Team Work

Åbo Akademi University

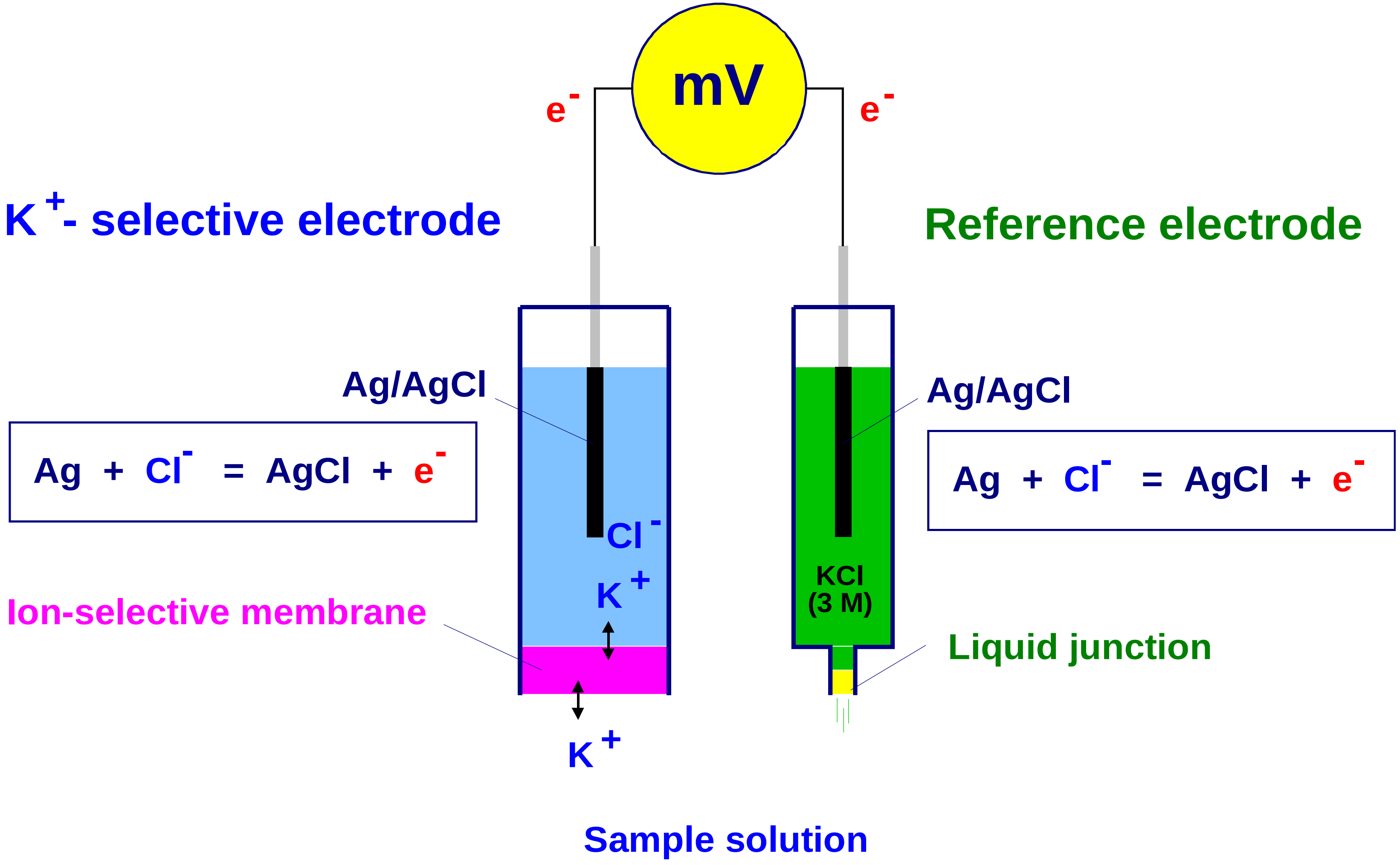
Ion-selective electrodes (ISEs)

Time	Monday 29.01.2024	Tuesday 30.01.2024 Common sessions for all	Wednesday 31.01.2024 Students	 Consortium	Thursay 01.02.2024 Students	 Consortium	Friday 02.02.2024
08.00-09.00		Breakfast	Breakfast		Breakfast		Breakfast
09.00-10:25		**Welcome and introduction (JB, IL) Presentations by 2nd year students**	**Alumni presentations (AR, ND) & Industry presentation (LG)**	CC Meeting	**Students' Team Work**	CC Meeting (optional)	**Departure**
10:25-10:35		Break	Break		Break		
10:35-12:00		**Presentations by 2nd year students Introduction to Team Work (JB)**	**Axel'One presentations (NC, FB)**	CC Meeting	**Students' Team Work**	CC Meeting (optional)	
12:00-13:00		Lunch	Lunch		Lunch		
13:00-14:30		**Discover Åbo/Turku (Local bus tickets will be provided)** Bus departs from Ruissalo Spa at 13:21 and 14:21.	**Industry presentations (TS, MB, HV)**		**Team work presentations by students**		
14:30-15:00	**Arrival**	Bus departs from Åbo/Turku (A8) at 16:51 and 17:53.	Break & **Deadline for selection of study track**		Break		
15:00-16:30		Including visit to **Aurum** (divided into **5 groups**):	**Sudents' Team Work**	CC Meeting, selecting students to study tracks	**Team work presentations by students**		
16:30-18:00		Group **1**: 14:30; Group **2**: 15:00; Group **3**: 15:30; Group **4**: 16:00; Group **5**: 16:30	**Announcement of 2nd year stydy tracks Group discussions within study tracks Interviews with 1 st year Lyon studens**		**Information about UT courses for 1st year students (IL)**		
18:00-19:30	Dinner	Dinner	Dinner		Dinner		
19:30-21:00	**Free time**	**Discussions between 1st year students, 2nd year students, alumni and professors**	**Employability Q&A session (students and alumni) with possibility to participate remotely (Zoom)**		**Free time**		

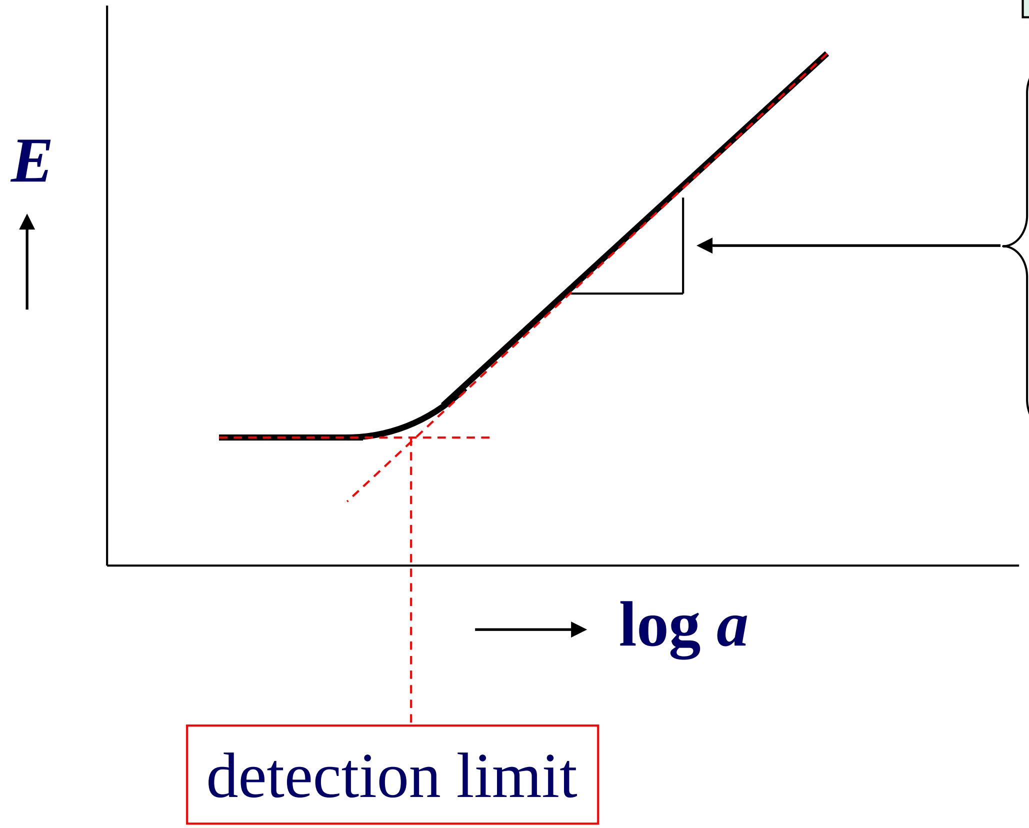
INTRODUCTION

ION-SELECTIVE ELECTRODE

Potentiometry



Potentiometric response (cationic)



Nernst equation

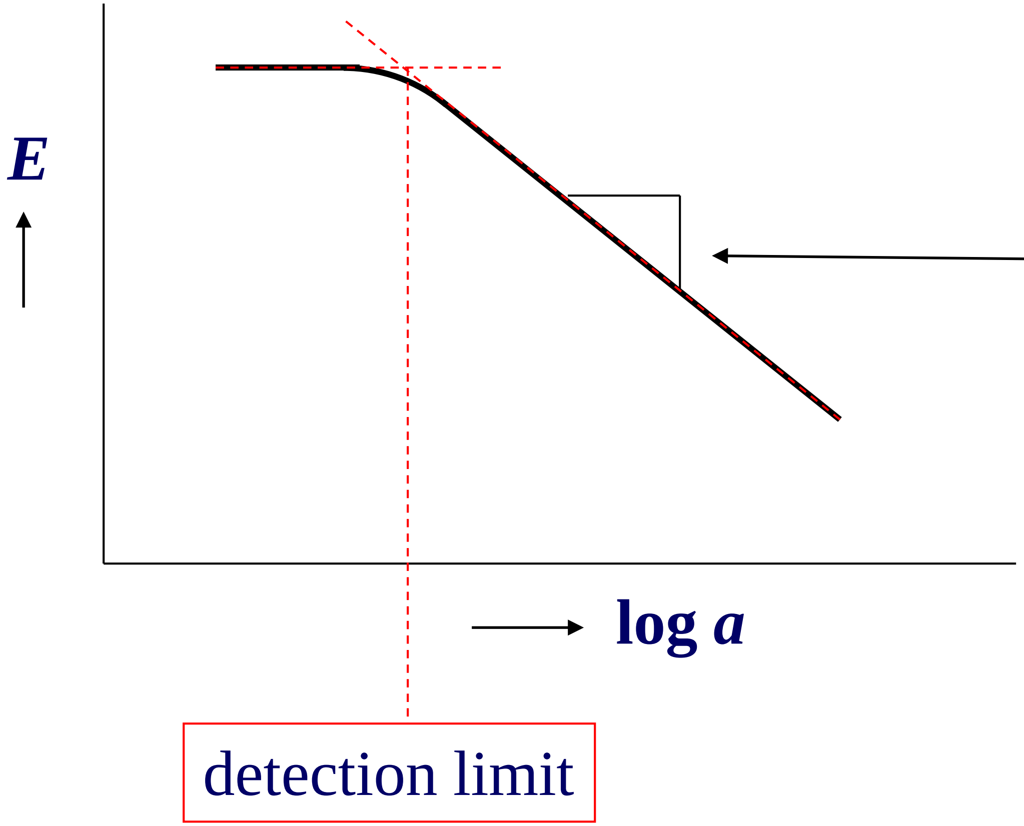
$$E = E^o + \frac{2.303 \times RT}{n_i F} \log a_i$$

When $\boldsymbol{n_i} = +1$
Slope = +59.16 mV / log a_i

When $\boldsymbol{n_i} = +2$
Slope = +29.58 mV / log a_i

a_i = activity of ion "i"

Potentiometric response (anionic)



Nernst equation

$$E = E^{o} + \frac{2.303 \times RT}{n_i F} \log a_i$$

When $\boldsymbol{n_i} = \mathbf{-1}$
Slope = -59.16 mV / log a_i

When $\boldsymbol{n_i} = \mathbf{-2}$
Slope = -29.58 mV / log a_i

a_i = activity of ion "i"

YOUR TASK

Team Work Groups

Group 1
Mustapha Adekomi Ganiyu
Carmen Kesküla
Anh Vu Nguyen

Group 2
Ma Elaine Falo
Felipe Shigueru Takano
Gloriana Rosabal Quiros

Group 3
Sunu Lama
Saif Aziz
Rafaela da Silva Barbosa

Group 4
Onyeka Francis Offor
Jocelyne Alvarez
Intasar Ul Haq

Group 5
Merili Tammiste
Juan Angel Guevara Garza
Anna Zobel

Group 6
Almira de Villa
Jeric Paul Cadiz
Favour O. Onoharigho

Group 7
Le Hoang Yen Nguyen
Eva-Lotta Palmiste
Conrado Pabustan IV

Group 8
Tetiana Kyrpel
Minh Phu Lu
Adrian Merino

Group 9
Emmaus Villa Falfan
Thi Phuong Thanh Duong
Maris Põdersalu

Group 10
Mauricio Huertas
Alina Politova
Adrián Geordi González García

Group 11
Angelo Bryan Lazo
Zamin Shafiyev
Sireethorn Poomborplab

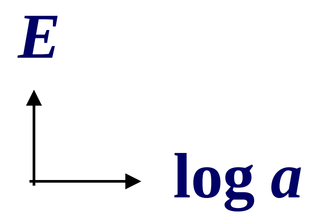
Experimental

1. Measure the potential (***E*/mV**) of your electrode in three different solutions (S1, S2, S3) with known composition, and two solutions with unknown compositionS (X1, X2). Write down the potentials.
2. Based on your potential values in solutions S1-S3 you can conclude for which ion your electrode is selective.
3. Calculate the **activity (*a*)** of your ion in solutions **S1-S3** and produce a calibration plot (***E* vs. log *a***) for that ion.
4. By using the calibration plot and the measured potentials in solutions X1 and X2, **calculate the activity of your ion in the unknown solutions X1 and X2**.

Results

Solution	*E*/mV
S1	
S2	
S3	
X1	
X2	

Ion =



a(X1) = mol/L
a(X2) = mol/L

Presentation (*ca* 12 min / group)

1. Describe shortly the principle of potentiometric measurements and the working principle of your ion-selective electrode.

2. Show a photo of your experimental setup for potentiometric measurements

3. Present your experimental results, including the calibration plot (E *vs.* log a) and the determined activity of your ion in the unknown solutions.

SUPPORTING INFORMATION

Reference:

E. Bakker, P. Bühlmann, E. Pretsch, *Chem. Rev.* **97** (1997) 3083.

Activity (a_i) *vs.* concentration (C_i)

$$a_i = \gamma_i \, C_i$$

activity coefficient

- *can be calculated based on the* ***Debye-Hückel*** *theory*
- *depends on the* ***ionic strength*** *of the solution*
- *depends on* ***ion size*** *(a_{Kjel})*

a_i = *activity of ion "i"*

γ_i = *activity coefficient of ion "i"*

C_i = *concentration of ion "i"*

Calculation of activity

$$a_i = \gamma_i C_i$$

$\boxed{J = \text{ionic strength}}$

$$J = \frac{1}{2}\sum_{k=1}^{n} C_k n_k^2$$

C_k = concentration of ion k
n_k = charge of ion k

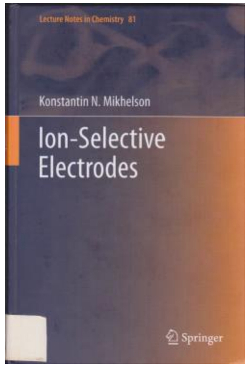
$$\log \gamma_i = -\frac{A n_i^2 \sqrt{J}}{1 + a_{Kjel} B \sqrt{J}}$$

$$\left.\begin{aligned} A &= 0.512 \\ B &= 0.328 \end{aligned}\right\}$$ Valid for aqueous solutions at 25 ^{o}C

Kjelland parameter (a_{Kjel}) ≈ hydrated ion size (Å)

Table 9.1 Kjelland parameter values (according to [9])

Ion	a_{Kjel}
H^+	9
Li^+	6
Rb^+, Cs^+, NH_4^+, Tl^+, Ag^+	2.5
K^+, Cl^-, Br^-, I^-, CN^-, NO_2^-, NO_3^-	3
OH^-, F^-, SCN^-, NCO^-, HS^-, ClO_3^-, ClO_4^-, BrO_3^-, IO_4^-, MnO_4^-	3.5
Na^+, $CdCl^+$, ClO_2^-, IO_3^-, HCO_3^-, $H_2PO_4^-$, HSO_3^-, $H_2AsO_4^-$	4.5
Hg_2^{2+}, SO_4^{2-}, $S_2O_3^{2-}$, SeO_4^{2-}, CrO_4^{2-}, HPO_4^{2-}	4
Pb^{2+}, CO_3^{2-}, SO_3^{2-}, MoO_4^{2-}	4.5
Sr^{2+}, Ba^{2+}, Cd^{2+}, Hg^{2+}, S^{2-}, WO_4^{2-}, $Fe(CN)_6^{4-}$	5
Ca^{2+}, Cu^{2+}, Zn^{2+}, Sn^{2+}, Mn^{2+}, Fe^{2+}, Ni^{2+}, Co^{2+}	6
Mg^{2+}, Be^{2+}	8
PO_4^{3-}, $Fe(CN)_6^{3-}$	4
Al^{3+}, Fe^{3+}, Cr^{3+}, La^{3+}, Ce^{3+}	9
$HCOO^-$, Citrate$^-$	3.5
Acetate$^-$, Cl-acetate$^-$, $(CH_3)_4N^+$, $(C_2H_5)_2NH_2^+$, Citrate^{2-}	4.5
Cl_3-acetate$^-$, $(C_2H_5)_3NH^+$, Citrate^{3-}	5



Example 1: *Calculate the activity of Na^+ in 0.01 M Na_2SO_4*

$$J = \frac{1}{2}\sum_{k=1}^{n} C_k n_k^2$$

C_{Na^+} = 0.02 M = **2×10⁻² M** = $10^{-1.70}$ M

n_{Na^+} = +1

$C_{SO_4^{2-}}$ = 0.01 M

$n_{SO_4^{2-}}$ = -2

$J = 0.5\,[0.02\times(+1)^2 + 0.01\times(-2)^2] = 0.03$ M

$$\log \gamma_i = -\frac{0.512 n_i^2 \sqrt{0.03}}{1 + a_{Kjel}\, 0.328 \sqrt{0.03}}$$

$$a_{Kjel} = 4.5$$

$\log \gamma_{Na} = -0.071$ $\gamma_{Na} = 0.85$

$\boldsymbol{a_{Na^+}}$ = 0.017 M = $\mathbf{1.7\times10^{-2}}$ **M** = $10^{-1.77}$ M

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Supervisors: Angelo Robiños, Hazzar Reyes, Majid Al-waeel, Rodney Salazar