Post-Lab 6 Help Sheet

Problem 5: For the following redox reaction:

$$Ti^{3+}_{(aq)} + MnO_4^-{}_{(aq)} \rightarrow TiO^{2+}_{(aq)} + MnO2_{(s)}$$

What is the sum of the stoichiometric coefficients in the balanced equation? Do not forget to add the coefficients that are 1.

First break the overall reaction into two half reactions. (I'm dropping the states to make things cleaner.) You have a titanium half-reaction and a manganese half-reaction

$$Ti^{3+} \rightarrow TiO^{2+}$$

and

$$MnO_4^- \rightarrow MnO_2$$

To balance each one,

1) balance the main atom
2) balance oxygens by adding H_2O to the other side
3) balance hydrogens by adding H^+ to the other side.
4) balance the charge by adding electrons

Looking at the titanium half-reaction:

1) The titaniums are already balanced

$$Ti^{3+} \rightarrow TiO^{2+}$$

2) One oxygen on the right, so add one H_2O to the left

$$Ti^{3+} + H_2O \rightarrow TiO^{2+}$$

3) The H_2O we just added gives us 2 H atoms on the left, so add 2 H^+ to the right.

$$Ti^{3+} + H_2O \rightarrow TiO^{2+} + 2H^+$$

4) Looking at the charge, the left side has Ti^{3+}, and the right side has TiO^{2+} and 2 H^+, for a total of +4. So we need one electron on the right to make both sides +3.

$$Ti^{3+} + H_2O \rightarrow TiO^{2+} + 2H^+ + e^-$$

This half-reaction is balanced.

Now do the same thing with the MnO_4^- → MnO_2 half-reaction:

1) Mn is already balanced
2) Add 2 H_2O on the right
3) Add 4 H^+ on the left
4) Left side is +3, right side is +0, so add $3e^-$ to the left side to make both sides +0.

You end up with

$$MnO_4^- + 4H^+ + 3e^- \rightarrow MnO_2 + 2H_2O$$

Before you can add the two half-reactions together, you have to make sure they have the same number of electrons so that the electrons will cancel out. The manganese reaction has $3e^-$ and the titanium reaction has $1e^-$, so multiply the titanium reaction ×3 to make them both the same.

$$\begin{aligned} 3Ti^{3+} + 3H_2O &\rightarrow 3TiO^{2+} + 6H^+ + 3e^- \\ MnO_4^- + 4H^+ + 3e^- &\rightarrow MnO_2 + 2H_2O \end{aligned}$$

Add them together and you get:

$$3Ti^{3+} + 3H_2O + MnO_4^- + 4H^+ + 3e^- \rightarrow 3TiO^{2+} + 6H^+ + 3e^- + MnO_2 + 2H_2O$$

Cross out the $3e^-$ from both sides, $2H_2O$ from both sides, and $4H^+$ from both sides and you're left with:

$$3Ti^{3+} + H_2O + MnO_4^- \rightarrow 3TiO^{2+} + 2H^+ + MnO_2$$

All of the atoms balance, and the charge also balances (+8 on each side).

Add up the coefficients in the balanced equation:

$$3 + 1 + 1 + 3 + 2 + 1 = 11.$$

Problem 7: Calculate the molarity of a $Ti^{3+}_{(aq)}$ solution if 100.0 mL of this solution requires 29.8 mL of 32.1 mM $MnO_4^-{}_{(aq)}$ for complete reaction. Use the balanced equation from Problem 3 to answer this question.

This is a three-step problem just like you did last week in Post-lab 5:

1) Calculate moles of MnO_4^- using M×V (32.1 mM is 32.1×10^{-3} M)
2) Convert moles of MnO_4^- to moles of Ti^{3+} using the balanced equation.
3) Calculate molarity using moles of Ti^{3+} ÷ volume of Ti^{3+}

The calculations are all multiplication and division, so just count the fewest digits in any of your measurements to determine how many significant digits to keep in your answer.