Oxidative Metabolism of Glucose / Introduction to ETC / Electrochemistry Review:

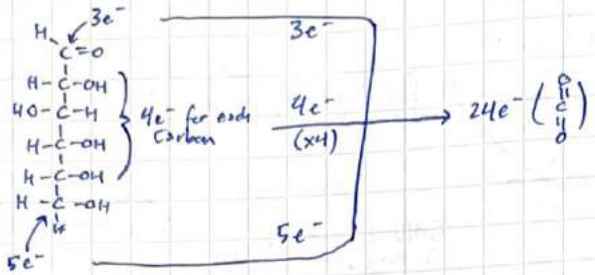
$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O + (\text{Energy})$ (Complete Oxidation of Glucose)

Energy → ATP synthesis

We must count electrons:

Recall that in CO_2,
- 0 e^- belong to carbon
- 4 e^- belong to each oxygen.

} How many electrons are removed from glucose to CO_2?



Glucose → $6CO_2$

$24e^-$ (in the form of NADH in ETC and $FADH_2$)

The $24e^-$ are split between 10 NADH molecules and 2 $FADH_2$ molecules from glycolysis → citric acid cycle.

Introducing Oxygen to the Equation:

$2NADH + O_2 \xrightarrow{2H^+} 2NAD^+ + 2H_2O$ is the reduction of oxygen to water via NADH.

Alternatively,

$NADH + \frac{1}{2}O_2 + H^+ \longrightarrow H_2O + NAD^+$

or alternatively,

$O_2 + 4e^- + 4H^+ \longrightarrow 2H_2O$

For $FADH_2$, the equation is:

$O_2 + 2FADH_2 \longrightarrow 2H_2O + 2FAD$

The reduction of O_2 occurs in the electron transport chain (ETC) and requires an understanding of electrochemistry, in particular the reduction potentials & redox reactions of species:

Consider the reaction:

$Fe^{+3} + \frac{1}{2}H_2 \rightleftharpoons Fe^{+2} + H^+$

Fe^{+3}: e^- acceptor (oxidizing agent); $\frac{1}{2}H_2$: e^- donor (reducing agent)

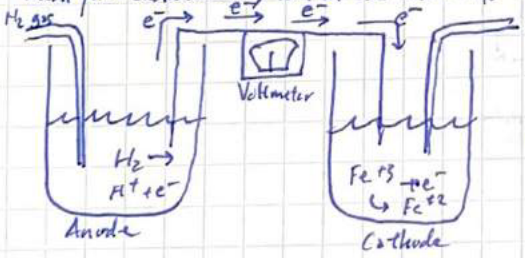
$\Delta G^{o'}$ tells us the spontaneity of this reaction:
It can also be thought of as: "which species has a greater affinity for electrons?"

$Fe^{+3} + e^- \longrightarrow Fe^{+2}$ $\quad \Delta E^\circ_{Fe^{+3}}$

$H^+ + e^- \longrightarrow \frac{1}{2}H_2$ $\quad \Delta E^\circ_{H^+}$

↑ Relative Affinities

Recall from electrochemistry that we use relative affinities, $\Delta E^{o'}$, to determine E°.



In this case ΔE° is +0.771 V, and electrons flow from the left anode to the right cathode.
(spontaneous process from left to right)

If $\Delta E^\circ > 0$, process is spontaneous.
If $\Delta E^\circ < 0$, process is non-spontaneous.

By definition, $E^\circ_{H^+} = 0\ V$

The relation between ΔE° and ΔG° is:

$\Delta G^{o'} = -nF(\Delta E^\circ)$

- $\Delta G^{o'}$: kJ/mol
- n: # of e^- transferred in the reaction (moles)
- F: Faraday constant: 96485 C/mole⁻ or 96.48 kJ/V·mol
- ΔE°: Units of V, J/C