Mechanical Properties Of Fluids

Short Answer Type Questions

1. The sap in trees, which consists mainly of water in summer, rises in a system of capillaries of radius $r = 2.5 \times 10^{-5}$ m. The surface tension of sap is $T = 7.28 * 10^{-2}$ Nm^{-1} and the angle of contact is $0°$. Does surface tension alone account for the supply of water to the top of all trees?

2. The free surface of oil in a tanker, at rest, is horizontal. If the tanker starts accelerating the free surface will be titled by an angle θ. If the acceleration is a m s^{-2}, what will be the slope of the free surface?.

3. Two mercury droplets of radii 0.1 cm. and 0.2 cm. collapse into one single drop. What amount of energy is released? The surface tension of mercury $T = 435.5 \times 10^{-3}$ N m^{-1}.

4. If a drop of liquid breaks into smaller droplets, it results in lowering of temperature of the droplets. Let a drop of radius R, break into N
small droplets each of radius r. Estimate the drop in temperature.

5. The surface tension and vapour pressure of water at 20°C is 7.28×10^{-2} Nm^{-1} and 2.33×10^{3} Pa, respectively. What is the radius of the smallest spherical water droplet which can form without evaporating at 20°C?

Long Answer Type Questions

1. (a) Pressure decreases as one ascends the atmosphere. If the density of air is ρ, what is the change in pressure dp over a differential height dh?
(b) Considering the pressure p to be proportional to the density, find the pressure p at a height h if the pressure on the surface of the earth is p_o.
(c) If $p_o = 1.03 \times 10^{5}$ N m^{-2}, $\rho_o = 1.29$ kg m^{-3} and g = 9.8 m s^{-2}, at what height will the pressure drop to (1/10) the value at the surface of the earth?
(d) This model of the atmosphere works for relatively small distances. Identify the underlying assumption that limits the model.

2. Surface tension is exhibited by liquids due to force of attraction between molecules of the liquid. The surface tension decreases with increase in temperature and vanishes at boiling

point. Given that the latent heat of vaporization for water L_v = 540 k cal kg^{-1}, the mechanical equivalent of heat J = 4.2 J cal^{-1}, density of water ρ_w = 10^3 kg l^{-1}, Avagadro's No N_A = 6.0 × 10^{26} k mole $^{-1}$ and the molecular weight of water M_A = 18 kg for 1 k mole.

- (a) estimate the energy required for one molecule of water to evaporate.
- (b) show that the inter–molecular distance for water is

$$d = \left[\frac{M_A}{N_A} \times \frac{1}{\rho_w} \right]^{1/3} \text{ and find its value.}$$

- (c) 1 g of water in the vapor state at 1 atm occupies 1601 cm^3. Estimate the intermolecular distance at boiling point, in the vapour state.
- (d) During vaporisation a molecule overcomes a force F, assumed constant, to go from an inter-molecular distance d to d'. Estimate the value of F.
- (e) Calculate F/d, which is a measure of the surface tension.

3. A hot air balloon is a sphere of radius 8 m. The air inside is at a temperature of 60°C. How large a mass can the balloon lift when the outside temperature is 20°C? (Assume air is an ideal gas, R = 8.314 J mole^{-1}K^{-1}, 1 atm. = 1.013 * 10^5 Pa; the membrane tension is 5 N m^{-1}.)