**CHE1031 Exam 2: Moles through stoichiometry & quantitative analysis KEY**

You’ll find a periodic table and table of conversion factors attached. You are allowed notes on one side of a 3x5-inch card and a calculator. Please show all work for partial credit and please ask if you have questions.

**3: Composition of substances & solutions**

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

**1.** For each compound:

(a) Write its molecular formula.

(b) Determine its molecular mass (or MW).



(a) C4H6 and Si2H2Cl4

(b) 54.10 g/mol and 200.00 g/mol

**2.** Compare 1 mole of H2, 1 mole of O2, and 1 mole of F2.

(a) Which has the largest number of molecules? Explain why.

(b) Which has the greatest mass? Explain why.

(a) One mole of anything has the same number of molecules: 6.02 E23 molecules per 1 mole.

(b) The mass of one mole is determined by molar mass. O2 has a molar mass of 31.98 g/mol while F2 has a MW of 38.00 g/mol, so the mass of a mole of F2 is greater.

**3.** Given 23 kg of calcium carbonate, Ca(CO3):

(a) Determine the number of moles of the compound.

(b) Determine the number of moles of each atom.

(a) 23 kg 1 E3 g 1 mol = 230 mol

 1 kg 100.06 g

(b) X 1 = 230 mol Ca, C and X 3 = 690 mol O

**4.** How many atoms of hydrogen are there in 12.0 g of sucrose, C12H22O11?

MW = 342.30 g/mol

12.0 g 1 mol 6.02 E23 molecules 22 atoms H = 4.64 E23 atoms H

 342.30 g 1 mole 1 molecule

**3.2: Determining empirical and molecular formulas**

**5.** Determine the percent composition of hydrazoic acid, HN3.

MW = 43.03 g/mol H = 1.01 (100) = 2.3% N = 42.03 (100) = 97.6%

 43.04 43.04

**6.** Determine the empirical formula for a compound with 15.8% carbon and 84.2% sulfur.

 15.8 g 1 mol = 1.32 mol C 84.2 g 1 mol = 2.63 mol 2.63 = 2 🡪 CS2

 12.01 g 32.06 g 1.32

**7.** A major textile dye manufacturer developed a new yellow dye. The dye has a percent composition of 75.95% C, 17.72% N, and 6.33% H by mass with a molar mass of about 240 g/mol. Determine the molecular formula of the dye.

75.95 g 1 mol = 6.324 mol C 17.72 g 1 mol = 1.265 mol N 6.33 mol N = 6.267 mol H

 12.01 g 14.01 g 1.01 g

Divide all by 1.265 mol C = 5

 N = 1 🡪 C5NH5 🡪 EW = 79.11

 H = 5

MW = 240 g/mol = 3 🡪 thus, MF = C15N3H15

EW 79.11 g/mol

**3.3: Molarity**

**8.** Determine the molarity of 20.54 g of Al(NO3)3 in 1575 mL of solution

20.54 g 1 mol = 6.126 E-2 M

 212.92 1.575 L

**9.** An Erlenmeyer flask contains 325 mL of 8.23 E-5 M KI, potassium iodide.

(a) Calculate the number of moles of KI in the flask.

(b) Calculate the mass of KI in the flask.

(a) 325 mL 1 L 8.23 E-5 mol = 2.67 E-5 mol

 1 E3 mL 1 L

(b) 2.67 E-5 mol 166.00 g = 4.43 E-3 g

 1 mol

**10.** If 0.1718 L of a 0.3556-M C3H7OH solution is diluted to a concentration of 0.1222 M, what is the volume of the resulting solution?

(0.1718 L)(0.3556 M) = (X L~~)(0.1222 M)~~ = 0.4999 L

 0.1222 M

**3.4: Other units for solution concentrations**

*Addressed as an extra credit problem.*

**4: Stoichiometry of chemical reactions**

**4.1: Writing and balancing chemical equations**

**11.** The mineral fluorite (calcium fluoride) occurs extensively in Illinois. Solid calcium fluoride can also be prepared by the reaction of aqueous solutions of calcium chloride and sodium fluoride, yielding aqueous sodium chloride as the other product. Write complete and net ionic equations for this reaction.

CaCl2(aq) + 2NaF(aq) 🡪 2NaCl(aq) + CaF2(s)

Ca+2 + ~~2Cl~~~~-1~~ ~~+ 2Na~~~~+1~~ + 2F-1 🡪 ~~2Na~~~~+1~~ ~~+ 2Cl~~~~-1~~ + CaF2(s)

**4.2: Classifying chemical reactions**

**12.** Identify the type(s) of reaction each equation represents.

(a) Ca(s) + Br2(l) ⟶ CaBr2(s)

(b) Ca(OH)2(aq) + 2HBr(aq) ⟶ CaBr2(aq) + 2H2O(l)

(c) C6H12(l) + 9O2(g) ⟶ 6CO2(g) + 6H2O(g)

(a) combination

(b) exchange & acid-base (neutralization)

(c) combustion

**13.** Which combination will produce a precipitate?

(a) NiBr2 + Ag(NO3) 🡪 🡸 AgBr is a solid

(b) NaI + KBr 🡪

(c) K2(SO4) + CrCl3 🡪

(d) K(OH) + Ba(NO3)2 🡪

(e) Li2(CO3) + CsI 🡪

**14.** Complete and balance this acid-base reaction: HCl gas reacts with solid Ca(OH)2(s).

2HCl(g) + Ca(OH)2(s) 🡪 2H2O(l) + CaCl2(aq)

**15.** Barium reacts with hydrobromic acid in a redox reaction: Ba(s) + HBr(aq) ⟶

(a) Complete and balance the reaction and

(b) Assign oxidation numbers to determine which reactant is oxidized and which is reduced.

(a) Ba(s) + 2HBr(aq) ⟶ BaBr2 + H2

(b) 0 +1/-1 +2/-1 0 Ba is oxidized; H is reduced

**16.** Balance this equation using the half-reaction method in acidic aqueous solution.

Zn(*s*) + NO3−1(*aq*) ⟶ Zn+2(*aq*) + N2(*g*)

(Zn(*s*) ⟶ Zn+2(*aq*) + **2e-** (in acid))x5
(2NO3−1(*aq*) + **12H+1 + 10e-** ⟶ N2(*g*) (in acid) + **6H2O)**

**4.3: Reaction stoichiometry**

**~~17.~~** ~~A chemist combusts 2.5 g of propane (C3H8) with excess oxygen. How many grams of water are produced?~~

 ~~C3H8 + 5O2 🡪 3CO2 + 4H2O~~

 ~~2.5 g 1 mol propane 4 mol water 18.02 g = 4.08 g water~~

 ~~44.11 g 1 mol propane 1 mol water~~

**4.4: Reaction yields**

**18.** Elemental aluminum is combined with diatomic chlorine gas to produce aluminum chloride.

(a) If 2.5 g of metal is mixed with 2.5 g of gas, how many grams of aluminum chloride are produced?

(b) If the actual yield of aluminum chloride is 2.0 g, what is the percent yield?

 (a) 2Al + 3Cl2 🡪 2AlCl3

 2.5 g Al 1 mol Al 2 mol AlCl3 133.33 g = 12.35 g AlCl3

 26.98 g 2 mol Al 1 mol AlCl3

 2.5 g Cl2 1 mol Cl2 2 mol AlCl3 133.33 g = 3.13 g AlCl3 🡨 limiting rc’t & theor. yield

 70.90 g 3 mol Cl2 1 mol AlCl3

(b) % yield = (2.0/3.13)(100) = 63.9%

**4.5: Quantitative chemical analysis**

**19.** What volume of a 0.00945-M solution of potassium hydroxide would be required to titrate 50.00 mL of a sample of acid rain with a H2SO4 concentration of 1.23 E-4 M.

H2(SO4)(aq) + 2K(OH)(aq) ⟶ K2(SO4)(aq) + 2H2O(l)
50.00 mL X mL

1.23 E-4 M 0.00945 M

0.05000 L 1.23 E-4 mol 2 mol K(OH) 1 L = 0.001302 L = 1.302 mL

 1 L 1 mol H2(SO4) 0.00945 mol

**20.** Benzene is a liquid compound composed of carbon and hydrogen. A sample of benzene is burned in excess oxygen and produces 1156 g of carbon dioxide and 236.6 g of water. The MW of benzene is 78.11 g/mol.

(a) What is the empirical formula of benzene?

(b) What is the molecular formula of benzene?

CxHy + O2 🡪 xCO2 + y/2H2O

1156 g CO2 1 mol CO2 1 mol C = 26.28 mol C mol ratio = 26.28 mol C = 1:1 🡪 CH

 43.99 g 1 mol CO2 26.27 mol H

236.6 g H2O 1 mol H2O 2 mol H = 26.27 mol H EW = 13.02 g/mol

 18.01 g 1 mol H2O

MW = 78.11 g/mol = 5.99 🡪 6 So, benzene is C6H6

EW 13.02 g/mol

**Extra credit**

**A.** The hardness of water (hardness count) is usually expressed in parts per million (by mass) of Ca(CO3), which is equivalent to milligrams of Ca(CO3) per liter of water. What is the molar concentration of Ca+2 ions in a water sample with a hardness count of 175 mg Ca(CO3)/L?

175 mg 1 g 1 mol = 1.75 E-3 M

 1 L 1 E3 mg 100.06 g

**B.** Sodium bicarbonate (baking soda), Na(HCO3), can be purified by dissolving it in hot water (60 °C), filtering to remove insoluble impurities, cooling to 0 °C to precipitate solid Na(HCO3), and then filtering to remove the solid, leaving soluble impurities in solution. Any Na(HCO3) that remains in solution is not recovered. The solubility of Na(HCO3) in hot water of 60 °C is 164 g/L. Its solubility in cold water of 0 °C is 69 g/L. What is the percent yield of Na(HCO3) when it is purified by this method?
% yield = 69 g/L = 42.1%

 164 g/L