

## Chapter 1: Stoichiometry

1. The atomic mass of C is 12.011 u. How many moles of C are there in a 3.50 g sample of carbon?

- \* a. 0.291 moles
- b. 0.374 moles
- c. 1.00 moles
- d. 3.43 moles
- e. 3.50 moles

$$n = \frac{m}{MM} = \frac{3.50}{12} = 0.291$$

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2. The formula mass of  $\text{Ni}(\text{H}_2\text{O})_6\text{Cl}_2$  is

- a. 157.69 u
- b. 193.00 u
- c. 227.61 u
- \* d. 237.69 u
- e. 296.83 u

$$1\text{Ni}=58.7, 12\text{H}=12, 6\text{O}=6 \times 16=96, 2\text{Cl}=2 \times 35.5=71 \quad MM = 58.7 + 12 + 96 + 71 = 237.69 \text{ u}$$

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3. If the atomic mass of gold is 196.9665 u, how many grams of gold are in 0.150 mol Au?

- a.  $7.62 \times 10^{-4}$  g
- \* b. 29.5 g
- c. 29.54498 g
- d.  $7.61551 \times 10^{-4}$  g
- e. 0.903 g

$$m = n \times MM = 0.150 \times 196.9665 = 29.5 \text{ g}$$

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4. How many molecules of carbon dioxide ( $\text{CO}_2$ ) are in 154.0 grams of carbon dioxide?

- a. 3.499
- \* b.  $2.107 \times 10^{24}$
- c.  $4.214 \times 10^{24}$
- d.  $9.274 \times 10^{25}$
- e.  $4.081 \times 10^{27}$

$$n = \frac{m}{MM} = \frac{154}{44} \qquad n \times N_A = 154 \times 6.02 \times 10^{23} / 44 = 2.107 \times 10^{24}$$

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5. A sample of  $\text{Ca}_3(\text{PO}_4)_2$  contains 3.51 moles of calcium ions. How many moles of  $\text{Ca}_3(\text{PO}_4)_2$  are in that sample?

- a. 3.55 moles
- b. 0.491 moles
- c. 10.5 moles
- \* d. 1.17 moles

e.  $3.51 \times 10^{21}$  moles

1 mol  $\text{Ca}_3(\text{PO}_4)_2$  contains 3 mol Ca  
? mol 3.51 mol Ca  
 $N = 3.51 \times 1 / 3 = 1.17 \text{ mol}$

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6. What is the percent, by mass, of chromium in  $\text{K}_2\text{CrO}_4$ ? Use a periodic table to find the atomic masses.

- \* a. 26.776 %  
b. 31.763 %  
c. 40.268 %  
d. 42.241 %  
e. 51.996 %

$\% \text{Cr} = (n \times \text{MM}_{\text{Cr}} / \text{MM}_{\text{K}_2\text{CrO}_4}) \times 100 = [(1 \times 52 / (2 \times 39 + 1 \times 52 + 4 \times 16)) \times 100] = 26.773\%$

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7. A sample of  $\text{Ni}(\text{CO})_4$ , a toxic transition-metal complex, has  $5.23 \times 10^{24}$  atoms of carbon. How many atoms of Ni does it contain?

- a.  $6.02 \times 10^{23}$  atoms  
b.  $1.50 \times 10^{23}$  atoms  
c. 1/4 atom  
d.  $20.9 \times 10^{23}$  atoms  
\* e.  $1.31 \times 10^{24}$  atoms

1 mol  $\text{Ni}(\text{CO})_4$  contain 4 mol C and 1 mol Ni  
 $4 \times 6.02 \times 10^{23}$  atoms  $1 \times 6.02 \times 10^{23}$  atoms  
 $5.23 \times 10^{24}$  ??  
 $? = 5.23 \times 10^{24} / 4 = 1.31 \times 10^{24}$  atoms

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8. A sample of sulfolane,  $\text{C}_4\text{H}_8\text{O}_2\text{S}$ , contains  $5.00 \times 10^{24}$  atoms. How many moles of sulfolane are in the sample?

- a. 0.120 moles  
\* b. 0.554 moles  
c. 1.81 moles  
d. 8.30 moles  
e.  $3.33 \times 10^{23}$  moles

1 mol  $\text{C}_4\text{H}_8\text{O}_2\text{S}$  contains  $(4+8+2+1)$  moles of atoms = 15 moles =  $15 \times 6.02 \times 10^{23}$  atoms  
?? mol  $5.00 \times 10^{24}$  atoms

$?? = 5.00 \times 10^{24} / (15 \times 6.02 \times 10^{23}) = 0.554 \text{ mol}$

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9. A sample of  $\text{C}_7\text{H}_5\text{N}_3\text{O}_4$  has a mass of 7.81 g. What is the mass of oxygen in this sample?

- a. 31.2 g  
\* b. 2.56 g

- c.  $3.20 \times 10^{23}$  g
- d. 64.0 g
- e. 1.75 g

$$1 \text{ mol } C_7H_5N_3O_4 = (7 \times 12 + 5 \times 1 + 3 \times 14 + 4 \times 16) = 195 \text{ g} \quad \text{contains 4 mol O} = 4 \times 16 \text{ g O}$$

$$7.81 \text{ g} \qquad \qquad \qquad ?? \text{ g}$$

$$?? = 7.81 \times 4 \times 16 / 195 = 2.56 \text{ g}$$

10. Which one of the following is definitely **not an** empirical formula?

- a.  $C_{12}H_{16}O_3$
- b.  $C_{12}H_{22}O_{11}$
- c.  $C_3H_8O_2$
- d.  $C_4H_{12}N_2O$
- \* e.  $C_6H_{12}O_4$

**Because can be divided by whole number (by 2)  $C_3H_6O_2$**

11. A compound has an empirical formula of  $CH_2Cl$ . An independent analysis gave a value of 99.0 for its molar mass. What is the molecular formula of the compound?

- a.  $CH_2Cl$
- \* b.  $C_2H_4Cl_2$
- c.  $C_2H_2Cl_4$
- d.  $C_3H_6Cl_3$
- e.  $C_3H_3Cl_6$

$$R.F = MM_{\text{compound}} / MM_{\text{empirical formula}} = 99 / (12 \times 1 + 2 \times 1 + 1 \times 35.5) = 2$$

$$(CH_2Cl)_2 = C_2H_4Cl_2$$

12. Magnetite is a binary compound containing only iron and oxygen. The percent, by weight, of iron is 72.36 %. What is the empirical formula of magnetite?

- a.  $FeO$
- b.  $FeO_2$
- \* c.  $Fe_3O_4$
- d.  $Fe_2O_3$
- e.  $Fe_2O_5$

$$100 - 72.36 = 27.64\% \text{ O}$$

<b>Fe</b>	<b>O</b>
72.360g	27.64g
72.36/55.8	27.64/16

13. Zinc metal reacts with aqueous hydrochloric acid to give an aqueous solution of zinc chloride and hydrogen gas. Select the correct balanced chemical equation for this reaction.

- a.  $Zn(s) + HCl(aq) \rightarrow 3ZnCl(aq) + H_2(g)$
- b.  $Zn(s) + HCl(g) \rightarrow ZnCl(aq) + H(g)$

- \* c.  $\text{Zn(s)} + 2\text{HCl(aq)} \rightarrow \text{ZnCl}_2\text{(aq)} + \text{H}_2\text{(g)}$   
 d.  $2\text{Zn(s)} + 4\text{HCl(aq)} \rightarrow 2\text{ZnCl}_2\text{(aq)} + \text{H}_2\text{(g)}$   
 e.  $2\text{Zn(s)} + \text{HCl(aq)} \rightarrow 2\text{ZnCl}_2\text{(aq)} + \text{H}_2\text{(g)}$

14. Given:  $3\text{H}_2\text{(g)} + \text{N}_2\text{(g)} \rightarrow 2\text{NH}_3\text{(g)}$

If the reaction starts with 0.500 mol of  $\text{H}_2$ , how many atoms of hydrogen in the compound  $\text{NH}_3$  would you expect to make?

- a.  $3.01 \times 10^{23}$  atoms  
 \* b.  $6.02 \times 10^{23}$  atoms  
 c.  $12.04 \times 10^{23}$  atoms  
 d. 1 atom  
 e. 6 atoms

**3 mol  $\text{H}_2$  gives 2 mol  $\text{NH}_3$**

**0.5 mol ??**

**$n = 0.5 \times 2 / 3 = 0.333 \text{ mol } \text{NH}_3$**

**1 mol  $\text{NH}_3$  contains 3 mol H**

**0.333 mol ??**

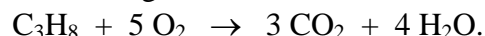
**$n = 0.333 \times 3 = 1 \text{ mol}$**

**$N = n \times N_A = 1 \times 6.02 \times 10^{23} = 6.02 \times 10^{23} \text{ atoms of H}$**

15. In a chemical reaction,  $3 \text{C}_2\text{H}_6\text{O} + 1 \text{PCl}_3 \rightarrow 3 \text{C}_2\text{H}_5\text{Cl} + 1 \text{H}_3\text{PO}_3$ , when the equation is balanced the sum of the coefficients of the reactants and products should be

- a. 4  
 b. 5  
 c. 6  
 d. 7  
 \* e. 8

16. You are given the balanced chemical equation:



If 0.3818 moles of  $\text{C}_3\text{H}_8$  and 1.718 moles of  $\text{O}_2$  are allowed to react, and this is the only reaction which occurs, theoretically how many moles of water should be produced?

- a. 1.336 moles  
 \* b. 1.374 moles  
 c. 1.527 moles  
 d. 1.718 moles  
 e. 3.426 moles

**$\text{C}_3\text{H}_8$  + 5  $\text{O}_2$**   
**1 mol 5 mol**  
**0.3818 mol 1.718 moles**  
 **$0.3818/1$   $1.718/5$**   
**0.3818 > 0.3436**

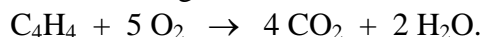
**smaller no is L.R  $\text{O}_2$  is limiting reactant**



$$?? = 1.718 \times 4 / 5 = 1.3744 \text{ mol}$$

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17. You are given the balanced chemical equation:



If 0.3618 moles of  $\text{C}_4\text{H}_4$  are allowed to react with 1.818 moles of  $\text{O}_2$ , and this is the only reaction which occurs, what is the maximum mass of water that could be produced?

- a. 11.02 g
- \* b. 13.04 g
- c. 13.20 g
- d. 19.64 g
- e. 65.50 g



$$?? = 0.3618 \times 2 \times 18 / 1 = 13.05 \text{ g H}_2\text{O}$$

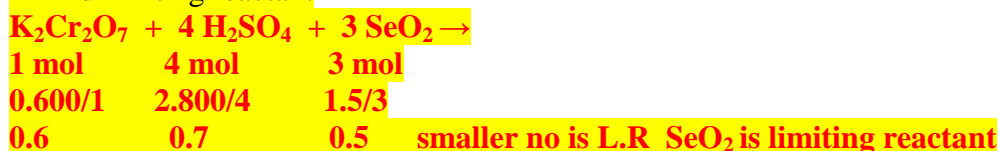
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18. The left side of a balanced chemical equation is:  $\text{K}_2\text{Cr}_2\text{O}_7 + 4 \text{ H}_2\text{SO}_4 + 3 \text{ SeO}_2 \rightarrow$

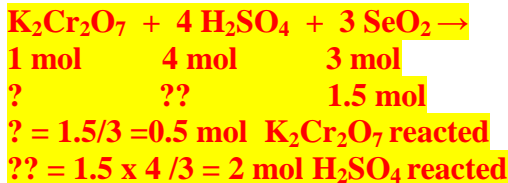
If 0.600 moles of  $\text{K}_2\text{Cr}_2\text{O}_7$ , 2.800 moles of  $\text{H}_2\text{SO}_4$  and 1.500 moles of  $\text{SeO}_2$  are brought together and allowed to react, then

- a.  $\text{H}_2\text{SO}_4$  is the limiting reagent
- b.  $\text{K}_2\text{Cr}_2\text{O}_7$  is the limiting reagent
- c. there are 1.300 moles of  $\text{H}_2\text{SO}_4$  in excess
- \* d. there are 0.800 moles of  $\text{H}_2\text{SO}_4$  in excess
- e. there are 0.300 moles of  $\text{SeO}_2$  in excess

1- find limiting reactant



## 2- Calculate the reacted



## 3- Calculate the unreacted (excess)

$$\begin{array}{l} 0.6 - 0.5 = 0.1 \text{ mol } \text{K}_2\text{Cr}_2\text{O}_7 \text{ excess} \\ 2.8 - 2 = 0.8 \text{ mol } \text{H}_2\text{SO}_4 \text{ excess} \end{array}$$

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19. In a chemical equation,  $\text{AsF}_3 + \text{C}_2\text{Cl}_6 \rightarrow \text{AsCl}_3 + \text{C}_2\text{Cl}_2\text{F}_4$ , the theoretical yield of  $\text{C}_2\text{Cl}_2\text{F}_4$  was calculated to be 1.86 moles. If the percent yield in the reaction was 77.2%, how many grams of  $\text{C}_2\text{Cl}_2\text{F}_4$  were actually obtained?
- a. 222 grams
  - b. 231 grams
  - \* c. 245 grams
  - d. 318 grams
  - e. 412 grams

$$\begin{array}{l} \text{Percent yield\%} = (\text{Actual yield} / \text{theoretical yield}) \times 100 \\ \text{Actual yield} = \text{theoretical yield} \times \text{Percent yield} / 100 \\ = 1.86 \times 77.2 / 100 = 1.44 \text{ mol} \\ M = n \times M_m = 1.44 \times (2 \times 12 + 2 \times 35.5 + 4 \times 19) = 245 \text{ g} \end{array}$$

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20. The density of an object is the ratio of its mass to its volume. What is the derived SI unit for density?
- a.  $\text{kg m/s}^3$
  - b.  $\text{kg m/s}$
  - \* c.  $\text{kg/m}^3$
  - d.  $\text{m/s}^2$
  - e. pounds per cubic inches

$$d = \text{mass/volume} = \text{kg/m}^3$$

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21. What is the number needed to complete the following: 1 dm = \_\_\_ m?
- a. 10
  - b. 20
  - c. 1
  - \* d. 0.1
  - e. 0.01

$$1 \text{ dm} = 1 \times 10^{-1} \text{ m} = 0.1 \text{ m}$$

22. The SI base units of **temperature and mass**, respectively, are

- a. degree and gram.
- \* b. **kelvin and kilogram.**
- c. Celsius and milligram.
- d. degree and kilogram.
- e. kelvin and gram.

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23. The SI prefixes giga and micro, indicate respectively:

- \* a.  **$10^9$  and  $10^{-6}$**
- b.  $10^{-9}$  and  $10^{-6}$
- c.  $10^6$  and  $10^{-3}$
- d.  $10^3$  and  $10^{-3}$
- e.  $10^{-9}$  and  $10^{-3}$

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24. A solution of sodium nitrite is prepared by mixing 3.25 g of  $\text{NaNO}_2$  with 12.0 g of water. The percent, by mass, of  $\text{NaNO}_2$  is:

- a. 28.0 %
- b. 23.3 %
- c. 27.0 %
- \* d. **21.3 %**
- e. 37.1 %

$$\% \text{ w/w} = \text{mass of solute} \times 100 / \text{mass of solution} = 3.25 \times 100 / (3.25 + 12) = 21.3 \%$$

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25. A solution of potassium nitrate is prepared by mixing 3.50 g of  $\text{KNO}_3$  with 12.0 g of water. The percent, by mass, of  $\text{KNO}_3$  is:

- \* a. **22.6 %**
- b. 23.3 %
- c. 28.0 %
- d. 29.2 %
- e. 41.8 %

$$\% \text{ w/w} = \text{mass of solute} \times 100 / \text{mass of solution} = 3.5 \times 100 / (3.5 + 12) = 22.6 \%$$

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26. A glucose solution is prepared by dissolving 5.10 g of glucose,  $\text{C}_6\text{H}_{12}\text{O}_6$ , in 110.5 g of water. What is the molality of the glucose solution?

- a. 0.283 *m*
- b. 0.000256 *m*
- c. 0.245 *m*
- \* d. **0.256 *m***
- e. 0.351 *m*

$$m = n(\text{solute}) / \text{Mass of solvent (kg)} = m(\text{solute}) / \text{MM}(\text{solute}) \times \text{Mass of solvent (kg)}$$
$$m = 5.1 / (6 \times 12 + 12 \times 1 + 6 \times 16) \times 110.5 \times 10^{-3} = 0.256 \text{ m}$$

27. An aqueous solution of glycerol,  $\text{C}_3\text{H}_8\text{O}_3$ , is 48.0% glycerol by mass and has a density of  $1.120 \text{ g mL}^{-1}$ . Calculate the molality of the glycerol solution.

- a.  $11.2 \text{ m}$
- b.  $5.84 \text{ m}$
- c.  $0.584 \text{ m}$
- d.  $0.521 \text{ m}$
- \* e.  $10.0 \text{ m}$

$$m = n(\text{solute}) / \text{Mass of solvent (kg)} = m(\text{solute}) / \text{MM}(\text{solute}) \times \text{Mass of solvent (kg)}$$

$$\begin{aligned} 48.0\% \quad \text{means} \quad & 48 \text{ g solute in } 100 \text{ g solution} \quad m(\text{solvent}) = 100 - 48 = 52 \text{ g} \\ m = & 48 / (3 \times 12 + 8 \times 1 + 3 \times 16) \times 52 \times 10^{-3} = 10.0 \text{ m} \end{aligned}$$

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28. Consider a  $0.900 \text{ M Al}(\text{NO}_3)_3$  solution. This solution has a nitrate ion concentration of:

- a.  $0.300 \text{ M}$
- b.  $0.900 \text{ M}$
- \* c.  $2.70 \text{ M}$
- d.  $3.60 \text{ M}$
- e.  $8.10 \text{ M}$

**1 mol  $\text{Al}(\text{NO}_3)_3$  contains 3 mol  $\text{NO}_3$  ions**

**0.900 mol                      ?? mol**

$$\mathbf{3 \times 0.900 = 2.7 \text{ mol}}$$

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29. Which is a concentration unit whose value changes if the temperature of an aqueous solution is changed?

- a. mole fraction
  - \* b. **molarity**
  - c. molality
  - d. mass fraction
  - e. percent by weight
-