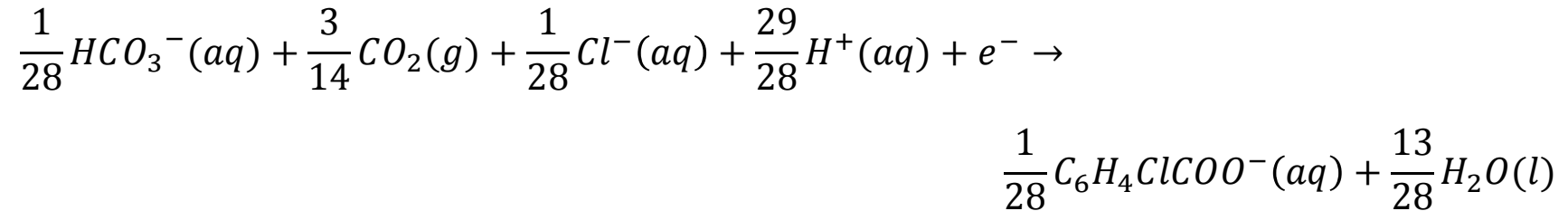


Q1



$$\Delta G_r^{0'} = - \left\{ \frac{1}{28} \times (-586.85) + \frac{3}{14} \times (-394.36) + \frac{1}{28} \times (-31.35) + \frac{29}{28} \times (-39.87) \right\}$$
$$+ \left\{ \frac{1}{28} \times (-237.9) + \frac{13}{28} \times (-237.18) \right\}$$
$$= 29.26 \text{ kJ/e}^- \text{ eq}$$

Q2

$$R_d: \text{O-5}; \quad \Delta G_r^{0'} = 31.18 \text{ kJ}/e^- \text{ eq}$$

$$R_a: \text{I-14}; \quad \Delta G_r^{0'} = -78.72 \text{ kJ}/e^- \text{ eq}$$

$$R_e = R_a - R_d \qquad \Delta G_r^{0'}(R_e) = \Delta G_r^{0'}(R_a) - \Delta G_r^{0'}(R_d)$$

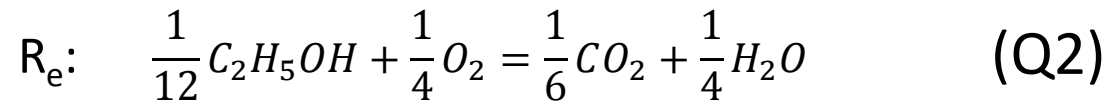
$$R_a: \quad \frac{1}{4}O_2 + H^+ + e^- = \frac{1}{2}H_2O \qquad = -78.72 - 31.18$$

$$-R_d: \quad \frac{1}{12}C_2H_5OH + \frac{1}{4}H_2O = \frac{1}{6}CO_2 + H^+ + e^- \qquad = \mathbf{-109.90 \text{ kJ}/e^- \text{ eq}}$$

$$R_e: \quad \frac{1}{12}C_2H_5OH + \frac{1}{4}O_2 = \frac{1}{6}CO_2 + \frac{1}{4}H_2O$$

Q3

$$\Delta G_r^{0'} = -109.90 \text{ kJ}/e^- \text{ eq}$$



$$\Delta G_r^0 = \Delta G_r^{0'} - RTv_H + \ln[10^{-7}] = G_r^{0'} - 0 = G_r^{0'}$$

$$\Delta G_r = \Delta G_r^0 + RT \sum_{i=1}^n v_{ir} \ln a_i$$

$$= -109.90 \text{ kJ}/e^- \text{ eq} + (8.314 \times 10^{-3} \text{ kJ}/\text{mole} - K) \times (293 \text{ K})$$

$$\times \left\{ -\frac{1}{12} \ln(2 \times 10^{-3}) - \frac{1}{4} \ln(0.21) + \frac{1}{6} \ln(3 \times 10^{-4}) + \frac{1}{4} \ln(1) \right\}$$

$$= -110.98 \text{ kJ}/e^- \text{ eq}$$

$a_{H_2O} = 1$ for aqueous solutions; you may omit the water term

Q4

From O-1, $\Delta G_c^{0'} = 27.40 \text{ kJ}/e^- \text{ eq}$

$$\Delta G_p = 35.09 - 27.40 = 7.69 \text{ kJ}/e^- \text{ eq}$$

$$\Delta G_r = \Delta G_a - \Delta G_d = -78.72 - 27.40 = -106.12 \text{ kJ}/e^- \text{ eq}$$

$\because \Delta G_d = 27.40 \text{ kJ}/e^- \text{ eq}, \Delta G_a = -78.72 \text{ kJ}/e^- \text{ eq}$ (from I-14)

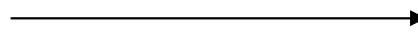
$$\Delta G_p > 0 \rightarrow n = +1$$

$$A = -\frac{\frac{\Delta G_p}{\epsilon^n} + \frac{\Delta G_{pc}}{\epsilon}}{\epsilon \Delta G_r} = -\frac{\frac{7.69}{\epsilon^{+1}} + \frac{18.8}{\epsilon}}{-106.12}$$

$$\epsilon = 0.4 : A = 1.56$$

$$\epsilon = 0.6 : A = 0.69$$

$$f_s^0 = \frac{1}{1 + A}$$



$$\epsilon = 0.4 : f_s^0 = 0.39$$

$$\epsilon = 0.6 : f_s^0 = 0.59$$