# SURFACE TENSION
## PREVIOUS EAMCET QUESTIONS
## ENGINEERING

1. A soap bubble of radius r is blown up to forma bubble of radius 2r under isothermal conditions. If T is the surface tension of soap solution, the energy spent in the blowing: **(2009 E)**

   1) $3\pi Tr^2$  2) $6\pi Tr^2$  3) $12\pi Tr^2$  4) $24\pi Tr^2$

Ans : 4

Sol: Soap bubble has two free surfaces

$\therefore$ work done to blow soap bubble from

Radius $r_1$ to $r_2$ = $2T\left(\Delta A\right)$

= $2T\left(4\pi r_2^2 - 4\pi r_1^2\right)$

= $2T\left(4\pi\left(2r\right)^2 - 4\pi r^2\right)$

= $24\pi r^2 T$

2. The surface tension of soap solution is 0.03 N/m. The work done in blowing to form a soap bubble of surface area 40 cm$^2$, in Joules, is **(2008-E)**

   1) 1.2 $\times$10-4  2) 2.4$\times$ 10-4  3) 12$\times$ 10-4  4) 24$\times$ 10-4

Ans : 2

Sol: Work done to blow a soap bubble = $T \times \Delta A$

= 2AT

$\therefore W = 2\times T\times 4\pi r^2$

$= 2\times 0.0.3\times 40\times 10^{-4}$

$= 2.4\times 10^{-4} J$



3. A liquid does not wet the solid surface if the angle of contact is **(2007-E)**

   1) $0^0$  2) $=45^0$  3) $= 90^0$  4) $>90^0$

Ans: 4

Sol: If the angle of contact between solid surface and liquid surface is greater than 90°, then the liquid does not wet the solid surface, since cohesive forces dominate adhesive forces.

4. Two soap bubbles combine to form a single bubble. In this process, the change in volume and surface area are respectively ‘V’ and ‘A’. If P is the atmospheric pressure, and T is the surface tension of the soap solution the following relation is true [2006 E]

   1) $4PV + 3TA = 0$  2) $3PV - 4TA = 0$  3) $4PV - 3TA = 0$  4) $3PV + 4TA = 0$

Ans : 4

Sol: Let the radii of two soap bubbles are a and b and radius of single large bubble is c. Let $P_a$, $P_b$, $P_c$ are the external pressures of soap bubbles a,b,c and P is the atmospheric pressure.

$$P_a = P - \frac{4T}{r_a},\ P_b = P - \frac{4T}{r_b},\ P_c = P - \frac{4T}{r_c}$$

$$V_a = \frac{4}{3}\pi a^3,\ V_b = \frac{4}{3}\pi b^3,\ V_c = \frac{4}{3}\pi c^3$$

As temperature remains constant

$$P_1V_1 + P_2V_2 = PV$$

$$\Rightarrow \left(P - \frac{4T}{r_a}\right)\left(\frac{4}{3}\pi r_a^3\right) + \left(P - \frac{4T}{r_b}\right)\left(\frac{4}{3}\pi r_b^3\right) = \left(P - \frac{4T}{r_c}\right)\left(\frac{4}{3}\pi r_c^3\right)$$

$$\Rightarrow P\left[r_c^3 - \left(r_a^3 + r_b^3\right)\right] - 4T\left(r_a^2 + r_b^2 - r_c^2\right) = 0$$

Let change in volume = $V = \frac{4}{3}\pi\left[r_c^3 - \left(r_a^3 + r_b^3\right)\right]$

Change in surface area $A = 4\pi\left(r_c^2 + \left(r_a^2 + r_b^2\right)\right)$

$$\therefore \frac{3PV}{4\pi} + \frac{AT}{\pi} = 0$$

$$\Rightarrow 3PV + 4TA = 0$$

5. A thin wire ring of 3 cm radius float on the surface of a liquid. The pull required to raise the ring before the film breaks is 30.14 x $10^{-3}$N more than its weight. The surface tension of the liquid (in $Nm^{-1}$) is **(2005-E)**

1) $80\times10^{-3}$ 2) $87\times10^{-3}$ 3) $90\times10^{-3}$ 4) $98\times10^{-3}$

Ans: 1

Sol: Force required to life the ring = force due to surface tension

$$\therefore F = 4\pi RT$$

$$\therefore 30.14\times10^{-3} = 4\times3.14\times3\times10^{-2}\times T$$

$$\therefore T = 80\times10^{-3}\,Nm^{-1}$$



6. One end of a uniform glass capillary tube of radius r = 0.025 cm is immersed vertically in water to a depth h = 1 cm. The excess pressure in N/$m^2$ required to below an air bubble out of the tube:

Surface tension of water = 7 x $10^{-2}$N/m, Density of water = $10^3$ kg/$m^3$

Acceleration due to gravity = 10 $ms^{-2}$ **[2004 E]**

1) $0.0048\times10^5$ 2) $0.0066\times10^5$ 3) $1.0048\times10^5$ 4) $1.0066\times10^5$

Ans : 2

Sol: Express pressure to blow an air bubble

Out of the tube = $hdg + \frac{2T}{r}$

$$= 10^{-2}\times10^3\times10 + \frac{2\times7\times10^{-2}}{25\times10^{-5}}$$

= 660 $Nm^{-2}$ = $0.0066\times10^5\,Nm^{-2}$

7. Two spherical soap bubbles of radii $r_1$ and $r_2$ in vaccum combine under isothermal conditions. The resulting bubble has a radius equal to **[2003 E ]**

1) $\frac{r_1+r_2}{2}$  2) $\frac{r_1r_2}{r_1+r_2}$  3) $\sqrt{r_1r_2}$  4) $\sqrt{r_1^2+r_2^2}$

Ans: 4

Sol: Let the excess pressure inside the first bubble = $P_1 = \frac{4T}{r_1}$ and volume $V_1 = \frac{4}{3}\pi r_1^3$ the excess pressure inside the second bubble $P_2 = \frac{4T}{r_2}$ and volume $V_2 = \frac{4}{3}\pi r_2^3$

$\therefore$ For larger bubble $P = \frac{4T}{r}, V = \frac{4}{3}\pi r^3$

$$\therefore PV = P_1V_1 + P_2V_2$$

$$\Rightarrow \frac{4T}{r}\left[\frac{4}{3}\pi r^3\right] = \frac{4T}{r_1}\times\frac{4}{3}\pi r_1^3 + \frac{4T}{r_2}\times\frac{4}{3}\pi r_2^3$$

$$\Rightarrow r = \sqrt{r_1^2+r_2^2}$$

8. A glass capillary tube of inner diameter 0.28 mm is lowered vertically into water in a vessel. The pressure to be applied on the water in the capillary tube so that water level in the tube is same as that in the vessel in N/m$^2$ is: [Surface Tension of water = 0.07 N/m, Atmospheric pressure = $10^5$ N/m$^2$] **[2002 E]**

1) $10^3$  2) $99\times10^3$  3) $100\times10^3$  4) $101\times10^3$

Ans : 4

Sol: We know surface tension $(T) = \frac{rhpg}{2}$

$\therefore$ Pressure $(P) = hpg = \frac{2T}{r}$

$$= \frac{2(7\times10^{-2})}{14\times10^{-5}} = 10^3\,Nm^{-2}$$

Atmospheric pressure ($P_0$) = $10^5$ NM$^{-2}$

$\therefore$ Pressure to be applied = P + $P_0$

$$10^3 + 10^5 = 101\times10^3\,Nm^{-2}$$

9. A mercury drop of radius 1 cm is sprayed into $10^6$ drops of equal size. The energy expended in joule is (surface tension of mercury is $460\ x\ 10^{-3}\,N/m$ ) **[2001-E]**

1) 0.057  2) 5.7  3) $5.7\times10^{-4}$  4) $5.7\times10^{-6}$

Ans : 1

Sol: Energy expanded = $4\pi R^2\left[n^{1/3}-1\right]T$

$$= 4\pi\left[10^{-2}\right]^2\left[10^2-1\right]\left[460\times10^{-3}\right]$$

$$= (12.56)(99)(46)10^{-6} = 0.057\,Joule$$

10. 8000 identical water drops combine together to form a big drop. Then the ratio of the final surface energy to the initial surface energy of all the drops together is. **(2000-E)**

1) 1 : 10  2) 1 : 15  3) 1 : 20  4) 1 : 25

Ans : 3

Sol: When 8000 identical drops are combined, the radius of the big drop formed will be

$$R_{res} = n^{1/3}(r) = 20(r)$$

Where ‘r’ is the radius of each small drop.

$$\therefore \frac{Energy\ of\ the\ big\ drop}{Energy\ of\ small\ drops}$$

$$= \frac{4\pi(20r)^2}{8000(4\pi r^2)} = \frac{1}{20}$$

= $E_1 : E_2$ = 1: 20

## MEDICAL

11. Eight drops of water of 0.6 mm radius each merge to form one big drop. If the surface tension of water is 0.072 N/m, the energy dissipated in the process is **(2009 M)**

Ans: 2

Sol: Energy dissipated $= 4\pi r^2 T\left(n - n^{2/3}\right)$

$$= 4\pi r^2 T n^{2/3}\left(n^{1/3} - 1\right)$$

$$= 4.15\pi \times 10^{-7}\ J$$



12. A capillary tube is taken from the Earth to the surface of the Moon. The rise of the liquid column on the Moon (acceleration due to gravity on the Earth is 6 times that of the Moon) i s **(2008-M)**

1) six times that on the Earth surface
2) $\frac{1}{6}$ that on the Earth’s surface
3) equal to that on the Earth’s surface
4) zero.

Ans: 1

Sol: From the relation $T = \frac{hrdg}{2\cos\theta} \Rightarrow h_1 g_1 = h_2 g_2$

$$\Rightarrow \frac{h_M}{h_E} = \frac{g_E}{g_M}$$

$$\Rightarrow \frac{h_M}{h_E} = \frac{6g_E}{g_M}$$

$$\Rightarrow \frac{h_M}{h_E} = 6$$

13. A. liquid drop of radius ‘R’ breaks into 64 tiny droplets each of radius ‘r’ if the surface tension of liquid is ‘T’ then gain in energy is **(2007-M)**

1) $48\pi R^2 T$
2) $12\pi r^2 T$
3) $96\pi r^2 T$
4) $192\pi r^2 T$

Ans: 4

Sol: Energy released = $w = E_2 - E_1$

= $4\pi r^2\left(n - n^{2/3}\right)T$

= $192\pi r^2 T$

14. A wire of length L metres, made of a material of specific gravity 8 is floating horizontally on the surface of water. If it is not wet by water, the maximum diameter of the wire (in mm) upto which it can continue to float is (surface tension of water is T = $70\times10^{-3}\,Nm^{-1}$ ) **(2006-M)**
1) 1.5 2) 1.1 3) 0.75 4) 0.55

Ans: 1

Sol:
$$d=\sqrt{\frac{8T}{\pi\rho g}}$$
$$=\sqrt{\frac{8\times70\times10^{-3}}{\frac{22}{7}\times8\times10^{-3}\times9.8}} = 1.5$$

15. The pressure inside two soap bubbles are 1.01 and 1.02 atmospheres respectively. The ratio of their respective volumes is **(2005 M)**
1) 16 2) 8 3) 4 4) 2

Ans :2

Sol: Excess pressure $\Delta P=\frac{4T}{r}\Rightarrow\Delta P\propto\frac{1}{r}$ ……………………….(1)

But volume of sphere = $\frac{4}{3}\pi r^3$

$\Rightarrow V\propto r^3$ ……………………………..(2)

From (1) & (2) $V\propto\frac{1}{(\Delta P)^3}$

$$\Rightarrow\frac{V_1}{V_2}=\left(\frac{\Delta P_2}{\Delta P_1}\right)^3$$
$$\frac{V_1}{V_2}=\left(\frac{1.02-1}{1.01-1}\right)^3=\frac{8}{1}$$



16. The radii of the two columns in a 'U' tube are '$r_1$' & '$r_2$', when a liquid of density ( angle of contact is 0° } is filled in it, the level difference of the liquid in the two arms in 'h'. The surface tension of the liquid is {g = acceleration due to gravity } **(2004-M)**
1) $\frac{\rho g h r_1 r_2}{2(r_2-r_1)}$ 2) $\frac{\rho g h(r_2-r_1)}{2r_2r_1}$ 3) $\frac{2(r_1-r_2)}{\rho g h r_2 r_1}$ 4) $\frac{2(r_1-r_2)}{\rho g h}$

Ans: 1

Sol: From the relation $T=\frac{hrpg}{2}$

$$\therefore h_1=\frac{2T}{r_1pg},h_2=\frac{2T}{r_2pg}$$
$$\therefore h_1-h_2=\frac{2T}{pg}\left[\frac{1}{r_1}-\frac{1}{r_2}\right]$$
$$\Rightarrow h=\frac{2T}{pg}\left[\frac{r_2-r_1}{r_1r_2}\right]$$

$$\Rightarrow h = \frac{hpg\left(r_1 r_2\right)}{2T\left(r_2 - r_1\right)} \qquad \therefore$$

17. Water raises to a height of 10cm in a capillary tube and mercury falls to a depth of 3.5cm in the same capillary tube. If the density of mercury is 13.6 gm/c.c and its angle of contact is $135^0$ and density of water is 1 gm/c.c and its angle of contact is $0^0$, then the ratio of surface tensions of two liquids is (cos $135^0$ = 0.7 **(2003-M)**

1) 1:14 2) 5:34 3) 1:5 4) 5:27

Ans: 2

Sol : From the relation $T = \frac{hrdg}{2\cos\theta}$

$$\Rightarrow \frac{T_1}{T_2} = \frac{h_1}{h_2} \times \frac{r_1}{r_2} \times \frac{d_1}{d_2} \times \frac{\cos\theta_2}{\cos\theta_1}$$

$$= \frac{5}{34}$$

18. The work done in increasing the size of a rectangular soap film with dimensions 8 cm x 3.75 cm to 10 cm x 6 cm is $2\times10^{-4}$ J. The surface tension of the film in N/m is **(2002 M)**

1) $1.65\times10^{-2}$ 2) $3.3\times10^{-2}$ 3) $6.6\times10^{-2}$ 4) $8.25\times10^{-2}$

Ans:2

Sol: Workdone= (surface tension ) (increase in area)

$$2\times10^{-4} = T\left(2\right)\left[60-30\right]10^{-4}$$

$$\therefore T = \frac{1}{30} = 3.3\times10^{-2}\, Nm^{-1}$$



19. Consider the following two statements A and B, and identify the correct choice in the given answer

(A) : The excess pressure inside a small liquid drop is more than that of a big drop.

(B) : As the aeroplane moves fast on the runway the pressure is more on the upper surface of its wings and less on the bottom surface of the wings **(2001 M)**

1) Both A and B are true 2) A is true but B is false

3) A is false but B is true 4) Both A and B are false

Ans :3

Sol: When an aeroplane moves fast on the runway, the pressure will be more on the bottom surface than the upper surface, according to Bernoulli's theorem.

$\therefore$ A is true and B is false

20. The surface energy of liquid film on a ring of area 0.15 $m^2$ is

[ surface tension of liquid = 5 $Nm^{-1}$] **(2000 M)**

1) 0.75 J 2) 1.5 J 3) 2.25 J 4) 3.0 J

Ans : 2

Sol: Area = $0.15 m^2$

Surface tension = 5 $Nm^{-1}$

W = (F) (displacement)

$$= \left(\frac{F}{l}\right)\left(area\right)^2$$

$$= 5\left(0.15\right)2 = 1.5J$$

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