

CH 3 : KINETIC THEORY OF GASES & RADIATION
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0. 1 : What is an ideal gas or perfect gas?			
State equation of an ideal gas	1) A gas consists of a very large number of		
Ans : Ideal gas : A gas obeying ideal gas	avtromoly small moloculos		
Ans . Ideal gas . A gas obeying ideal gas	2) The molecules of gas are spherical in		
equation at an pressures & temperature is	2) The molecules of gas are spherical in		
calleu as all lueal gas.	Shape, rigid & perfectly elastic.		
In an ideal gas intermolecular interactions	3) All the molecules of the same gas are		
are absent. It can't be liquefied by application	identical.		
of pressure or lowering the temperature. It	4) The actual volume occupied by the		
obeys all gas laws ie. Boyles' law, Charle's law,	molecules is very small compared to the		
Gay Lussacs's law.	total volume of the gas.		
The perfect gas equation is	5) The intermolecular forces of attraction		
PV = nRT	between gas molecules are negligible.		
where, n = No. of moles	6) The molecules moves in all possible		
R = Universal gas constant	direction with all possible velocities.		
P = Pressure of enclosed gas	7) The collisions of the gas molecules with		
V = Volume of enclosed gas	the wall of the cor	ntainer give rise to the	
T = Absolute temp.	pressure exerted by	the gas.	
	8) The collision are pe	rfectly elastic ie. There	
Q. 2 : What is equation of state? Derive the	is no loss of kine	tic energy during the	
equation of state for an ideal gas.	collision.		
OR Derive the ideal gas equation. PV = nRT.	9) Between two successive collisions, a		
Ans : Boyle's law : The volume of a gas is	molecule travels in a straight line with a		
inversely proportional to the pressure.	constant velocity.		
temperature being held constant	10) The time of collision is very small		
$\lambda = \frac{1}{2}$ (at constant T)	compared to the time for successive		
$\sqrt{\alpha} - \frac{1}{p}$ (at constant 1)	collisions		
Charle's law : The volume of a gas is directly			
proportional to the temperature, pressure	0.4 · Distinguish between ideal gas and real		
being held constant.			
V α T (at constant P)	Ans ·		
Gay Lussac's law : The pressure of a gas is		Pool Cos	
directly proportional to the temperature,			
volume being held constant.	1. luedi gas molecules	1. Redi gas molecules	
$P \alpha T$ (at constant V)	benave as ideal	nave finite size and	
Combining the 3 laws into a single relation for	particles le. They are	structure.	
a fixed mass of gas gives ideal gas equation.	like geometrical		
ΡV α Τ	points without size		
If the fixed mass of gas is n moles then -	and structure.		
PVαnT	2. These molecules	2. These molecules	
PV = nRT	have only	have translational,	
	translational motion.	vibrational and	
Where B is the proportionality constant or		rotational motion.	
Universal gas constant	3. There are no	3. Intermolecular	
	intermolecular forces	forces are present in	
0.3 · State the basic assumptions of kinetic	in this case.	this case.	
theory of gasses $[2M - Mar' 12 - Mar' 12]$			
M_{22}^{-1}			
iviai 11], [Sivi – iviai 12]			



Q. 5 : Mention the conditions under which a real gas obeys ideal gas equation.

Ans : A real gas obey ideal gas equation when temperature is very high and pressure is very low.

This is because the density of gas is very low under these conditions. Hence, molecules are far away from each other. At low temp. and high pressure, intermolecular forces become very important as the average separation between 2 molecules is very less compared to that at high temp & low pressures.

Q. 6 : Define the following :

Ans : 1) Free path : The distance travelled by the molecule between two successive collisions is called the free path.

It is denoted by λ .

S.I. unit = m, Dimension =
$$[L^1 M^0 T^0]$$

2) Mean free path : The average distance traversed by a molecule with constant velocity between two successive collisions is called the mean free path.

Maxwell formula for mean free path (λ) on the basis of law of distribution of molecular speed is - $\lambda = \frac{1}{N}$

ed is -
$$\lambda = \frac{1}{\sqrt{2}\pi d^2 \left(\frac{\Lambda}{V}\right)}$$

where, d = Diameter of molecule

N = No. of molecules in volume V S.I unit = m , Dimension = $[L^1 M^0 T^0]$

3) Mean (Average) speed (\bar{v}) : It is defined as the arithmetic mean of the speeds of all molecules of the gas at given temperature.

$$\overline{v} = \frac{v_1 + v_2 + \dots + v_N}{N}$$

4) Mean square speed $(\overline{\nu^2})$: It is defined as the square root of the arithmetic mean of the squares of the speeds of all molecules of gas at given temperature.

$$\overline{\boldsymbol{v}^2} = \frac{v_1^2 + v_2^2 + \dots + v_N^2}{N}$$

5) Root mean square velocity ($\sqrt{v^2}$) : It is defined as the square root of the arithmetic mean of the squares of the speeds of all molecules of gas at given temperature.

$$V_{\rm rms} = \sqrt{\overline{\boldsymbol{v}^2}} = \sqrt{\frac{v_1^2 + v_2^2 + \dots + v_N^2}{N}}$$

Q. 7 : Derive an expression for the pressure exerted by the gas on the basis of kinetic theory of gases.

Ans: Consider a gas enclosed in a cube having perfectly elastic sides.



Consider a molecule of mass m moving with velocity \bar{v} , about to collide with shaded wall S. The wall is parallel to YZ-plane. During collision v_x component of velocity will get reversed and $v_y \& v_z$ components are unchanged.

Hence change in momentum of the particle is- \triangle Px = Final momentum – Initial momentum

$$= (-m v_x) - (m v_x)$$

.

 \div Gain in momentum by the surface S =+2m v_x Time required to reach same wall again –

$$\triangle t = \frac{2L}{v_x}$$

Force on 1st molecule, $f_1 = \frac{change in momentum}{time}$

$$=\frac{2m\,v_{x1}}{\triangle t} = \frac{2m\,v_{x1}}{\frac{2L}{v_x}} = \frac{m\,v_{x1}^2}{L}$$

Where v_{x1} is the x-component of velocity of molecule 1.



:. Total force by other molecules 2,3,4, etc is- $F = \frac{m}{L} (v_{x1}^2 + v_{x2}^2 + v_{x3}^2 +)$

$$P = \frac{F}{A} = \frac{m (v_{x1}^2 + v_{x2}^2 + v_{x3}^2 + \dots)}{L \cdot L^2}$$

= $\frac{m N v_x^2}{V} \quad \dots (\overline{v_x^2} = \text{mean square speed})$

Now by symmetry,

$$\overline{v_x^2} + \overline{v_y^2} + \overline{v_z^2} = \frac{1}{3} \overline{v^2} = \frac{1}{3} v_{rms}^2$$

$$\mathbf{P} = \frac{1}{3} \frac{m N v_{rms}^2}{V}$$

Now, mN = M & $\frac{M}{V} = \rho$

:.
$$P = \frac{1}{3} \rho v_{rms}^2 = \frac{1}{3} \frac{M}{V} v_{rms}^2$$

Q. 8 : State Boyle's law. Deduce it on the basis of kinetic theory of an ideal gas.

Ans : Boyle's law : The volume of a gas is inversely proportional to the pressure, temperature being held constant.

ie.
$$V \propto \frac{1}{p}$$
(at constant T)
ie. PV = constant

On the basis of kinetic theory of gases, the pressure exerted by the gas is given by the gas is given by -

 $\mathsf{P} = \frac{1}{3} \, \boldsymbol{\rho} \, v_{rms}^2 = \frac{1}{3} \, \frac{M}{V} \, v_{rms}^2 = \frac{1}{3} \, \frac{m \, N \, v_{rms}^2}{V}$

where, N = No. of molecules of gas

m = mass of single molecule

V = Volume of gas

& v_{rms} = rms speed of gas

$$P V = \frac{1}{2} (m v_{rms}^2) \times \frac{2}{3} N$$

= (K.E. of gas molecule) x $\frac{2}{3} N$

For a fixed mass of gas, N is constant. Also since intermolecular forces are ignored, P.E. is zero. Thus only K.E. is the total energy which is always conserved.

∴ P V = constant

Q. 9 : Using expression for pressure exerted by gas, deduce expression for kinetic energy of a gas.

<u>OR</u> Assuming the expression for pressure exerted by gas, prove that K.E. per unit volume of gas is $\frac{3}{2}$ P.

<u>OR</u> Find expression for K.E. per unit volume of gas based on kinetic theory of gases.

Ans: On the basis of kinetic theory of gases, the pressure exerted by the gas is given by -

$$P = \frac{1}{3} \rho v_{rms}^2 = \frac{1}{3} \frac{M}{V} v_{rms}^2$$

where, v_{rms} = rms speed of gas M, V & ρ = Mass, Volume & Density of gas resp.

$$\therefore P V = \frac{1}{3} M v_{rms}^2$$
$$= \frac{2}{3} x \left(\frac{1}{2} M v_{rms}^2 \right)$$
$$= \frac{2}{3} x (K.E.)$$
$$K E = -\frac{3}{3} P V$$

 $\therefore \left[\begin{array}{c} \text{K.E.} = \frac{1}{2} \text{PV} \\ \text{Kinetic energy per unit volume is} - \end{array} \right]$

$$\therefore \qquad \frac{K.E.}{V} = \frac{3}{2} \mathsf{P}$$

Q. 10 : Using expression for pressure exerted by gas, deduce expression for rms speed of a gas molecule.

<u>OR</u>

Show that R.M.S. velocity of a gas molecule is directly proportional to the square root of it's absolute temperature.

Ans : On the basis of kinetic theory of gases, the pressure exerted by the gas is given by -

$$P = \frac{1}{3} \rho v_{rms}^2 = \frac{1}{3} \frac{M}{V} v_{rms}^2$$

where, $v_{rms} = rms$ speed of gas M, V & ρ = Mass, Volume & Density of gas resp.

$$\therefore \mathsf{P} \mathsf{V} = \frac{1}{3} \mathsf{M} v_{rms}^2 \qquad \dots \dots (1)$$

Now, $M = n M_0$ where, n = No. of moles of gas

& M₀ = Molar mass

$$PV = \frac{1}{3} n M_0 v_{rms}^2$$
(2)

Also the equation of state of ideal gas is -PV = nRT(3) where, R = universal gas constant





Thus rms speed of molecules of gas is directly proportional to square root of absolute temperature.

Q. 11 : Deduce expression for K.E. per mole of gas & K.E. per unit mass of gas.

Ans : Write up to equation (*) from Q. No. (7).

$$\frac{1}{3} n M_0 v_{rms}^2 = nRT$$

$$M_0 v_{rms}^2 = 3 nRT$$

$$\frac{1}{2} M_0 v_{rms}^2 = \frac{3}{2} nRT$$

$$K.E. \text{ per mole of gas} = \frac{3}{2} RT$$

Now, K.E. per unit mass of gas = $\frac{K.E. \text{ per mole}}{Molar \text{ mass}}$

K.E. per unit mass of gas =
$$\frac{3 R T}{2 M_0}$$

Q. 12 : Explain, on the basis of kinetic theory of gases, how the pressure of a gas changes if it's volume is reduced at constant temperature.

Ans : The average K.E. per molecule of a gas is constant at constant temperature. If volume of gas is reduced at constant temperature no. of collisions of gas molecules per unit time with the walls of the container increases. Thus increasing the momentum transferred per unit time per unit area ie. The force exerted by the gas on the walls. Hence, the pressure of gas increases.

Q. 13 : Explain Maxwell distribution of molecular speeds with necessary graph.

Ans : For a given mass of gas, the velocities of all molecules are not same, even when bulk parameters like pressure, volume & temperature are fixed. rms speed gives general idea of speeds.

Collisions change the direction & the speed of molecules, but in a state of equilibrium, the distribution of speed is constant.

Maxwell – Boltzmann distribution of molecular speeds is a relation that describes the distribution of speeds among the molecules of a gas at a given temperature.

We plot the graph of fraction of molecules (n_v) Vs. velocity (v) of gas molecules at particular temperature.



The total area under the curve gives fraction of the molecules whose speed is between 0 to ∞ . Since all then N molecules fall into this category, total area is –

$$\int_{0}^{\infty} n_{v} \, dv = 1$$

The area of strip with height n_v and width dv give the fraction $\frac{dn_v}{N}$.

$$\frac{dn_v}{n} = n_v dv$$

These are relative no. of molecules in the shaded portion of strip.

Q. 14 : What do you mean by Monatomic gas & Diatomic gas molecules.

Ans : Monatomic molecules : It has only 1 atom in a molecule. They need not be bound with any other atom.

eg. All noble gases like He, Ne, Ar, Cr, Xe etc.



Diatomic molecules : It has 2 atoms in a molecule. They need to bound with other molecule as they are unstable. eg. Br_2 , I_2 , N_2 , CI_2 , H_2 etc.

Q. 15 : What is meant by degrees of freedom? Explain the degrees of freedom for 1) an atom 2) a diatomic molecule.

Ans : Degrees of freedom : It is defined as the total number of co-ordinates or independent quantities required to describe the position & configuration of the system completely.

1) An atom : An atom (or a monatomic molecule) like He, treated as a point mass, has no rotational motion. Hence, it has only 3 degrees of translational freedom.

2) A diatomic molecule : The diatomic molecule can rotate about any axis at right angles to its own axis. Hence it has two degrees of freedom of rotational motion in addition to 3 degrees of freedom of translational motion along the three axes. So, a diatomic molecule has five degrees of freedom.

At high temperature, a diatomic molecule has 7 degrees of freedom - 3 of translation & 2 each of rotation & vibrational motion.

Q. 16 : State the law of equipartition of energy & hence calculate the molar specific heat of monatomic & diatomic gases at constant volume & constant pressure.

Ans : At absolute temperature T, the average energy for a gas molecule in thermal equilibrium, associated with each quadratic term (each degree of freedom), is $\frac{1}{2}$ K_BT, where K_B Is Boltzmann constant.

Monatomic gas : Here, each atom has only
 degrees of freedom of translational motion.
 ∴ Total internal energy per mole of gas is –

 $E = 3 \times \frac{1}{2} K_B T \times N_A$

where N_A is Avagadro number

 $\therefore E = \frac{3}{2} N_A K_B T$

Molar specific heat at constant volume is -

 $C_{v} = \frac{dE}{dT} = \frac{3}{2} N_{A} K_{B} = \frac{3}{2} R$ Now, By Mayer's relation - $C_{p} - C_{v} = R$... Molar specific heat at constant pressure is - $C_p = C_v + R$ $=\frac{3}{2}R + R = \frac{5}{2}R$ 2) Diatomic gas : Here, each molecule has 3 translational & 2 rotational degrees of freedom. ... Total internal energy per mole of gas is - $E = [3 (\frac{1}{2} K_B T) + 2 (\frac{1}{2} K_B T)] N_A$ $=\frac{5}{2}K_{B}T \times N_{A}$ $=\frac{5}{2}$ N_A K_B T Molar specific heat at constant volume is - $C_v = \frac{dE}{dT} = \frac{5}{2} N_A K_B = \frac{5}{2} R$ And at constant pressure is – $C_{p} = C_{v} + R$ $=\frac{5}{2}R + R = \frac{7}{2}R$ Note : For a monatomic gas, adiabatic constant - $\gamma = \frac{C_p}{C_p} = \frac{\frac{3}{2}R}{\frac{3}{2}R} = \frac{5}{3}$

For a diatomic gas, adiabatic constant -

$$\gamma = \frac{C_p}{C_v} = \frac{\frac{7}{2}R}{\frac{5}{2}R} = \frac{7}{5}$$

Q. 17 : Derive Mayer's relation between the molar specific heat of a gas at constant pressure & that at constant volume.

<u>**OR</u> Prove that** $C_p - C_v = R$ with usual notation. **Ans :** Consider one mole of an ideal gas that is enclosed in a cylinder by light, frictionless air tight piston.</u>

Let P, V & T be the pressure, volume & temp. of the gas respectively.

1) If the gas is heated so that it's temperature rises by dT, but the **volume remains constant** then the amount of heat supplied (dQ_1) is used to increase the internal energy of gas (dE). Since volume of gas is constant, no work is done in moving the piston.

 $\label{eq:Q1} \begin{array}{ll} \therefore \ dQ_1 = dE = C_v \ dT &(1) \\ \mbox{Where, } C_v \implies \mbox{Molar specific heat of gas at constant volume} \end{array}$





Now, $C_p = M_0 s_p \& C_v = M_0 s_v$ \therefore Equation (1) becomes => $M_0 s_p - M_0 s_v = R$

$$S_p - S_v = \frac{R}{M_0}$$

If heat is measured in calories and work in joules then -

 $S_p - S_v = \frac{R}{M_0 J}$

Q. 19 : What is thermal radiation or heat radiation? State it's characteristic properties. Ans : Radiation is the mode of heat transfer or in general energy transfer by electromagnetic waves. Thermal radiation is the radiation produced by thermal agitation of the particles of a body & it's spectrum is continuous form far infrared to extreme UV region depending on the temp of the body.

Properties :

- 1) Thermal radiations are electromagnetic waves extending from far infrared to extreme UV region.
- They have same speed as that of light ie. 3 x 10⁸ m/s, which makes radiation the most rapid mode of heat transfer.
- 3) The exhibit all the optical phenomena of light like reflection, absorption, refraction, interference, diffraction & polarization.
- 4) Radiation incident on a body is partly reflected, partly absorbed & partly transmitted.

Q. 20 : Define coefficient of absorption, reflection & transmission. Obtain relation between them.

Ans: 1) Coefficient of absorption (Absorptive power or absorptivity) : The ratio of amount of radiant energy absorbed to total energy incident is called the coefficient of absorption.

a =
$$\frac{Q_a}{Q}$$

2) Coefficient of reflection (reflectance) : The ratio of amount of radiant energy reflected to total energy incident is called the coefficient of reflection.



$$r = \frac{Q_r}{Q}$$

3) Coefficient of transmission (transmittance) : The ratio of amount of radiant energy transmitted to total energy incident is called the coefficient of transmission.

 $\mathsf{t} = \frac{Q_t}{Q}$

Relation between a, t & r :

Let Q be the total radiant energy incident on the surface of the body.

 Q_{a} , Q_{r} , Q_{t} be the quantities of heat absorbed, reflected & transmitted by the body resp.

Then , $Q_a + Q_r + Q_t = Q$ Dividing by Q –

$$\therefore \frac{Q_a}{Q} + \frac{Q_r}{Q} + \frac{Q_t}{Q} = 1$$
$$\therefore a + r + t = 1$$

Q. 21 : Define athermanous substance & diathermanous substance with example. Ans : Athermanous substance : A substance which is largely opaque to thermal radiations ie. Do not transmit heat radiations incident on it, is called athermanous substance.

Here, t = 0 \therefore a + r = 1& coefficient of transmission t = 0. eg. Water, Wood, Iron , copper etc.

Diathermanous substances : A substance through which heat radiations can pass is known as diathermanous substance.

Here, $t \neq 0$. A diathermanous body is neither a good absorber nor a good reflector. eg. Glass, Quartz, hydrogen, Oxygen etc.

Q. 22 : What is a perfectly black body? State it's properties. How can it be realized in practice?

Ans: A body which absorbs the entire radiant energy incident on it, is called a perfectly black body.

For perfectly black body, a = 1, r = 0 & t = 0

Properties of perfectly black body :

- A perfectly black absorbs all the radiant heat incident upon it. (ie. a = 1)
- 2) The coefficient of emission of a perfectly black body is 1. It is very good emitter of heat.
- 3) It does not reflect or transmit the radiant heat incident upon it. (i.e. r = 0 & t = 0)
- 4) A perfectly black body does not exist in nature. For practical purposes lampblack or platinum black is treated as a perfectly black body which absorbs nearly 97% of incident radiant heat.

Realization of perfectly black body in practice :



Lampblack

Ferry designed a spherical black body which consists of a hollow double – walled sphere having tiny hole or aperture, through which radiant heat can enter. The space between the walls is evacuated & outer surface of the sphere is silvered. The inner surface of the sphere is coated with lamp black. There is a conical projection on the inner surface opposite to aperture.

Working : Radiations entering through the aperture suffers multiple internal reflections. Whenever the radiation falls on lampblack, about 97% of the incident radiation is absorbed. After a large number of reflections, almost all the radiant heat is absorbed by the sphere. Thus the aperture acts as a perfectly black body.



Q. 23 : With a neat labeled diagram explain,
Ferry's perfectly black body. [2M – Oct'14]
Ans : Draw diagram of Perfectly black body
from Q. No. (22).

Q. 24 : Define the terms :

 emissive power or radiant power
 coefficient of emission of body (Emissivity)
 Ans : 1) Emissive power (Radiant Power) : The quantity of radiant energy emitted by the body per unit area per unit time is called its emissive power at that temperature.

Every body radiates energy at all temperature except at the absolute zero temperature (0 K). If Q = Amount of radiant energy emitted

Q = Amount of radiant energy en

A = surface area of body

t = time for which body radiates energy then,

 $\mathsf{R} = \frac{Q}{At}$

S.I. unit = J/m^2s or W/m^2 Dimensions = $[L^0 M^1 T^{-3}]$

2) Coefficient of emission (emissivity) : It is the ratio of emissive power (R) of the surface to the emissive power of a perfectly black $body(R_B)$, at the same temperature.

 $e = \frac{R}{R_b}$

Note : For perfectly black body, e = 1 For perfect reflector, e = 0 For ordinary bodies, 0 < e < 1

Q. 25 : State Kirchhoff's law of radiation & give it's the theoretical proof. [3M – Mar'12] Ans : It states that the coefficient of absorption of a body is equal to its coefficient of emission at any given temperature.

 $\therefore a = e$ Theoretical proof :



Consider two bodies, ordinary body (A) & a perfect black body (B) of identical shapes placed in an enclosure. In thermal equilibrium, both bodies will at same temperature as that of the enclosure.

Let R = Emissive power of ordinary body A

R_b = Emissive power of black body B

Q = Quantity of radiant heat incident on each body in unit time

Q_a = Quantity of radiant heat absorbed by body A

a = coefficient of absorption

e = coefficient of emission

As the temp. of both bodies remain the same, both must emit the same amount as they absorb in unit time.

1) For ordinary body A:

Quantity of heat Quantity of radiant heat absorbed emitted $Q_a = R$ ∴ a Q = R(1) 2) For black body B : Quantity of radiant Quantity of heat = heat absorbed emitted $Q = R_B$(2) Equation (1) & (2) =>

quation (1) & (2) => $\frac{a Q}{Q} = \frac{R}{R_B}$ $\therefore a = \frac{R}{R_B}$ $\therefore a = e \qquad (\because \frac{R}{R_B} = e)$



Q. 26 :Explain about spectrum of black body radiation in term of wavelength. [2M–Oct'13] OR

Show graphical representation of energy distribution spectrum of perfectly black body. [2M – Mar'14]

<u>OR</u>

Explain spectral distribution of black body radiation. State it's characteristics.

Ans : Blackbody radiation the is electromagnetic radiation emitted by a blackbody due to temperature. It extends over the whole range of wavelengths of EM waves. Lummer & Pringsheim studied the energy distribution of blackbody radiation as a function of wavelength. The distribution of energy over the entire range of EM waves as a function of wavelength or frequency is known as the spectral distribution of blackbody radiation.



The curve shows graphical representation of variation of radiant power per unit area as a function of wavelength (λ) at different constant temperatures.

Characteristics :

- 1) The intensity of emitted radiation increases with increase in wavelength.
- 2) The intensity is maximum for a particular wavelength (λ_{max}) & then intensity decreases with further increase in wavelength.
- Area under the curve represents total energy emitted per second per unit area by the blackbody including all the

wavelengths & is proportional to T⁴ (Stefan – Boltzmann law).

4) λ_{max} depends on the absolute temp & with increasing temp, it shifts towards shorter wavelengths (Wien's displacement law).

Q. 27 : State Wien's displacement law.

Ans: It states that the wavelength for which emissive power of black body is maximum is inversely proportional to the absolute temperature of the black body.

i.e.
$$\lambda_{\max} \propto \frac{1}{T}$$

 $\therefore \lambda_{\max} = b \times \frac{1}{T}$

where b = Wien's constant = $2.897 \times 10^{-3} \text{ mK}$

This law is called displacement law because as temperature increases, the maximum intensity of radiation emitted by it gets shifted or displaced towards the shorter wavelength side.

Uses : To determine very high temperature of stars, sun, moon or celestial bodies.

Q. 28 : State Stefan - Boltzmann law of radiation.

Ans: The amount of radiant energy emitted per unit time per unit surface area of perfectly black body is directly proportional to the fourth power of its absolute temperature.

ie.
$$\frac{Q}{eAt} \propto T^4$$

or $R_b \propto T^4$
 $\therefore R_b = \sigma T^4$

where σ = Stefan's constant = 5.67 x 10⁻⁸ J m⁻² s⁻¹ k⁻⁴

- Q = Amount of radiant energy emitted by perfectly black body.
- A = Surface area of the perfect black body
- t = time for which black body emits radiant energy
- T = Absolute temperature of black body



FORMULAE
1) Ideal Gas equation :
$$PV = n \ R \ T$$

 $PV = N \ K_B \ T$ $(K_B = \frac{R}{N_A} \ \& \ N_A = \frac{N}{n}$)
2) No. of moles $= \frac{mass of gas}{Malar Mass} (M_0)$
 $= \frac{N_0 \ of gas molecules}{N_A = x^{M_A}} \ \& \ N_A = \frac{N}{n}$)
3) Coeff. of reflection : $r = \frac{Q_c}{Q}$
14) Coeff. of reflection : $r = \frac{Q_c}{Q}$
15) Coeff. of transmission : $t = \frac{Q_c}{Q}$
16) Relation between a, $r \ \& t$:
 $a + r + t = 1$
3) Mean free path : $\lambda = \frac{1}{\sqrt{2\pi} d^2} (\frac{R_0}{\sqrt{2}})$
4) Mean velocity (Average velocity)
 $p = \frac{V_A + V_B^A + \dots + V_A}{N}$
5) Mean square velocity :
 $\overline{v^Z} = \frac{v^2 + v_B^2 + \dots + v_A}{N}$
6) Root mean square velocity :
 $\overline{v^Z} = \frac{v^2 + v_B^2 + \dots + v_A^2}{N} = \sqrt{\frac{2R^2}{M_0}}$
7) Pressure exerted by gas molecules :
 $P = \frac{1}{3}\rho \ v_{rms}^2 = \frac{1}{3} \frac{M}{V} v_{rms}^2 = \frac{1}{3} \frac{mN}{W} v_{rms}^2$
8) Kinetic energy of gas molecules :
 $P = \frac{1}{3}\rho \ v_{rms}^2 = \frac{1}{3} \frac{M}{V} v_{rms}^2 = \frac{1}{2} \frac{mN}{V} v_{rms}^2$
8) Kinetic energy of gas molecules :
 $P = \frac{1}{3}\rho \ v_{rms}^2 = \frac{3}{2} RT$
() K.E. per unit volume $= \frac{3}{2} PV$
() K.E. per unit mass $= \frac{3R^2}{2M_0}$
9) Mayer's relation :
 $C_p - C_v = \frac{R}{M_0}$ (Molar specific heat)
 $S_p - S_v = \frac{R_M}{M_0}$ (Principal specific heat)
10) Relation betwen specific heat :
 $C_p = M_0 \ S_p \ \& C_v = M_0 \ S_v$
11) K.E. of monatomic gas :
 $E = \frac{3}{2} nRT$
(1) K.E. for monatomic gas :
 $E = \frac{3}{2} nRT$
(1) K.E. of monatomic gas :
 $E = \frac{3}{2} nRT$
(1) K.E. of monatomic gas :
 $E = \frac{3}{2} nRT$
(2) Kas 1.3 $X 10^{-23}$ particles per mole
(3) $R = 8.314 \ J/mol-K$
(4) $N_n = 6.022 \times 10^{23} \ pricides per mole$