$FW_{NH_4NO_3} = 80.0434\ g/mol$

$$2\,NH_4NO_3(s) \longrightarrow 2\,N_2(g) + O_2(g) + 4\,H_2O(g)$$

At 300.°C, ammonium nitrate violently decomposes to produce nitrogen gas, oxygen gas, and water vapor. What is the total volume of gas that would be produced at 1.00 atm by the decomposition of 15.0 grams of ammonium nitrate?

Shorter soliution: Calculate TOTAL MOLES of gas, then use ideal gas equation to find volume rather than treating each different gas alone.

1 - Convert 15.0 g of ammonium nitrate to moles. Use formula weight.
2 - Convert moles ammonium nitrate to TOTAL MOLES OF GAS using chemical equation.
3 - Convert TOTAL MOLES OF GAS to volume using ideal gas equation

$80.0434\ g\ NH_4NO_3 = mol\ NH_4NO_3$ | $2\ mol\ NH_4NO_3 = 7\ mol\ gas\ (2+1+4)$

$$15.0\ g\ NH_4NO_3 \times \frac{mol\ NH_4NO_3}{80.0434\ g\ NH_4NO_3} \times \frac{7\ mol\ gas}{2\ mol\ NH_4NO_3} = 0.6558941774\ mol\ gas$$

① ②

$PV = nRT$

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

$n = 0.6558941774\ mol\ gas$

$R = 0.08206\ \frac{L \cdot atm}{mol \cdot K}$

$T = 300.°C = 573\ K$

$P = 1.00\ atm$

$$V = \frac{(0.6558941774\ mol\ gas)\left(0.08206\ \frac{L \cdot atm}{mol \cdot K}\right)(573\ K)}{(1.00\ atm)} = \boxed{30.8\ L}$$

30,800 mL

REAL GASES

- The empirical gas laws (including the ideal gas equation) do not always apply.

  - The gas laws don't apply in situations where the assumptions made by kinetic theory are not valid.

    - When would it be FALSE that the space between gas molecules is much larger than the molecules themselves?

      - at high pressure, molecules would be much closer together!

    - When would it be FALSE that attractive and repulsive forces would be negligible?

      - at high pressure, attractions and repulsions should be stronger!

      - at low temperature, attractions and repulsions have a more significant affect on the paths of molecules

-The gas laws are highly inaccurate near the point where a gas changes to liquid!

- In general, the lower the pressure and the higher the temperature, the more IDEAL a gas behaves.

van der Waals equation

- an attempt to modify PV = nRT to account for several facts.
    - gas molecules actually have SIZE (they take up space)
    - attractive and repulsive forces

$$PV = nRT$$

Ideal gas equation

$$\left(P + \frac{n^2 a}{V^2}\right)\left(V - nb\right) = nRT$$

van der Waals equation

nb: attempts to account for molecular size

$\frac{n^2 a}{V^2}$: attempts to account for attractive / repulsive forces

* "a" and "b" are experimentally determined parameters that are different for each gas. p 208

He: a = 0,0346, b = 0,0238 tiny, no special attractive forces

H_2O: a = 5.537, b = 0.03049 small, but strong attractions between moleculres

CH_3CH_2OH: a = 12.56 b = 0,08710 larger, and strong attractions between molecules

147 $25\bar{0}0$ L of chlorine gas at 25.0 C and 1.00 atm are used to make hydrochloric acid. How many kilograms of hydrochloric acid could be produced if all the chlorine reacts?

$$H_2 + Cl_2 \rightarrow 2\,HCl$$

---

1 - Convert 2500 L of chlorine gas to moles using ideal gas equation.
2 - Convert moles chlorine gas to moles hydrochloric acid
3 - Convert moles hydrochloic acid to mass using formula weight

---

① $PV = nRT$

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

$P = 1.00\text{ atm}$ $\quad V = 25\bar{0}0\text{ L}$

$R = 0.08206\,\frac{\text{L}\cdot\text{atm}}{\text{mol}\cdot\text{K}}$ $\quad T = 25.0°C = 298.2\text{ K}$

$$n_{Cl_2} = \frac{(1.00\text{ atm})(25\bar{0}0\text{ L})}{\left(0.08206\,\frac{\text{L}\cdot\text{atm}}{\text{mol}\cdot\text{K}}\right)(298.2\text{ K})} = 102.1646983\text{ mol } Cl_2$$

---

mol Cl_2 = 2 mol HCl | 36.458 g HCl = mol HCl | Kg = 10^3 g

$$102.1646983\text{ mol } Cl_2 \times \frac{2\text{ mol HCl}}{\text{mol } Cl_2} \times \frac{36.458\text{ g HCl}}{\text{mol HCl}} \times \frac{\text{Kg}}{10^3\text{ g}} = \boxed{7.45\text{ kg HCl}}$$

② ③

Calculate the mass of 22650 L of oxygen gas at 25.0 C and 1.18 atm pressure.*

O_2

*Volume of a 10'x10'x8' room

1 - Convert volume of oxygen gas to moles using ideal gas law
2 - Convert moles of oxygen gas to mass using formula weight

$PV = nRT$

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

$P = 1.18 \text{ atm}$

$V = 22650 \text{ L}$

$R = 0.08206 \frac{\text{L·atm}}{\text{mol·K}}$

$T = 25.0°C = 298.2 \text{ K}$

① $n_{O_2} = \frac{(1.18 \text{ atm})(22650 \text{ L})}{(0.08206 \frac{\text{L·atm}}{\text{mol·K}})(298.2 \text{ K})} = 1092.222357 \text{ mol } O_2$

$32.00 \text{ g } O_2 = \text{mol } O_2$

$1092.222357 \text{ mol } O_2 \times \frac{32.00 \text{ g } O_2}{\text{mol } O_2} = 35000 \text{ g } O_2$

35.0 kg

77 lb