NEET Important Questions with Solutions from Properties of Bulk Matter

Q.1. What kind of physical quantity is stress?

A) Scalar

B) Vector

C) Tensor

D) Dimensionless

Answer: Tensor

Solution: At equilibrium, restoring force is equal in magnitude to external force, stress can therefore also be defined as external force per unit area on a body that tends to cause it to deform. Stress is a tensor quantity.

Q.2. The Young's modulus of a perfectly rigid body,

A) is zero.

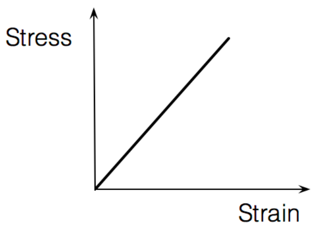
B) is unity.

C) is infinity.

D) may have any finite non-zero value.

Answer: is infinity.

Solution: Hooke's law states that, within elastic limit, the applied stress on an object is directly proportional to the strain developed. The proportionality constant is called modulus of elasticity.



The ratio of longitudinal stress and longitudinal strain is called Young's modulus of elasticity Y.

$$Y=\frac{\text{longitudinal stress}}{\text{longitudinal strain}}$$

For a perfectly rigid body, change in length is always 0, i.e., $\text{longitudinal strain}=0$ which means that Young's modulus is infinity.

Q.3. If S is the stress and Y is Young's modulus of material of a wire, the energy stored in the wire per unit volume is

A) $\frac{S}{2Y}$

B) $\frac{2Y}{S}$

C) $\frac{S^2}{2Y}$

D) $2S^2Y$

Answer: $\frac{S^2}{2Y}$

Solution: Energy stored in the wire per unit volume

$=\frac{1}{2}\times$Stress $\times$ Strain

$=\frac{1}{2}\times \text{Stress} \times \frac{\text{Stress}}{\text{Young's Modulus}}=\frac{S^2}{2Y}$

Q.4. A vessel contains oil (density$=0.8 \text{ g cm}^{-3}$) over mercury (density$=13.6 \text{ g cm}^{-3}$). A uniform sphere floats with half its volume immersed in mercury and the other half in oil. The density of the material of the sphere (in g cm^{-3}) is

A) 3.3

B) 6.4

C) 7.2

D) 12.8

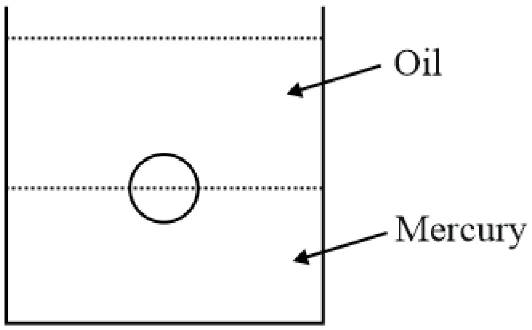
Answer: 7.2

Solution: Given,

density of oil $=\rho_{\text{oil}}=0.8 \text{ g cm}^{-3}$,

density of mercury $=\rho_{\text{Hg}}=13.6 \text{ g cm}^{-3}$.

A uniform sphere floats with half its volume immersed in mercury and the other half in oil, as shown in the figure below.



Weight of the sphere is acting vertically downwards and buoyant force is acting vertically upwards.

So, in the equilibrium condition,

weight of the sphere $=$total buoyant force,
where, Buoyant force$=$volume submerged$\times$density of liquid$\times g$

So, $V\rho_{\text{m}}g=\frac{V}{2}\rho_{\text{Hg}}g+\frac{V}{2}\rho_{\text{oil}}g$

$\rho_{\text{m}}=\frac{\rho_{\text{Hg}}+\rho_{\text{oil}}}{2}=\frac{13.6+0.8}{2}=\frac{14.4}{2}=7.2.$

Q.5. The length of elastic string obeying Hooke's law is l_1 metres when the tension is 4 N and l_2 metres when the tension is 5 N. The length in metres when the tension is 9 N is,

A) $5l_1-4l_2$

B) $5l_2-4l_1$

C) $9l_1 - 8l_2$

D) $9l_2 - 8l_1$

Answer: $5l_2 - 4l_1$

Solution: Let l_0 be the unstretched length and l_3 be the length under a tension of $9\ \mathrm{N}$. Then,

$Y = \frac{FL}{A\Delta L}$.

Equating the expression for Young's modulus for all three cases, we get,

$Y = \frac{4l_0}{A(l_1 - l_0)} = \frac{5l_0}{A(l_2 - l_0)}$

$= \frac{9l_0}{A(l_3 - l_0)}$.

This gives,

$\frac{4}{l_1 - l_0} = \frac{5}{l_2 - l_0} \Rightarrow l_0 = 5l_1 - 4l_2$.

Further, $\frac{4}{l_1 - l_0} = \frac{9}{l_3 - l_0}$.

Substituting the value of l_0 and solving, we get,

$l_3 = 5l_2 - 4l_1$.

Q.6. Two wires A and B of the same material, have their radii in the ratio $2\ :1$ and lengths in the ratio $4\ :1$. The ratio of the normal forces required to produce the same change in the lengths of these two wires is

A) $1:1$

B) $2:1$

C) $1:4$

D) $1:2$

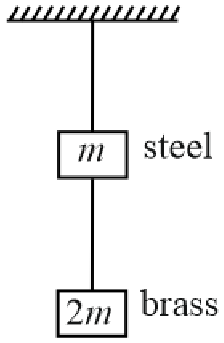
Answer: $1:1$

Solution: Young's modulus of a material, which has a length L and is changed by ΔL, is
$Y = \left(\frac{F}{A}\right)\left(\frac{\Delta L}{L}\right)\ \ldots\left(1\right)$
where F is the force applied and A is the area of cross section.

According to the question, the ratio of their radii, $\frac{r_1}{r_2} = \frac{2}{1}$

And the ratio of their lengths, $\frac{L_1}{L_2} = \frac{4}{1}$
And we know that
$Y = \frac{F \times L}{A \times \Delta L}$
$\Rightarrow F = \frac{Y \times A\Delta L}{L}$
$\Rightarrow F \propto \frac{A}{L}$
$\Rightarrow \frac{F_1}{F_2} = \frac{\pi r_1^2}{\pi r_2^2} \times \frac{L_2}{L_1}$
$\Rightarrow \frac{F_1}{F_2} = \left(\frac{r_1}{r_2}\right)^2 \times \left(\frac{L_2}{L_1}\right)$
$\Rightarrow \frac{F_1}{F_2} = \left(2\right)^2 \times \frac{1}{4} = 1$
Hence, the ratio of normal forces is,
$\frac{F_1}{F_2} = \frac{1}{1}$
or 1 : 1

Q.7. If the ratio of lengths, radii and Young's modulus of steel and brass wires in the figure are a, b, c, respectively, then the corresponding ratio of increase in their lengths would be



A) $\frac{2ac}{b^2}$

B) $\frac{3a}{2b^2c}$

C) $\frac{3c}{2ab^2}$

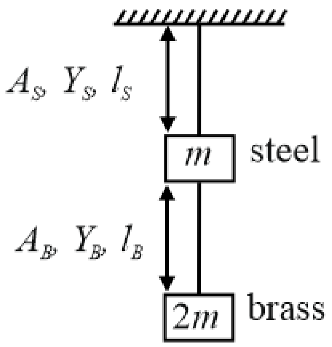
D) $\frac{2a^2c}{b}$

Answer: $\frac{3a}{2b^2c}$

Solution: It is given in the question that

$\frac{L_S}{L_B}=a;\frac{r_S}{r_B}=b$ and $\frac{Y_S}{Y_B}=c$

According to the question,



We know that
$\text{Stress }=Y\times\text{Strain}$
Where, Y is Young's modulus
$\text{Stress }=\frac{F}{A}$ and $\text{strain}=\frac{\Delta L}{L}$
$\Rightarrow\frac{F}{A}=Y\frac{\Delta L}{L}$

Consider the expression of elongation of steel rod:

$$\Rightarrow\ \Delta L_S=\frac{F_S L_S}{Y_S A}=\frac{(3mg)\ L_S}{\pi r_S^2 Y_S}\quad\ldots(1)$$

and elongation of brass rod is

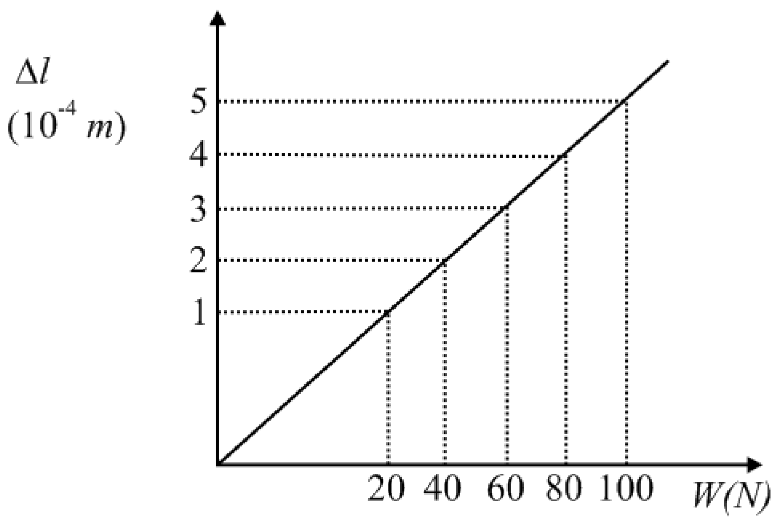
$$\Rightarrow\ \Delta L_B=\frac{F_B L_B}{Y_B A_B}=\frac{(2mg)\ L_B}{\pi r_B^2 Y_B}\quad\ldots(2)$$

Taking the ratio of the above equations, we obtain

$$\frac{\Delta L_S}{\Delta L_B}=\frac{(3mg)L_S}{\pi r_S^2 Y_S}\cdot\frac{\pi r_B^2 Y_B}{(2mg)L_B}=\frac{3}{2}\frac{L_S}{L_B}\frac{Y_B}{Y_S}\frac{r_B^2}{r_S^2}$$

$$\Rightarrow\frac{\Delta L_S}{\Delta L_B}=\frac{3a}{2b^2c}.$$

Q.8. A $1\ \mathrm{m}$ long metal wire of cross-sectional area $10^{-6}\ \mathrm{m}^2$ is fixed at one end from a rigid support and a weight W is hanging at its other end. The graph shows the observed extension of length L of the wire as a function of W. Young's modulus of material of the wire in SI units is



A) 5×10^{4}

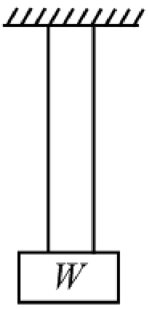
B) 2×10^{5}

C) 2×10^{11}

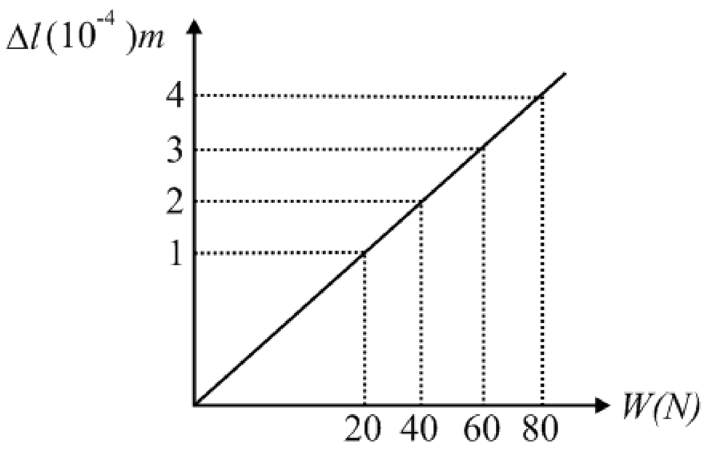
D) 5×10^{11}

Answer: 2×10^{11}

Solution: According to question,



Given graph



According to Hooke's law,

$Y = \frac{\text{Stress}}{\text{Strain}} = \left(\frac{F}{A}\right)\frac{L}{\Delta L}$

Here, given that

$W = 20\ \mathrm{N},\ \Delta L = 1 \times 10^{-4}\ \mathrm{m},$

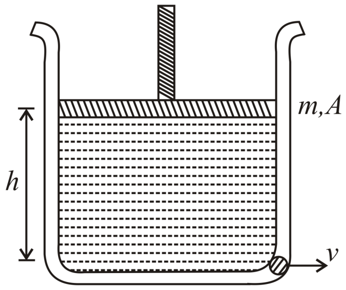
where W is weight

Also given that $A = 10^{-6}\ \mathrm{m}^2$

$L = 1\ \mathrm{m}$

$Y = \frac{20 \times 1}{10^{-6} \times 1 \times 10^{-4}} = 2 \times 10^{11}\ \mathrm{N\ m}^{-2}.$

Q.9. A cylindrical vessel contains a liquid of density ρ up to a height h. The liquid is closed by a piston of mass m and area of cross-section A. There is a small hole at the bottom of the vessel. The speed v with which the liquid comes out of the hole is



A) $\sqrt{2gh}$

B) $\sqrt{2\left(gh+\frac{mg}{\rho A}\right)}$

C) $\sqrt{2\left(gh+\frac{mg}{A}\right)}$

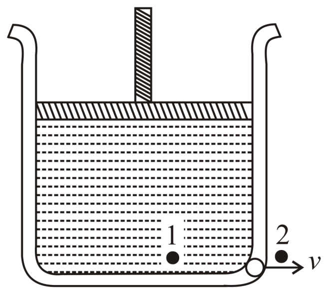
D) $\sqrt{2gh+\frac{mg}{A}}$

Answer: $\sqrt{2\left(gh+\frac{mg}{\rho A}\right)}$

Solution: Pressure at point 1 will be $P_1=P_{atm}+\rho gh+\frac{mg}{A}$

Pressure at point 2 is $P_2=P_{atm}$

Applying Bernoulli's theorem at 1 and 2,



or $\rho gh+\frac{mg}{A}=\frac{1}{2}\rho v^2$

or $v=\sqrt{2gh+\frac{2mg}{\rho A}}=\sqrt{2\left(gh+\frac{mg}{\rho A}\right)}$

Q.10. A cylindrical tank has a hole of $1\ \mathrm{cm}^2$ in its bottom. If the water is allowed to flow into the tank from a tube above it at the rate of $70\ \mathrm{cm}^3\ \mathrm{s}^{-1}$ then the maximum height up to which water can rise in the tank is :

A) $2.5\ \mathrm{cm}$

B) $5\ \mathrm{cm}$

C) $10\ \mathrm{cm}$

D) $0.25\ \mathrm{cm}$

Answer: 2.5 cm

Solution: Given: Rate of water flowing in is $70 \text{ cm}^3 \text{ s}^{-1}$

Rate of water flowing out is given by Av

where A is the area of cross-section of hole and v is the velocity of efflux.

$v=\sqrt{2gh} \quad \ldots(\mathrm{i})$

When the volume of water flowing out per second becomes equal to the volume of water flowing in per second, then height of water in the tank becomes maximum.

$Av=70 \text{ cm}^3 \text{ s}^{-1} \ \ldots(\mathrm{ii})$

From (i) and (ii), we get

$A\sqrt{2\mathrm{g}h}=70$

$\Rightarrow 1\times\sqrt{2\mathrm{g}h}=70$

$\Rightarrow \sqrt{2\times 980\times h}=70$ (Taking $g=980 \text{ cm}^2 \text{ s}^{-1}$)

$1960\times h=4900$

$\therefore\ h=\frac{4900}{1960}=2.5 \text{ cm}$

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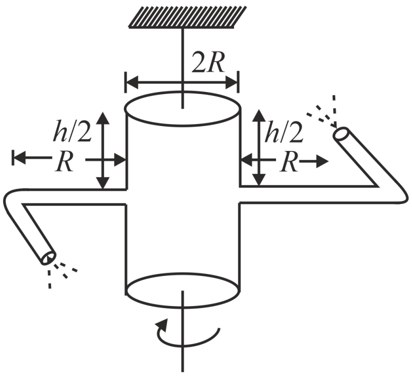
Q.11. A cylindrical container of radius R and height h is completely filled with a liquid. Two horizontal L shaped pipes of a small cross-section area a are connected to the cylinder as shown in the figure. Now the two pipes are opened and fluid starts coming out of the pipes horizontally in opposite directions. Then the torque due to ejected liquid on the system is:



A) $4 agh\rho R$

B) $8agh\rho R$

C) $2agh\rho R$

D) $agh\rho R$

Answer: $4agh\rho R$

Solution: From Torricelli's law, we have

Velocity of efflux of water at a depth $\frac{h}{2}$ from free surface is $(v)=\sqrt{2g\left(\frac{h}{2}\right)}=\sqrt{gh}$, here, g is acceleration due to gravity.

Force of thrust on ejected water is equal to the rate of change of momentum of ejected water.

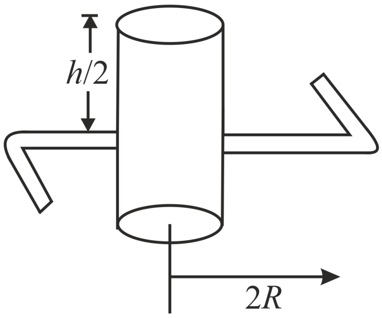
$F=\frac{\mathrm{d}p}{\mathrm{d}t}=\frac{\mathrm{d}(mv)}{\mathrm{d}t}=\frac{\mathrm{d}(V\rho v)}{\mathrm{d}t}$, where V is volume and ρ is density.

$=\frac{\mathrm{d}(al\rho v)}{\mathrm{d}t}=\rho a v^2$ (Since $V=\mathrm{area}\times\mathrm{length}$ and $\frac{\mathrm{d}l}{\mathrm{d}t}=v$)

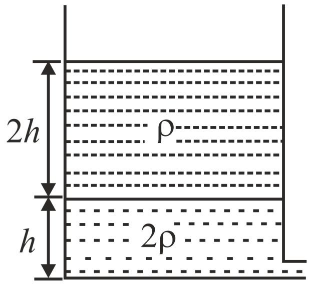
$F=\rho a\left(\sqrt{gh}\right)^2=\rho agh$

Torque of these forces about central line

$\tau=2\,(F\times l)=(\rho\mathrm{av}^2)2R\times 2=4\rho aghR$



Q.12. The velocity of the liquid coming out of a small hole of a large vessel containing two different liquids of densities 2ρ and ρ as shown in the figure is



A) $\sqrt{6gh}$

B) $2\sqrt{gh}$

C) $2\sqrt{2gh}$

D) $\sqrt{gh}$

Answer: $2\sqrt{gh}$

Solution: Pressure at the intersection of both liquids, i.e., at (1) is

$P_1 = P_{\text{atm}} + \rho g(2h)$

Applying Bernoulli's theorem at intersection of two liquids and at the bottom of container, i.e., between points (1) and (2)

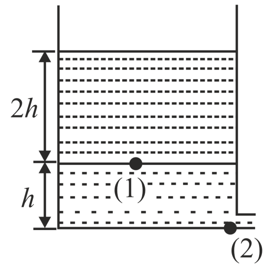
$P_1 + \rho g(2h) + \frac{1}{2}\rho v_1^2 = P_2 + \frac{1}{2}\left(2\rho\right)v_2^2 + 2\rho g(0)$

Velocity, $v_1 = 0$ and pressure at both points is atmospheric, so

$\Rightarrow P_{\text{atm}} + 2\rho gh + 2\rho gh + 0 = P_{\text{atm}} + 0 + \frac{1}{2}2\rho v_2^2$

$4\rho gh = \rho v_2^2$

$\Rightarrow v_2 = 2\sqrt{gh}$



Q.13. The lower end of a glass capillary tube is dipped in water. Water rises to a height of $9\ \text{cm}$. The tube is then broken at a height of $5\ \text{cm}$. The height of the water column and angle of contact will be

A) $5\ \text{cm},\ \cos^{-1}\left(\frac{5}{9}\right)$

B) $4\ \text{cm},\ \cos^{-1}\left(\frac{5}{4}\right)$

C) $5\ \text{cm},\ \cos^{-1}\left(\frac{9}{5}\right)$

D) $5\ \text{cm},\ \cos^{-1}\left(\frac{6}{7}\right)$

Answer: $5\ \text{cm},\ \cos^{-1}\left(\frac{5}{9}\right)$

Solution: When a capillary tube is broken at a height 5 cm, meaning that water will rise to height $5\ \text{cm}$, hence $h_2 = 5\ \text{cm}$.

Since, we know, for capillarity phenomenon $h = \frac{2S\cos\theta}{r\rho g}$, where symbols have their usual meaning.

or $\frac{h}{\cos\theta} =$ constant

Thus, $\frac{h_1}{\cos\theta_1} = \frac{h_2}{\cos\theta_2}$

$\Rightarrow \frac{9}{\cos\theta} = \frac{5}{\cos\theta_2}$ [for glass $\theta_1 = 0$]

$\Rightarrow \cos\theta_2 = \frac{5}{9}\ [\because\ \cos 0^o = 1]$

$\therefore \theta_2 = \cos^{-1}\left(\frac{5}{9}\right)$

Q.14. A material has Poisson's ratio 0.50. If a uniform rod of it suffers a longitudinal strain of $2\ \times 10^{-3}$, then the percentage change in volume is

A) 0.6

B) 0.4

C) 0.2

D) zero

Answer: zero

Solution: Longitudinal strain is defined as the ratio of length of a material to its original length. Hence
Longitudinal strain $=\frac{\mathrm{d}L}{L}$
Here, $\mathrm{d}L$ is a small change in length and L is the original length.
Poisson's ratio, defined as the ratio of lateral contraction strain to the longitudinal elongation strain.
It can be written as

$$\sigma=-\frac{\left(\frac{\mathrm{d}r}{r}\right)}{\left(\frac{\mathrm{d}L}{L}\right)} \ldots(1)$$

where r and L are the radius and the length of the rod, respectively.

Given, Longitudinal strain $=\frac{\mathrm{d}L}{L}=2\times10^{-3}$ and Poisson's ratio $\sigma=0.5$,

$$0.5=\frac{-\left(\frac{\mathrm{d}r}{r}\right)}{2\times10^{-3}}$$

$$\frac{\mathrm{d}r}{r}=-10^{-3}$$

$$\Rightarrow -2\frac{\mathrm{d}r}{r}=\frac{\mathrm{d}L}{L}$$

Volume of the rod, i.e., $V=\pi r^2L$
Differentiating both sides,

$$\mathrm{d}V=\pi(r^2\mathrm{d}L+2Lr\mathrm{d}r)$$

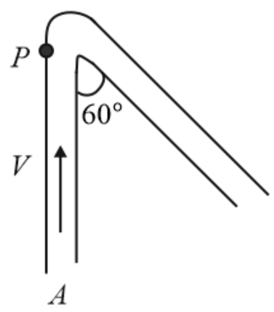
$$\Rightarrow \frac{\mathrm{d}V}{V}\times100=\pi\left(\frac{r^2\mathrm{d}L+2Lr\mathrm{d}r}{\pi r^2L}\right)\times100$$

$$=\left(\frac{\mathrm{d}L}{L}+2\frac{\mathrm{d}r}{r}\right)\times100$$

$$\frac{\mathrm{d}V}{V}\times100=0$$

$\therefore$ Percentage change in volume is zero.

Q.15. Water (density ρ) is flowing through the uniform tube of cross-sectional area A with a constant speed v as shown in the figure. The magnitude of force exerted by the water on the curved corner of the tube is (neglect viscous forces)



A) $\sqrt{3}\rho Av^2$

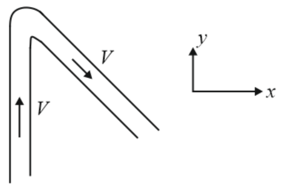
B) $2\rho Av^2$

C) $\sqrt{2}\rho Av^2$

D) $\frac{\rho Av^2}{\sqrt{2}}$

Answer: $\sqrt{3}\rho Av^2$

Solution:



Magnitude of change in momentum of water in x-direction

$$\left|\Delta \overrightarrow{P}_{\mathrm{x}}\right| = mv\sin\left(60^{\circ}\right) = \frac{\sqrt{3}}{2}mv$$

Magnitude of change in momentum of water in y-direction

$$\left|\Delta \overrightarrow{P}_{\mathrm{y}}\right| = \left|-mv\cos\left(60^{\circ}\right) - mv\right| = \frac{3}{2}mv$$

$$\Rightarrow \left|\Delta \overrightarrow{P}_{\mathrm{net}}\right| = \sqrt{\Delta P_{\mathrm{x}}^{2} + \Delta P_{\mathrm{y}}^{2}} = \sqrt{\left(\frac{9}{4} + \frac{3}{4}\right)}mv$$

$$\Rightarrow \left|\Delta \overrightarrow{P}_{\mathrm{net}}\right| = \sqrt{3}mv$$

$$\left|\Delta \overrightarrow{F}_{\mathrm{net}}\right| = \sqrt{3}\left(\frac{\mathrm{d}m}{\mathrm{d}t}\right)\cdot v = \sqrt{3}\rho A v^{2}$$

(since $\mathrm{d}m = A\left(v\mathrm{d}t\right)\rho \Rightarrow \frac{\mathrm{d}m}{\mathrm{d}t} = A\rho v$)

Q.16. A big drop of a liquid is spread into 5 identical droplets. In this process,

A) energy will be released.

B) energy is absorbed.

C) mass will not be conserved.

D) energy will neither be released nor be absorbed.

Answer: energy is absorbed.

Solution: For a drop of liquid to spread into five different drops the total volume of liquid remains the same.

Let,

The volume and the radius of the big drop be V and R.

The volume and the radius of the small drops be v and r.

As the volume remains constant we have,

$$\frac{4}{3}\pi(R)^{3} = 5 \times \frac{4}{3}\pi(r)^{3}$$

$$\Rightarrow r = \frac{R}{(5)^{\frac{1}{3}}}$$

The surface energy of the big drop is, $SA = S \times 4\pi(R)^{2}$

The surface energy of the smaller drops is $Sa = S \times 5 \times 4\pi(r)^{2} = S \times 5 \times 4\pi\left(\frac{R}{(5)^{\frac{1}{3}}}\right)^{2}$

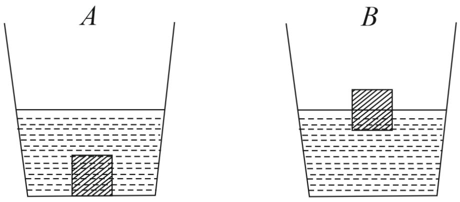
On solving we get

$$S \times 4\pi(R)^{2} \times (5)^{\frac{1}{3}}$$

Thus energy of the smaller drops is more than that of one big drop.

Thus the energy is absorbed.

Q.17. A piece of ice is tied using a string to the bottom of bucket A. The bucket is filled with water with ice completely submerged in it. Another bucket B is filled with water and a piece of ice is released in water. If floats on the surface of water (see Fig.). What would be the impact on the level of water in the two buckets, when ice pieces melt away completely?



A) Level of water remain unchanged in both the buckets.

B) Level of water will go down in bucket A, but will remain unchanged in bucket B

C) Level of water will go down in bucket, A but will go up in bucket B.

D) Level of water will remain unchanged in bucket A but will go up in bucket B

Answer: Level of water will go down in bucket A, but will remain unchanged in bucket B

Solution: Since we know, The density of ice $<$ The density of water. For the bucket A, when the piece of ice melt it's water level will decrease.

For the bucket B, when ice melts it's water level remain unchanged. Thus, the correct option is (b).

Q.18. What will be the approximate terminal velocity of a rain drop of diameter 1.8×10^{-3} m, when density of rain water $\approx 10^{3} \mathrm{kgm}^{-3}$ and the coefficient of viscosity of air $\approx 1.8 \times 10^{-5} \mathrm{~N}-\mathrm{sm}^{-2}$? (Neglect buoyancy of air)

A) $49 \mathrm{~ms}^{-1}$

B) $98 \mathrm{~ms}^{-1}$

C) $392 \mathrm{~ms}^{-1}$

D) $980 \mathrm{~ms}^{-1}$

Answer: $98 \mathrm{~ms}^{-1}$

Solution: Terminal velocity, $v=\frac{2}{9} r^{2} \frac{(\rho-\sigma)}{\eta} g$

Neglecting buoyancy effect of the fluid,

$v=\frac{2}{9} \cdot \frac{\rho}{\eta} r^{2} g$

Putting the given values, we get

$v=\frac{2}{9} \times \frac{10^{3} \times\left(0.9 \times 10^{-3}\right)^{2}}{1.8 \times 10^{-5}} \times 9.8=98 \mathrm{~ms}^{-1}$

Q.19. The velocity of water in the river is $9 \mathrm{~km} \mathrm{~hr}^{-1}$ of the upper surface. The river is $10 \mathrm{~m}$ deep. If the coefficient of viscosity of water is 10^{-2} poise then the shearing stress between horizontal layers of water is

A) $0.25 \times 10^{-2} \mathrm{~N} \mathrm{~m}^{-2}$

B) $0.25 \times 10^{-3} \mathrm{~N} \mathrm{~m}^{-2}$

C) $0.5 \times 10^{-3} \mathrm{~N} \mathrm{~m}^{-2}$

D) $0.75\times10^{-3}\,\mathrm{N\,m^{-2}}$

Answer: $0.25\times10^{-3}\,\mathrm{N\,m^{-2}}$

Solution: As we have to calculate shearing stress, so according to Newton's law of viscosity,
$|F|=\eta A\frac{dV}{dx}$

where η is coefficient of viscosity, A is the area and $\frac{dV}{dx}$ is the rate of shear deformation.

$\Rightarrow \frac{F}{A}=\eta\frac{dV}{dx}$

$\Rightarrow \frac{F}{A}=10^{-3}\times\frac{9\times\left(\frac{5}{18}\right)}{10}$
where, $\eta=10^{-2}$ poise $=10^{-3}$ Pa s
Velocity of water at surface
$V=9\ \mathrm{km\ hr^{-1}}=9\times\frac{5}{18}\,\mathrm{m\,s^{-1}}$,
Velocity of water at ground is 0,
and Height of river, $x=10\ \mathrm{m}$

$\Rightarrow \frac{F}{A}=\frac{1}{4}\times10^{-3}$

$\Rightarrow \frac{F}{A}=0.25\times10^{-3}\,\mathrm{N\,m^{-2}}$

Q.20. A mountain climber finds that water boils at $80^{\circ}\mathrm{C}$. The temperature of this boiling water is_________Fahrenheit.

A) 50°

B) 150°

C) 176°

D) 200°

Answer: 176°

Solution: The Celsius scale and the Fahrenheit scale are related by given below relation,

$\frac{C}{5}=\frac{F-32}{9}$

where, C is the temperature in degree Celsius and F is in Fahrenheit.

Given:

$C=80\ ^{\circ}\mathrm{C}$

$\frac{F-32}{9}=\frac{80}{5}$

or, $\frac{F-32}{9}=16$

$\Rightarrow F=176\ ^{\circ}\mathrm{F}$

So, the temperature in Fahrenheit scale will be $176\ ^{\circ}\mathrm{F}$.

Q.21. If a liquid takes 30 s in cooling from $95^{\circ}\mathrm{C}$ to $90^{\circ}\mathrm{C}$ and 70 s in cooling from $55^{\circ}\mathrm{C}$ to $50^{\circ}\mathrm{C}$, then the temperature of the room is:

A) $16.5^{\circ}\mathrm{C}$.

B) $22.5^{\circ}\mathrm{C}$.

C) $28.5^{\circ}\mathrm{C}$.

D) $32.5^{\circ}\mathrm{C}$.

Answer: $22.5^{\circ}\mathrm{C}$.

Solution: If the temperature of body decreases from T_1 and T_2 and temperature of surroundings is T_0 then according to Newton's law of cooling:

$$\left[\frac{T_1-T_2}{t}\right]=k\left[\frac{T_1+T_2}{2}-T_0\right]$$

For cooling from $95^{\circ}\mathrm{C}$ to $90^{\circ}\mathrm{C}$ we can write

$$\frac{(95-90)}{30}=k\left[\frac{95+90}{2}-T_0\right]\ \ldots(1)$$

Similarly, for cooling from $55^{\circ}\mathrm{C}$ to $50^{\circ}\mathrm{C}$

$$\frac{(55-50)}{70}=k\left[\frac{55+50}{2}-T_0\right]\ \ldots(2)$$

On dividing both the equations, we get:

$T_0=22.5^{\circ}\mathrm{C}$.

Q.22. If a bimetallic strip is heated, it will:

A) Bend towards the metal with lower thermal expansion coefficient

B) Bend towards the metal with higher thermal expansion coefficient

C) Twist itself into helix

D) Have no bending

Answer: Bend towards the metal with lower thermal expansion coefficient

Solution: When two strips of equal length but of different materials (different coefficient of linear expansion) are joined together, it is called " **Bimetallic strip** ". It has the characteristic property of bending on heating due to unequal linear expansion of the two metals. The metallic strip which has larger temperature coefficient will expand more and it will lie on outer edge of the arc. Hence, on heating it bends towards the metal with lower thermal expansion coefficient.

Q.23. The two-metre scales, one of steel and the other of aluminium agree at $20\ ^{\circ}\mathrm{C}$. The ratio of aluminium $(\mathrm{in\ cm})$ to steel $(\mathrm{in\ cm})$ at $0\ ^{\circ}\mathrm{C}$. (α for steel is $1.1\times10^{-5}\ ^{\circ}\mathrm{C}^{-1}$ and for aluminium is $2.3\times10^{-5}\ ^{\circ}\mathrm{C}^{-1}$) is

A) 0.89096

B) 0.99976

C) 1.00025

D) 1.00096

Answer: 0.99976

Solution: $\therefore\ l = l_0(1+\alpha\Delta\theta)$

$l_0 = l_{\text{an}},\ \Delta\theta = -20\ ^{\circ}\text{C}$

$l_{\text{s}} = l_{\text{an}}[1+\alpha_{\text{s}}(-20)]$

$l_{\text{Al}} = l_{\text{an}}[1+\alpha_{\text{Al}}(-20)]$

$\frac{l_{\text{Al}}}{l_{\text{s}}} = \frac{[1-20\alpha_{\text{Al}}]}{[1-20\alpha_{\text{s}}]}$

$\Rightarrow \frac{l_{\text{Al}}}{l_{\text{s}}} = \left[\frac{1-20\times2.3\times10^{-5}}{1-20\times1.1\times10^{-5}}\right]$

$\Rightarrow \frac{l_{\text{Al}}}{l_{\text{s}}} = \left[\frac{1-46\times10^{-5}}{1-22\times10^{-5}}\right]$

$\Rightarrow \frac{l_{\text{Al}}}{l_{\text{s}}} = \frac{[1-0.00046]}{[1-0.00022]}$

$\Rightarrow \frac{l_{\text{Al}}}{l_{\text{s}}} = \frac{0.99954}{0.99978} \approx 0.99975$

Q.24. 100 g of ice at 0°C is mixed with 100 g of water at 100°C . What will be the final temperature of the mixture?

Specific heat capacity of water is $s_{\text{w}} = 1\ \text{cal}\ \text{g}^{-1}\ ^{\circ}\text{C}^{-1}$

Specific heat capacity of ice is $s_i = 0.5\ \text{cal}\ \text{g}^{-1}\ ^{\circ}\text{C}^{-1}$

Latent heat of the water $L = 80\ \text{cal}\ \text{g}^{-1}\ ^{\circ}\text{C}^{-1}$

A) 13.33°C

B) 20°C

C) 23.33°C

D) 40°C

Answer: 13.33°C

Solution: Let the final temperature of the mixture be T.

Specific heat capacity of water is $s_{\text{w}} = 1\ \text{cal}\ \text{gm}^{-1}\ ^{\circ}\text{C}^{-1}$

Specific heat capacity of ice is $s_i = 0.5\ \text{cal}\ \text{gm}^{-1}\ ^{\circ}\text{C}^{-1}$

Latent heat of the water $L = 80\ \text{cal}\ \text{gm}^{-1}\ ^{\circ}\text{C}^{-1}$

Mass of water $m_{\text{w}} = 100\ \text{gm}$

Mass of ice $m_{\text{i}} = 100\ \text{gm}$

Heat lost is given by,

$Q_1 = m_{\text{i}}L + m_{\text{i}}s_{\text{i}}\,\Delta T$

$Q_1 = 100\times80 + 100\times0.5\times(T-0)$

Heat gained by the system is given by,

$Q_2 = m_{\text{w}}s_{\text{w}}\,\Delta T$

$Q_2 = 100\times1\times(100-T)$

Heat lost by the system will be equal to the heat gained by the system,

$Q_1 = Q_2$

$100\times80 + 100\times0.5\times(T-0) = 100\times1\times(100-T)$

$\Rightarrow T = 13.33\ ^{\circ}\text{C}.$

Q.25. Rate of heat conduction through a window is $1000 \mathrm{~W}$, when the inside temperature is $10^{\circ} \mathrm{C}$ and the outside temperature is $-10^{\circ} \mathrm{C}$. Same heat will be conducted through the window when the outside temperature is $-23^{\circ} \mathrm{C}$ and inside temperature is:

A) $23^{\circ} \mathrm{C}$

B) $230 \mathrm{~K}$

C) $270 \mathrm{~K}$

D) $296 \mathrm{~K}$

Answer: $270 \mathrm{~K}$

Solution: For the same heat to be conducted, the temperature difference must be same.

Initial temperature difference $10-(-10)=$20°C $=20 \mathrm{~K}$

Outside temperature = -23°C $=-23+273=250 \mathrm{~K}$

Inside temperature $=250+20=270 \mathrm{~K}$

Practice more on Properties of Bulk Matter