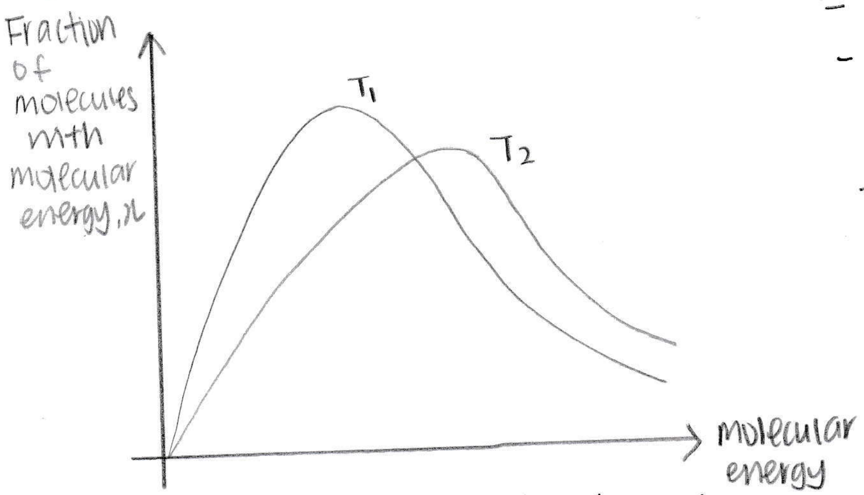
Chapter 7: The gaseous state

Assumptions of Ideal Gas

*1. gas particles are of negligible size and occupy negligible volume
*2. gas particles have negligible intermolecular forces of attraction
3. gas particles are in continuous, rapid, linear and random motion
4. collisions between gas particles are perfectly elastic
5. Average kinetic energy is proportional to temperature on the kelvin scale

Maxwell-Boltzmann Distribution of Molecular speeds / Energies



* area under the graph must remain the same at different temperatures
  ↳ for the same gas

- maximum point : most probable speed
- area under graph : proportional to the total number of gas molecules
- at higher temperature, peak of the graph shifts right and down and graph becomes flatter
  ↳ average energy of the molecules increases
    · fraction of molecules with low energies decreases
    · fraction of molecules with high energies increases
  ↳ fewer molecules with the most probable speed but higher proportion of molecules moving at greater speeds.

Ideal gas equation

$$\boxed{pV = nRT}$$

pressure in Pa or Nm^{-3} (p)
volume in m^3 (V)
no. of moles (n)
from data booklet 8.31 $JK^{-1}mol^{-1}$ (R)
temperature in K (T)

when it involves molar mass,

$$\boxed{M_r = \frac{mRT}{pV}}$$

when it involves density,

$$\boxed{\rho = \frac{m}{V} = \frac{pM}{RT}}$$

Partial Pressures

Dalton's law states that the total pressure of a mixture of gases is equal to the sum of the partial pressures of each component gas (provided the gases do not react chemically).

$$\boxed{P_T = P_A + P_B + P_C + \dots}$$

- pressure each gas would exert if it was alone in the container at the same temperature

mole fraction

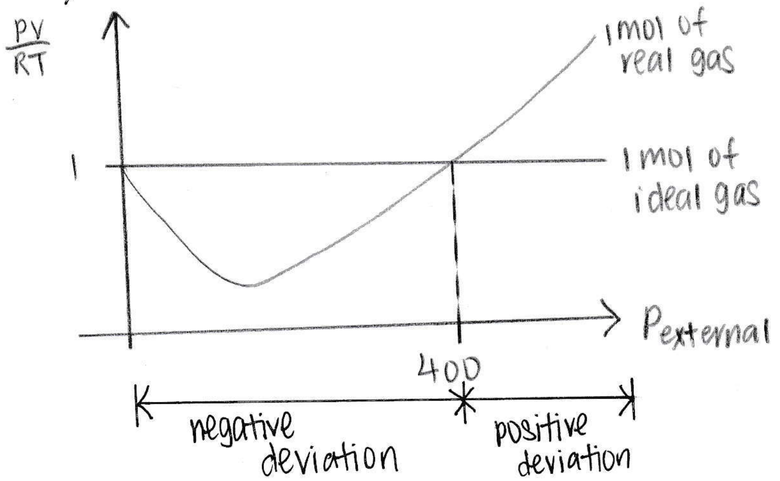
$$\boxed{P_A = \frac{n_A}{n_T} P_T}$$

Real gases and deviations from ideality

Real gases behave most ideally under

① Low pressures
↳ gas particles are far apart
↳ occupy negligible volume compared to the volume of container
(assumption 1)
↳ forces of attraction between gas particles are virtually zero
(assumption 2)

⇒ Deviations



negative deviations:
- due predominantly to intermolecular forces of attraction
↳ molecules that are about to strike the walls of the container experiences intermolecular attraction
↳ impact on walls is reduced
↳ pressure is less than expected
↳ pv is smaller than ideal

Positive deviations:
- due predominantly to molecular volume
↳ molecules are pushed so close together that size cannot be considered negligible
↳ molecules occupy a significant volume
↳ gas is less compressible
↳ volume is greater than expected
↳ pv is higher than ideal

* H_2 and He do not show the typical dip
↳ intermolecular forces in these gases are too weak
↳ molecular volume predominates at all pressures

② High temperatures

↳ high kinetic energy

↳ can overcome forces of attraction between particles

↳ negligible intermolecular forces of attraction between the particles (assumption 2)

⇒ Deviations

↳ By lowering temperatures, gas molecules slow down

- kinetic energy of these molecules decrease
- not high enough to overcome the intermolecular forces of attraction
- molecule striking the wall of the container experiences a force of attraction from other molecules
- pulled back
- lessens the impact on the wall
- pressure is less than ideal

Types of gases that deviate from ideality + reason

① Polar gases deviate more

↳ strong intermolecular forces of attraction like pd-pd & H-bond

② Non-polar deviate less

↳ weak intermolecular forces of attraction like id-id

③ Large and heavy molecules deviate more

↳ significant molecular volume