What's E°_{cell} and E_{cell} for:

$$Zn \,|\, Zn^{2+}(0.25M) \,\|\, Ag^+(0.0025M) \,|\, Ag$$

$$E^\circ_{cell} = E^\circ_{RHS} - E^\circ_{LHS}$$
$$= +0.80V - -0.76V$$
$$= +1.56V$$

rxn:

ox: $Zn \longrightarrow Zn^{2+} + 2e^-$

red: $(e^- + Ag^+ \longrightarrow Ag) \times 2$

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

25°C

$$E = E^\circ - \frac{RT}{nF} \ln Q$$

$$= +1.56V - \frac{8.3145\ J/mol\cdot K \times 298K}{2 \times 96{,}500\ C/mol} \ln Q$$

$$Q = \frac{[Zn^{2+}]}{[Ag^+]_i^2} = \frac{0.25}{0.0025^2}$$

$$E = 1.56V - \frac{8.3145\ J/mol\cdot K \times 298K}{2 \times 96{,}500\ C/mol} \cdot \ln\left(\frac{0.25}{0.0025^2}\right)$$

$$= +1.56V - 0.0128\frac{J}{C} \times 10.597$$

elec work = charge × voltage.

$$1J = 1C \times 1V \quad \Rightarrow 1\frac{J}{C} = 1V$$

$$\Rightarrow \boxed{E = 1.42V}$$

Electrolysis

Voltaic/Galvanic cells ~ produce elec energy from a spontaneous redox rxn.

E°_{cell} = +ve

ΔG° = -ve

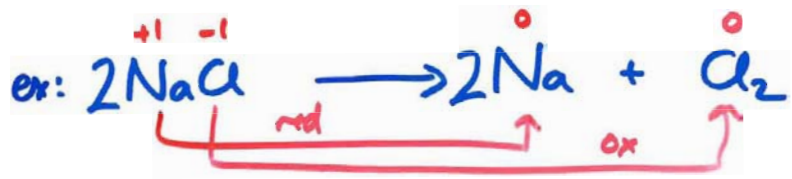
$K \gg 1$

Electrolytic cells ~ consume elec energy to drive an otherwise non-spont. rxn.

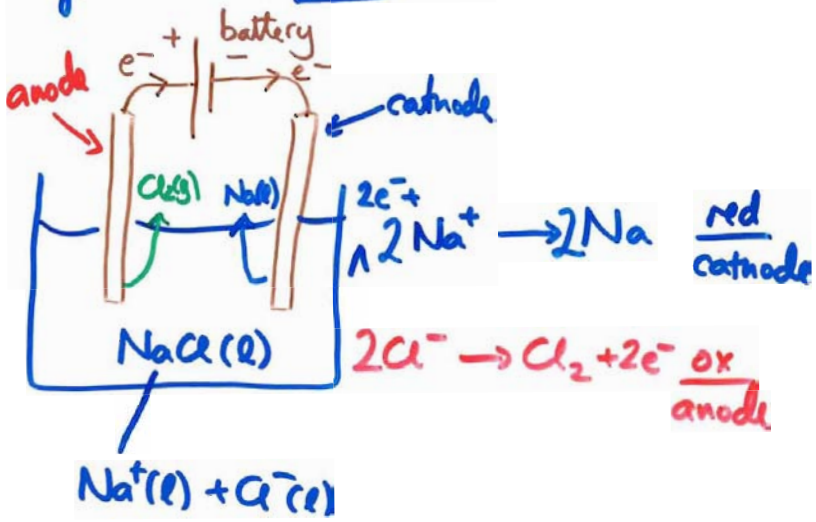
E°_{cell} = -ve

ΔG° = +ve

$K \ll 1$



electrolysis can DRIVE this rxn!



Down's Cell: $2NaCl(l) \xrightarrow{elec} 2Na(l) + Cl_2(g)$

$E^\circ_{cell} \cong -4V$

have to supply >4V to drive rxn.

Quantitative aspects of electrolysis

Michael Faraday ... he noticed that the mass of products formed @ electrodes

$\propto$ time
$\propto$ electrical current
$\propto$ molar mass of element.

Electrical Current = $\frac{\text{Charge}}{\text{time}}$ $\quad \frac{Q\ (C)}{t\ (s)}$

$I\ (A)$

$$I = \frac{Q}{t} \qquad (C),\ (s),\ (A)$$

$1A = 1\frac{C}{s}$

$1A = 1\frac{C}{s}$, $15A = 15\frac{C}{s}$

total charge: $\boxed{Q = I \cdot t}$

ex: What's charge when a 13A current flows for 3.0 min?

$$Q = 13\frac{C}{\cancel{s}} \times 3.0\cancel{\text{min}} \times \frac{60\cancel{s}}{1\cancel{\text{min}}}$$

$= 2300C$

How many mol e^-s ?

$$2300C \times \frac{1 \text{ mole}^-}{96{,}500C} = 0.024 \text{ mol } e^-$$

let's say we're electrolyzing NaCl.

$2NaCl \longrightarrow 2Na + Cl_2$

in general: compound → elements

$2e^- + 2Na^+ \longrightarrow 2Na$

$2Cl^- \longrightarrow Cl_2 + 2e^-$

ex: What mass of Na + what mass Cl_2 would we make?

$$0.024\,mol\,e^- \left| \frac{2\,mol\,Na}{2\,mol\,e^-} \right| \frac{22.99\,g\,Na}{1\,mol\,Na} = 0.55\,g\,Na$$

$$0.024\,mol\,e^- \left| \frac{1\,mol\,Cl_2}{2\,mol\,e^-} \right| \frac{70.90\,g\,Cl_2}{1\,mol\,Cl_2} = 0.85\,g\,Cl_2$$

let's try another one!

$$2Al_2O_3 \xrightarrow{elec} 4Al + 3O_2$$

$$4Al^{3+} + 6O^{2-} \xrightarrow{elec} 4Al + 3O_2$$

$$12e^- + 4\,Al^{3+} \xrightarrow{red} 4\,Al \quad (cathode)$$

$$6O^{2-} \xrightarrow{ox} 3O_2 + 12e^- \quad (anode)$$

let's electrolyze Al_2O_3 for 10.d @ current 12 A.

Q. How many grams of Al?

Mol e^-?

$$12\,\frac{C}{s} \times 10.d \times \frac{24h}{1d} \left| \frac{60\,min}{1h} \right| \frac{60\,s}{1\,min} =$$

$$1.0\times10^7\,C \left| \frac{1\,mol\,e^-}{96{,}500\,C} \right| = 110\,mol\,e^-$$

$$110\,mol\,e^- \left| \frac{4\,mol\,Al}{12\,mol\,e^-} \right| \frac{26.98\,g\,Al}{1\,mol\,Al} = 970\,g\,Al$$

$\approx$ 2 lbs.