CHEM 103
R&R 2
31 May 2024
Adapted from a 25 May 2016 document

1. Label each substance as pure (P) or as a mixture (M):

    a. H_2O _P_

    b. Orange juice (with pulp) _M_

    c. Blood _M_ ← plasma AND red blood cell AND others.

    d. Iron _P_   Is not homogeneous.

    e. Sucrose _P_

2. Label each substance as heterogeneous (Het) or homogeneous (Hom):

    a. Air _Hom_

    b. Sand on the beach _Het_

    c. A cup of black coffee _Hom_

    d. Rainwater _Hom_

    e. Maple syrup _Hom_

3. Label each property as extensive (E) or intensive (I):

    a. Volume _E_

    b. Density _I_

    c. Mass _E_

    d. Melting point _I_

    e. Boiling point _I_   a bit tricky, but remember that

    f. Solubility _I_ ← solubility is the quotient of two extensive properties.

4. Does the following description of a compound or element refer to its physical properties (phys) or chemical properties (chem)?

    a. The atomic weight of carbon is 12 amu _phys_

    b. Magnesium burns in air to produce a white solid _chem_

    c. The melting point of gold is 1062 °C _phys_

    d. The density of uranium is 18.70 $g \cdot cm^{-3}$ _phys_

    e. Zinc reacts with hydrochloric acid to produce hydrogen gas _chem_

5. Label each as kinetic (K) or potential (P) energy:

    a. Wheel spinning _K_

    b. Skier at the top of a mountain _P_

    c. Fuel before it is burned _P_

    d. Current in a wire _K_

    e. Vibrations of water molecules in an ice cube _K_

6. For each of the following elements, give both the name and the chemical formula of its ion. (Feel free to use the periodic table.)

<div align="center">Ex: Sodium: Na⁺, sodium cation</div>

    a. Calcium: Ca^{2+}, calcium cation

    b. Silver: Ag^{+}, silver cation

    c. Sulfur: S^{2-}, sulfur anion

    d. Copper (two answers!): Cu^{+}, copper (I) cation; Cu^{2+}, copper (II) cation

    e. Iodine: I^{-}, iodine anion

    f. Hydrogen (two answers!): H^{+}, hydrogen cation (AKA proton!); H^{-}, hydride anion

7. The element copper has two stable isotopes. Isotope A has an atomic mass of 62.9296 u, while Isotope B has an atomic mass of 64.9278 u. According to the periodic table, copper has an atomic mass of 63.5463. Assuming that copper exists only as isotopes A and B, determine the percentage occurrence of each isotope.

Let   x = proportion of isotope A
       y = proportion of isotope B.

$$x + y = 1 \; ; \; (62.9296 \, u)x + (64.9278 \, u)y = 63.5463 \, u$$

$x = 1-y$

$$62.9296(1-y) + 64.9278y = 63.5463$$

$$(-62.9296 + 64.9278)y = 63.5463 - 62.9296$$

$$0.6167 \, y = 1.9982 \Rightarrow y = 0.3086$$
$$x = 0.6914$$

69.14% A, 30.86% B

8. Theobromine, $C_7H_8N_4O_2$, is found in chocolate and has been shown to have properties that stimulate the heart, dilate blood vessels, and increase fluid loss in the urine.

a. What is the molar mass of theobromine?

$$7\left(12.01\,\frac{g}{mol}\right) + 8\left(1.008\,\frac{g}{mol}\right) + 4\left(14.01\,\frac{g}{mol}\right) + 2\left(15.999\,\frac{g}{mol}\right)$$

$$= 180.172\,\frac{g}{mol} \cdot \text{ Because } C, N \text{ only known to hundredths}$$
place, express as $\boxed{180.17\,\frac{g}{mol}}$

b. What is the percent composition by moles of each of the elements in theobromine?

$$C: \frac{7}{7+8+4+2} = \frac{7}{21} = 33\% \qquad H: \frac{8}{21} = 38\%$$

$$N: \frac{4}{21} = 19\% \qquad O: \frac{2}{21} = 10.\%$$

c. What is the percent composition by mass of each of the elements in theobromine?

$$C: \frac{7(12.01\ g/mol)}{180.17\ g/mol} = 46.66\% \qquad H: \frac{8(1.008\ g/mol)}{180.17\ g/mol} = 4.476\%$$

$$N: \frac{4(14.01\ g/mol)}{180.17\ g/mol} = 31.10\% \qquad O: \frac{2(16.00\ g/mol)}{180.17\ g/mol} = 17.76\%$$

9. I poured 1.50 mL of 100% isopropyl alcohol, $CH_3CHOHCH_3$ (density 0.786 g/mL at room temperature), on a paper cut to clean it. How many carbon atoms did I just pour on my finger?

molar mass $= 3(12.01\ g/mol) + 8(1.008\ g/mol) + 15.999\ g/mol = 60.09\,\frac{g}{mol}$

$$1.50\,mL \cdot \frac{0.786g\ iPrOH}{mL} \cdot \frac{mol\ iPrOH}{60.09\ g\ iPrOH} \cdot \frac{3\ mol\ C}{mol\ iPrOH} \cdot \frac{6.022\times10^{23}\ atoms\ C}{mol\ C}$$

$$= 3.54 \times 10^{22}\ atoms\ C$$

10. Gypsum, $CaSO_4 \cdot 2\,H_2O$, is a common material used to make drywall. A *dihydrate* of calcium sulfate, there are two molecules of water for every molecule of calcium sulfate; moreover, these water molecules are incorporated into the crystal structure.

   a. What is the molar mass of gypsum?

$$40.08 \text{ g/mol} + 32.07 \text{ g/mol} + 4(15.999 \text{ g/mol}) + 4(1.008 \text{ g/mol}) + 2(15.999 \text{ g/mol})$$

$$= 172.176 \text{ g/mol} \implies \boxed{172.18 \frac{g}{mol}}$$

   b. What is the percent composition by moles of each element in gypsum?

$$Ca: \frac{1}{1+1+4+2(2+1)} = \frac{1}{12} = 8.3\% \qquad S: \frac{1}{12} = 8.3\%$$

$$O: \frac{4+2}{12} = 50.0\% \qquad\qquad H: \frac{4}{12} = 33.3\%$$

   c. Suppose I heat 175 g of gypsum to obtain anhydrous calcium sulfate. How much mass is lost as water vapor?

$$\text{I have} \quad 175g \cdot \frac{\text{mol gypsum}}{172.18 \text{ g}} = 1.016 \text{ mol gypsum.}$$

$$\text{Mass water lost} = 1.016 \text{ mol gypsum} \cdot \frac{2 \text{ mol } H_2O}{\text{mol gypsum}} \cdot \frac{18.015 g\ H_2O}{\text{mol } H_2O}$$

$$= 36.6 \text{ g } H_2O$$