Focus 1: Properties of gases

Focus 2: The First Law

Focus 3: The Second and Third Laws

Focus 4: Physical transformation of pure substances

Focus 5: Simple mixtures

Focus 6: Chemical equilibrium

Focus 17: Chemical kinetics

Focus 18: Reaction dynamics

Focus 19: Processes at solid surfaces

Focus 1: Properties of gases

Perfect gas

Kinetic model

Real gases

The perfect gas

physical properties ⟷ TD state of a system

n, v, p, and T

The perfect gas

physical properties ⟷ state of a system

↓

n, v, p, and T

Pressure

The perfect gas

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Pressure

Name	Symbol	Value
pascal	Pa	**1 Pa = 1 N m^{-2}, 1 kg m^{-1} s^{-2}**
bar	bar	**1 bar = 10^{5} Pa**
atmosphere	atm	**1 atm = 101.325 kPa**
torr	Torr	**1 Torr = (101 325/760) Pa** = 133.32… Pa
millimetres of mercury	mmHg	1 mmHg = 133.322… Pa
pounds per square inch	psi	1 psi = 6.894 757… kPa

* Values in bold are exact.

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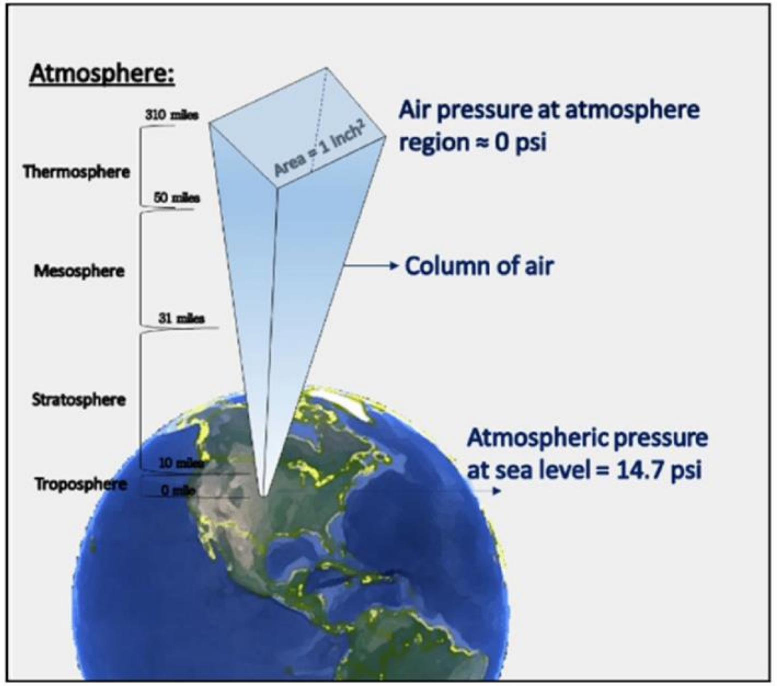
← SI unit for pressure

← $p^{\ominus}$

A pressure of 1 bar is the standard pressure for reporting data

Atmospheric pressure



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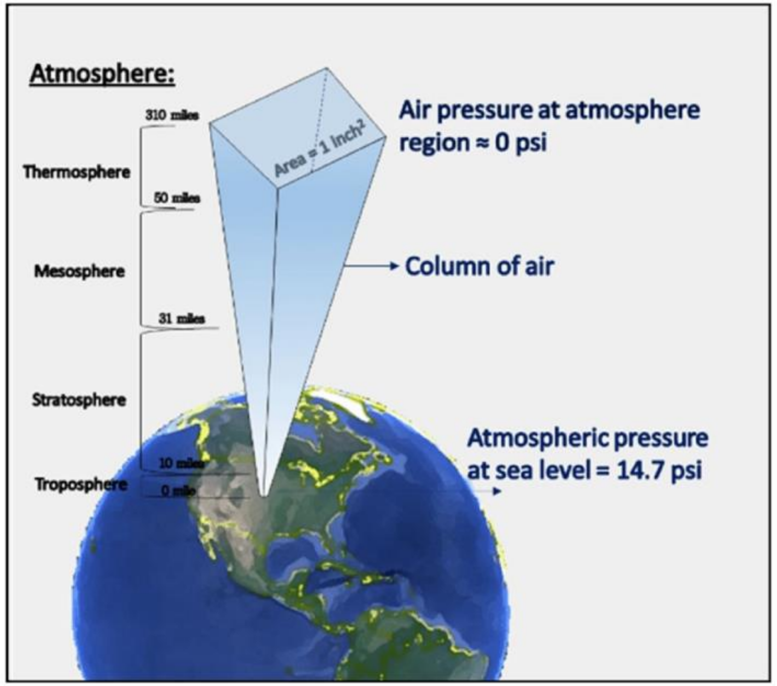

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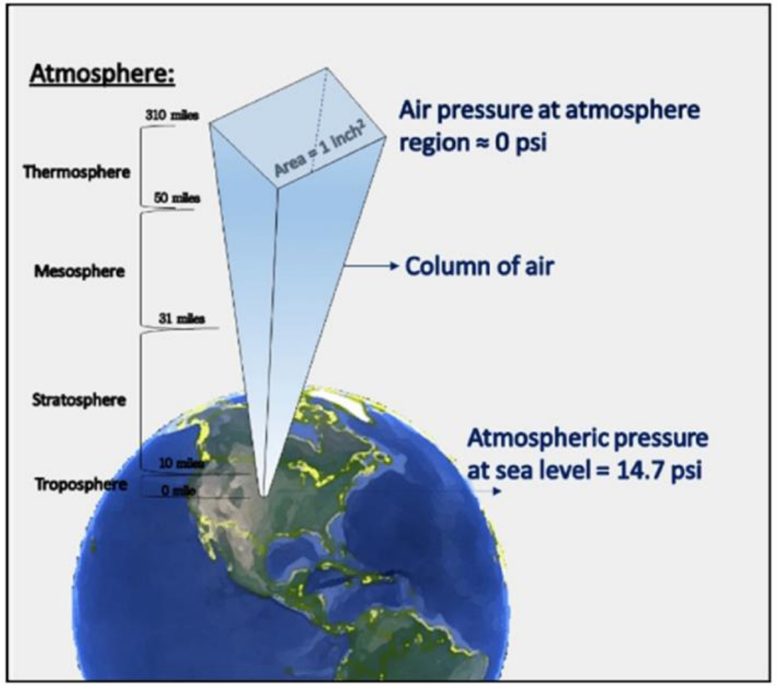
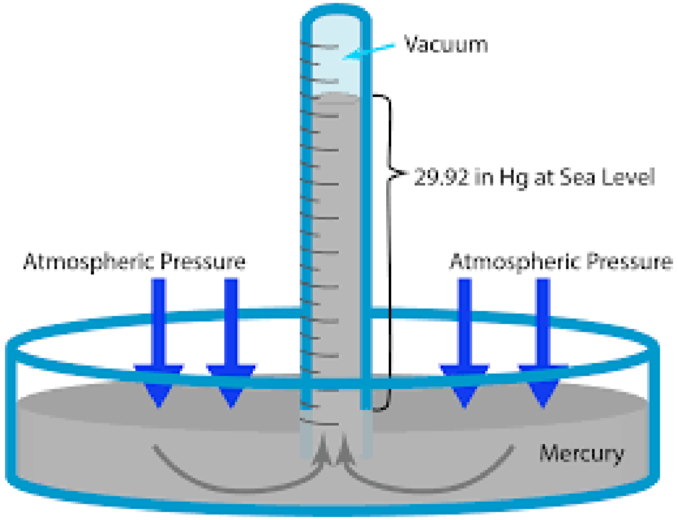
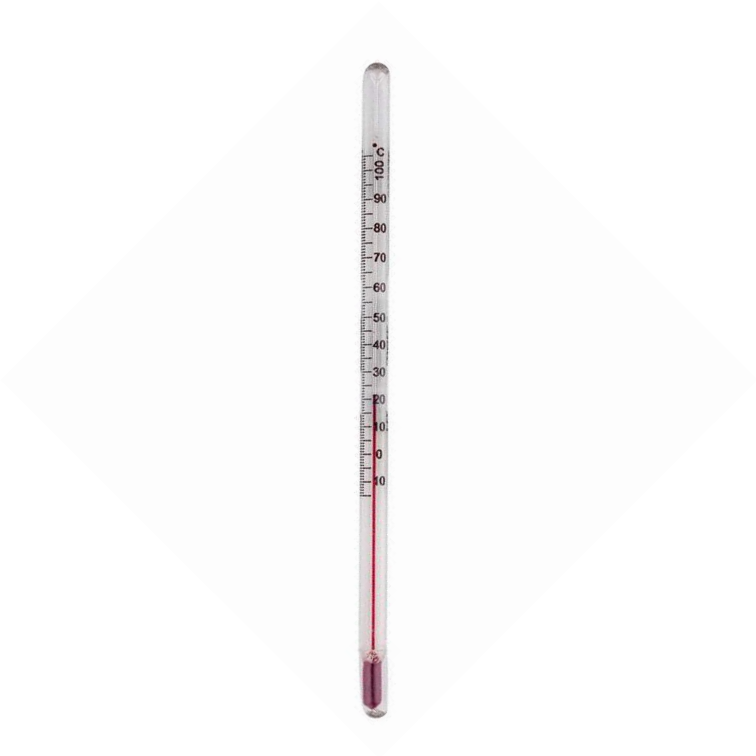




Pressure gauges

Temperature



Temperature is related to a length of a column of Hg

Thermocouple, resistance, solid-state sensor based

Temperature

On the thermodynamic temperature scale, temperatures are denoted T and are normally reported in kelvins (K; not °K).

$$T/\mathrm{K} = \theta/{}^\circ\mathrm{C} + 273.15$$

The temperature of the triple point of water is defined to be exactly 273.16 kelvin

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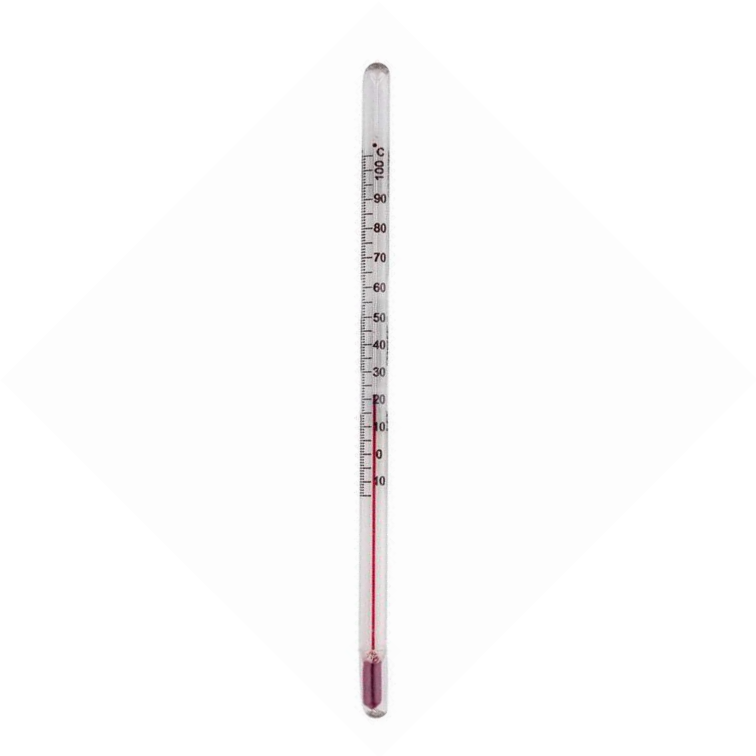

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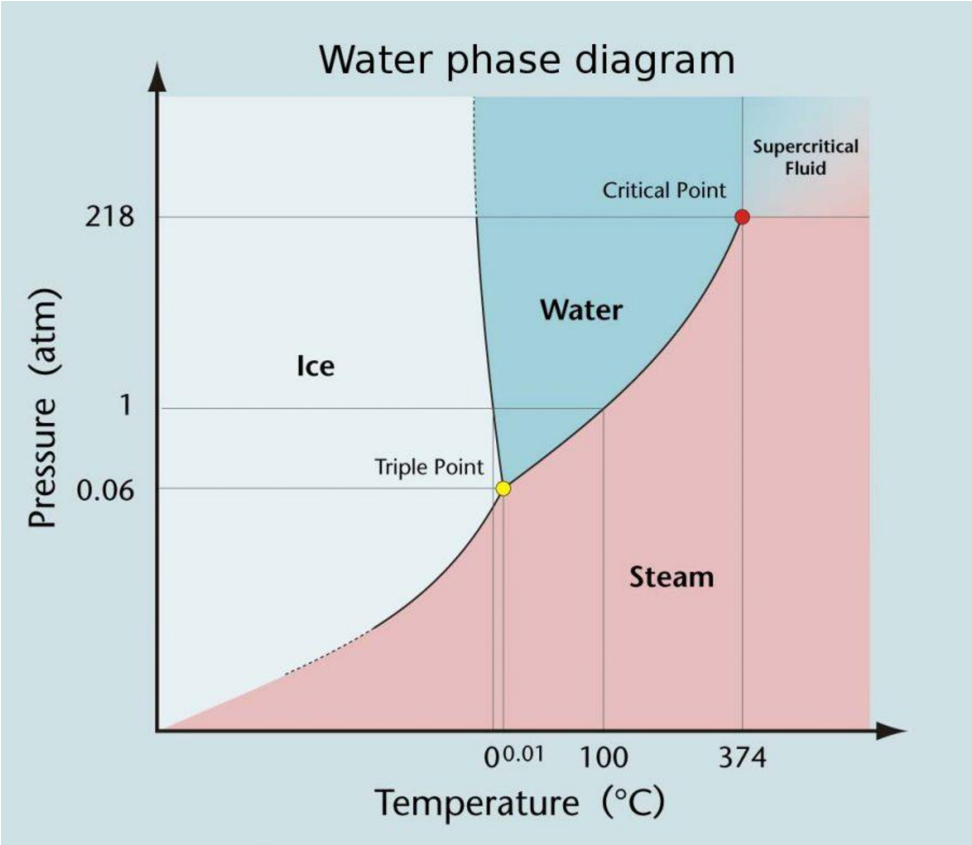

mole (n), Avogadro number (N_A), molar mass (M)

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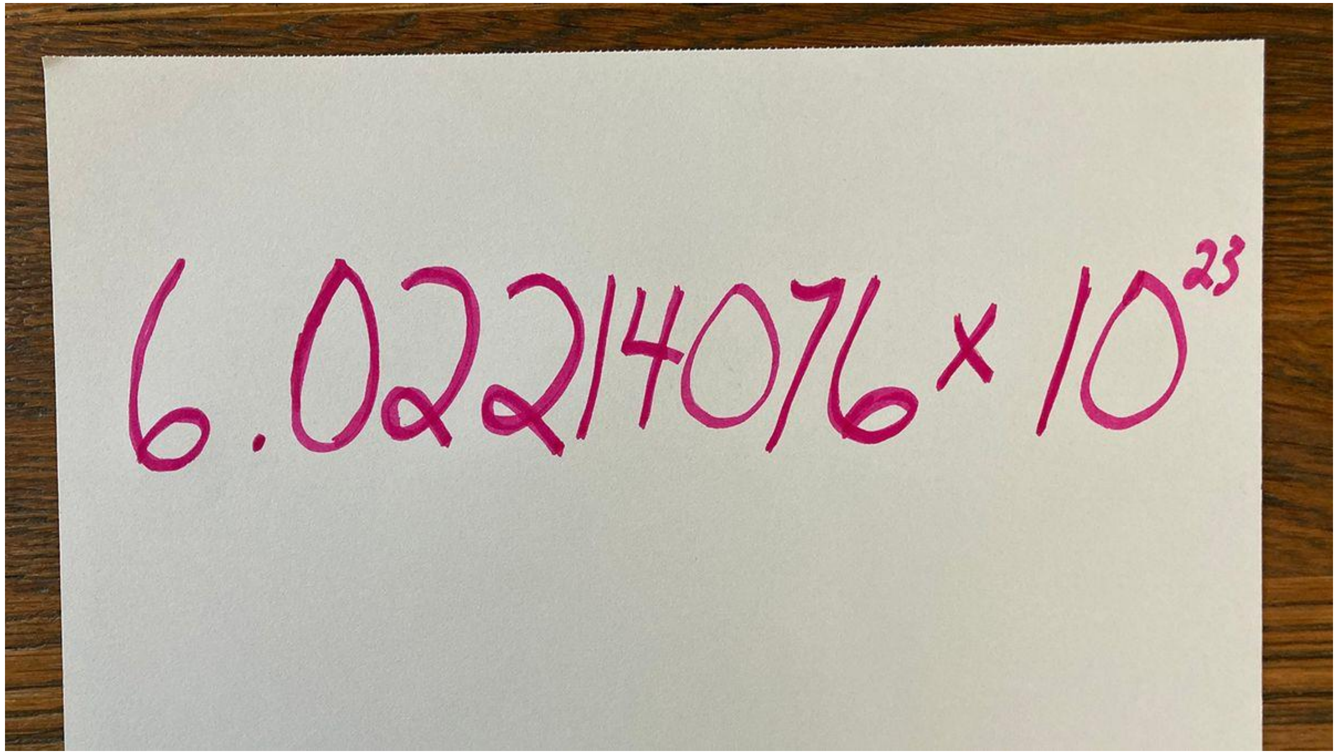
Measures the amount of substance



Equations of state

Empirical gas laws

Boyle's law: $pV = \text{constant, at constant } n, T$

Charles's law: $V = \text{constant} \times T, \text{ at constant } n, p$

$p = \text{constant} \times T, \text{ at constant } n, V$

Avogadro's principle:

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ideal gases

Ideal gas molecules do not attract or repel each other.

Ideal gas molecules themselves take up no volume.

The gas particles move randomly in agreement with Newton's Laws of motion.

The gas particles have perfect elastic collisions with no energy loss.

Equations of state

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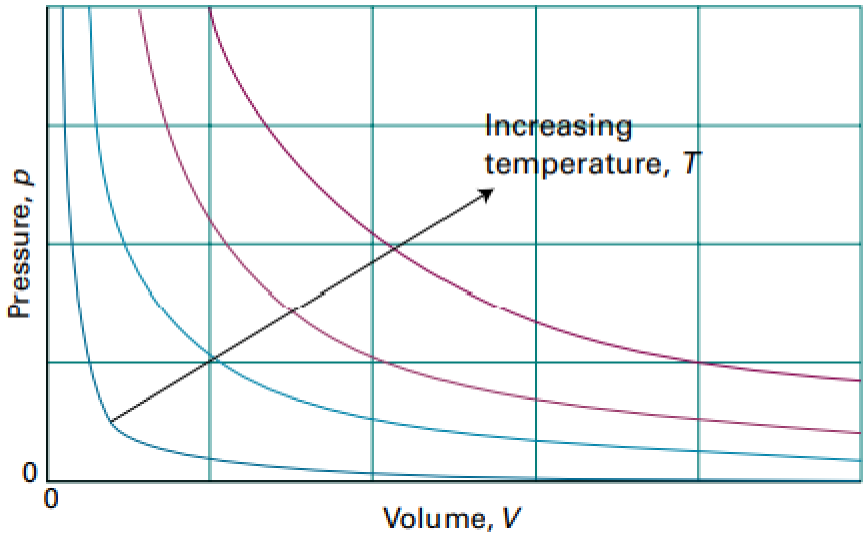
Energy can be transferred between the colliding objects, the total kinetic energy of the system remains the same before and after the collision.

Equations of state

Boyle's law: $pV = \text{constant, at constant } n, T$



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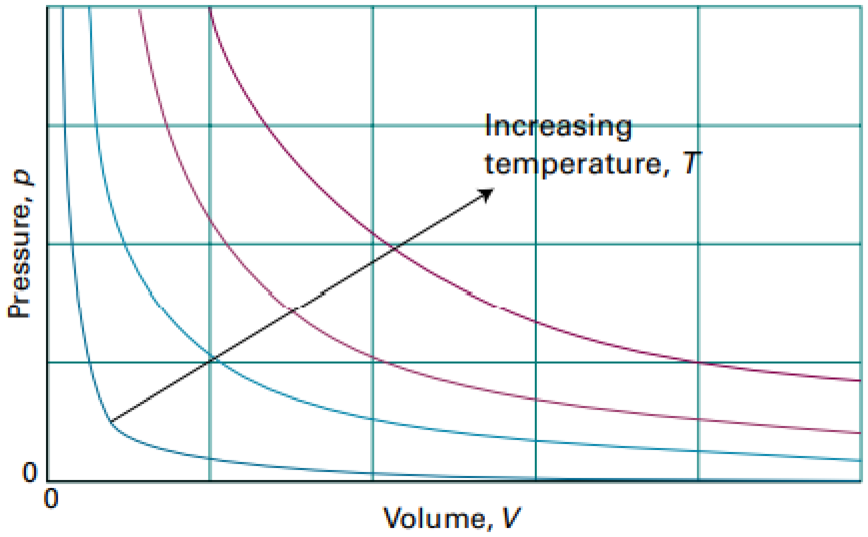
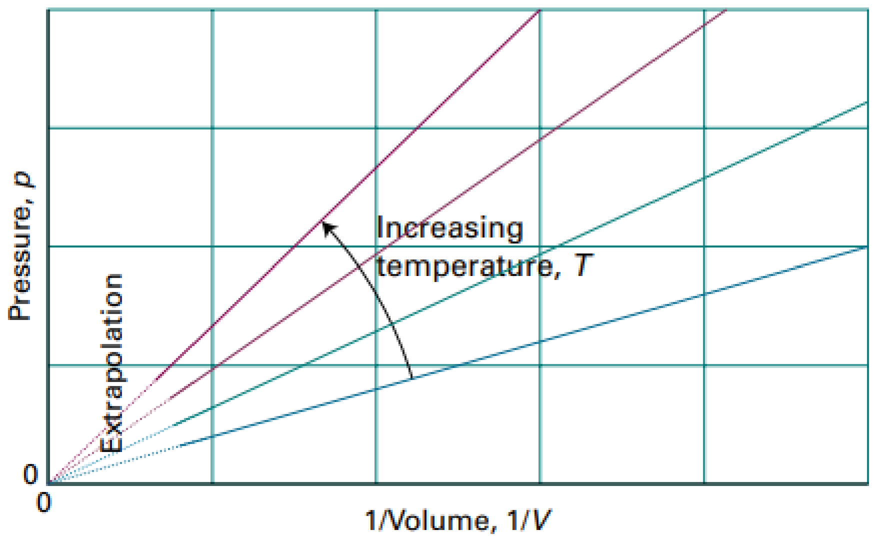
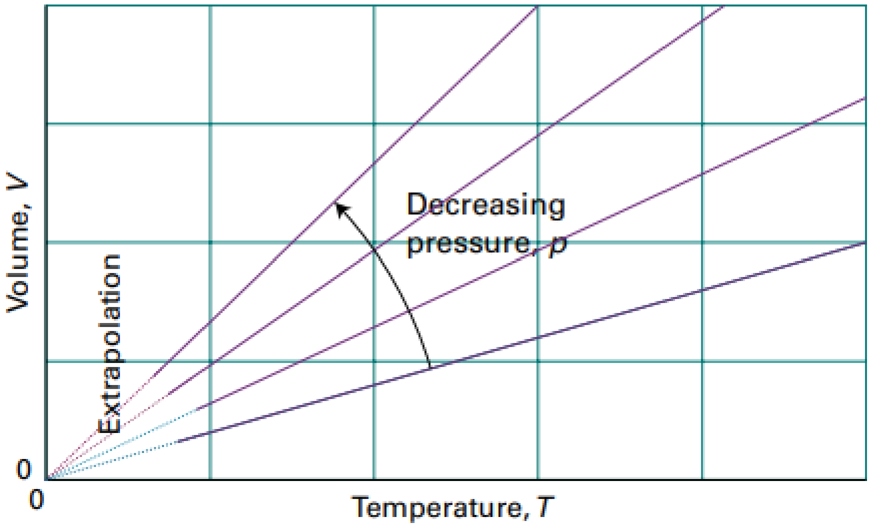




Equations of state

Charles's law: $V = \text{constant} \times T$, at constant n, p

$$p = \text{constant} \times T, \text{ at constant } n, V$$



The lines in this diagram are isobars

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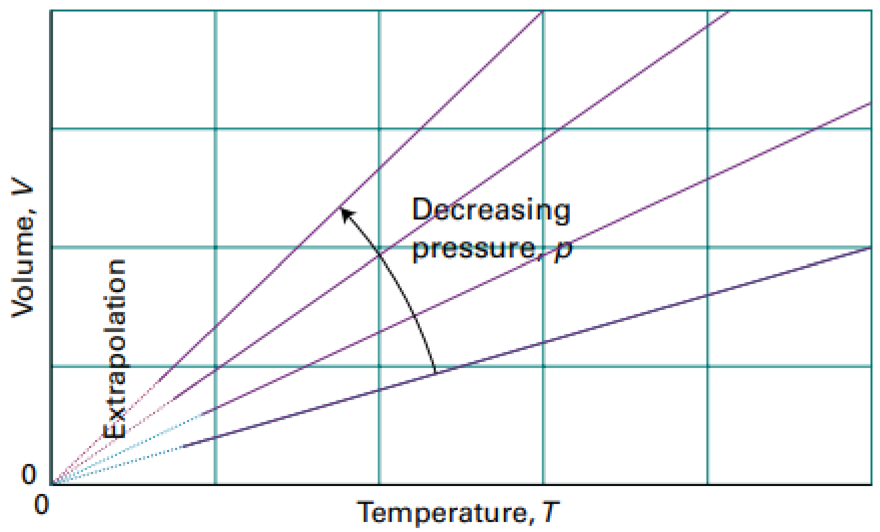

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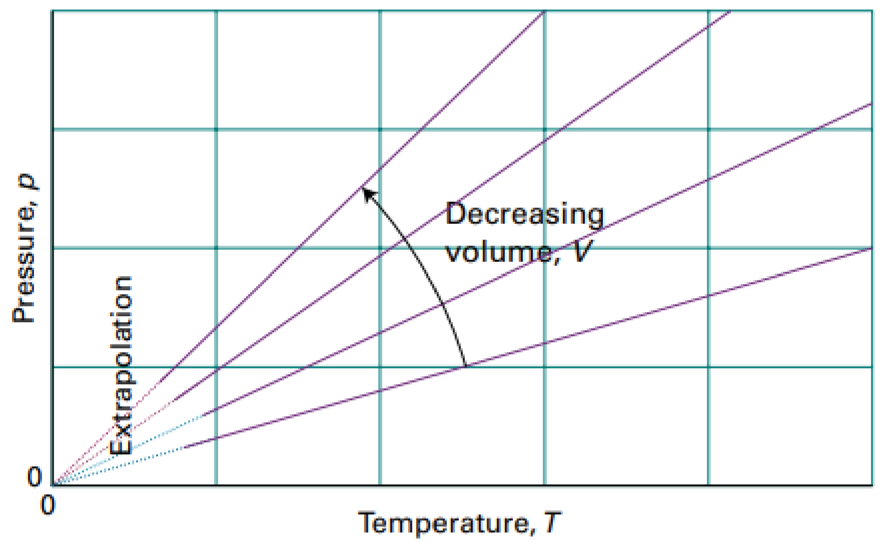

The lines in this diagram are isochores

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$$pV = \text{constant} \times nT$$

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Perfect gas law

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Perfect gas law

A gas that obeys the above equation exactly under all conditions is called a perfect gas

SATP and STP conditions

SATP

Standard ambient temperature and pressure

T = 298. 15 K (25 ^{O}C)

P = 1 bar

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SATP

Standard ambient temperature and pressure

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$P = 1$ bar

Molar volume = v/n = 24.789 $dm^3\ mol^{-1}$

STP

Standard temperature and pressure

$T = 273.15$ K ($0\ ^{O}C$)

$P = 1$ atm

Molar volume = v/n = 24.414 $dm^3\ mol^{-1}$

Gas mixtures

For ideal gases,

partial pressure; $$p_J = x_J p$$

Gas mixtures

partial pressure: $p_J = x_J p$

mole fraction

$x_J = \frac{n_J}{n}$ $\qquad$ $n = n_A + n_B + \cdots$

Gas mixtures

$$p_A + p_B + \cdots = (x_A + x_B + \cdots)p = p$$

total pressure

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Dalton's law:

Only for ideal gases =>

The pressure exerted by a mixture of gases is the sum of the pressures that each one would exert if it occupied the container alone.