4 - Properties of Matter

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4.1 Surface Tension

- (1999) Explain in terms of surface energy, what is meant by the surface tension, γ of a liquid.
- (1999) What energy is required to form a soap bubble of radius 1.00 mm if the surface tension of the soap solution is $2.5 \times 10\ E - 4\ \ \mathrm{N/m^2}$?
- (2000) Find the work done required to break up a drop of water of radius 0.5 cm into drops of water each having radius of 1.0 mm, assuming isothermal condition.
- (2010) State surface tension In terms of energy.
- (2010) The Surface tension of water at 20°C is $7.28 \times 10^{-2} N/m^2$. The vapor pressure of water at this temperature is 2.33×10^3 Pa Determine the radius of smallest spherical water droplet which it can form without evaporating
- (2010) A circular ring of thin wire 3 cm in radius is suspended with its plane horizontal by a thread passing through the 10 cm mark of a metre rule pivoted at its centre and is balanced by 8 g weight suspended at the 80 cm mark. When the ring is just brought in contact with the surface of a liquid, the 8 g weight has to be moved to the 90 cm mark to just detach the ring from the liquid. Find the surface tension of the liquid (assume zero angle of contact.)
- (2013) Using the method of dimensions, indicate which of the following equations are dimensionally correct and which are not, given that, f = frequency, γ = surface tension, ρ = density, r = radius and k = dimensionless constant.
  - $\rho^2 = k\sqrt{r^3 f/\gamma}$
  - $f = (kr^3\sqrt{\gamma})/(\rho^{1/2})$
  - $f = (k\gamma^{1/2})/(\sqrt{\rho}r^{3/2})$
- (2013) Distinguish surface tension from surface energy.
- (2013) Explain the phenomenon of surface tension in terms of the molecular theory.
- (2013) A clean open ended glass U-tube has vertical limbs one of which has a uniform internal diameter of 4.0 mm and the other of 20.0 mm. Mercury is poured into the tube; and observed that the height of mercury column in the two limbs ts different.

- Explain this observation
- Calculate the difference in levels

- (2016) Define the following terms:
  - Free surface energy
  - Capillary action
  - Angle of contact

- (2016) Briefly explain the following observations:
  - Soap solution is a better cleansing agent than ordinary water.
  - When a piece of chalk is put into water, it emits bubbles in all directions.

- (2016) Two spherical soap bubbles are combined. If v is the change in volume of the contained air, A is the change in total surface area, show that $3P_AV + 4AT = 0$. Where T is the surface tension and P_A is the atmospheric pressure.

- (2016) There is a soap bubble of radius 3.6×10^{-4} m in air cylinder which is originally at a pressure of 10^5 N/m^2 . The air in the cylinder is now compressed isothermally until the radius of the bubble is halved. Calculate the pressure of air in the cylinder.

- (2017) Define free surface energy in relation to the quid surface.
  - Explain what will happen if two bubbles of unequal radii are joined by a tube without bursting.

- (2017) A spherical drop of mercury of radius 5 mm falls on the ground and breaks into 1000 droplets. Calculate the work done in breaking the drop.

- (2018) Mention any two factors which affect the surface tension of the liquid and in each case explain two typical examples.

- (2018) Why molecules on the surface of a liquid have more potential energy than those within the liquid? Briefly explain.

- (2018) Derive an expression for excess pressure inside a soap bubble of radius R and surface tension γ when the pressures inside and outside the bubble are P_2 and P_1 respectively.

- (2018) A soap bubble has a diameter of 5 mm. Calculate the pressure inside it if the atmospheric pressure is 10^5 Pa and the surface tension of a soap solution is 2.8×10^{-2} N/m.

- (2018) Water rises up in a glass capillary tube up to a height of 9.0 cm while mercury falls down by 3.4 cm in the same capillary. Assume angles of contact for water-glass and . mercury-glass as $0°$ and $135°$ respectively. Determine the ratio of surface tensions of mercury and water.

4.2 Elasticity

- (1999) Define "Young's Modulus" of a material and give its SI units.
- (1999) With the aid of a sketch graph, explain what happens when a steel wire is stretched gradually by an increasing load until it breaks.
- (1999) A force F is applied to a long steel wire of length L and cross-sectional area A.
  - Show that if the wire is considered to be a spring, the force constant k is given by: $k = AY/L$, where Y is Young's Modulus of the wire.
  - Show that the energy stored in the wire is $U = 1/2F\Delta L$ where ΔL is the extension of the wire
- (2000) Define the bulk modulus of a gas
- (2000) Find the ratio of the adiabatic bulk modulus of a gas to that of its isothermal bulk modulus in terms of the specific heat capacities of the gas.
- (2000) Explain Youngs Modulus of rigidity
- (2000) Find the work done in stretching a steel wire of 1.0 mm^2 cross-sectional area and 2.0 m in length through 0.1 mm.
- (2007) With the aid of a diagram describe a simple laboratory experiment to measure Youngs modulus of a wooden bar acting as a loaded cantilever from its period of vibration given that the depression s is given by $S = (WL^3)/(3IE)$.
- (2007) Differentiate between tensile and shear stress.
- (2007) A lift is designed to hold a maximum of 12 people. The lift cage has a mass of 500 kg and the distance from the top floor of the building to the ground floor is 50 m.
  - What minimum cross-sectional area should the cable have in order to support the lift and the people in it?
  - Why should the cable have to be thicker than the minimum cross-sectional area above in practice?
  - How much will the lift cable above stretch if 10 people get into the lift at the ground floor, assuming that the lift cable has a cross section of 1.36 cm?
  - Note: Mass of an average person = 70 kg . $E_{steel} = 2 \times 10^{11}$ N/m^2 , Tensile strength of steel = 4×10^{11} N/m^2 .
- (2009) Define the following terms:
  - Tensile stress
  - Tensile strain
  - Youngs modulus
- (2009) Derive the expression for the work done in stretching a wire of length L by a load W through an extension X .

- (2009) A vertical wire made of steel of length 2.0 m and 1.0 mm diameter has a load of 5.0 kg applied to its lower end. What is the energy stored in the wire?
- (2009) A copper wire 2.0 m long and 1.22×10^{-3} m diameter is fixed horizontally to two rigid supports 2.0 m apart. Find the mass in kg of the load, which when suspended at the mid point of the wire, produces a sag of 2.0×10^{-2} m at the point.
- (2013) The bulk modulus of elasticity for lead is 8×10^9 N/m^2 . Find the density of lead if the pressure applied is 2×10^8 N/m^2 .
- (2013) Define the terms: proportional limit, elastic limit, yield point and elasticity.
- (2013) Use a sketch graph to show how the extension of the wire varies with the applied force and mark the elastic limit and yield point on it. Explain how the magnitude of the Young's modulus is obtained from the graph.
  - A block of metal weighing 20 N with a volume of 8×10^{-4} m? is completely immersed
  - in oil of density 700 kg/m^3 then attached to one end of a vertical wire of length 4.0 m and diameter of 0.6 mm whose other end is fixed. If the length of the wire is increased by 1.0 mm. find the:
  - youngs modulus of the wire.
  - energy stored in the wire.
- (2015) Define the following materials as classified on the basis of elastic properties:
  - Ductile materials
  - Brittle materials
  - Elastomers
- (2015) Briefly explain why the stretching of a coil spring is determined by its shear modulus.
- (2015) A copper wire of negligible mass, 1 m long and cross-sectional area 10^{-5} m^2 is kept on a smooth horizontal table with one end fixed. A ball of 1 kg is attached to the other end. The wire and the ball are rotating with an angular velocity of 35 rad/s. If the elongation of the wire is 10^{-3} m, find Youngs modulus of wire. If on increasing the angular velocity to 100 rad/s, the wire breaks down, find the breaking stress.
- (2015) Differentiate bulk modulus from shear modulus.
- (2015) Two wires, one of steel and one of phosphor bronze each 1.5 m long and 2 mm diameter are joined end to end as a composite wire of length 3 cm. What tension in the composite wire will produce total extension of 0.064 cm?
- (2016) What is strain energy?
- (2017) A steel rod of length 0.60 m and cross-sectional area 2.5×10^{-5} m^2 at a temperature of 100°C is clamped so that when it cools was unable to contract. Find the tension in the rod when it has cooled to 20°C.
- (2017) A spring 60 cm long is stretched by 2 cm for the application of load of 200 g. What will be the length when a load of 500 g is applied?