ANSWER KEY.

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4.6 Introduction to Titration

AP Chemistry | ANSWER KEY

Show all work with units and correct significant figures. Remember: mol = M × V, with V in liters.

1. A student titrates a sample of nitric acid, HNO_3, of unknown concentration with 0.100 M KOH from a buret.

(a) Which solution is the titrant, and which is the analyte?

(b) What is the difference between the equivalence point and the endpoint?

(c) What makes a good indicator for this titration?

(a) Titrant: KOH (known, in the buret). Analyte: HNO_3 (unknown, in the flask).

(b) Equivalence point: the analyte is all used up. Endpoint: the indicator changes color.

(c) One whose endpoint is very close to the equivalence point.

2. A 15.00 mL sample of HCl is titrated with 0.125 M NaOH. The equivalence point is reached after 22.35 mL of NaOH. What is the concentration of the HCl?

$HCl + NaOH \rightarrow NaCl + H_2O$

mol NaOH = (0.125 mol/L)(0.02235 L) = 0.002794 mol
1 : 1 ratio, so mol HCl = 0.002794 mol
[HCl] = 0.002794 mol ÷ 0.01500 L = 0.186 M

3. What volume, in mL, of 0.250 M NaOH is needed to reach the equivalence point with 30.00 mL of 0.150 M HNO_3?

$HNO_3 + NaOH \rightarrow NaNO_3 + H_2O$

mol HNO_3 = (0.150 mol/L)(0.03000 L) = 0.00450 mol
1 : 1 ratio, so mol NaOH = 0.00450 mol
V = 0.00450 mol ÷ 0.250 mol/L = 0.0180 L = 18.0 mL

4. Nitric acid, HNO_3, is titrated with KOH. List the ions present in the flask (ignore water) at each stage, and describe the pH.

(a) at the start, before any KOH is added

(b) at the equivalence point

(c) after more KOH is added past the equivalence point

(a) H^+ and NO_3^-. pH is low.

(b) K^+ and NO_3^- only (all H^+ reacted with OH^- to make water). pH 7.

(c) K^+, NO_3^-, and extra OH^-. pH is high.

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5. A 25.00 mL sample of H_2SO_4 requires 28.60 mL of 0.200 M NaOH to reach the equivalence point.

$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$

(a) Find the concentration of the H_2SO_4.

(b) A classmate gets 0.229 M. What mistake did the classmate most likely make?

(a) mol NaOH = (0.200 mol/L)(0.02860 L) = 0.005720 mol
0.005720 mol NaOH × (1 mol H_2SO_4 / 2 mol NaOH) = 0.002860 mol H_2SO_4
[H_2SO_4] = 0.002860 mol ÷ 0.02500 L = 0.114 M

(b) The classmate used a 1 : 1 ratio and forgot the 1 : 2 mole ratio, giving double the right answer.

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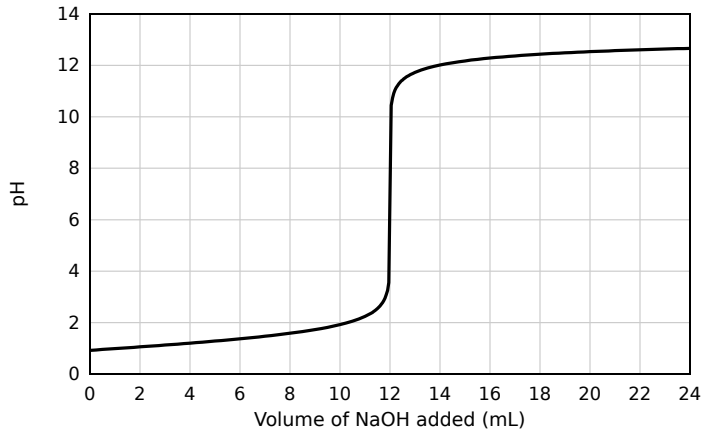
6. A 20.00 mL sample of barium hydroxide, $Ba(OH)_2$, is titrated with 0.100 M HCl. The equivalence point is reached after 34.80 mL of HCl. Find the concentration of the $Ba(OH)_2$.

$2HCl + Ba(OH)_2 \rightarrow BaCl_2 + 2H_2O$

mol HCl = (0.100 mol/L)(0.03480 L) = 0.003480 mol
0.003480 mol HCl × (1 mol $Ba(OH)_2$ / 2 mol HCl) = 0.001740 mol $Ba(OH)_2$
[$Ba(OH)_2$] = 0.001740 mol ÷ 0.02000 L = 0.0870 M

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7. A 15.00 mL sample of HCl is titrated with 0.150 M NaOH. The titration curve is shown.



(a) What volume of NaOH was added at the equivalence point?

(b) What is the pH at the equivalence point? Explain why.

(c) Find the concentration of the HCl.

(a) The middle of the steep jump: 12.0 mL of NaOH.

(b) pH 7. Strong acid + strong base, so at equivalence the flask holds only water and the neutral salt NaCl.

(c) mol NaOH = (0.150 mol/L)(0.0120 L) = 0.00180 mol = mol HCl (1 : 1)
[HCl] = 0.00180 mol ÷ 0.01500 L = 0.120 M

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