5.7 Chemical Reactions and Aqueous Reactions (Exercises)

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These are homework exercises to accompany the Textmap created for Chemistry: A Molecular Approach by Nivaldo Tro. Complementary General Chemistry question banks can be found for other Textmaps and can be accessed here. In addition to these publicly available questions, access to private problems bank for use in exams and homework is available to faculty only on an individual basis; please contact Delmar Larsen for an account with access permission.

Additional Questions

1. The Kingston Steam Plant burns 14,000 tons of coal each day and generates 10^{10} kilowatts-hours of electricity each year (enough for 700,000 homes). Coal is primarily carbon which undergoes combustion in the following reaction: $C(s) + O_2(g) \rightarrow CO_2(g)$

   How many grams of oxygen is required for the combustion of 1 day's coal?

   a. How much carbon dioxide is produced each day?
2. CO_2 is removed from the atomsphere by trees and converted into cellulose. The basic reaction for this is: $6\ CO_2(g) + 5\ H_2O(l) \rightarrow C_6H_{10}O_5(s) + 6\ O_2(g)$
   a. How many grams of water are required to process the CO_2 from one day's electrical production at the Kingston Steam Plant?
   b. How much oxygen is produced by this process?
   c. How much cellulose is produced?
   d. If you assume that a tree weigh's 2 tons, how many trees are required to process the CO_2 produced in one day?
3. A typical automobile gets 30 miles per gallon of gas and drives 12,000 miles every year. Assuming that octane (C_8H_{18}, density 0.7025 g cm^{-3}) is a principal component of gasoline;
   a. How much oxygen is required for a car to run for 1 year?
   b. How much CO_2 is produced by the car in 1 year?
   c. How many trees are required to remove the CO_2 produced by the car in 1 year?
4. Modern instrumental techniques are capable of detecting lead in a milliliter sample at picomolar concentration.
   a. How many moles of lead are in the sample?
   b. What is the mass of lead in this sample?
   c. How many grams of sodium chloride would be required to precipitate all the lead in this sample as lead (II) chloride?
   d. What would the mass of the lead (II) chloride precipitate be?

1.The Kingston Steam Plant burns 14,000 tons of coal each day and generates 1010 kilowatts-hours of electricity each year (enough for 700,000 homes). Coal is primarily carbon which undergoes combustion in the following reaction: C(s) + O2 (g) -> CO2 (g) a.How many grams of oxygen is required for the combustion of 1 day's coal? b.How much carbon dioxide is produced each day? Coal is the limiting reageint in this reaction (unless the earth runs out of oxygen, but then we are all in really big trouble). So first calculate the number of moles of coal. Mass coal 14000. ton Mass = coal 1.4 104 . . ton 2000. lb 1. ton 453.6.gm lb Mass = coal 1.27 1010 gm MW C 12.011.gm.mole 1 Mole C Mass coal MW C Mole = C 1.057 109 mole From the balanced reaction; for every mole of carbon, one mole of oxygen is required, and one mole of CO2 is produced. Mass of O2 Mole O2 Mole C MW O2 2.15.9994.gm.mole 1 Mass O2 Mole . O2 MW O2 Mass = O2 3.384 1010 gm Mass of CO2 Mole CO2 Mole C MW CO2 . . (12.011) 2.15.9994 gm mole 1 Mass CO2 Mole . CO2 MW CO2 Mass = CO2 4.654 1010 gm S.E. Van Bramer Widener University 11/4/97 2.CO2 is removed from the atomsphere by trees and converted into cellulose. The basic reaction for this is: 6 CO2 (g) + 5 H2O (l) -> C6H10O5 (s) + 6 O2 (g) a.How many grams of water are required to process the CO2 from one day's electrical production at the Kingston Steam Plant? b.How much oxygen is produced by this process? c.How much cellulose is produced? d.If you assume that a tree weigh's 2 tons, how many trees are required to process the CO2 produced in one day? From the balanced chemical reaction, five moles of water are required for 6 moles of carbon dioxide: Mole H2O Mole . CO2 5 6 Mole = H2O 8.812 108 mole MW H2O . . ( ) 2.1.00794 15.9994 gm mole 1 Mass H2O Mole . H2O MW H2O Mass = H2O 1.587 1010 gm Density H2O 1. gm mL Volume H2O Mass H2O Density H2O Volume = H2O 1.587 1010 mL Volume = H2O 4.194 106 gal From the balanced chemical reaction, 6 moles of O2 are produced from 6 moles of carbon dioxide: Mole O2 Mole . CO2 6 6 Mole = O2 1.057 109 mole MW O2 . . ( ) 2.15.9994 gm mole 1 Mass O2 Mole . O2 MW O2 Mass = O2 3.384 1010 gm Notice that this is

identical to the mass of O2 used in the combustion reaction. All the oxygen is recovered by the tree. S.E. Van Bramer Widener University 11/4/97 From the balanced chemical reaction, 1 mole of cellulose is produced from 6 moles of carbon dioxide: Mole cellulose Mole . CO2 1 6 Mole = cellulose 1.762 108 mole MW cellulose . . ( ) 12.011.6 1.00794.10 15.9994.5 gm mole 1 Mass cellulose Mole . cellulose MW cellulose Mass = cellulose 2.858 1010 gm Assuming that a tree weighs 2 tons and is all cellulose: tree 2. ton tree = 1.814 106 gm Mass = cellulose 2.857 107 kg 1. tree 1.814.10 . 6 gm Mass = cellulose 15749 tree So from this "back of the envelope" calculation, about 16 thousand trees must be grown to absorb the carbon dioxide produced in one day by this power plant. 3.A typical automobile gets 30 miles per gallon of gas and drives 12,000 miles every year. Assuming that octane (C8H18, density 0.7025 g cm-1) is a principal component of gasoline; a.How much oxygen is required for a car to run for 1 year? b.How much CO2 is produced by the car in 1 year? c.How many trees are required to remove the CO2 produced by the car in 1 year? Let's start with a balanced reaction: 2 C8H18 + 25 O2 --> 16 CO2 + 18 H2O Next calculate the amout of octane used: mileage 30.mi.gal 1 distance 12000.mi volume gas distance mileage volume = gas 4 102 gal volume = gas 1.514 106 mL S.E. Van Bramer Widener University 11/4/97 density gas 0.7025.gm.cm 3 Mass gas density . gas volume gas Mass = gas 1.064 106 gm MW octane . . ( ) 12.011.8 1.00794.18 gm mole 1 Mole octane Mass gas MW octane Mole = octane 9.312 103 From the balanced chemical reaction, 25 moles of O2 are required for 2 moles of octane: Mole O2 Mole . octane 25 2 Mole = O2 1.164 105 mole MW O2 . . ( ) 2.15.9994 gm mole 1 Mass O2 Mole . O2 MW O2 Mass = O2 3.725 106 gm Mass = O2 4.106 ton From the balanced chemical reaction, 16 moles of CO2 are produced by 2 moles of octane: Mole CO2 Mole . octane 16 2 Mass CO2 Mole . CO2 MW CO2 Mass = CO2 3.278 106 gm Mass = CO2 3.614 ton From the balanced chemical reaction, 1 mole of cellulose is produced from 6 moles of carbon dioxide: Mole cellulose Mole . CO2 1 6 Mole = cellulose 1.242 104 mole Mass cellulose Mole . cellulose MW cellulose Mass = cellulose 2.013 106 gm Mass = cellulose 1.1 tree S.E. Van Bramer Widener University 11/4/97 4.Modern instrumental techniques are capable of detecting lead in a milliliter sample at picomolar concentration. a.How many moles of lead are in the sample? b.What is the mass of lead in this sample? c.How many grams of sodium chloride would be required to precipitate all the lead in this sample as lead (II) chloride? d.What would the mass of the lead (II) chloride precipitate be? Calculate the amount of lead in the sample from the concentration and the total volume Concentration Pb 10 . . 12 mole liter 1 Volume Pb 1.mL Volume = Pb 1 10 3 liter Mole Pb Concentration . Pb Volume Pb Mole = Pb 1 10 15 mole MW Pb 207.2.gm.mole 1 Mass Pb MW . Pb Mole Pb Mass = Pb 2.072 10 13 gm First write out the balanced equation: Pb2+ + 2 NaCl --> PbCl2 + 2 Na1+ (Note: the lead is an ion in aqueous solution) From the balanced reaction, 2 moles of NaCl are required for each mole of Pb2+ Mole NaCl Mole . Pb 2 1 Mole = NaCl 2 10 15 mole MW NaCl . . (22.989768 35.4527) gm mole 1 MW = NaCl 58.442 gm.mole 1 Mass NaCl MW . NaCl Mole NaCl Mass = NaCl 1.169 10 13 gm From the balanced reaction, 1 mole of PbCl2 is produced for each mole of Pb2+ Mole PbCl2 Mole . Pb 1 1 Mole = PbCl2 1 10 15 mole MW PbCl2 . . (107.2) 2.35.4527 gm mole 1 MW = PbCl2 1.781 102 gm.mole 1 Mass NaCl MW . NaCl Mole NaCl Mass = NaCl 1.169 10 13 gm

Q1

When the following solutions are mixed, does a precipitate form? Write out the total, total ionic, and net ionic equations.

1. a. silver nitrate and rubidium chloride
2. b. lead nitrate and potassium chloride
3. c. mercury (I) nitrate and hydrochloric acid
4. d. calcium chloride and sodium carbonate
5. e. magnesium nitrate and calcium chloride
6. f. potassium sulfate and barium chloride

Q2

Precipitation Reactions and Solubility.

1. a. Step 1: 0.8765 g of silver (I) nitrate is placed in a 250 mL volumetric flask diluted to the mark with deionized water. Determine the concentration of each ion in solution.
2. b. Step 2: 1.8793 g of potassium chloride is placed in a 250 mL volumetric flask diluted to the mark with deionized water. Determine the concentration of each ion in solution.
3. c. Step 3: 50.0 mL of the silver (I) nitrate solution and 50.0 mL of the potassium chloride solution are mixed together in an erlenmyer flask. Determine the mass of any precipitate formed and the concentration of each ion in solution.