AP® Chemistry
2003 Sample Student Responses
Form B

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5A 1

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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, $H_2C_2O_4$, is a primary standard used to determine the concentration of potassium permanganate, $KMnO_4$, in solution. The equation for the reaction is as follows.

$$2\,KMnO_4(aq) + 5\,H_2C_2O_4(aq) + 3\,H_2SO_4(aq) \rightarrow 2\,MnSO_4(aq) + 10\,CO_2(g) + 8\,H_2O(l) + K_2SO_4(aq)$$

1 3 -2 4 -2

A student dissolves a sample of oxalic acid in a flask with 30 mL of water and 2.00 mL of 3.00 *M* H_2SO_4. The $KMnO_4$ solution of unknown concentration is in a 25.0 mL buret. In the titration, the $KMnO_4$ solution is added to the solution containing oxalic acid.

(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 $KMnO_4$ solution?

(d) Without doing any calculations, explain how to determine the molarity of the unknown $KMnO_4$ solution.

(e) How would the calculated concentration of the $KMnO_4$ solution be affected if 40 mL of water was added to the oxalic acid initially instead of 30 mL? Explain your reasoning.

a) ~~KMnO4~~ $H_2C_2O_4$ oxalic acid.
since carbon oxidation number increased indicating that ~~it~~ it lost ~~an~~ 1 electron hence oxidised

b) $KMnO_4$, The titrated solution would change color from ~~purple to colorless~~ colorless to purple

c) volume of $KMnO_4$ used for titration to the ~~eq~~ equivelence point ~~and the mass of Oxalic acid used.~~ ~~volume~~ mass of the sample of oxalic acid used, ~~volume of oxalic acid titrated~~ ~~against~~

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d) I would calculat the ~~concentration~~ ~~of~~ 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 $KMnO_4$ required to react ~~$~~ completthly with ~~the~~ 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 disolve 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 in~~ experemental error would most ~~po~~ propably occur in the process of titration or wieghing the sample of oxalic acid.

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a). $H_2C_2O_4$ is being oxidized.

b). The presence of purple / pink in solution because of the $KMnO_4$

c). ~~The volume of KMnO4 used,~~ the mass of the sample of oxalic acid, the volume of $KMnO_4$ 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 $KMnO_4$ by using the $\frac{2}{5}$ ratio. Then taking the volume of $KMnO_4$ to reach equivalence point, use $M = \frac{moles}{L}$ to find the molar concentration.

e) It would make the solution more diluted, therefore requiring less volume of $KMnO_4$ to neutralize, hence a higher or larger concentration

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a) To find the oxidation number of C in $H_2C_2O_4$ ∴ assume it is x

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

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

∴ oxidation number of C is 3+

in CO_2, the oxidation number is $x - 8 = 0$

$\Rightarrow x = 8$

Since the oxidation number of C increases, $H_2C_2O_4$ is being oxidized. The oxidation number of S in H_2SO_4 remains the same.

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 5C2

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.

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

② At the equivalence point:

$2n_{KMnO_4} = 5n_{H_2C_2O_4}$.

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

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.

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