Assignment 1 Solutions (2351 – W11)

1. (a) For this question, you need to balance the equations:

$Ce \text{ ---> } Ce^{3+}$ $\quad -E° = +2.34$ V

$TiO^{2+} \text{ ---> } Ti$ $\quad E° = \dfrac{(0.15)(1) + (-0.37)(1) + (-1.63)(2)}{4} = -0.87$

Which should give you this:

$4\,Ce + 3\,TiO^{2+} + 6\,H^+ \text{ ---> } 4Ce^{3+} + 3\,Ti + 3\,H_2O$ $\quad \Delta E° = 2.34\text{-}0.87 = 1.47$ V

1. (b) It turns out that, given the amount of Ce available, it will fully reduce the TiO2+ with some left over, therefore the products are Ti (*s*), Ce^{3+} (*aq*), and leftover Ce (*s*).

mass Ce used = (0.25 g TiO^{2+})(1 mol TiO^{2+}/63.9 g)(4 mol Ce/3 mol Ti)(140.1 g Ce/1 mol) = 0.73 g Ce

If only 0.73 g of Ce is used, there is 1.25-0.73 = 0.52 g excess Ce.

2. (a) The disproportionation reaction means that the Co^{3+} is both oxidized and reduced (reacts with itself to form two products, the reduced form and the oxidized form). Using the voltages from the handouts (the predominance diagrams I gave you in class):

$Co^{3+} + 2\,H_2O \text{ ---> } CoO_2 + 4\,H^+ + e^-$ $\quad -E° = -1.42$ V

$Co^{3+} + e^- \text{ ---> } Co^{2+}$ $\quad E° = 1.92$ V

$\Delta E° = 0.50$ V (therefore spontaneous!)

2. (b) The new voltages at pH 5 will be as follows:

$Co^{3+} + 2\,H_2O \text{ ---> } CoO_2 + 4\,H^+ + e^-$ $\quad -E°_{pH5} = -1.42 - (4/1)(0.0592)(5) = -2.60$ V

$Co^{3+} + e^- \text{ ---> } Co^{2+}$ $\quad E° = 1.92$ V

$\Delta E° = -0.68$ V

(Note: the "4" is the number of H^+ in the balanced equation, "1" is the number of electrons, and "5" is the pH; the latter equation, having 0 H^+, does not change potential with change in pH)

2. (c) As above, the disproportionation reaction for RuO_4^- is:

$RuO_4^- \text{ ---> } RuO_4 + e^-$ $\quad -E° = -0.99$ V

$RuO_4^- + 4\,H^+ + 3\,e^- \text{ ---> } RuO_2 + 2\,H_2O$ $\quad E°_{pH7} = 1.53 - (4/3)(0.0592)(7) = 0.98$ V

$\Delta E° = -0.01$ V

(not spontaneous!)

3.

	$2\ Fe^{3+} + 2\ e^- \rightarrow 2\ Fe^{2+}$				$E° = 0.77$ V
		$Cd \rightarrow Cd^{2+} + 2\ e^-$			$-E° = 0.44$ V
	$2\ Fe^{3+}(aq)$	+ $Cd(s)$	$\rightarrow 2\ Fe^{2+}(aq)$	+ $Cd^{2+}(aq)$	$\Delta E° = 1.21$ V
I	1.00	0	0	0	
C	-0.99	-	+0.99	+½(0.99)	
E	0.01	-	0.99	0.495	

$$\Delta E = \Delta E° - \frac{0.0592}{n} \log\left(\frac{[\mathbf{Fe}^{2+}]^2[\mathbf{Cd}^{2+}]}{[\mathbf{Fe}^{3+}]^2}\right) = 1.21 - (0.0592/2)\ \log\{(0.99)^2(0.495)/(0.01)^2\} = 1.10\ \text{V}$$