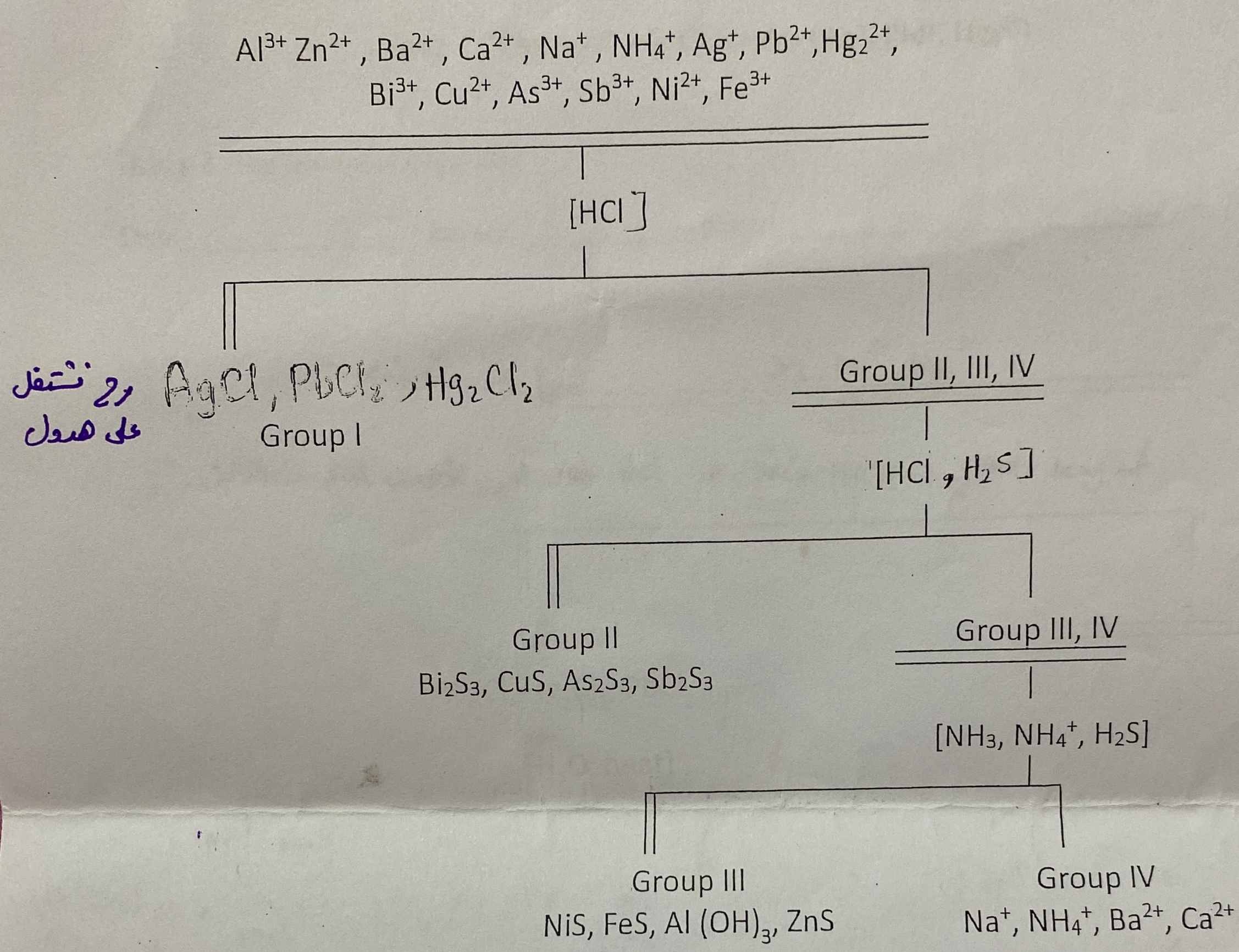
Flow Diagram for the separation of cations into qualitative Groups.



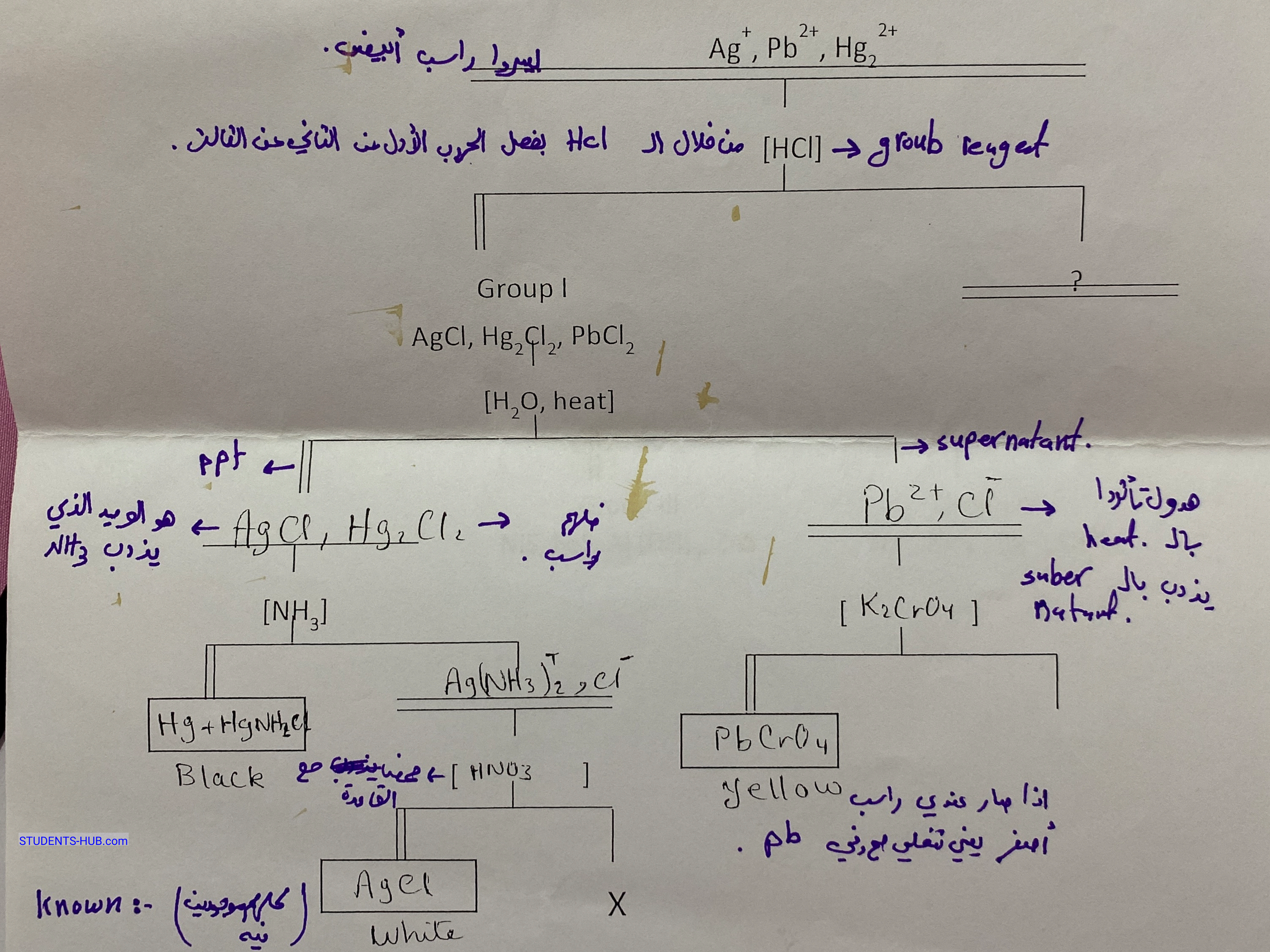
① precipitation → ② separation

Prelaboratory Assignment

Group I. The Insoluble Chlorides (Ag^+, Pb^{2+}, Hg_2^{2+})

Group I. The Insoluble Chlorides

Date_____ lab sec. _____ Name _____



Known :- (كل المحلول فيه)

1- 2 drops HCl على السليوشن بيصير عنا راسب أبيض.

2- 10 drops H_2O water بعدين بحطه ب bath

G.II (flow diagram)

$Cu^{2+}, Bi^{3+}, Sb^{3+}, As^{3+}$

* $CH_3CSNH_2 + 2H_2O \xrightarrow{\Delta} CH_3COO^- + H_2S + NH_4^+$

$H_2S + 2H_2O \rightleftharpoons 2H_3O^+_{(aq)} + S^{-2}_{(aq)}$

مصدر S.

$H_2S_{(g)} \rightleftharpoons 2H^+_{(aq)} + S^{-2}_{(aq)}$

← في البيئة.

هاد بعطي اللون الأسود

وهاد لونه كاشف

black ← هون بيصير اللون

light black أو

total charge = 0 عشان

[Thioacetamide* + HCl] يرسب جميع الأيونات

$CuS, Bi_2S_3, As_2S_3, Sb_2S_3$

?

[Thioacetamide + KOH]

Subgroup II B

Procedure E, F, G

CuS, Bi_2S_3 تترسب في وسط محمض

Subgroup II A

Procedure C, D

AsS_3^{-3}, SbS_3^{-3} ← ما منتبه

لا تترسب في وسط محمض لانها : البيئة فيه

[Conc. HCl] 14 drop

[HNO_3] ← ال acid يحرر ال cations

S

Cu^{2+}, Bi^{3+} suber natant.

[Conc NH_4OH]

white

$Bi(OH)_3$

[Stannite ion $Sn(OH)_3^-$]

Bi

Black

X

suber natant.

$Cu(NH_3)_4^{2+}$

deep blue

As_2S_3 ← منتبه نوقف هون.

yellow

[H_2O_2 + NH_3]

AsO_4^{-3}

[$AgNO_3$]

Ag_3AsO_4

dark brown

X

$SbCl_6^{-3}$

NH_3

Sb^{3+}

[thioacetamide + HNO_3]

Sb_2S_3

Orange

X

excess to force the forward reaction →

① shahd Abu Rajab

$Fe^{+3}_{(aq)} + SCN^-_{(aq)} \rightleftharpoons FeSCN^{+2}_{(aq)}$

0.2 M 0.002 M

$K_{eq} = \frac{[FeSCN^{+2}]_{(aq)}}{[Fe^{+3}]_{(aq)}[SCN^-]_{(aq)}}$

Cosmic rays

الأقصر طول موجي هي الأقوى والعكس صحيح.

X-rays violet
uv-light indigo
visible blue
green
yellow
at 447 nm
red orange

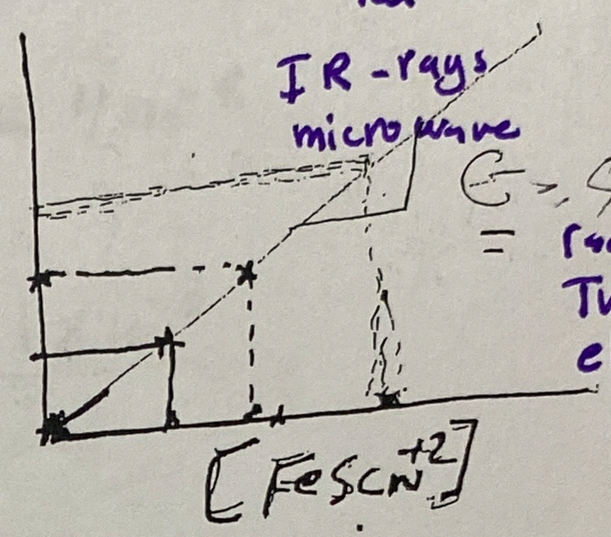
IR-rays
microwave
radio wave
TV
electric wave

For calibration curve

$[SCN^-] = [FeSCN^{+2}]$ → because $[Fe(NO_3)]$ is in large excess compared to SCN^- (0.2 M → 0.002 M)

$A = \epsilon C$

$\epsilon = \text{slope} = \frac{A}{C}$



For equilibrium concentrations

$C = \frac{A}{\epsilon}$ or $\frac{A}{\text{slope}}$

$\text{slope} = \frac{A_2 - A_1}{[FeSCN]_2 - [FeSCN]_1}$

C in Molarity $= \frac{\#\text{ of moles}}{\text{Volume (L)}}$

# of moles = M × V

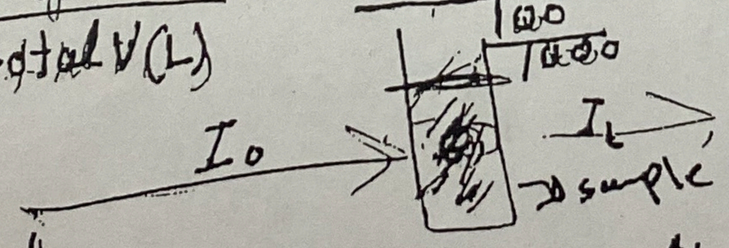
M of $FeSCN^{+2}$ For calibration curve = M of SCN^-

example ① volume mls of $NaSCN$ = 2 ml

M of SCN^- = 0.002 M

# of moles = M×V = $0.002 \times \frac{2}{1000} = \frac{4}{1000 \times 1000} = 4 \times 10^{-6}$ moles

M of $SCN^- = \frac{\#\text{ of moles}}{\text{total V (L)}} = \frac{4 \times 10^{-6}}{\frac{100}{1000}} = \frac{4 \times 10^{-6} \times 1000}{100} = \boxed{4 \times 10^{-5}\ M}$

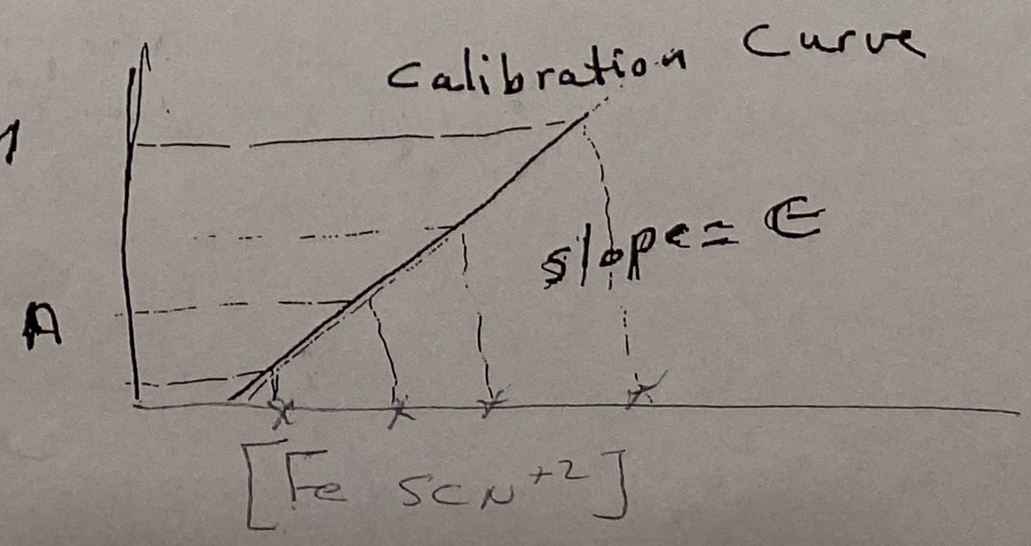


example ② # of moles = M×V = $0.002 \times \frac{4}{1000} = 8 \times 10^{-6}$ moles

$M = \frac{8 \times 10^{-6}}{\frac{100}{1000}} = \boxed{8 \times 10^{-5}\ M}$

example ③ $\frac{12 \times 10^{-6}}{0.1} = 12 \times 10^{-5}$ M

example ④ $\frac{16 \times 10^{-6}}{0.1} = 16 \times 10^{-5}$ M



For equilibrium concentrations to determine $K_{eq} = K_c$
First we should determine the initial concentrations of Fe^{+3} + SCN^-

Example (1)

	$Fe(NO_3)_3$	$NaSCN$
M →	0.002M	0.002M
# of moles = M×V =	$0.002 \times \frac{5}{1000} = 10\times10^{-6} = 1\times10^{-5}$	$0.002 \times \frac{2}{1000} = 4\times10^{-6}$

(3) $M_{initial} = \frac{10\times10^{-6}}{\frac{10}{1000}} = \frac{10\times10^{-6}\times1000}{10} = 1\times10^{-3}$

$[Fe^{+3}]_{initial}$

$M = \frac{\#\text{ of moles}}{\text{volume in liter}}$

$[SCN^-]_{initial} = \frac{4\times10^{-6}}{\frac{10}{1000}} = \frac{4\times10^{-6}\times1000}{10} = 4\times10^{-4}$

Example (2) Fe^{+3}

# of moles $= 0.002M \times \frac{5}{1000} = 10\times10^{-6} = 1\times10^{-5}$

$[Fe^{+3}]_{initial} = \frac{10\times10^{-6}}{\frac{10}{1000}} = 1\times10^{-3}$

$[SCN^-]_{initial} = \frac{8\times10^{-6}}{\frac{10}{1000}} = 8\times10^{-4}$ M

(3) $\frac{12\times10^{-6}}{\frac{10}{1000}} = 12\times10^{-4}$

(4) $\frac{16\times10^{-6}}{\frac{10}{1000}} = 16\times10^{-4}$

3

Spectrophotometric determination of an Equilibrium Constant

Date _____ lab sec. _____ Name _____

DATA

A. Set of Standard Solutions

1. Molar concentration $Fe(NO_3)_3$ _____

2. Molar concentration NaSCN _____

Standard Solutions	1	2	3	4	5
a. Volume NaSCN (mL)	0	2	4	6	8
b. Moles SCN^- (M x V)	0	4×10^{-6}	8×10^{-6}	12×10^{-6}	16×10^{-6}
c. $[SCN^-]$ IN 100 mL solution moles/V (L)	0	4×10^{-5}	8×10^{-5}	12×10^{-5}	16×10^{-5}
d. $[FeSCN^{2+}]$ total volume	0	4×10^{-5}	8×10^{-5}	12×10^{-5}	16×10^{-5}
e. Absorbance, A					

f. Construct a standardization curve for A Vs $[FeSCN^{2+}]$

B. **Set of Equilibrium Solutions**

1. Molar concentration $Fe(NO_3)_3$ 0.002 M

2. Molar concentration NaSCN 0.002 M

3. Solutions

Solutions number	1	2	3	4
a. Volume $Fe(NO_3)_3$ (mL)	5	5	5	5
b. Moles Fe^{3+}, initial	$10\times10^{-6} = 1\times10^{-5}$	1×10^{-5}	1×10^{-5}	1×10^{-5}
c. Volume NaSCN (mL)	0	2	3	4
d. Moles SCN^-, initial	0	4×10^{-6}	6×10^{-6}	8×10^{-6}
e. Absorbance				

total volume 10 ml

example to determine # of initial moles of SCN^-

For SCN^- initial = # of moles = $M \times V = 0.002 \times \frac{2}{1000} = 4\times10^{-6}$

example take 2 ml

Data To determine K_e (4)

$1 - 0.08 = 0.92$

# of moles = M × V

Example ~~suppose~~ topic from calibration curve

1. $[FeSCN^{+2}]_{eq} = 8 \times 10^{-5} M$ = suppose its like that

2. $[Fe^{+3}]$ initial = 1×10^{-3}

2a. # of moles of $FeSCN^{+2}$ in solution at eq = $M \times V = 8 \times 10^{-5} \times \frac{10}{1000} = 8 \times 10^{-7}$

2. (b) moles of Fe^{+3} complexed = moles of $FeSCN^{+2}$ at eq = 8×10^{-7}

2(c) moles of Fe^{+3} uncomplexed at equilibrium = initial moles − complexed

$= 1 \times 10^{-5} - 8 \times 10^{-7} = 1 \times 10^{-5} - 0.08 \times 10^{-5}$

$= 0.92 \times 10^{-5}$

2d $[Fe^{+3}]_{eq} = \frac{\text{\# of moles}}{V(L)} = \frac{0.92 \times 10^{-5}}{0.01} = 0.92 \times 10^{-3}$

0.01 = 10/1000 total volume = 10 mL

3. $[SCN^-]$

3a. moles of SCN^- complexed = moles of $FeSCN^{+2}$ at equilibrium = 8×10^{-7} mol

3b. moles of SCN^- uncomplexed = initial moles − complexed

$= 4 \times 10^{-6} - 8 \times 10^{-7}$

$= 4 \times 10^{-6} - 0.8 \times 10^{-6}$

$= 3.20 \times 10^{-6}$

4.00
0.80
3.20

= at complex.

3c. $[SCN^-]_{eq} = \frac{\text{\# of moles}}{V(L)} = \frac{3.20 \times 10^{-6}}{0.01} = 3.20 \times 10^{-4}$

From calibration curve

4.0 $K_c = \frac{[FeSCN^{+2}]_{eq}}{[Fe^{+3}]_{eq}[SCN^-]_{eq}} = \frac{8 \times 10^{-5}}{(0.92 \times 10^{-3})(3.20 \times 10^{-4})}$

$\approx \frac{8 \times 10^{-5}}{2.94 \times 10^{-7}} = \frac{80 \times 10^{-6}}{2.94 \times 10^{-7}} \approx \frac{27.16 \times 10^{-1}}{1}$

$\approx 2.7 \times 10$

$\approx 2.7 \times 10^{2}$

$\boxed{\approx 270}$

literature value = 138 at 25°C

5

CALCULATIONS:

Determination of K_c

	1	2	3	4
1. $[FeSCN^{2+}]$, from calibration curve	from calibration curve			
2. $[Fe^{3+}]_{initial}$ (eq.)	1×10^{-3}	1×10^{-3}	1×10^{-3}	1×10^{-3}
a. Moles $FeSCN^{2+}$ in solution at equilibrium (the same)				
b. Moles Fe^{3+} complexed (the same)				
c. Moles Fe^{3+} uncomplexed	initial − complexed			
d. $[Fe^{3+}]$ equilibrium, uncomplexed (mole/liter)				
3. $[SCN^-]$ initial				
a. Moles SCN^- complexed = moles of $FeSCN$ in equilib				
b. Moles SCN^- uncomplexed				
c. $[SCN^-]$ at equilibrium, uncomplexed (mole/liter)				
4. $K_c = \frac{[FeSCN^{2+}]_{(eq)}}{[Fe^{3+}]_{(eq)}[SCN^-]_{(eq)}}$				

5. Average K_c $\frac{Kc_1 + Kc_2 + Kc_3 + Kc_4}{4}$

6. Average deviation. Sum all of the absolute differences between each K_c and the average K_c and divide by 4 (the number of measurements).

Determination of energy of activation

$$S_2O_8^{-2} + 3I^- \longrightarrow 2SO_4^{2-} + I_3^-$$

The rxn is 2nd order (1st order in each reactant)

The rxn occures in several steps with the first step is:

$$S_2O_8^{2-} + I^- \longrightarrow 2\,S_2O_8I^{3-}$$ (slowest step, rate determing step)

when the I^- is present in large excess the rxn is pseudo first order

0.5M its concent remains const

$$\ln\left(\frac{[A_t]}{[A_0]}\right) = -kt$$

or

$$t = \frac{-\ln\left(\frac{[A_t]}{[A_0]}\right)}{k}$$

$$I_3^- + S_2O_3^{-2} \longrightarrow SO_4O_6^{2-} + 3I^-$$

$$I_3^- + \text{starch} \longrightarrow \text{blue color complex}$$

when $[A_t] = \frac{1}{2}[A_0] \longrightarrow t = t_{1/2}$

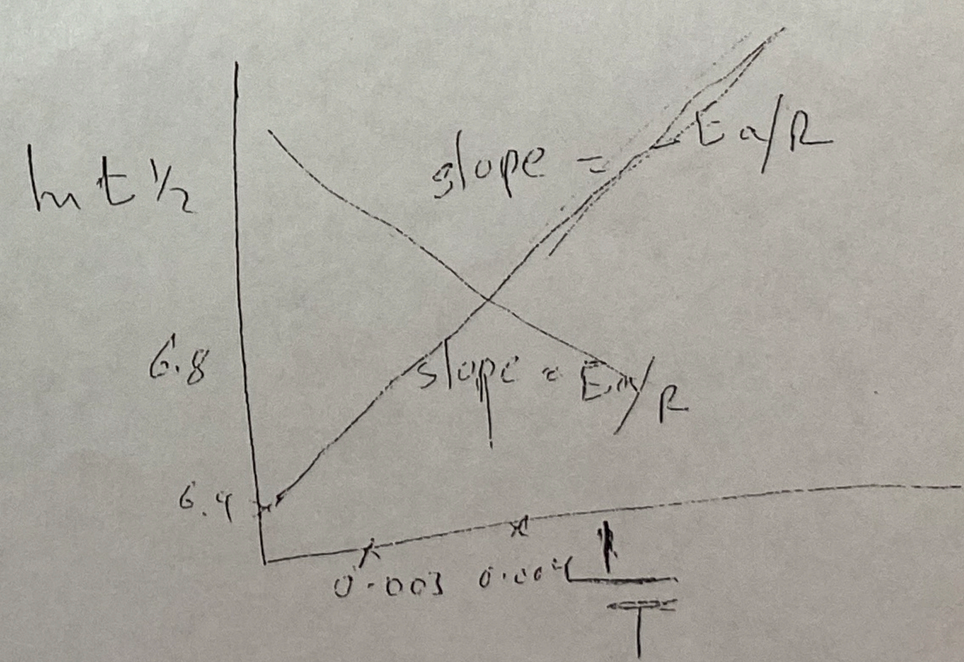
$$k = \ln\frac{n}{t_{1/2}} = A e^{\left(\frac{-E_a}{RT}\right)}$$ → Arrhenius equation

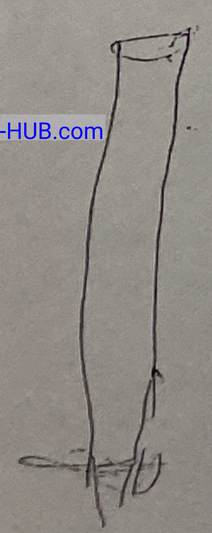
$R = 8.314\ J\,mol^{-1}K^{-1}$

T in kelvin

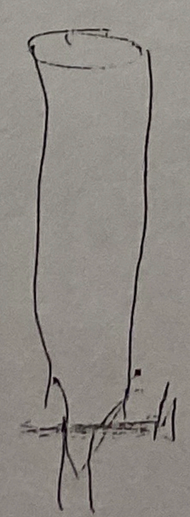
$$t_{1/2} = \frac{\ln(n)\, e^{\left(\frac{E_a}{RT}\right)}}{A}$$

$$\ln t_{1/2} = \ln\left[\frac{\ln(n)}{A}\right] + \frac{E_a}{RT}$$

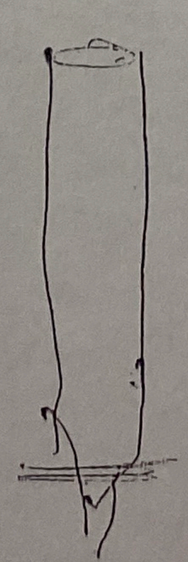




$S_2O_3^{-2}$
0.01 M
10 ml



$S_2O_8^{-2}$
0.01 M
20 ml



KI
0.5M
20 ml

$A + B \rightleftharpoons C + D.$

$K_{eq} = \frac{[C][D]}{[A][B]}$.

Exp # 1

Le Chatelier's Principle

1- Temperature effect → change in equilibrium constant
2- Concentration effect

A. Saturated Nacl Solution — concentration effect

$Nacl_{(s)} \rightleftharpoons Na^+_{(aq)} + cl^-_{(aq)}$

add $HCl_{(aq)}$ shift the equilibrium to the left because it increase the cl^- ion

كأنا أضفنا Cl^- فأصبح عنا زيادة فيذهب التفاعل نحو اليسار ويتكون راسب من Nacl

$HCl_{(aq)} \rightarrow H^+ + cl^-$

B. $SbCl_3 - H_2O$ Equilibrium — concentration effect

solid

$SbCl_{3(s)} + H_2O \rightleftharpoons SbOCl_{(s)} \downarrow + 2H^+ + 2cl^-$

form solution. ppt

add Hcl the $SbOCl_{(s)}$ will dissolve the equilibrium shift to the left

add H_2O again the equilibrium shifts to the right and $SbOCl_{(s)}$ will ppt

يزيد تركيز Cl ويذهب لليسار وبصار أربع أنيونات في يرجع يترسب.

يترسب H_2O

يذوب Cl

C. $CrO_4^{-2} - Cr_2O_7^{-2}$ Equilibrium — concentration effect

$2CrO_{4(aq)}^{-2} + H_2O \rightleftharpoons Cr_2O_7^{-2} + 2OH^-$

Yellow — orange

6M HNO_3 ($H^+ + NO_3^-$) → add this to the solutions

في الماء

add H^+ from HNO_3 it will react with OH^- and shift the rxn to the left.

D. Equilibrium involving silver ion Ag^+

① $Na_2CO_{3(aq)} + 2AgNO_{3(aq)} \rightleftharpoons Ag_2CO_{3(s)} \downarrow + 2Na^+ + NO_3^-$

ppt راسب — spectator ions.

$Ag_2CO_{3(s)} \rightleftharpoons 2Ag^+_{aq} + CO_{3(aq)}^{-2}$

② add 6M $HNO_3 = (H^+ + NO_3^-)$

$Ag_2CO_3 + H^+ \rightarrow H_2CO_3 \rightarrow 2H_2O + CO_2$

$(2Ag^+ + CO_3^{-2}) + H^+ \rightarrow H_2CO_3 + CO_2 + 2Ag^+$ → Free Ag.

③ add Hcl $(H^+ + cl^-)$ $+ Ag^+_{aq} \rightarrow AgCl_{(s)} \downarrow$ white ppt

$A + B \rightleftharpoons C + D$

$K_{eq} = \frac{[C][D]}{[A][B]}$

لو حطيت CN بدل Ag بطلع عنا لون أزرق سماوي.

④ $AgCl_{(s)} + 2NH_{3(aq)}$ (dropwise) $\longrightarrow [Ag(NH_3)_2]^+_{(aq)}$ solution بطلع عنا لون

↓ add 6M HNO_3 this will react with NH_3

H^+ (acid) $+ NH_3$ (base) $\longrightarrow NH_4^+{}_{(aq)}$ and the $[Ag(NH_3)_2]^+$ will precipitated as $AgCl_{(s)}$ by shifting the rxn to the left

ppt برجع بتفكك وبرجع

AgI → yellow

in test tube.

E. $Cu(H_2O)_4^{2+} - CuBr_4^{2-}$ Equilibrium concentration effect

① $CuBr_{2(s)} + 0.5\,ml\ H_2O \longrightarrow A$ observe color

أول اشي نفصل وشوف اللون.

$A + 2\,ml\ H_2O \longrightarrow B$ observe color $+ x\,ml\ H_2O \longrightarrow C$ observe color

$x\ H_2O$ continue adding H_2O until 15 ml is added

$[Cu(H_2O)_4]^{+2}$ D blue color

save this solution

② أبيض بالعادة. $1g\ KBr_{(s)} + 2H_2O \longrightarrow K^+_{(aq)} + Br^-_{(aq)} \longrightarrow$ colorless

From KBr

③ $Cu(H_2O) + 4Br^- \rightleftharpoons [Cu(Br)_4]^{2-}_{(aq)} + 4H_2O \longrightarrow$ green solution.

↓ blue solution

اللون النهائي green. blue

مصنوع بكبه بستخدمه كيه g

save this solution for Part G

كيف بردم مذاهد لواه.

F. $[Co(H_2O)_6]^{+2} - [CoCl_4]^{-2}$ Equilibrium Temperature effect

شوف اللون بـ $[Co(H_2O)_6]Cl_2$ مدبع

common ion effect

$NaCl_{(s)} \longrightarrow Na^+_{aq} + Cl^-_{aq}$

$4Cl^-_{(aq)} + Co(H_2O)_6^{2+} \rightleftharpoons CoCl_4^{-2} + 6H_2O$

pink — with heat — blue

* Solution 1: Blank 1M $CoCl_{2\,aq}$ only
* Solution 2: place solution 1 in a boiling water bath وشوف اللون. زهري أغمق
* Solution 3 & 4: Saturate both with NaCl & compare the color with solution 1.
* Heat solution 3 to examine temp effect compair with solution 1, explain the color
* Decant ~ 2 ml of solution 4 into small test tube, add 5-10 drops of 1M $AgNO_3$ take the supernatant liquid and explain your observation

برجع يتكون راسب أبيض

صار تفاعل مع Ag ال.

G. $4Br^-_{(aq)} + Cu(H_2O)_4^{2+} \rightleftharpoons CuBr_4^{-2}{}_{(aq)} + 4H_2O$

blue — green

temp

$-2Cl$

$[Co(H_2O)_4(H_2O)_2]$

the rxn is endothermic: $\Delta H +$

So when heating the solution the rxn will shift to the right and the color change from blue to green.