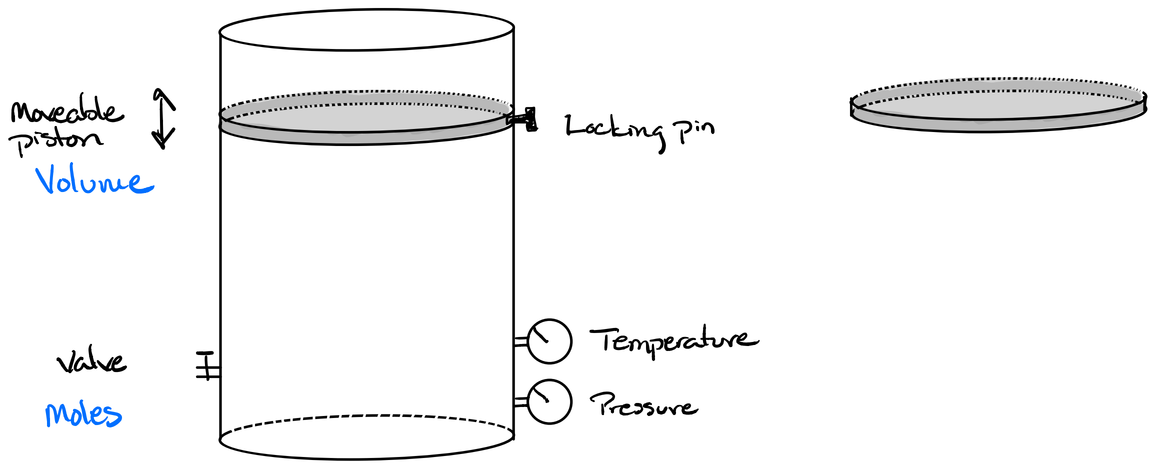
Gas Laws Chapter 8



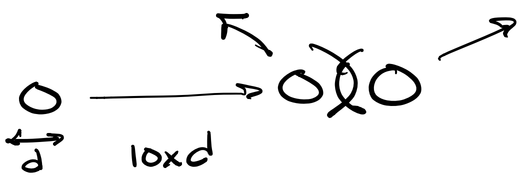
Ideal Gas Assumptions

- Gas molecules move in straight lines, unaffected by gravity, change speed & direction through collisions.
- Size of molecule is not important, think of a gas molecule as a point mass $\Rightarrow$ a mass without volume.
- There are no attractive forces between gas molecules.
- Kinetic Molecular theory $\Rightarrow$ speed of gas molecule is proportional to it's temperature.
  Hotter = faster motion.

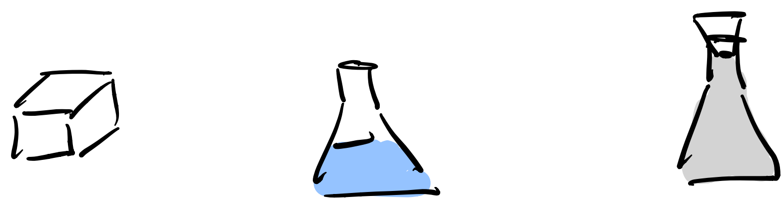
- Collisions with "walls" result in the transfer of force per unit area = pressure.
  \# of Collisions & the force of collisions
  $\propto$ to pressure

α = protortional to
alpha

N_2 & O_2 @ 25°C traveling @ almost 500mph



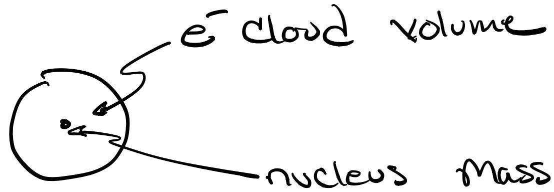
on average



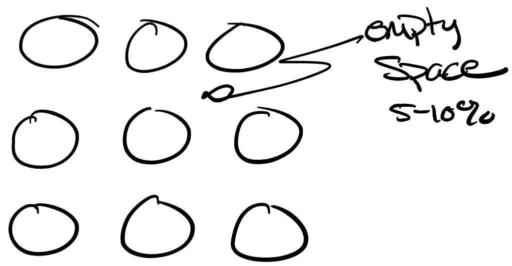
Solid	liquid	gas
90-95% particles	85-90% particles	0.1% particles
5-10% empty	10-15% empty	99.9% empty

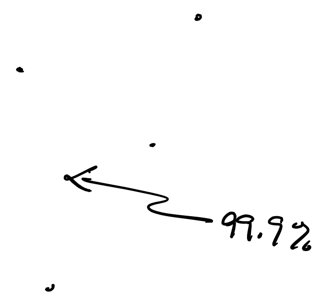
$\underbrace{\text{solid} \quad \text{liquid}}_{\text{Condensed Matter}}$

Condensed Matter



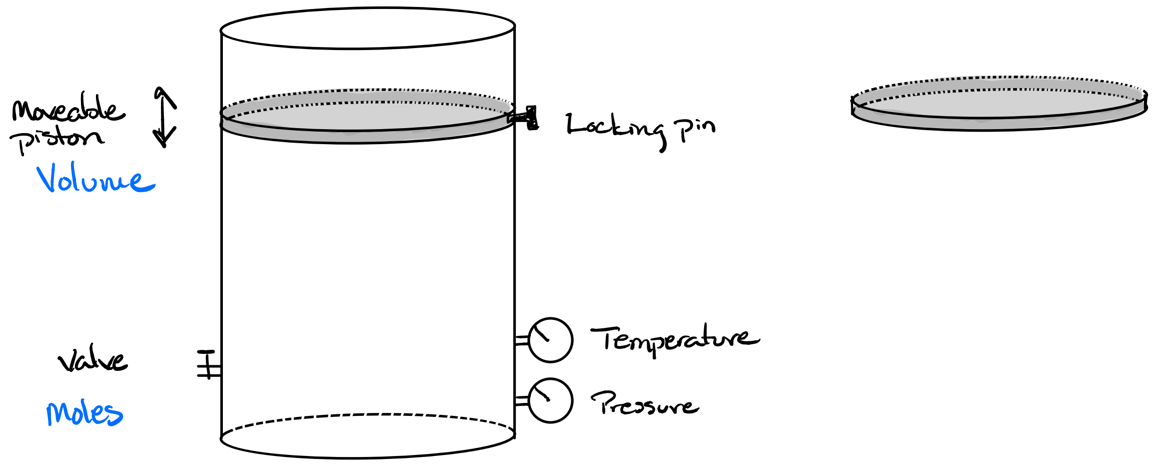
Solid | gas



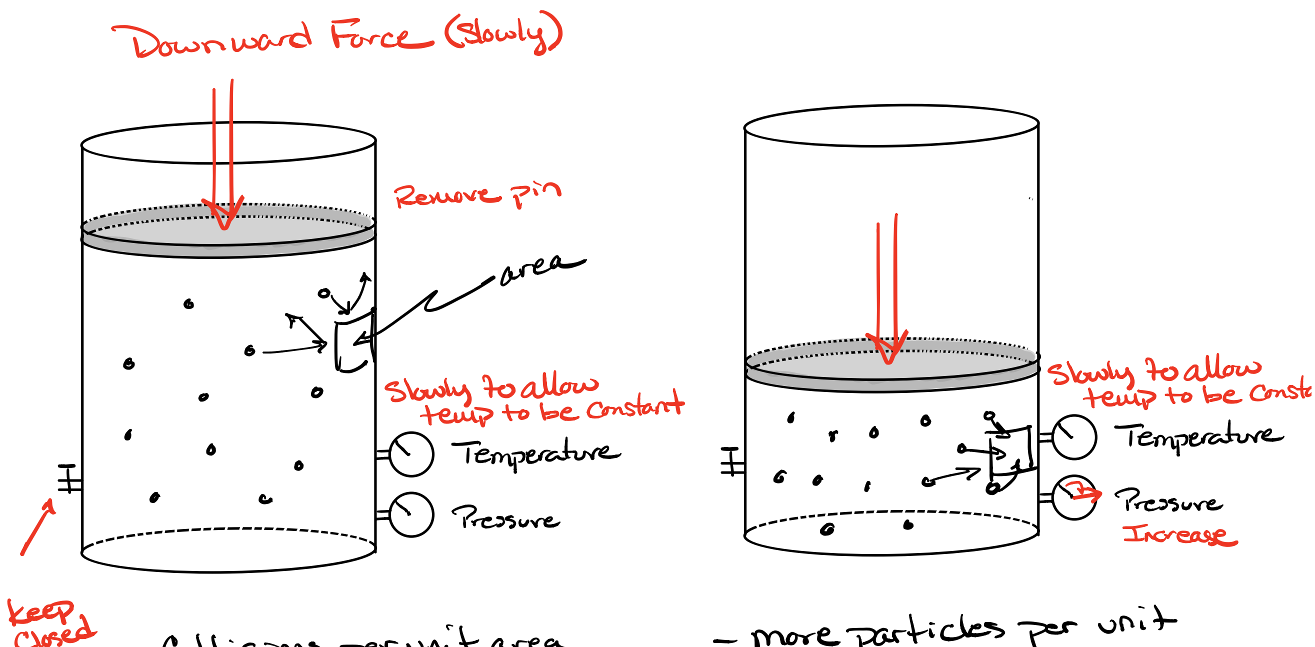


Properties of Gases

- Volume
- Temperature
- amount of molecules
- Pressure



Pressure vs Volume (hold temp & moles constant)



Collisions per unit area = pressure

few collisions w/ area

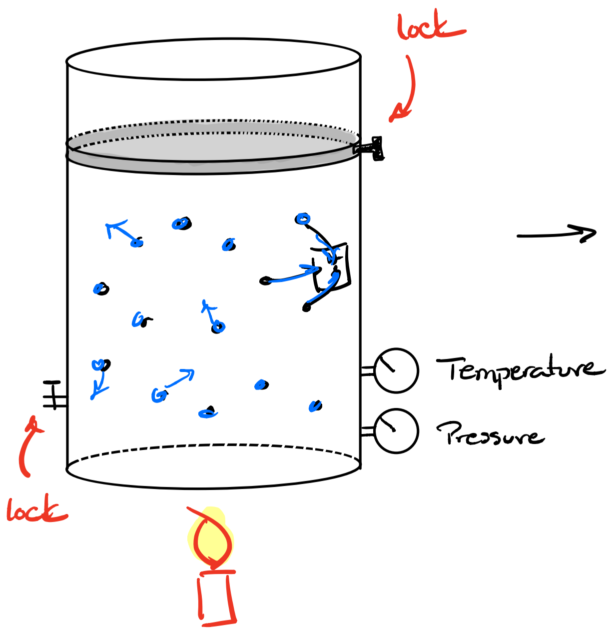
- more particles per unit Volume
- more collisions per unit area

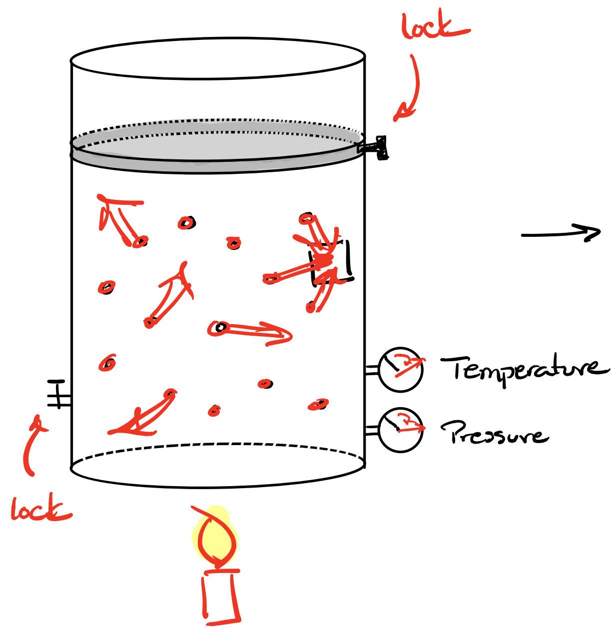
$\Rightarrow$ Higher pressure

down ↓V $\quad$ P↑ up $\quad$ Inverse Relationship

$\frac{1}{V} \propto P$ Inversely proportional to each other

Temperature & Pressure (hold Vol & moles Const)





- particles moving slowly & colliding w/ initial frequency & velocity

= $P_{initial}$

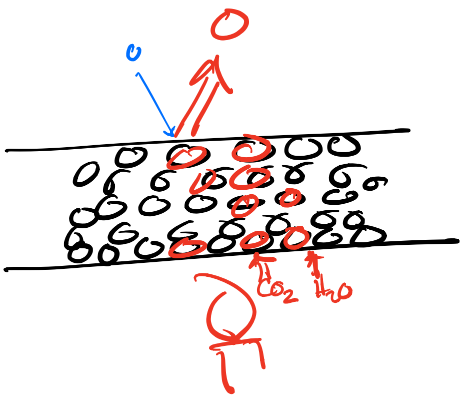
- particles are moving faster
- collide w/ the wall w/ more frequency per area

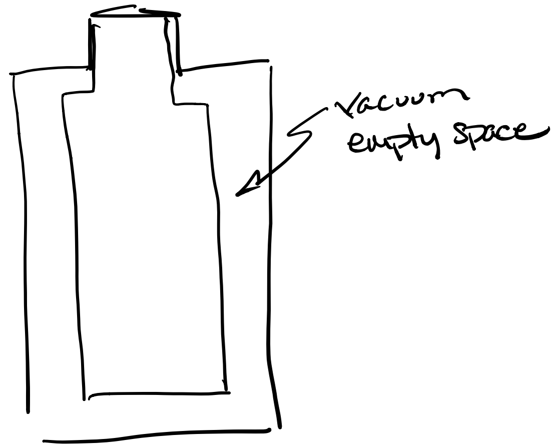
= collisions are more forceful

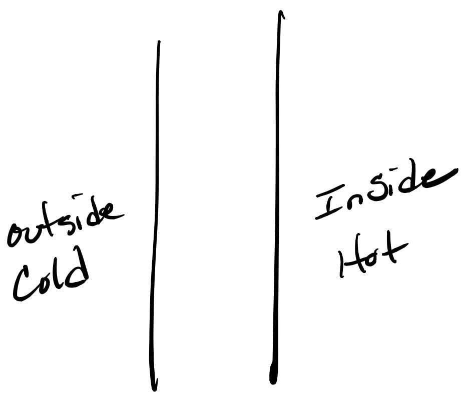
= more pressure

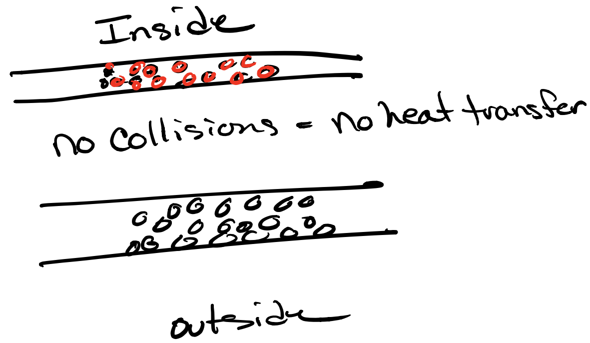
↑ increase in pressure

$\uparrow P \propto T \uparrow$ Directly proportional

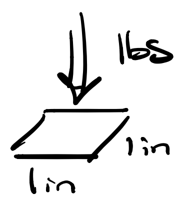








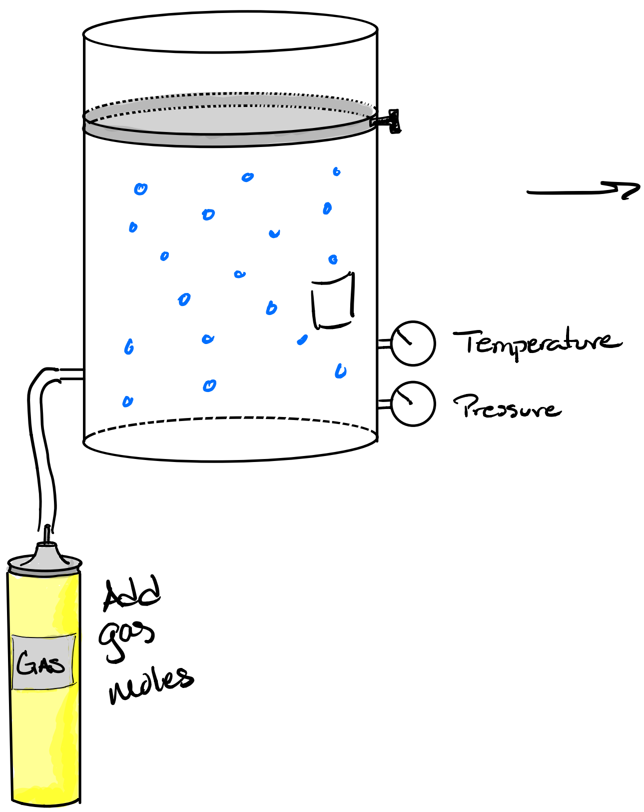
lbs/in^2

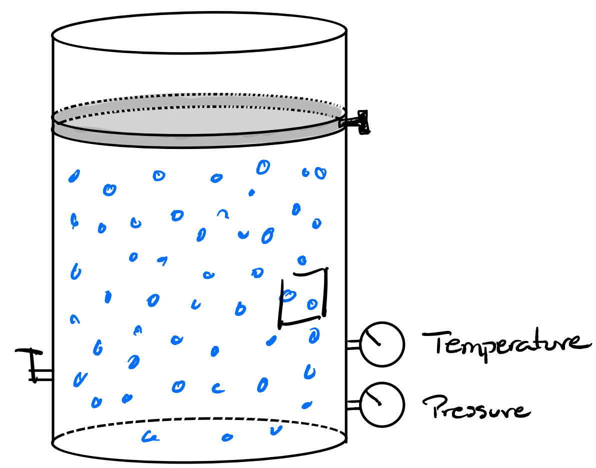


1 atmosphere = 14.7 lbs/in^2

Pressure vs. Moles

Temperature & Volume Constant





As more gas particles are added $\Rightarrow$ The number of collisions goes up.

# of collisions $\propto$ pressure

pressure goes up

$\uparrow P \propto n$ (moles) $\uparrow$

Directly proportional

Three things that are true

$$P \propto \frac{1}{V}$$

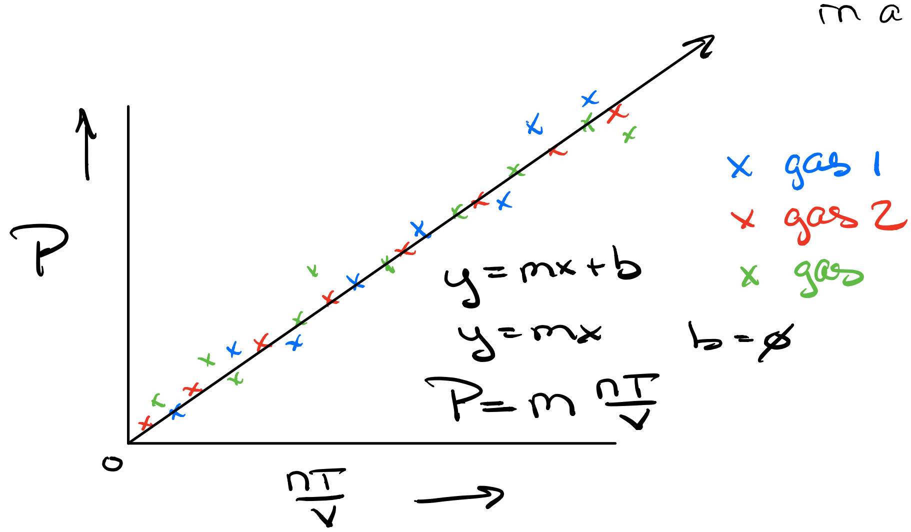
$$P \propto T$$

$$P \propto n \text{ (moles)}$$

$$P \propto \frac{nT}{V}$$

n — moles

N_A — # of atoms in a mole



$$y = mx + b$$

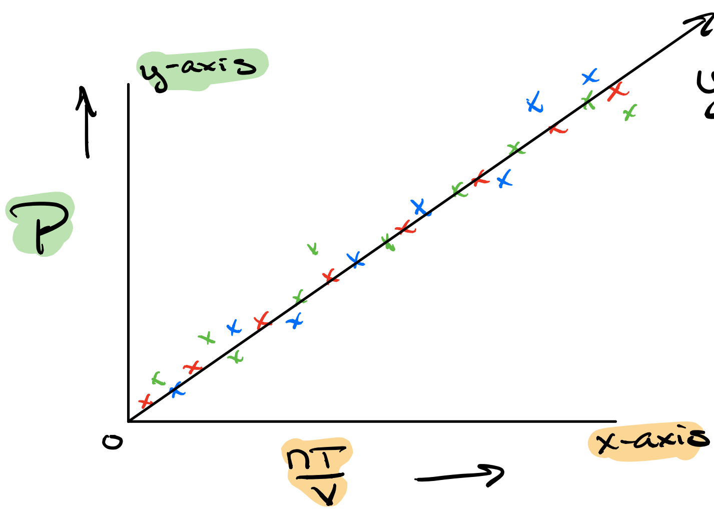
$$y = mx \qquad b = \emptyset$$

$$P = m\,\frac{nT}{V}$$

Slope $m = 0.0821 \ \frac{\text{L atms}}{\text{mole K}}$ = Universal Gas Constant

Formula for a line $\quad y = mx + b$

$\uparrow$ slope $\quad \uparrow$ y-intercept



$y = mx + b$

$\uparrow$ 0.0821 $\frac{L\,atm}{mole\,K}$ $\quad \uparrow$ y-int = 0

$$y = mx + b$$

$$P = m\,\frac{nT}{V} + 0$$

$$P = m\,\frac{nT}{V}$$

0.0821 $\frac{L\,atm}{mole\,K}$ = Universal Gas Constant & give it the variable R

3 sig figs

$$R = 0.0821\ \frac{L \cdot atm}{mole \cdot K}$$

Universal Gas Law

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

$$\boxed{PV = nRT}$$

where $R = 0.0821 \frac{L\,atm}{mole\,K}$

n = moles

P = pressure in atm

T = Temp in K

V = volume in Liters

Pressure Units

lbs/in^2 – physics

pascal = $1\ N/m^2$ 1 atm = 101,325 Pa

Chemistry

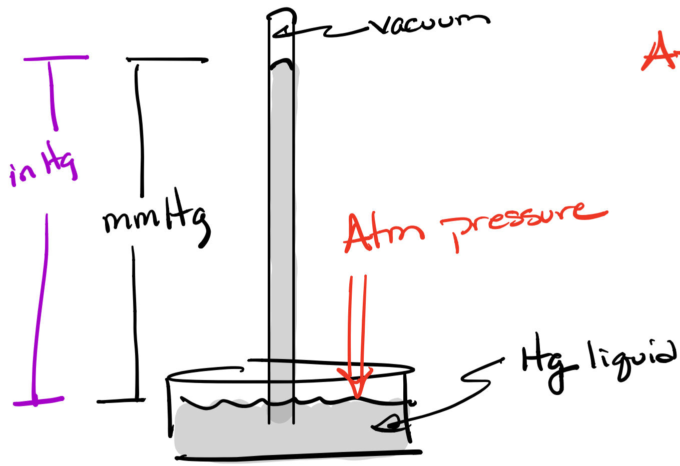
atmosphere (atm) 1 atm = 14.7 lbs/in^2

mmHg 1 atm = 760 mmHg

Torr = $\frac{1}{760}$ atm 1 atm = 760 torr

1 mmHg = 1 torr

mmHg - Barrometer



At 1 atm = 760 mmHg

1 atm = 29.9 in Hg

Ex Problems

A container holds 0.0362 moles of nitrogen gas. The container has a volume of 100.mL and a temperature of 25°C. What is the pressure in the container.

$P = ?$

$T = 25°C + 273.15 = 298.15\ K$

$V = 100.\ mL \times \frac{1\ L}{1000\ mL} = 0.100\ L$

$n = 0.0362$ moles N_2

$R = 0.0821\ \frac{L\,atm}{mol\,K}$

$$\begin{array}{r} 25 \\ 273.15 \\ \hline 298.15 \end{array}$$

$PV = nRT$

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

$$P = \frac{(0.0362\ \cancel{moles})(0.0821\ \frac{\cancel{L}\,atm}{\cancel{mol}\,\cancel{K}})(298.15\ \cancel{K})}{0.100\ \cancel{L}}$$

$= 8.86107763$ atm

$= \boxed{8.86\ atm}$

Ex

A can with a volume of 22.4 L has 6.753 g of nitrogen gas at 24.6 °C. What is the pressure in the can?

molar mass N_2 = 2 x 14.01 g/mole
= 28.02 g/mole

$P = ?$

$T = 24.6\,°C + 273.15 = 297.75\,K$ ✓

$V = 22.4\,L$ ✓

$n = \overset{4}{6.753\,g\,N_2} \times \dfrac{1\,\text{mole}\,N_2}{\underset{4}{28.02\,g\,N_2}} = 0.24\,|1006423983\text{ moles}$ ✓

$R = 0.0821\,\dfrac{L\,atm}{mol\,K}$ ✓

$PV = nRT$

$$P = \frac{nRT}{V} = \frac{\overset{4}{(0.2410064\text{ moles})}\overset{3}{\left(0.0821\,\frac{L\cdot atm}{mole\cdot K}\right)}\overset{4}{(297.75\,K)}}{\underset{3}{22.4\,L}}$$

extended →

$= 0.263|01197171\text{ atm } N_2$

$= \boxed{0.263\text{ atm } N_2}$

Temp Conversions

$\left(\frac{5}{9}\right)$

$°F \rightarrow °C$ $\quad (°F - 32) \times \frac{100}{180} = °C$

$°C \rightarrow °F$ $\quad °C \times \frac{180}{100} + 32 = °F$

$°C \rightarrow K$ $\quad °C + 273.15 = K$

°C	K
100°C	373.15
0°C	273.15

$$PV = nRT$$

$$\frac{P_1V_1}{n_2T_2} = R \leftarrow \text{constant}$$

$$\frac{P_2V_2}{n_2T_2} = R$$

$$\boxed{\frac{P_1V_1}{n_1T_1} = \frac{P_2V_2}{n_2T_2}}$$

Combined Gas Law