FuelCell Addendum - Gas Stoichiometry Constants

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Introduction

This document describes the calculations used for the stoichiometric gas flow requirements. All conditions are defined for a standard state (STP) of 0 ^{o}C and 1 atm.

The calculation is fundamentally based on Faradays Law:

$$I = \frac{N \cdot z \cdot F}{t}$$

where *I* is the current (Amp, A), *N* is the moles of species, *z* is the moles of electrons exchanged per mole of species (mole e^-/mole X), *F* is Faraday's constant (96,487 C/mole e^-) and *t* is time (s).

To convert to a mass flow rate, we use the ideal gas law at standard temperature and pressure (STP):

$$P \cdot V = N \cdot R \cdot T$$

where *P* is pressure (atm), *V* is volume (L), *R* is the gas constant (0.0821 L-atm/mole-K) and *T* is temperature (K).

Combining these two equations and rearranging for the gas mass flow rate which is usually expressed in standard L/min/A,

$$\frac{V}{t \cdot I} = \frac{R \cdot T}{z \cdot F \cdot P} = \frac{\left(0.0821 \frac{L \cdot atm}{mole \cdot K}\right) \cdot (273.15\ K)}{\left(z \frac{mole\ e^-}{mole}\right) \cdot \left(\frac{96{,}487\ C}{mole\ e^-}\right) \cdot (1\ atm)} \cdot \frac{C}{A \cdot s} \cdot \frac{60\ s}{min} = \frac{0.013945}{z} \frac{L}{min \cdot A}$$

Hydrogen (H_2)

z: 2 mole e^- / mole H_2

$$\left(\frac{V}{t \cdot I}\right)_{H_2} = \frac{0.013945}{2} \frac{L}{min \cdot A} = 0.00697 \frac{L}{min \cdot A} = 6.97 \frac{mL}{min \cdot A}$$

Therefore, it takes 6.97 mL/min H_2 to sustain a current of 1 A.

Oxygen (O_2)

z: 4 mole e$^-$ / mole O_2

$$\left(\frac{V}{t \cdot I}\right)_{O_2} = \frac{0.013945}{4} \frac{L}{min \cdot A} = 0.00349 \frac{L}{min \cdot A} = 3.49 \frac{mL}{min \cdot A}$$

Therefore, 3.49 mL/min O_2 is required to generate 1 A.

Air (20.95% O_2)

Air is 20.95 vol. % O_2 so:

$$\left(\frac{V}{t \cdot I}\right)_{Air} = \left(0.00349 \frac{L}{min \cdot A}\right) \cdot \left(\frac{1}{0.2095}\right) = 0.0166 \frac{L}{min \cdot A} = 16.6 \frac{mL}{min \cdot A}$$

Therefore, 16.6 mL/min air is required to generate 1 A.