SNS COLLEGE OF TECHNOLOGY

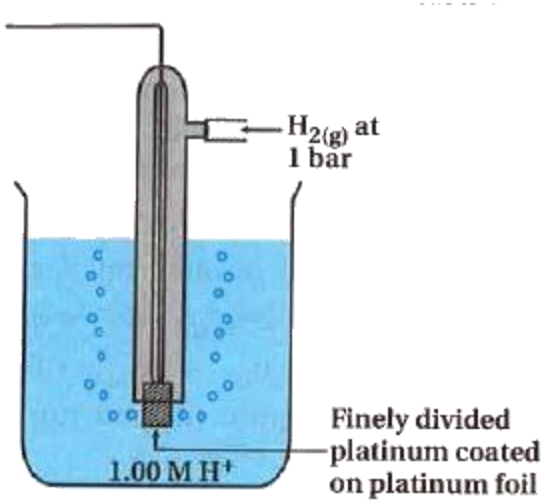
AN AUTONOMOUS INSTITUTION

Coimbatore – 641035

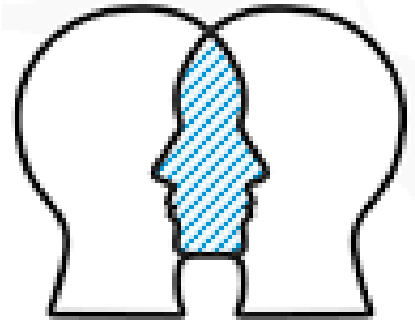
23CHT101-ENGINEERING CHEMISTRY

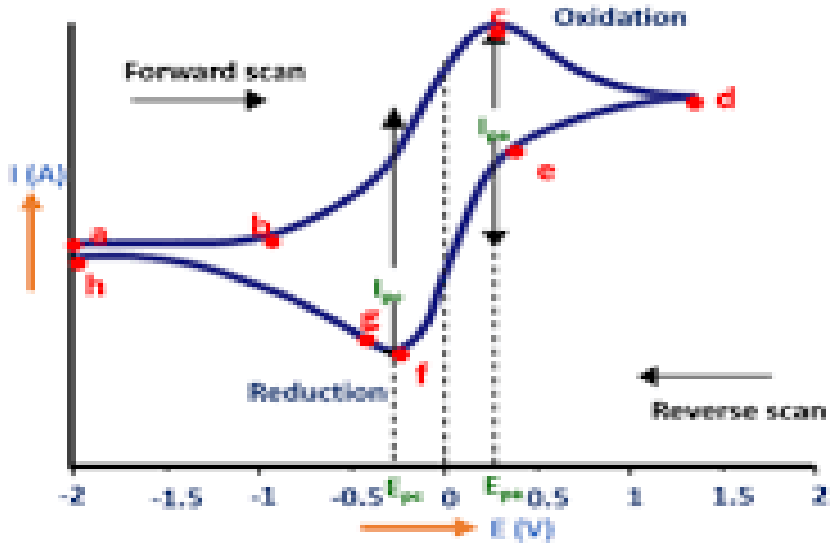
UNIT I - ELECTROCHEMISTRY

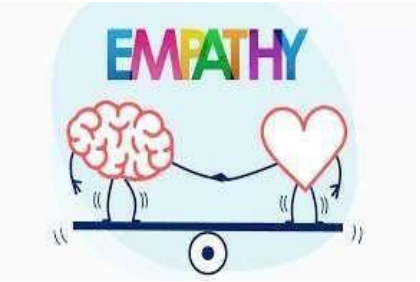
2.3. Standard Hydrogen Electrode (SHE)

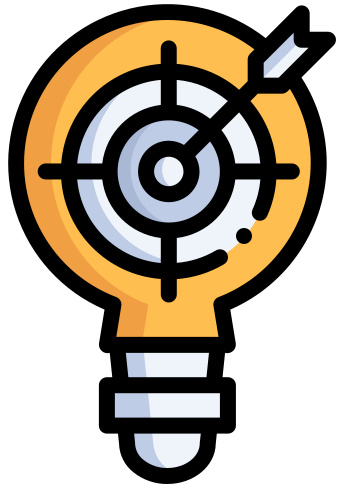


- **Reference electrode** to measure electrode potentials.
- **Accuracy, Reproducibility, Simplicity**



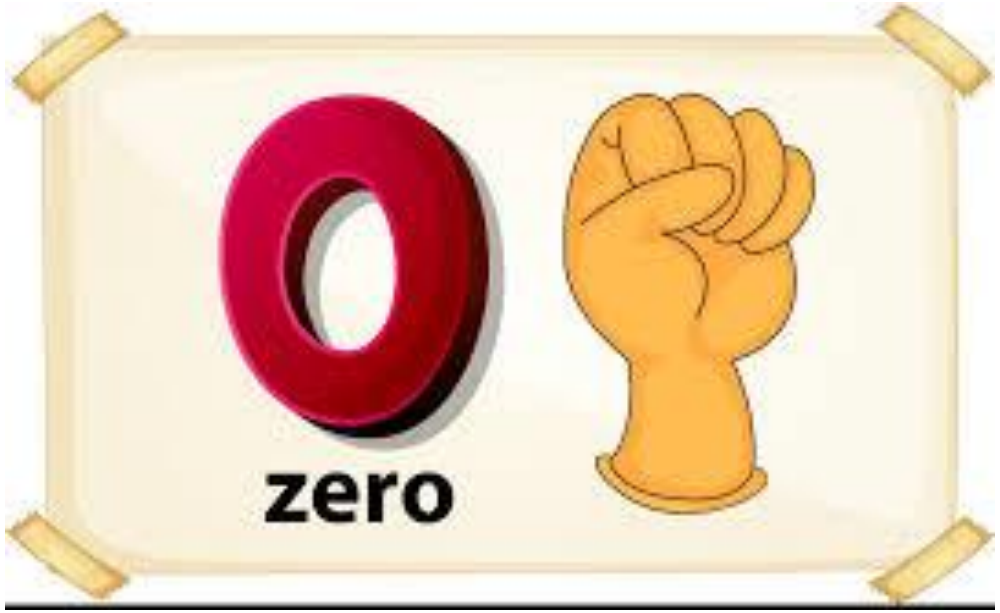






Create a **stable and reproducible zero-potential reference electrode**.

- Standard conditions:
  - H_2 gas at 1 atm
  - 1 M H^+ concentration
  - Temperature 25°C



IDEATE:

Explored reference electrodes:

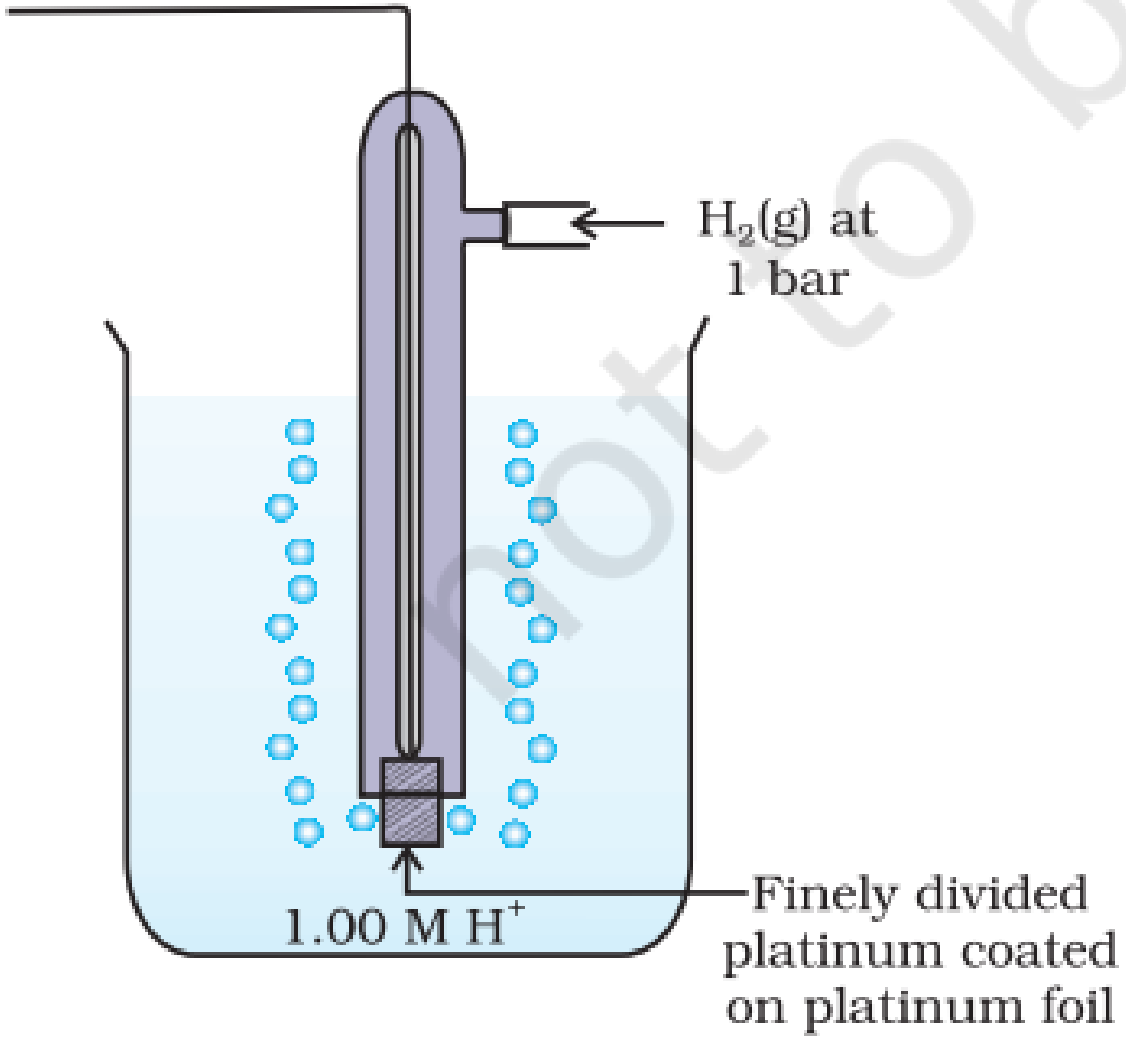
Calomel

Ag/AgCl

Hydrogen electrode.

•**Hydrogen electrode chosen** for:

- Defined **0 V potential**
- **High accuracy** and reproducibility
- **Simple design** under standard conditions



Working Principle:

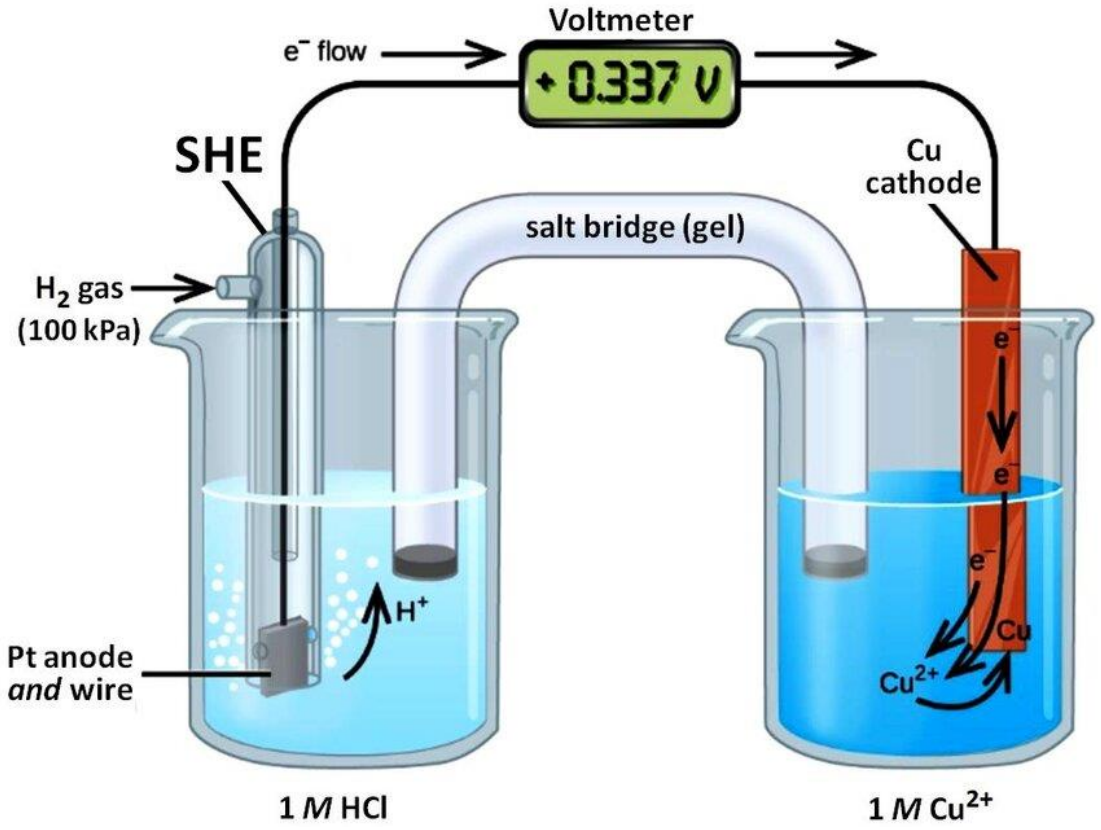
At the platinum surface, the following equilibrium is established:

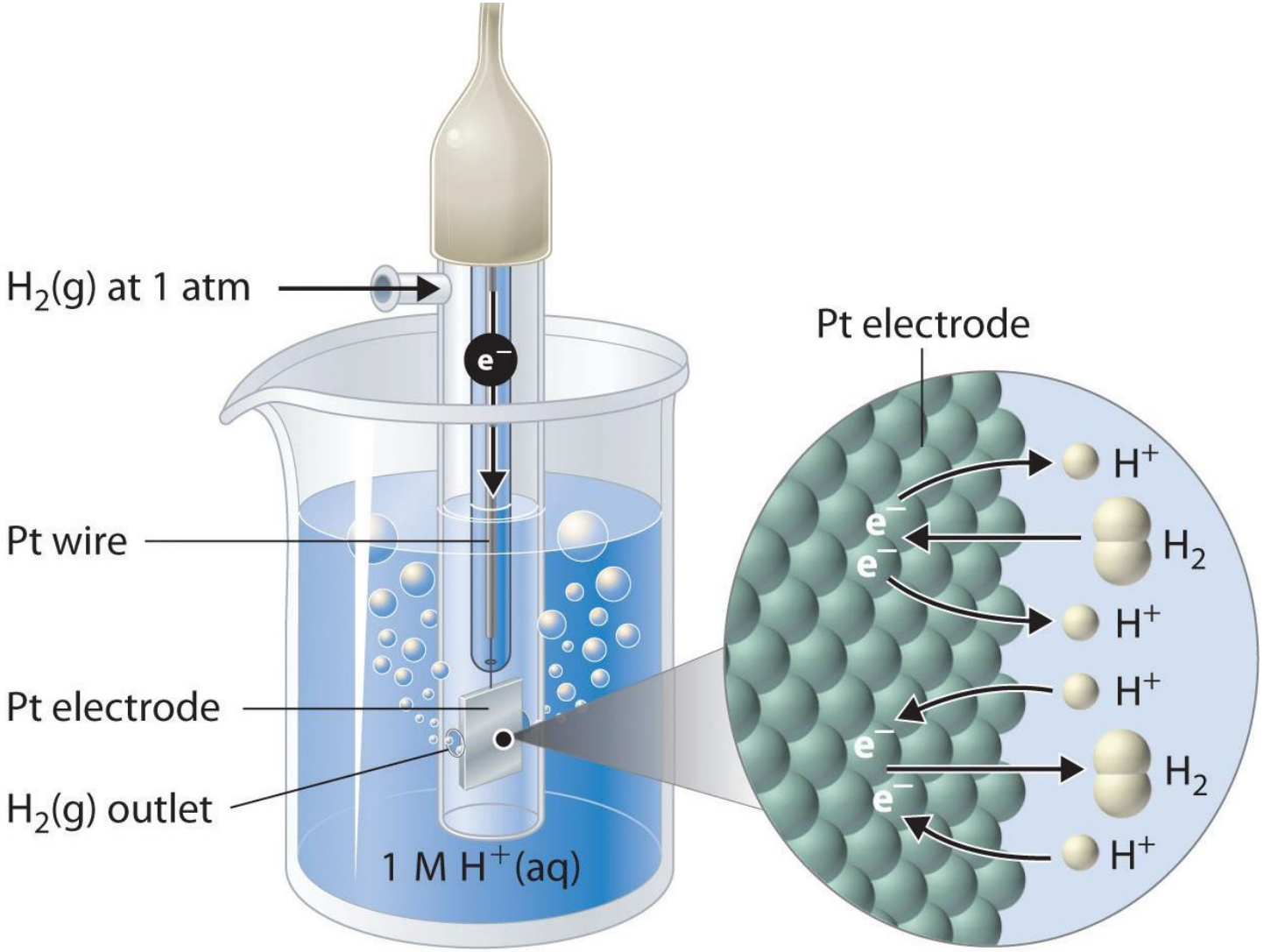
$$2H^+(aq) + 2e^- \leftrightarrow H_2(g)$$

Depending on the cell combination, the SHE can act as:

Anode (oxidation): $H_2 \rightarrow 2H^+ + 2e^-$

Cathode (reduction): $2H^+ + 2e^- \rightarrow H_2$

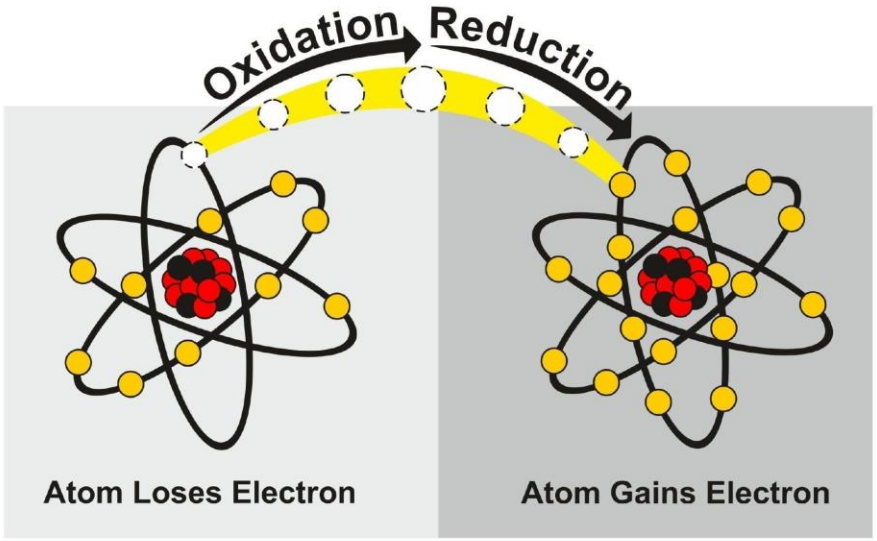




half-reaction at Pt surface:

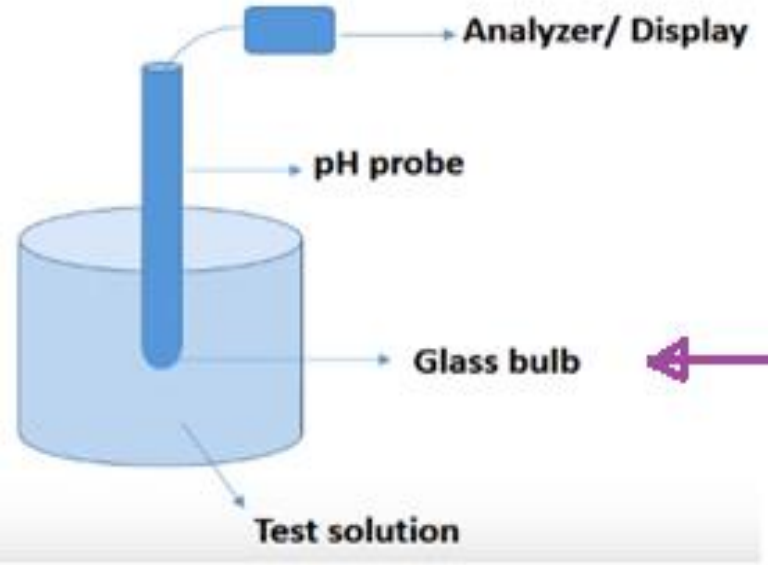
$2H^+(aq) + 2e^- \rightleftharpoons H_2(g)$

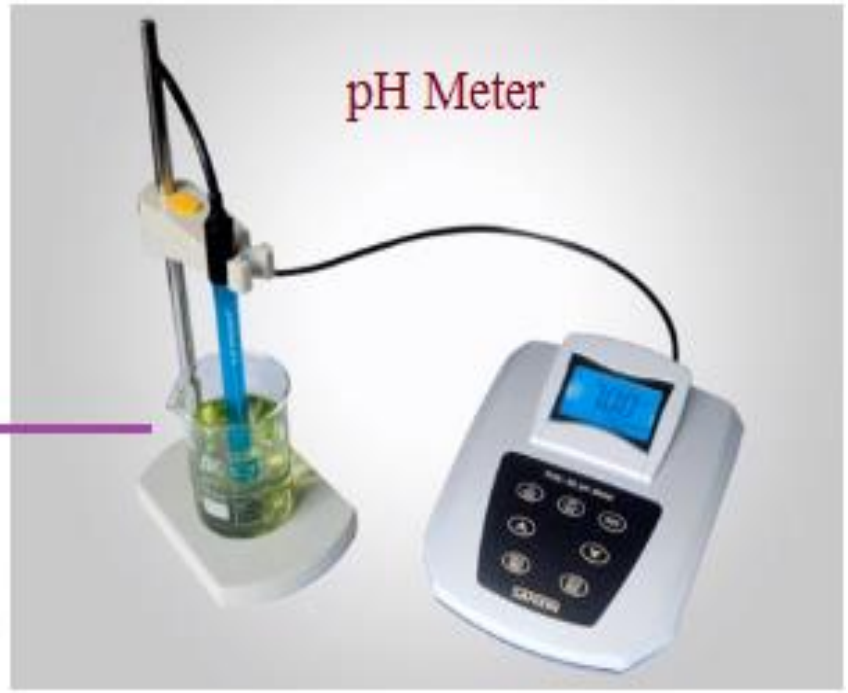
Oxidation and Reduction Reactions

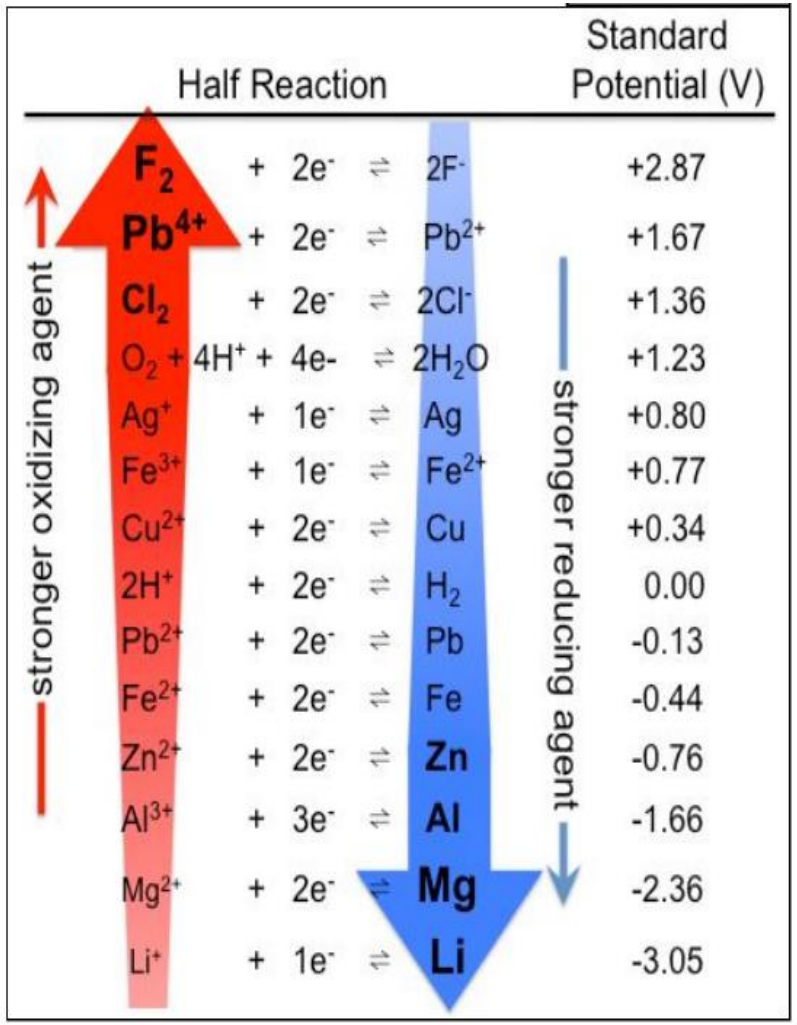


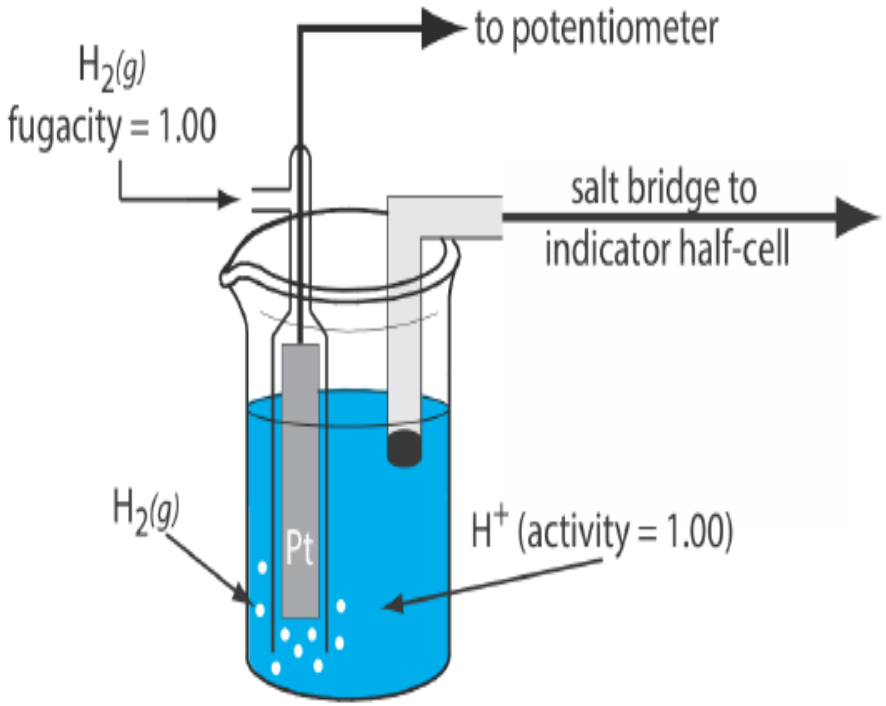
The Nernst Equation

$$E_{cell} = E^0 - \left(\frac{RT}{nF}\right) \ln Q$$

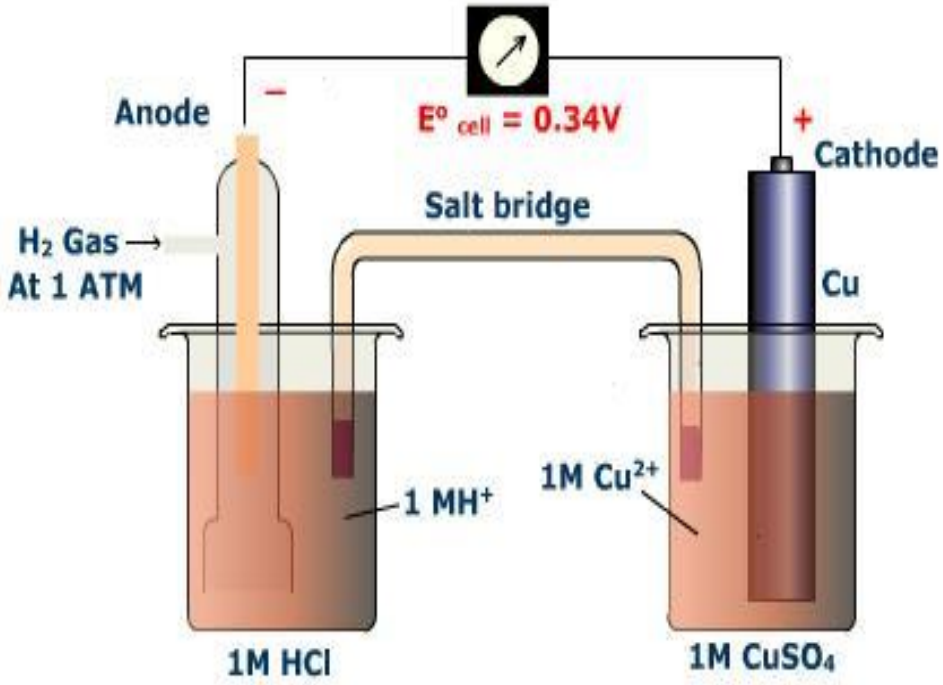

Analyzer/ Display
pH probe
Glass bulb
Test solution


pH Meter


Half Reaction
Standard Potential (V)
stronger oxidizing agent
stronger reducing agent
F2 + 2e- ⇌ 2F- +2.87
Pb4+ + 2e- ⇌ Pb2+ +1.67
Cl2 + 2e- ⇌ 2Cl- +1.36
O2 + 4H+ + 4e- ⇌ 2H2O +1.23
Ag+ + 1e- ⇌ Ag +0.80
Fe3+ + 1e- ⇌ Fe2+ +0.77
Cu2+ + 2e- ⇌ Cu +0.34
2H+ + 2e- ⇌ H2 0.00
Pb2+ + 2e- ⇌ Pb -0.13
Fe2+ + 2e- ⇌ Fe -0.44
Zn2+ + 2e- ⇌ Zn -0.76
Al3+ + 3e- ⇌ Al -1.66
Mg2+ + 2e- ⇌ Mg -2.36
Li+ + 1e- ⇌ Li -3.05


to potentiometer
$H_2(g)$
fugacity = 1.00
salt bridge to
indicator half-cell
$H_2(g)$
Pt
H^+ (activity = 1.00)


WHAT
WILL
YOU DO
NEXT?

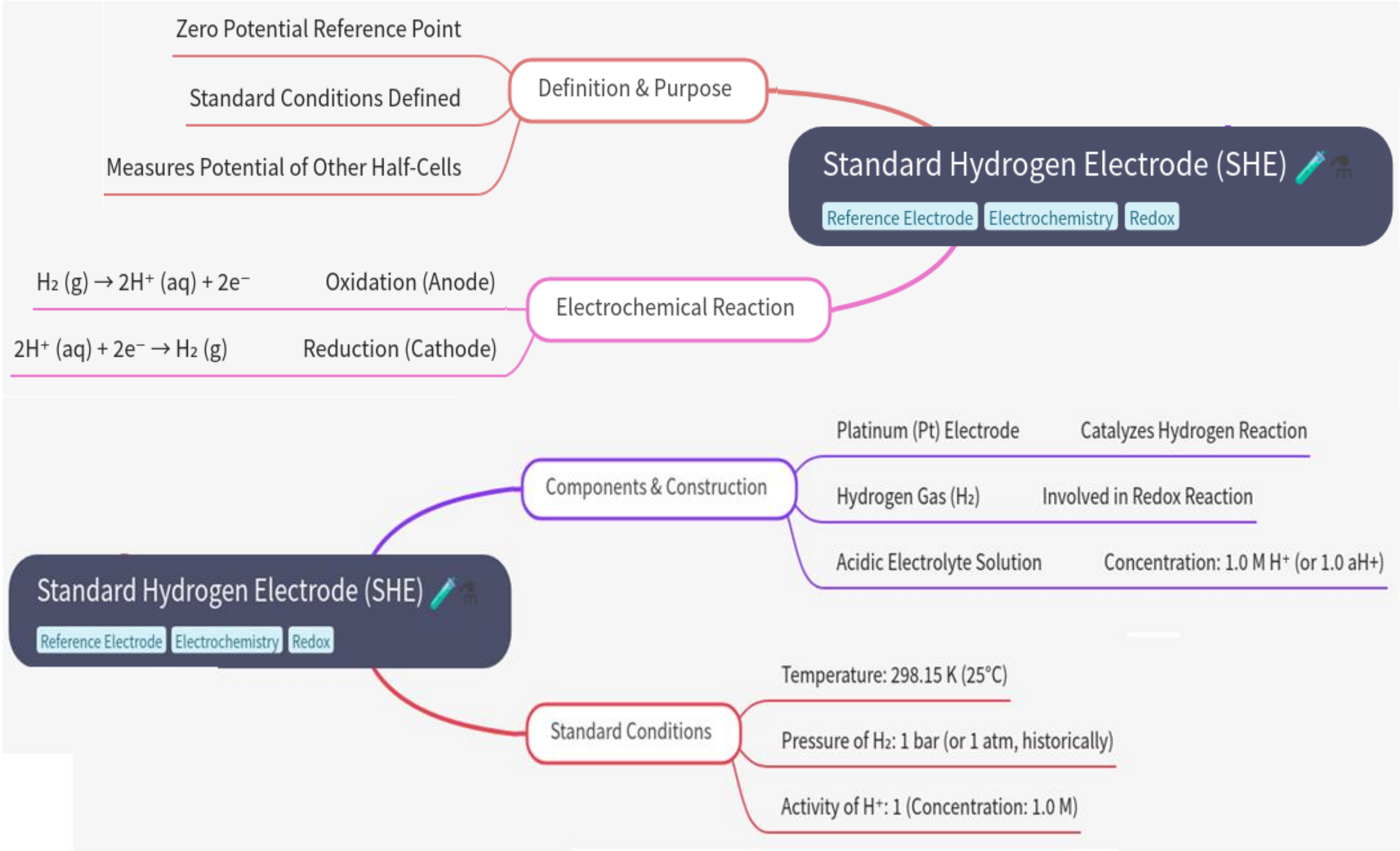

Anode
−
E°_{cell} = 0.34V
+
Cathode
Salt bridge
H_2 Gas →
At 1 ATM
Cu
1 MH^+
1M Cu^{2+}
1M HCl
1M $CuSO_4$

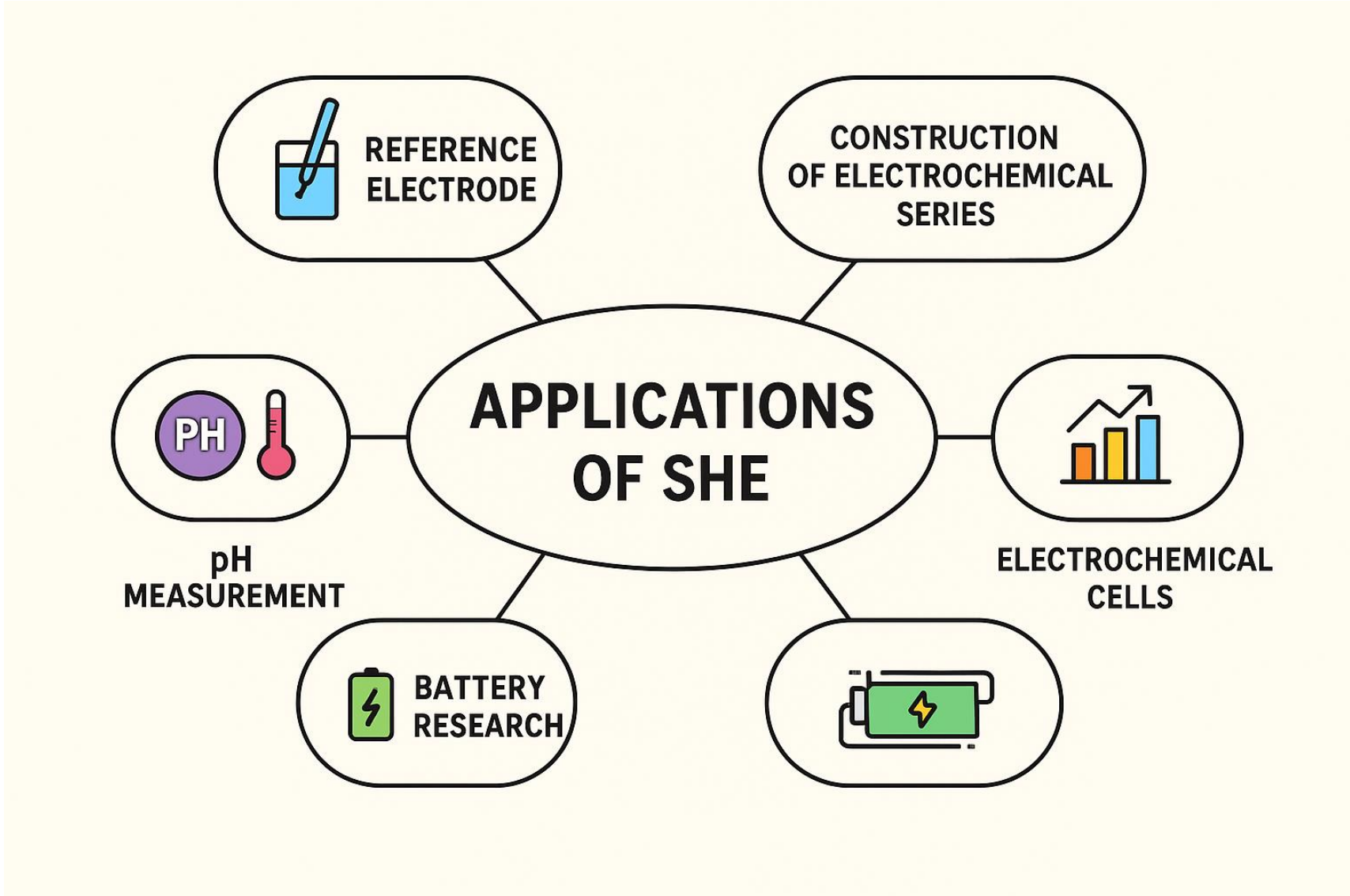
Construction:

- ✓ A **platinum electrode** coated with **platinum black** (for large surface area).
- ✓ Immersed in a **1 M H^+ solution** (usually HCl).
- ✓ **Hydrogen gas** at **1 atm pressure** is bubbled over the electrode surface.

Diagrammatically:

$H_2(g, 1\ atm) \mid H^+(aq, 1\ M) \mid Pt(s)$


Standard Hydrogen Electrode (SHE)
Reference Electrode
Electrochemistry
Redox
Definition & Purpose
Zero Potential Reference Point
Standard Conditions Defined
Measures Potential of Other Half-Cells
Electrochemical Reaction
$H_2 (g) \rightarrow 2H^+ (aq) + 2e^-$
Oxidation (Anode)
$2H^+ (aq) + 2e^- \rightarrow H_2 (g)$
Reduction (Cathode)
Components & Construction
Platinum (Pt) Electrode
Catalyzes Hydrogen Reaction
Hydrogen Gas (H_2)
Involved in Redox Reaction
Acidic Electrolyte Solution
Concentration: 1.0 M H^+ (or 1.0 aH+)
Standard Conditions
Temperature: 298.15 K (25°C)
Pressure of H_2: 1 bar (or 1 atm, historically)
Activity of H^+: 1 (Concentration: 1.0 M)


APPLICATIONS OF SHE
REFERENCE ELECTRODE
CONSTRUCTION OF ELECTROCHEMICAL SERIES
PH
pH MEASUREMENT
ELECTROCHEMICAL CELLS
BATTERY RESEARCH

References

https://en.wikipedia.org/wiki/Standard_hydrogen_electrode

https://chem.libretexts.org/Bookshelves/Introductory_Chemistry/Introductory_Chemistry_(CK-12)/23%3A_Electrochemistry/23.05%3A_Standard_Hydrogen_Electrode