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Sample Titration Problems

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Problem #1

A 20.00 mL sample of an unknown H_3PO_4 solution is titrated with a 0.100 M NaOH solution. The equivalence point is reached when 18.45 mL of NaOH solution is added. What is the concentration of the original H_3PO_4 solution?

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$H_3PO_{4\,(aq)} + 3\ NaOH_{(aq)} \rightarrow 3\ H_2O_{(l)} + Na_3PO_{4\,(aq)}$

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Problem #1

$\frac{0.100 \text{ moles NaOH}}{\text{L NaOH solution}} * 0.01845 \text{ L NaOH} = 0.001845 \text{ moles NaOH}$

$0.001845 \text{ moles NaOH} * \frac{1 \text{ mol } OH^-}{1 \text{ mol NaOH}} * \frac{1 \text{ mol } H^+}{1 \text{ mol } OH^-} = 0.001845 \text{ mol } H^+$

$0.001845 \text{ mol } H^+ * \frac{1 \text{ mol } H_3PO_4}{3 \text{ mol } H^+} = 0.0006150 \text{ mol } H_3PO_4$

$\frac{0.0006150 \text{ mol } H_3PO_4}{0.020 \text{ L}} = 0.03075 \text{ M } H_3PO_4$

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Problem #1

$i_2M_1V_1 = i_1M_2V_2$

$i_{NaOH}M_{H3PO4}V_{H3PO4} = i_{H3PO4}\ M_{NaOH}V_{NaOH}$

$H_3PO_{4\,(aq)} + 3\ NaOH_{(aq)} \rightarrow 3\ H_2O_{(l)} + Na_3PO_{4\,(aq)}$

$(3)\ (M_{H3PO4})\ (20 \text{ mL}) = (1)\ (0.100 \text{ M})(18.45 \text{ mL})$

$M_{H3PO4} = 0.03075 \text{ M } H_3PO_4$

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Problem #3

100.00 mL of a wastewater solution is diluted to 250.00 mL and titrated with 0.1106 M NaOH. Equivalence is reached after addition of 9.62 mL of the sodium hydroxide solution. What is the pH of the original wastewater sample?

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$H^+ + OH^- \rightleftharpoons H_2O$

$i_2M_1V_1 = i_1M_2V_2$
$i_{OH}M_{H+}V_{H+} = i_{H+}\ M_{OH}V_{OH}$

(1) (M_{H+}) (100 mL) = (1) (0.1106 M)(9.62 mL)

$M_{H+} = 0.01064$ M H^+
pH = - log [H+] = - log (0.01064 M)
pH = 2.97

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Problem #3

100.00 mL of wastewater is titrated with a 0.1062 M solution of $Pb(NO_3)_2$. Lead will react with chloride ion to form lead chloride. If it requires 6.52 mL of lead nitrate to reach equivalence, what was the concentration of chlorie in the original solution?

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$Pb(NO_3)_{2\,(aq)} + 2\ Cl^-_{(aq)} \rightleftharpoons PbCl_{2\,(s)} + 2\ NO_3^-{}_{(aq)}$

$Pb^{2+}_{(aq)} + 2\ Cl^-_{(aq)} \rightleftharpoons PbCl_{2\,(s)}$

NO_3^- is a "spectator ion"

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$Pb^{2+}_{(aq)} + 2\ Cl^{-}_{(aq)} \rightarrow PbCl_{2\,(s)}$

$i_2M_1V_1 = i_1M_2V_2$

$i_{Cl^-}M_{Pb2+}V_{Pb2+} = i_{Pb+}\ M_{Cl^-}V_{Cl^-}$

(2) (0.1062 M) (6.52 mL) = (1) (M_{Cl^-})(100.00 mL)

M_{Cl^-} = 0.01385 M Cl-

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Problem #4

A solution is prepared by mixing 0.10 L of 0.12 M sodium chloride with 0.23 L of a 0.18 M $MgCl_2$ solution. What volume of a 0.20 M $AgNO_3$ solution is required to precipitate all of the chloride ion as silver chloride?

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$Cl^-_{(aq)} + Ag^+_{(aq)} \rightarrow AgCl_{(s)}$

$i_2M_1V_1 = i_1M_2V_2$

$i_{Cl^-}M_{Ag+}V_{Ag+} = i_{Ag+}\ M_{Cl^-}V_{Cl^-}$

(1) (0.20 M) (V_{Ag+}) = (1) (M_{Cl^-})(V_{Cl^-})

What is the volume of the chloride solution?
What is the Molarity of Chloride?

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(1) (0.20 M) (V_{Ag+}) = (1) (M_{Cl-})(V_{Cl-})

What is the volume of the chloride solution?

0.10 L + 0.23 L = 0.33 L
What is the Molarity of Chloride?

(.12 M * 0.10 L) + (0.18M*0.23L) = 0.0534 mol Cl-
$\frac{0.0534 \text{ mol } Cl^-}{0.33 \text{ L}}$ = 0.1618 M Cl-

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(1) (0.20 M) (V_{Ag+}) = (1) (M_{Cl-})(V_{Cl-})
(1) (0.20 M) (V_{Ag+}) = (1) (0.1618 M.)(0.33 L)

V_{Ag+} = 0.2670 L

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Might have been easier just to go with the moles from beginning.

Total moles of Cl^- = 0.0534 mol Cl-
[(.12 M * 0.10 L) + (0.18M*0.23L) = 0.0534 mol Cl-]

$0.0534 \text{ mol } Cl^- * \frac{1 \text{ mol } Ag^+}{1 \text{ mol } Cl^-} = 0.0534 \text{ mol } Ag^+$

$0.0534 \text{ mol } Ag^+ * \frac{1 \text{ L Ag solution}}{0.20 \text{ mol Ag solution}} = 0.2670 \text{ L Ag solution}$