AP® Chemistry
2004 Sample Student Responses
Form B

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. An experiment is performed to determine the molar mass of an unknown solid monoprotic acid, HA, by titration with a standardized NaOH solution.

   (a) What measurement(s) must be made to determine the number of moles of NaOH used in the titration?

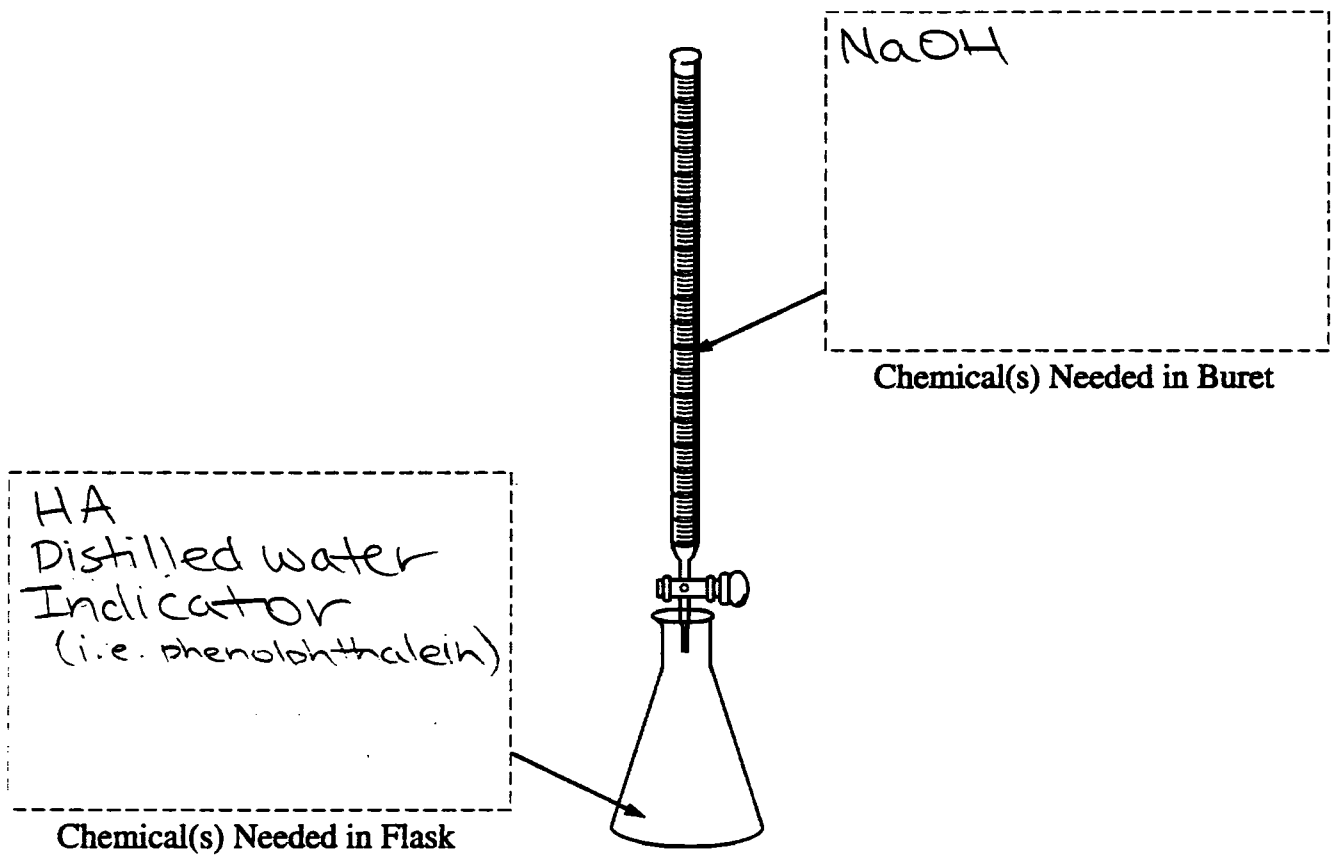
   (b) Write a mathematical expression that can be used to determine the number of moles of NaOH used to reach the endpoint of the titration.

   (c) How can the number of moles of HA consumed in the titration be determined?

   (d) In addition to the measurement(s) made in part (a), what other measurement(s) must be made to determine the molar mass of the acid, HA ?

   (e) Write the mathematical expression that is used to determine the molar mass of HA.

   (f) The following diagram represents the setup for the titration. In the appropriate boxes below, list the chemical(s) needed to perform the titration.



   (g) Explain what effect each of the following would have on the calculated molar mass of HA. Justify your answers.

      (i) The original solid acid, HA, was not completely dry at the beginning of the experiment.

      (ii) The procedure called for 25 mL of H_2O in the Erlenmeyer flask, but a student used 35 mL of H_2O.

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ADDITIONAL PAGE FOR ANSWERING QUESTION 5.

(a) initial volume of NaOH in the pipet, final volume of NaOH in the pipet.

moles of NaOH = (molarity of NaOH)(final volume NaOH - initial volum

where molarity is in $\frac{mol}{L}$ and volume in L.

(c) HA is monoprotic, so it reacts stoichiometrically with NaOH in a 1:1 ratio. Thus, the number of moles of HA consumed equals the number of moles of NaOH used.

(d) The mass of HA used should also be measured to determine the molar mass of HA.

(e) Molar mass of HA = $\frac{\text{mass of HA consumed}}{\text{moles of HA consumed}}$

where moles of HA consumed = moles of NaOH used (found in part a)

(f) on diagram

(g) (i) The calculated molar mass will be too large because the mass of the HA found would have been too large if the HA was not dry when it was massed. Molar mass of HA is directly proportional to mass of HA used, so the calculated molar mass would be too large.

(ii) The calculated molar mass will be unaffected because the volume of the water used in the Erlenmeyer flask does not factor into the calculation of the molar mass. The calculation of the molar mass depends only on the mass of HA used and the moles of NaOH used.

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$OH^- + HA \rightarrow H_2O + A^-$

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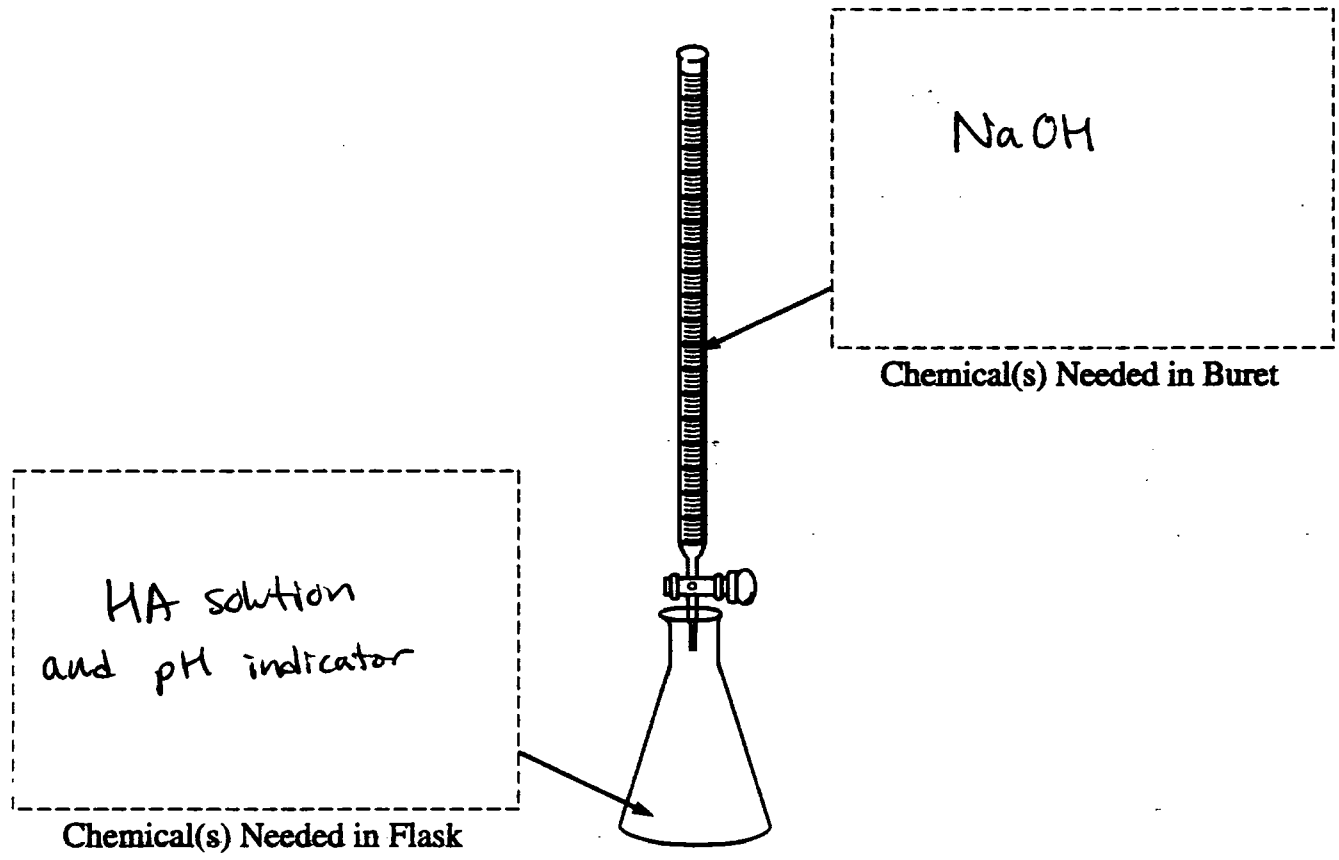

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ADDITIONAL PAGE FOR ANSWERING QUESTION 5.

5a) To determine the number of moles of NaOH used in the titration, one must measure the volume of NaOH used in the titration, ~~and the molarity~~, the end pH of the titration, ~~and the K of the OH~~

b) ~~K~~ of NaOH = ~~[NaOH]~~

c) ~~If the~~ The ~~number of grams of HA put into solution must be recorded.~~ Once the ~~molarity~~ molarity of the NaOH solution has been determined, you could assume a one to one molar ratio between NaOH and HA (because the acid is monoprotic). The number of moles of NaOH used in the titration equals the number of moles of HA

d) You must record the number of grams of HA put into solution

e) $\frac{\text{grams of HA put into solution}}{\text{moles of HA}}$ = molar mass of HA

~~f) This would increase the mass of HA and so the molar mass~~ g)i It would ~~seem~~ increase the ~~volume~~ mass of HA and so you would think you were putting more into solution than you really were, so the calculated molar mass would be lower than the actual molar mass.

g)ii This shouldn't make a difference ~~to be~~ when calculating molar mass because the number of moles of HA remains unchanged.

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 5C,

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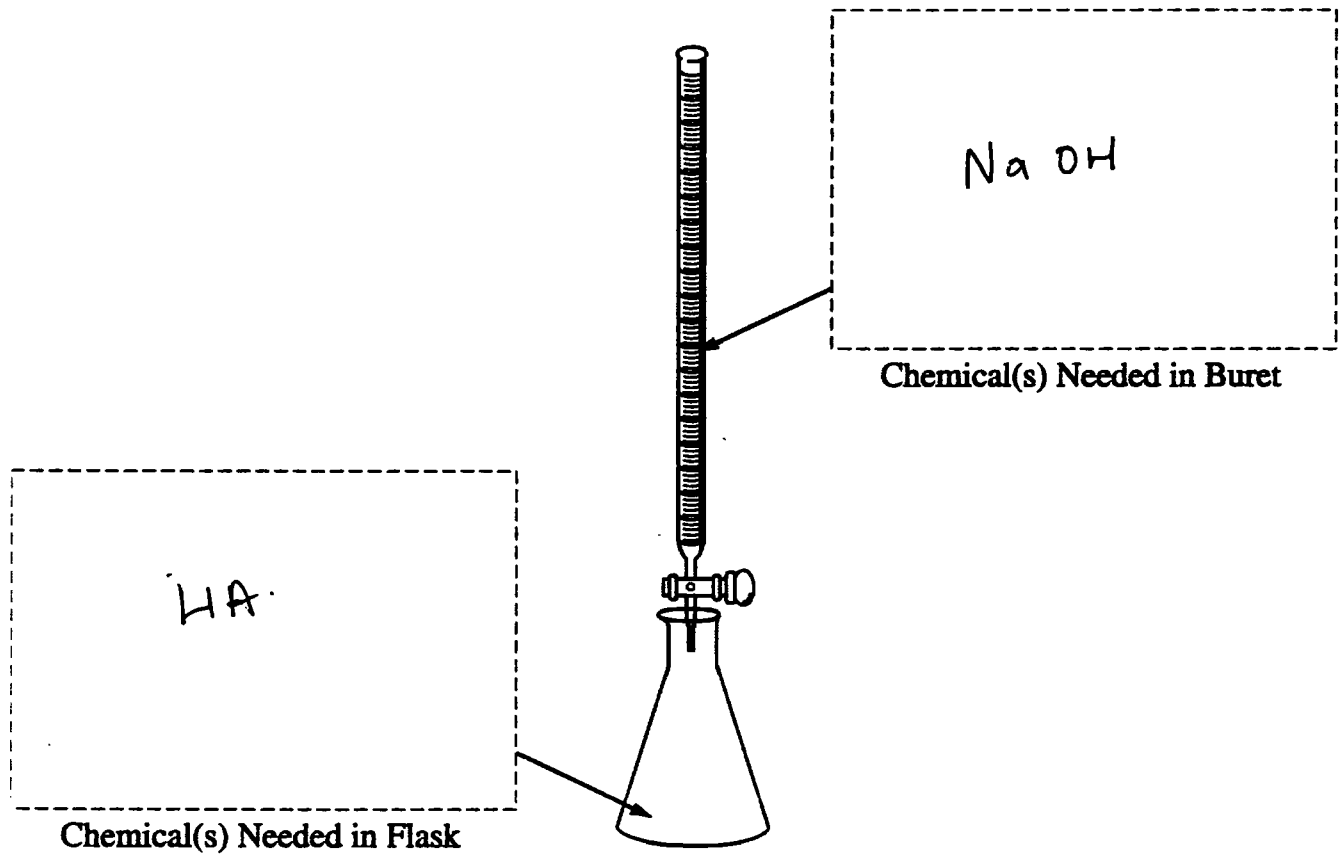

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ADDITIONAL PAGE FOR ANSWERING QUESTION 5.

5. a) Volume of NaOH can be measured.
~~density of solution~~
Concentration of solution.

b) $n = C \times V$
number of moles = concentration × Volume.

c) At the equivalence point, the number of moles of NaOH = number of moles of HA.
Therefore when we calculate the number of moles of NaOH by C×V, we have found the the consumed number of moles of HA.

d) the mass of the compound used in the acid.

e) $n = \frac{m}{M} \Rightarrow M = \frac{m}{n}$.

Molar mass = $\frac{\text{mass of acid (solid)}}{\text{number of moles of acid}}$.

f) —

g) i) The Molar mass of HA will appear greater, as the mass of the acid is not accurate due to the water in it when measured.

ii) $n = C \times V \Rightarrow$ if the volume is increased, the number of moles will also increase there for the ~~not~~ calculated molar mass of HA will appear ~~greater~~ lower than needed. $(M = \frac{m}{n})$

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