Mole Review
Chemistry 11 ADVANCED

1. Calculate the number of moles in each of the following.
   a) 125 mL of hydrogen gas at STP

$$\frac{0.125\ L}{22.4\ L/mol} = 0.005\,58\ mol \quad \text{or} \quad 5.58 \times 10^{-3}\ mol$$

   b) 1.26×10^{24} molecules of carbon dioxide

$$\frac{1.26 \times 10^{24}}{6.022 \times 10^{23}} = 2.09\ mol$$

   c) 12.6 g water

$$\frac{12.6\ g}{18.015\,28\ g/mol} = 0.699\ mol$$

   d) 12.6 g sodium chloride

$$\frac{12.6\ g}{58.442\,77\ g/mol} = 0.216\ mol$$

2. Calculate the mass of each of the following.
   a) 1.95×10^{22} molecules of sucrose, $C_{12}H_{22}O_{11}$

$$\left(\frac{1.95 \times 10^{22}}{6.022 \times 10^{23}}\right)(342.300\,08\ g/mol) = 11.1\ g$$

   b) 2.50 L of propane, C_3H_8, at STP

$$\left(\frac{2.50\ L}{22.4\ L/mol}\right)(44.096\,52\ g/mol) = 4.92\ g$$

   c) 0.780 mol $Ca(CN)_2$

$$(0.780\ mol)(92.1134\ g/mol) = 71.8\ g$$

3. Determine the number of atoms in each of the following.

a) 1 molecule of $C_{17}H_{19}NO_3$

40 atoms

b) 2.85 mol of Ag

$(2.85\ mol)(6.022 \times 10^{23}) = 1.72 \times 10^{24}$ atoms

c) 0.875 L of carbon dioxide at STP

$\left(\frac{0.875\ L}{22.4\ L/mol}\right)(6.022 \times 10^{23})(3\ atoms/molecule)$

$= 7.06 \times 10^{22}$ atoms

d) 12.9 g of $CaCO_3$

$\left(\frac{12.9\ g}{100.0872\ g/mol}\right)(6.022 \times 10^{23})(5\ atoms/molecule)$

$= 3.88 \times 10^{23}$ atoms

e) 12.9 g of $Fe(NO_3)_3$

$\left(\frac{12.9\ g}{241.8617\ g/mol}\right)(6.022 \times 10^{23})(13\ atoms/molecule)$

$= 4.18 \times 10^{23}$ atoms

4. Determine the volume of the following gases at STP.

a) 12.5 g of carbon dioxide

$\left(\frac{12.5\ g}{44.0098\ g/mol}\right)(22.4\ L/mol) = 6.36\ L$

b) 2.15 mol of propane

$(2.15\ mol)(22.4\ L/mol) = 48.2\ L$

c) 6.88×10^{20} atoms of helium

$\left(\frac{6.88 \times 10^{20}}{6.022 \times 10^{23}}\right)(22.4\ L/mol) = 0.0256\ L$

d) 125 g of sulfur trioxide

$$\left(\frac{125\ g}{80.0642\ g/mol}\right)(22.4\ L/mol) = 35.0\ L$$

5. What volume of 0.125 M $CaCl_2$ can be made from 15.0 g?

$$\frac{15.0\ g}{110.984\ g/mol} = 0.135\ mol \qquad V = \frac{n}{C} = \frac{0.135\ mol}{0.125\ mol/L}$$

$$= 1.08\ L$$

6. What is the molarity of 325 g of $NaHCO_3$ dissolved in 2500.0 mL of solution?

$$\frac{325\ g}{84.00691\ g/mol} = 3.87\ mol \qquad C = \frac{n}{V} = \frac{3.87\ mol}{2.5000\ L} = 1.55\ mol/L$$

7. What volume of 14.0 M nitric acid would be required to make 750.0 mL of 0.100 M nitric acid?

$$C_1V_1 = C_2V_2$$

$$V_1 = \frac{C_2V_2}{C_1} = \frac{(0.100\ M)(0.7500\ L)}{(14.0\ M)} = 0.00536\ L \text{ or } 5.36\ mL$$

8. What is the molarity of a solution that contains 36.1 g of $MgCl_2$ in 895 mL of solution.

$$\frac{36.1\ g}{95.211\ g/mol} = 0.379\ mol \qquad C = \frac{n}{V} = \frac{0.379\ mol}{0.895\ L}$$

$$= 0.424\ mol/L$$

9. You need to prepare 2.50 L of a 0.125 M solution of hydrochloric acid, but the only solution available is 12.0 M. What volume of the 12.0 M solution must be diluted?

$$C_1V_1 = C_2V_2$$

$$V_2 = \frac{C_1V_1}{V_2} = \frac{(0.125\ M)(2.50\ L)}{(12.0\ M)} = 0.0260\ L$$

or

$$26.0\ mL$$

10. What mass of sodium sulfate is required to prepare 750.0 mL of a 0.275 M solution?

$n = C \cdot V = (0.275\ mol/L)(0.7500\ L) = 0.206\ mol$

$(0.206\ mol)(142.04314\ g/mol) = 29.3\ g$

*11. 225.0 mL of 0.500 M nitric acid is added to 100.0 mL of 2.00 M nitric acid. What is the molarity of the mixture?

$$C_{AB} = \frac{C_A V_A + C_B V_B}{V_A + V_B} = \frac{(0.500\ M)(225.0\ mL) + (2.00\ M)(100.0\ mL)}{225.0\ mL + 100.0\ mL}$$

$$= \frac{112.5 + 200}{325.0} = \frac{312.5}{325.0} = 0.962\ M$$

*12. Two solutions are mixed together. The first solution is 250.0 mL of 0.450 M hydrochloric acid. The second solution consists of 600.0 mL of 2.800 M hydrochloric acid. What is the concentration of the solution that is obtained when the two are mixed together?

$$C_{AB} = \frac{C_A V_A + C_B V_B}{V_A + V_B} = \frac{(0.450\ M)(250.0\ mL) + (2.800\ M)(600.0\ mL)}{250.0\ mL + 600.0\ mL}$$

$$= \frac{112.5\ mmol + 1680\ mmol}{850.0\ mL}$$

$$= \frac{179.25\ mmol}{850.0\ mL} = 2.11\ mol/L$$

13. Determine the percentage composition of each element in gallium nitrate.

$\%\ Ga = \frac{69.72}{255.7347} = 27.266\%\ Ga$

$\%\ N = \frac{3(14.0067)}{255.7347} = 16.43\%\ N$

$\%\ O = \frac{9(15.9994)}{255.7347} = 56.31\%\ O$

$Ga(NO_3)_3$

14. The density of a gaseous compound is 1.964 g/L at STP. Calculate the molar mass of this gas.

$\frac{\text{mass}}{\text{molmass}} = \frac{\text{vol}}{\text{molvol}}$ $\quad \frac{1.964\ g}{\text{mol mass}} = \frac{1000\ L}{22.4\ L/mol}$ $\quad \text{mol mass} = 44.0\ g/mol$

15. Determine the empirical formula of the compound with the following percentage composition: 32.00% carbon, 42.66% oxygen, 18.67% nitrogen & 6.67% hydrogen

$\frac{32.00\ g\ C}{12.011\ g/mol}$ $\quad \frac{42.66\ g\ O}{15.9994\ g/mol}$ $\quad \frac{18.67\ g\ N}{14.0067\ g/mol}$ $\quad \frac{6.67\ g\ H}{1.00794\ g/mol}$

$\frac{2.664224\ mol}{1.332934}$ $\quad \frac{2.666350}{1.332734}$ $\quad \frac{1.332934}{1.332434}$ $\quad \frac{6.617457}{1.332434}$

1.994 : 2.00 : 1 : 4.965

2 : 2 : 1 : 5

$C_2O_2NH_5$

16. Determine the empirical formula of the compound with the following percentage composition: 27.59% carbon, 1.15% hydrogen, 16.09% nitrogen & 55.17% oxygen

$\frac{27.59\ g\ C}{12.011}$ $\quad \frac{1.15\ g\ H}{1.00794}$ $\quad \frac{16.09\ g\ N}{14.0067}$ $\quad \frac{55.17\ g\ O}{15.9994}$

$\frac{2.297061}{1.140940}$ $\quad \frac{1.140940}{1.140940}$ $\quad \frac{1.148759}{1.14940}$ $\quad \frac{3.448254}{1.140940}$

1.9996 $\quad$ 1 $\quad$ 1.007 $\quad$ 3.022

2 : 1 : 1 : 3

C_2HNO_3

17. An organic compound contains 37.5% carbon, 58.3% oxygen and 4.20% hydrogen. The substance has a molar mass of 192.10 g/mol. Determine the molecular formula of this compound.

$\frac{72.0375\ g\ C}{12.011}$ $\frac{111.9443\ g\ O}{15.9994}$ $\frac{8.0682\ g\ H}{1.00794}$

5.998 6.9994 8.005

$C_6O_7H_8$

18. Determine the molecular formula of methyl butanoate, a compound that smells like apples. Its percent composition is 58.8% carbon, 9.8% hydrogen and 31.4% oxygen. In the gaseous state, 782 mL has a mass of 3.56 g.

$\frac{3.56g}{\text{mol mass}} = \frac{0.782L}{22.4\ L/mol}$ mol mass = 101.97 g/mol

$\frac{59.96\ g\ C}{12.011}$ $\frac{9.993\ g\ H}{1.00794}$ $\frac{32.01447\ g\ O}{15.9994}$

4.992 9.91477 2.001

$C_5H_{10}O_2$