SECOND MID-TERM TEST 2024

Std. : 11 **PHYSICS**

Marks : 35 Time : 1.30 Hrs

I. Choose the Correct Answer: 10x1=10

1. If a wire is stretched to double of its original length, then the strain in the wire is
   (a) 1 (b) 2 (c) 3 (d) 4

2. For a given material, the rigidity modulus is $\left(\frac{1}{3}\right)^{\text{rd}}$ of Young's modulus. Its Poisson's ratio is
   (a) 0 (b) 0.25 (c) 0.3 (d) 0.5

3. A small sphere of radius 2cm falls from rest in a viscous liquid. Heat is produced due to viscous force. The rate of production of heat when the sphere attains its terminal velocity is proportional to
   (a) 2^2 (b) 2^3 (c) 2^4 (d) 2^5

4. With an increase in temperature, the viscosity of liquid and gas, respectively will
   (a) increase and increase (b) increase and decrease
   (c) decrease and increase (d) decrease and decrease

5. If the temperature of the wire is increased, then the Young's modulus will
   (a) remain the same (b) decrease
   (c) increase rapidly (d) increase by very a small amount

6. Copper of fixed volume V is drawn into a wire of length l. When this wire is subjected to a constant force F, the extension produced in the wire is Δl. If Y represents the Young's modulus, then which of the following graphs is a straight line?
   (a) Δl versus V (b) Δl versus Y
   (c) Δl versus F (d) Δl versus $\frac{1}{l}$

7. In a horizontal pipe of non-uniform cross section, water flows with a velocity of $1 ms^{-1}$ at a point where the diameter of the pipe is 20 cm. The velocity of water ($1.5 ms^{-1}$) at a point where the diameter of the pipe is (in cm)
   (a) 8 (b) 16 (c) 24 (d) 32

8. In hot summer after a bath, the body's
   (a) internal energy decreases (b) internal energy increases
   (c) heat decreases (d) no change in internal energy and heat

9. The graph between volume and temperature in Charles' law is

(a) an ellipse (b) a circle

(c) a straight line (d) a parabola

10. Triple point of water is

(a) 273.1 K (b) 278.1 K (c) $273.^0C$ (d) 278.1^0C

II. Answer any 3 questions. Question No. 15 is compulsory. 3x2=6

11. Which one of these in more elastic, steel or rubber? Why?
12. State the laws of floatation.
13. Define specific heat capacity and give its unit.
14. Define latent heat capacity. Give its unit.
15. The surface Tension of a soap solution is 0.0 Nm^{-1}. How much work is done in producing soap bubble of radius 0.05m.

III. Answer any 3 questions. Question No. 20 is compulsory. 3x3=9

16. Distinguish between streamlined flow and turbulent flow.
17. State and prove Archimedes principle.
18. Give the applications of surface Tension.
19. Discuss the ideal gas laws.
20. Jogging every day is good for health. Assume that when you jog a work of 500kJ is done and 230 kJ of heat is given off. What is the change in internal energy of your body?

IV. Answer the following questions: 2x5=10

21. (a) State Hooke's law and verify it with the help of an experiment.

(OR)

(b) State and prove Bernoulli's theorem for a flow of incompressible, non-viscous, and streamlines flow of fluid.

22. (a) Explain in detail Newton's law of cooling.

(OR)

(b) Derive Mayer's relation for an ideal gas.

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ANSWER KEY

I. Choose the Correct Answer: 10x1=10

1. (a) 1
2. (d) 0.5
3. (d) 2^5
4. (c) decrease and increase
5. (b) decrease
6. (c) Δl versus F
7. (b) 16
8. (a) internal energy decreases
9. (c) a straight line
10. (a) 273.1 K

II. Answer any 3 questions. Question No. 15 is compulsory. 3x2=6

11. Steel is more elastic than rubber because **the steel has higher young's modulus** than rubber. That's why, if equal stress is applied on both steel and rubber, the **steel produces less strain**.

12. **Law of floatation.**

The law of floatation states that **a body will float in a liquid if the weight of the liquid displaced by the immersed part of the body equals the weight of the body.**

13. **Specific heat capacity:**

The amount of heat energy required to raise the temperature of 1kg of a substance by 1 Kelvin or 1°C

$\Delta Q = ms\,\Delta T$; Therefore, $s = \frac{1}{m}\frac{\Delta Q}{\Delta T}$

The SI unit for **specific heat capacity is $Jkg^{-1}K^{-1}$**

14. **Latent heat capacity:**

The amount of heat energy required to change the state of a unit mass of the material.

$Q = m \times L$; $L = \frac{Q}{m}$

Where L = Latent heat capacity of the substance; Q = Amount of heat m = mass of the substance. The SI unit for **Latent heat capacity is $J\,kg^{-1}$.**

15. $W = 2T \times A$ (or) $W = 2T \times 4\pi r^2$

$W = 2 \times 4 \times 3.14 \times (0.05)^2 \times 0.03$

$W = 1.884 \times 10^{-3}$ J

III. Answer any 3 questions. Question No. 20 is compulsory. 3x3=9

16. **Streamlined flow and turbulent flow:**

Streamlined flow:

When a liquid flows such that each particle of the liquid passing through a point moves along the same path with the same velocity as its predecessor then the flow of liquid is said to be a streamlined flow.

The velocity of the particle at any point is constant. It is also referred to as steady or laminar flow.

The actual path taken by the particle of the moving fluid is called a streamline, which is a curve, the tangent to which at any point gives the direction of the flow of the fluid at that point.

Turbulent flow:

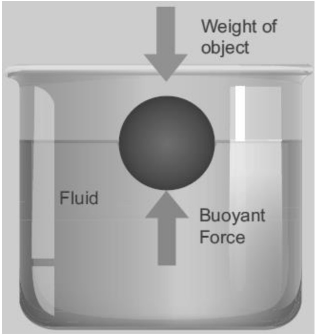
When the speed of the moving fluid exceeds the critical speed, v_c the motion becomes turbulent.

The velocity changes both in magnitude and direction from particle to particle.

The path taken by the particles in turbulent flow becomes erratic and whirlpool-like circles called eddy current or eddies.

17. **Archimedes principle.**

It states that when a **body is partially or wholly immersed in a fluid**, it experiences an upward thrust equal to **the weight of the fluid displaced by it and its up-thrust acts through the centre of gravity of the liquid displaced.**



Up-thrust or buoyant force = weight of liquid displaced.

18. **Applications of surface tension:**

1) **Oil pouring on the water** reduces surface tension. So that the **floating mosquitos' eggs drown and killed.**
2) Finely adjusted surface tension of the liquid makes droplets of desired size, which **helps in desktop printing, automobile painting and decorative items.**
3) **Specks of dirt are removed** from the cloth when it is washed in detergents added hot water, which has low surface tension.
4) **A fabric can be made waterproof, by adding suitable waterproof material (wax) to the fabric.** This increases the angle of contact due to surface tension.

19. **Boyle's law:**

1) For a given gas at low pressure (density) **kept in a container of volume V, experiments revealed the following information.**
When the gas is kept at constant temperature, the pressure of the gas is inversely proportional to the volume.
$P \; \alpha \frac{1}{V}$ 1
Charles' law:
2) When the gas is kept at constant pressure, the volume of **the gas is directly proportional to absolute temperature. V α T 2**
By combining these two equations we have PV = CT. Here C is a positive constant.
3) C is proportional to the number of particles in the gas container by considering the following argument.
4) If we take **two containers of same type of gas with same volume V, same pressure P and same temperature T, then the gas in each container obeys the above equation. PV = CT.**
Ideal gas law:
C must depend on the number of particles in the gas and also should have the dimension of $\left[\frac{PV}{T}\right]$ = JK^{-1}.
we can write the constant C as k times the number of particles N.
Here k is the **Boltzmann constant ($1.381\times10^{-23} JK^{-1}$)** and it is found to be a universal constant. So the ideal gas law can be stated as follows PV = NkT
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20. Work done by the system (body), W = +500 kJ

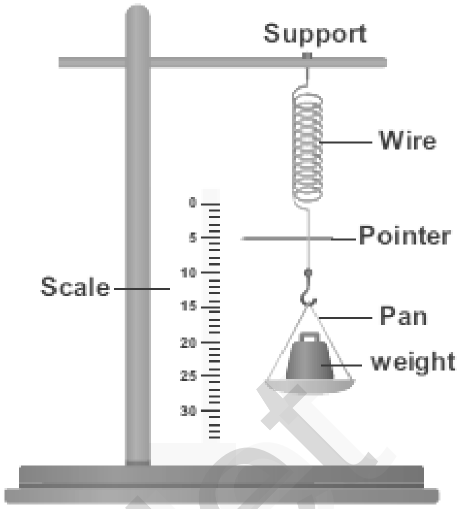
Heat released from the system (body),Q = –230 kJ

The change in internal energy of a body = ΔU=–230 kJ–500 kJ = –730 kJ

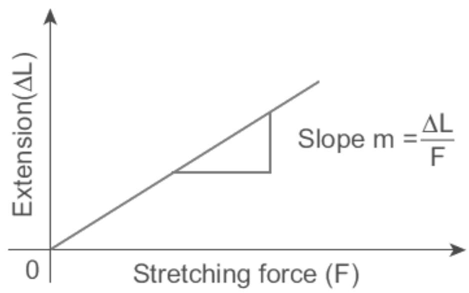
IV. Answer the following questions: 2x5=10

21. (a) **<u>Hooke's law and verify it with the help of an experiment:</u>**

1) Hooke's law is for a small deformation, when the stress and strain are proportional to each other.
2) It can be verified in a simple way by stretching a thin straight wire (stretches like spring) of length L and uniform cross-sectional area A suspended from a fixed-point O.
3) A pan and a pointer are attached at the free end of the wire as shown in Figure (a).



4) The extension produced on the wire is measured using a Vernier scale arrangement. The experiment shows that for a given load, the corresponding stretching force is F and the elongation produced on the wire is ΔL.
5) It is directly proportional to the original length L and inversely proportional to the area of cross section A. A graph is plotted using F on the X- axis and ΔL on the Y- axis.
6) This graph is a straight line passing through the origin as shown in Figure (b).



Therefore, ΔL = (slope)F

Multiplying and dividing by volume,

V = A L,

F (slope) = $\frac{AL}{AL}\Delta L$

Rearranging, we get, $\frac{F}{A} = \left[\frac{L}{A(slope)}\right]\frac{\Delta L}{L}$ Therefore, , $\frac{F}{A}\,\alpha \left[\frac{\Delta L}{L}\right]$

Comparing with stress equation and strain equation, we get $\sigma\alpha\varepsilon$

i.e., the stress is proportional to the strain in the elastic limit.

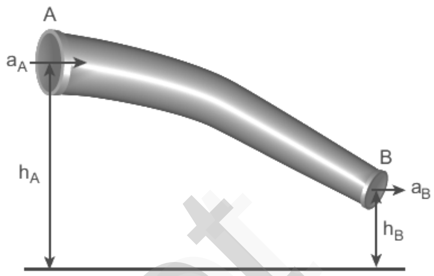
(OR)

(b) **Bernoulli's theorem:**

According to Bernoulli's theorem, **the sum of pressure energy, kinetic energy, and potential energy per unit mass of an incompressible, non-viscous fluid in a streamlined flow remains a constant**.

$\frac{P}{\rho} + \frac{1}{2}v^2 + gh =$ **Constant**, this is known as Bernoulli's equation.

Proof:



Let us consider a flow of liquid through a pipe AB as shown in Figure. Let V be the volume of the liquid when it enters Ain a time *t* which is equal to the volume of the liquid leaving *B* in the same time. Let a_A, v_A and PA be the area of cross section of the tube, velocity of the liquid and pressure exerted by the liquid at *A* respectively.

Let the **force exerted by the liquid at A is $F_A = P_A a_A$**

Distance travelled by the liquid in time t is $d = v_A t$

Therefore, the work done is $W = F_A d = P_A a_A v_A t$

But **$a_A v_A t = a_A d = V$,** volume of the liquid entering at A.

Thus, the **work done is the pressure energy (at A), $W = F_A d = P_A V$**

Pressure energy per unit volume at A = $\frac{\text{Pressure energy}}{\text{Volume}} = \frac{P_A V}{V} = P_A$

Pressure energy per unit mass at A = $\frac{\text{Pressure energy}}{\text{Mass}} = \frac{P_A V}{m} = \frac{P_A}{\frac{m}{V}} = \frac{P_A}{\rho}$

Since m is the mass of the liquid entering at A in a given time, therefore, pressure energy of the liquid at A is $E_{PA} = P_A V = P_A V \times \left(\frac{m}{m}\right) = m\frac{P_A}{\rho}$

Potential energy of the liquid at A, $P_{EA} = mg\, h_A$,

Due to the flow of liquid, the **kinetic energy of the liquid at A, $KE_A = \frac{1}{2} m v_A^2$**

Therefore, the total energy due to the flow of liquid at A,

$$E_A = EP_A + KE_A + PE_A \; ; \; \mathbf{E_A = m\frac{P_A}{\rho} + \frac{1}{2} m v_A^2 + mgh_A}$$

Similarly, let a_B, v_B, and P_B be the area of cross section of the tube, velocity of the liquid, and pressure exerted by the liquid at B. Calculating the total energy at E_B, we get $\mathbf{E_B = m\frac{P_B}{\rho} + \frac{1}{2} m v_B^2 + mgh_B}$

From the **law of conservation of energy, $E_A = E_B$**

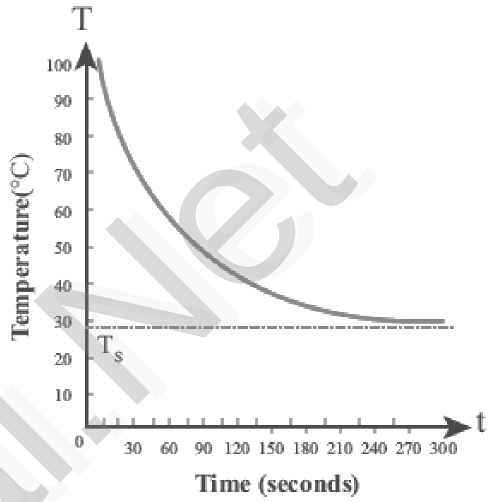
$$E_A = m\frac{P_A}{\rho} + \frac{1}{2} mV_A^2 + mgh_A = E_B = m\frac{P_B}{\rho} + \frac{1}{2} mV_B^2 + mgh_B$$

$$\frac{P_A}{\rho} + \frac{1}{2} V_A^2 + gh_A = \frac{P_B}{\rho} + \frac{1}{2} V_B^2 + gh_B = \text{constant}$$

Thus, the above equation can be written as $\frac{P}{\rho g} + \frac{1}{2}\frac{v^2}{g} + h = \text{constant}$

22. (a) **Newton's law of cooling:**

1) Newton's law of cooling states that the **rate of loss of heat of a body is directly proportional to the difference in the temperature between that body and its surroundings.**



$$\frac{dQ}{dt} \alpha - (T - T_s) \text{ ------------ } 1$$

2) The **negative sign indicates that the quantity of heat lost by liquid goes on decreasing with time.** Where,

T = Temperature of the object

T_s = Temperature of the surrounding.

From the **graph** in Figure, it is clear that **the rate of cooling is high initially and decreases with falling temperature.**

3) Let us consider an object of mass m and specific heat capacity s at temperature T. Let **Ts be the temperature of the surroundings**. If the temperature falls by a small amount dT in time dt, then the amount of heat lost is, **dQ = msdT** --------------- 2

4) Dividing both sides of equation (2) by $\frac{dQ}{dt} = \frac{msdT}{dt}$ ------------3

From Newton's law of cooling $\frac{dQ}{dt} \alpha - (T - T_S)$

$$\frac{dQ}{dt} = -a(T - T_S) \text{ --------- } 4$$

Where a is some positive constant. From equation (2) and (4)

$$-a(T - T_S) = ms\frac{dT}{dt}$$

$$\frac{dT}{(T - TS)} = -\frac{a}{ms}dt \text{ ------------------- } 5$$

Integrating equation (5) on both sides,

$$\int_0^{\infty} \frac{dT}{(T - TS)} = -\int_0^{t} \frac{a}{ms} dt$$

$$\ln (T - T_S) = \frac{a}{ms} t + b_1$$

Where b_1 is the constant of integration. taking exponential both sides, we get,

$T = T_S + b_2 e^{-\frac{a}{ms}t}$. Here $b_2 = e^{b1}$ = Constant

(OR)

(b) **Meyer's relation:**

1) Consider μ mole of an ideal gas in a container with volume V, pressure P and temperature T.

2) When **the gas is heated at constant volume the temperature increases by dT. As no work is done by the gas, the heat that flows into the system will increase only the internal energy**. Let the change in internal energy be dU.

If Cv is the molar specific heat capacity at constant volume,

$\mathbf{dU = \mu C_v dT}$ ------------- 1

3) Suppose the gas is heated at constant pressure so that the temperature increases by dT. If 'Q' is the heat supplied in this process and 'dV' the change in volume of the gas. $\mathbf{Q = \mu C_p dT}$ ----------- 2

4) If W is the work done by the gas in this process, then

W = PdV -----------3

But from the first law of thermodynamics, **Q = dU + W** --------4

Substituting equations (1), (2) and (3) in (4), we get,

$\mathbf{\mu C_p dT = \mu C_v dT + PdV}$ -----------5

5) For mole of ideal gas, the equation of state is given by

$PV = \mu RT \Rightarrow PdV+VdP = \mu RdT$ --------- 6

Since the pressure is constant, **dP=0**

$\therefore C_p dT = C_v dT + RdT$

$\mathbf{\therefore C_P = C_v + R}$ **(or)** $\mathbf{C_p - C_v = R}$ ---------- 7

This relation is called Meyer's relation.