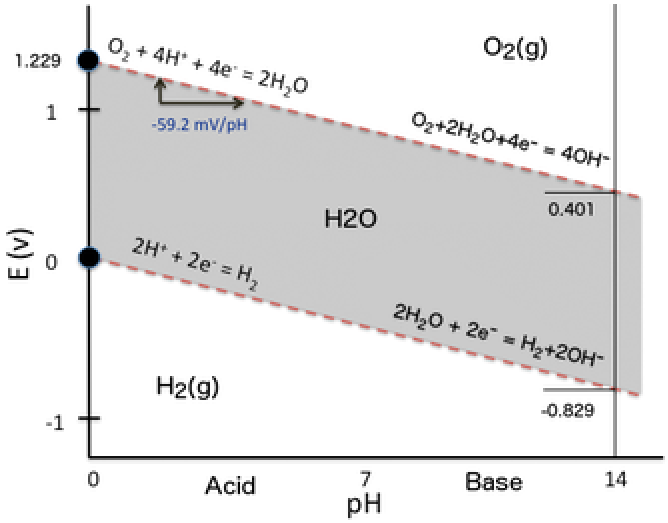
Electrolysers

1) A lab scale 1 kW alkaline water electrolyser operates at 70% HHV efficiency. The stack is operated at 60°C and is electrically connected in series, with each cell having a surface of 100 cm^2. The supporting electrolyte used is 1 M potassium hydroxide (pH=14), in conjunction with Zirfon Perl UTP 500μm thick diaphragm separator. The nominal current density of operation is 0.5 A cm^{-2}. The Pourbaix diagram for water electrolysis is given in the figure below.



Calculate:

i) Reversible cell potential for hydrogen evolution ($E_{rev,H2}$) and oxygen evolution ($E_{rev,O2}$) reactions. (considering pH=14)
ii) The thermoneutral voltage (E_{tn}) at 25°C and at 60°C. (E_{tn} corresponds to -ΔH/nF)
iii) The number of cells in the stack and the corresponding operating voltage of each cell.
iv) The water flowrate in L min^{-1} necessary at the cathode to reach a conversion rate of 80%, assuming a Faradaic efficiency (=current efficiency) of 100%.

Further thinking:

a) Is Faradaic efficiency of 100% a relevant assumption?
b) How does the thermoneutral voltage change with the phase change of water to steam?

Hints:

HHV efficiency is defined as: $\eta_{HHV} = \frac{E_{tn}}{E_{Cell}}$

for the reaction H_2O (l) -> H_2(g) + O_2(g) assume

$\Delta H_{25C} =$ 285.83 kJ mol^{-1}
$\Delta H_{60C} =$ 284.72kJ mol^{-1}
HHV = 141.88 $MJkg^{-1}$
ρ_{H2} = 0.0813 gL^{-1}