# UNIT – VII

# PROPERTIES OF BULK MATTER

## KEY CONCEPTS

- **Plasticity :** The inability associated with a body in regaining the original status on the removal of the deforming forces is called plasticity.
- **Elasticity :** It is the property of the body by virtue of which the body regains its original configuration (length, volume or shape) when the deforming forces are removed.
- **Stress :** The internal restoring force acting per unit area of a deformed body is called stress, *i.e.*,

  Stress = restoring force/area.
- **Strain :** It is defined as the ratio of change in configuration to the original configuration of the body *i.e.*, $\text{Strain} = \dfrac{\text{change in configuration}}{\text{original configuration}}$

  Strain can be of three types : (i) Longitudinal strain (ii) Volumetric strain (iii) Shearing strain.
- **Hooke's law :** It states that within elastic limit stress is directly proportional to strain.
- **Modulus of Elasticity or Coetificient of elasticity** of a body is defined as elastic limit the ratio of the stress to the corresponding strain produced.
- Types of Modulus of elasticity

  (i) *Young's Modulus elasticity (Y)*. Within elastic limit the ratio of normal stress to the longitudinal strain. *i.e.*,

  $$Y = \frac{\text{normal stress}}{\text{longitudinal strain}} = \frac{F/a}{\Delta L/L} = \frac{F}{a} \times \frac{l}{\Delta l}$$

  (ii) *Bulk Modulus of elasticity (K)*. It is defined as within the elastic limit the ratio of normal stress to the volumetric strain. *i.e.*,

  $$B = \frac{\text{normal stress}}{\text{longitudinal strain}} = \frac{(-)\ F/a}{\Delta V/V} = -\frac{F}{a} \times \frac{V}{\Delta V} = -p\frac{V}{\Delta V}$$

(iii) *Modulus of Rigidity* ($\eta$). It is defined as the ratio of tangential stress to the shearing strain, within the elastic limit, *i.e.*,

$$\eta = \frac{\text{tangential stress}}{\text{shearing strain}} = \frac{F / a}{\theta} = \frac{F}{A\,\theta}$$

- Compressibility $= \dfrac{1}{\text{Bulk modulus}} = -\dfrac{\Delta V}{pV}$

- **Poisson's ratio** ($\sigma$) is defined as the ratio of lateral strain to the longitudinal strain, *i.e.*,

$$\sigma = \frac{\text{lateral strain}}{\text{longitudinal strain}} = \frac{-\Delta R / R}{\Delta L/L} = \frac{-\Delta R . l}{R . \Delta L}$$

Theoretical value of $\sigma$ lies between $-1$ and $\dfrac{1}{+2}$. The practical value of $\sigma$ lies between 0 and +1/2. If there is no change in the volume of wire on loading, then its Poisson's ratio is 0.5.

- Workdone in a stretching a wire is $W = \dfrac{1}{2} \times \text{stress} \times \text{strain} \times \text{volume}$

$$= \frac{1}{2}\frac{F}{A} \times \frac{\Delta L}{L} \times AL = \frac{1}{2} F \times \Delta L = \frac{1}{2}\ \text{load} \times \text{extension}$$

- **Elastic potential energy stored per unit volume of a strained body**

$$u = \frac{1}{2} \times \text{stress} \times \text{strain} = \frac{(\text{stress})^2}{2Y} = \frac{Y \times (\text{strain})^2}{2}$$

where $Y$ is the Young's modulus of elasticity of a solid body.

- Total pressure at a point inside the liquid of density $\rho$ at depth $h$ is $P = h \rho g + P_0$ where $P_0$ is the atmospheric pressure.

- **Pascal's law :** Pascal's law states that the increase in pressure at one point of the enclosed liquid in equilibrium of rest is transmitted (provided the effect of gravity is neglected) undiminished in all direction.

- **Viscosity :** Viscosity is the property of a fluid by virtue of which an internal frictional force comes into play when the fluid is in motion and opposes the relative motion of its different layers.

  Viscous drag F, acting between two layers of liquid each of area A, moving with velocity gradient *dv/dx* is given by $F = -\eta A\, dv/dx$

  where $\eta$ is the coefficient of viscosity of liquid.

  SI unit of $\eta$ is poiseuille of $N\ s\ m^{-2}$ or Pascal-second

- **Stoke's law :** It states that the viscous drag (backward dragging force) F acting on a small spherical body of radius r, moving through a medium of viscosity with velocity v is given by $F = 6\pi\eta r v$.

- **Terminal velocity :** It is the maximum constant velocity acquired by the body while falling freely in a viscous medium. Terminal velocity v of a spherical body of radius *r*, density p while falling freely in a viscous medium of viscosity $\rho$, density $\sigma$ is given by $v = \dfrac{2r^2(\rho - \sigma)g}{9\eta}$

- **Stream lined flow of a liquid** is that flow in which every particle of the liquid follows exactly the path of its preceding particle and has the same velocity in magnitude and direction as that of its preceding particle while crossing through that point.

- **Turbulent flow :** It is that flow of liquid in which the motion of the particles of liquid becomes disorderly or irregular.

- **Critical velocity :** It is that velocity upto which the flow of liquid is a streamlined and above which it becomes turbulent. Critical velocity of a liquid ($v_c$) flowing through a tube is given by

$$v_c = \frac{N\eta}{\rho D}$$

  where p is the density of liquid flowing through a tube of diameter D and $\eta$ is the coefficient of viscosity of liquid. N = Reynold number

- **Equation of continuity,** a v = constant **where a = area of cross section v = velocity of flow of liquid.**

- **Ideol liquid :** An incompressible, non viscous homogeneous liquid.

- **Conduction :** is the process of transfer of heat between two adjacent part of a body due to temperature difference.

- **Quantitatively :** it is defined as the time rate of heat flow in a material for a given temperature difference

  The rate of transfer of heat $\frac{d\theta}{dt} = KA\frac{d\theta}{dx}$

  k – is thermal conductivity, A is the area of cross section.

  $\frac{d\theta}{dt}$ – is the temperature gradient.

- **Connection :** is the mode of transfer of heat in which molecules leave their place to transfer the heat

- Radiation is the mode of transfer of heat in which no medium is required. It is the fastest mode of transfer of heat.

- The relation between linear expansion ($\alpha$), superficial expansion ($\beta$) and volume expansion ($\gamma$) is

$$\alpha = \frac{\beta}{2} = \frac{\gamma}{3}$$

- **Bernoulli's Theorem :** It states that for the stream line flow of an ideal liquid, the total energy (the sum of pressure energy, the potential energy and kinetic) per unit volume remains constant at every cross-section throughout the tube, *i.e.*,

$$P + \rho gh + \frac{1}{2}\rho\nu^2 = \text{ constant, } \quad \text{or} \quad \frac{P}{\rho g} + h + \frac{1}{2}\frac{\nu^2}{g} = \text{ constant}$$

- **Torricelli's Theorem :** It states that the velocity of efflux, *i.e.*, the velocity with which the liquid flows out of an orifice is equal to that which a freely falling body would acquire in falling through a vertical distance equal to the depth of orifice below the free surface of liquid. Quantitatively velocity of efflux, $\nu = \sqrt{2gh}$, where $h$ is the depth of orifice below the free surface of liquid.

- **Surface tension :** Surface Tension is the tendency of the liquid at rest to attain least potential energy by reducing the surface area and as such it behaves as a stretched membrane. Surface tension,

$$S = \frac{F}{l}$$

  where $F$ is the force acting on the imaginary line of length $l$, drawn tanentially to the liquid surface at rest. SI unit of surface tension is $Nm^{-1}$

- **Surface energy :** Energy possessed by the surface of the liquid is called surface energy surface tension × change in surface area of the liquid surface at costt temperature

  (i) Excess of pressure inside a liquid drop, $P = 2S/R$

  (ii) Excess of pressure inside a soap bubble, $P = 4S/R$

  where $S$ is the surface tension and $R$ is the radius of the drop or bubble.

- **Angle of contact :** Angle between tangents drawn at point of contact to liquid surface and to solid surface drawn into liquid.


- **Capillarity :** The phenomenon of rise or fall of liquid in a capillary tube is called capillarity. The height ($h$) through which a liquid will rise in a capillary tube of radius $r$ which wets the sides of the tube will be given by

$$h = \frac{2S\cos\theta}{r\rho g}$$

where $S$ is the surface tension of liquid, $\theta$ is the angle of contact, $\rho$ is the density of liquid and g is the acceleration due to gravity.

- **Excess pressure :** For a curved surface in equilibrium; the convex side will have more pressure than convex side.

## VERY SHORT ANSWER TYPE QUESTIONS (1 MARK)

1. Define term (i) stress (ii) strain
2. Differentiate the terms plasticity and elasticity of material
3. Draw stress – strain curve for elastomers (elastic tissue of Aorta)
4. How are we able to break a wire by repeated bending?
5. What is the value of bulk modulus for an incompressible liquid?
6. Define Poisson's ratio? What is its unit?
7. What is elastic fatigue?
8. It is easier to swim in sea water than in the river water. Why?
9. Railway tracks are laid on large sized wooden sleepers. Why?
10. The dams of water reservoir are made thick near the bottom. Why?
11. Why is it difficult to stop bleeding from a cut in human body at high attitudes?
12. The blood pressure in human is greater at the feet than at the brain. Why?
13. Define coefficient of viscosity and write its SI unit.
14. Why machine parts get jammed in winter?
15. Why are rain drops spherical?
16. Why do paints and lubricants have low surface tension?
17. What will be the effect of increasing temperature on (i) angle of contact (ii) surface tension.
18. For solids with elastic modulus of rigidity, the shearing force is proportional to shear strain. On what factor does it depend in case of fluids?
19. How does rise in temperature effect (i) viscosity of gases (ii) viscosity of liquids.

20. Explain do why detergents have small angle of contact?

21. Write the dimensions of coefficient of viscosity and surface tension.

22. Obtain a relation between SI unit and cgs unit of coefficient of viscosity.

23. Explain, how the use of parachute helps a person jumping from an aeroplane.

24. Why two ships moving in parallel directions close to each other get attracted?

25. Why the molecules of a liquid lying near the free surface possess extra energy?

26. Why is it easier to wash clothes in hot soap solution?

27. Why does mercury not wet glass?

28. Why ends of a glass tube become rounded on heating?

29. What makes rain coats water proof?

30. What happens when a capillary tube of insufficient length is dipped in a liquid?

31. Does it matter if one uses gauge pressure instead of absolute pressure in applying Bernoulli's equation?

32. State Wein's displacement law for black body radiation.

33. State Stefan Boltzmann law.

34. Name two physical changes that occur on heating a body.

35. Distinguish between heat and temperature.

36. Which thermometer is more sensitive a mercury or gas thermometer?

37. Metal disc has a hole in it. What happens to the size of the hole when disc is heated?

38. Name a substance that contracts on heating.

39. A gas is free to expand what will be its specific heat?

40. What is Deby's temperature?

41. What is the absorptive power of a perfectly black body?

42. At what temperature does a body stop radiating?

43. If Kelvin temperature of an ideal black body is doubled, what will be the effect on energy radiated by it?

44. In which method of heat transfer does gravity not play any part?

45. Give a plot of Fahrenheit temperature versus celsius temperature

46. Why birds are often seen to swell their feather in winter?

47. A brass disc fits snugly in a hole in a steel plate. Should we heat or cool the system to loosen the disc from the hole.

## SHORT ANSWER TYPE QUESTIONS (2 MARKS)

1. State Hooke's law. Deduce expression for young's modulus of material of a wire of length 'l', radius of crossection 'r' loaded with a body of mass M producing an extension $\Delta l$ in it.

2. A wire of length l, area of crossection A and young's modulus Y is stretched by an amount x. What is the work done?

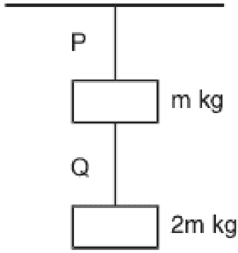
3. Prove that the elastic potential energy per unit volume is equal to $\frac{1}{2} \times \text{stress} \times \text{strain}$.

4. Define the term bulk modulus. Give its SI unit. Give the relation between bulk modulus and compressibility.

5. Define shear modulus. With the help of a diagram explain how shear modulus can be calculated.

6. Which is more elastic steel or rubber? Explain.

7. Two wires P and Q of same diameter are loaded as shown in the figure. The length of wire P is L m and its young's modulus is Y N/m$^2$ while length of wire Q is twice that of P and its material has young's modulus half that of P. Compute the ratio of their elongation.




8. What is Reynold's number? Write its significance. On what factors does it depend?

9. Define surface tension and surface energy. Obtain a relation between them.

10. State and prove Torricelli's theorem for velocity of efflux.

11. Using dimensional method obtain Stoke's law exp ression for viscous force $F = 6\pi\eta rv$

12. The fig (a) & (b) refer to the steady flow of a non viscous liquid. Which one of the two figures is incorrect? Why?

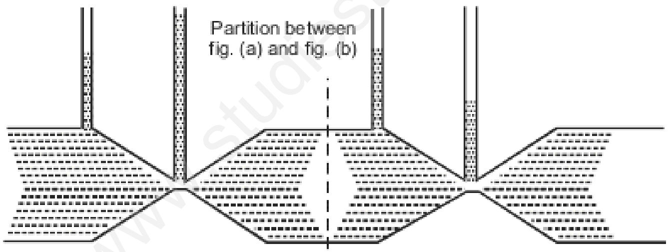
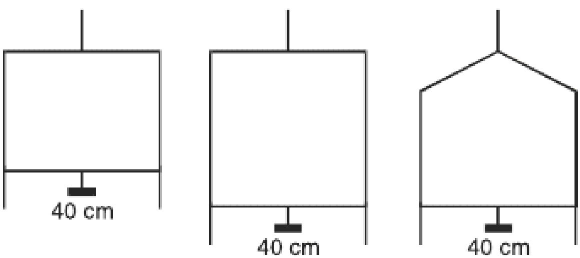



Fig. (a) Fig. (b)

13. The fig a below shows a thin liquid supporting a small weight $4.5 \times 10^{-2}$N. What is the weight supported by a film of same liquid at the same temperature in fig (b) & (c) Explain your answer.



14. Two soap bubbles of different diameter are in contact with a certain portion common to both the bubbles. What will be the shape of the common boundary as seen from inside the smaller bubble? Support your answer with a neat diagram and justify your answer.

15. During blood transfusion the needle is inserted in a vein where gauge pressure is $p_g$ and atmospheric pressure is p. At what height must the blood container be placed so that blood may just enter the vein. Given density of blood is $\rho$.

16. Why we cannot remove a filter paper from a funnel by blowing air into narrow end.

17. On a hot day, a car is left in sunlight with all windows closed. Explain why it is considerably warmer than outside, after some time?

18. Name the suitable thermometers to measure the following temperatures

    (a) –100°C (b) 80° C

    (c) 780°C (d) 2000°C

19. If a drop of water falls on a very hot iron, it does not evaporate for a long time. Why?

20. The earth without its atmosphere would be inhospitably cold. Why?

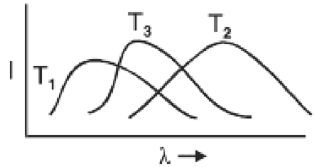
21. The coolant used in a nuclear plant should have high specific heat. Why?

22. A sphere, a cube and a disc made of same material and of equal masses heated to same temperature of 200°C. These bodies are then kept at same lower temperature in the surrounding, which of these will cool (i) fastest, (ii) slowest. Explain.

23. (a) Why pendulum clocks generally go faster in winter and slow in summer?

    (b) Why the brake drums of a car are heated when it moves down a hill at constant speed?

24. The plots of intensity versus wavelength for three blackbodies at temperature $T_1$, $T_2$ and $T_3$ respectively are shown.




Arrange the temperature in decreasing order. Justify your answer.

25. The triple point of water is a standard fixed point in modern thermometry. Why? Why melting point of ice or boiling point of water not used as standard fixed points.

## SHORT ANSWER TYPE QUESTION (3 MARKS)

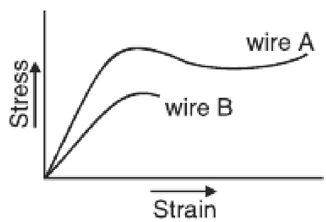
1. How is the knowledge of elasticity useful in selecting metal ropes used in cranes for lifting heavy loads.

2. The torque required to produce unit twist in a solid shaft of radius r, length l and made of material of modulus of rigidity $\eta$ is given by

$$\tau = \frac{\pi \eta r^4}{2 l}$$

Explain why hollow shafts are preferred to solid shafts for transmitting torque?

3. Stress strain curve for two wires of material A and B are as shown in Fig.




(a) which material is more ductile?

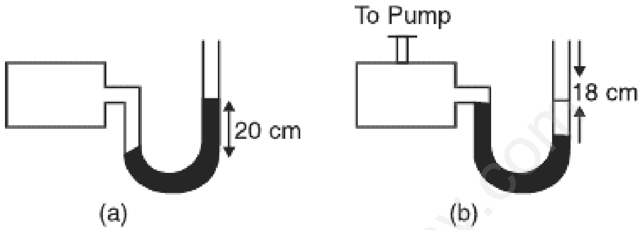
(b) which material has greater value of young's modulus?

(c) which of the two is stronger material?

(d) which material is more brittle?

4. State Pascal's law for fluids with the help of a neat labelled diagram. Explain the principle and working of hydraulic brakes.

5. A manometer reads the pressure of a gas in an enclosure as shown in the fig (a) when some of the gas is removed by a pump, the manometer reads as in fig (b) The liquid used in manometer is mercury and the atmospheric pressure is 76 cm of mercury. (i) Give absolute and gauge pressure of the gas in the enclosure for cases (a) and (b).




6. How would the levels change in (b) if 13.6 cm of $H_2O$ (immensible with mercury) are poured into the right limb of the manometer in the above numerical.

7. Define Capillarity and angle of contact. Derive an expression for the ascent of a liquid in a capillary tube.

8. The terminal velocity of a tiny droplet is v. N number of such identical droplets combine together forming a bigger drop. Find the terminal velocity of the bigger drop.

9. Two spherical soap bubble coalesce. If v be the change in volume of the contained air, A is the change in total surface area then show that 3PV + 4AT = 0 where T is the surface tension and P is atmospheric pressure.

10. Give the principle of working of venturimeter. Obtain an expression for volume of liquid flowing through the tube per second.

11. A big size balloon of mass M is held stationary in air with the help of a small block of mass M/2 tied to it by a light string such that both float in mid air. Describe the motion of the balloon and the block when the string is cut. Support your answer with calculations.

12. Two vessels have the same base area but different shapes. The first vessel takes twice the volume of water that the second vessel requires to fill upto a particular common height. Is the force exerted by the water on

the base of the vessel the same? Why do the vessels filled to same height give different reading on weighing scale.

13. A liquid drop of diameter D breaks up into 27 tiny drops. Find the resulting change in energy. Take surface tension of liquid as $\sigma$.

14. Define the coefficients of linear expansion. Deduce relation between it and coefficient of superficial expansion and volume expansion.

15. Describe the different types of thermometers commonly used. Give the relation between temperature on different scales. Give four reasons for using mercury in a thermometer.

16. Two rods of different metals of coefficient of linear expansion $\alpha_1$ and $\alpha_2$ and initial length $l_1$ and $l_2$ respectively are heated to the same temperature. Find relation in $\alpha_1$, $\alpha_2$, $l_1$ and $l_2$ such that difference between their lengths remain constant.

17. Explain the principle of platinum resistance thermometer.

18. Draw a graph to show the anomalous behaviour of water. Explain its importance for sustaining life under water.

19. A steel rail of length 5m and area of cross section 40cm$^2$ is prevented from expanding while the temperature rises by 10°C. Given coefficient of linear expansion of steel is $1.2 \times 10^{-5}$ k$^{-1}$. Explain why space needs to be given for thermal expansion.

20. Define (i) Specific heat capacity (ii) Heat capacity (iii) Molar specific heat capacity at constant pressure and at constant volume and write their units.

21. Plot a graph of temperature versus time showing the change in the state of ice on heating and hence explain the process (with reference to latent heat)

22. What is the effect of pressure on melting point of a substance? What is regelation. Give a practical application of it.

23. What is the effect of pressure on the boiling point of a liquid. Describe a simple experiment to demonstrate the boiling of $H_2O$ at a temperature much lower than 100°C. Give a practical application of this phenomenon.

24. State and explains the three modes of transfer of heat. Explain how the loss of heat due to these three modes is minimised in a thermos flask.

25. Define coefficient of thermal conductivity. Two metal slabs of same area of cross-section, thickness $d_1$ and $d_2$ having thermal conductivities $K_1$ and $K_2$ respectively are kept in contact. Deduce expression for equivalent thermal conductivity.

## LONG ANSWER TYPE QUESTIONS (5 MARKS)

1. Draw and discuss stress versus strain graph, explaining the terms elastic limit, permanent set, proportionality limit, elastic hysteresis, tensible strength.

2. Show that there is always an excess pressure on the concave side of the meniscus of a liquid. Obtain an expression for the excess pressure inside (i) a liquid drop (ii) liquid bubble (iii) air bubble inside a liquid.

3. State and prove Bernoullis theorem. Give its limitation. Name any two applications of the principle.

4. Define terminal velocity. Obtain an expression for terminal velocity of a sphere falling through a viscous liquid. Use the formula to explain the observed rise of air bubbles in a liquid.

5. State Newton's law of cooling. Deduce the relations :

$$\log_e(T - T_0) = -kt + c$$

and $$T - T_0 = C\ e^{-kt}$$

where the symbols have their usual meanings. Represent Newton's law of cooling graphically by using each of the above equation.

6. On what factors does the rate of heat conduction in a metallic rod in the steady state depend. Write the necessary expression and hence define the coefficient of thermal conductivity. Write its unit and dimensions.

7. Distinguish between conduction, convection and radiation.

8. What is meant by a block body. Explain how a black body may be achieved in practice. State and explain Stefan's law?

9. Explain the construction and working of a constant volume gas thermometer. What are its main draw backs?

10. Discuss energy distribution of a black body radiation spectrum. Explain Wein's displacement law of radiation and Stefan's law of heat radiation.

# NUMERICALS

1. An aluminium wire 1m in length and radius 1mm is loaded with a mass of 40 kg hanging vertically. Young's modulus of Al is $7.0 \times 10^{-10}$ N/m$^2$ Calculate (a) tensile stress (b) change in length (c) tensile strain and (d) the force constant of such a wire.

2. The average depth of ocean is 2500 m. Calculate the fractional compression $\left(\frac{\Delta V}{V}\right)$ of water at the bottom of ocean, given that the bulk modulus of water is $2.3 \times 10^9$ N/m$^2$.

3. A force of $5 \times 10^3$ N is applied tangentially to the upper face of a cubical block of steel of side 30 cm. Find the displacement of the upper face relative to the lower one, and the angle of shear. The shear modulus of steel is $8.3 \times 10^{10}$ pa.

4. How much should the pressure on one litre of water be changed to compress it by 0.10%.

5. Calculate the pressure at a depth of 10 m in an Ocean. The density of sea water is 1030 kg/m$^3$. The atmospheric pressure is $1.01 \times 10^5$ pa.

6. In a hydraulic lift air exerts a force F on a small piston of radius 5cm. The pressure is transmitted to the second piston of radius 15 cm. If a car of mass 1350 kg is to be lifted, calculate force F that is to be applied.

7. How much pressure will a man of weight 80 kg f exert on the ground when (i) he is lying and (2) he is standing on his feet. Given area of the body of the man is 0.6 m$^2$ and that of his feet is 80 cm$^2$.

8. The manual of a car instructs the owner to inflate the tyres to a pressure of 200 k pa. (a) What is the recommended gauge pressure? (b) What is the recommended absolute pressure (c) If, after the required inflation of the tyres, the car is driven to a mountain peak where the atmospheric pressure is 10% below that at sea level, what will the tyre gauge read?

9. Calculate excess pressure in an air bubble of radius 6mm. Surface tension of liquid is 0.58 N/m.

10. Terminal velocity of a copper ball of radius 2 mm through a tank of oil at 20°C is 6.0 cm/s. Compare coefficient of viscosity of oil. Given $\rho_{cu} = 8.9 \times 10^3$ kg/m$^3$, $\rho_{oil} = 1.5 \times 10^3$ kg/m$^3$

11. Calculate the velocity with which a liquid emerges from a small hole in the side of a tank of large cross-sectional area if the hole is 0.2m below the surface liquid ($g = 10\ ms^{-2}$).

12. A soap bubble of radius 1 cm expands into a bubble of radius 2cm. Calculate the increase in surface energy if the surface tension for soap is 25 dyne/cm.

13. A glass plate of $0.20\ m^2$ in area is pulled with a velocity of 0.1 m/s over a larger glass plate that is at rest. What force is necessary to pull the upper plate if the space between them is 0.003m and is filled with oil of $\eta = 0.01\ Ns/m^2$

14. The area of cross-section of a water pipe entering the basement of a house is $4 \times 10^{-4}\ m^2$. The pressure of water at this point is $3 \times 10^5\ N/m^2$, and speed of water is 2 m/s. The pipe tapers to an area of cross section of $2 \times 10^{-4}\ m^2$, when it reaches the second floor 8 m above the basement. Calculate the speed and pressure of water flow at the second floor.

15. A metal black of area $0.10\ m^2$ is connected to a 0.010 kg mass via a string that passes over an ideal pulley. A liquid with a film thickness of 0.30 mm is placed between the block and the table when released the block moves with a constant speed of $0.085\ ms^{-1}$. Find the coefficient of viscosity of the liquid.

16. Water rises to a height of 9 cm in a certain capillary tube. If in the same tube, level of Hg is depressed by 3 cm, compare the surface tension of water and mercury. Specific gravity of Hg is 13.6 and the angle of contact for Hg is 135°

17. Two stars radiate maximum energy at wavelength, $3.6 \times 10^{-7}$ m respectively. What is the ratio of their temperatures?

18. Find the temperature of 149°F on kelvin scale.

19. A metal piece of 50 g specific heat 0.6 cal/g°C initially at 120°C is dropped in 1.6 kg of water at 25°C. Find the final temperature or mixture.

20. A iron ring of diameter 5.231 m is to be fixed on a wooden rim of diameter 5.243 m both initially at 27°C. To what temperature should the iron ring be heated so as to fit the rim (Coefficient of linear expansion of iron is $1.2 \times 10^5\ k^{-1}$?

21. 100g of ice at 0°C is mixed with 100 g of water at 80°C. The resulting temperature is 5°C. Calculate heat of furion of ice.

22. Calculate heat required to covert 3kg of water at 0°C to steam at 100°C Given specific heat capacity of $H_2O$ = 4186J $kg^{-1}$ $k^{-1}$ and latent heat of stem = $2.256 \times 10^6$ J/kg

23. Given length of steel rod 15 cm; of copper 10 cm. Their thermal conductivities are 50.2 j – s $m^{-1}$ $k^{-1}$ and 385 j – s – $m^{-1}$ $k^{-1}$ respectively. Area of crossection of steel is double of area of Copper rod?

24, A body at temperature 94°C cools to 86°C in 2 min. What time will it take to cool from 82°C to 78°C. The temperature of surrounding is 20°C.

25. A body re-emits all the radiation it receives. Find surface temperature of the body. Energy received per unit area per unit time is 2.835 watt/$m^2$ and $\sigma = 5.67 \times 10^{-8}$ W $m^{-2}$ $k^{-4}$.

26. At what temperature the resistance of thermometer will be 12% more of its resistance at 0°C (given temperature coefficient of resistance is $2.5 \times 10^{-3}$ °$C^{-1}$?

## VERY SHORT ANSWER (1 MARK)

4. Repeated bending of wire decreases elastric strength and therefore it can be broken easily.

5. $K = \frac{\text{stress}}{\text{strain}} = \frac{\text{stress}}{o} = \infty$ Infinity

6. Poisson's ratio is the ratio of lateral strain to the longitudinal strain. It has no units.

7. It is the loss in strength of a material caused due to repeated alternating strains to which the material is subjected

8. The density of sea water is more than the density of river water, hence sea water gives more up thrust for the same volume of water displaced.

9. This spreads force due to the weight of the train on a larger area and hence reduces the pressure considerably and in turn prevents yielding of the ground under the weight of the train.

10. Pressure exerted by liquid column = $h \rho g$ so as '$h$' increases $\rho$ increases so to with stand high pressure dams are made thick near the bottom.

11. The atmospheric pressure is low at high altitudes. Due to greater pressure difference in blood pressure and the atmospheric pressure, it is difficult to stop bleeding from a cut in the body.

12. The height of blood clumn is quite large at feet than at the brain, hence blood pressure at feet is greater.

14. In winter i.e. at low temperature the viscosity of lubricants increases.

15. Due to surface thension the drops try to occupy minimum surface area, and for a given volume sphere has minimum surface area.

16. Low surface tension makes paints and lubricants to spread more effectively.

17. Angle of contact increases with increase of temperature while surface tension generally decreases with increase of temperature

18. Rate of Shear Strain.

19. Viscosity of gases increases while viscosity of liquid decreases.

20. Detergents should have small angle of contact so that they have low surface tension and greater ability to wet a surface. Further as $h = \frac{2T \cos\theta}{r\rho g}$ i.e. $\theta$ is small Cos $\theta$ will be large so *h* i.e. penetration will be high.

21. $[\eta] = M^1 L^{-1} T^{-1}$

$[S] = M^1 T^{-2} L^0$

22. c.g.s unit of $\eta$ = poise

S.I Unit of $\eta$ = poiseuille or deca poise

1 poise = 1 g $cm^{-1}$ $s^{-2}$ = $10^{-1}$ kg $m^{-1}$ $s^{-1}$

= 0.1 poiseuille

23. Viscous force on the parachute is large as $F = 6\pi \eta r v$, $F \alpha r$, so its terminal velocity becomes small so the person hits the ground with this small velocity and does not get injured.

24. According to Bernoulli's theorem for horizontal flow $P + \frac{1}{2}\rho\upsilon^2 = \text{constant}$. As speed of water between the ships is more than outside them pressure between them gets reduced & pressure outside is more so the excess pressure pushes the ships close to each other therefore they get attracted.

25. The molecules in a liquid surface have a net downward force (cohesion) on them, so work done in bringing them from within the body of liquid to the surface increases surface energy.

26. Hot water soap solution has small surface tension therefore can remove the dirt from clothes by wetting them effectively.

27. Mercury does not wet glass because of larger cohesive force between Hg-Hg molecules than the adhesive forces between mercury-glass molecules.

28. When glass is heated, it melts. The surface of this liquid tends to have a minimum area. For a given volume, the surface area is minimum for a sphere. This is why the ends of a glass tube become rounded on heating.

29. The angle of contact between water and the material of the rain coat is obtuse. So the rain water does not wet the rain coat.

30. When a capillary tube of insufficient length is dipped in a liquid, the radius of curvature of the mensicus increase so that hr = constant. That is pressure on concave side becomes equal to pressure exerted by liquid column so liquid does not overflow.

31. No. Unless the atmospheric pressures at the two points where Bernoulli's equation is applied, are significantly different.

34. Volume and electrical resistance.

36. Gas thermometer is more sensitive as coefficient of expansion of Gas is more than mercury.

37. Expansion is always outward, therefore the hole size increased on heating.

38. Ice

39. Infinity

40. The temperature above which molar heat capacity of a solid substance becomes constant.

41. One.

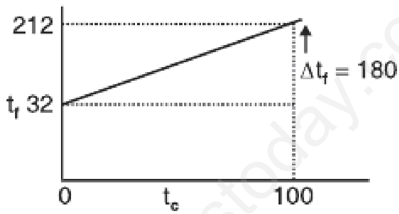
42. At oK.

43. $E \alpha T^4 \therefore \frac{E_2}{E_1} = \left(\frac{T_2}{T_1}\right)^4 = \left(\frac{2T_1}{T_1}\right)^4 = 16$

$\therefore E_2 = 16 E_1$

44. In conduction and radiation

45.




46. When birds swell their feathers, they trap air in the feather. Air being a poor conductor prevents loss of heat and keeps the bird warm.

47. The temp. coefficient of linear expansion for brass is greater than that for teel. On cooling the disc shrinks to a greater extent than the hole, and hence brass disc gets lossened.

## SHORT ANSWER TYPE (2 MARKS)

2. Restoring force in extension $x$ = F = $\frac{AYx}{L}$

Work done in stretching it by dx = dw = F. dx

Work done in stretching it from zero to x = W = $\int dw = \int_0^x F\, dx$

$$W = \int_0^x \frac{AYx}{L} dx = \frac{1}{2} \frac{AYx^2}{L}$$

3. Energy Density $= \dfrac{\text{Energy}}{\text{Volume}} = \dfrac{\frac{1}{2}\frac{AY}{L}x^2}{AL}$

$$= \frac{1}{2}\left(\frac{AYx}{AL}\right) \times \frac{x}{L}$$

$$= \frac{1}{2}\frac{F}{A} \times \frac{x}{L}$$

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

6. $Y_s = \dfrac{F}{A}\dfrac{l}{\Delta l_s}$

$$Y_r = \frac{F}{A}\frac{l}{\Delta l_r}$$

For same force applied to wires made of steel & rubber of same length and same area of cross section

$$\Delta l_s < \Delta l_r$$

$$\frac{Y_s}{Y_r} = \frac{\Delta l_r}{\Delta l_s} > 1$$

$$\therefore \quad Y_s > Y_r$$

7. $\Delta l_p = \dfrac{3mg}{A} \times \dfrac{L}{Y}$ $\qquad \Delta l_Q = \dfrac{2mg}{A} \cdot \dfrac{2L}{Y/2} = \dfrac{8mg}{A}\dfrac{L}{Y}$

$$\therefore \frac{\Delta l_P}{\Delta l_Q} = \frac{3}{8}$$

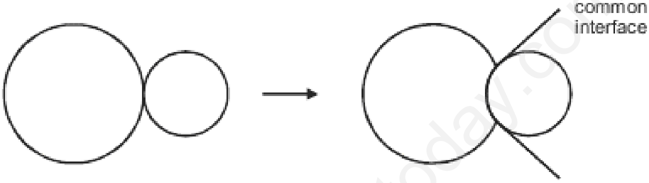
8. Definition of Reynold number $N_R$ is the ratio of inertial force to viscous force.

12. Fig. (a) is correct.

At the constriction, the area of cross section is small so liquid velocity is large, consequently pressure must be small so height of liquid must be less.

13. The weight supported by (b) & (c) are same as that in (a) and is equal to $4.5 \times 10^{-2}$ N.

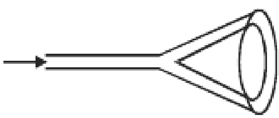
The weight supported = 2 σ l, where σ is surface tension and *l* is the length which is same in all the three cases, hence weight supported is same.

14. 


When seen from inside the smaller bubble the common surface will appear concave as (1) the pressure (excess) $= \frac{2T}{R}$ will be greater for concave surface & as R is small for the smaller bubble, the pressure will be greater.

15. $P_g = \rho g$

$$h = \frac{P_g}{\rho g}$$

16. 

When air is blown into the narrow end its velocity in the region between filter paper and glass increases. This decreases the pressure. The filter paper gets more firmly held with the wall of the tunnel.

17. Glass transmits 50% of heat radiation coming from a hot source like sun but does not allow the radiation from moderately hot bodies to pass through it.

18. (*a*) Gas thermometer;

(*b*) Mercury thermometer;

(*c*) Platinum resistance thermometer;

(*d*) Radiation pyrometer.

19. A vapour film is formed between water drop and the hot iron. Vapour being a poor conductor of heat makes the water droplet to evaporate slowly.

20. Due to green house effect, the presence of atmosphere prevents heat radiations received by earth to go back. In the absence of atmosphere radiation will go back at night making the temperature very low and inhospitable.

21. So, that it absorbs more heat with comparatively small change in temperature and extracts large amount of heat.

22. Rate of energy emission is directly proportional to area of surface for a given mass of material. Surface area of sphere is least and that of disc is largest. Therefore cooling of (i) disc is fastest and (ii) sphere is slowest.

23. (*a*) Time period of pendulum = $T = 2\pi\sqrt{\frac{l}{g}}$ or $T \times \sqrt{l}$

In winter *l* becomes shorter so its time period reduces so it goes faster. In summer *l* increases resulting in increase in time period so the clock goes slower.

(*b*) When the car moves down hill, the decrease in gravitational potential energy is converted into work against force of friction between brake shoe and drum which appears as heat.

24. $\lambda_m^1 < \lambda_m^3 < \lambda_m^2$

$\therefore$ from Wein displacement law

$T_1 > T_3 > T_2$

25. The melting point of ice as well as the boiling point of water changes with change in pressure. The presence of impurities also changes the melting and boiling points. However the triple point of water has a unique

temperature and is independent of external factors. It is that temperatures at which water, ice & water vapour co-exist that is 273.16K and pressure 0.46 cm of Hg.

## ANSWERS FOR SHORT QUESTIONS (3 MARKS)

1. The ultimate stress should not exceed elastic limit of steel ($30 \times 10^7$ N/m$^2$)

$$U = \frac{F}{A} = \frac{M9}{\pi r^2} = \frac{10^5 \times 9.8}{\pi r^2} = 30 \times 10^7$$

$\therefore \quad r = 3.2$ cm

So to lift a load of $10^4$kg, crane is designed to withstand $10^5$kg. To impart flexibility the rope is made of large number of thin wires braided.

2. Torque required to produce unit twist in hollow shaft of internal radius $r_1$ and external radius $r_2$ is

$$\tau' = \frac{\pi\eta\left(r_2^4 - r_1^4\right)}{2l}$$

$$\therefore \quad \frac{\tau'}{\tau} = \frac{r_2^4 - r_1^4}{r^4} = \frac{\left(r_2^2 + r_1^2\right)\left(r_2^2 - r_1^2\right)}{r^4}$$

If the shafts are made of material of equal volume.

$$\pi r^2 l = \pi\left(r_2^2 - r_1^2\right) l \text{ or } r_2^2 - r_1^2 = r^2$$

$\therefore \quad$ Since $r_2^2 + r_1^2 > r^2 \; \tau' > \tau$

3. (*a*) Wire with larger plastic region is more ductile material A

(*b*) Young's modulus is $\frac{\text{Stress}}{\text{Strain}}$

$\therefore Y_A > Y_B$

(*c*) For given strain, larger stress is required for A than that for B.

$\therefore$ A is stronger than B.

(*d*) Material with smaller plastic region is more brittle, therefore B is more brittle than A.

5. (*i*) In case (*a*) Pressure head, h = + 20 cm of Hg

Absolute pressure = P + h = 76 + 20 = 96 cm of Hg.

Gauge Pressure = h = 20 cm of Hg.

In case (b) Pressure Head h = –18 cm of Hg

Absolute Pressure = 76 – 18 = 58 cm of Hg

Gauge Pressure = h = – 18 cm of Hg

6. as $h_1 \rho_1 g = h_2 \rho_2 g$

$h_1 \times 13.6 \times g = 13.6 \times 1 \times g$

$h_1 = 1$ cm

Therefore as 13.6 cm of $H_2O$ is poured in right limb it will displace Hg level by 1 cm in the left limb, so that difference of levels in the two limbs will become 19 cm.

8. $\upsilon = \frac{2}{9}\left[\frac{g(\sigma - \rho)r^2}{\eta}\right]$

$\upsilon \propto r^2$

If N drops coalesce, then

Volume of one big drop = volume of N droplets

$\frac{4}{3}\pi R^3 = N\left(\frac{4}{3}\pi r^3\right)$

$R = N^{1/3} r$ ....(2)

$\therefore$ Terminal velocity of bigger drop $= \left(\frac{R}{r}\right)^2 \times \upsilon$ from eq.(1)

$= N^{2/3}$ v from eq. (2)

9. Let $P_1$ & $P_2$ be the pressures inside the two bubbles then

$$P_1 - P = \frac{4T}{r_1} \Rightarrow P_1 = P + \frac{4T}{r_1}$$

$$P_2 - P = \frac{4T}{r_2} \Rightarrow P_2 = P + \frac{4T}{r_2}$$

When bubbles coalesce

$$P_1V_1 + P_2 V_2 = PV \qquad (1)$$

$\therefore$ The pressure inside the new bubble $p = P + \frac{4T}{r}$

substituting for $P_1$ & $V_1$ in eq.(1)

$$\left(P + \frac{4T}{r_1}\right)\frac{4}{3}\pi r_1^3 + \left(P + \frac{4T}{r_2}\right)\frac{4}{3}\pi r_2^3 = \left(P + \frac{4T}{r}\right)\frac{4}{3}\pi r^3$$

or $\frac{4}{3}\pi P\left(r_1^3 + r_2^3 - r^3\right) + \frac{16\pi T}{3}\left[r_1^2 + r_2^2 - r^2\right] = 0$

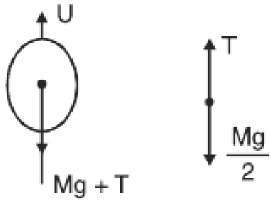
Given change in volume.

$$V = \frac{4}{3}\pi r_1^3 + \frac{4}{3}\pi r_2^3 - \frac{4}{3}\pi r^3 \qquad (3)$$

Change in Area

$$A = 4\pi r_1^2 + 4\pi r_2^2 - 4\pi r^2 \qquad (4)$$

Using eq. (3) & (4) in (2) we get $PV + \frac{4T}{3}A = 0 = 3\ PV + 4TA = 0$

11. 


When the balloon is held stationary in air, the forces acting on it get balance

Up thrust = Wt. of Balloon + Tension in string

$$U = Mg + T$$

For the small block of mass $\frac{M}{2}$ floating stationary in air

$$T = \frac{M}{2} g$$

$$\therefore \qquad U = Mg + \frac{M}{2} g = \frac{3}{2} Mg$$

When the string is cut T = 0, the small block begins to fall freely, the balloon rises up with an acceleration 'a' such that

$$U - Mg = Ma$$

$$\frac{3}{2} Mg - Mg = Ma$$

$$a = \frac{g}{2} \text{ in the upward direction.}$$

12. (*i*) As the two vessels have liquid to same height and the vessels have same base area, the force exerted = pressure × base area will be same as pressure = h ρ g.

(*ii*) Since the volume of water in vessel 1 is greater than in vessel (2), the weight of water = volume × density × h, so weight of first vessel will be greater than the water in second vessel.

13. Radius of larger drop = $\frac{D}{2}$

radius of each small drop = r

$$\therefore \qquad 27 \times \frac{4}{3}\pi r^3 = \frac{4}{3}\pi\left(\frac{D}{2}\right)^2 \Rightarrow r = \frac{D}{6}$$

Initial surface area of large drop $4\pi\left(\frac{D}{2}\right)^2 = \pi D^2$

Final surface area of 27 small drop = $27 \times 4\pi r^2 = 27 \times 4\pi \frac{D^2}{36} = 3\pi D^2$

$\therefore$ Change in energy = Increase in area × σ

$$= 2\pi D^2 \sigma$$

16. $l_1^1 = l_1\left[1 + \alpha_1 (t_2 - t_1)\right]$

$l_2^1 = l_2\left[1 + \alpha_2 (t_2 - t_1)\right]$

Given that the difference in their length remain constant

$$\therefore \qquad l_2^1 - l_1^1 = l_2 - l_1$$

$$l_2[1 + \alpha_2 (t_1 - t_1)] - l_1[1 + \alpha_1 (t_2 - t_1)] = l_2 - l_1$$

$$\therefore \qquad l_2 \alpha_2 = l_1\alpha_1$$

19. The Compressive strain $\frac{\Delta l}{l} = \alpha T = 1.2 \times 10^{-5} \times 10 = 1.2 \times 10^{-4}$

Thermal stress $= \frac{\Delta F}{A} = Y\frac{\Delta L}{L} = 2 \times 10^{11} \times 1.2 \times 10^{-4}$

$$= 2.4 \times 10^{7} Nm^{-2}$$

which corresponds to an external force

$$\Delta F = 2.4 \times 10^{7} \times 40 \times 10^{-4} = 10^5 \text{ N}.$$

A force of this magnitude can easily bend the rails, hence it is important to leave space for thermal expansion.

25. Definition of coefficient of thermal conductivity.

In steady state the heat passing in unit time through the rod remain same that is

$$\frac{Q}{t} = \frac{K_1A(T_1 - T)}{d_1} = \frac{K_2A(T - T_2)}{d_2} = \frac{KA(T_1 - T_2)}{d_1 + d_2}$$

where k is the coefficient of thermal conductivity

Also $T_1 - T_2 = (T_1 - T) + (T - T_2)$

$$\therefore \quad \frac{d_1 + d_2}{kA} = \frac{d_1}{K_1A} + \frac{d_2}{K_2A}$$

$$\therefore \quad \frac{d_1 + d_2}{K} = \frac{d_1}{K_1} + \frac{d_2}{K_2} = \frac{K_2d_1 + K_1d_2}{K_1K_2}$$

$$K = \frac{K_1K_2(d_1 + d_2)}{K_2d_1 + K_1d_2}$$

## ANSWER FOR NUMERICALS

1. (*a*) Stress $= \frac{F}{A} = \frac{mg}{\pi r^2} = \frac{40 \times 10}{\pi \times \left(1 \times 10^{-3}\right)^2} = 1.27 \times 10^{8} \text{N / m}^2$

(*b*) $\Delta L = \frac{FL}{AY} = \frac{40 \times 10 \times 1}{\pi \times \left(1 \times 10^{-3}\right)^2 \times 7 \times 10^{10}} = 1.8 \times 10^{-3} \text{m}$

(*c*) Strain $= \frac{\Delta L}{L} = \frac{1.8 \times 10^{-3}}{1} = 1.8 \times 10^{-3}$

(*d*) $F = Kx = K\Delta L$ K = Force constant

$$K = \frac{F}{\Delta L} = \frac{40 \times 10}{1.8 \times 10^{-3}} = 2.2 \times 10^{5} N / m$$

2. Pressure exerted at the bottom layer by water column of height *h* is

$$P = h\rho g = 2500 \times 1000 \times 10$$

$$= 2.5 \times 10^{7}\ N\ m^{-2}$$

$$= \text{Stress}$$

Bulk modulus $K = \frac{\text{Stress}}{\text{Strain}} = \frac{P}{\Delta V / V}$

$$\therefore \quad \frac{\Delta V}{V} = \frac{P}{K} = \frac{2.5 \times 10^{7}}{2.3 \times 10^{9}} = 1.08 \times 10^{-2}$$

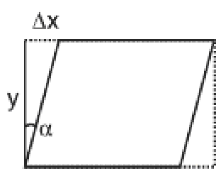
$$= 1.08\%$$

3. Area *A* of the upper face = $(0.30)^2\ m^2$

The displacement $\Delta x$ of the upper face relative to the lower one is given by

$$\Delta x = \frac{yF}{\eta A} \quad \because \eta = \frac{F / A}{\Delta x / y}$$

$$= \frac{0.30 \times 5 \times 10^{3}}{8.3 \times 10^{10} \times (0.30)^{2}} = 2 \times 10^{-7} / n$$



$\therefore$ Angle of shear $\propto$ is given by $\tan \propto = \dfrac{\Delta x}{y}$

$$\propto = \tan^{-1}\left(\frac{\Delta x}{y}\right)$$

$$= \tan^{-1}\left(\frac{2 \times 10^{-7}}{0.30}\right) = \tan^{-1}\left(0.67 \times 10^{-6}\right)$$

4. $V = 1$ litre $= 10^{-3} m^3$

$$\frac{\Delta V}{V} = 0.10\% = \frac{0.10}{100} = 0.001$$

$$K = \frac{P}{\Delta V / V} \Rightarrow P = \frac{K \Delta V}{V} = 2.2 \times 10^9 \times 0.001$$

$P = 2.2 \times 10^6$ N $m^{-2}$

5. Pressure at a depth of 10m = $h\rho g$

$= 10 \times 1030 \times 10 = 1.03 \times 10^5$ N/m$^2$

ATM. pressure = $1.01 \times 10^5$ pa.

Total pressure at a depth of 10 m = $1.03 \times 10^5 + 1.01 \times 10^5$

$= 2.04 \times 10^5$ pa.

6. $\dfrac{F_1}{A_1} = \dfrac{F_2}{A_2}$

$$F_1 = F_2 \frac{A_1}{A_2} = F_2 \left(\frac{\pi r_1^2}{\pi r_2^2}\right)$$

$$F_1 = 1350 \times 9.8 \left(\frac{5 \times 10^{-2}}{15 \times 10^{-2}}\right)^2$$

$= 1470$ N

7. (i) When man is lying $P = \frac{F}{A} = \frac{80 \times 9.8}{0.6} = 1.307 \times 10^3 N / m^{-2}$

(ii) When man is standing then A = 2 × 80 cm² = 160 × 10⁻⁴ m²

$$\therefore \quad P = \frac{80 \times 9.8}{160 \times 10^{-4}} = 4.9 \times 10^4 N\ m^{-2}$$

8. (*a*) Pressure Instructed by manual = $P_g$ = 200K Pa

(*b*) Absolute Pressure = 101 kP + 200 k Pa = 301 k Pa

(*c*) At mountain peak Pa' is 10% less

Pa' = 90 k Pa

If we assume absolute pressure in tyre does not change during driving then $P_g = P - P'_a = 301 - 90 = 211$ k Pa

So the tyre will read 211 k Pa, pressure.

9. Excess pressure in soap bubble = $p = \frac{4T}{r} = \left(\frac{4 \times 0.58}{6 \times 10^{-3}}\right)$

$= 387\ N\ m^{-2}$

10. $$v_t = \frac{2}{9}\left[\frac{g(\sigma - \rho)r^2}{\eta}\right]$$

$$\eta = \frac{2}{9}\left[\frac{9.8\left(8.9 \times 10^3 - 1.5 \times 10^3\right)\left(2 \times 10^{-3}\right)^2}{6 \times 10^{-2}}\right]$$

$= 1.08\ kg\ m^{-1}\ s^{-1}$

11. From Torricelli theorem, velocity of efflux $\upsilon = \sqrt{2gh}$

$= \sqrt{2 \times 10 \times 0.2}$

$= 2 m/s$

12. Surface energy per unit area is equal to surface tension.

$$E = \text{increase in surface area} \times ST$$

$$= 4\pi\left(2^2 - 1^2\right) \times 2.5$$

$$= 4\pi \times 3 \times 25$$

$$= 1.02 \times 10^3 \text{ erg}$$

13. $F = \eta A \dfrac{dv}{dy}$

$$= 0.01 \times 0.20 \times \frac{0.1}{0.003} = 66.7 \times 10^{-3} N$$

14. Since $A_1 v_1 = A_2 v_2$

$$v_2 = \frac{2 \times 4 \times 10^{-4}}{2 \times 10^{-4}} = 4m / s$$

Using Bernoulli's Theorem

$$P_2 = P_1 + \frac{1}{2}\rho\left(\upsilon_1^2 - \upsilon_2^2\right) + \rho g\left(h_1 - h_2\right)$$

$\therefore$ $v_2 > v_1$

$h_2 > h_1$

$$= 3 \times 10^5 \frac{1}{2}(1000)\left[(4)^2 - (2)^2\right] - 1000 \times 9.8 \times 8$$

$$= 2.16 \times 10^5 \text{ N/m}^2$$

15. Shear Stress $= \dfrac{F}{A} = \dfrac{9.8 \times 10^{-2}}{0.10} = F^1$

Strain Rate $= \dfrac{\upsilon}{l} = \dfrac{0.085}{0.30 \times 10^{-3}}$

$$\eta = \frac{\text{Stress}}{\text{Strain}} = \frac{9.8 \times 10^{-2} \times 0.30 \times 10^{-3}}{0.085 \times 0.10}$$

$$= 3.45 \times 10^{-3} \text{ Pa s}$$

16. $$\frac{\sigma_w}{\sigma_m} = \frac{h_1\rho_1 \text{Cos } \theta_2}{h_2\rho_2 \text{ Cos } \theta_1} = \frac{10 \times 1 \times \text{Cos } 135^\circ}{-3.42 \times 13.6 \times \text{Cos } o^\circ}$$

$$= \frac{10 \times (-0.7071)}{-3.42 \times 13.6}$$

$$= 0.152$$

17. By Wien's Displacement Law

$$\lambda_m T = \lambda_m^1 T^1$$

$$\therefore \frac{T}{T'} = \frac{\lambda m'}{\lambda m} = \frac{4.8 \times 10^{-7}}{3.6 \times 10^{-7}}$$

$$= 4:3$$

18. $$\frac{F - 32}{180} = \frac{T - 273}{100}$$

$$\frac{149 - 32}{180} = \frac{T - 273}{100} \Rightarrow \frac{117}{9} = T - 273$$

$$T = 286\text{k}$$

19. $$m_1c_1(\theta_1 - \theta) = m_2c_2(\theta - \theta_2)$$

$\because \quad C_2 = 1$ cal/gm°c

$$\therefore \quad 50 \times 0.6 \times (120 - \theta) = 1.6 \times 10^3 \times 1 \times (\theta - 25)$$

$$\theta = 26.8^\circ\text{C}$$

20. $d_2 = d_1[1 + \propto \Delta t]$

$5.243 = 5.231[1 + 1.2 \times 10^{-5} (T - 300)]$

$$\left[\frac{5243}{5231} - 1\right] = 1.2 \times 10^{-5} (T - 300)$$

$$T = 191 + 300 = 491 \text{ k} = 218°C$$

21. $\underset{\text{at } 0°C}{\text{ice}} \rightarrow \underset{\text{at } 0°C}{\text{water}} \rightarrow \underset{\text{at } 6°C}{\text{water}}$

$m_1c_1 (80 - 6) = m_2 L + m_2c_2(6 - 0)$

$100 \times 1 \times 74 = 100 L + 100 \times 1 \times 6$

$L = (1 \times 74) - 6$

$= 68$ cal/g.

22. Heat required to convert $H_2O$ at 0° to $H_2O$ at 100° $= m_1c_1 t$

$= 3 \times 4186 \times 100$

$= 1255800$ J

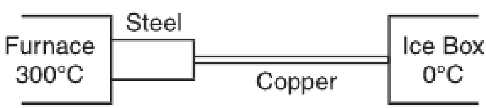
Heat required to convert $H_2O$ at 100°C to steam at 100°C is $= mL$

$= 3 \times 2.256 \times 10^6$

$= 6768000$J

Total heat $= 8023800$ J

23.




$$\frac{Q}{t} = \frac{k_1A_1(T_1 - T)}{d_1} = \frac{k_2A_2(T - T_2)}{d_2}$$

$A_1 = 2A_2$

$$\therefore \frac{50.2 \times 2\ A_2 (573 - T)}{15 \times 10^{-2}} = \frac{385 \times A_2 (T - 273)}{10 \times 10^{-2}}$$

T = 317.43 k = 44.43°C

24. $$\frac{\theta_1 - \theta_2}{t} \propto \left(\frac{\theta_1 + \theta_2}{2}\right) - \theta_0$$

$$\frac{94 - 86}{2} = k\left[\frac{94 + 86}{2} - 20\right] \Rightarrow 4 = k \times 70$$ ...1

$$\frac{82 - 78}{t'} = k\left[\frac{82 + 78}{2} - 20\right] \Rightarrow \frac{4}{t'} = k60$$ ...2

dividing eq. (1) by eq (2)

$$4 / \frac{4}{t'} = \frac{k \times 70}{k \times 60}$$ $$t' = \frac{7}{6} = 1.16 \text{ min}$$

25. $E = \sigma T^4$

$$T = \left(\frac{E}{\sigma}\right)^{1/4} = \left(\frac{2.835}{5.670 \times 10^{-8}}\right)^{1/4} = 84.92k$$

= 85 k

26. $R_t = R_0 (1 + \alpha \Delta t)$

$R_t = R_0 +$ 12% of $R_0 = 1.12\ R_0$

$1.12R_0 = R_0\ (1 + 2.5 \times 10^{-3}\ \Delta t)$

$$\Delta t = \frac{0.12}{2.5 \times 10^{-3}} = 48°C$$