Essay Questions

1986

$$H_2SO_3 \qquad HSO_3^- \qquad HClO_4 \qquad HClO_3 \qquad H_3BO_3$$

Oxyacids, such as those above, contain an atom bonded to one or more oxygen atoms; one or more of these oxygen atoms may also be bonded to hydrogen.

(a) Discuss the factors that are often used to predict correctly the strengths of the oxyacids listed above.
(b) Arrange the examples above in the order of <u>increasing</u> acid strength.

1990

Give a brief explanation for each of the following.

(a) For the diprotic acid H_2S, the first dissociation constant is larger than the second dissociation constant by about 10^5 ($K_1 = 10^5 K_2$).
(b) In water, NaOH is a base but HOCl is an acid.
(c) HCl and HI are equally strong acids in water but, in pure acetic acid, HI is a stronger acid than HCl.
(d) When each is dissolved in water, HCl is a much stronger acid than HF.

1994

A chemical reaction occurs when 100. milliliters of 0.200-molar HCl is added dropwise to 100. milliliters of 0.100-molar Na_3PO_4 solution.

(a) Write the two net ionic equations for the formation of the major products.
(b) Identify the species that acts as both a Brönsted acid and as a Brönsted base in the equation in (a), Draw the Lewis electron-dot diagram for this species.
(c) Sketch a graph using the axes provided, showing the shape of the titration curve that results when 100. milliliters of the HCl solution is added slowly from a buret to the Na_3PO_4 solution. Account for the shape of the curve.


(d) Write the equation for the reaction that occurs if a few additional milliliters of the HCl solution are added to the solution resulting from the titration in (c).

2000

A volume of 30.0 mL of 0.10 M $NH_3(aq)$ is titrated with 0.20 M $HCl(aq)$. The value of the base-dissociation constant, K_b, for NH_3 in water is 1.8×10^{-5} at 25°C.

(a) Write the net-ionic equation for the reaction of $NH_3(aq)$ with $HCl(aq)$.

(b) Using the axes provided below, sketch the titration curve that results when a total of 40.0 mL of 0.20 M $HCl(aq)$ is added dropwise to the 30.0 mL volume of 0.10 M $NH_3(aq)$.

Volume of 0.20 M HCl Added (mL)
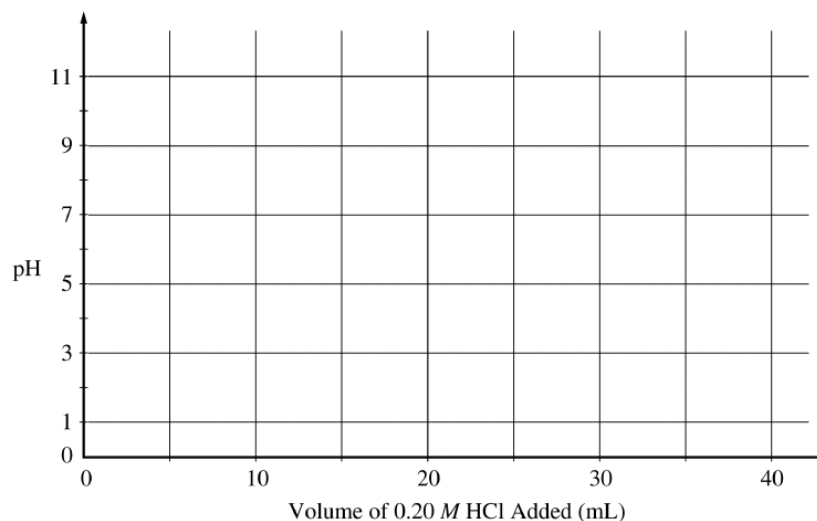
(c) From the table below, select the most appropriate indicator for the titration. Justify your choice.

Indicator	pK_a
Methyl Red	5.5
Bromothymol Blue	7.1
Phenolphthalein	8.7

(d) If equal volumes of 0.10 M $NH_3(aq)$ and 0.10 M $NH_4Cl(aq)$ are mixed, is the resulting solution acidic, neutral, or basic? Explain.

Volume of Titrant Added (mL)
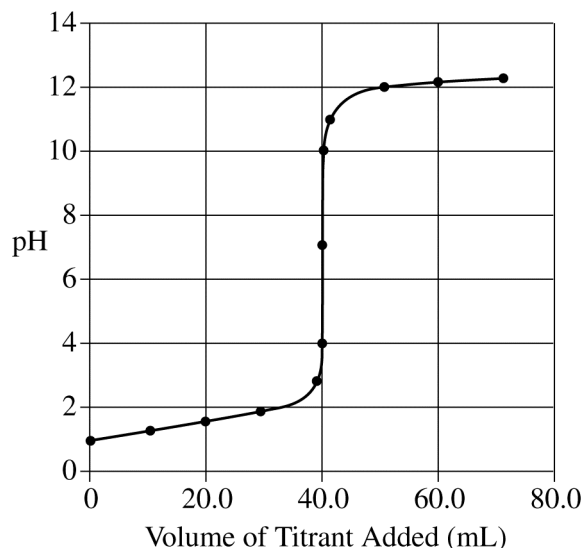
A solution of 0.100 *M* HCl and a solution of 0.100 *M* NaOH are prepared. A 40.0 mL sample of one of the solutions is added to a beaker and then titrated with the other solution. A pH electrode is used to obtain the data that are plotted in the titration curve shown above.

(a) Identify the solution that was initially added to the beaker. Explain your reasoning.

(b) On the titration curve above, circle the point that corresponds to the equivalence point.

(c) At the equivalence point, how many moles of titrant have been added?

(d) The same titration is to be performed again, this time using an indicator. Use the information in the table below to select the best indicator for the titration. Explain your choice.

Indicator	pH Range of Color Change
Methyl violet	0 – 1.6
Methyl red	4 – 6
Alizarin yellow	10 – 12

(e) What is the difference between the <u>equivalence point</u> of a titration and the <u>end point</u> of a titration?

(f) On the grid provided below, sketch the titration curve that would result if the solutions in the beaker and buret were reversed (i.e., if 40.0 mL of the solution used in the buret in the previous titration were titrated with the solution that was in the beaker).

Volume of Titrant Added (mL)
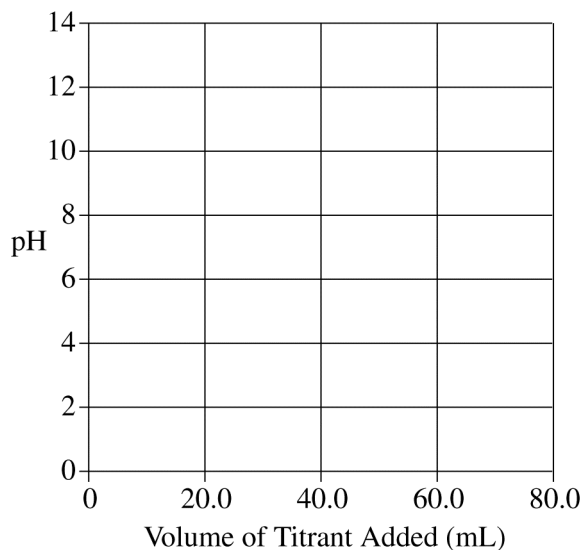
Problems

1987

The percentage by weight of nitric acid, HNO_3, in a sample of concentrated nitric acid is to be determined.

(a) Initially a NaOH solution was standardized by titration with a sample of potassium hydrogen phthalate, $KHC_8H_4O_4$, a monoprotic acid often used as a primary standard. A sample of pure $KHC_8H_4O_4$ weighing 1.518 grams was dissolved in water and titrated with the NaOH solution. To reach the equivalence point, 26.90 milliliters of base was required. Calculate the molarity of the NaOH solution. (Molecular weight: $KHC_8H_4O_4 = 204.2$)

(b) A 10.00 milliliter sample of the concentrated nitric acid was diluted with water to a total volume of 500.00 milliliters. Then 25.00 milliliters of the diluted acid solution was titrated with the standardized NaOH solution prepared in part (a). The equivalence point was reached after 28.35 milliliters of the base had been added. Calculate the molarity of the concentrated nitric acid.

(c) The density of the concentrated nitric acid used in this experiment was determined to be 1.42 grams per milliliter. Determine the percentage by weight of HNO_3 in the original sample of concentrated nitric acid.

1996

Concentrated sulfuric acid (18.4-molar H_2SO_4) has a density of 1.84 grams per milliliter. After dilution with water to 5.20-molar, the solution has a density of 1.38 grams per milliliter and can be used as an electrolyte in lead storage batteries for automobiles.

(a) Calculate the volume of concentrated acid required to prepare 1.00 liter of 5.20-molar H_2SO_4.

(b) Determine the mass percent of H_2SO_4 in the original concentrated solution.

(c) Calculate the volume of 5.20-molar H_2SO_4 that can be completely neutralized with 10.5 grams of sodium bicarbonate $NaHCO_3$.

(d) What is the molality of the 5.20-molar H_2SO_4?