# Physics Notes

BY

Er. Lalit Sharma
B.Tech (Electrical)
Ex. Lecturer Govt. Engg. College Bathinda
Physics Faculty Ranker's Point, Bathinda

Arun Garg
M.Sc. Physics
Gold Medalist
Physics Faculty Ranker's Point, Bathinda

Class:10+1

Unit: VII-*D,E*

Topic: **Properties of Bulk Matter**

*SYLLABUS*: UNIT-VII

| | |
|---|---|
| Elastic behavior, Stress-stain relationship, Hooke's law, Young's modulus, bulk modulus, shear, modulus of rigidity. | *7A* |
| Pressure due to a fluid column; Pascal's law and its applications (hydraulic lift and hydraulic brakes). Effect of gravity on fluid pressure. Surface energy and surface tension, angle of contact, application of surface tension ideas to drops, bubbles and capillary rise. | *7B* |
| Viscosity, Stokes law, terminal velocity, Reynolds's number, streamline and turbulent flow, Bernoulli's theorem and its applications. | *7C* |
| Heat, temperatures, thermal expansion; specific heat-calorimetry; change of state- latent heat. | *7D* |
| Heat transfer-conduction, convection and radiation, thermal conductivity, Newton's law of cooling. | *7E* |

*Unit 7-D (Thermal properties of matter)*

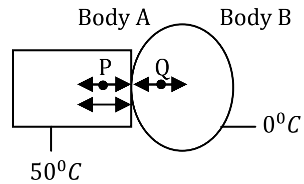
**Q.1.a) What is Heat?**
**b) Units?**

Ans.a) **HEAT**:-

Heat is a form of energy which is transferred from one body at higher temperature to another body at lower temperature when they are placed in contact with each other.

Explanation:-

Molecule P of body A oscillates with high energy in comparison to molecule of body B which is at lower temp. When the two bodies A and B come in contact with each other. Energy is transferred from A to B due to temperature difference. This form of energy is known as Heat.




b) **UNITS**:-

S.I units → J

Practical unit → cal

| 1cal = 4.18 J |
|---|

**Q.2a) What is a Thermometer? Various types of thermometer?**
**b) Relationship between various types of temperature scales.**

Ans.ai) **THERMOMETER**:-

Thermometer is a device which uses any property of the matter that changes with temperature with a purpose to measure temperature of a body.

**Types of Thermometer**:-

1. Variation of volume of liquid with temperature.

   eg:- Domestic thermometers used mercury as a liquid which expands on heating.

2. Variation of pressure or volume of gas with temperature.

   eg:- Gas thermometer used in the lab.

3. Variation of resistance of metal with temperature.

   eg:- Resistance thermometers used in air conditioning system.

4. Variation of thermo emf with temperature.

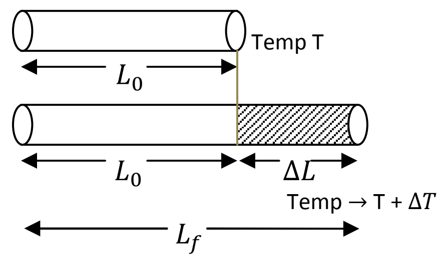
   eg:- thermocouple.

**RELATIONSHIP**:-

$$\frac{T_c - 0}{100 - 0} = \frac{T_k - 273.15}{373.13 - 273.15} = \frac{T_F - 32}{212 - 32}$$

**Q.3.a) Explain the following:-**
**Co-eff. Of Linear expansion**
**Co-eff. Of Area expansion**
**Co-eff. Of Volume expansion.**
**b) Derive relation between $\propto, \beta, \gamma$.**

Ans.a)i) **Co-eff. Of Linear expansion, $\propto$** :-




Increase in length $\Delta L \propto L_0$

$\propto \Delta T$

$\Delta L \propto L_0 . \Delta T$

$\Delta L = \propto . L_0 . \Delta T$

$$\boxed{\propto = \frac{\Delta L}{L_0 . \Delta T}}$$

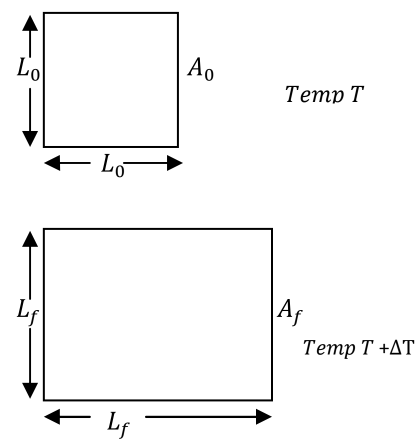
Increase in length per unit initial length per unit rise in temp.

$L_f = L_0 + \Delta L$

$L_f = L_o + \propto . L_0 . \Delta T$

$$\boxed{L_f = L_0 (1 + \propto . \ \Delta T)}$$

ii) **Co-eff. of Area expansion, $\beta$**:-




Increase in Area $\Delta A \propto A_0$

$\propto \ \Delta T$

$\Delta A \propto A_0 . \Delta T$

$\Delta A = \beta . A_0 . \Delta T$

$\frac{dA}{A} = \frac{2. \ L. \ dL}{L^2}$

$\left(\frac{dA}{A}\right) = 2. \left(\frac{dL}{L}\right)$

$\beta . \ \Delta T = 2. \propto . \ \Delta T$

$$\boxed{\beta = 2. \propto}$$

$A_f = A_0 (1 + \beta . \Delta T)$

$\beta = \frac{\Delta T}{A_0 . \Delta T}$

iii) **Co-eff. of Volume expansion, Y**:-

Volume $V = L^3$ → (1)

Diff. both sides

$dV = d(L^3)$

$$\boxed{dV = 3. L^2 . dL}$$ → (2)

Dividing (1) by (2)

$\frac{dV}{V} = \frac{3. \ L^2 . \ dL}{L^3}$

$\left(\frac{dV}{V}\right) = 3 \left(\frac{dL}{L}\right)$

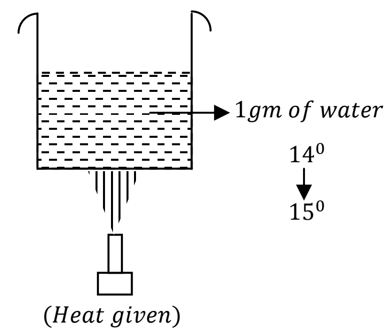
$\gamma . \ \Delta T = 3. \propto . \ \Delta T$

$$\boxed{\gamma = 3. \propto}$$

**Q.4. Explain the following with examples:-**
**a) Specific Heat**
**b) Molar specific heat**
**c) Latent heat.**

Ans.a) **Specific Heat**:-

"The amount of heat required to increase the temp. of unit mass by unit rise i.e. $1^0C$".




$$\Delta Q \propto m.\Delta.T$$
$$= s.m.\Delta T$$

↓

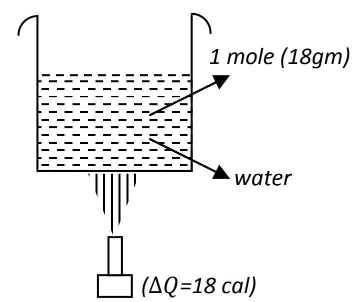
Constant of proportionality depends on material

$$\boxed{s = \frac{\Delta Q}{m.\ \Delta T}}$$

Ex-1→ Water →s is $\frac{1\ cal}{gm°c}$

Ex-2 → $H_2$ → s is $\frac{3.5\ cal}{gm°c}$ (Maximum)

b) **Molar Specific Heat**:-




The amount of heat required to increase the temp of 1 mole of a substance by $1^0C$.

Ex-1→ water $\frac{18cal}{mole°c}$

c) **Latent Heat**:-

Latent heat of a substance is the amount of heat energy required to change the state of unit mass of a substance from solid to liquid or liquid to gas without change in any temp.

Ex-1→ Ice to water, Latent heat of fusion, 80 $\frac{cal}{gm}$

Ex-2→ Water to steam, Latent heat of Vapourisation, 540 $\frac{cal}{gm}$

**Q.5.** **a) Define and explain $C_V$ and $C_P$ (Molar specific heats for gases)**
**b) Relation between $C_P$ and $C_V$.**

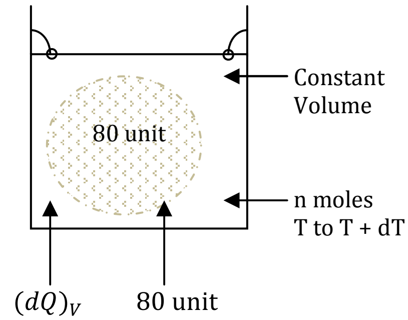
Ans.a) ***$C_V$***:-

$(dQ)_V \propto n.\,dT$

$(dQ)_V = C_V.\,n.\,dT$

$(dQ)_V = n.\,C_V.\,dT$

$$\boxed{C_v = \frac{(dQ)_V}{n.dT}}$$



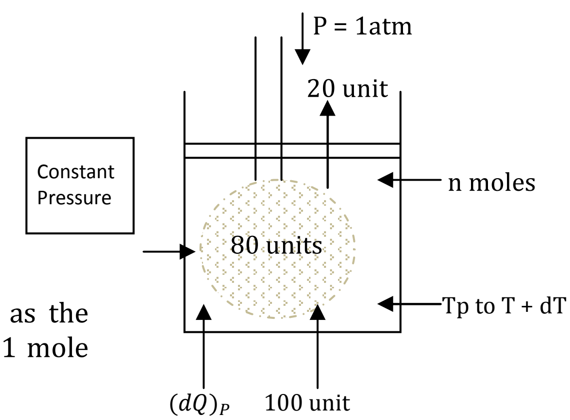

"Molar specific heat at constant volume is defined as heat required to raise the temperature of 1 mole of a gas though $1^0C$ keeping the volume constant".

***$C_P$***:- $(dQ)_P \propto n.\,dT$

$= C_P.\,n.\,dT$

$= n.\,C_P.\,dT$

$$\boxed{C_P = \frac{(dQ)_P}{n.\ dT}}$$




"Molar specific heat at constant pressure is defined as the amount of heat required to raise the temperature of 1 mole of a gas through $1^0C$ keeping the pressure constant.

c) **Relation between $C_P$ and $C_V$:-**

$C_P - C_V = R$

and $\frac{C_P}{C_V} = \gamma$

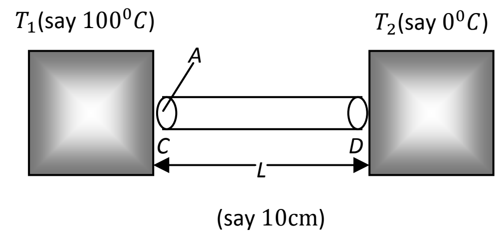
*Unit 7-E (Transfer of Heat)*

**Q1. Explain the following:**

**a) Conduction**
**b) Convection**
**c) Radiation**

Ans.a) **Conduction**:

It is a mode of transfer of heat from one part of the body to another, from particle to particle, in the direction of fall of temperature without any movement of the heated particles.

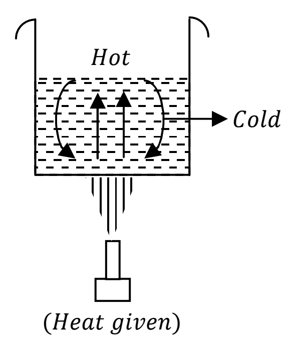



**Example**:

When we heat one end of a metal rod, its other end becomes hot. In fact, when one end of a metal rod is heated, atoms or molecules at the hotter end starts vibrating with greater amplitude. This disturbance is transferred to other end of rod. Solids are generally heated by conduction.

b) **Convection**:

It is a mode of transfer of heat from one part of the medium to another part by actual movement of the heated particles of the medium. Convection can be natural or forced.




**Example**:

When we heat a liquid, the particles of liquid at the bottom, get heated, become lighter and rise up. The cold particles, at lower temperature from above, being heavy come down and receive heat. Fluids i.e. (liquids and gases) are heated by convection.

c) **Radiation**:

Radiation is a mode of transmission of heat from the source to the receiver without any actual movement of source or receiver and also without heating the intervening medium.

**Example**:

Heat from sun comes to us through radiation. On standing near fire, we feel hot as heat comes to us through radiation.

**Q2.** **a) Write expression for heat flowing per sec across a thermal conductor.**
**b) Discuss '*Thermal*' & '*Electrical*' energy flow?**

Ans.a)

$$\frac{Heat}{sec} \propto A$$

$$\propto \frac{\Delta T}{\Delta x}$$

$$\frac{Heat}{sec} \propto A \cdot \frac{\Delta T}{\Delta x}$$

$$\boxed{\frac{Heat}{sec} = K\ A \cdot \frac{\Delta T}{\Delta x}}$$

K → Thermal conductivity of material

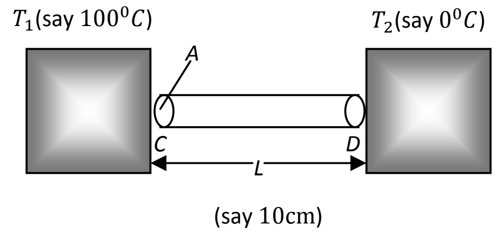
SI unit of K $= \dfrac{Heat/sec}{A\left(\frac{Temp}{distance}\right)}$

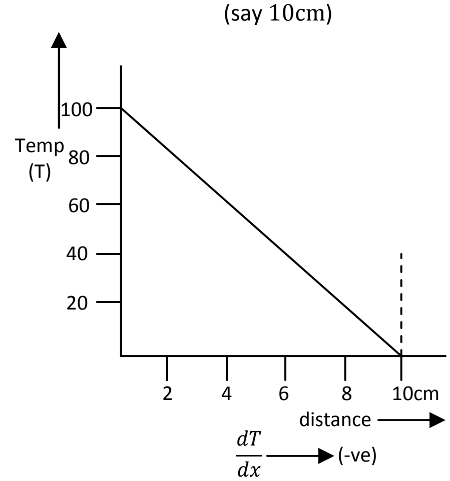
$= \dfrac{J/sec}{m^2\left(\frac{Kel}{m}\right)}$

$= \text{J}\, m^{-1}\ Kel^{-1}\ \ sec^{-1}$

*OR*

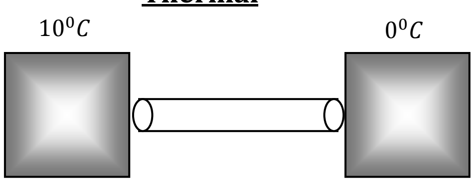
Watt $m^{-1}\ Kel^{-1}$




b)

**<u>Thermal</u>**



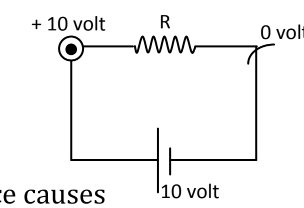

1. Temperature difference causes flow of heat.
2. $\dfrac{Heat}{sec} = K\ A \cdot \dfrac{\Delta T}{\Delta x}$

$= \dfrac{\Delta T}{\left(\frac{\Delta x}{KA}\right)}$

$$\boxed{\text{Heat} = \frac{\Delta T}{\left(\frac{l}{KA}\right)} = R_{th}}$$

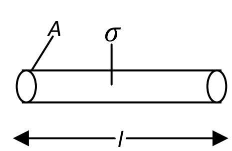
Where $\frac{l}{KA}$ is equal to thermal resistance $R_{th}$

**<u>Electrical</u>**




1. Voltage difference causes flow of charge or currents.
2. Current $= \dfrac{V}{R_E}$

$$\boxed{\frac{charge}{sec} = \frac{V}{R_E}}$$




Where $R_E$ is $\rho\,\frac{l}{A}$

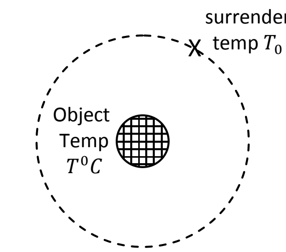
OR

$R_E = \frac{l}{\sigma A}$ is electrical resistance.

**Q3. a) State and explain 'Newton's law of cooling'.**
**b) Derive Newton's law of cooling from Stefan's law.**

Ans. **Newton's Law of Cooling**:

Newton's law of cooling states that the rate of loss of heat of a body is directly proportional to the difference in temperature of the body and the surroundings, provided the difference in temperature is small, not more than $40^0C$.



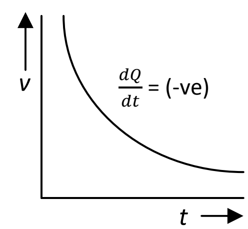

$$\frac{Heat}{sec} \propto (T - T_0)$$

$$\frac{-dQ}{dt} \propto (T - T_0) \qquad [dQ = m.s.dT]$$

$$\frac{-m.s.dT}{dt} \propto (T - T_0)$$

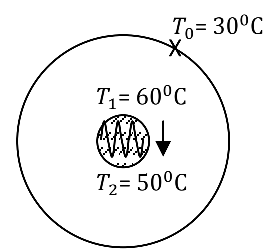
$$\frac{-dT}{dt} \propto \frac{(T-T_0)}{m.s}$$

$$\boxed{\frac{-dT}{dt} \propto (T - T_0)}$$




(m.s. are constants)

**Example**:




Average temp body is taken

$$\frac{-dT}{dt} \propto \left[\frac{T_1+T_2}{2} - T_0\right]$$

**Additional Information**:

$$\frac{dT}{dt} = -K\,(T - T_0)$$

(where T, t → are 2 variables)

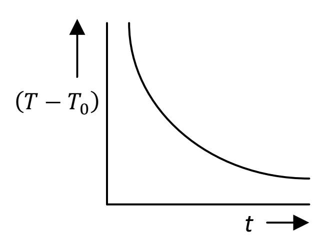
$$\frac{dT}{(T-T_0)} = -K\,dt$$

Integrate both sides

$$\int \frac{dT}{T-T_0} = -K \int dt$$

$$log_e\,(T - T_0) = -K\,t \qquad \left[\int \frac{dx}{x-a} = log_e\,(x-a)\right]$$

$$\boxed{(T - T_0) = e^{-Kt}}$$



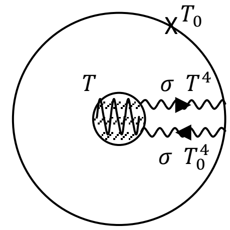

Put limits also if required.

**Stefan's Law**:

$$\frac{Heat\ lost}{Area\ time} \propto (T^4 - T_0^4)$$

$$\boxed{\frac{Heat\ lost}{Area\ time} = \sigma\ (T^4 - T_0^4)}$$

($\sigma$ → Stefan's constant)




Derivation of Newton's Law from Stefan's Constant:

$$\frac{Heat\ lost}{Area.time} = \sigma\ [(T_0 + \Delta T)^4 - T_0^4]$$

$$= \sigma\ \left[T_0^4\ \left(1 + \frac{\Delta T}{T_0}\right)^4 - T_0^4\right]$$

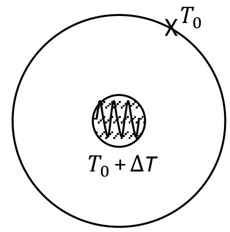
$$= \sigma\ T_0^4\ \left[\left(1 + \frac{\Delta T}{T_0}\right)^4 - 1\right]$$

$$= \sigma\ T_0^4\ \left[\not{1} + 4\ \frac{\Delta T}{T_0} - \not{1}\right]$$

$$= \sigma\ T_0^4\ \times 4\ \frac{\Delta T}{T_0}$$

$$= (4\ \sigma\ T_0^3)\ \Delta T$$

$$\propto \Delta T$$




| |
|---|
| $(1 + x)^n \simeq 1 + n.x$ <br> *n* is very small than 1 |

$$\boxed{\frac{Heat\ Lost}{Area.Time} \propto \text{(Temperature difference)}}$$