

2.9 with heat capacity.  $C_p$

$$\Delta h = -41.13 \text{ kJ/mol} + \left( \overset{37.2}{\cancel{29.2}} + 28.8 \right) - \left( \overset{29.2}{\cancel{33.6}} + 33.6 \right) \cdot \Delta T \text{ (in J/mol)}$$

$\text{CO}_2$     $\text{H}_2$                        $\text{CO}$     $\text{H}_2\text{O}$

$$= -41.13 \text{ kJ/mol} + 3.2 \Delta T \text{ (J/mol)}$$

$$\Delta S = -42.00 \text{ J/mol}\cdot\text{K} + 3.2 \text{ J/mol} \cdot \ln \frac{T}{298.15}$$

$$\Delta G = -41.13 \text{ kJ/mol} - T[-0.042 \text{ kJ/mol}\cdot\text{K}] + \overset{0.0032}{\cancel{3.2}} \Delta T - 0.0032 T \ln \frac{T}{298.15}$$

Note.  $T = \Delta T + 298.15$

Hence we need:

~~$$-41.13 \text{ kJ/mol}$$~~

$$-42.08 + 0.0452 T - 0.0032 T \ln \left( \frac{T}{298.15} \right) = 0.$$

A transcendental equation.

Solved by Mathematica or Wolfram Alpha.

$$T = 1019.75 \text{ K} = 721.6^\circ\text{C}, \quad \text{minor correction } \sim 4\%$$

2.10. (2.72):  $\left( \frac{dE}{dT} \right)_P = \frac{\Delta \hat{S}}{nF}$

(2.80)  $\left( \frac{dE}{dp} \right)_T = -\frac{\Delta n_g RT}{nFp}$        $\Delta n_g$ : gas mole change.

~~Write~~ Write  $dE = \left( \frac{dE}{dT} \right)_P dT + \left( \frac{dE}{dp} \right)_T dp$

$$dE = \frac{1}{nF} \left[ \Delta \hat{S} dT + \frac{\Delta n_g RT}{p} dp \right]$$

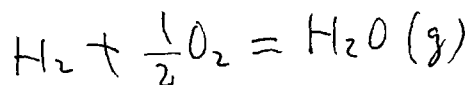
Integrate both side, wrt the variables T, P

$$\Delta E = \frac{1}{nF} \left[ \hat{\Delta S} \Delta T - \frac{\Delta n_g RT}{1} \ln \frac{P_2}{P_1} \right]$$

to make  $\Delta E = 0$ .

$$\hat{\Delta S} [T_2 - T_1] = \Delta n_g RT \ln \frac{P_2}{P_1}$$

For  $H_2 - O_2$  fuel cell



$$\hat{\Delta S} = -44.34 \text{ J/mol}\cdot\text{K}$$

$$\Delta n_g = 1 - 1 - 0.5 = -0.5 \text{ mol}$$

$$-44.34 \cdot [T - 298] = -0.5 \cdot 8.31 \cdot 298 \ln \frac{1}{10}$$

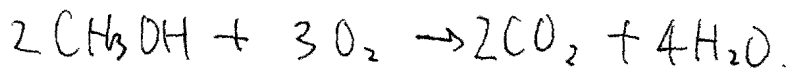
$$-44.34 \cdot [T - 298] = +2851$$

$$T - 298 = -64.3$$

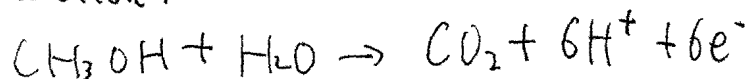
$$T \doteq 235 \text{ K.}$$

Note : if using liquid water as the product; you get slightly different answer.

2.13.



half reaction:



It's a six electron transfer reaction.

(a) The MeOH reaction rate is

$$\frac{1000A}{nF} = \frac{1000A}{6F} = 0.001727 \text{ mol/s}$$

So, the MeOH out rate:

$$v_{\text{MeOH, out}} = 0.003 - 0.001727 = 0.001273 \text{ mol/s}$$

$$v_{\text{H}_2\text{O, out}} = 0.001727 \times 2 = 0.003454 \text{ mol/s}$$

$$\text{O}_2 \text{ consumption is } 0.001727 \times \frac{3}{2} = 0.00259 \text{ mol/s}$$

$$\text{air consumption rate is the } 0.00259 \text{ mol/s} / 20.946\% \\ = 0.01237 \text{ mol/s}$$

So one can say the "air out rate" is

$$v_{\text{air, out}} = 0.03 - 0.01237 = 0.01763 \text{ mol/s} = 0.0176 \text{ mol/s}$$

Water:

$$v_{\text{water, out}} = 0.001727 \times 2 = 0.003454 \text{ mol/s}$$

$$\text{CO}_2 : v_{\text{CO}_2, \text{out}} = 0.001727 \times 1 = 0.001727 \text{ mol/s}$$

$$(b) \quad \lambda_{\text{MeOH}} = \frac{v_{\text{MeOH, in}}}{1/nF} = 1.737$$

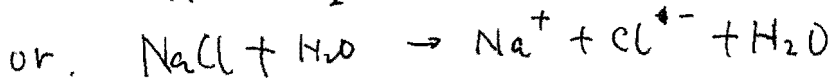
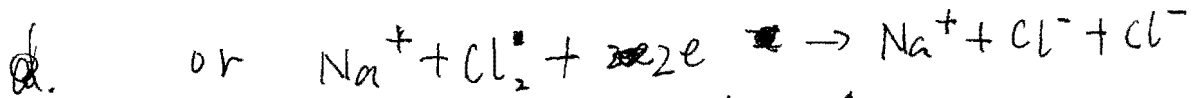
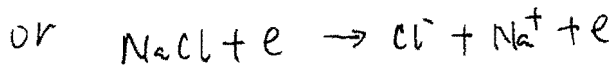
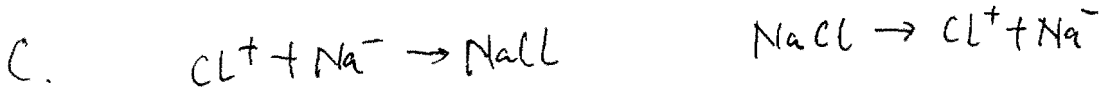
$$\lambda_{\text{air}} = \frac{v_{\text{air, in}}}{\frac{3}{2} \cdot i/nF / 0.21} = \frac{0.03}{0.01237} = 2.4252$$

$$(c) \quad \text{Heat generation} = 719.19 \times 0.001727 - 0.3 \times 1000 / 1000 \\ = 1.242 - 0.3 = 0.942 \text{ kW}$$

(3)

4. a. Carbon felt/cloth.  $\text{Na}^{\text{ion}} \rightarrow \text{Na}^+$

b.  $\text{Na}^+$ ,  $\text{Cl}^-$  (less)



d. 
$$V = \frac{RT}{F} \ln \frac{[\text{Na}^+]_{\text{sat}}}{[\text{Na}^+]_{\text{dil}}} = \frac{\Delta G_{\text{solution}}}{F}$$
 or dilution free energy.

e. Concentration equilibrium.

f. Solvation energy of NaCl at ocean T ( $\sim 15^\circ\text{C}$ ) vs at 298K

g. 
$$\frac{\Delta G_{\text{solution}}(RT)}{\Delta H_{\text{solution}}(RT)}$$
 dilution (top), dilution (bottom)

$$\frac{\Delta G_{\text{solution}}(80^\circ\text{C})}{\Delta H_{\text{solution}}(80^\circ\text{C})}$$
 dilution (top), dilution (bottom)

h. acid + alkali type.  $\text{OCV} \sim 0.7 \text{ V}$ .

bigger  $\Delta G$  per mole.