**CHE1031 HW set 3: Composition of substances & solutions - KEY**

*Please solve these problems on green engineering graph paper.*

*Problems are assigned at each class meeting and are due at the next class.*

*Please number each problem, show all work for credit and box your answer.
Note that answers to quantitative problems are provided in blue.*

**3.1: Formula mass and the mole concept**

**1.** What is the total mass (amu) of carbon in each of the following molecules?

(a) CH4

(b) CHCl3

(c) C12H10O6

(d) CH3CH2CH2CH2CH3

(a) 12.01 amu

(b) 12.01 amu

(c) (12)(12.01 amu) = 144.12 amu

(d) (5)(12.01 amu) = 60.05 amu

**2.** Determine the molecular mass (MW) of the following compounds:



(a) 98.90 g/mol

(b) 26.04 g/mol

(c) 185.84 g/mol

(d) 98.04 g/mol

**3.** Which contains the greatest number of moles of oxygen atoms: 1 mol of ethanol (C2H5OH), 1 mol of formic acid (HCO2H), or 1 mol of water (H2O)? Explain why.

1 mole & 1 atom O/molecule

 1 mole & 2 atoms O/molecule 🡨

 1 mole & 1 atom O/molecule

**4.** Calculate the molar mass of each of the following compounds:

(a) hydrogen fluoride, HF

(b) ammonia, NH3

(c) nitric acid, H(NO3)

(d) silver sulfate, Ag2(SO4)

(e) boric acid, B(OH)3

(a) 20.00 g/mol

(b) 17.04 g/mol

(c) 62.99 g/mol

(d) 311.76 g/mol

(e) 61.81 g/mol

**5.** Determine the number of moles of compound and the number of moles of each type of atom in each of the following:

(a) 25.0 g of propylene, C3H6

(b) 3.06 × 10−3 g of the amino acid glycine, C2H5NO2

(a) 25.o g 1 mol = 0.594 mol C3H6 X 3 = 1.78 mol C

 42.09 g X 6 = 3.56 mol H

(b) 3.06 E-3 g 1 mol = 4.08 E-5 mol X 2 = 8.15 E-5 mol C

 75.06 g X 5 = 2.04 E-4 mol H

 X 1 = 4.08 E-5 mol N

 X 2 = 8.15 E-5 mol O

**6.** Determine the mass of each of the following:

(a) 0.0146 mol KOH

(b) 10.2 mol ethane, C2H6

(c) 1.6 E-3mol Na2(SO4)

(a) 0.0146 mol 56.10 g = 0.819 g

 1 mol

(b) 10.2 mol 30.08 g = 306 g

 1 mol

(c) 1.6 E-3 mol 142 g = 0.23 g

 1 mol

**7.** The approximate minimum daily dietary requirement of the amino acid leucine, C6H13NO2, is 1.1 g. What is this requirement in moles?

1.1 g 1 mol = 8.4 E-3 mol

 131.18 g

**8.** A 55-kg woman has 7.5 × 10−3 mol of hemoglobin (molar mass = 64,456 g/mol) in her blood. How many hemoglobin molecules is this? What is this quantity in grams?

7.5 E-3 mol 6.02 E23 molecules = 4.5 E 21 molecules

 1 mol

7.5 E-3 mol 64456 g = 483.4 g

 1 mol

**9.** The Cullinan diamond was the largest natural diamond ever found (January 25, 1905). It weighed 3104 carats (1 carat = 200 mg). How many carbon atoms were present in the stone?

 3104 carats 2oo mg 1 g 1 mol 6.02 E23 atoms C = 3.112 E25 atoms C

 1 carat 1 E3 mg 12.01 g 1 mol

**10.** A tube of toothpaste contains 0.76 g of sodium monofluorophosphate (Na2PO3F) in 100 mL.

(a) What mass of fluorine atoms in mg was present?

(b) How many fluorine atoms were present?

(a) 0.76 g 1 mol 1 mol F 19 g = 0.10 g F

 143.92 g 1 mol Na2PO3F 1 mol F

 (b) 0.76 g 1 mol 1 mol F 6.02 E23 atoms F = 3.2 E21 atoms F

 143.92 g 1 mol Na2PO3F 1 mol F

**3.2: Determining empirical and molecular formulas**

**11.** Calculate the following to four significant figures:

(a) the percent composition of ammonia, NH3

(b) the percent composition of photographic fixer solution (“hypo”), Na2S2O3

(a) MW = 17.04 g/mol N = 14.01 (100) = 82.2% H = 3.03 (100) = 17.8%

 17.04 17.04

(b) MW = 158.07 g/mol Na = 45.98 (100) = 29.1% S = 64.12 (100) = 40.6%

 158.07 158.07

 O = 47.97 (100) = 30.3%

 158.07

**12.** Determine the percent water in CuSO4∙5H2O to three significant figures.

 MW = 249.67 g/mol %H2O = 90.10 (100) = 36.1%

 249.67

**13.** Determine the empirical formulas for compounds with the following percent compositions:

(a) 43.6% phosphorus and 56.4% oxygen

(b) 28.7% K, 1.5% H, 22.8% P, and 47.0% O

(a) 43.6 g 1 mol = 1.41 mol P 56.4 g 1 mol = 3.53 mol O 3.53 mol O = 2.50 X 2 = 5

 30.97 g 15.99 g 1.41 mol P 1 X 2 = 1
 🡪 P2O5

(b) 28.7 g 1 mol = 0.734 mol K 1.5 g 1 mol = 1.49 mol H 22.8 g P 1 mol = 0.736 mol P

 39.10 g 1.01 g 30.97 g 47.0 g 1 mol = 2.94 mol O

 15.99 g

 Divide all by 0.734 K = 1 🡪 KH2PO4

 H = 2

 P = 1

 O = 4

**14.** A compound of carbon and hydrogen contains 92.3% C and has a molar mass of 78.1 g/mol. What is its molecular formula?

92.3 g 1 mol = 7.69 mol C (100 – 92.3 g) 1 mol = 7.62 mol H CH = 13.02 g/mol

 12.01 g 1.01 g
 78.1 g/mol = 6 🡪 C6H6

 13.02 g/mol

**3.3: Molarity**

**15.** Explain what changes and what stays the same when 1.00 L of a solution of NaCl is diluted to 1.80 L.
The amount of solute remains constant while the amount of solvent increases. And the concentration of solute drops.

**16.** Determine the molarity for each of the following solutions:

(a) 0.444 mol of CoCl2 in 0.654 L of solution

(b) 98.0 g of phosphoric acid, H3(PO4), in 1.00 L of solution

(c) 0.2074 g of calcium hydroxide, Ca(OH)2, in 40.00 mL of solution

(a) 0.444 mol = 0.679 M

 0.654 L

(b) 98.0 g 1 mol = 1.00 M

 98.00 g 1 L

(c) 0.2074 g 1 mol = 0.06999 M

 74.08 g 0.04000 L

**17.** Consider this question: What is the mass of the solute in 0.500 L of 0.30 M glucose, C6H12O6, used for intravenous injection?

(a) Outline the steps necessary to answer the question.

(b) Answer the question.

(a) Start with L and use M to convert to moles. Then use MW (g/mol) to convert moles to grams.

(b) 0.500 L 0.30 mol 180.12 g = 27 g

 1L 1 mol

**18.** Calculate the number of moles and the mass of the solute in each of these following solutions:

(a) 2.00 L of 18.5 M H2(SO4), concentrated sulfuric acid

(b) 100.0 mL of 3.8 × 10−5 M Na(CN), the minimum lethal concentration of sodium cyanide in blood serum

(a) 2.00 L 18.5 mol = 37.0 mol 98.00 g = 3.63 E3 g

 1 L 1 mol

(b) 100.0 mL 1 L 3.8 E-5 mol = 3.8 E-6 mol 49.01 g = 1.862 E-4 g

 1 E3 mL 1 L 1 mol

**19.** Consider this question: What is the molarity of HCl if 35.23 mL of a solution of HCl contain 0.3366 g of HCl?

(a) Outline the steps necessary to answer the question.

(b) Answer the question.

(a) Convert mass to moles using MW (g/mol). Then divide moles by volume (L) for M.

(b) 0.3366 g 1 mol 1 E3 mL = 0.2621 M

 36.46 g 35.23 mL 1 L

**20.** Calculate the molarity of each of the following solutions:

(a) 0.195 g of cholesterol, C27H46O, in 0.100 L of serum, the average concentration of cholesterol in human serum

(b) 4.25 g of NH3 in 0.500 L of solution, the concentration of NH3 in household ammonia

(a) 0.195 g 1 mol = 5.04 E-3 M

 386.72 g 0.100 L

(b) 4.25 g 1 mol = 0.499 M

 17.04 g 0.500 L

**21.** What volume of a 1.00-M Fe(NO3)3 solution can be diluted to prepare 1.00 L of a solution with a concentration of 0.250 M?

~~(1.00 M~~)(X L) = (0.250 M)(1.00 L) = 0.250 L

 1.00 M

**22.** What is the concentration of the NaCl solution that results when 0.150 L of a 0.556-M solution is allowed to evaporate until the volume is reduced to 0.105 L?

(0.150 L)(0.556 M) = ~~(0.105 L)(~~X M) = 0.794 M

 0.105 L

**23.** What is the molarity of the diluted solution when each of the following solutions is diluted to the given final volume?

(a) 1.00 L of a 0.250-M solution of Fe(NO3)3 is diluted to a final volume of 2.00 L

(b) 0.5000 L of a 0.1222-M solution of C3H7OH is diluted to a final volume of 1.250 L

(a) (1.00 L)(0.250 M) = ~~(2.00 L)(~~X M) = 0.125 M

 2.00 L

(b) (0.5000 L)(0.1222 M) = ~~(1.250 L)(~~X M) = 0.04888 M

 1.250 L

**3.4: Other units for solution concentrations**

*This section is optional. While there are no required problems, you’ll find optional problems in the Module 3 practice problem set.*