

## Chem12 Redox Titrations : Notes/W.S. - 70

The method of titration was used earlier to find the concentration of an unknown base or acid by titrating with an acid or base of known concentration. In an acid-base titration, the equivalence point (moles  $\text{OH}^- = \text{moles H}^+$ ) is found using an indicator.

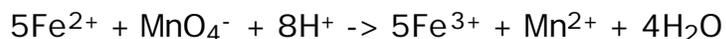
Another type of titration is called a redox titration. As with the acid-base titration, we must find the equivalence point for the titration. This occurs when the moles of oxidizing agent and the moles of reducing agent are combined in the proper stoichiometric ratio.

Example : We can find the purity of a sample of iron ore by converting the  $\text{Fe(s)}$  in a sample of the ore to  $\text{Fe}^{2+}(\text{aq})$ . We then add an oxidizing agent (drop by drop using a burette) until all of the  $\text{Fe}^{2+}$  has been oxidized to  $\text{Fe}^{3+}$ . An oxidizing agent that can be used is the permanganate ion  $\text{MnO}_4^- (\text{aq})$  (in acid).

The half reactions are :



The balanced redox reaction is :



In this reaction, all ions are colorless except for the  $\text{MnO}_4^-$  ion. This ion gives a deep purple color to a solution. As the  $\text{MnO}_4^-$  solution is added to the  $\text{Fe}^{2+}$  solution, the  $\text{MnO}_4^-$  is reduced to  $\text{Mn}^{2+}$  so the solution remains clear until the stoichiometric point is reached, when all of the  $\text{Fe}^{2+}$  has been oxidized.

Problems.

1)a) A flask contains 0.40 moles of  $\text{Fe}^{2+}$  ions. How many moles of  $\text{MnO}_4^-$  ions must be added using a burette to oxidize all  $\text{Fe}^{2+}$  of the ions?

b) Give the color of the solution in the flask both before and after the stoichiometric point is reached.

2) Find the concentration of 50.0 mL of an acidified  $\text{Fe}^{2+}(\text{aq})$  solution if 18.72 mL of 0.01500 M solution of  $\text{KMnO}_4$  solution is required during a titration to reach the equivalence point.

3) One way to find the vitamin C ( $\text{C}_6\text{H}_8\text{O}_6$ ) content of a pill is to titrate a vitamin C solution with a  $\text{Br}_2$  solution. The redox reaction is :

$\text{C}_6\text{H}_8\text{O}_6 + \text{Br}_2 \rightarrow 2\text{HBr} + \text{C}_6\text{H}_6\text{O}_6$  Find the vitamin C content (in grams) of a 1.50 g pill if 23.75 ml of 0.140 M  $\text{Br}_2$  solution is required to reach the equivalence point. (the pill also contains sugar and some other inactive ingredients)

4) Find the concentration of an acidified  $\text{Cr}_2\text{O}_7^{2-}$  solution if 32.0 ml of the solution is titrated with 14.28 ml of 0.200 M  $\text{Fe}^{2+}$  solution. Find the balanced redox reaction first. Use the table.

5) When a police officer suspects that a driver has been drinking an alcoholic beverage, he may ask the driver to; "take the breathalyzer test". This test involves a redox reaction. The redox reaction is:  $2\text{Cr}_2\text{O}_7^{2-} + 3\text{CH}_3\text{CH}_2\text{OH} + 16\text{H}^+ \rightarrow 4\text{Cr}^{3+} + 3\text{CH}_3\text{COOH} + 11\text{H}_2\text{O}$ . In this reaction, ethanol ( $\text{CH}_3\text{CH}_2\text{OH}$ ) is oxidized to ethanoic acid ( $\text{CH}_3\text{COOH}$ ). There is a color change during this reaction. The dichromate ion is orange in solution and the chromium ion is green in solution.

During the test, the driver (whose breath may contain ethanol) breathes into the breathalyzer device which contains a dichromate solution (in acid). Explain briefly what happens in the test.

Answers : 1)a) 0.080 moles, b) before, colorless; after purple, 2) 0.0281 M, 3) 0.586 grams, 4) The balanced redox reaction is :  $\text{Cr}_2\text{O}_7^{2-} + 6\text{Fe}^{2+} + 14\text{H}^+ \rightarrow 2\text{Cr}^{3+} + 6\text{Fe}^{3+} + 7\text{H}_2\text{O}$ , 0.0149 M, 5) The solution stays orange if no ethanol is present but changes color from orange to green if a certain amount of ethanol is present in the breath sample.