Basic Physics

Time: 2 Hrs.] Prelim Question Paper Solution [Marks : 50

Q.1 Attempt any NINE of the following. **[18]**

Q.1(a) State any two factors affecting elasticity. **[2]**

(A) Factors affecting on elasticity:

(i) Change of temperature.
(ii) Effect of hammering & rolling.
(iv) Effect of annealing.
(v) Effect of impurities.
(vi) Effect of recurring stress.

Q.1(b) Define compressibility. State its SI unit. **[2]**

(A) Definition

Unit Compressibility: The reciprocal of bulk modulus of elasticity is called as compressibility.

OR

The property on account of which the body can be compressed by the application of external force is called compressibility.

S.I. Unit:- m2/N

Q.1(c) Define the two specific heats of gas. **[2]**

(A) Specific heat of a gas at constant volume:

Specific heat of a gas at constant volume is defined as the amount of heat required to increase the temperature of unit mass of a gas by one degree at constant volume.

Specific heat of a gas at constant pressure:

Specific heat of a gas at constant pressure is defined as the amount of heat required to increase the temperature of unit mass of a gas by one degree at constant pressure.

Q.1(d) State relation between °C, °F and K. **[2]**

(A) $C = \frac{F - 32}{1.8} = K - 273$

Q.1(e) State Hooke's law of elasticity. **[2]**

(A) Statement

Hooke's Law

Within elastic limit, stress is directly proportional to strain.

Q.1(f) A 100 ml of air is measured at 20 °C. If the temperature of air is raised to 50 °C, calculate its volume as pressure remains constant. **[2]**

(A) **Given :** $V_1 = 100$ ml $\quad V_2 = ?$

$t_1 = 20°C \quad t_2 = 50°C$

$T_1 = 20 + 273 \quad T_2 = 50 + 273$

$= 293°K \quad = 323°K$

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

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

$$V_2 = \frac{100 \times 323}{293}$$

$V_2 = 110.24$ ml

Q.1(g) Define : (i) Adhesive force (ii) Cohesive force **[2]**

(A) **(i) Adhesive force :**
It is the force of attraction between two molecules of different substance.

(ii) Cohesive force :
It is the force of attraction between two molecules of same substance.

Q.1(h) What is absolute scale of temperature? **[2]**

(A) **Definition**

Absolute scale of temperature:
It is the scale of temperature in which the lower fixed point is -2730 K and upper fixed point is 3730 K and it is then divided into 100 equal parts , each part is one degree Kelvin or degree absolute.

Q.1(i) Define velocity gradient and state its unit. **[2]**

(A) **Definition**
Unit

Velocity Gradient: It is defined as the change in velocity per unit change in vertical distance of the layer from the fixed layer.
Unit = per second OR 1/ sec

Q.1(j) The wave travels with speed of 3×10^8 m/s and frequency 90 MHz. Calculate its wavelength. **[2]**

(A) Formula and substitution
Answer with unit

Given v = 3 x 108 m/s
n = 90 MHz = 90 x 106Hz
λ = ?

We have, v = nλ
λ = v / n
= 3 x 108 / 90 x 106
λ = 0.033 x 102 m.

Q.1(k) A radio wave of frequency 91.1 MHz travels with speed of 3×10^8 m/s. Find its wavelength. **[2]**

(A) **Given :** $v = 3 \times 10^8$ m/s, $n = 91.1$ MHz $= 91.1 \times 10^3$ Hz

$$v = n\lambda$$

$$\lambda = \frac{v}{n} = \frac{3 \times 10^8}{91.1 \times 10^3}$$

$$\lambda = 0.0329 \times 10^5 \text{ m}$$

Q.1(l) Define Resonance. State its one example. **[2]**

(A) **Resonance**

When the frequency of the external periodic force applied to a body is exactly equal to (matches) natural frequency of body, the body vibrates with maximum amplitude, the effect is known as resonance.

Examples:

(1) Bridge may collapse in earth quake if forced frequency of earth quake becomes equal to the natural frequency of the bridge.
(2) Use of musical instruments like flute, harmonium, sitar, violin, guitar.
(3) Radio receiver set.

Q.2 Attempt any FOUR of the following : [16]

Q.2(a) Differentiate between streamline and turbulent flow of liquid. [4]

(A)

	Streamline flow	**Turbulent flow**
(i)	The path of every particle is same.	The path of every particle is different.
(ii)	The velocity of particle is constant in magnitude and direction.	The velocity of particle at each point is not constant.
(iii)	Flow is regular.	Flow is irregular.
(iv)	No circular currents or eddies are developed.	Random circular currents called vertices are developed.
(v)	The liquid flows steady.	The flow is speedy.
(vi)	Example – The flow of liquid through pipe, water flow of river in summer etc.	Example – flow of river in flood, water fall etc.
(vii)	$V < V_C$	$V > V_C$
(viii)	$R < 2000$	$R > 3000$

Q.2(b) State and explain law of thermal conductivity. Define coefficient of thermal conductivity. [4]

(A) Statement :

It states that the amount of heat flowing from metal rod at steady state is directly proportional to

(1) Cross-sectional area of rod (A)
(2) Temperature difference between two surfaces of the conductor $(\theta_1 - \theta_2)$
(3) Time for which heat flows (t) and inversely proportional to distance between two surfaces (d)

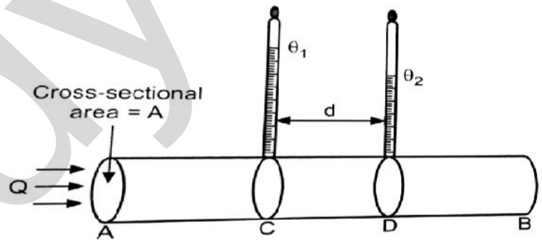
$Q \propto A$

$Q \propto (\theta_1 - \theta_2)$

$Q \propto t$

$Q \propto \frac{1}{d}$

Where K = Coefficient of thermal conductivity.



Definition : It is defined as the amount of heat conducted in one second, in steady state of temperature through unit cross-sectional area of an element of material of unit thickness with unit temperature difference between its opposite faces.

Q.2(c) A wire of diameter 4 mm and length 2 m extends by 2 mm when a force of 10 N is applied. Find Young's modulus of the wire. [4]

(A) Given : Diameter (d) = 4 mm = 4×10^{-3}m

Radius (r) = $\frac{d}{2} = 2 \times 10^{-3}$ m

Original length (L) = 2 m

Extended length (l) = 2mm = 2×10^{-3}m

Force (F) = 10 N

Young's modulus (Y) = ?

Formula : $Y = \frac{FL}{\pi r^2 l}$

$$y = \frac{10 \times 2}{3.14 \times (2 \times 10^{-3}) \times 2 \times 10^{-3}}$$

$y = 0.7961 \times 10^9$ N/m^2

Q.2(d) State Newton's law of viscosity. Define coefficient of viscosity and state its SI unit. [4]

(A) Statement
Definition
SI Unit
Newton's law of viscosity:
Statement: The viscous force (F) developed between two liquid layers is
(i) directly proportional to surface area of liquid layer, (A) i.e. [F α A]
(ii) directly proportional to velocity gradient
i.e. [F α (dv/dx)]

F α A dv/dx

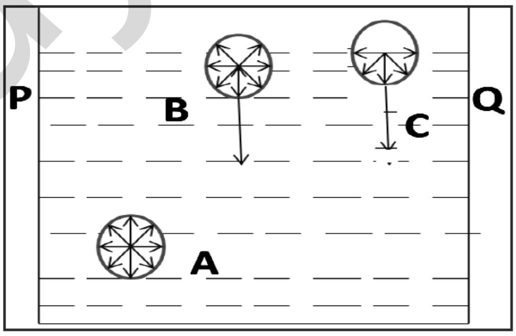
F = η A dv/dx

Where, η is the coefficient of viscosity of the liquid.

Coefficient of viscosity:- The coefficient of viscosity η is defined as the viscous force developed between two liquid layers of unit surface area in contact which maintains unit velocity gradient.
SI Unit :- Ns / m2

Q.2(e) Explain Laplace's molecular theory of surface tension of liquid. [4]

(A) Laplace's molecular theory of surface tension
1. Consider three molecules A, B & C of the liquid. A sphere of influence is drawn as shown in fig.
2. The sphere of influence of molecule 'A' is completely inside the liquid, so it is equally attracted in all directions by the other molecules lying within its sphere. Hence the resultant force acting on it is zero.
3. The part of the sphere of influence of molecule 'B' lies outside the liquid & the major part lie inside the liquid. Therefore resultant force acting on it is directed downward.
4. For Molecule 'C' half of its sphere of influence lies inside the liquid and half lies outside the liquid. So, the maximum resultant downward force is acting on molecule 'C

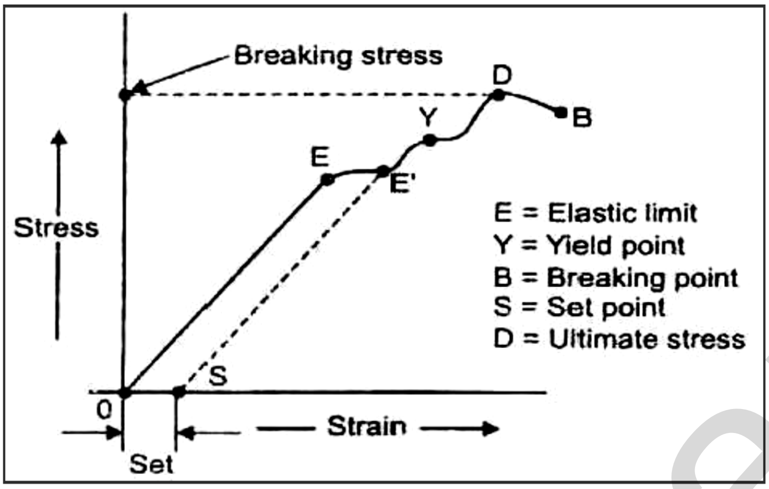


5. Thus molecule A experiences zero resultant force, B experience downward resultant force, C experience more downward resultant force. In short molecules below imaginary line PQ experience zero resultant force and molecules about line PQ experience some or more downward resultant force.
6. Thus molecules which lie on the surface of liquid (surface film) experience downward resultant force and are being pulled inside the liquid. To balance this downward force, molecules come closer to each other. This reduces the surface area of liquid.
7. This gives rise to surface tension. It is the contraction force which decreases the surface area of the liquid.

Q.2(f) Explain stress-strain diagram for a wire under continuously increasing load. [4]

(A) Neat labeled diagram

Explanation



A graph or diagram of stress and strain is shown as above. OE Portion is straight line which indicates that stress is proportional to strain. Therefore the wire obeys Hooke's law upto the point E this point is called elastic limit.

EE' Portion is curved towards strain axis this shows that increase in strain is more, than increase in stress. In this region stress is not proportional to strain. Between any point E and E' if all load is removed then some permanent elonganation/ Expansion / increase in length takes place in the wire this is called set. When wire is again loaded, a new straight line SE' is obtained which obey

Hooke's law.

Some portion after the point Y is almost parallel to strain axis this shows that strain increases without increase in stress just like wire flows. This is called plastic flow. The point at which the plastic flow begins is called yield point. During the plastic flow the wire becomes thin and thin. Some weak points called neck are formed in the wire. At weakest point (neck), wire breaks.

The maximum stress upto which wire can be loaded or wire can bear is called breaking stress. Point B is breaking point. Before point B the point D is ultimate stress

Q.3 Attempt any FOUR of the following : [16]

Q.3(a) State law of thermal conductivity. Define coefficient of thermal conductivity. [4]

(A) Statement : It states that the amount of heat flowing through metal rod at steady state is directly proportional to

(i) Cross-sectional area of rod (A)

(ii) Temperature difference between two surfaces of the conductor($\theta_1 - \theta_2$)

(iii) Time for which heat flows. (t) and inversely proportional to

(iv) Distance between two surfaces. (d)

$Q \propto A$

$Q \propto (\theta_1 - \theta_2)$

$Q \propto t$

$Q \propto 1/d$

$$Q \propto \frac{A(\theta_1 - \theta_2)}{d}$$

$$Q = \frac{K \times A(\theta_1 - \theta_2) \times t}{d}$$

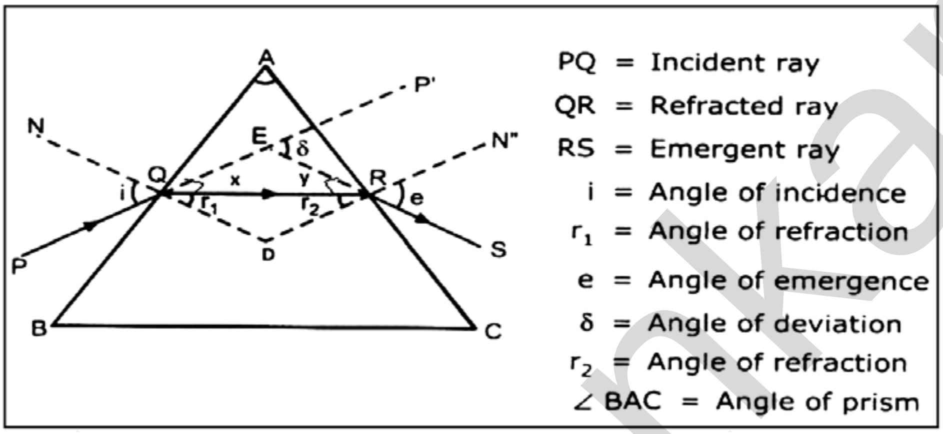
$$K = \frac{Q \times d}{A \times (\theta_1 - \theta_2) \times 1}$$

Where K = Coefficient of thermal conductivity.

Definition of K : It is defined as the amount of heat conducted in one second, in steady state of temperature through unit cross sectional area of an element of material of unit thickness with unit temperature difference between its opposite faces.

Q.3(b) Derive an equation for prism formula using neat labelled diagram. **[4]**

(A)



Let PQ be the incident ray obliquely incident on refracting face AB. At point Q the ray enters from air to glass therefore at Q the incident ray is refracted and travels along QR by making $\angle r_1$ as angle of refraction.
At point R the ray of light enter from glass to air and get refracted along RS.
From ΔEQR
$\delta = x + y$
$\delta = (i - r_1) + (e - r)$
$\delta = (i + e) - (r_1 + r_2)$ … (1)

Q.3(c) (i) A particle performing SHM has period of 3 sec. Calculate its acceleration at 2 cm from mean position. **[4]**

(ii) A tuning fork of frequency 512 Hz resonates with an air column of length 14 cm. Calculate the velocity of sound in air, if end correction is 26 mm.

(A) (i) Given : Required:
T= 3 sec. $a = ?$
$x = 2 \text{ cm} = 2 \times 10^{-2}$ m
$a = \omega^2 x$
$a = (2\pi / T)^2 . x$
$a = (2 \times 3.14/3)^2 . (2 \times 10^{-2})$
$a = 0.087 \text{ m/s}^2$

(ii) Given
n = 512 Hz.
$l = 14 \text{ cm} = 14 \times 10^{-2}$m
$e = 26\text{mm} = 26 \times 10^{-3}$ m
v =?

Formula
$v = 4n(l + e)$
$v = 4 \times 512 \times (14 \times 10^{-2} + 26 \times 10^{-3})$
v = 339.9 m/s

Q.3(d) Differentiate between isothermal and adiabatic process. **[4]**

(A)

	Isothermal process	Adiabatic process
(i)	Gas volume is changed by keeping temperature constant.	Gas volume and also its temperature changes.
(ii)	For this, changes in volume are made very slowly.	For this, changes in volume are made very quick.
(iii)	Exchange of heat between system and surrounding takes place.	Exchange of heat between system and surrounding does not takes place.
(iv)	For carrying out this process, a perfect gas is taken in a cylinder having conducting walls.	For carrying out this process, a perfect gas is taken in cylinder having insulating walls.
(v)	Boyle's law is valid.	Boyle's law is not valid.
(vi)	Expansion of gas takes place.	Compression of gas takes place.
(vii)	There is no change in internal energy.	There is change in internal energy.
(viii)	Example – Melting of solid and boiling of water.	Example – Bursting of cycle rubber tube.

Q.3(e) Define transverse wave and longitudinal wave with example. **[4]**

(A) **Transverse waves :** The wave in which direction of vibration of particles of material medium is perpendicular to the direction of propagation of wave is called transverse wave.

Example: Light wave, electromagnetic waves etc.

Longitudinal wave: The wave in which direction of vibration of particles of material medium is parallel to the direction of propagation of wave is called longitudinal wave.

Example: Sound waves, Waves produced in organ pipe etc.

Q.3(f) State any four characteristics of stationary waves. **[4]**

(A) **The characteristics of stationary waves:**

(1) The velocities of the two waves being equal and opposite, the resultant velocity are zero. So, the waveform remains stationary.
(2) Nodes and antinodes are formed alternately.
(3) The velocity of the particles at the nodes is zero. It increases gradually and is maximum at the antinodes.
(4) There is no transfer of energy.
(5) Pressure is maximum at nodes and minimum at antinodes.
(6) All the particles except those at the nodes, execute simple harmonic motions of same period.
(7) Amplitude of each particle is not the same; it is maximum at antinodes and is zero at the nodes.
(8) Distance between any two consecutive nodes or antinodes is equal to $\lambda/2$.
(9) The distance between a node and its adjacent antinode is equal to $\lambda/4$.
(10) Particles in the same loop vibrate in the same phase.
(11) Particles in the adjacent loop vibrate in the opposite phase.

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