# Properties of Reservoir Fluids (PGE 362)

# Gasses

BY
DR. MOHAMMED A. KHAMIS
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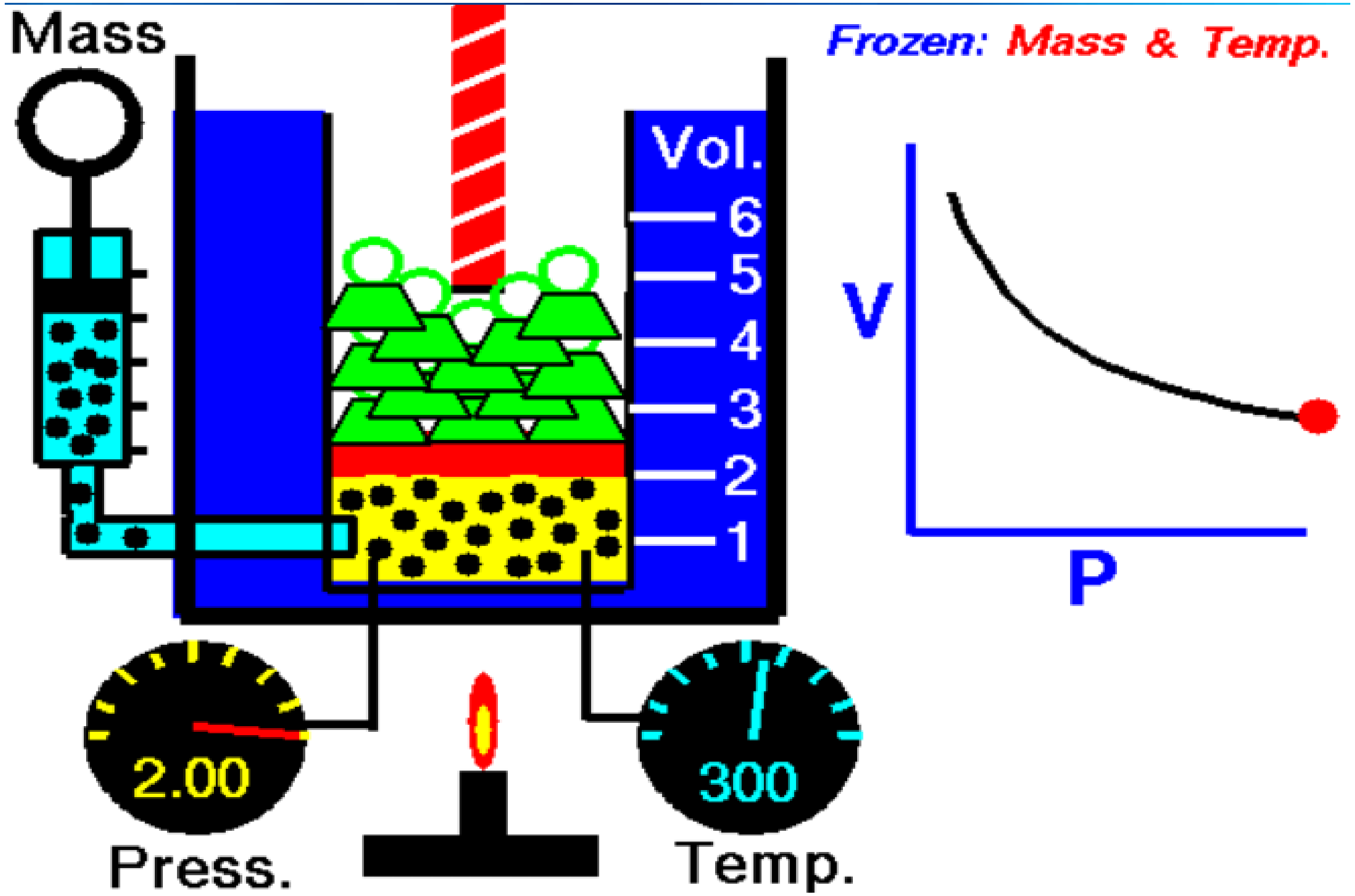
# Gas Laws



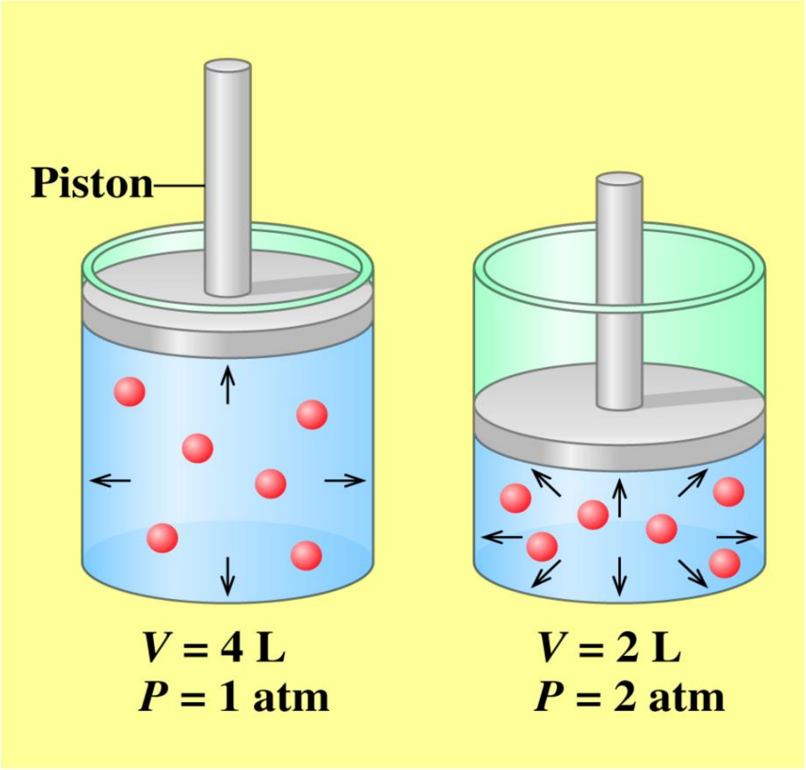
# Boyle's Law

The product of pressure and volume for a gas is constant for a fixed amount of gas at fixed temperature.

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

$$PV = constant$$

$P_i V_i = P_f V_f$ (T, n are constant)



# Boyle’s Law

In Boyle’s Law, the product pf PV is constant as long as T and n do not change.

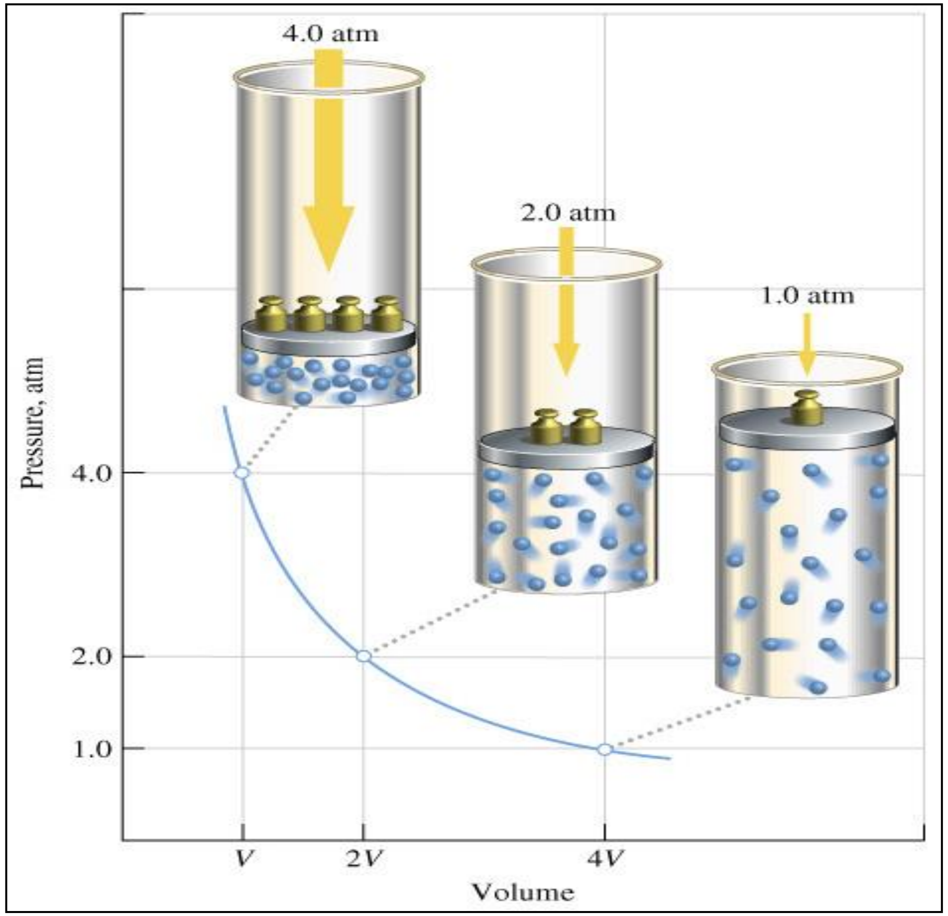
**Example:**

- $P_1V_1 = 10.0\ atm \times 4.0\ L = 40.0\ atm\ L$
- $P_2V_2 = 8.0\ atm \times 5.0\ L = 40.0\ atm\ L$
- $P_3V_3 = 4.0\ atm \times 10.0\ L = 40.0\ atm\ L$
- $P_4V_4 = 2.0\ atm \times ??\ L = 40.0\ atm\ L$

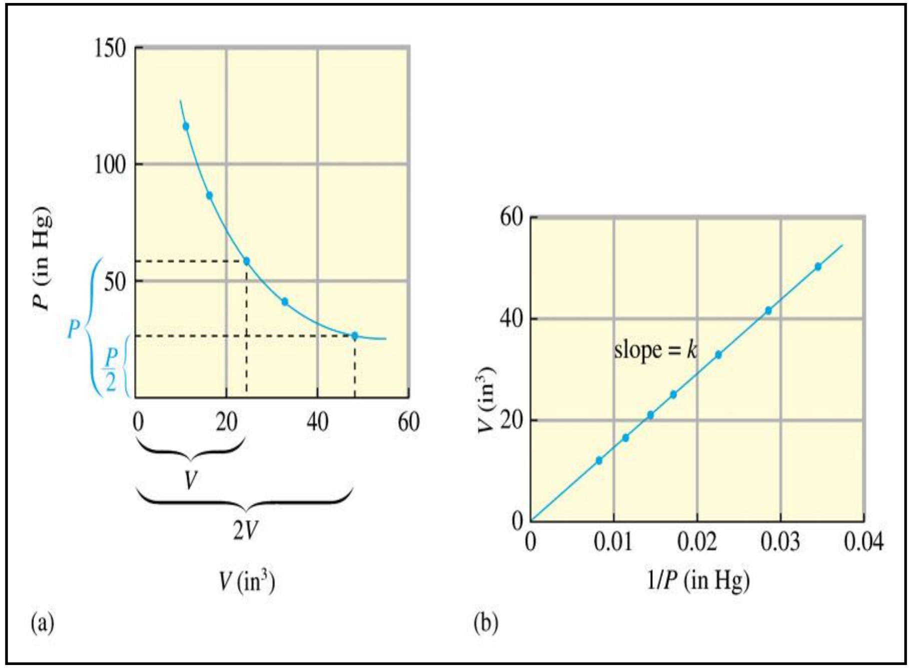
**Answer :**

$V_4$ = 20 L

# Boyle’s Law



4.0 atm
2.0 atm
1.0 atm
Pressure, atm
4.0
2.0
1.0
V
2V
4V
Volume

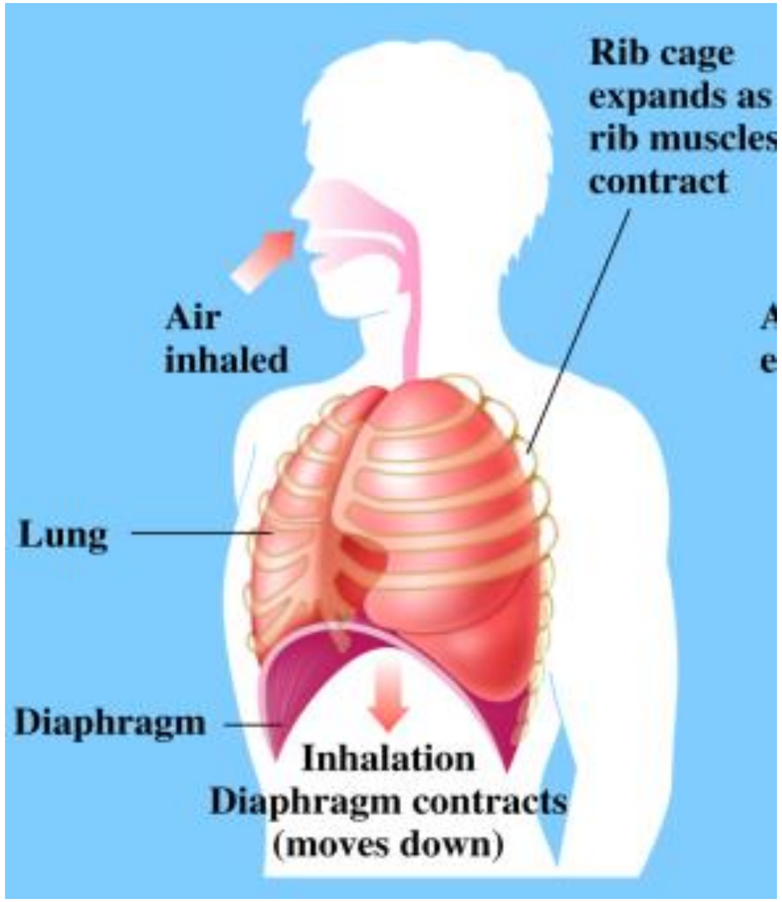



150
100
50
P (in Hg)
P
P/2
0
20
40
60
V
2V
V (in³)
(a)
60
40
20
0
slope = k
V (in³)
0
0.01
0.02
0.03
0.04
1/P (in Hg)
(b)

# Boyle’s Law

During an inhalation:

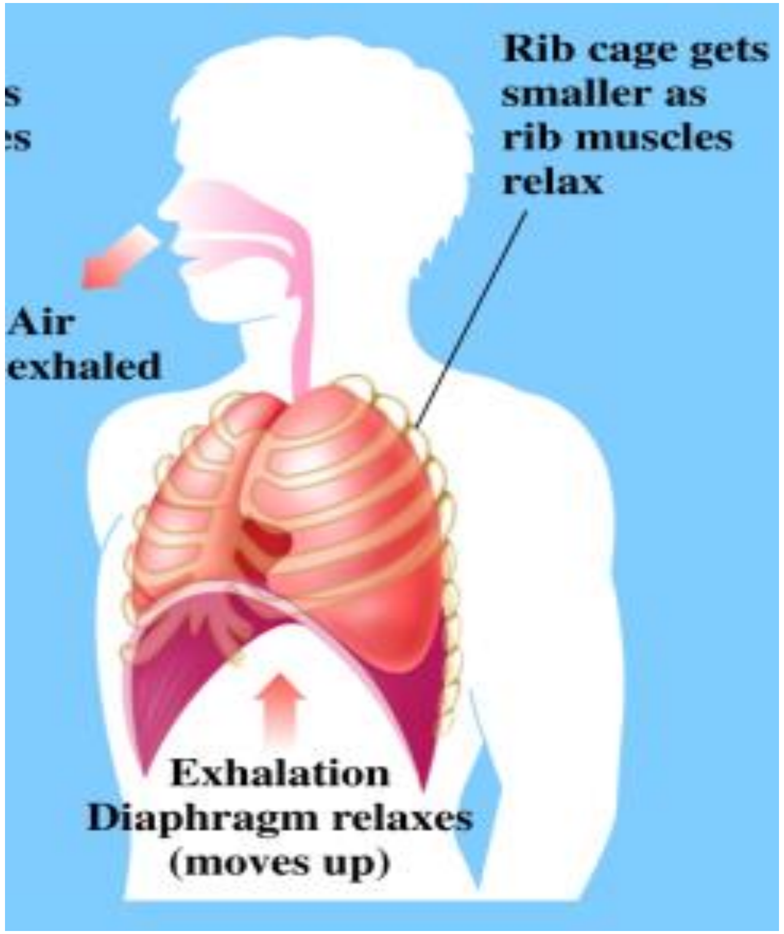
- ➢The lungs expand.
- ➢The pressure in the lungs decreases.
- ➢Air flows towards the lower pressure in the lungs.



# Boyle’s Law

During an exhalation:

- ➢The lungs volume decreases.
- ➢The pressure in the lungs increases.
- ➢Air flows from the higher pressure in the lungs to the outside.



# Charles Law

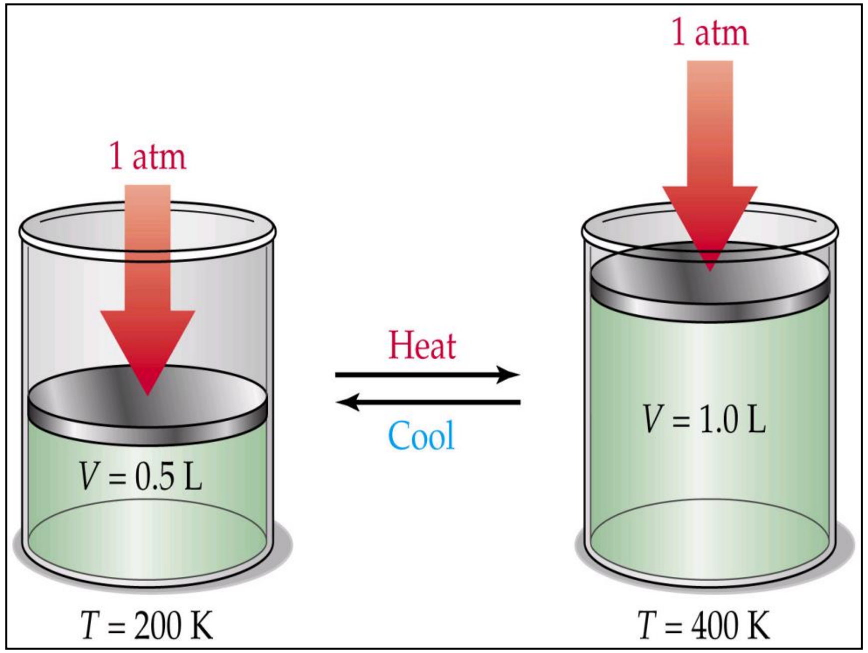
Volume of a gas varies directly with the absolute temperature at constant pressure.

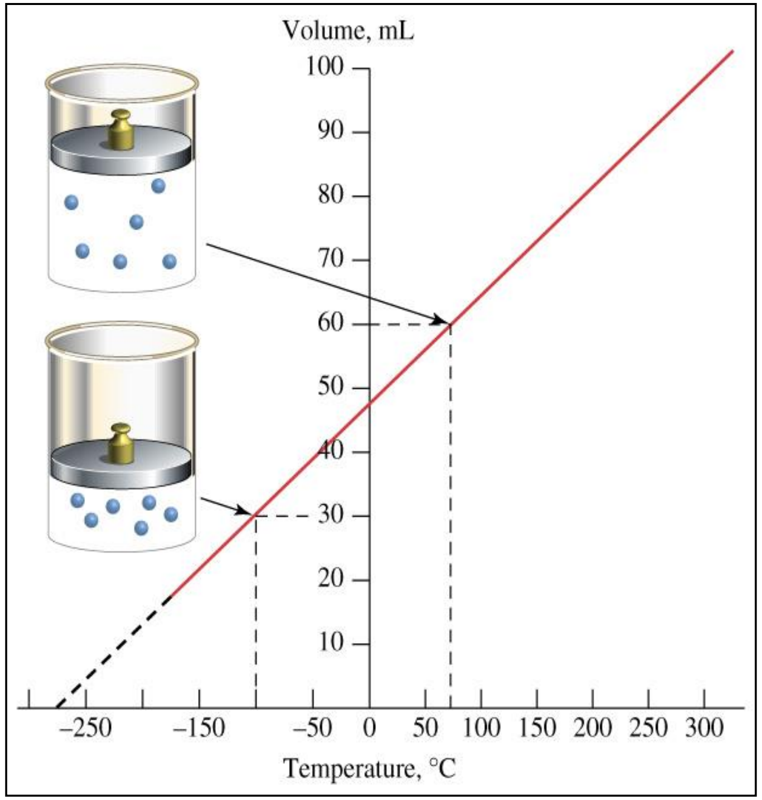
$V \propto T$

$\frac{V}{T} = constant$

$\frac{V_1}{T_1} = \frac{V_2}{T_2}$

$\frac{V_1}{V_2} = \frac{T_1}{T_2}$



# Avogadro's Law

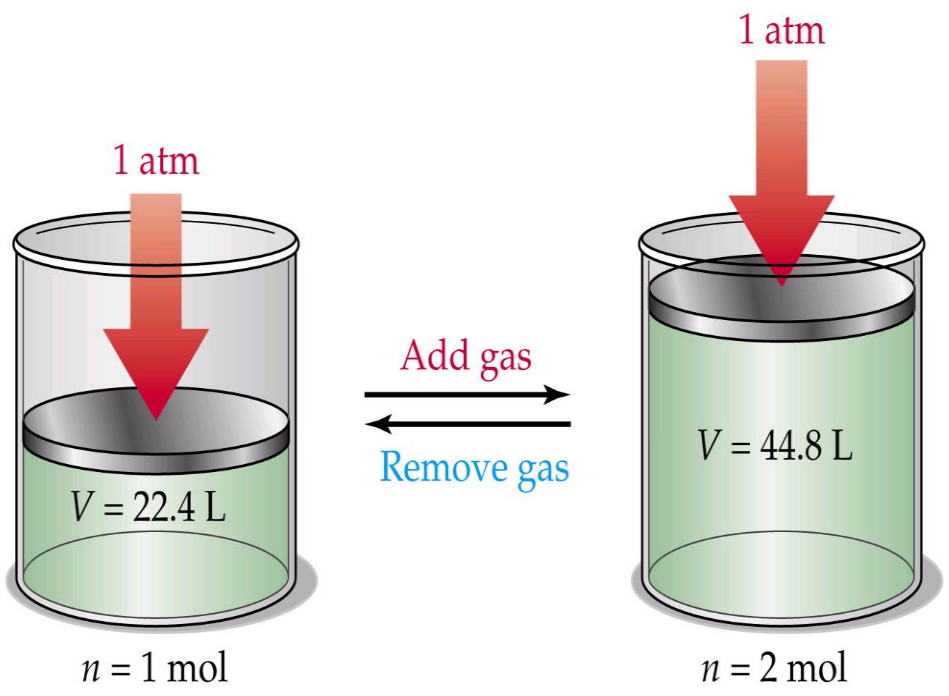
At constant temperature and pressure, the volume of a gas is directly related to the number of moles.

$V \propto n$

$\frac{V}{n} = constant$

$\frac{V_1}{n_1} = \frac{V_2}{n_2}$

$\frac{V_1}{V_2} = \frac{n_1}{n_2}$



# Gay-Lussac's Law

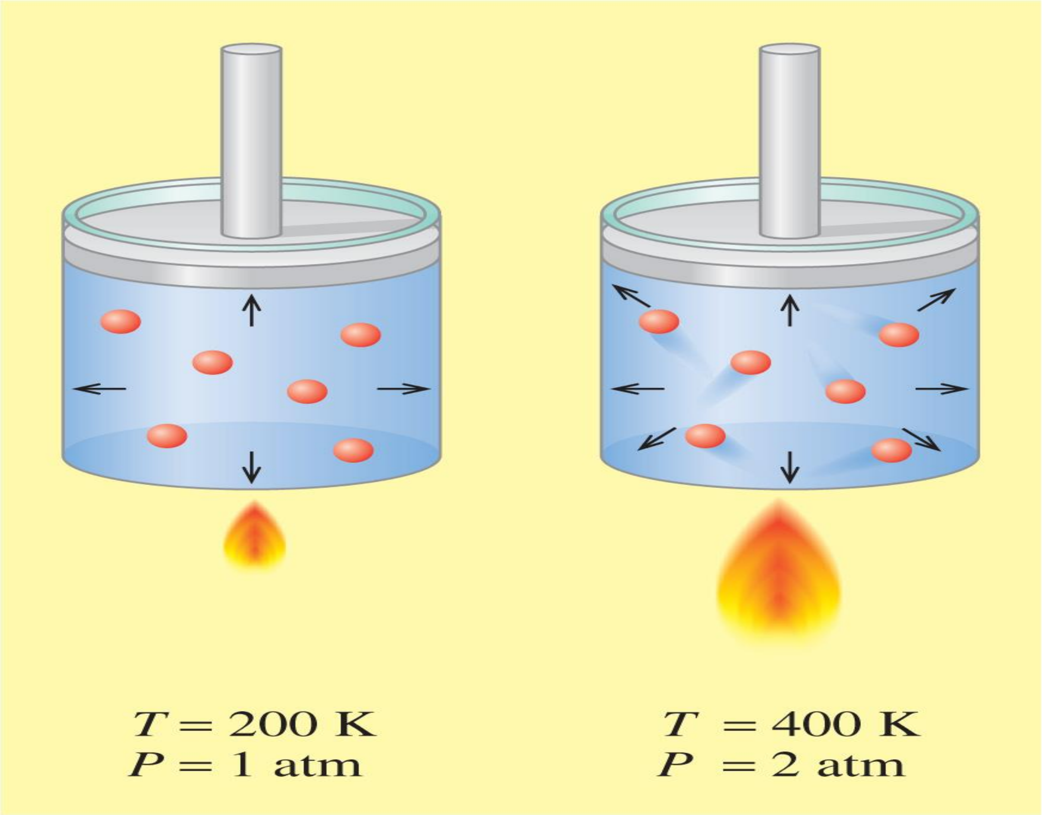
At constant volume, pressure and absolute temperature of a gas are directly related.

$$P \propto T$$

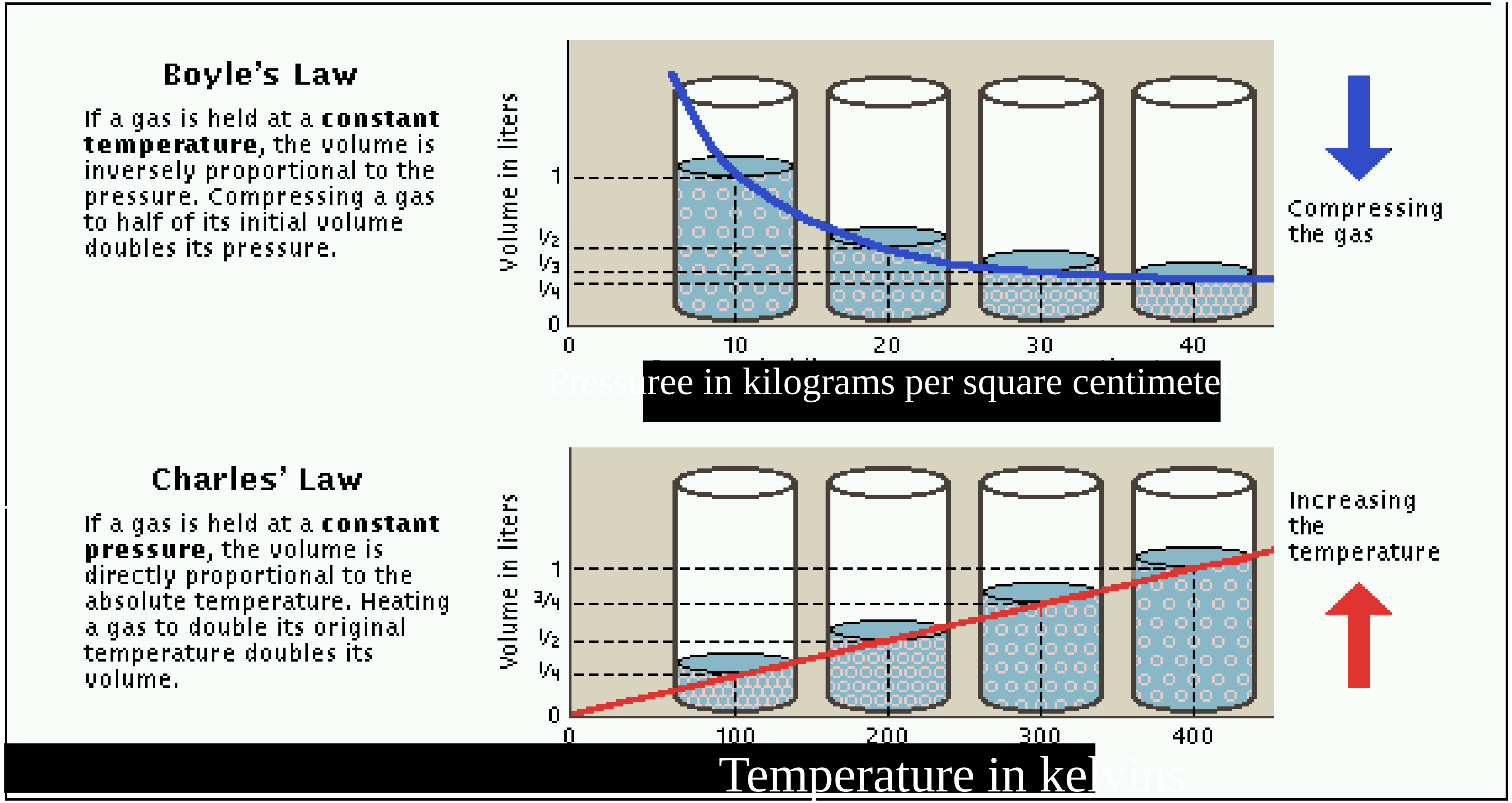
$$\frac{P}{T} = constant$$

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

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



# Combined Law



# Combined Law

| | | |
|---|---|---|
| Boyle's Law | $V = kP^{-1}$ | $P_1V_1 = P_2V_2$ (at a fixed temperature) |
| Charles' Law | $V = bT$ | $V_1 / V_2 = T_1 / T_2$ (at a fixed pressure) |
| Avogadro | $V = an$<br>$n$ = number of moles | (at a fixed pressure and temperature) |

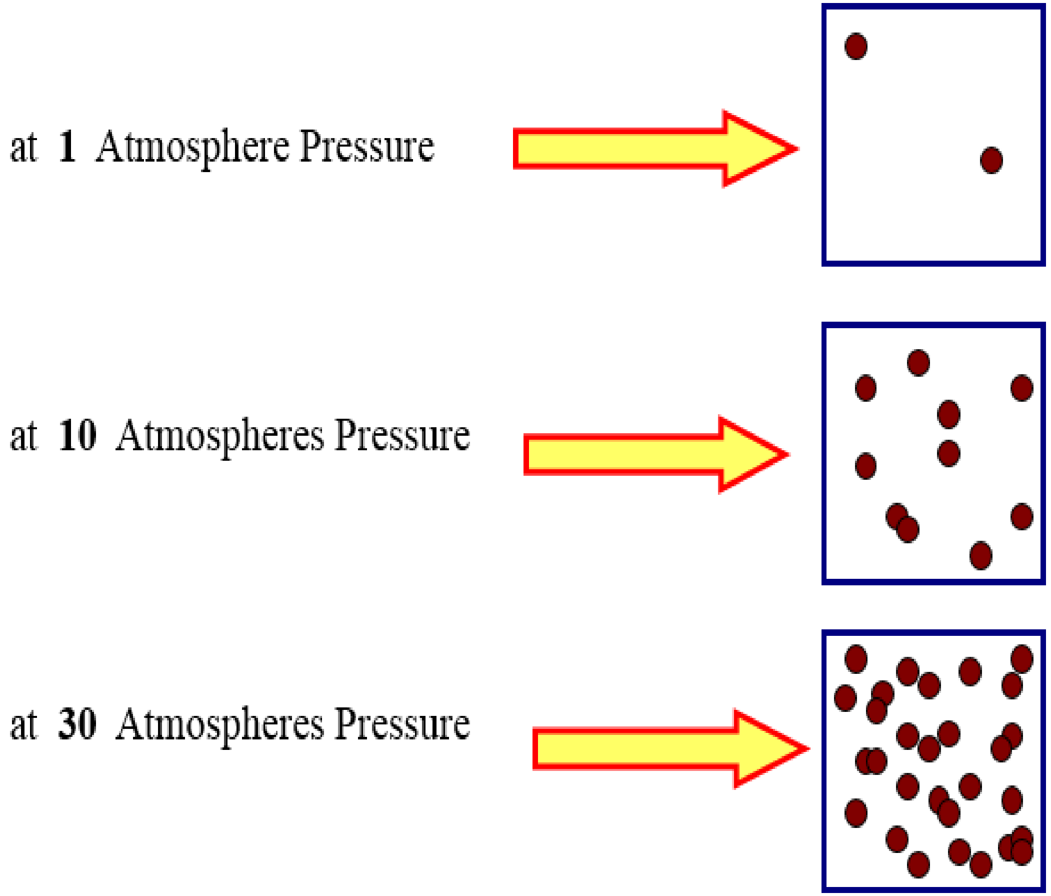
| | | |
|---|---|---|
| $V = nRTP^{-1}$ | **$PV = nRT$**<br>**ideal gas law** | an empirical law |

# Ideal vs. Real Gases

| | **Ideal Gas** | **Real Gas** |
|---|---|---|
| **Obey PV=nRT** | **Always** | **Only at very low P and high T** |
| **Molecular volume** | **Zero** | **Small but nonzero** |
| **Molecular attractions** | **Zero** | **Small** |
| **Molecular repulsions** | **Zero** | **Small** |

# Real Gases

- Real molecules do take up space and do interact with each other (especially polar molecules).
- Need to add correction factors to the ideal gas law to account for these.
- Ideally, the volume of the molecules was neglected



# Real Gases

But since real gases do have volume, we need:

## **Volume Correction**

- The actual volume free to move in is less because of particle size.
- More molecules will have more effect.
- Corrected volume $V' = V - nb$
- "*b*" is a constant that differs for each gas.

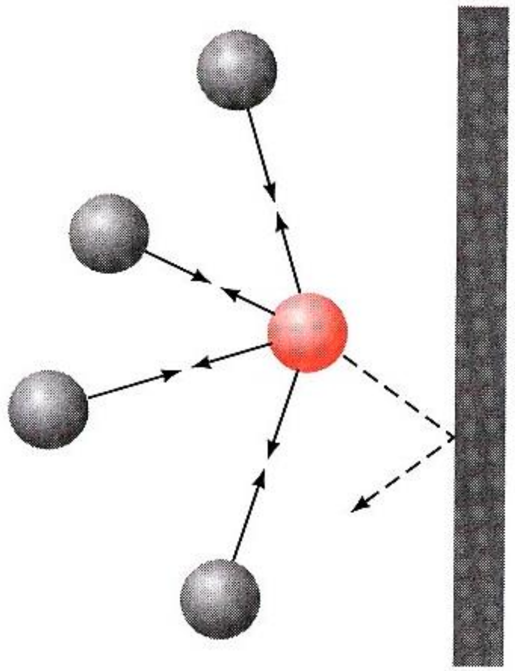
# Real Gases

But since real gases do have volume, we need:

## **Pressure Correction**

- Because the molecules are attracted to each other, the pressure on the container will be less than ideal.
- Pressure depends on the number of molecules per liter.
- Since two molecules interact, the effect must be squared

$$P_{observed} = P - a\left(\frac{n}{V}\right)^2$$



# Van Der Waal's Equation

$$[P_{obs} + a\left(\frac{n}{V}\right)^2](V - nb) = nRT$$

Corrected Pressure Corrected Volume

- "a" and "b" are determined by experiment
- "a" and "b" are different for each gas
- bigger molecules have larger "b"
- "a" depends on both size and polarity