



## AP<sup>®</sup> Chemistry 2003 Sample Student Responses Form B

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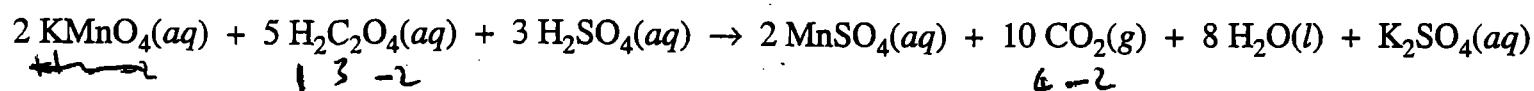
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Your responses to the rest of the questions in this part of the examination will be graded on the basis of the accuracy and relevance of the information cited. Explanations should be clear and well organized. Examples and equations may be included in your responses where appropriate. Specific answers are preferable to broad, diffuse responses.

Answer BOTH Question 5 below AND Question 6 printed on page 20. Both of these questions will be graded. The Section II score weighting for these questions is 30 percent (15 percent each).

5. Oxalic acid,  $\text{H}_2\text{C}_2\text{O}_4$ , is a primary standard used to determine the concentration of potassium permanganate,  $\text{KMnO}_4$ , in solution. The equation for the reaction is as follows.



A student dissolves a sample of oxalic acid in a flask with 30 mL of water and 2.00 mL of 3.00 M  $\text{H}_2\text{SO}_4$ . The  $\text{KMnO}_4$  solution of unknown concentration is in a 25.0 mL buret. In the titration, the  $\text{KMnO}_4$  solution is added to the solution containing oxalic acid.

- What chemical species is being oxidized in the reaction?
- What substance indicates the observable endpoint of the titration? Describe the observation that shows the endpoint has been reached.
- What data must be collected in the titration in order to determine the molar concentration of the unknown  $\text{KMnO}_4$  solution?
- Without doing any calculations, explain how to determine the molarity of the unknown  $\text{KMnO}_4$  solution.
- How would the calculated concentration of the  $\text{KMnO}_4$  solution be affected if 40 mL of water was added to the oxalic acid initially instead of 30 mL? Explain your reasoning.

a)  ~~$\text{KMnO}_4$~~   $\text{H}_2\text{C}_2\text{O}_4$  oxalic acid.  
 since carbon oxidation number increased indicating  
 that ~~the~~ it lost ~~an~~ <sup>1</sup> electron hence oxidised

b)  $\text{KMnO}_4$ , This <sup>titrated</sup> solution would change color  
 from ~~purple to colorless~~ colorless to purple

c) volume of  $\text{KMnO}_4$  used for titration  
 to the ~~equivalence point~~ <sup>end</sup> ~~the~~ ~~mass~~ of  
~~oxalic acid used~~ <sup>mass</sup> ~~volume~~ of the sample of  
 oxalic acid used, ~~volume of oxalic acid titrated~~  
~~against~~

## ADDITIONAL PAGE FOR ANSWERING QUESTION 5.

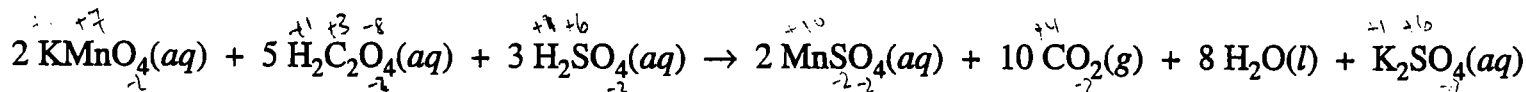
- d) I would calculate the ~~concentration~~ number of moles of oxalic acid by dividing its mass by 90. Then I would multiply the number of moles of oxalic acid by  $\frac{2}{5}$  to get the number of moles of  $\text{KMnO}_4$  required to react completely with the oxalic acid. divide the number of moles of oxalic acid by the volume obtained in your titration.
- e) No effect. Since the 30ml water was used prior to dissolve the ~~solution~~ oxalic acid and it was all titrated the number of moles of oxalic acid would not be affected by the amount of water added. And the ~~error~~ experimental error would most probably occur in the process of titration or weighing the sample of oxalic acid.

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a)  $\text{H}_2\text{C}_2\text{O}_4$  is being oxidized.

b) The presence of purple/pink in solution because of the  $\text{KMnO}_4$

c) ~~The volume of  $\text{KMnO}_4$  used~~, the mass of the sample of oxalic acid, the volume of  $\text{KMnO}_4$  at the equivalence point, the initial buret reading

d) Take the mass of oxalic acid and change it into moles then find how many moles of  $\text{KMnO}_4$  by using the  $\frac{2}{5}$  ratio. Then taking the volume of  $\text{KMnO}_4$  to reach equivalence point, use  $M = \frac{\text{moles}}{L}$  to find the molar concentration.

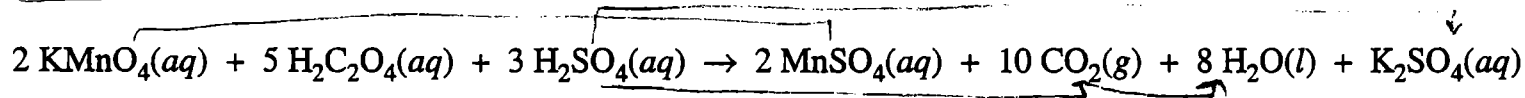
e) It would make the solution more diluted, therefore requiring less volume of  $\text{KMnO}_4$  to neutralize, hence a higher or larger concentration

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- (a) What chemical species is being oxidized in the reaction?
- (b) What substance indicates the observable endpoint of the titration? Describe the observation that shows the endpoint has been reached.
- (c) What data must be collected in the titration in order to determine the molar concentration of the unknown  $\text{KMnO}_4$  solution?
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- (e) How would the calculated concentration of the  $\text{KMnO}_4$  solution be affected if 40 mL of water was added to the oxalic acid initially instead of 30 mL? Explain your reasoning.

a) To find the oxidation number of C in  $\text{H}_2\text{C}_2\text{O}_4$ ; assume it is x

$$2(1) + 2x + 4(-2) = 0$$

$$2 + 2x - 8 = 0 \Rightarrow 2x = 6 \Rightarrow x = 3$$

$\therefore$  oxidation number of C is 3+

in  $\text{CO}_2$ , the oxidation number is  $x - 8 = 0$   
 $\Rightarrow x = 8$

since the oxidation number of C increases,  $\text{H}_2\text{C}_2\text{O}_4$  is being oxidized. The oxidation number of S in  $\text{H}_2\text{SO}_4$  remains the same.

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ADDITIONAL PAGE FOR ANSWERING QUESTION 5.

b)  $KMnO_4$  indicates the end point of the titration when it turns from colorless to a light pink/purple color.

c) In order to determine the molar concentration of  $KMnO_4$  solution, the volume of  $KMnO_4$  solution required to reach the endpoint of the titration.

d) ① Determine the number of moles of  $H_2C_2O_4$  that have been added.

$$n_{H_2C_2O_4} = [H_2C_2O_4] \times \text{Volume of } H_2C_2O_4$$

② At the equivalence point:



By the ratio method, the number of moles of  $KMnO_4$  at the equivalence point can be calculated.

$$\text{③ molarity} = \frac{n_{KMnO_4 \text{ at equiv}}}{\text{Vol.}}$$

e) The concentration of  $KMnO_4$  should not be affected if the ratios of the moles are taken properly.