Name _____ Period _____

LTHS: Chemistry

Unit 6 Review - The Mole

1. What is a mole? What are different ways it can be represented?

1 mole is the # of particles that have the same mass in grams as the atomic mass in amu

1 mole is avogadro's #

1 mole is 6.022×10^{23} particles

LT1: I can calculate the molar mass of a compound based on the formula and molar mass of elements within that compound

2. Explain the difference between atomic mass and molar mass (use units).

atomic mass is the mass of 1 atom (amu)

molar mass is the mass of 1 mol (6.022×10^{23} atoms) (grams)

the # is the same, but the unit changes

3. Determine the **molar mass** of each of the following.
   a. Nitric acid (HNO_3)

$1.01 + 14.01 + 3(16.00) = 63.02\ g/mol$

   b. Ammonium nitrate (NH_4HNO_3)

$2(14.01) + 5(1.01) + 3(16.00) = 81.07\ g/mol$

   c. Saccharin ($C_7H_5NO_3S$)

$7(12.01) + 5(1.01) + 14.01 + 3(16.00) + 32.07 = 183.20\ g/mol$

LT2: I can convert between units using Avogadro's number, molar mass and molar volume.

4. Perform the following particle conversions.
   a. 1.51×10^{15} atoms Si to moles Si

$$1.51 \times 10^{15}\ \text{atoms Si} \times \frac{1\ \text{mol Si}}{6.022 \times 10^{23}\ \text{atoms}} = 2.51 \times 10^{-9}\ \text{mol Si}$$

   b. 4.25×10^{-2} mol H_2SO_4 to molecules H_2SO_4

$$4.25 \times 10^{-2}\ \text{mol } H_2SO_4 \times \frac{6.022 \times 10^{23}\ \text{molecules } H_2SO_4}{1\ \text{mol}} = 2.56 \times 10^{22}\ \text{molecules } H_2SO_4$$

   c. 7.952 mol NaCl to formula units NaCl

$$7.952\ \text{mol NaCl} \times \frac{6.022 \times 10^{23}\ \text{f.units NaCl}}{1\ \text{mol}} = 4.789 \times 10^{24}\ \text{f.units}$$

   d. 5.90 mol Ca to atoms Ca

$$5.90\ \text{mol Ca} \times \frac{6.022 \times 10^{23}\ \text{atoms Ca}}{1\ \text{mol Ca}} = 3.55 \times 10^{24}\ \text{atoms Ca}$$

5. Perform the following mass conversions.
   a. 3.50 mole Li_2O to g Li_2O

$$3.50\,mol\,Li_2O \times \frac{29.88\,g\,Li_2O}{1\,mol\,Li_2O} = 105\,g\,Li_2O$$

   b. 7.65 g CO_2 to mole CO_2

$$7.65\,g\,CO_2 \times \frac{1\,mol\,CO_2}{44.01\,g} = .174\,mol\,CO_2$$

   c. 5.62 g Kr to mol Kr

$$5.62\,g\,Kr \times \frac{1\,mol\,Kr}{83.80\,g} = .0671\,mol\,Kr$$

   d. 0.0550 mol As to g As

$$.0550\,mol\,As \times \frac{74.92\,g\,As}{1\,mol\,As} = 4.12\,mol\,As$$

6. Perform the following volume conversions
   a. 84.6 L of CO_2 at STP to mole CO_2

$$84.6\,L\,CO_2 \times \frac{1\,mol\,CO_2}{22.4\,L} = 3.78\,mol\,CO_2$$

   b. 2.53 mole of CH_3 to L CH_3 at STP

$$2.53\,mol\,CH_3 \times \frac{22.4\,L}{1\,mol\,CH_3} = 56.7\,L$$

7. Convert the following mixed conversions
   a. 4.22 x 10^{15} atoms U to grams U

$$4.22\times10^{15}\,atoms\,U \times \frac{1\,mol}{6.022\times10^{23}\,atoms} \times \frac{238.03\,g\,U}{1\,mol\,U} = 1.67\times10^{-6}\,g\,U$$

   b. 8.65 x 10^{25} molecules H_2O vapor at STP to L H_2O vapor

$$8.65\times10^{25}\,molecules\,H_2O \times \frac{1\,mol}{6.022\times10^{23}\,molecules} \times \frac{22.4\,L}{1\,mol} = 3220\,L\,H_2O$$

   c. 84.57 g Fe_2O_3 to molecules Fe_2O_3

$$84.57\,g\,Fe_2O_3 \times \frac{1\,mol\,Fe_2O_3}{159.7\,g\,Fe_2O_3} \times \frac{6.022\times10^{23}\,molecules}{1\,mol} = 3.189\times10^{23}\,molecules\,Fe_2O_3$$

   d. 14.44 g CH_4 to L CH_4 at STP

$$14.44\,g\,CH_4 \times \frac{1\,mol\,CH_4}{16.05\,g} \times \frac{22.4\,L}{1\,mol} = 20.15\,L\,CH_4$$

LT3: I can calculate the percent composition of a compound based on the formula and/or mass of individual elements

8. Express the percent composition of each element in the following:
   a. Magnetite (Fe_3O_4) $3(55.85) + 4(16.00) =$
   $167.55 + 64.00 = 231.55$

$\%\,Fe = \frac{167.55}{231.55} \times 100 = 72.36\%$ $\%\,O = \frac{64.06}{231.55} \times 100 = 27.64\%$

   b. Aluminum sulfate ($Al_2(SO_4)_3$)
   $2(26.98) + 3(32.07) + 12(16.00) =$
   $53.96 + 96.21 + 192 = 342.17$

$\%\,Al = \frac{53.96}{342.17} \times 100 = 15.77\%$ $\%\,S = \frac{96.21}{342.17} \times 100 = 28.12\%$ $\%\,O = \frac{192.06}{342.17} = 56.11\%$

9. Which of the following iron compounds contain the greatest percentage of iron: pyrite (FeS_2), hematite (Fe_2O_3), or siderite ($FeCO_3$)?

$FeS = 55.85 + 2(32.07) = 119.99$ $\%\,Fe = \frac{55.85}{119.99} \times 100 = 46.55\%$

$Fe_2O_3 = 2(55.85) + 3(16.00) = 159.7$ $\%\,Fe = \frac{111.7}{159.7} \times 100 = 69.94\%$ ← greatest %. Fe

$FeCO_3 = 55.85 + 12.01 + 3(16.00) = 115.86$ $\%\,Fe = \frac{55.85}{115.86} \times 100 = 48.21\%$

LT4: I can find empirical formula based on the relative ratio of moles in a compound

10. A compound was analyzed and found to contain 13.5 g Ca, 10.8 g O, and 0.675g H. What is the empirical formula of the compound?

$13.5\,g\,Ca \times \frac{1\,mol}{40.08\,g} = \frac{.337\,mol}{.337} = 1$

$10.8\,g\,O \times \frac{1\,mol}{16.00\,g} = \frac{.675\,mol}{.337} = 2$

$.675\,g\,H \times \frac{1\,mol}{1.01\,g} = \frac{.668\,mol}{.337} = 2$

CaO_2H_2

11. Ascorbic acid is another name for Vitamin C. It is composed of 40.92% carbon, 4.58% hydrogen, and 54.50% oxygen, by mass. Determine the empirical formula for ascorbic acid.

$40.92\%\,C \rightarrow 40.92\,g\,C \times \frac{1\,mol}{12.01\,g} = \frac{3.41\,mol\,C}{3.41} = 1 \times 3$

$4.58\%\,H \rightarrow 4.58\,g\,H \times \frac{1\,mol}{1.01\,g} = \frac{4.53\,mol\,H}{3.41} = 1.33 \times 3$

$54.50\%\,O \rightarrow 54.50\,g\,O \times \frac{1\,mol}{16.00\,g} = \frac{3.41\,mol\,O}{3.41} = 1 \times 3$

$C_3H_4O_3$

LT5: I can find molecular formula based on empirical formula and molecular mass

12. NutraSweet is 57.14% C, 6.16% H, 9.52% N, and 27.18% O. Calculate the empirical formula of NutraSweet and find the molecular formula. (The molar mass of NutraSweet is 294.30 g/mol)

57.14%C → $57.14\text{g C} \times \frac{1\text{mol}}{12.01\text{g}} = \frac{4.76\text{mol}}{.680} = 7 \times 2$

6.16%H → $6.16\text{g H} \times \frac{1\text{mol H}}{1.01\text{g H}} = \frac{6.10\text{mol}}{.680} = 9 \times 2$

9.52%N → $9.52\text{g N} \times \frac{1\text{mol}}{14.01\text{g}} = \frac{.680\text{mol}}{.680} = 1 \times 2$

27.18%O → $27.18\text{g O} \times \frac{1\text{mol}}{16.00\text{g}} = \frac{1.699\text{mol}}{.680} = 2.5 \times 2$

$C_{14}H_{18}N_2O_5$

$14(12.01) + 18(1.01) + 2(14.01) + 5(16.00) = 294.34$

$\frac{294.30}{294.34} = 1$

$C_{14}H_{18}N_2O_5$

13. A compound contains 18.8% sodium, 29.0% chlorine, and 52.2% oxygen, by mass. If the molar mass of the compound is 122.44 g/mol, determine the empirical and molecular formulas.

18.8%Na → $18.8\text{g Na} \times \frac{1\text{mol}}{22.99\text{g}} = \frac{.8177\text{mol Na}}{.818} = 1$

29.0%Cl → $29.0\text{g Cl} \times \frac{1\text{mol}}{35.45\text{g}} = \frac{.818\text{mol Cl}}{.818} = 1$

52.2%O → $52.2\text{g O} \times \frac{1\text{mol}}{16.00\text{g}} = \frac{3.26\text{mol O}}{.818} = 4$

$NaClO_4$

$22.99 + 35.45 + 4(16.00) = 122.44$

$\frac{122.44}{122.44} = 1$

$NaClO_4$

14. A 4.99 gram sample of a compound contains 1.52 grams of nitrogen atoms and 3.47 grams of oxygen atoms. The molar mass of the compound is 92.04 g. Determine the empirical and molecular formulas.

$1.52\text{g N} \times \frac{1\text{mol}}{14.01\text{g}} = \frac{.108\text{mol}}{.108} = 1$

$3.47\text{g O} \times \frac{1\text{mol}}{16.00\text{g}} = \frac{.2169\text{mol}}{.108} = 2$

NO_2

$14.01 + 2(16.00) = 46.01$

$\frac{92.04}{46.01} = 2$

N_2O_4