

Show all your work on these problems. If a question involves stoichiometry, be sure to balance the equation

1. Calculate the heat needed to heat 100 g of water from 26 °C to 100 °C. Then calculate the amount of heat needed to vaporize it.

$$\textcircled{1} \Delta H = m \cdot C \cdot \Delta T \quad \textcircled{2} \Delta H = m \cdot L_v$$

$$\frac{100 \text{ g}}{1} \cdot \frac{1 \text{ cal}}{\text{g} \cdot \text{C}^\circ} \cdot (100 - 26) \text{ C}^\circ = 7400 \text{ cal}$$

$$\frac{100 \text{ g}}{1} \cdot \frac{540 \text{ cal}}{\text{g}} = 54000 \text{ cal}$$

2. Calculate the amount of water that is needed to cool a 485 g block of aluminum from 277 °C to 25 °C, if the water was originally at 20 °C. (Specific heat of aluminum is 0.22 cal/gC°).

$$\Delta H_{\text{gained}} = \Delta H_{\text{lost}}$$

$$m \cdot C \cdot \Delta T = -(m \cdot C \cdot \Delta T) \quad \frac{485 \text{ g Al}}{1} \cdot \frac{0.22 \text{ cal}}{\text{g} \cdot \text{C}^\circ} \cdot -(25 - 277) \text{ C}^\circ \cdot \frac{1 \text{ cal}}{1} \cdot \frac{1}{(25 - 20) \text{ C}^\circ} \cdot \frac{1}{\text{H}_2\text{O}} = 5400 \text{ g H}_2\text{O}$$

3. A gas in a 600.0 mL cylinder is under a pressure of 650 mm Hg at 298 K. What will be the temperature of the gas if the pressure is increased to 3230 mm Hg?

$$\frac{P_1}{T_1} = \frac{P_2}{T_2} \quad T_2 = \frac{P_2 T_1}{P_1}$$

$$\frac{650 \text{ mm Hg}}{298 \text{ K}} = \frac{3230 \text{ mm Hg}}{T_2} \quad T_2 = 1500 \text{ K}$$

4. A syringe contains an enclosed gas that has a volume of 10.0 cm³ at a pressure of 14.7 psi. What pressure is needed to compress the gas to 2.00 cm³?

$$P_1 V_1 = P_2 V_2 \quad P_2 = \frac{P_1 V_1}{V_2}$$

$$\frac{14.7 \text{ psi}}{1} \cdot \frac{10.0 \text{ cm}^3}{1} = \frac{P_2}{1} \cdot \frac{2.00 \text{ cm}^3}{1} \quad P_2 = 73.5 \text{ psi}$$

5. For an ideal gas, calculate the following quantities:

- a. the pressure of the gas if 1.34 moles occupies 3.28 L at 25.0 °C
b. the volume occupied by 6.72×10^{-3} mol at 145 °C and a pressure of 59.0 torr
c. the number of moles in 2.50 L at 37.0 °C and 725 mm Hg
d. the temperature which 0.270 mol occupies 15.0 L at 1.88 atm

$$PV = nRT$$

$$c) n = \frac{PV}{RT}$$

$$d) T = \frac{PV}{nR}$$

a. $P = \frac{nRT}{V}$

$$\frac{1.34 \text{ mol}}{1} \cdot \frac{0.0821 \text{ L} \cdot \text{atm}}{\text{mol} \cdot \text{K}} \cdot \frac{(25.0 + 273.15) \text{ K}}{1} = \frac{P}{1} \cdot \frac{3.28 \text{ L}}{1} \quad P = 10.0 \text{ atm}$$

b. $V = \frac{nRT}{P}$

$$\frac{6.72 \times 10^{-3} \text{ mol}}{1} \cdot \frac{0.0821 \text{ L} \cdot \text{atm}}{\text{mol} \cdot \text{K}} \cdot \frac{(145 + 273.15) \text{ K}}{1} = \frac{V}{1} \cdot \frac{59.0 \text{ torr}}{1 \text{ atm}} \quad V = 2.97 \text{ L}$$

c. $n = \frac{PV}{RT}$

$$\frac{725 \text{ mm Hg}}{1} \cdot \frac{2.50 \text{ L}}{1} \cdot \frac{1 \text{ atm}}{760 \text{ mm Hg}} = \frac{n}{1} \cdot \frac{0.0821 \text{ L} \cdot \text{atm}}{\text{mol} \cdot \text{K}} \cdot \frac{(37.0 + 273.15) \text{ K}}{1} \quad n = 0.0937 \text{ mol}$$

d. $T = \frac{PV}{nR}$

$$\frac{1.88 \text{ atm}}{1} \cdot \frac{15.0 \text{ L}}{1} = \frac{0.270 \text{ mol}}{1} \cdot \frac{0.0821 \text{ L} \cdot \text{atm}}{\text{mol} \cdot \text{K}} \cdot \frac{T}{1} \quad T = 1270 \text{ K}$$

6. A mixture of gases contains 3.50 g of N₂, 2.15 g of H₂ and 5.27 g of NH₃. If the total pressure of the mixture is 2.50 atm, what is the partial pressure of each component? (Hint: percent composition is not by mass but by mole)

$$\frac{3.50 \text{ g N}_2}{28.02 \text{ g}} = 0.125 \text{ mol N}_2 \quad \frac{5.27 \text{ g NH}_3}{17.04 \text{ g}} = 0.309 \text{ mol NH}_3$$

$$\frac{2.15 \text{ g H}_2}{2.02 \text{ g}} = 1.06 \text{ mol H}_2 \quad \text{Total mol} = 0.125 \text{ mol} + 1.06 \text{ mol} + 0.309 \text{ mol} = 1.494 \text{ mol}$$

$$P_{\text{N}_2} = \left(\frac{0.125 \text{ mol}}{1.494 \text{ mol}} \right) \cdot 2.50 \text{ atm} = 0.209 \text{ atm}$$

$$P_{\text{H}_2} = \left(\frac{1.06 \text{ mol}}{1.494 \text{ mol}} \right) \cdot 2.50 \text{ atm} = 1.78 \text{ atm}$$

$$P_{\text{NH}_3} = \left(\frac{0.309 \text{ mol}}{1.494 \text{ mol}} \right) \cdot 2.50 \text{ atm} = 0.518 \text{ atm}$$

7. A quantity of N₂ gas originally held at 3.80 atm pressure in a 1.00 L container at 26.0 °C is transferred into a 10.0 L container at 20.0 °C. A quantity of O₂ gas originally at 4.75 atm and 26.0 °C in a 5.00 L container is transferred into the same new container. What is the total pressure in the new container?

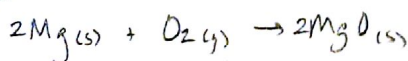
$$n_{\text{N}_2} = \frac{P_1 V_1}{RT_1} = \frac{3.80 \text{ atm} \cdot 1.00 \text{ L}}{0.0821 \text{ L} \cdot \text{atm} \cdot \text{mol}^{-1} \cdot \text{K}^{-1} \cdot (26.0 + 273.15) \text{ K}} = 0.155 \text{ mol N}_2$$

$$n_{\text{O}_2} = \frac{P_1 V_1}{RT_1} = \frac{4.75 \text{ atm} \cdot 5.00 \text{ L}}{0.0821 \text{ L} \cdot \text{atm} \cdot \text{mol}^{-1} \cdot \text{K}^{-1} \cdot (26.0 + 273.15) \text{ K}} = 0.967 \text{ mol O}_2$$

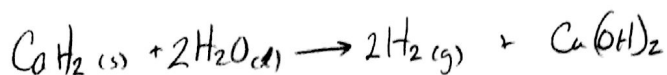
$$P_{\text{total}} = \frac{(n_{\text{N}_2} + n_{\text{O}_2})RT_2}{V_2} = \frac{(0.155 \text{ mol} + 0.967 \text{ mol}) \cdot 0.0821 \text{ L} \cdot \text{atm} \cdot \text{mol}^{-1} \cdot \text{K}^{-1} \cdot (20.0 + 273.15) \text{ K}}{10.0 \text{ L}} = 2.70 \text{ atm}$$

8. Magnesium metal reacts with oxygen gas (O₂) to produce magnesium oxide. How many liters of oxygen gas will be produced at 35.0 °C and a pressure of 1.00 atm from 28.4 g of magnesium?

are required



$$\frac{28.4 \text{ g Mg}}{24.31 \text{ g Mg}} \cdot \frac{1 \text{ mol}}{1} \cdot \frac{1 \text{ mol O}_2}{2 \text{ mol Mg}} \cdot \frac{0.0821 \text{ L} \cdot \text{atm}}{\text{mol} \cdot \text{K}} \cdot \frac{(35.0 + 273.15) \text{ K}}{1} = \frac{V}{1} \cdot \frac{1.00 \text{ atm}}{1} \quad V = 14.8 \text{ L O}_2$$

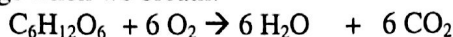


9. Calcium hydride (CaH_2) reacts with water to form hydrogen gas and calcium hydroxide [Ca(OH)_2]. How many grams of CaH_2 are needed to generate 10.0L of H_2 gas if the pressure is 740 torr at 23.0°C ?

$$n = \frac{PV}{RT}$$

$$g \text{ CaH}_2 \parallel \frac{740 \text{ torr}}{760 \text{ torr}} \parallel \frac{1 \text{ atm}}{1 \text{ atm}} \parallel \frac{10.0 \text{ L}}{0.0821 \text{ L}\cdot\text{atm}} \parallel \frac{\text{mol}\cdot\text{K}}{(23+273.15) \text{ K}} \parallel \frac{1 \text{ mol CaH}_2}{2 \text{ mol H}_2} \parallel \frac{42.10 \text{ g CaH}_2}{1 \text{ mol CaH}_2} = \boxed{8.4 \text{ g CaH}_2}$$

10. The metabolic breakdown of glucose, $\text{C}_6\text{H}_{12}\text{O}_6$, in our bodies produces carbon dioxide, which is expelled from our lungs when we breath:



Calculate the volume of dry CO_2 produced at body temperatures (37°C) and 1.00 atm when 5.00 g of glucose is consumed in this reaction.

$$V = \frac{nRT}{P}$$

$$V \text{ CO}_2 \parallel \frac{5.00 \text{ g C}_6\text{H}_{12}\text{O}_6}{180.18 \text{ g}} \parallel \frac{1 \text{ mol}}{1 \text{ mol C}_6\text{H}_{12}\text{O}_6} \parallel \frac{6 \text{ mol CO}_2}{1 \text{ mol C}_6\text{H}_{12}\text{O}_6} \parallel \frac{0.0821 \text{ L}\cdot\text{atm}}{\text{mol}\cdot\text{K}} \parallel \frac{(37+273.15) \text{ K}}{1.00 \text{ atm}} = \boxed{4.24 \text{ L CO}_2}$$

11. Calculate the density ($D = \text{mass/volume}$) of chlorine gas at STP. (Hint: assume you have 1 mole of Cl_2)

$$d = \frac{m}{V} = \frac{70.9 \text{ g Cl}_2}{22.4 \text{ L}} = 3.17 \text{ g/L}$$

12. A chemist isolated a gas in a glass bulb with a volume of 255 mL at a temperature of 25.0°C and a pressure of 10.0 torr. The gas weighed 12.1 mg. What is the molar mass of the gas?

$$n = \frac{PV}{RT}$$

$$m.m. = \frac{m}{n} = \frac{m}{\frac{PV}{RT}} = \frac{m \cdot RT}{PV} \parallel \frac{12.1 \text{ mg}}{1000 \text{ mg}} \parallel \frac{1 \text{ g}}{1 \text{ g}} \parallel \frac{0.0821 \text{ L}\cdot\text{atm}}{\text{mol}\cdot\text{K}} \parallel \frac{(25.0+273.15) \text{ K}}{10.0 \text{ torr}} \parallel \frac{760 \text{ torr}}{1 \text{ atm}} \parallel \frac{255 \text{ mL}}{1 \text{ L}} = \boxed{88.3 \text{ g/mol}}$$

13. What will be the effusion rate (v_1/v_2) of helium versus sulfur dioxide (SO_2)? (Hint: use Graham's Law)

$$\frac{(He)}{(SO_2)} \frac{v_1}{v_2} = \sqrt{\frac{m_2(SO_2)}{m_1(He)}} \quad \frac{v_1}{v_2} = \sqrt{\frac{64.07 \text{ g/mol}}{4.00 \text{ g/mol}}} = \boxed{4.00 \text{ x's faster}}$$

14. Ammonia effuses at a rate that is 2.93 times faster than an unknown gas. What is the molecular mass of the unknown gas?

$$\frac{(NH_3)}{(x)} \frac{v_1}{v_2} = \sqrt{\frac{m_2(x)}{m_1(NH_3)}} \Rightarrow \frac{2.93}{1} = \sqrt{\frac{x}{17.04 \text{ g/mol}}} = \boxed{x = 146. \text{ g/mol}}$$

15. A sample of an unknown gas with a mass of 3.620 g was made to decompose into 2.172 g of O_2 and 1.448 g of Sulfur. Prior to the decomposition, this sample occupied a volume of 1120 mL at 750 torr and 25.0°C .

- What is the percentage composition of the elements in this gas?
- What is the empirical formula of the gas?
- What is its molecular formula?

a)

$$\% \text{ O}_2 = \frac{2.172 \text{ g}}{3.620 \text{ g}} = 59.9\%$$

$$\% \text{ S} = \frac{1.448 \text{ g}}{3.620 \text{ g}} = 39.9\%$$

$$b) \parallel \frac{2.172 \text{ g O}}{16.00 \text{ g}} \parallel \frac{1 \text{ mol}}{1 \text{ mol}} = \frac{0.1358 \text{ mol O}}{0.452} = 3$$

$$\parallel \frac{1.448 \text{ g S}}{32.07 \text{ g}} \parallel \frac{1 \text{ mol}}{1 \text{ mol}} = \frac{0.0452 \text{ mol S}}{0.0452} = 1$$

$$\boxed{\text{EF} = \text{SO}_3}$$

$$m.m. = \frac{mRT}{PV} \parallel \frac{3.620 \text{ g}}{1 \text{ g}} \parallel \frac{0.0821 \text{ L}\cdot\text{atm}}{\text{mol}\cdot\text{K}} \parallel \frac{(25.0+273.15) \text{ K}}{750 \text{ torr}} \parallel \frac{760 \text{ torr}}{1 \text{ atm}} \parallel \frac{1120 \text{ mL}}{1 \text{ L}} = \frac{80.3 \text{ g/mol}}{80.07} = \boxed{80.3 \text{ g/mol}}$$

$$\boxed{\text{M.F.} = \text{SO}_3}$$