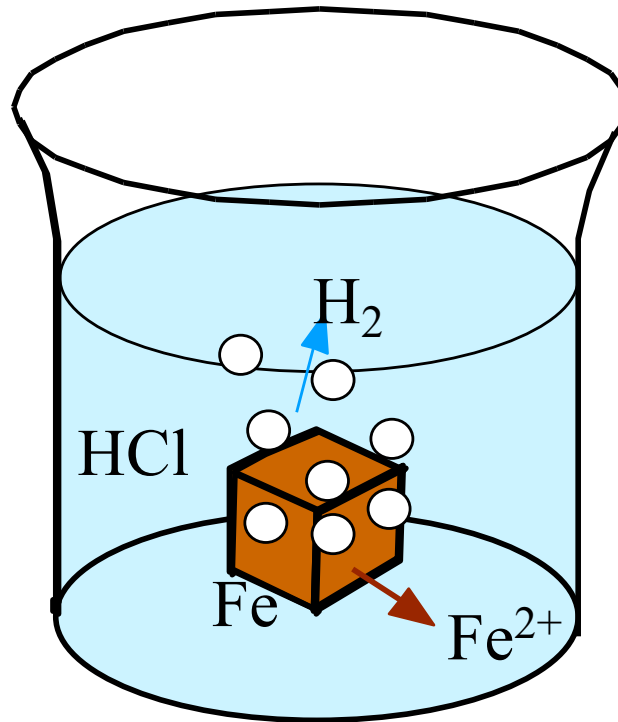


Electrochemistry for materials technology

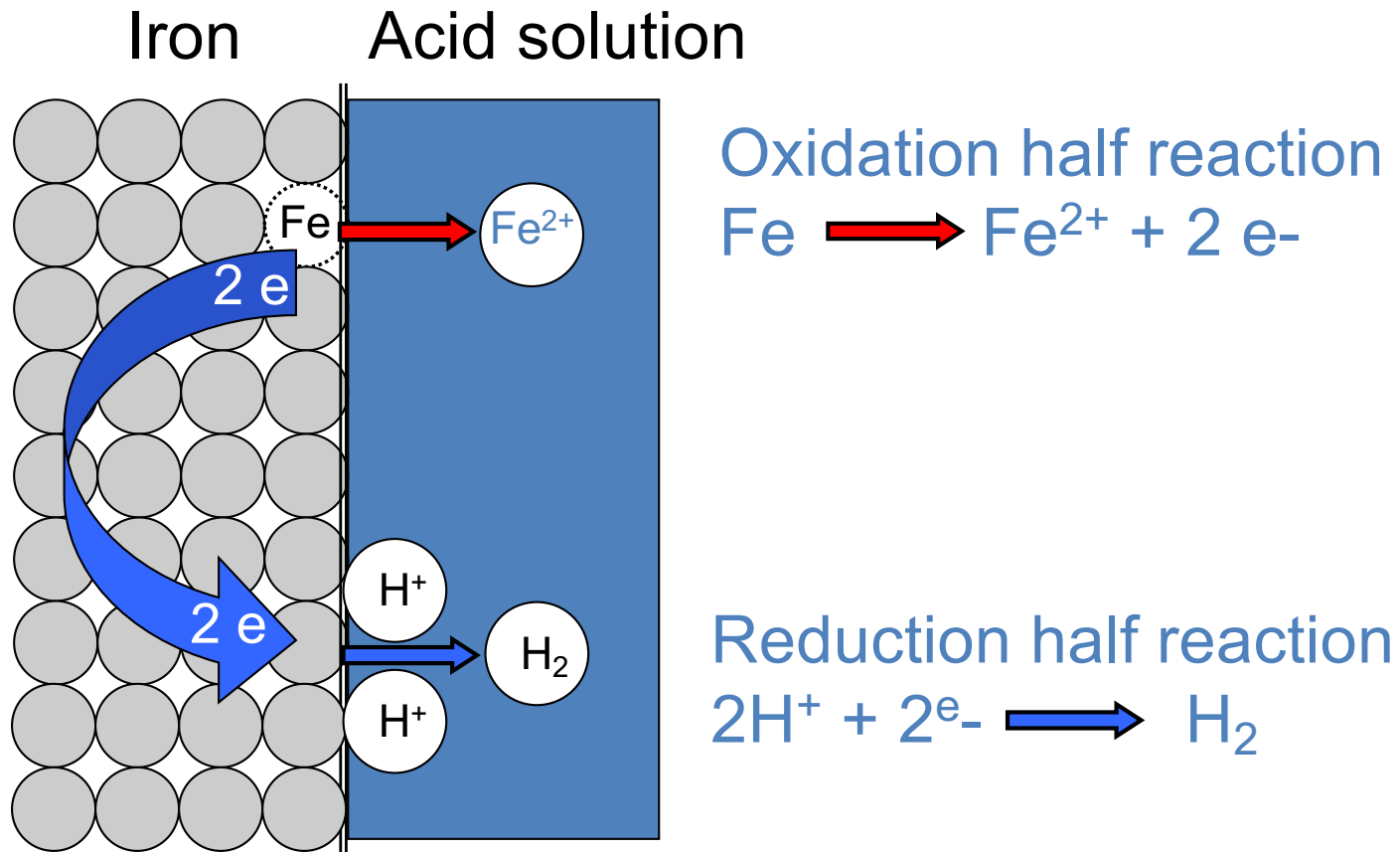
Chapter 2

Electrode reactions

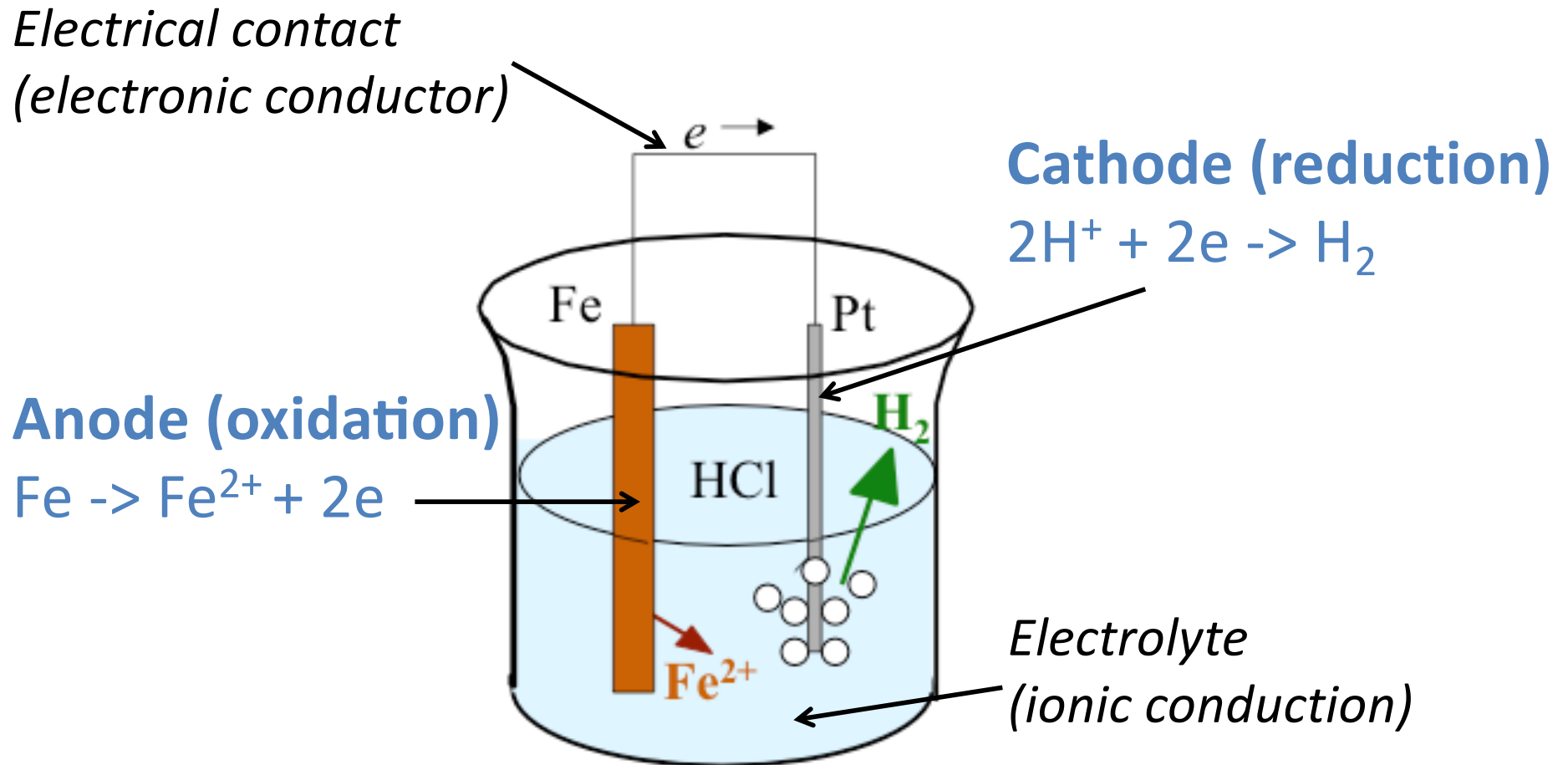
Electrochemical reactions: case of iron corrosion in acid



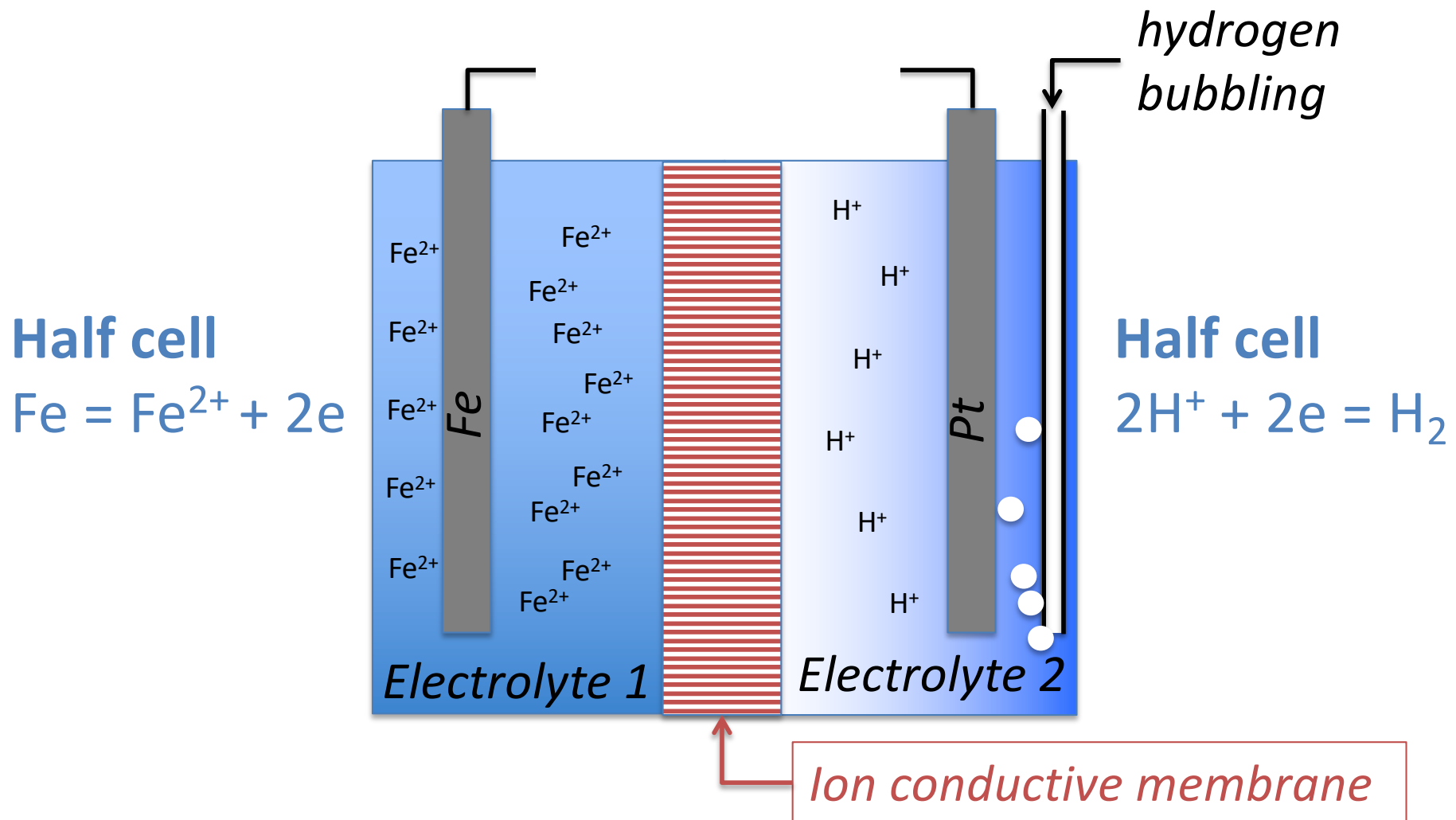
Corrosion of iron as an electrochemical reaction



Oxidation and reduction can occur on distinct but connected electrodes



Electrochemical cells and half cells



The reaction rate of electrochemical reactions can be described as a current

Faraday's law (electrolysis)

$$\frac{d m}{d t} = \frac{I M}{n F}$$

m: mass of the reacted substance [g]

t : time [s]

I : current [A]

F: Faraday constant (96485 A s mol⁻¹)

M: the molar mass of the substance [g/mol]

n: stoichiometric coefficient of the electrons in the reaction

Different ways of expressing electrode reaction rates

Current density i [A m^{-2}]

$$i = I / A_{\text{electrode}}$$

Number of moles n_m reacted per unit surface and per unit time [$\text{mol m}^{-2} \text{s}^{-1}$]

$$n_m = i / nF$$

Mass loss m_r per unit surface and per unit time [$\text{g m}^{-2} \text{s}^{-1}$]

$$m_r = i M / nF$$

Reacted depth d_r per unit of time [$\mu\text{m/s}$]

$$d_r = i M / nF\rho$$

- I : current [A]
- F : Faraday constant ($96485 \text{ A s mol}^{-1}$)
- M : the molar mass of the substance [g mol^{-1}]
- n : stoichiometric coefficient of the electrons in the reaction
- $A_{\text{electrode}}$: surface area of the electrode [m^2]
- ρ : density [g cm^{-3}]

Conversion table

to obtain units in the 1st row :

multiply unit in the 1st column by the corresponding factor

| | $\frac{\text{mol}}{\text{m}^2\text{s}}$ | $\frac{\text{mol}}{\text{cm}^2\text{s}}$ | $\frac{\text{A}}{\text{m}^2}$ | $\frac{\mu\text{A}}{\text{cm}^2}$ | $\frac{\text{mg}}{\text{dm}^2\text{j}}$ | $\frac{\text{mm}}{\text{an}}$ |
|------------------------------------------|-----------------------------------------|------------------------------------------|-------------------------------|-----------------------------------|-----------------------------------------|----------------------------------------|
| $\frac{\text{mol}}{\text{m}^2\text{s}}$ | 1 | 10^{-4} | $9.65 \times 10^4 n$ | $9.65 \times 10^6 n$ | $8.64 \times 10^5 M$ | $3.15 \times 10^4 \frac{M}{\rho}$ |
| $\frac{\text{mol}}{\text{cm}^2\text{s}}$ | 10^4 | 1 | $9.65 \times 10^8 n$ | $9.65 \times 10^{10} n$ | $8.64 \times 10^9 M$ | $3.15 \times 10^8 \frac{M}{\rho}$ |
| $\frac{\text{A}}{\text{m}^2}$ | $\frac{1.04 \times 10^{-5}}{n}$ | $\frac{1.04 \times 10^{-9}}{n}$ | 1 | 100 | $8.96 \frac{M}{n}$ | $0.327 \frac{M}{n \rho}$ |
| $\frac{\mu\text{A}}{\text{cm}^2}$ | $\frac{1.04 \times 10^{-7}}{n}$ | $\frac{1.04 \times 10^{-11}}{n}$ | 0.01 | 1 | $8.96 \times 10^{-2} \frac{M}{n}$ | $3.27 \times 10^{-3} \frac{M}{n \rho}$ |
| $\frac{\text{mg}}{\text{dm}^2\text{j}}$ | $\frac{1.16 \times 10^{-6}}{M}$ | $\frac{1.16 \times 10^{-10}}{M}$ | $0.112 \frac{n}{M}$ | $11.2 \frac{n}{M}$ | 1 | $\frac{3.65 \times 10^{-2}}{\rho}$ |
| $\frac{\text{mm}}{\text{an}}$ | $3.17 \times 10^{-5} \frac{\rho}{M}$ | $3.17 \times 10^{-9} \frac{\rho}{M}$ | $3.06 \frac{n \rho}{M}$ | $306 \frac{n \rho}{M}$ | 27.4ρ | 1 |

$M = \text{atomic mass (g/mol)}$, $\rho = \text{density (g/cm}^3\text{)}$, $n = \text{charge number (adimensional)}$)