Chapter

12

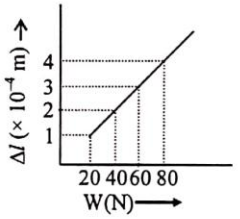
# Properties of matter

## Single Correct Option Type Questions

**Q.1** What is the velocity $v$ of a metallic ball of radius $r$ falling in a tank of liquid at the instant when its acceleration is one half that of a freely falling body ? (The densities of metal and of liquid are $\rho$ and $\sigma$ respectively and the coefficient of viscosity of the liquid is $\eta$) -

(A) $\frac{r^2 g}{9\eta}(\rho - 2\sigma)$ (B) $\frac{r^2 g}{9\eta}(2\rho - \sigma)$ (C) $\frac{r^2 g}{9\eta}(\rho - \sigma)$ (D) $\frac{2r^2 g}{9\eta}(\rho - \sigma)$

**Q.2** The graph shows the extension ($\Delta l$) of a wire of length 1 m suspended from the top of a roof at one end and with a load W connected to the other end. If the cross-sectional area of the wire is $10^{-6}$ $m^2$, calculate the Young's modulus (i.e., Y) of the material of the wire is S.I. units




(A) $2 \times 10^6$ N/m$^2$ (B) $5 \times 10^6$ N/m$^2$ (C) $2 \times 10^{11}$ N/m$^2$ (D) $5 \times 10^{11}$ N/m$^2$

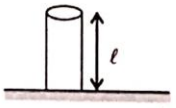
**Q.3** A steel ring of radius r and cross-sectional area A is fitted on to a wooden disc of radius R(R > r). If Young's modulus be Y, then the force with which the steel ring is expanded is :

(A) $AY\frac{R}{r}$ (B) $AY\left(\frac{R-r}{r}\right)$ (C) $\frac{Y}{A}\frac{(R-r)}{r}$ (D) $\frac{Yr}{AR}$

**Q.4** A cubical block of wood of specific gravity 0.5 and a chunk of concrete of specific gravity 2.5 are fastened together. The ratio of the mass of wood to the mass of concrete which makes the combination to float with its entire volume submerged under water is :

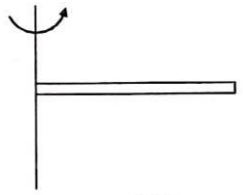
(A) 1/5 (B) 1/3 (C) 3/5 (D) 2/5

**Q.5** A solid cylinder of mass m, length $l$ and area of cross section A is placed as shown in the figure. If Young's modulus is Y then strain energy stored in the cylinder is



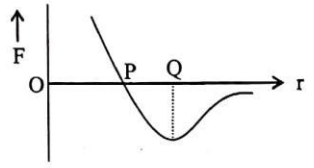

(A) $\frac{m^2 g^2 l}{3AY}$ (B) $\frac{m^2 g^2 l}{6AY}$ (C) $\frac{m^2 g^2 l}{2AY}$ (D) $\frac{m^2 g^2 l}{AY}$

**Q.6** A thin rod of length 3 m is being rotated with 10 rad/sec about its one end. The change in length of the rod due to rotation is (Given : Young's modulus of elasticity of the wire, $Y = 3 \times 10^8$ SI unit. Linear density of mass of the rod is $10^4$ SI Unit.)



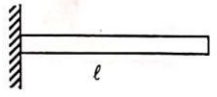
(A) 2 cm (B) 4.5 cm (C) 1 cm (D) 3 cm

**Q.7** Figure shows roughly how the force (F) between two adjacent atoms in a solid varies with separation (r)



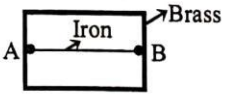

(i) OQ is equilibrium separation
(ii) Hooke's law is obeyed around P
(iii) the potential energy of the atom is the gradient of the graph at all points
(iv) the energy to separate the atoms completely is obtained from the area enclosed below the axis or r.
(A) (i) and (ii) only (B) (ii) and (iv) only
(C) (i) and (iii) only (D) (i), (ii) and (iii) only.

**Q.8** In the given figure a rod is free at one end and other end is fixed. when we change the temperature of rod by $\Delta\theta$, the strain produced in rod is -




(A) $\alpha\Delta\theta$ (B) $\frac{1}{2}\alpha\Delta\theta$ (C) Zero (D) $2\alpha\Delta\theta$

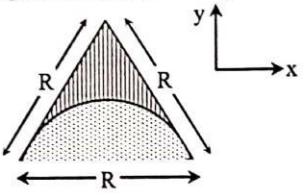
**Q.9** The diagram shows an iron wire AB mounted in a brass frame and attached to the frame at both ends A and B at 0°C. Length of AB at 0°C is 300 cm and the diameter of the wire is 0.6 mm. What extra tension will be set up in the stretched wire when the temperature of the system is raised to 40°C in power of $10^6$ dyne ? Given $\alpha_{brass} = 8 \times 10^{-6}/°C$ $\alpha_{iron} = 12 \times 10^{-6}/°C$ and $Y_{iron} = 21 \times 10^{11}$ dyne/cm$^2$




(A) 0.95 (B) 0.165 (C) 0.142 (D) 0.125

**Q.10** A material has normal density $\rho$ and bulk modulus K. The increase in the density of the material when it is subjected to an external pressure P from all sides is
(A) $P/\rho K$ (B) $K/\rho P$ (C) $\rho P/K$ (D) $\rho K/P$

**Q.11** A light, rigid sheet of triangular shape has a curved portion cut from it as shown in figure. It floats on the surface of water. Some soap solution is dropped over dotted region. Surface tension of water and soap film are $T_1$ & $T_2$ respectively. $T_1 = 1.5\ T_2$. Choose the correct option.




(A) The frame experiences a net forces $F = (T_1 - T_2)R$ in $y < 0$ direction
(B) The frame experiences force $F = (T_1 - T_2)R$ in $y > 0$ direction
(C) The frame experiences force $(T_1 - T_2)(2-\pi)R$ in $y > 0$ direction
(D) Resultant force on wire frame is zero.

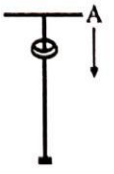
**Q.12** A plastic circular disc of radius R is placed on a thin oil film, spread over a flat horizontal surface. The torque required to spin the disc about its central vertical axis with a constant angular velocity is proportional to
(A) $R^2$ (B) $R^3$ (C) $R^4$ (D) $R^6$

**Q.13** What should be the stress $\left(\frac{F}{A}\right)$ in a stretched wire of a material whose young modulus is Y for the speed of longitudinal waves to equal 30 times the speed of transverse waves.
(A) $\frac{Y}{30}$ (B) $\frac{Y}{900}$ (C) 30 Y (D) $\frac{Y}{90}$

**Q.14** There is rectangular wire frame having a thin film of soap solution. A massless circular loop of thin wire of radius R is placed on the surface of film, and inside portion of the film is pricked. If surface tension of soap solution is S and Young's modulus of wire is Y then change in radius if the wire is (Area of cross section of wire is A)


(A) $\frac{SR^2}{AY}$ (B) $\frac{2SR^2}{AY}$ (C) $\frac{SR^2}{3AY}$ (D) None of these

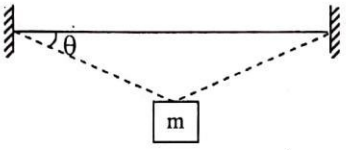
**Q.15** An elastic cord of constant K and length L is hung from point A having a massless block at the other end. A smooth ring of mass M falls from point A, the maximum elongation of cord is




(A) $\frac{Mg}{K}\left(1+\frac{1+2KL}{Mg}\right)^{1/2}$ (B) $\frac{Mg}{K}\left(1-\left(1-\frac{2KL}{Mg}\right)^{1/2}\right)$

(C) $\frac{MgL}{K}$ (D) $\frac{Mg}{K}\left(1+\left(1+\frac{2KL}{Mg}\right)^{1/2}\right)$

**Q.16** A wire of cross-sectional area A. Young's modulus Y and certain length is suspended from two horizontal rigid supports at the end. A mass m is suspended at midpoint of wire. Find angle $\theta$ (assumed to be very small) in radian made by the end of wire with horizontal at equilibrium position.




(A) $\left(\frac{2mg}{AY}\right)^{\frac{1}{2}}$ (B) $\left(\frac{mg}{2AY}\right)$ (C) $\left(\frac{mg}{AY}\right)^{\frac{1}{3}}$ (D) none of these

**Q.17** Consider a uniform rod of mass m suspended from ceiling from one of its ends. Original length of rod is L. Cross sectional area of rod is A. Young's Modulus of material of rod is Y. Find energy stored in rod due to extension of rod because of its own-weight.

(A) $\frac{m^2g^2L}{2AY}$ (B) $\frac{m^2g^2}{2LY}$ (C) $\frac{m^2g^2L}{6AY}$ (D) none of these

**Q.18** A uniform thin ring of radius R is made of a material of density $\rho$ and Young's Modulus Y. The ring is rotated in gravity free space about a vertical axis passing through its centre with uniform angular velocity $\omega$. Find the small increase in radius

(A) $\frac{\rho\omega^2R^3}{Y}$ (B) $\frac{2\rho\omega^2R^3}{3Y}$ (C) $\frac{\rho\omega^2R^3}{2Y}$ (D) none of these

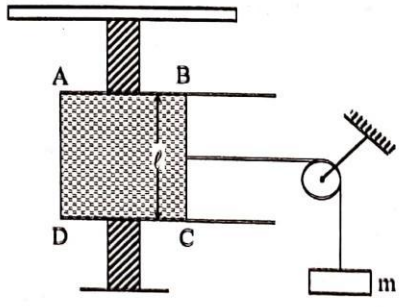
**Q.19** A liquid drop at temperature t, isolated from its surrounding breaks into a number of droplets the temperature of the droplets will be

(A) equal to t (B) greater than t (C) less than t (D) none of these

**Q.20** A metallic sphere of mass 2 gm falls through a liquid with terminal velocity v. If we drop a sphere of mass 0.25 gm of the same metal through same liquid its terminal velocity would be

(A) v (B) 2v (C) v/2 (D) v/4

**Q.21** A wire frame ABCD has a soap film. The wire BC can slide on the frame without friction and it is in equilibrium in the position shown in the figure. Find m, if T is the surface tension of the liquid.




(A) $\frac{2T\ell}{g}$ (B) $\frac{T\ell}{g}$ (C) $\frac{T\ell^2}{2g}$ (D) $\frac{T\ell}{2g}$

## Statement Based Questions

**Q.22** **Statement-1 :** If a metal wire is attached to the ceiling of a room and mass m is attached to another end, the energy stored in the stretched wire is $\frac{mg\ell}{2}$ where $\ell$ is the increment in length of wire.

**Statement-2 :** If the above statement loss in gravitational energy is $mg\ell$ while the loss in energy to surrounding is $\frac{mg\ell}{2}$.

(A) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(B) Statement-1 is true, statement-2 true and statement-2 is NOT is correct explanation for statement.

(C) Statement-1 is true, statement-2 is false.

(D) Statement-1 is false, statement-2 is true.

## Multiple Correct Option Type Questions

**Q.23** Two soap bubbles ($\sigma$ – surface tension) of radii a and b are given ($a < b$) :

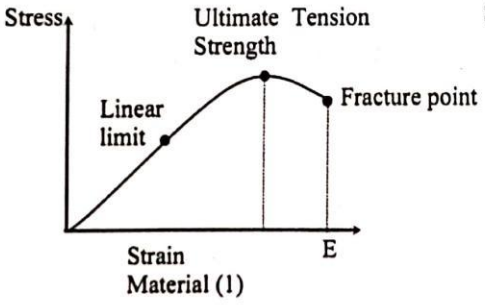
(A) The radius at the contact point is $\frac{1}{r} = \frac{1}{a} - \frac{1}{b}$

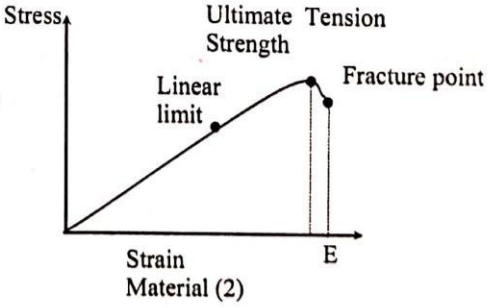
(B) The radius on merging them is $r = \sqrt{a^2 + b^2}$ under isothermal conditions

(C) The new radius depends on atmospheric pressure

(D) The radius on merging them is $r = \sqrt{\left(\frac{a^2 + b^2}{\sigma}\right)}$.

**Q.24** The stress strain graph for two materials are shown in the figures on same scale. Mark the correct statements.




(A) Material (2) is more elastic than material (1) and hence material (2) is more brittle

(B) Material (1) and (2) have same elasticity and same brittleness

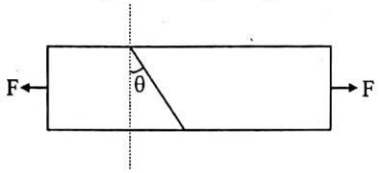
(C) Material (2) is elastic over a larger region of strain as compared to (1)

(D) Material (2) is more brittle that material (1)

## Passage Based Questions

**Passage # 1 (Q.25 to 27)**

A bar of cross-section A is subjected to equal and opposite tensile forces F at its ends. Consider a plane through the bar making an angle θ with a plane at right angles to the bar as shown in figure.




**Q.25** The tensile stress at this plane in terms of F; A and θ is

(A) $\frac{F\cos^2\theta}{A}$ (B) $\frac{F}{A\cos^2\theta}$ (C) $\frac{F\sin^2\theta}{A}$ (D) $\frac{F}{A\sin^2\theta}$

**Q.26** In the above problem, for what value of θ is the tensile stress a maximum?

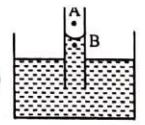
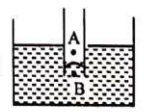
(A) Zero (B) 90° (C) 45° (D) 30°

**Q.27** The shearing stress at the plane, in terms of F, A and θ is

(A) $\frac{F\cos 2\theta}{2A}$ (B) $\frac{F\sin 2\theta}{2A}$ (C) $\frac{F\sin\theta}{A}$ (D) $\frac{F\cos\theta}{A}$

## Column Matching Type Questions

**Q.28** Capillary rise and shape of droplets on a plate due to surface tension are shown in column II.

| Column I | Column II |
|---|---|
| (A) Adhesive forces is greater than cohesive forces | (P)   |
| (B) Cohesive forces is greater than adhesive forces | (Q)   |
| (C) Pressure at A > pressure at B | (R) A mercury drop is pressed between two parallel plates of glass   |
| (D) Pressure at B > Pressure at A | (S)   |
| | (T) None |

**Q.29** A steel rod of length 6 m and radius 1 mm is fixed between two rigid supports Given, $Y = 2 \times 10^6$ kg cm$^{-2}$ and $\alpha = 12 \times 10^{-6}$ °C$^{-1}$ (stress is denoted by $\sigma$).


| List-I | List-II |
|---|---|
| (P) When the temperature increases by 80°C and the ends do not yield. | (1) $\sigma = 1920$ kg cm$^{-2}$ |
| (Q) When the temperature increases by 80° C and the ends yield by 1 mm. | (2) $\sigma = 1578$ kg cm$^{-2}$ |
| (R) When the temperature increases by 100°C and the ends do not yield. | (3) $\sigma = 2400$ kg cm$^{-2}$ |
| (S) When the temperature increases by 100°C and the ends yield by 2 mm. | (4) $\sigma = 1733$ kg cm$^{-2}$ |

**Codes :**

| | P | Q | R | S |
|---|---|---|---|---|
| (A) | 3 | 4 | 2 | 1 |
| (B) | 1 | 2 | 3 | 4 |
| (C) | 4 | 3 | 1 | 2 |
| (D) | 3 | 4 | 1 | 2 |

## Numeric Response Type Questions

**Q.30** A glass capillary sealed at the upper end is of length 0.11 m and internal diameter $2 \times 10^{-5}$ m. This tube is immersed vertically into a liquid of surface tension $5.06 \times 10^{-2}$ N/m. When the length $x \times 10^{-2}$ m of the tube is immersed in liquid then the liquid level inside and outside the capillary tube becomes the same, then the value of x is : (Assume atmospheric pressure is $1.01 \times 10^5 \frac{N}{m^2}$)

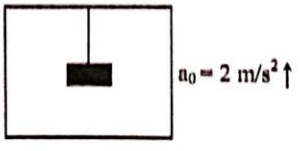
**Q.31** A wire of length '2m' is clamped horizontally between two fixed support. A mass m = 5kg is hanged from middle of wire. The vertical depression in wire (in cm) in equilibrium is (Young modulus of wire $= 2.4 \times 10^9$ N/m$^2$, cross-sectional area = 1 cm$^2$)

**Q.32** A very narrow capillary tube records a rise of 20 cm when dipped in water. When the area of cross section is reduced to one fourth of the former value, water will rise to a height of n × 10cm. Find 'n'.

**Q.33** A sphere of radius 10 cm and mass 25 kg is attached to the lower end of a steel wire which is suspended from the ceiling of a room. The point of support is 521 cm above the floor. When the sphere is set swinging as a simple pendulum it's lowest point just grazes the floor. Speed of ball at it's lowest position is $\frac{7.6}{n}$ m/s find n.

**(Given data :** unstretched length of wire = 500cm radius of steel wire = 0.05 cm. Young modulus of steel = $2 \times 10^{11}$ N/m$^2$)

**Q.34** One end of a light steel wire is fixed to celling of an elevator moving up with an acceleration 2 m/s$^2$ and a load of 10 kg hangs from other end. Area of cross-section of the wire is 2 cm$^2$. The longitudinal strain in the wire is $x \times 10^{-6}$. find x ($g = 10$ m/s$^2$ and $Y = 2 \times 10^{11}$ N/m$^2$)



**Q.35** A copper piece of mass 10 kg is suspended by a vertical spring. The spring elongates 1 cm over its natural length to keep the piece in equilibrium. A beaker containing water is now placed below the piece so as to immerse the piece completely in water. If the elongation of the spring is $89 \times 10^{-n}$cm, find the value of n. (Density of copper = 9000 kg/m$^3$. Take g = 10 m/s$^2$)

**Q.36** A block of weight 10 N is fastened to one end of a wire of cross-sectional area 3 mm$^2$ and is rotated in a vertical circle of radius 20 cm. The speed of the block at the bottom of the circle is 2 m/s. If the elongation of the wire when the block is at the bottom of the circle is $10^{-n}$ cm, find the value of n. (Young's modulus of the material of the wire = $2 \times 10^{11}$ N/m$^2$)

**Q.37** A light rod of length 200 cm is suspended from the ceiling horizontally by means of two vertical wires of equal length tied to its end. One of the wires is made of steel and is of cross-section 0.1 cm$^2$ and the other of brass of cross-section 0.2 cm$^2$. Along the rod at which distance (in meter) a weight be hung to produce equal strains in both the wires? (Y for brass and steel are $10 \times 10^{11}$ and $20 \times 10^{11}$ dyne/cm$^2$ respectively).

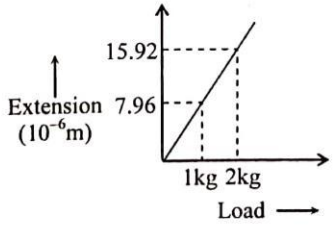
**Q.38** Excess pressure inside a spherical drop of volume V of a given soap solution is $\Delta P$. Energy E is required to double the diameter of a separate soap bubble of same volume V of the same soap solution. Find the value of $\frac{E}{\Delta PV}$.

**Q.39** A glass capillary sealed at upper end is of length 1.05 m and internal radius 0.1 mm. Tube is lowered vertically into liquid of surface tension 0.25 N/m. To what length in cm should the capillary be immersed so that liquid level inside & outside capillary becomes same. Atmospheric pressure = $10^5$ Pa.
(angle of contact = 0°)

**Q.40** A solid cylindrical glass rod of 1 mm diameter is inserted symmetrically into a glass capillary with inside diameter 2 mm. The entire arrangement is vertically oriented and brought in contact with surface of distilled water. To what height in cm will water rise in capillary. Assume water wets glass completely. Surface tension of water = 0.075 N/m. Density of water = 1gm/cm$^3$ g = 10 m/s$^2$.

**Q.41** Two soap bubbles of radii 3 cm and 2 cm come in contact and sticks to each other. The radius (in cm) of curvature of common surface is

**Q.42** In determination of Young's Modulus by Searle's Method, the extension Vs load curve is shown below. The radius of the wire is 1mm and length of the wire used is 2m. The Young's modulus is X × $10^{11}$ N/m$^2$. Then X = _____



# ANSWER KEY

**Single Correct Option type Questions**

| | | | | | | |
|---|---|---|---|---|---|---|
| **1.** (A) | **2.** (C) | **3.** (B) | **4.** (C) | **5.** (B) | **6.** (D) | **7.** (B) |
| **8.** (C) | **9.** (A) | **10.** (C) | **11.** (B) | **12.** (C) | **13.** (B) | **14.** (B) |
| **15.** (D) | **16.** (C) | **17.** (C) | **18.** (A) | **19.** (C) | **20.** (D) | **21.** (A) |

**Statement Based Questions**

**22.** (C)

**Multiple Correct Option type Questions**

**23.** (A,C) **24.** (C,D)

**Passage Based Questions**

**25.** (A) **26.** (A) **27.** (D)

**Column Matching Type Questions**

**28.** A $\rightarrow$ P ; B $\rightarrow$ Q,R ; C $\rightarrow$ P,S ; D $\rightarrow$ Q,R **29.** (B)

**Numeric Response Type Questions**

| | | | | | | |
|---|---|---|---|---|---|---|
| **30.** 1 | **31.** 5 | **32.** 4 | **33.** 2 | **34.** 3 | **35.** 2 | **36.** 3 |
| **37.** 1 | **38.** 9 | **39.** 5 | **40.** 3 | **41.** 6 | **42.** 8 | |