

$$3. (a) \% \text{ mass} = \left( \frac{\text{mass of solute}}{\text{mass of solution}} \right) \times 100\% = \left( \frac{0.325 \text{ g}}{2.00 \text{ g}} \right) \times 100\%$$

$$\% \text{ mass} = 16.3\%$$

$$(b) ? \text{ g H} = 1.20 \text{ g H}_2\text{O} \left( \frac{2.00 \text{ g H}}{18.0 \text{ g H}_2\text{O}} \right) = 0.133 \text{ g H}$$

$$PV = nRT$$

$$\left( \frac{750 \text{ mmHg}}{760 \text{ mmHg}} \right) \cdot (3.72 \text{ L}) = n_{\text{CO}_2} (0.0821 \text{ L} \cdot \text{atm} / \text{K} \cdot \text{mol}) \cdot (298 \text{ K})$$

$$n_{\text{CO}_2} = 0.150 \text{ mole CO}_2$$

$$? \text{ g C} = 0.150 \text{ mole CO}_2 \left( \frac{12.0 \text{ g C}}{1 \text{ mole CO}_2} \right) = 1.80 \text{ g CO}_2$$

$$m_{\text{C}} + m_{\text{H}} + m_{\text{O}} = m_{\text{Total}}$$

$$1.80 \text{ g} + 0.133 \text{ g} + m_{\text{O}} = 3.00 \text{ g}$$

$$m_{\text{O}} = 1.07 \text{ g}$$

$$m_{\text{C}} = 0.133 \text{ g}$$

$$m_{\text{H}} = 1.80 \text{ g}$$

$$m_{\text{O}} = 1.07 \text{ g}$$

$$(c) \text{ molarity} = \left( \frac{\# \text{ moles of solute}}{L \text{ of solution}} \right)$$

$$0.102 \text{ M NaOH} = \left( \frac{\# \text{ moles of solute}}{0.08843 \text{ L of solution}} \right)$$

$$\# \text{ moles of solute} = 0.00902 \text{ moles NaOH}$$

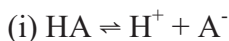


Since the number of moles of  $\text{OH}^-$  equals the number of moles of  $\text{H}^+$  (the mole ratio is 1:1) during neutralization and there is only one ionizable hydrogen, then the number of moles of NaOH equals the number of moles of acetylsalicylic acid.

$$? \text{ g acid} = 1 \text{ mole acid} \left( \frac{1.625 \text{ g acid}}{0.00902 \text{ moles acid}} \right)$$

$$1 \text{ mole acetylsalicylic acid} = 180 \text{ g}$$

$$(d) \text{ molarity} = \left( \frac{\# \text{ moles of solute}}{L \text{ of solution}} \right) = \left( \frac{2.00 \times 10^{-3} \text{ moles}}{0.01500 \text{ L of solution}} \right) = 0.133 \text{ M acetylsalicylic acid}$$



$$\text{pH} = -\log[\text{H}^+]$$

$$2.22 = -\log[\text{H}^+]$$

$$[\text{H}^+] = 6.03 \times 10^{-3} \text{ M} = [\text{A}^-]$$

$$[\text{HA}] = 0.133 \text{ M} - 6.03 \times 10^{-3} \text{ M} = 0.127 \text{ M}$$

$$K_a = \frac{[\text{H}^+][\text{A}^-]}{[\text{HA}]} = \frac{(6.03 \times 10^{-3}) \cdot (6.03 \times 10^{-3})}{0.127} = 2.86 \times 10^{-4} = K_a$$

3. (d) (continued)

(ii) The acetylsalicylic acid will be neutralized when 0.00200 moles of NaOH have been added.

$$\text{molarity} = \left( \frac{\# \text{ moles of solute}}{L \text{ of solution}} \right)$$

$$0.100 \text{ M} = \left( \frac{0.00200 \text{ moles NaOH}}{? L \text{ of solution}} \right)$$

$$? L \text{ of solution} = 0.0200 \text{ L} = 20.00 \text{ mL}$$

After this amount has been added, any additional NaOH added will just increase the concentration of  $\text{OH}^-$ . So, 25.00 mL - 20.00 mL = 5.00 mL  $\text{OH}^-$ .

$$\text{molarity} = \left( \frac{\# \text{ moles of solute}}{L \text{ of solution}} \right)$$

$$0.100 \text{ M} = \left( \frac{\# \text{ moles } \text{OH}^-}{0.00500 L \text{ of solution}} \right)$$

$$\# \text{ moles of } \text{OH}^- = 5.00 \times 10^{-4} \text{ moles}$$

$$V_{\text{Total}} = 15.00 \text{ mL (from acid)} + 25.00 \text{ mL (from NaOH)} = 40.00 \text{ mL} = 0.04000 \text{ L of solution}$$

$$\text{molarity} = \left( \frac{\# \text{ moles of solute}}{L \text{ of solution}} \right) = \left( \frac{5.00 \times 10^{-4} \text{ moles } \text{OH}^-}{0.04000 L \text{ of solution}} \right) = 0.0125 \text{ M} = [\text{OH}^-]$$

$$\text{pOH} = -\log[\text{OH}^-] = -\log(0.0125 \text{ M})$$

$$\text{pOH} = 1.903$$

$$\text{pOH} + \text{pH} = 14.000$$

$$1.903 + \text{pH} = 14.000$$

$\text{pH} = 12.097$
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$$3. (a) \% \text{ mass C} = \frac{\text{mass C}}{\text{formulamass}} \times 100\% = \frac{12.0\text{gC}}{151.0\text{gBeC}_2\text{O}_4 \cdot 3\text{H}_2\text{O}} \times 100\%$$

$$\% \text{ mass C} = 7.95\% \text{ C}$$

$$(b) (i) ? \text{ g BeC}_2\text{O}_4 = 3.21 \text{ g BeC}_2\text{O}_4 \cdot 3\text{H}_2\text{O} \left( \frac{1\text{moleBeC}_2\text{O}_4 \cdot 3\text{H}_2\text{O}}{151.0\text{gBeC}_2\text{O}_4 \cdot 3\text{H}_2\text{O}} \right) \left( \frac{1\text{moleBeC}_2\text{O}_4}{1\text{moleBeC}_2\text{O}_4 \cdot 3\text{H}_2\text{O}} \right) \left( \frac{97.0\text{gBeC}_2\text{O}_4}{1\text{moleBeC}_2\text{O}_4} \right)$$

$$? \text{ g BeC}_2\text{O}_4 = 2.06 \text{ g BeC}_2\text{O}_4$$

$$(ii) ? \text{ moles H}_2\text{O} = 3.21 \text{ g BeC}_2\text{O}_4 \cdot 3\text{H}_2\text{O} \left( \frac{1\text{moleBeC}_2\text{O}_4 \cdot 3\text{H}_2\text{O}}{151.0\text{gBeC}_2\text{O}_4 \cdot 3\text{H}_2\text{O}} \right) \left( \frac{1\text{moleH}_2\text{O}}{1\text{moleBeC}_2\text{O}_4 \cdot 3\text{H}_2\text{O}} \right)$$

$$? \text{ moles H}_2\text{O} = 0.0213 \text{ moles H}_2\text{O}$$

PV = nRT

$$\left( \frac{735\text{mmHg}}{760\text{mmHg/atm}} \right) V = (0.0213 \text{ moles}) \left( 0.0821 \frac{\text{L} \cdot \text{atm}}{\text{K} \cdot \text{mol}} \right) (493 \text{ K})$$

$$V = 41.9 \text{ L H}_2\text{O}$$

(c) (i) Carbon is the reducing agent.

$$(ii) ? \text{ moles MnO}_4^- = 17.80 \text{ mL KMnO}_4 \left( \frac{0.0150\text{moleKMnO}_4}{1000\text{mLKMnO}_4} \right) \left( \frac{1\text{moleMnO}_4^-}{1\text{moleKMnO}_4} \right)$$

$$= 2.67 \times 10^{-4} \text{ moles MnO}_4^-$$

$$? \text{ moles C}_2\text{O}_4^{2-} = 17.80 \text{ mL KMnO}_4 \left( \frac{0.0150\text{moleKMnO}_4}{1000\text{mLKMnO}_4} \right) \left( \frac{1\text{moleMnO}_4^-}{1\text{moleKMnO}_4} \right) \left( \frac{5\text{molesC}_2\text{O}_4^{2-}}{2\text{molesMnO}_4^-} \right)$$

$$= 6.68 \times 10^{-4} \text{ moles C}_2\text{O}_4^{2-}$$

$$(iii) ? \text{ moles C}_2\text{O}_4^{2-} = 100 \text{ mL BeC}_2\text{O}_4 \left( \frac{6.68 \times 10^{-4} \text{ moles C}_2\text{O}_4^{2-}}{20\text{mLBeC}_2\text{O}_4} \right)$$

$$? \text{ moles C}_2\text{O}_4^{2-} = 3.34 \times 10^{-4} \text{ moles C}_2\text{O}_4^{2-}$$

$$(iv) ? \text{ g BeC}_2\text{O}_4 = 3.34 \times 10^{-4} \text{ moles C}_2\text{O}_4^{2-} \left( \frac{1\text{moleBeC}_2\text{O}_4}{1\text{moleC}_2\text{O}_4^{2-}} \right) \left( \frac{97.0\text{gBeC}_2\text{O}_4}{1\text{moleBeC}_2\text{O}_4} \right) = 0.324 \text{ g BeC}_2\text{O}_4$$

$$\% \text{ mass C} = \left( \frac{\text{massBeC}_2\text{O}_4\text{actual}}{\text{massBeC}_2\text{O}_4\text{sample}} \right) \times 100\% = \left( \frac{0.324\text{g}}{0.345\text{g}} \right) \times 100\%$$

$$\% \text{ mass C} = 93.9\% \text{ pure}$$