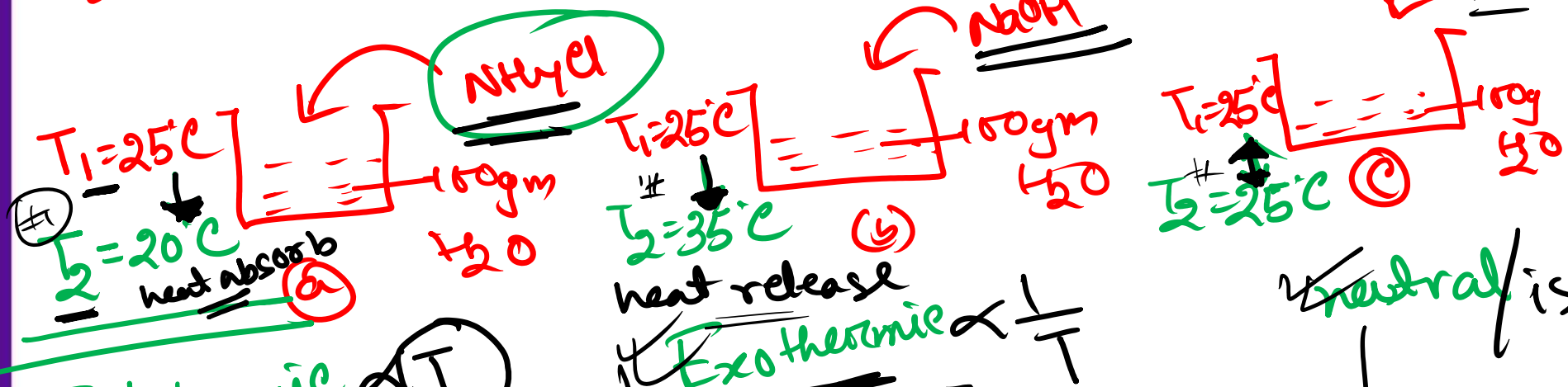
seal off → Pressure ↓ → less CO_2 is dissolved

∴ Pressure ∝ Solubility

Dependency of Solubility

T_1 = Temperature before adding solute — Temperature

T_2 = " after " "



Endothermic $\propto T$

T ↑ reaction forward,
more soluble/dissolve
∴ solubility ↑
$T \propto$ solubility

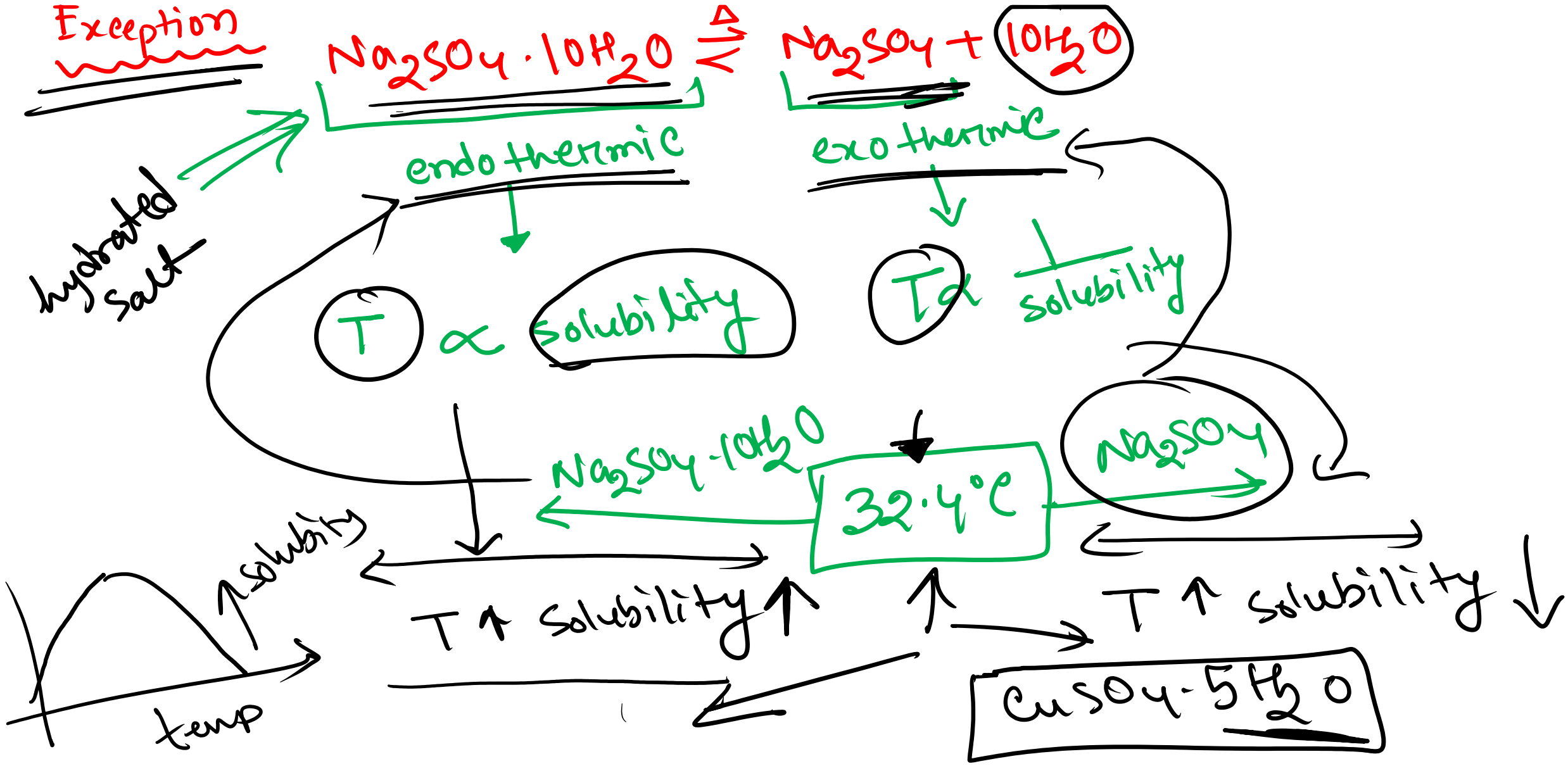
Exothermic $\propto \frac{1}{T}$

T ↑ reaction backward,
less dissolve/soluble
∴ solubility ↓
→ $T \propto \frac{1}{\text{solubility}}$ (*)

~~Neutral~~ / isothermic $\neq T$

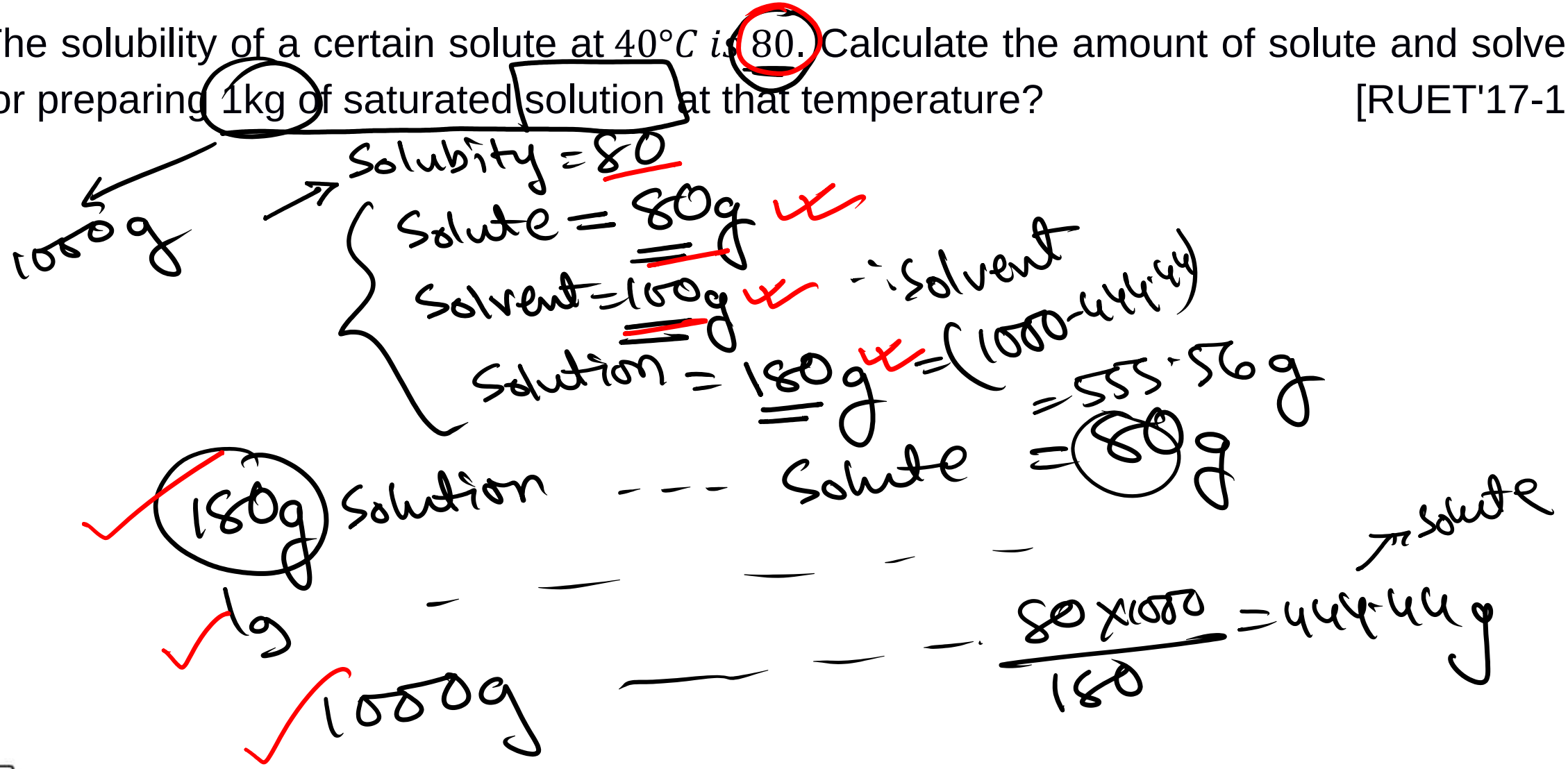
no 'T' effect

no effect of 'T' in solubility.


Exception
$Na_2SO_4 \cdot 10H_2O \rightleftharpoons Na_2SO_4 + 10H_2O$
hydrated salt
endothermic
exothermic
T ∝ solubility
T ∝ 1/solubility
$Na_2SO_4 \cdot 10H_2O$
32.4°C
Na_2SO_4
solubility
temp
T ↑ solubility ↑
T ↑ solubility ↓
$CuSO_4 \cdot 5H_2O$

Mathematical Problems

- The solubility of a certain solute at $40°C$ is 80. Calculate the amount of solute and solvent for preparing 1kg of saturated solution at that temperature? [RUET'17-18]



Mathematical Problems

Unitary

At 25°C, solubility of KCl = 80

To prepare 2kg saturated solution, what will be the solute and solvent's quantity?

Solute = 80g
Solvent = 100g
∴ Solution = 180g

∴ 180g solution → Solute = 80g

1g " = $\frac{80}{180}$

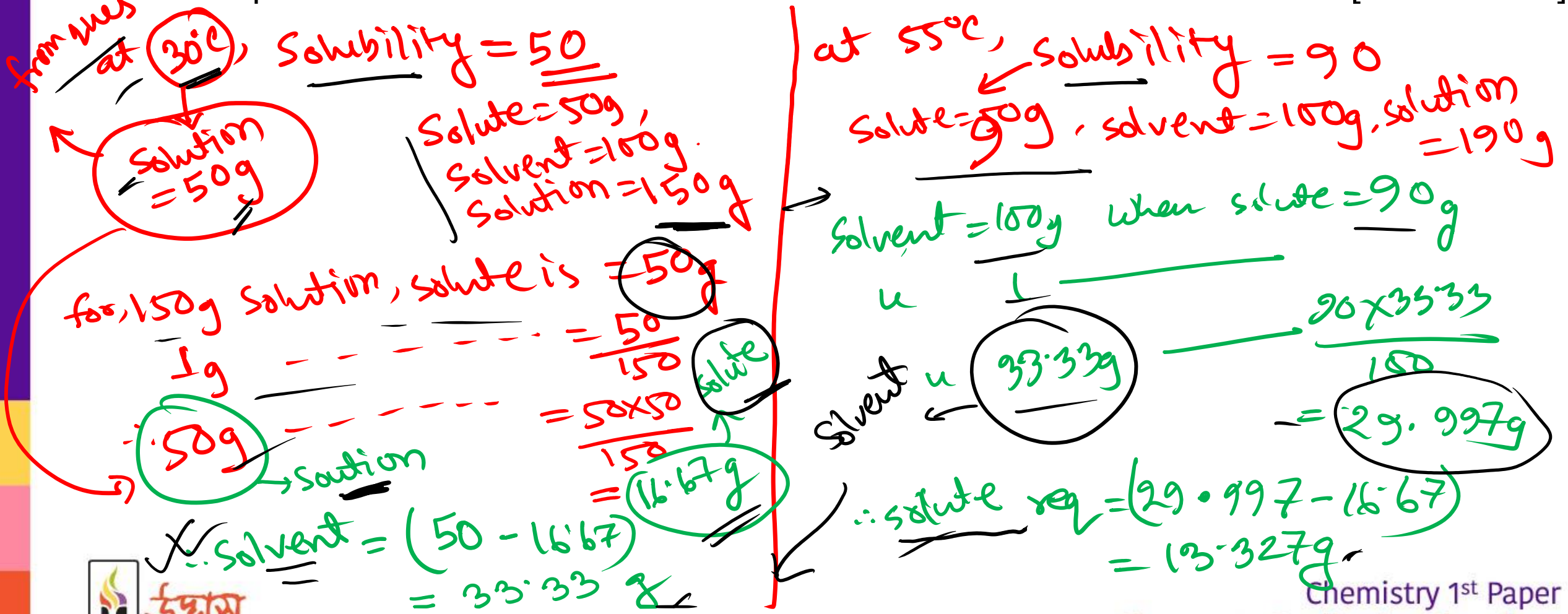
2000g " = $\frac{80 \times 2000}{180}$ = 888.88g

∴ Solvent = (2000 − 888.88)
= 1111.11g

Mathematical Problems

we will always compare with respect to solvent's quantity

➢ The solubility of a solute at $30°C$ & $55°C$ temperatures are respectively 50 & 90. 50g solution at $30°C$ temperature is raised to $55°C$ temperature. How many gram excess solute will be required to saturate the solution in this condition? [KUET'17-18]



Mathematical Problems

(*) The solubility of KCl at 20°C and 80°C is respectively 30 and 90. 200g solution at 20°C is formed. It is now heated to 80°C, what quantity of solute is needed for forming saturated solution?

at 20°C → 200g solution

solubility = 30

∴ solute = 30g, solvent = 100g, solution = 130g

130g solution — solute = 30g

200g → $\frac{30 \times 200}{130}$ = 46.15g

∴ Solvent = (200 − 46.15) g = 153.85g

at 80°C, solubility = 90

{solute = 90g, solvent = 100g} solution = 190g

100g solvent, solute = 90g

153.85g → $\frac{90 \times 153.85}{100}$ = 138.465g

∴ excess solute = (138.465 − 46.15) = 92.315g Ans

Mathematical Problems

Mathematical Problems

Poll question -2

- The solubility of a certain solute at $40°C$ is 50. Calculate the amount of solute for preparing 300g of saturated solution at that temperature?

(a) 100g

(b) 200g

(c) 300g

(d) 400g

Solubility = 50

solute = 50

solvent = 100

∴ solution = 150

∴ 150g ---- 50

1 ---- $\frac{50}{150}$

2 ---- $\frac{50 \times 300}{150} = 100g$

300

Mathematical Problems

- At 85°C temperature definite mass of KCl is dissolved in 250g water to produce saturated solution. If this solution is cooled to 20°C temperature then how much of KCl will be precipitated? The solubility of KCl at 85°C & 20°C temperatures are respectively 53.5 & 34.0.

at 20°C, Solubility = 34
Solvent = 100
Solute = 34
Solution = 134

Solvent = 100 ⟶ Solute = 34

250 ⟶ $\frac{34 \times 250}{100}$ = 85g

∴ ppt = (133.75 − 85) = 48.75g

at 85°C, Solubility = 53.5
Solvent = 100
Solute = 53.5
Solution = 153.5

Solvent = 100g = Solute = 53.5g

250g = $\frac{53.5 \times 250}{100}$ = 133.75g

Solvent was given directly

Mathematical Problems

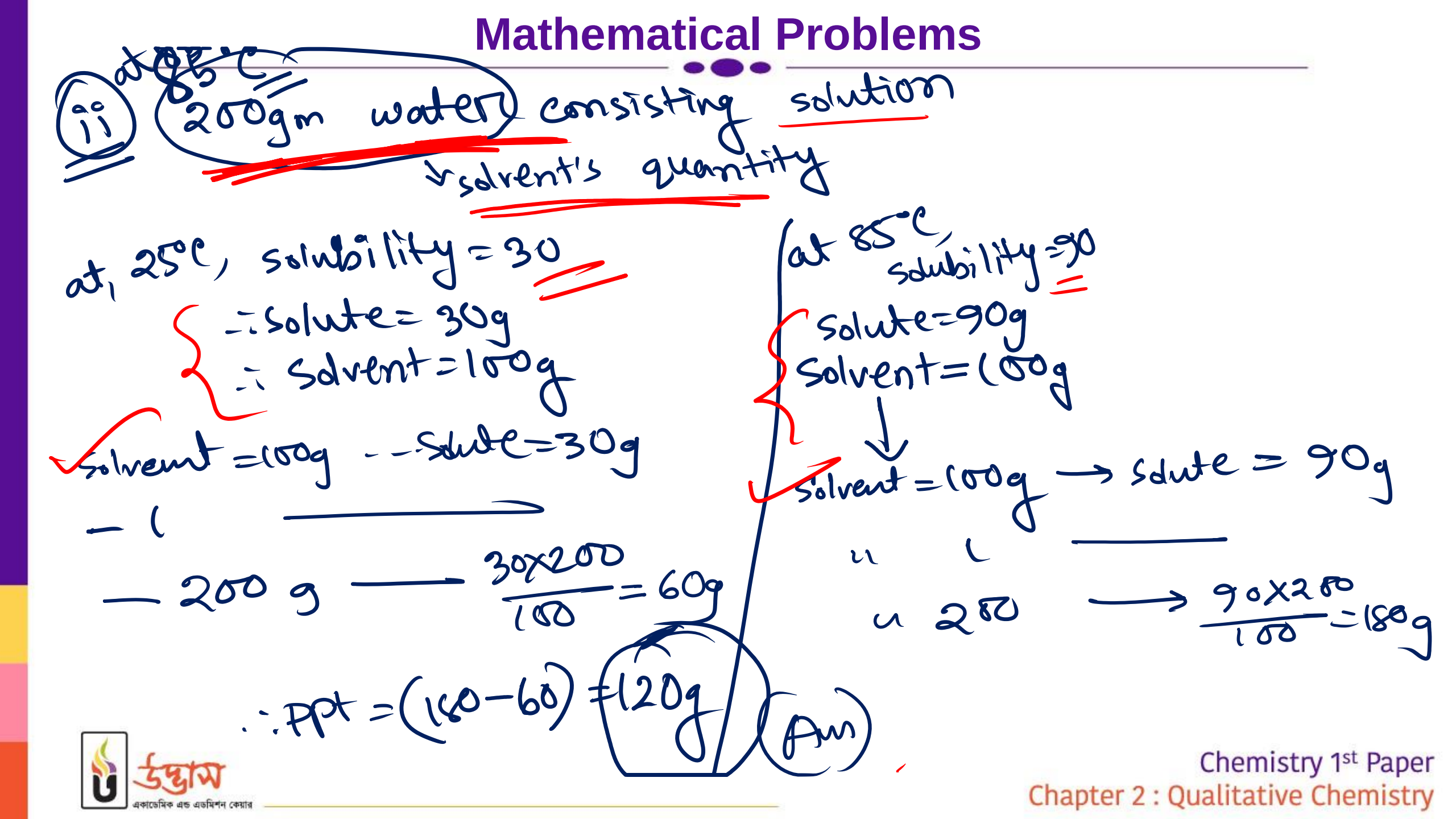
(*) At 85°C and 25°C, solubility of KCl is respectively 90 & 30, at 85°C, (i) 200g saturated solution is present.
(ii) 200g water consisting solution is present.

If we cool down the solution to 25°C, what will be the quantity of precipitated KCl ?

ppt/excess = (solute, - solute,)

if solvent is given then math is direct.
if solution is given, we need to find solvent first

Mathematical Problems



Mathematical Problems

always compare with solvent

① 200gm solution at 85°C → we need to find the quantity of solvent!

at, 25°C, solubility = 30

solute=30, solvent=100

solution=130g

solvent=100 -- solute=30

" "

" 105.26 — 30×105.26 / 100 = 31.578

Solute at 85°C

∴ppt = (94.74 − 31.578) = 63.162

at, 85°C → solubility=90

∴ solute=90, solvent=100

solution=190 g

Solution=190 --- solute=90

" "

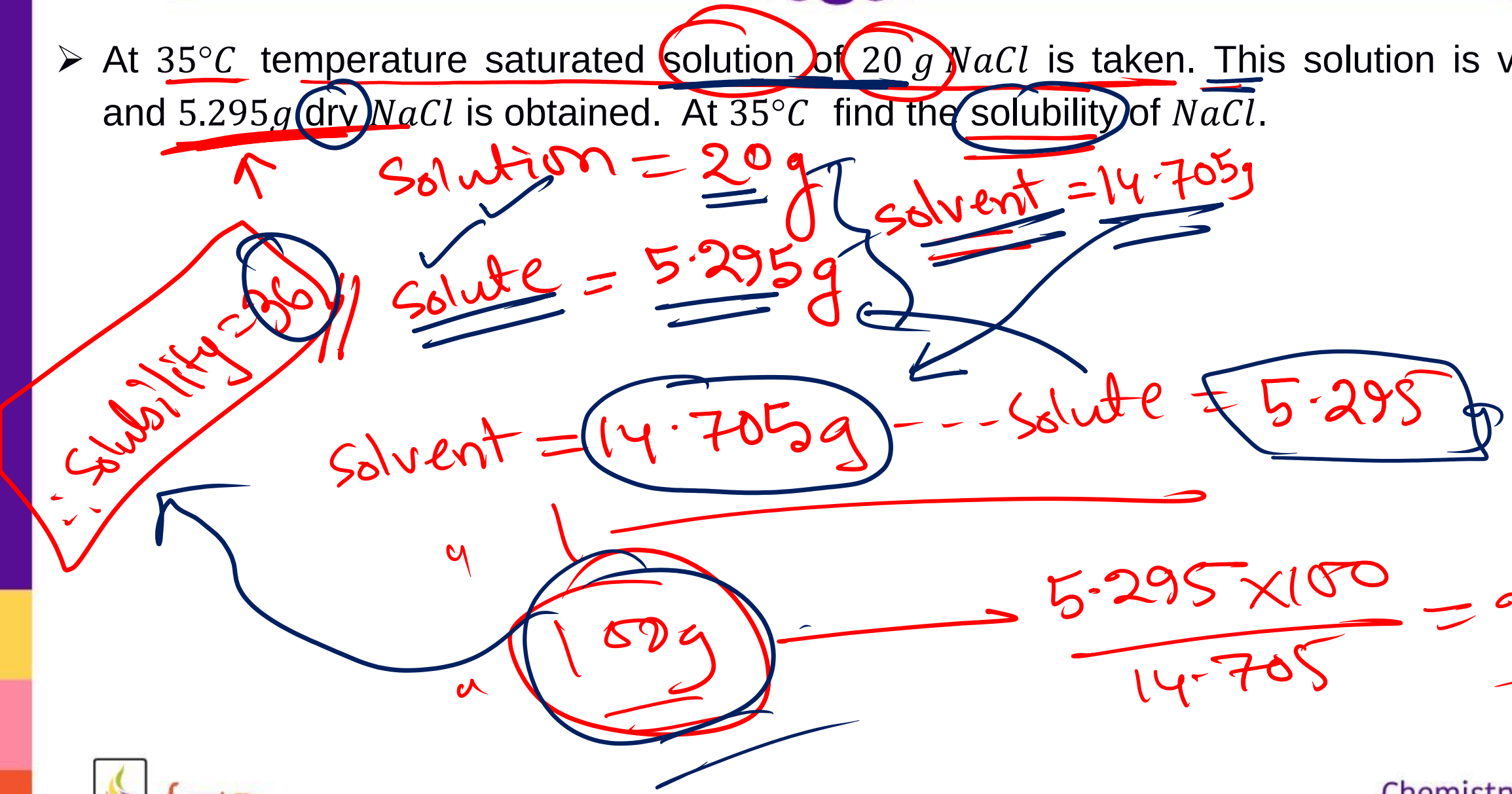
" 200 — 90×200 / 190 = 94.74g

Solute at 25°C

∴solvent = (200 − 94.74) = 105.26g

Mathematical Problems

- At $35°C$ temperature saturated solution of $20\ g\ NaCl$ is taken. This solution is vaporized and $5.295g$ dry $NaCl$ is obtained. At $35°C$ find the solubility of $NaCl$.



Solubility Product and Ionic Product

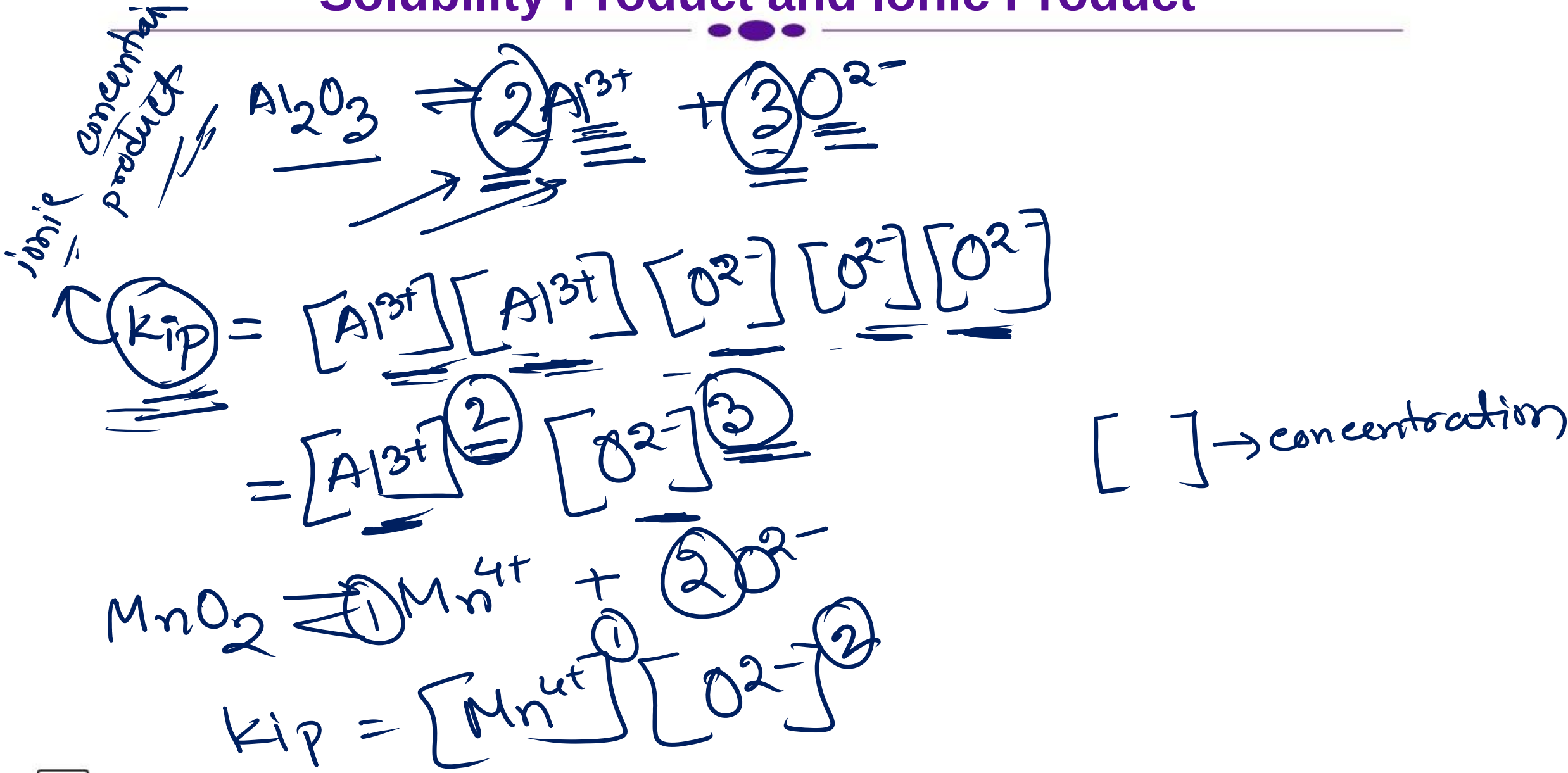
♦ **Solubility product and Ionic product:**

At a particular temperature, mathematical product of the dissolved ion's concentrations raised to the power of their stoichiometric coefficients of a saturated solution of one mole of partially soluble salt is constant. This constant is called the solubility product of the salt at that temperature. That is, solubility product is the maximum value of ionic product of the salt.

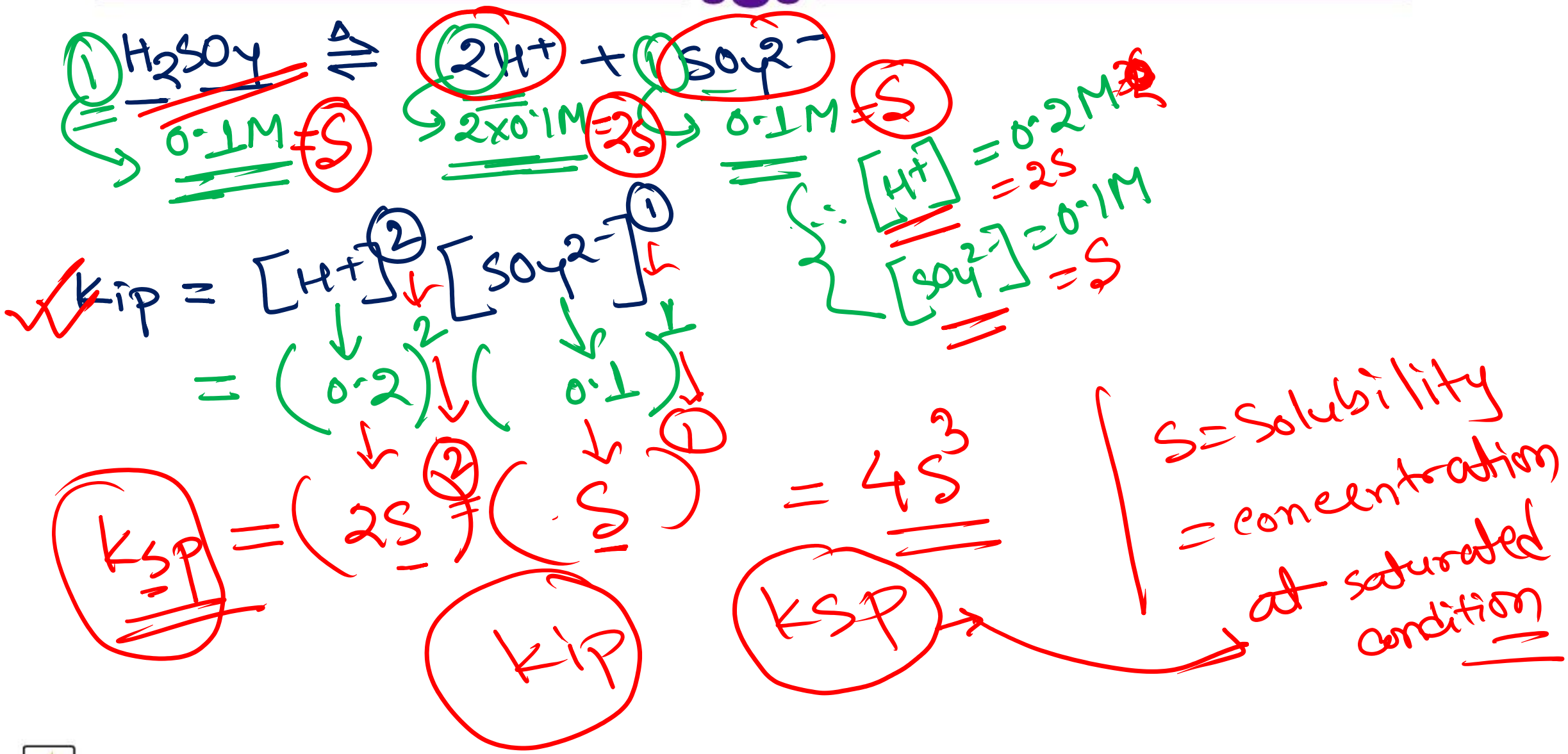
** The product of concentration of ions of a salt(electrolyte), each raised to the power of their coefficients in the balanced chemical equation in solution at any concentration is called ionic product.

Ionic product is not constant, but at a fixed temperature solubility product is constant. Ionic product is considered for any concentration of any solution whereas solubility product is considered only for saturated solution.

Solubility Product and Ionic Product



Solubility Product and Ionic Product



Solubility Product and Ionic Product

$Al_2O_3 \rightleftharpoons 2Al^{3+} + 3O^{2-}$

S → $2S$, $3S$

$\therefore [Al^{3+}] = 2S$

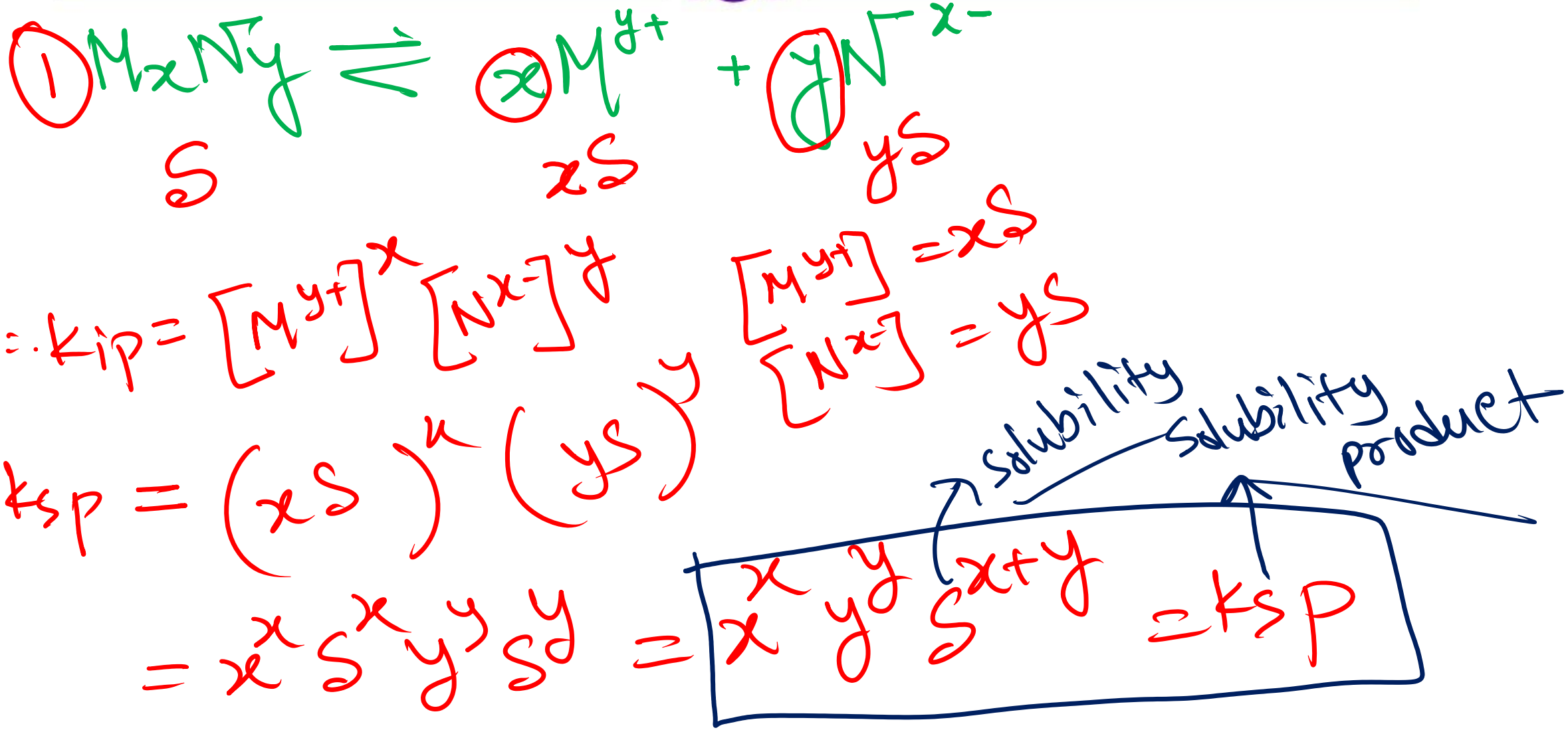
$[O^{2-}] = 3S$

$K_{sp} = [Al^{3+}]^2 [O^{2-}]^3$

$K_{sp} = (2S)^2 (3S)^3$

$= 2^2 S^2 3^3 S^3 = 108 S^5$

Solubility Product and Ionic Product



Solubility Product and Ionic Product

$M_xN_y \Rightarrow K_{sp} = x^x y^y s^{x+y}$

$Al_2O_3 \rightarrow x=2,\ y=3 \quad \therefore K_{sp} = 2^2 3^3 s^{2+3} = 108 s^5$

$MnO_2 \rightarrow x=1,\ y=2 \quad \therefore K_{sp} = 1^1 . 2^2 . s^{1+2} = 4s^3$

$AgBr \rightarrow x=1,\ y=1 \quad \therefore K_{sp} = 1^1 1^1 s^{1+1} = s^2$

Mathematical Problems

- What is the solubility product of $Pb_3(AsO_4)_2$ if its solubility is $S\ mole/L$?

$x=3 \quad y=2$

$\therefore Ksp = 2^2 3^3 S^{2+3}$

$= 108\, S^5$

Mathematical Problems

- At $25°C$, the solubility product of CaF_2 is $3.4\times10^{-11}mol^3L^{-3}$. What is its solubility at that temperature?

$ksp = 3.4 \times 10^{-11}$

CaF_2

$x = 1$

$y = 2$

$\therefore ksp = 1^1 2^2 s^{1+2} = 4s^3$

$\therefore S = \sqrt[3]{\frac{3.4\times10^{-11}}{4}} = 2.041\times10^{-4}$

Poll Question-03

- What is the solubility product of AgCl if its solubility is $S\ mole/L$?

(a) $4S^2$

(b) $27S^2$

(c) $108S^2$

(d) S^2

$x=1$

$y=1$

$K_{sp}=S^2$

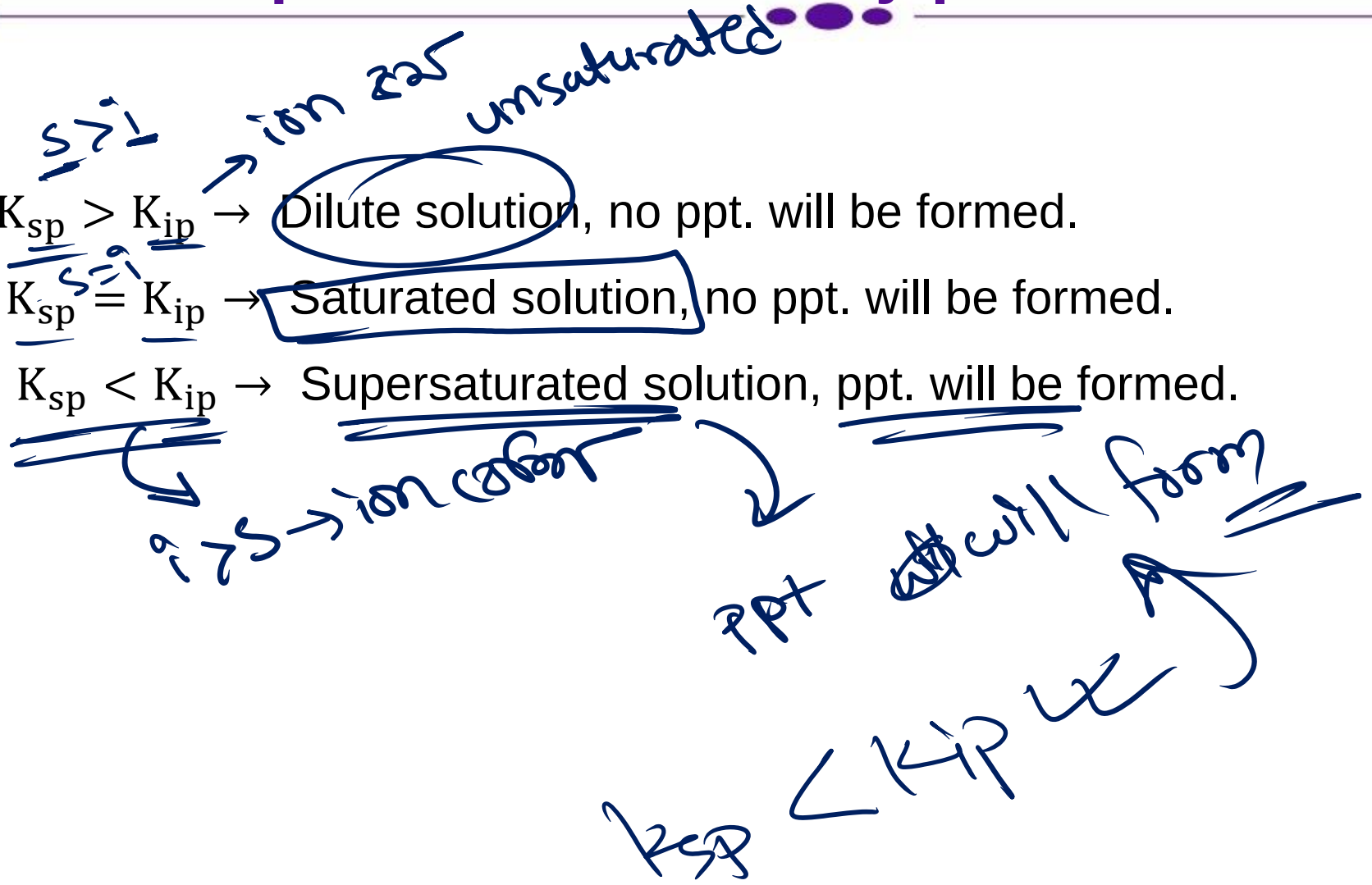
$=1^1.1^1.S^{1+1}=S^2$

Relationship Between Solubility product and ionic product

(i) $K_{sp} > K_{ip}$ → Dilute solution, no ppt. will be formed.

(ii) $K_{sp} = K_{ip}$ → Saturated solution, no ppt. will be formed.

(iii) $K_{sp} < K_{ip}$ → Supersaturated solution, ppt. will be formed.



Poll Question-04

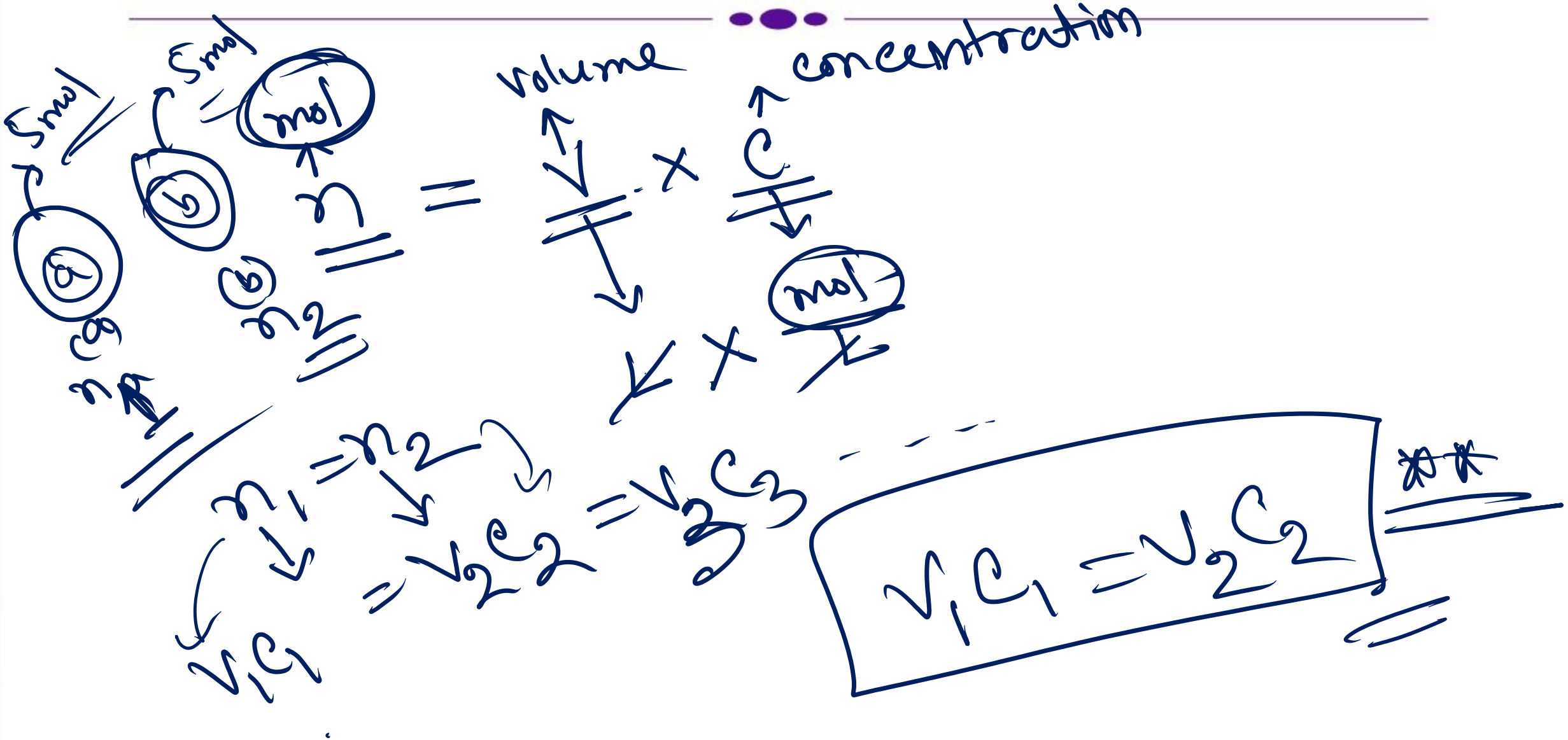
- If $K_{sp} = 4.4\ x\ 10^{-3}$ and $K_{ip} = 6.8\ x\ 10^{-10}$ ppt will be formed or not?

  (a) ppt will be formed

  (b) ppt will not be formed

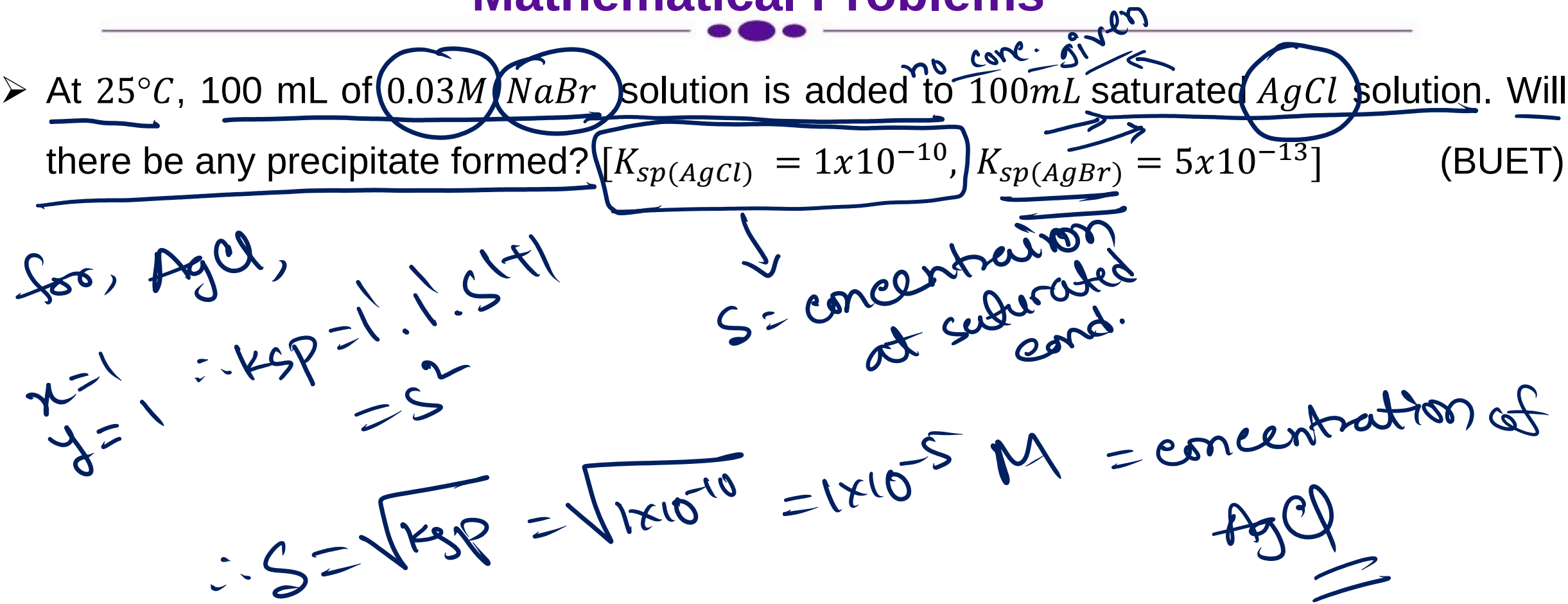
$K_{SP} > K_{IP}$

no ppt

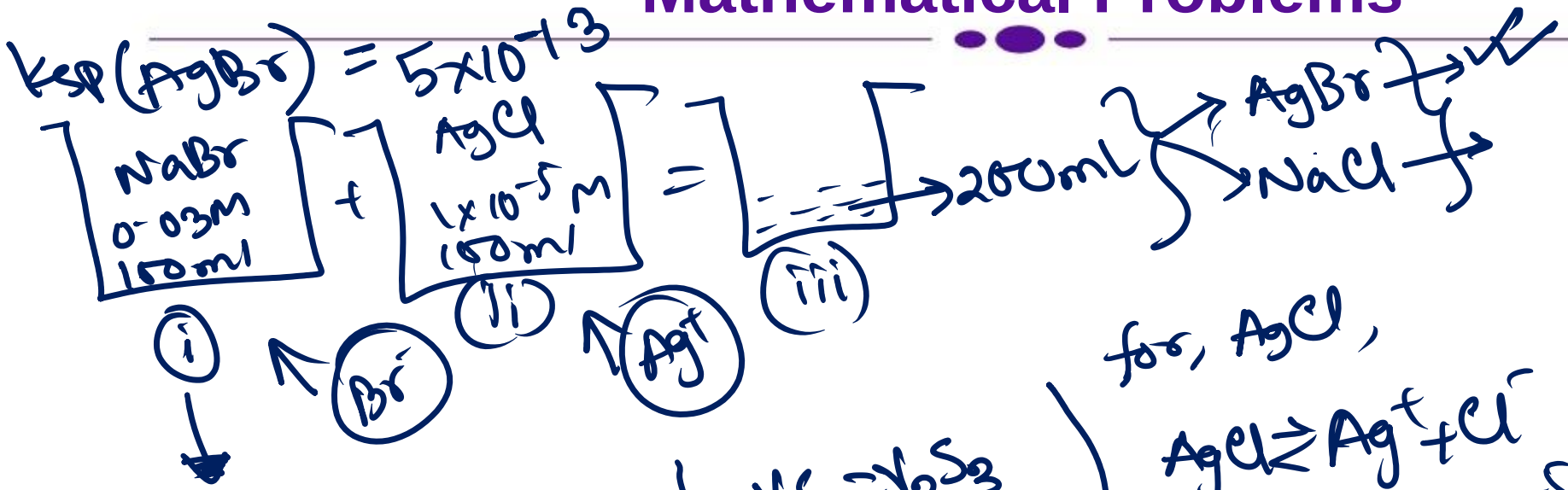

Smol
Smol
Smol
mol
volume
concentration
mol
$n_1 = n_2$
$V_1C_1 = V_2C_2 = V_3C_3$
$V_1C_1 = V_2C_2$

Mathematical Problems

- At $25°C$, 100 mL of $0.03M$ $NaBr$ solution is added to $100mL$ saturated $AgCl$ solution. Will there be any precipitate formed? $[K_{sp(AgCl)} = 1x10^{-10}, K_{sp(AgBr)} = 5x10^{-13}]$ (BUET)



Mathematical Problems



① $NaBr \rightleftharpoons Na^+ + Br^-$

0·03 0·03 0·03

$\therefore S_1 = [Br^-]_{old} = 0·03$

$V_1 = 150mL$

$V_3 = 200ml$

$\therefore S_3 = [Br^-]_{new}$

$V_1S_1 = V_3S_3$

$\therefore S_3 = \frac{V_1S_1}{V_3}$

$= 0·015M$

$= [Br^-]_{new}$

for, AgCl,

$AgCl \rightleftharpoons Ag^+ + Cl^-$

1×10^{-5} 1×10^{-5} 1×10^{-5}

$\therefore S_2 = [Ag^+]_{old} = 1\times10^{-5}$

$V_2 = 150mL$

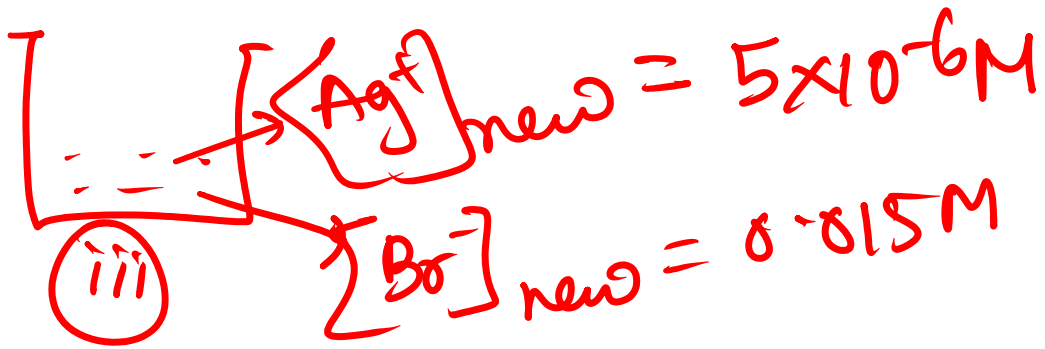
& $V_3 = 200mL$

$S_3 = [Ag^+] = ?$

$S_3 = \frac{V_2S_2}{V_3}$

$= 5\times10^{-6}M$

$= [Ag^+]_{new}$



$AgBr \rightleftharpoons Ag^+ + Br^-$

$\therefore Kip = [Ag^+]\,[Br^-]$

$= (5\times10^{-6})(0.015)$

$= 7.5\times10^{-8}$

from ques,

$Ksp(AgBr) = 5\times10^{-13}$

$Kip(AgBr) = 7.5\times10^{-8}$

$\therefore Kip > Ksp$

$\therefore$ ppt will form

The Solubility of Ionic Compounds in Water

- **Lattice Energy :** → energy req to create crystal structure.
- **Crystals :** → structure (cubic, square)

∴ lattice energy ↑↑
bond energy ↑↑
dissolve ↓↓
solubility ↓↓

লেগে থাকো সৎ ভাবে,
স্বপ্ন জয় তোমারই হবে।