

Chapter 4 Solution Stoichiometry Problems

Key

1. A stock solution of sodium hydroxide is prepared by dissolving 120.0 g of NaOH in 500.0 mL of water. What is the molarity of the stock solution?

$$M = \frac{\text{moles}}{L} = \frac{120.0 \text{ g NaOH}}{500.0 \text{ mL}} \left(\frac{1000 \text{ mL}}{1 L} \right) \left(\frac{1 \text{ mole NaOH}}{40.0 \text{ g}} \right) = \boxed{6.000 \text{ M NaOH}}$$

2. A stock solution of HCl is prepared by adding V_1 mL of a M_1 M HCl solution to water and diluting to a final volume of V_2 mL. What is the molarity of the stock solution? $M_2 = ?$

$$M_1 V_1 = M_2 V_2$$

$$(12.00 \text{ M})(30.00 \text{ mL}) = M_2 (250.0 \text{ mL})$$

$$\boxed{M_2 = 1.440 \text{ M HCl}}$$

3. A chemistry student wants to verify the molarity of the acid stock solution prepared in problem 2, so she titrates a 25.00 mL aliquot (measured sample) with the NaOH solution described in problem 1. If she wants to use 40.00 mL of the NaOH solution as the titrant, what molarity would her NaOH solution need to be? How would she prepare 100.0 mL of that solution?

$$M_A V_A = M_B V_B$$

$$(1.440 \text{ M})(25.00 \text{ mL}) = M_B (40.00 \text{ mL})$$

$$\boxed{M_B = 0.9000 \text{ M NaOH}}$$

$$(6 \text{ M NaOH})(V_1) = (0.9000 \text{ M})(100 \text{ mL})$$

$$V_1 = 15.00 \text{ mL NaOH to make } 100 \text{ mL of } 0.9 \text{ M NaOH}$$

$$M_A = 1.440 \text{ M HCl}$$

$$V_A = 25.00 \text{ mL}$$

$$M_B = ?$$

$$V_B = 40.00 \text{ mL}$$

4.

What is the concentration of the following in ppm?

a. 1.0×10^{-2} g Cu^{2+} in 2.0 L of solution.

b. The concentration of Pb^{2+} in 2.1×10^{-5} M $\text{Pb}(\text{NO}_3)_2$.

$$\text{ppm} = \frac{\text{mg}}{\text{L}}$$

$$\text{a) } \frac{1.0 \times 10^{-2} \text{ g Cu}^{2+}}{2.0 \text{ L}} \left(\frac{1000 \text{ mg}}{1 \text{ g}} \right) = \boxed{5.0 \text{ mg/L} = 5.0 \text{ ppm}}$$

$$\text{b) } \frac{2.10 \times 10^{-5} \text{ mol Pb}(\text{NO}_3)_2}{\text{L}} \left(\frac{1 \text{ mol Pb}^{2+}}{1 \text{ mol Pb}(\text{NO}_3)_2} \right) \left(\frac{207.2 \text{ g}}{1 \text{ mol Pb}^{2+}} \right) \left(\frac{1000 \text{ mg}}{1 \text{ g}} \right) = \boxed{4.35 \frac{\text{mg}}{\text{L}} = 4.35 \text{ ppm}}$$

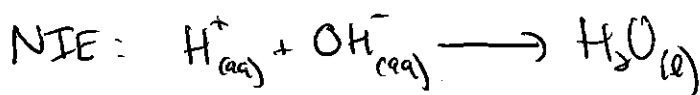
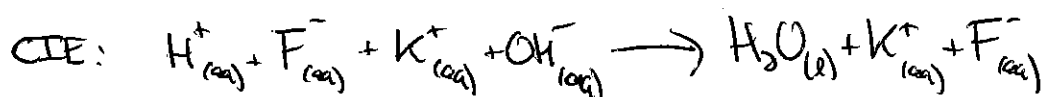
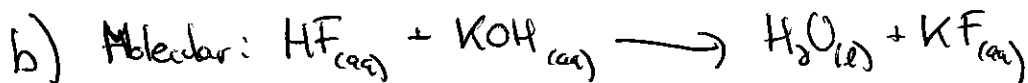
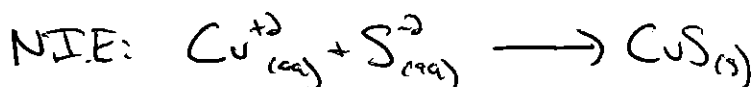
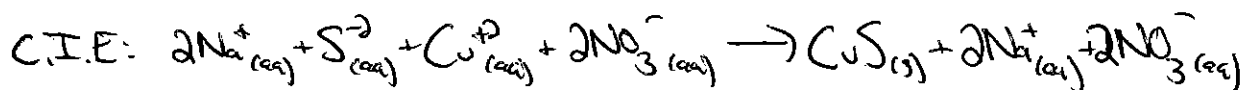
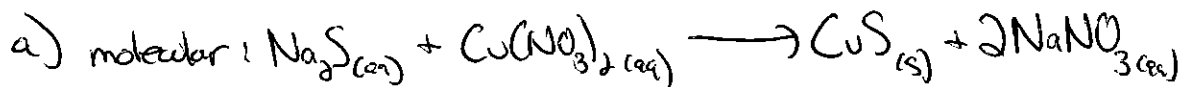
5. A solution contains Ag^+ , Pb^{2+} , and Fe^{3+} . If you want to precipitate the Pb^{2+} selectively, what anion would you choose?

You could mix it in some sort of sulfate solution (e.g. Na_2SO_4)

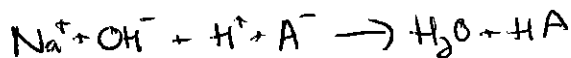
The sulfate ion is soluble in Ag^+ and Fe^{3+} , it is insoluble in Pb^{2+} , thus forming a PbSO_4 precipitate.

Write molecular, complete ionic, and net ionic equations for the following reactions:

6. a. aqueous sodium sulfide reacts with aqueous copper (II) nitrate
 b. aqueous hydrogen fluoride reacts with aqueous potassium hydroxide to give water and aqueous potassium fluoride



7. A titration is done using 0.1302 M NaOH to determine the molar mass of an acid. The acid contains one acidic hydrogen per molecule. If 1.863 g of the acid require 70.11 mL of the NaOH solution, what is the molar mass of the acid?



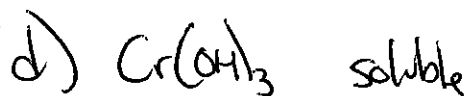
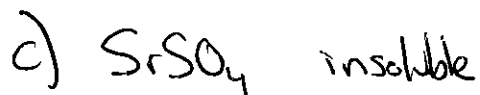
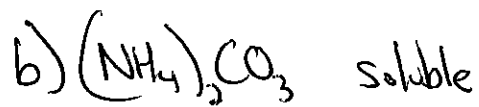
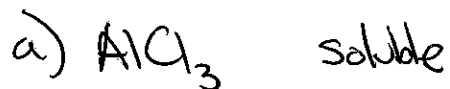
$$70.11 \text{ mL NaOH} \left(\frac{1 \text{ L}}{1000 \text{ mL}} \right) \left(\frac{0.1302 \text{ mol NaOH}}{\text{L}} \right) \left(\frac{1 \text{ mol OH}^-}{1 \text{ mol NaOH}} \right) \left(\frac{1 \text{ mol H}^+}{1 \text{ mol OH}^-} \right) \left(\frac{1 \text{ mol Acid}}{1 \text{ mol H}^+} \right) =$$

$$\text{MM}_{\text{acid}} = \frac{\text{g acid}}{\text{moles acid}} = \frac{1.863 \text{ g}}{0.009128 \text{ mol}} = \boxed{204.13 \text{ g/mol}} \quad 0.009128 \text{ mol Acid}$$

Precipitation Reactions and Solubility

8. Write the formulas of the following compounds and decide which are soluble in water.

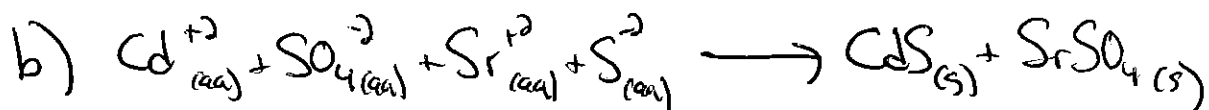
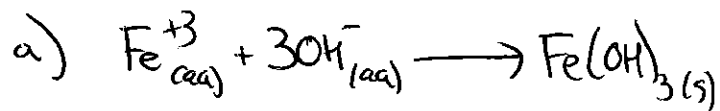
- (a) aluminum chloride
- (b) ammonium carbonate
- (c) strontium sulfate
- (d) chromium(III) hydroxide



9. Write net ionic equations to explain the formation of

(a) a red precipitate when solutions of iron(III) chloride and sodium hydroxide are mixed.

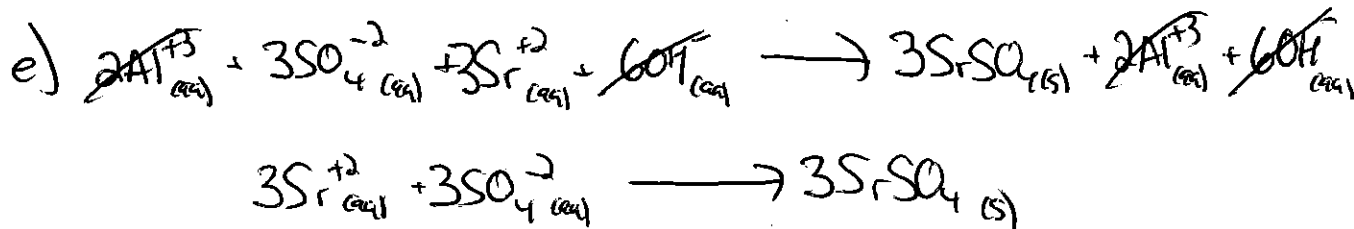
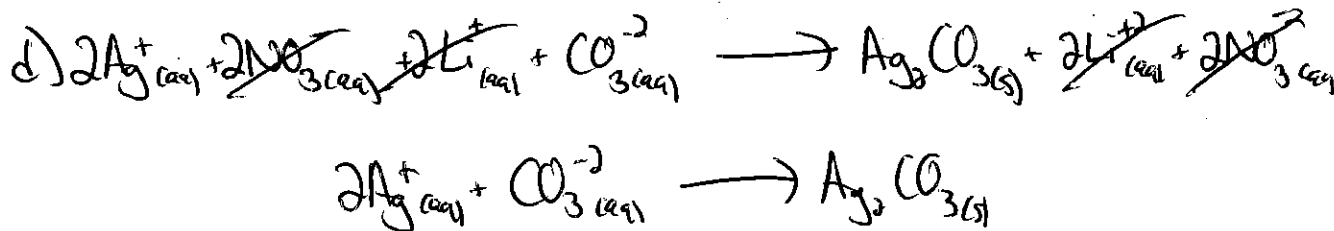
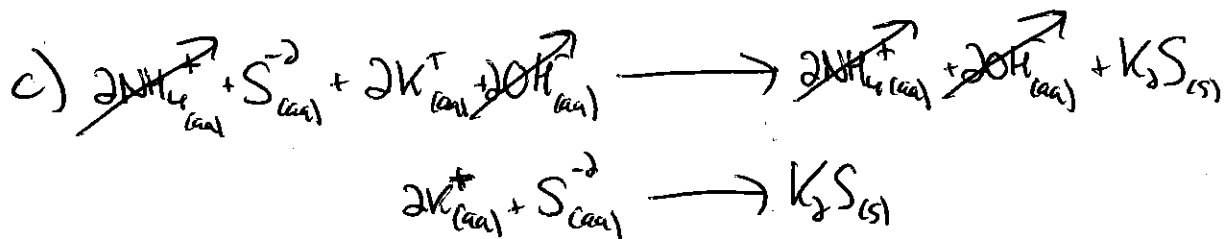
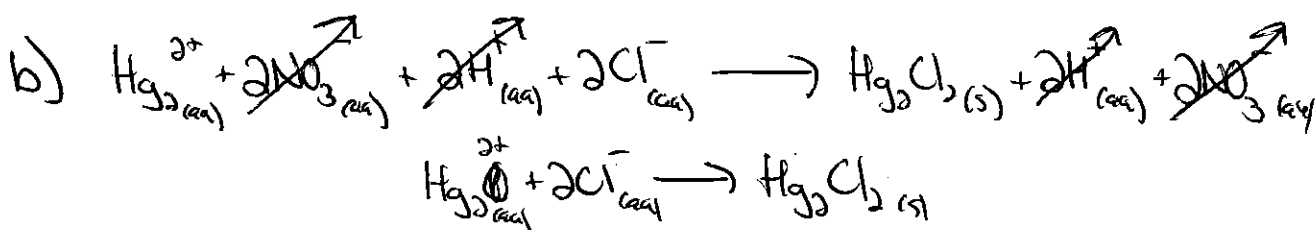
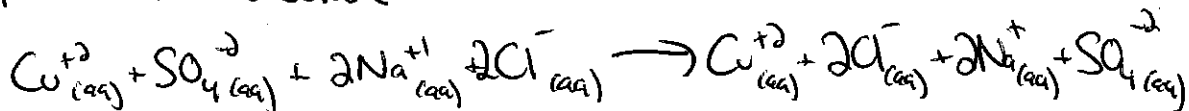
(b) two different precipitates, one yellow and the other white, when solutions of cadmium(II) sulfate and strontium sulfide are mixed.



10. Decide whether a precipitate will form when the following solutions are mixed. If a precipitate forms, write a net ionic equation for the reaction.

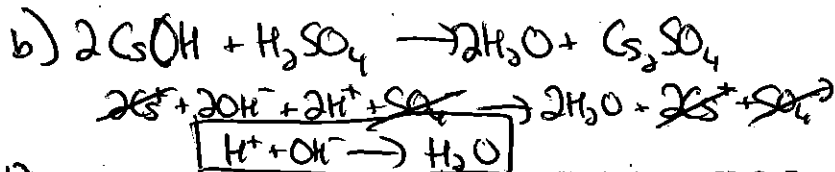
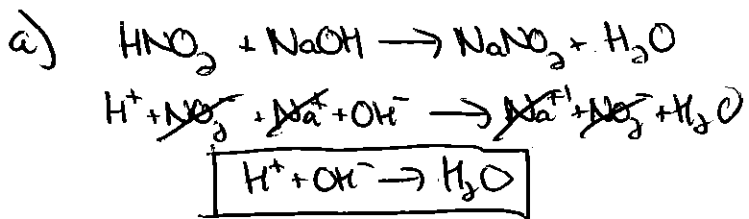
- (a) copper(II) sulfate and sodium chloride.
- (b) mercury(I) nitrate and hydrochloric acid.
- (c) ammonium sulfide and potassium hydroxide.
- (d) silver nitrate and lithium carbonate.
- (e) aluminum sulfate and strontium hydroxide.

a) No PPT - both combs soluble



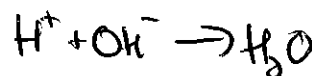
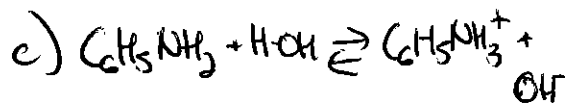
11. Write a balanced net ionic equation for each of the following acid-base reactions in water.

- (a) nitrous acid and sodium hydroxide.
- (b) cesium hydroxide and sulfuric acid.
- (c) aniline ($C_6H_5NH_2$) and nitric acid.



12. Consider the equation $H^+(aq) + OH^-(aq) \rightarrow H_2O$. For which of the following pairs would this be the correct equation for the acid-base reaction in solution? If it is not correct, write the proper equation for the acid-base reaction between the pair.

- (a) nitric acid and $C_2H_5NH_2$
- (b) perchloric acid and cesium hydroxide
- (c) $HC_2H_3O_2$ and $LiOH$
- (d) sulfuric acid and calcium hydroxide
- (e) barium hydroxide and hydriodic acid



S/A / S/B Combo

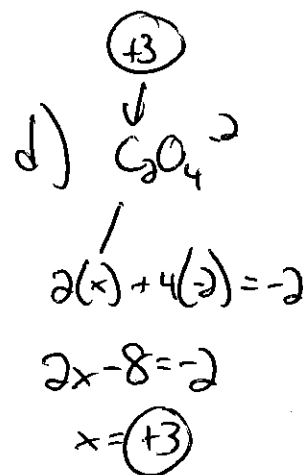
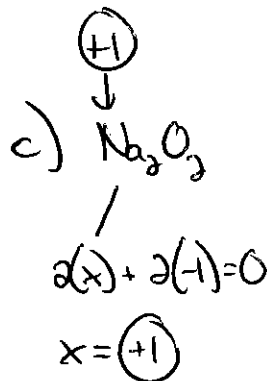
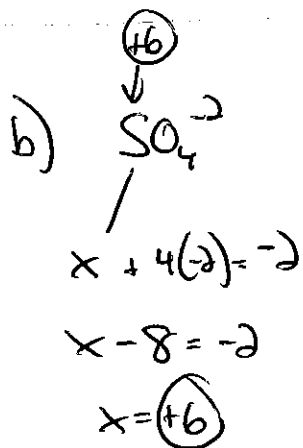
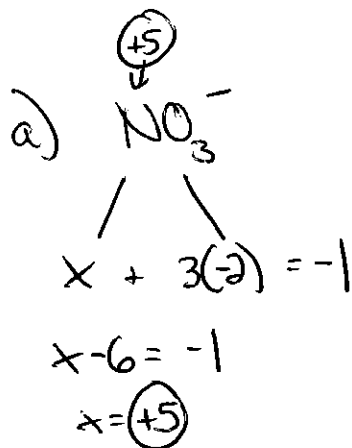
13. Assign oxidation numbers to each element in

(a) nitrate ion NO_3^-

(b) sulfate ion SO_4^{2-}

(c) sodium peroxide (Na_2O_2)

(d) oxalate ion ($\text{C}_2\text{O}_4^{2-}$)



14. Assign oxidation numbers to each element in

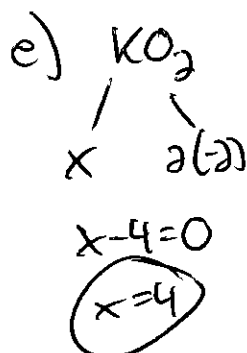
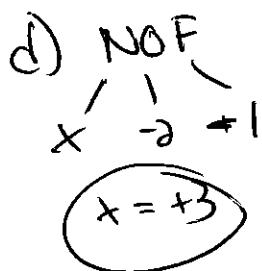
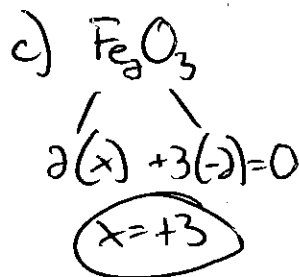
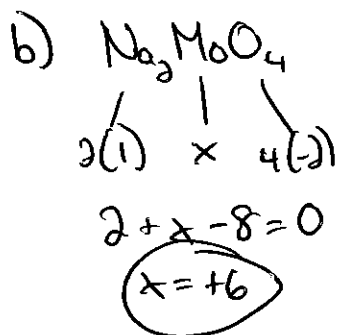
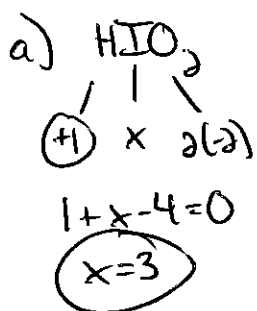
(a) HIO_2

(b) Na_2MoO_4

(c) Fe_2O_3

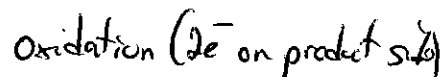
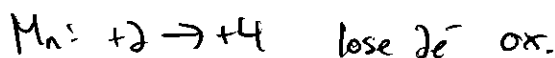
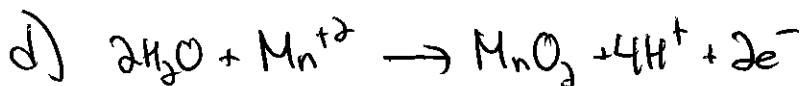
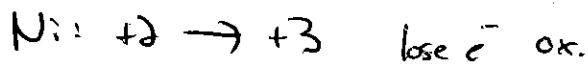
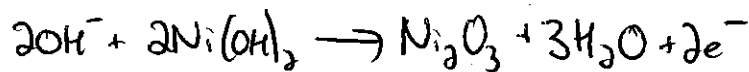
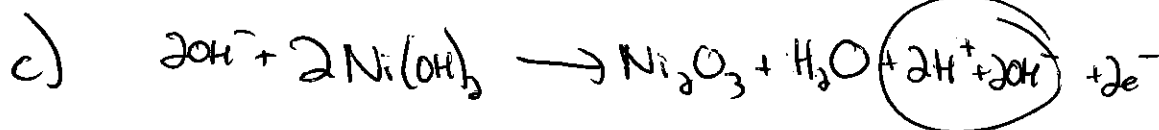
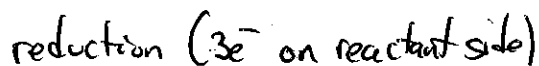
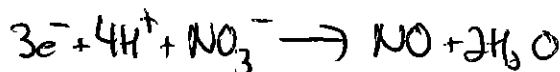
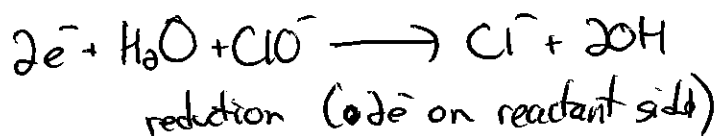
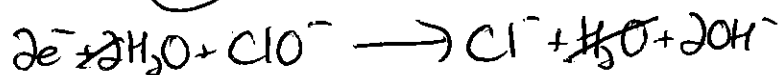
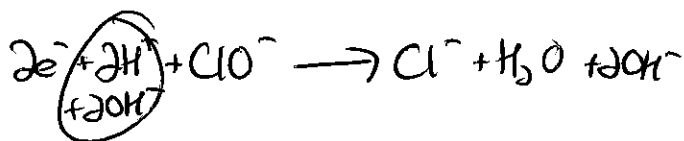
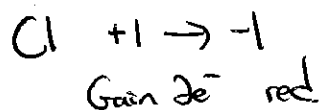
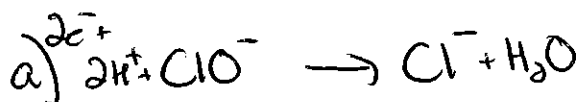
(d) NOF

(e) KO_2



6. Classify each of the following half-equations as oxidation or reduction and balance.

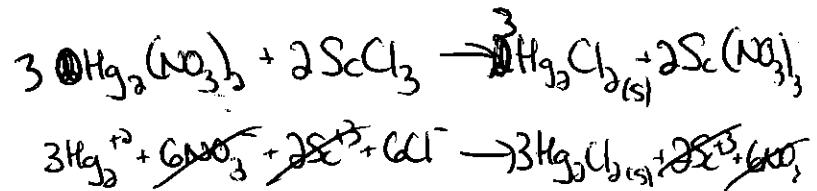
- (a) (basic) $\text{ClO}^-(\text{aq}) \rightarrow \text{Cl}^-(\text{aq})$
 (b) (acidic) $\text{NO}_3^-(\text{aq}) \rightarrow \text{NO}(\text{g})$
 (c) (basic) $\text{Ni}(\text{OH})_2(\text{s}) \rightarrow \text{Ni}_2\text{O}_3(\text{s})$
 (d) (acidic) $\text{Mn}^{2+}(\text{aq}) \rightarrow \text{MnO}_2(\text{s})$



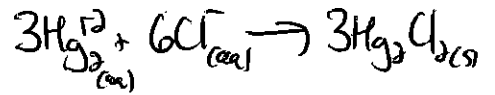
Chemistry-II/AP

Chapter 4: Section 4.5

Solution Stoichiometry



16. A 50.00-mL sample of 0.0250 M mercury(I) nitrate, $\text{Hg}_2(\text{NO}_3)_2$, is mixed with 0.0500 M scandium chloride.



(a) What is the minimum volume of scandium chloride required to completely precipitate mercury(I) chloride (also known as calomel)?

(b) How many grams of calomel are produced from (a)?

(a) 1. Compute the moles of $\text{Hg}_2(\text{NO}_3)_2$ used.

$$\left(\frac{0.0250 \text{ mol Hg}_2(\text{NO}_3)_2}{\cancel{\text{L}}} \right) \left(\frac{1 \cancel{\text{L}}}{1000 \cancel{\text{mL}}} \right) (50.00 \cancel{\text{mL}}) = 0.00125 \text{ mol Hg}_2(\text{NO}_3)_2$$

2. How many moles of Hg_2^{2+} were present?

$$0.00125 \text{ mol Hg}_2(\text{NO}_3)_2 \left(\frac{1 \text{ mol Hg}_2^{2+}}{1 \text{ mol Hg}_2(\text{NO}_3)_2} \right) = 0.00125 \text{ mol Hg}_2^{2+}$$

3. How many moles of Cl^- were used?

$$0.00125 \text{ mol Hg}_2^{2+} \left(\frac{6 \text{ mol Cl}^-}{3 \text{ mol Hg}_2^{2+}} \right) = 0.0025 \text{ mol Cl}^-$$

4. Compute the moles of ScCl_3 required to furnish the moles of Cl^- .

$$0.0025 \text{ mol Cl}^- \left(\frac{1 \text{ mol ScCl}_3}{3 \text{ mol Cl}^-} \right) = 0.000833 \text{ mol ScCl}_3$$

5. Compute the volume of ScCl_3 required for the precipitation.

$$M = \frac{\text{moles}}{L} \quad L = \frac{\text{moles}}{M} = \frac{0.000833 \text{ mol ScCl}_3}{0.0500 \frac{\text{mol ScCl}_3}{L}} =$$

(b)

$$0.0250 \frac{\text{mol}}{\text{L}} \text{Hg}_2(\text{NO}_3)_2 \times 0.05000 \text{L}$$

$$L = 0.0167 \text{ L} \quad \boxed{16.67 \text{ mL}}$$

$$0.00125 \text{ mol Hg}_2(\text{NO}_3)_2 \left(\frac{3 \text{ mol Hg}_2\text{Cl}_2}{3 \text{ mol Hg}_2(\text{NO}_3)_2} \right) \left(\frac{471.1 \text{ g}}{1 \text{ mol Hg}_2\text{Cl}_2} \right) = \boxed{0.534 \text{ g}}$$

Chemistry-II/AP

Chapter 4: Section 4.5

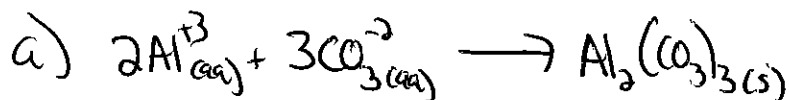
Solution Stoichiometry: Precipitation and Acid-Base Reactions

n. Aluminum ions react with carbonate ions to form an insoluble compound, aluminum carbonate. $\overset{\text{Al}^{3+}}{\text{Al}_2(\overset{\text{CO}_3^{2-}}{\text{CO}_3})_3}$

(a) Write the net ionic equation for this reaction.

(b) What is the molarity of a solution of aluminum chloride if 25.0 mL is required to react with 35.5 mL of 0.155 M sodium carbonate?

(c) How many grams of aluminum carbonate are formed?

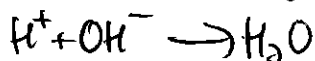
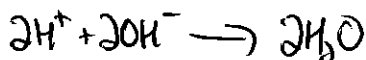
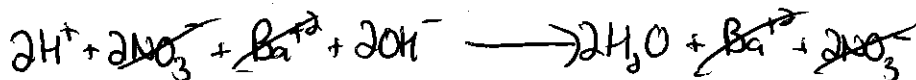


$$b) 35.5 \text{ mL Na}_2\text{CO}_3 \left(\frac{1 \text{ L}}{1000 \text{ mL}} \right) \left(\frac{0.155 \text{ mol Na}_2\text{CO}_3}{1 \text{ L}} \right) \left(\frac{1 \text{ mol CO}_3^{2-}}{1 \text{ mol Na}_2\text{CO}_3} \right) \left(\frac{2 \text{ mol Al}^{3+}}{3 \text{ mol CO}_3^{2-}} \right) \left(\frac{1 \text{ mol AlCl}_3}{1 \text{ mol Al}^{3+}} \right) = 3.67 \times 10^{-3} \text{ mol AlCl}_3$$

$$M = \frac{\text{moles AlCl}_3}{L \text{ AlCl}_3} = \frac{3.67 \times 10^{-3} \text{ mol AlCl}_3}{0.025 \text{ L AlCl}_3} = \boxed{.147 \text{ M AlCl}_3}$$

$$c) 35.5 \text{ mL Na}_2\text{CO}_3 \left(\frac{1 \text{ L}}{1000 \text{ mL}} \right) \left(\frac{0.155 \text{ mol Na}_2\text{CO}_3}{1 \text{ L}} \right) \left(\frac{1 \text{ mol CO}_3^{2-}}{1 \text{ mol Na}_2\text{CO}_3} \right) \left(\frac{1 \text{ mol Al}_2(\text{CO}_3)_3}{3 \text{ mol CO}_3^{2-}} \right) \left(\frac{234 \text{ g}}{1 \text{ mol Al}_2(\text{CO}_3)_3} \right) = \boxed{.429 \text{ g Al}_2(\text{CO}_3)_3}$$

18. What is the molarity of a solution of nitric acid if 0.216 g of barium hydroxide is required to neutralize 20.00 mL of nitric acid?



$$.216 \text{ g Ba(OH)}_2 \left(\frac{1 \text{ mol Ba(OH)}_2}{171.34 \text{ g}} \right) \left(\frac{2 \text{ mol OH}^-}{1 \text{ mol Ba(OH)}_2} \right) \left(\frac{1 \text{ mol H}^+}{1 \text{ mol OH}^-} \right) \left(\frac{1 \text{ mol HNO}_3}{1 \text{ mol H}^+} \right) = .00252 \text{ mol HNO}_3$$

$$M = \frac{\text{moles}}{L} = \frac{.00252 \text{ mol HNO}_3}{.02000 \text{ L}} = \boxed{.126 \text{ M}} \text{ HNO}_3$$

19. Pennies made after 1982 contain about 97% zinc by mass. A student wants to prove this by filing the copper outside of a penny until he sees zinc and then putting the penny in a 1.00 M HCl solution. The zinc will be oxidized and the H^+ (from HCl) will be reduced:

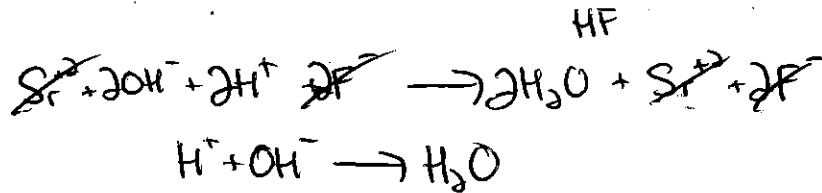


If the entire penny has a mass of 2.80 grams, how many mL of 1.00 M HCl are required to just react with all the zinc? (You would, in reality, add much more to completely surround the penny.)

$$2.80 \text{ g penny} \left(\frac{.97 \text{ g Zn}}{100 \text{ g penny}} \right) \left(\frac{1 \text{ mol Zn}}{65.4 \text{ g}} \right) \left(\frac{2 \text{ mol H}^+}{1 \text{ mol Zn}} \right) \left(\frac{1 \text{ mol HCl}}{1 \text{ mol H}^+} \right) \left(\frac{1 \text{ L}}{1 \text{ mol HCl}} \right) \left(\frac{1000 \text{ mL}}{1 \text{ L}} \right) =$$

83.1 mL of
1.00 M HCl

19. What volume of 0.185 M strontium hydroxide is required to neutralize 35.00 mL of 0.175 M hydrogen fluoride?



$$35.00 \text{ mL HF} \left(\frac{1 \cancel{\text{L}}}{1000 \cancel{\text{mL}}} \right) \left(\frac{0.175 \cancel{\text{mol HF}}}{\cancel{\text{L}}} \right) \left(\frac{1 \cancel{\text{mol H}^+}}{1 \cancel{\text{mol HF}}} \right) \left(\frac{1 \cancel{\text{mol OH}^-}}{1 \cancel{\text{mol H}^+}} \right) \left(\frac{1 \cancel{\text{mol Sr(OH)}_2}}{2 \cancel{\text{mol OH}^-}} \right) \left(\frac{1 \cancel{\text{L}}}{0.185 \cancel{\text{mol Sr(OH)}_2}} \right) \left(\frac{1000 \cancel{\text{mL}}}{1 \cancel{\text{L}}} \right) =$$

16.56 mL of 0.185 M Sr(OH)_2

20. A vitamin C capsule is analyzed by titrating it with 0.250 M sodium hydroxide. It is found that 10.3 mL of base is required to react with a capsule weighing 0.518 g. What is the percentage of vitamin C ($\text{C}_6\text{H}_8\text{O}_6$) in the capsule? (One mole of vitamin C reacts with one mole of hydroxide ion.)

$$10.3 \text{ mL NaOH} \left(\frac{1 \cancel{\text{L}}}{1000 \cancel{\text{mL}}} \right) \left(\frac{0.250 \cancel{\text{mol NaOH}}}{\cancel{\text{L}}} \right) \left(\frac{1 \cancel{\text{mol OH}^-}}{1 \cancel{\text{mol NaOH}}} \right) \left(\frac{1 \cancel{\text{mol VitC}}}{1 \cancel{\text{mol OH}^-}} \right) \left(\frac{176 \text{g}}{1 \cancel{\text{mol VitC}}} \right) =$$

0.4532 g Vitamin C

$$\% \text{ VitC} = \frac{\text{mass VitC}}{\text{mass capsule}} \times 100$$

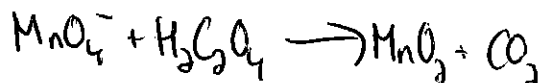
$$\frac{0.4532 \text{g}}{0.518 \text{g}} \times 100 = \boxed{87.5\% \text{ Vitamin C}}$$

Chemistry-II/AP

Chapter 4: Section 4.6

Solution Reactions in Quantitative Analysis

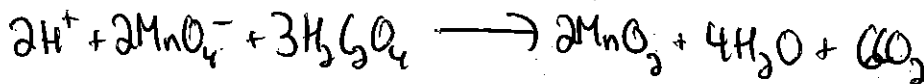
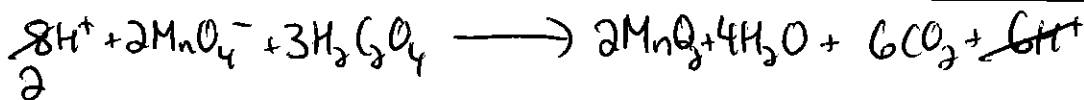
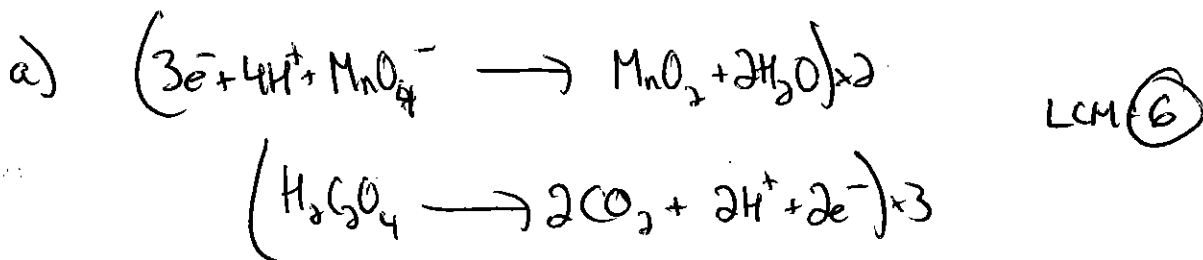
21. Potassium permanganate reacts with oxalic acid, $\text{H}_2\text{C}_2\text{O}_4$, to form carbon dioxide and solid manganese(IV) oxide (MnO_2).



(a) Write a balanced net ionic equation for the reaction.

(b) If 25.0 mL of 0.500 M potassium permanganate is required to react with 15.0 mL of oxalic acid, what is the molarity of the oxalic acid?

(c) What is the mass of manganese(IV) oxide formed?

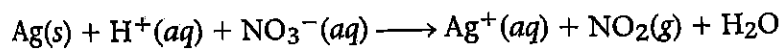


b) $25.0 \text{ mL KMnO}_4 \left(\frac{1 \text{ L}}{1000 \text{ mL}} \right) \left(\frac{.500 \text{ mol KMnO}_4}{1 \text{ L}} \right) \left(\frac{1 \text{ mol MnO}_4^-}{1 \text{ mol KMnO}_4} \right) \left(\frac{3 \text{ mol H}_2\text{C}_2\text{O}_4}{2 \text{ mol MnO}_4^-} \right) = .01875 \text{ mol H}_2\text{C}_2\text{O}_4$

$$M = \frac{.01875 \text{ mol H}_2\text{C}_2\text{O}_4}{.015 \text{ L}} = \boxed{1.25 \text{ M H}_2\text{C}_2\text{O}_4}$$

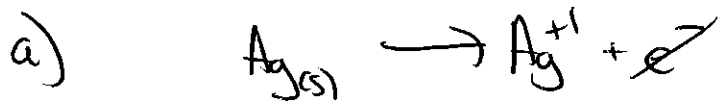
c) $25.0 \text{ mL KMnO}_4 \left(\frac{1 \text{ L}}{1000 \text{ mL}} \right) \left(\frac{.500 \text{ mol KMnO}_4}{1 \text{ L}} \right) \left(\frac{1 \text{ mol MnO}_4^-}{1 \text{ mol KMnO}_4} \right) \left(\frac{2 \text{ mol MnO}_2}{2 \text{ mol MnO}_4^-} \right) \left(\frac{86.94 \text{ g}}{1 \text{ mol MnO}_2} \right) = \boxed{1.09 \text{ g MnO}_2}$

22. Consider the reaction between silver and nitric acid for which the unbalanced equation is

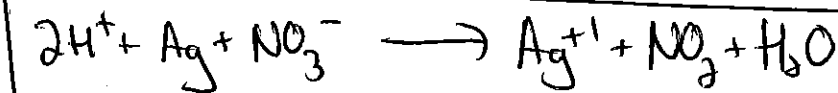
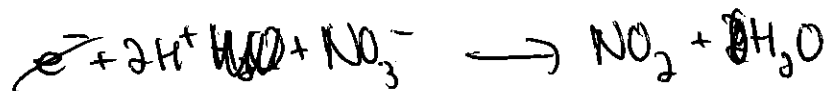


(a) Balance the equation.

(b) If 35.00 mL of 12.0 M nitric acid furnishes enough H^+ to react with silver, how many grams of silver react?



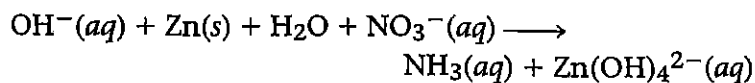
LCM = 1



$$\text{b) } 35.00 \text{ mL HNO}_3 \left(\frac{1 \text{ L}}{1000 \text{ mL}} \right) \left(\frac{12 \text{ mol HNO}_3}{1 \text{ L}} \right) \left(\frac{2 \text{ mol H}^+}{1 \text{ mol HNO}_3} \right) \left(\frac{1 \text{ mol Ag}}{2 \text{ mol H}^+} \right) \left(\frac{108 \text{ g}}{1 \text{ mol Ag}} \right) =$$

$$\boxed{22.68 \text{ g Ag}}$$

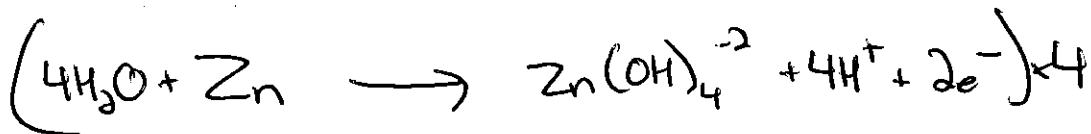
23. Zinc metal reacts with nitrate ion in basic solution. The unbalanced equation for the reaction is



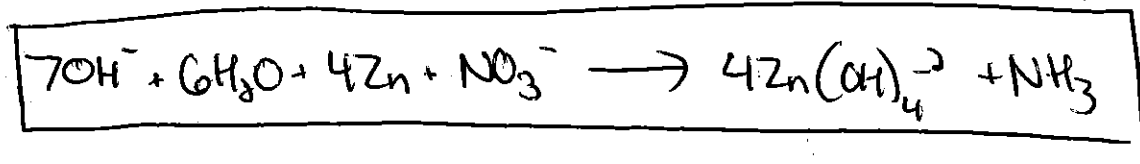
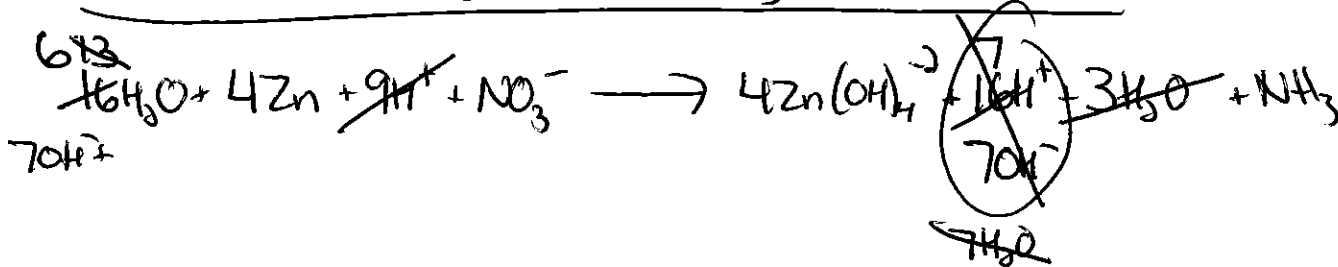
(a) Balance the equation.

(b) What volume of 0.250 M barium hydroxide is required to react completely with 2.50 g of zinc?

$\text{Ba}(\text{OH})_2$



LCM = 8



$$b) \quad 2.50 \text{ g Zn} \left(\frac{1 \text{ mol Zn}}{65.4 \text{ g Zn}} \right) \left(\frac{7 \text{ mol OH}^-}{4 \text{ mol Zn}} \right) \left(\frac{1 \text{ mol Ba}(\text{OH})_2}{2 \text{ mol OH}^-} \right) \left(\frac{1 \text{ L}}{250 \text{ mL Ba}(\text{OH})_2} \right) \left(\frac{1000 \text{ mL}}{1 \text{ L}} \right) =$$

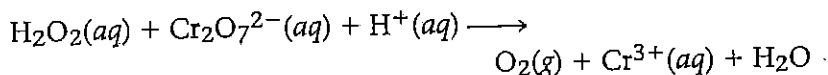
133.8 mL of 0.250 M $\text{Ba}(\text{OH})_2$

Chem-II/AP

Chapter 4 Section 4.6

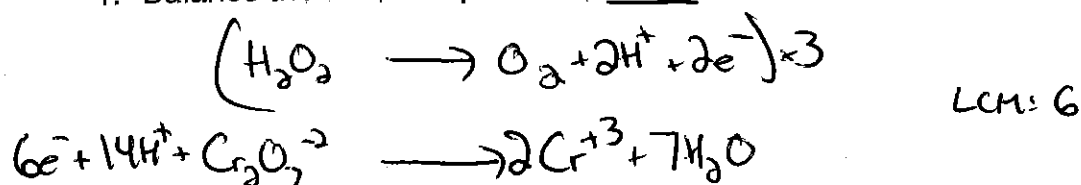
Solution Reactions in Chemical Analysis: Redox Reactions

24. Hair bleaching solutions contain hydrogen peroxide, H_2O_2 . The hydrogen peroxide content can be determined by reacting H_2O_2 with a potassium dichromate acidic solution. The unbalanced equation for the reaction is



A 15.0-g bleach solution needed 75.8 mL of 0.388 M $\text{K}_2\text{Cr}_2\text{O}_7$ to react completely with the H_2O_2 in the hair bleach. What is the mass % of H_2O_2 in the bleach?

1. Balance the overall equation in acidic solution.



2. Compute moles of $\text{Cr}_2\text{O}_7^{2-}(\text{aq})$ used in the titration.

$$75.8 \text{ mL } \text{K}_2\text{Cr}_2\text{O}_7 \left(\frac{1 \text{ L}}{1000 \text{ mL}} \right) \left(\frac{388 \text{ mol } \text{K}_2\text{Cr}_2\text{O}_7}{1 \text{ L}} \right) \left(\frac{1 \text{ mol } \text{Cr}_2\text{O}_7^{2-}}{1 \text{ mol } \text{K}_2\text{Cr}_2\text{O}_7} \right) = 0.0294 \text{ mol } \text{Cr}_2\text{O}_7^{2-}$$

3. From the balanced equation, compute the moles of $\text{H}_2\text{O}_2(\text{aq})$ titrated.

$$0.0294 \text{ mol } \text{Cr}_2\text{O}_7^{2-} \left(\frac{3 \text{ mol } \text{H}_2\text{O}_2}{1 \text{ mol } \text{Cr}_2\text{O}_7^{2-}} \right) = 0.0882 \text{ mol } \text{H}_2\text{O}_2$$

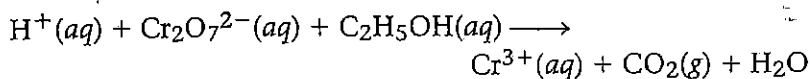
4. Compute the mass of $\text{H}_2\text{O}_2(\text{aq})$ titrated.

$$0.0882 \text{ mol } \text{H}_2\text{O}_2 \left(\frac{34.0 \text{ g}}{1 \text{ mol}} \right) = 2.999 \text{ g} = 3.00 \text{ g } \text{H}_2\text{O}_2$$

5. Compute the mass percent H_2O_2 in the sample.

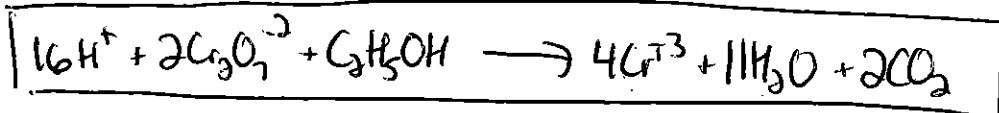
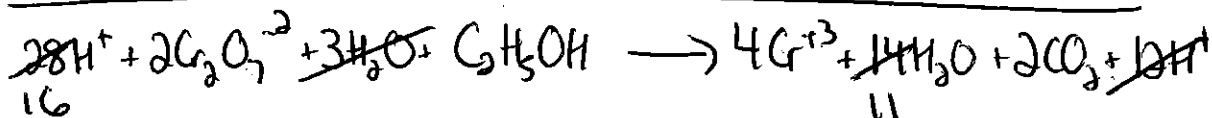
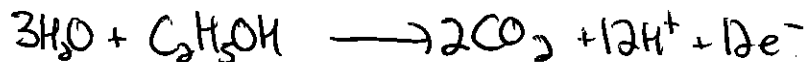
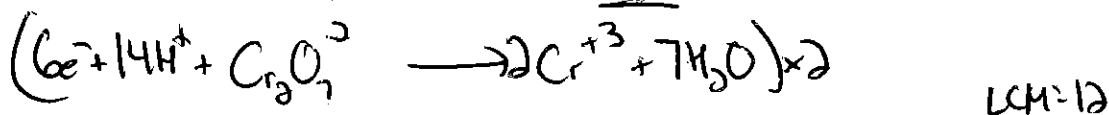
$$\% \text{H}_2\text{O}_2 = \frac{\text{mass } \text{H}_2\text{O}_2}{\text{mass bleach}} \times 100 \quad \frac{3.00}{15.0} \times 100 = \boxed{20.0\% \text{ H}_2\text{O}_2}$$

5. Laws passed in some states define a drunk driver as one who drives with a blood alcohol level of 0.10% by mass or higher. The level of alcohol can be determined by titrating blood plasma with potassium dichromate according to the unbalanced equation



Assuming that the only substance that reacts with dichromate in blood plasma is alcohol, is a person legally drunk if 45.02 mL of 0.05000 M potassium dichromate is required to titrate a 50.00 g sample of blood plasma?

1. Balance the overall equation in acidic solution.



2. Compute moles of $\text{Cr}_2\text{O}_7^{2-}(\text{aq})$ used in the titration.

$$45.02 \text{ mL } \text{K}_2\text{Cr}_2\text{O}_7 \left(\frac{1\text{L}}{1000\text{mL}} \right) \left(\frac{0.05000 \text{ mol}}{1\text{L}} \right) \left(\frac{1\text{ mol Cr}_2\text{O}_7^{2-}}{1\text{ mol K}_2\text{Cr}_2\text{O}_7} \right) = 0.002251 \text{ mol Cr}_2\text{O}_7^{2-}$$

3. From the balanced equation, compute the moles of $\text{C}_2\text{H}_5\text{OH}(\text{aq})$ titrated.

$$0.002251 \text{ mol Cr}_2\text{O}_7^{2-} \left(\frac{1\text{ mol C}_2\text{H}_5\text{OH}}{2\text{ mol Cr}_2\text{O}_7^{2-}} \right) = 0.0011255 \text{ mol C}_2\text{H}_5\text{OH}$$

4. Compute the mass of $\text{C}_2\text{H}_5\text{OH}(\text{aq})$ titrated.

$$0.0011255 \text{ mol C}_2\text{H}_5\text{OH} \left(\frac{46\text{g}}{1\text{mol}} \right) = 0.05177 \text{ g C}_2\text{H}_5\text{OH}$$

5. Compute the mass percent $\text{C}_2\text{H}_5\text{OH}$ in the sample. Compare to 0.100% ← Limit

$$\% \text{ alcohol} = \frac{\text{mass alcohol}}{\text{mass sample}} \times 100 = \frac{0.05177 \text{ g C}_2\text{H}_5\text{OH}}{50.0 \text{ g sample}} \times 100 = 0.1035\%$$

DRUNK!