CH20 Dynamic Equilibrium (Part 2.2)

Cell Diagram of IUPAC

A. Types of Half-cells

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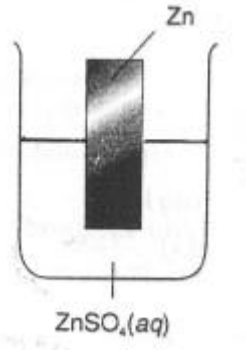
⌖ Metal-metal ion half cell

e.g. 1 **Zn electrode**

$Zn^{2+}(aq) + 2e^- \leftrightarrows Zn(s)$

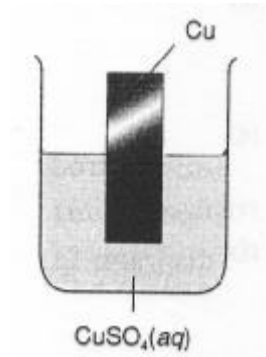


Half cell diagram:

$Zn^{2+}(aq) \,|\, Zn(s)$ *(IUPAC)*

e.g. 2 **Cu electrode**

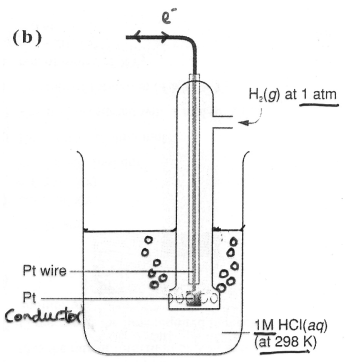
$Cu^{2+}(aq) + 2e^- \leftrightarrows Cu(s)$



Half cell diagram:

$Cu^{2+}(aq) \,|\, Cu(s)$ *(IUPAC)*

⌖ Non-metal – non metal ion half cell



e.g. 1 **Hydrogen electrode**

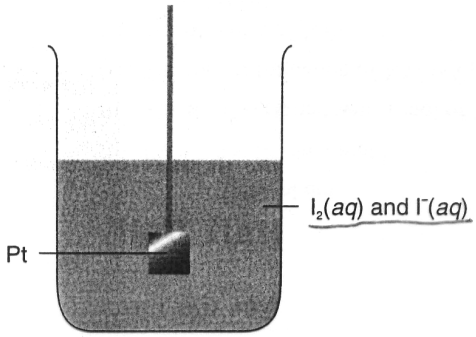
$2H^+(aq) + 2e^- \leftrightarrows H_2(g)$

Half cell diagram:

$2H^+(aq) \,|\, H_2(g) \,|\, Pt(s)$ *(IUPAC)*

OR

$H^+(aq) \,|\, H_2(g) \,|\, Pt(s)$



e.g. 2 **Iodine electrode**

$I_2(aq) + 2e^- \leftrightarrows 2I^-(aq)$

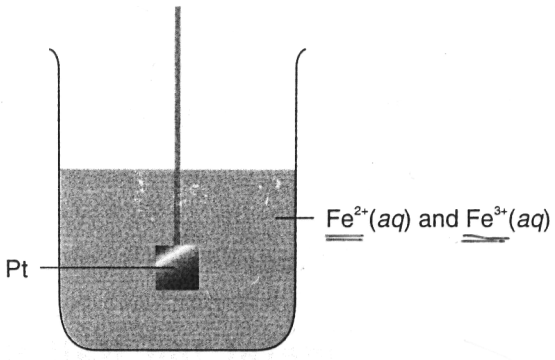
Half cell diagram:

$I_2(aq),\ 2I^-(aq) \,|\, Pt(s)$ *(IUPAC)*

OR

$I_2(aq),\ I^-(aq) \,|\, Pt(s)$

⌖ Ion-ion half cell



e.g. **Fe^{3+} - Fe^{2+} electrode**

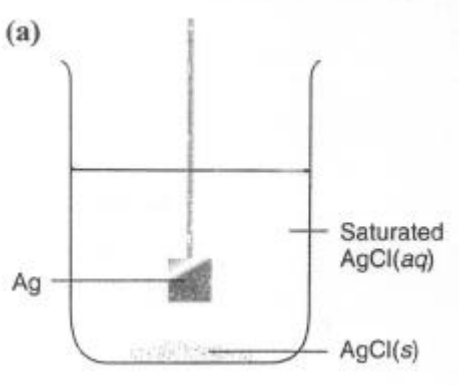
$Fe^{3+}(aq) + e^- \leftrightarrows Fe^{2+}(aq)$

Half cell diagram:

$Fe^{3+}(aq),\ Fe^{2+}(aq) \,|\, Pt(s)$ *(IUPAC)*

Metal-metal salt half cell

e.g. 1 **Ag-AgCl electrode**



$$AgCl(s) + e^- \leftrightarrows Ag(s) + Cl^-(aq)$$

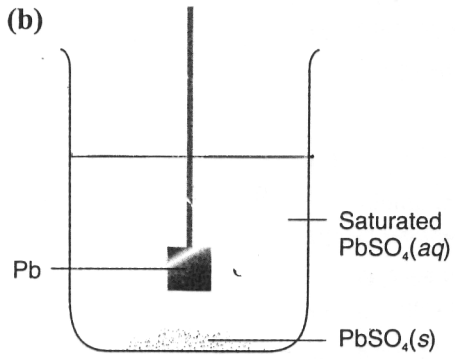
Half cell diagram:

$AgCl(s), [Ag(s) + Cl^-(aq)] \,|\, Pt(s)$ *(IUPAC)*

OR

$Cl^-(aq) \,|\, AgCl(s) \,|\, Ag(s)$

e.g. 2 **Pb-$PbCl_2$(aq) electrode**



$$PbSO_4(s) + 2e^- \leftrightarrows Pb(s) + SO_4^{2-}(aq)$$

Half cell diagram:

$PbSO_4(s)$, $[Pb(s) + SO_4^{2-}(aq)] \,|\, Pt(s)$ *(IUPAC)*

OR

$SO_4^{2-}(aq) \,|\, PbSO_4(s) \,|\, Pb(s)$

e.g. 3 **Calomel electrode**

$$Hg_2Cl_2(s) + 2e^- \leftrightarrows 2Hg(l) + 2Cl^-(aq)$$

Half cell diagram:

$Hg_2Cl_2(s)$, $[2Hg(l) + 2Cl^-(aq)] \,|\, Pt(s)$ *(IUPAC)*

OR

$Cl^-(aq) \,|\, Hg_2Cl_2(s) \,|\, Hg(l)$

B. Cell diagrams

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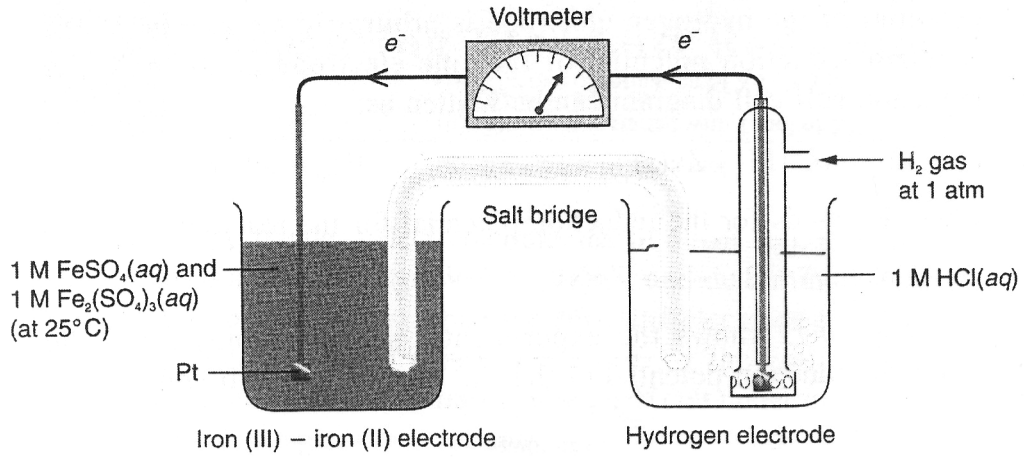
⌖ Ion-ion system

e.g.



Anode: $H_2(g) \leftrightarrows 2H^+(aq) + 2e^-$

Cathode: $Fe^{3+}(aq) + e^- \leftrightarrows Fe^{2+}(aq)$

Overall: $H_2(g) + 2Fe^{3+}(aq) \leftrightarrows 2H^+(aq) + 2Fe^{2+}(aq)$

Cell diagram

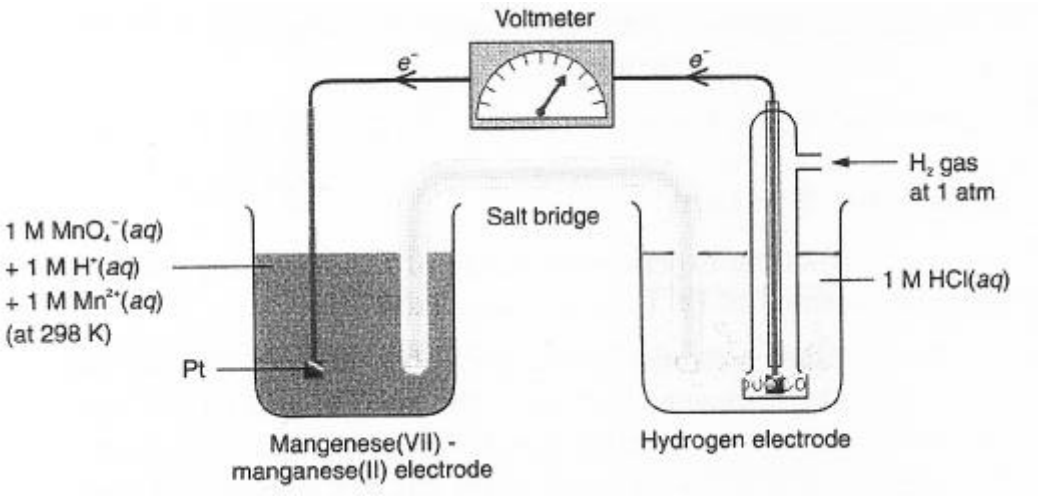
$Pt(s) \mid H_2(g, 1\ atm) \mid 2H^+(aq, 1M) \,\|\, Fe^{3+}(aq, 1M),\ Fe^{2+}(aq, 1M) \mid Pt(s)$ *(IUPAC)*

OR

$Pt(s) \mid H_2(g, 1\ atm) \mid H^+(aq, 1M) \,\|\, Fe^{3+}(aq, 1M),\ Fe^{2+}(aq, 1M) \mid Pt(s)$

⌗ Other system

e.g.



Anode: $H_2(g) \leftrightarrows 2H^+(aq) + 2e^-$

Cathode: $MnO_4^-(aq) + 8H^+(aq) + 5e^- \leftrightarrows Mn^{2+}(aq) + 4H_2O(l)$

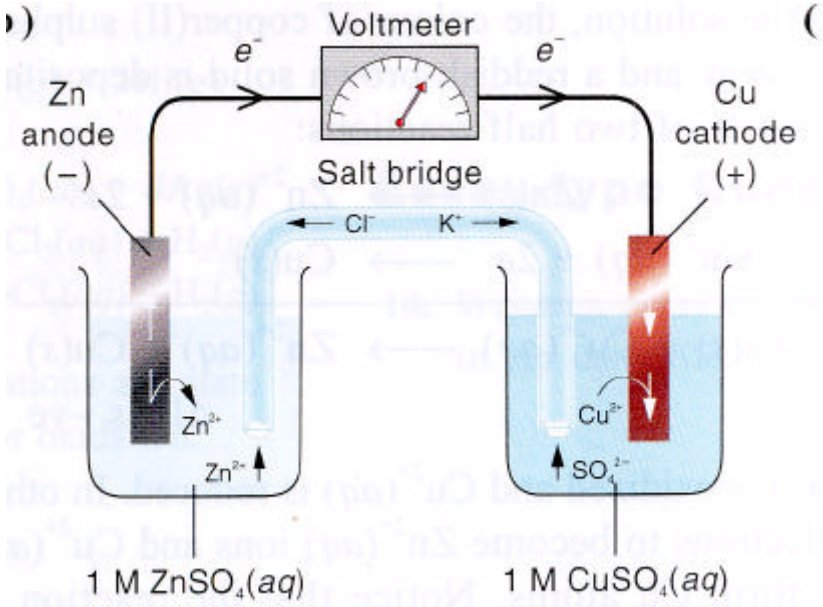
Overall: $5H_2(g) + 2MnO_4^-(aq) + 6H^+(aq) \leftrightarrows 2Mn^{2+}(aq) + 8H_2O(l)$

Pt(s) | H_2(g, 1 atm) | $2H^+$(aq, 1M) ‖ [MnO_4^-(aq) + $8H^+$(aq)], [Mn^{2+}(aq) + $4H_2O$(l)] | Pt(s) ***IUPAC***

OR

Pt(s) | H_2(g, 1 atm) | H^+(aq, 1M) ‖ H^+(aq, 1M), MnO_4^-(aq, 1M), Mn^{2+}(aq, 1M) | Pt(s)

Predicting Cell e.m.f



Calculate the standard e.m.f. of the cell

$$E^o_{cell} = E^o_{cathode} - E^o_{anode}$$

$Cu^{2+}(aq) + 2e^- == Cu(s)$ $\quad E^o = +0.34V$ *(cathode)*

--) $Zn^{2+}(aq) + 2e^- == Zn(s)$ $\quad E^o = -0.76V$ *(anode)*

$E^o_{cell} =$

Think about it

$Ag^+(aq) + e^- == Ag(s)$ ……..(1) $E^o_{red} = +0.8V$

2x(1) $2Ag^+(aq) + 2e^- == 2Ag(s)$ …(2) E^o_{red}=

Calculate the e.m.f. of the cell

$Ag^+(aq) + e^- == Ag(s)$ $E^o = +0.8V$ *(cathode)*

--) $Cu^{2+}(aq) + 2e^- == Cu(s)$ $E^o = +0.34V$ *(anode)*

E^o_{cell} =

Draw the cell diagram of the above cell.

Predict the feasibility of redox Rx

Consider the following Rx

$$A + B == C + D$$

If $E^o > 0$

$E^o = 0$

$E^o < 0$

Question

Will a reaction take place if a bar of Ag(s) is placed into 1M of $Fe_2SO_4(aq)$

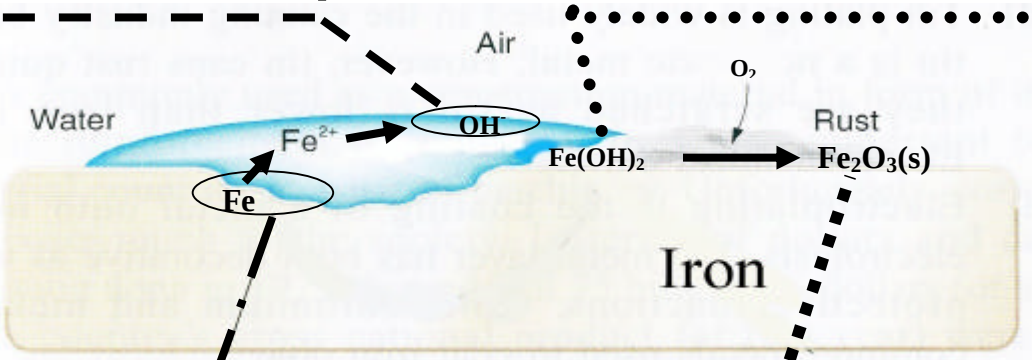
2

Cathode

$O_2(g) + 2H_2O(l) + 4e^- \rightarrow 4OH^-(aq)$

3

$Fe^{2+}(aq) + 2OH^-(aq) \rightarrow Fe(OH)_2(s)$



1

Anode

$Fe(s) \rightarrow Fe^{2+}(aq) + 2e^-$

4

$2Fe(OH)_2(s) + \frac{1}{2}O_2(g) + (x-2)H_2O(l) \rightarrow Fe_2O_3 \cdot 3xH_2O(s)$