1. Calculate the volume of 20.5 g of NH₃ at 0.658 atm and 25 °C.

2. Calculate the volume of 359 g of CH₃CH₃ at 0.658 atm and 75 °C.

3. Calculate the volume of 525 g of O₂ at 25.7 torr and 25 °C.

4. A spherical space colony proposed by Gerald O'Neill (Princeton University) has a diameter of 1.00 km. How many grams of N₂ are needed to fill the interior of the colony at one atmosphere and 20 °C (room temperature)?

5. A 2.00 L container is placed in a constant temperature bath and is filled with 3.05 g of CH₃CH₃. The pressure stabilizes at 800 torr. What is the temperature of the constant temperature bath?

6. The density of a gas is typically given as: density \( d \) = \( \frac{\text{grams}}{\text{liter}} \). Use this definition of density and the ideal gas law to derive an equation that has only the density on the left-hand side and the other variables \( (P, T, MW) \) on the right-hand side.

7. Calculate the density of NH₃ at 850 torr and 100 °C.

8. A 2.00 L container holds 4.00 moles of O₂ and 2.70 moles of He at 293 K. What is the partial pressure of O₂? Of He? What is the total pressure?

9. The density of air at 1.000 atm and 25 °C is 1.186 g/L.
   a) Calculate the average molecular mass of air.
   b) From this value, and assuming that air contains only molecular nitrogen and molecular oxygen gases, calculate the mass % of N₂ and O₂ in air.

10. Ammonium sulfate, an important fertilizer, can be prepared by the reaction of ammonia with sulfuric acid according to the following balanced equation:

    \[ 2 \text{NH}_3(g) + \text{H}_2\text{SO}_4 \rightarrow (\text{NH}_4)_2\text{SO}_4 (aq) \]

    Calculate the volume of NH₃ (in liters) needed at 20°C and 25.0 atm to react with 150 kg of H₂SO₄.

    \[ 2860 \text{ L} \]

11. If 45.0 L of natural gas, which is essentially methane (CH₄), undergoes complete combustion at 730 mm Hg and 20°C, how many grams of each product are formed?

    \[ N = \frac{PV}{RT} \]

    \[ 79.2 \text{ g CO}_2 \]

    \[ 64.8 \text{ g H}_2\text{O} \]

12. Fritz Haber, a German chemist, discovered a way to synthesize ammonia gas (NH₃) by combining hydrogen and nitrogen gases at extremely high temperatures and pressures.

    a. Write the balanced equation for this reaction.
    \[ N_2 + 3H_2 \rightarrow 2NH_3 \]

    b. If 10 kg of nitrogen combines with excess hydrogen at 550°C and 250 atm, what volume of ammonia gas is produced?

    \[ 193 \text{ L} \]
1. Consider the three flasks in the figure below. Assume that the connecting tubes have no volume and the temperature is held constant.

   a) Calculate the partial pressure of each gas when all stopcocks are open.
   b) Calculate the total pressure when all stopcocks are open.

   \[
   P_{\text{He}} = 50 \text{ torr} \quad P_{\text{Ne}} = 103 \text{ torr} \quad P_{\text{Ar}} = 125 \text{ torr}
   \]

   \[P_{\text{Total}} = 50 + 103 + 125 = 278 \text{ torr}\]

2. Some commercial drain cleaners contain two components: sodium(l) hydroxide and aluminum powder. When the mixture is poured down a clogged drain, the following reaction occurs:

   \[2 \text{NaOH(aq)} + 2 \text{Al(s)} + 6 \text{H}_2\text{O(l)} \rightarrow 2 \text{NaAl(OH)}_4(\text{aq}) + 3 \text{H}_2(\text{g})\]

   The heat generated in this reaction helps melt away grease and the dihydrogen gas released stirs up the solids clogging the drain. Calculate the volume of \text{H}_2 formed at 20 °C and 750 torr if 3.12 g of Al is treated with excess NaOH.

   \[4.12 \text{ L}\]

3. A certain gaseous hydrocarbon is found to be 88.8% C and 11.2% H by mass. The compound has a density of 2.12 g/L at 31 °C and 742 torr.

   a) What is the empirical formula of the compound? \(C_2H_3\)
   b) What is the molecular weight of the compound? \(MW = 54.2 \text{ g/mol}\)
   c) What is the molecular formula of the compound? \(C_4H_{16}\)
   d) Draw a possible structural formula for the compound.

   \[H\overset{\text{C}}{\text{C-}}\overset{\text{C}}{\text{C}}=\overset{\text{H}}{\text{C}}\overset{\text{H}}{\text{C}}\]

4. Assume that 5.60 L of hydrogen gas at STP reacts with copper (II) oxide according to the following balanced equation:

   \[\text{CuO (s)} + \text{H}_2 (\text{g}) \rightarrow \text{Cu (s)} + \text{H}_2\text{O (g)}\]

   \(\frac{5.60 \text{ L}}{22.4 \text{ L}} = 0.25 \text{ mol}\)

   a. How many moles of \text{H}_2 react? \(0.25 \text{ mol}\)
   b. How many moles of copper are produced? \(0.25 \text{ mol}\)
   c. How many grams of copper are produced? \(15.6 \text{ g}\)

5. Assume that 8.5 L of iodine gas (I\(_2\)) are produced at STP according to the following balanced equation:

   \[2 \text{KI (aq)} + \text{Cl}_2 (\text{g}) \rightarrow 2 \text{KCl (aq)} + \text{I}_2 (\text{g})\]

   a. How many moles of I\(_2\) are produced? \(0.38 \text{ mol}\)
   b. How many moles of KI were used? \(0.76 \text{ mol}\)
   c. How many grams of KI were used? \(126 \text{ g}\)
\[ \frac{359 \text{g}}{30} = n \]

\[ V = (12.0)(0.08206)(348) \]

\[ = 521 \]

\[ \frac{525}{32} \]

\[ (16.4)(62.4)(298) \]

\[ = 25.7 \]

\[ \frac{4 \pi r^3}{3} \]

\[ 0.5 \text{km} \left| 10^3 m \right| \left| 10^2 cm \right| = 5 \times 10^4 \]

\[ 1 \text{km} \left| 1 \text{m} \right| \]

\[ 5.24 \times 10^{14} \text{cm}^3 = 5.24 \times 10^{14} \text{ml} \]

\[ 1 \text{L} = \frac{10^3 \text{ml}}{5.24 \times 10^{11} \text{L}} \]

\[ n = \frac{PV}{RT} \]

\[ = \frac{(800 \text{ atm})(32)}{(0.08206)(293)} \]

\[ = 25 \text{ mol} \]

\[ 2.18 \times 10^{10} \text{ mol} \left| 28 \text{ g} \right| \]

\[ 1 \text{ mol} \]

\[ PV = nRT \]

\[ T = \frac{PV}{nR} \]

\[ = \frac{(800 \text{ atm})(32)}{(0.08206)(293)} \]

\[ = 251 \text{ K} \]

\[ 3.05 \text{g} \]

\[ \frac{30}{39} \]

\[ \frac{850 \times 17}{62.4 \times 373} \]

\[ = 48.1 \text{ atm} \]

\[ \frac{P}{V} = \frac{4.0 \text{ mol} \times 0.08206 \times 293}{2.007} \]

\[ = 48.1 \text{ atm} \]

\[ 32.5 \text{ atm} \]

\[ 28^2 - 28y + 32y = 29 \]

\[ 28 + 4y = 29 \]

\[ 4y = 1 \]

\[ y = \frac{25}{29} \]
150 kg $H_2SO_4$ | 1 mol | 2 mol | 17 g = 56.5 kg $NH_3$

should be 98

150,000 g | 1 mol | 2 mol = 2970 mol

$V = \frac{nRT}{P} = \frac{(2970)(0.08206)(293)}{25} = 2856 = 2860$

$n = \frac{(730 \text{ mmHg})(45.0)}{162.4(293)} = 1.80 \text{ mol } CH_4$

$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

\[
\frac{1.80 \text{ mol}}{} \times \frac{1 \text{ mol}}{} = 79.2
\]

\[
\frac{1.80 \text{ mol}}{} \times \frac{2 \text{ mol}}{} = 3.6
\]

12. 10,000 g $N_2$ | 1 mol | 2 mol $NH_3 = 714 \text{ mol}$

$V = \frac{nRT}{P} = \frac{(714)(0.08206)(823)}{250 \text{ atm}} = 193 L$

1. a) $\frac{1.0 \text{ L}(200 \text{ torr})}{200 \text{ torr}} = 50 \text{ torr}$
\[ \frac{3.12 \text{ g Al}}{26.98 \text{ g Fe}} \times \frac{1 \text{ mol Al}}{3 \text{ mol H}_2} = 0.173 \text{ mol H}_2 \]

\[ V = \frac{nRT}{P} = \frac{(0.173 \text{ mol H}_2)(62.36)(298 \text{ K})}{750 \text{ torr}} = 4.21 \text{ L} \]

\[ \frac{88.8 \text{ g C}}{1 \text{ mol C}} = \frac{7.39 \text{ mol}}{12.01} = 1 \times 2 \]

\[ \frac{11.2 \text{ g H}}{1 \text{ mol H}} = \frac{11.1 \text{ mol}}{1.008} = 1.5 \times 2 \]

\[ 2 \text{ C}_2 \text{H}_3 \]

\[ MW = \frac{RTd}{P} = \frac{(62.36)(304 \text{ K})}{742} = 54.2 \]

\[ \text{H}_4 \text{C}_4 \text{H}_6 \]

\[ \text{H} \]

\[ \text{C} \]

\[ \text{H} \]

\[ \text{C} \]

\[ \text{C} \]

\[ \text{C} \]

\[ \text{H} \]