CH 302 Spring 2007 Worksheet 11

Half-reaction	ΔE_r^0 (V)
$Li^+(aq) + e^- \rightarrow Li(s)$	-3.05
$Al^{3+}(aq) + 3e^- \rightarrow Al(s)$	-1.68
$TiO(s) + 2H^+ + 2e^- \rightarrow Ti(s) + H_2O$	-1.31
$Ti^{3+}(aq) + 3e^- \rightarrow Ti(s)$	-1.21
$Ni^{2+}(aq) + 2e^- \rightarrow Ni(s)$	-0.25
$CO_2(g) + 2H^+ + 2e^- \rightarrow HCOOH(aq)$	-0.11
$2H^+(aq) + 2e^- \rightarrow H_2(g)$	0
$SO_4^{2-}(aq) + 4H^+ + 2e^- \rightarrow 2H_2O(l) + SO_2(aq)$	+0.17
$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$	+0.34
$Fe^{3+}(aq) + e^- \rightarrow Fe^{2+}(aq)$	+0.77
$NO_3^-(aq) + 2H^+(aq) + e^- \rightarrow NO_2(g) + H_2O(l)$	+0.80
$Au^{3+}(aq) + 3e^- \rightarrow Au(s)$	+1.52
$Ag_2O_3(s) + 6H^+ + 4e^- \rightarrow 2Ag^+(aq) + 3H_2O$	+1.67
$F_2(g) + 2e^- \rightarrow 2F^-(aq)$	+2.87

For problems 1-5, calculate ΔE for the given electrochemical cell.

1. Pt | F^-(1.3 M) | F_2(0.75 atm) || Cu^{2+}(0.25 M) | Cu

Answer: Balanced reaction: $Cu^{2+} + 2\ F^- \rightarrow Cu + F_2$

$\Delta E^0 = 0.34 - 2.87 = -2.53$ V

$\Delta E = \Delta E^0 - 0.059/n \log(p_{F2}/[Cu^{2+}][F^-]^2)$

$= -2.53\ V - 0.059/2 \log(0.75\ atm/(0.25\ M)(1.3\ M)^2) =$ **-2.54 V**

2. Au | Au^{3+}(0.1 M) || Ni^{2+}(0.05 M) | Ni

Answer: $3\ Ni^{2+} + 2\ Au \rightarrow 3\ Ni + 2\ Au^{3+}$

$\Delta E = -1.77\ V - 0.059/6 \log((0.1\ M)^2/(0.05\ M)^3) =$ **-1.79 V**

3. Pt | Cu | Cu^{2+}(0.025 M) || Fe^{3+}(0.9 M) | Fe^{2+}(2.05 M) | Ag

Answer: $2\ Fe^{3+} + Cu \rightarrow 2\ Fe^{2+} + Cu^{2+}$

$\Delta E = 0.43\ V - 0.059/2 \log((2.05\ M)^2(0.025\ M)/(0.9\ M)) =$ **0.458 V**

4. Ti | Ti^{3+}(1.3 M) || Au^{3+} (0.05 M) | Au

Answer: $Au^{3+} + Ti \rightarrow Au + Ti^{3+}$

$\Delta E = 2.73V - 0.059/3 \log((1.3\ M)/(0.05\ M)) =$ **2.70 V**

5. Pt | F^-(0.5 M) | F_2 (0.8 atm) || H^+ (10^{-7} M) | H_2(0.25 atm) | Pt

Answer: $2\ H^+ + 2\ F^- \rightarrow H_2 + F_2$

$\Delta E = -2.87\ V - 0.059/2 \log((0.25\ atm)(0.8\ atm)/(0.5\ M)^2(10^{-7}\ M)^2) =$ **-3.28 V**

For problems 6-10, calculate the current generated by the reaction when the given amount of reactant is used up in one hour.

6. $Ag_2O_3(s) + Ni(s) \rightarrow Ag^+(aq) + Ni^{2+}(aq)$ 5 g Ni

Answer: Balanced reaction: $Ag_2O_3 + 2\ Ni \rightarrow 2Ag^+ + 2\ Ni^{2+}$ (the O's aren't important)

$\frac{5\ g\ Ni}{1\ hour} \times \frac{1\ mol\ Ni}{58.7\ g\ Ni} \times \frac{1\ hour}{3600\ s} \times \frac{4\ electrons}{2\ Ni} \times \frac{96{,}483\ C}{1\ mol} = 4.57\ C/s =$ **4.57 amps**

7. $Au^{3+}(aq) + Li(s) \rightarrow Au(s) + Li^+(aq)$ 0.01 M Au^{3+}

Answer: $Au^{3+} + 3\ Li \rightarrow Au + 3\ Li^+$

0.01 M Au^{3+} x (1 hr/3600 s) x (3 e^-/1 Au^{3+}) x (96,483 C/mol) = **0.804 amps**

8. $Fe^{3+}(aq) + Ti(s) \rightarrow Fe^{2+}(aq) + Ti^{3+}(aq)$ 10 g Ti

Answer: $3\ Fe^{3+} + Ti \rightarrow 3\ Fe^{2+} + Ti^{3+}$

10 g Ti x (1 hr/3600 s) x (1 mol/47.9 g) x (3 e^-/1 Ti) x (96,483 C/mol) = **16.8 amps**

9. $NO_3^-(aq) + Al(s) \rightarrow NO_2(g) + Al^{3+}(aq)$ 0.25 M NO_3^-

Answer: $3\ NO_3^- + Al \rightarrow 3\ NO_2 + Al^{3+}$

0.25 M NO_3^- x (1 hr/3600 s) x (3 e^-/3 NO_3^-) x (96,483 C/mol) = **6.70 amps**

10. $Au^{3+}(aq) + Fe^{2+}(aq) \rightarrow Au(s) + Fe^{3+}(aq)$ 0.03 M Fe^{2+}

Answer: $Au^{3+} + 3\ Fe^{2+} \rightarrow Au + 3\ Fe^{3+}$

0.03 M Fe^{2+} x (1 hr/3600 s) x (3 e^-/3 Fe^{2+}) x (96,483 C/mol) = **0.804 amps**

11. If the rate of the following reaction is 1.3 x 10^{-5} M/s, what is $\Delta[O_2]/\Delta t$?

$$2\ C_6H_6OH + {}^{29}/_2O_2 \rightarrow 12\ CO_2 + 7\ H_2O$$

Answer: rate = $-\Delta[O_2]/(29/2\Delta t) \Rightarrow \Delta[O_2]/\Delta t = -1.3 \times 10^{-5} \times 29/2 =$ **-1.88×10^{-4} M/s**

12. If $\Delta[CO_2]/\Delta t = 10^{-4}$ M/s for the same reaction as in problem 11, what is the rate of the reaction?

Answer: rate = $\Delta[CO_2]/12\Delta t = 10^{-4}/12 =$ **8.33×10^{-6} M/s**

13. Predict whether the rate of the reaction in problem 11 will increase, decrease, or stay the same if the following changes are made to the system.

a. Add C_6H_6OH

Answer: Increase

b. Remove O_2

Answer: Decrease

c. Increase the temperature

Answer: Increase

d. Keep the same amount of everything, but double the size of the reaction vessel.

Answer: Decrease – the same amount of stuff in a larger area gives a lower conc./pressure

e. Add a catalyst

Answer: Increase

For the reactions in problems 14-20, calculate either the rate or the $\Delta[\ ]/\Delta t$ using the information given.

14. $2\ CH_4 + 3\ Cl_2 \rightarrow 2\ CHCl_3 + 3\ H_2$ $\Delta[H_2]/\Delta t = 5.3 \times 10^{-5}$ M/s rate = _____

Answer: rate = $\Delta[H_2]/3\Delta t = 5.3 \times 10^{-5}/3 =$ **1.77×10^{-3} M/s**

15. $3\ H_2 + N_2 \rightarrow 2\ NH_3$ rate = 2.7×10^{-3} M/s $\Delta[H_2]/\Delta t =$ ___

Answer: $\Delta[H_2]/\Delta t = -3(2.7 \times 10^{-3}) =$ **-8.1×10^{-3} M/s**

16. $H_2 + I_2 \rightarrow 2HI$ rate = 4.2×10^{-4} M/s $\Delta[HI]/\Delta t =$ ___

Answer: $\Delta[HI]/\Delta t = 2(4.2 \times 10^{-4}) =$ **8.4×10^{-4} M/s**

17. $4\ Al + 3\ O_2 \rightarrow 2\ Al_2O_3$ $\Delta[Al]/\Delta t = -9.4 \times 10^{-3}$ M/s rate = _____

Answer: rate = $-(-9.4 \times 10^{-3})/4 =$ **2.35×10^{-3} M/s**

18. $C_8H_{18} + {}^{25}/_2\ O_2 \rightarrow 8\ CO_2 + 9\ H_2O$ $\Delta[O_2]/\ \Delta t = -3.6 \times 10^{-5}$ M/s $\Delta[H_2O]/\Delta t =$ _

Answer: $\Delta[H_2O]/\Delta t = -(3.6 \times 10^{-5})(9/(25/2)) =$ **2.59×10^{-5} M/s**

19. $CH_2S + 6\ F_2 \rightarrow CF_4 + 2\ HF + SF_6$ rate = 1.5×10^{-2} M/s $\Delta[F_2]/\Delta t =$ ___

Answer: $\Delta[F_2]/\Delta t = -6(1.5 \times 10^{-2}) =$ **0.090 M/s**

20. $Fe_2O_3 + 2\ Al \rightarrow Al_2O_3 + 2\ Fe$ $\Delta[Fe]/\Delta t = 1.1 \times 10^{-4}$ M/s rate = _____

Answer: rate = $(1.1 \times 10^{-4})/2 =$ **5.5×10^{-5} M/s**