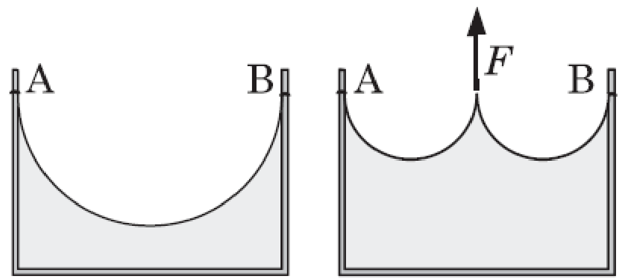
PHYSICS Max. Marks: 61

SECTION – I
(SINGLE CORRECT CHOICE TYPE)

This section contains **7 multiple choice questions.** Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which **ONLY ONE is correct.**

Marking scheme +3 for correct answer , 0 if not attempted and -1 in all other cases.

1. A film of a soap solution created in a loop formed by a rectangular wire frame and an inextensible light thread AB of length l, pulls the thread in the shape of a semicircle. If a force F applied at midpoint of the thread perpendicular to line segment AB turns the wire into two semicircles as shown in the figure, calculate surface tension of the soap solution.



A) $\frac{\pi F}{l}$ B) $\frac{\pi F}{2l}$ C) $\frac{\pi F}{4l}$ D) $\frac{2\pi F}{l}$

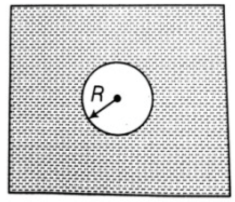
2. Two soap bubbles of equal radii 4cm are touching each other with an intermediate film separating them. Surface tension of solution forming bubbles is $7\times10^{-2}\,N/m$. What is the distance between the centres of soap bubbles (in cm)?

A) 4 B) 6 C) 8 D) 5

3. A glass plate of length 0.1 m, breadth $15\times10^{-3}\,\text{m}$ and thickness $2\times10^{-3}\,\text{m}$ weighs $8\times10^{-3}\,\text{kg}$ in air. It is held vertically with its largest face vertical and its lower half immersed in water. If the surface tension of water is $72\times10^{-3}\,\text{N/m}$, the apparent weight of the plate will be (approximately)

A) $97.4\times10^{-3}\,\text{N}$ B) $36.1\times10^{-3}\,\text{N}$ C) $72.2\times10^{-3}\,\text{N}$ D) $79.4\times10^{-3}\,\text{N}$

4. There is a rectangular wire frame having a thin film of soap solution. A circular ring of massless thin wire of area of cross-section A is placed on the surface of the film. The radius of the ring is R. Now, inside portion of the ring is pricked. If the surface tension of soap solution is T and Young's modulus of wire is Y, then change is radius of the wire is

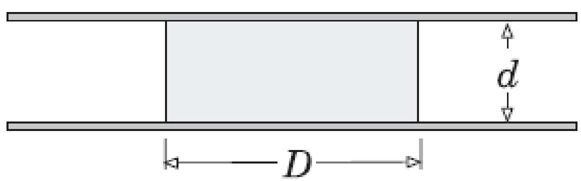


A) $\frac{TR^2}{AY}$ B) $\frac{2TR^2}{AY}$ C) $\frac{TR^2}{3AY}$ D) $\frac{TR^2}{2AY}$

5. A spherical soap bubble of radius 1.0 cm is formed inside another of radius 2 cm. If a single soap bubble is formed which maintains the same pressure difference as inside the smaller and outside the larger bubble, the radius of this bubble is

A) 0.005 m B) 0.05 m C) 0.0067 m D) 0.067 m

6. In a zero gravity region, a drop of a liquid of surface tension σ assumes a cylindrical shape of diameter D between two parallel glass plates that are a distance d apart. If curved surface of the drop is at right angles to the plates as shown in the figure, find force exerted by the drop on a plate.



A) $\frac{\pi\sigma D}{2}$ B) $\frac{\pi\sigma D}{4}$ C) $2\pi\sigma D$ D) $\pi\sigma D$

7. Two spherical soap bubbles merge to form a single spherical bubble. If V is the consequent change in volume of the contained air and S is the change in the total surface area and T is the surface tension of the soap solution, then if P_0 is atmospheric pressure): Assume temperature of the air remain same in all the bubbles

A) $3P_0V + 4ST = 0$ B) $4P_0V + 3ST = 0$ C) $P_0V + 4ST = 0$ D) $4P_0V + ST = 0$

SECTION-II

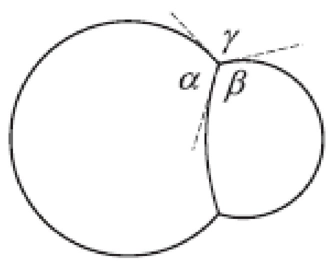
(ONE OR MORE OPTIONS CORRECT TYPE)

This section contains 7 multiple choice equations. Each question has four choices **(A)** **(B)**,**(C)** and **(D)** out of which **ONE** or **MORE THAN ONE** are correct.

Marking scheme: +4 for all correct options & +1 partial marks, 0 if not attempted and -2 in all wrong cases

8. Consider two hollow glass spheres, one containing water and the other containing mercury. Each liquid fills about one tenth of the volume of the sphere. In zero gravity environment.
A) Water and mercury float freely inside the spheres.
B) Water forms a layer on the glass while mercury takes the form of a sphere.
C) mercury forms a layer on the glass while water takes the form of a sphere.
D) water and mercury both form a layer on the glass.

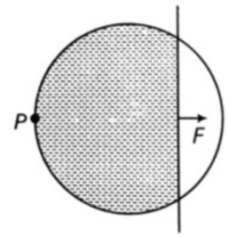
9. When two soap bubbles of different radii coalesce, some portions of their surfaces make a common surface. At any point on the circumference of the common surface, the three surfaces meet at angles α, β and γ. Which of the following is INCORRECT?



A) $\alpha > \beta$ B) $\alpha > \beta < \gamma$ C) $\alpha = \beta < \gamma$ D) $\alpha = \beta = \gamma$

10. When liquid medicine of density ρ is to be put in the eye, it is done with the help of a dropper.As the bulb on the top of the dropper is pressed, a drop forms at the opening of the dropper. We wish to estimate the size of the drop.We first assume that the drop formed at the opening is spherical because that requires a minimum increase in its surface energy. To determine the size, we calculate the net vertical force due to the surface tension T when the radius of the drop is R. When this force becomes smaller than the weight of the drop, the drop gets detached from the dropper.
Identify the correct option(s)
A) If the radius of the opening of the dropper is r, the vertical force due to the surface tension on the drop of radius R (*assuming* $r << R$) is $\frac{2\pi r^2 T}{R}$
B) If the radius of the opening of the dropper is r, the vertical force due to the surface tension on the drop of radius R (*assuming* $r << R$) is $\frac{\pi r^2 T}{R}$
C) If $r = 5\times10^{-4} m, \rho = 10^3 kgm^{-3}, g = 10ms^{-2}, T = 0.11Nm^{-1}$, the radius of the drop when it detaches from the dropper is approximately $\sqrt[4]{4.125} \times 10^{-3} m$
D) If $r = 5\times10^{-4} m, \rho = 10^3 kgm^{-3}, g = 10ms^{-2}, T = 0.11Nm^{-1}$, the radius of the drop when it detaches from the dropper is approximately $\sqrt[4]{2.0625} \times 10^{-3} m$

11. A circular wire, 10 cm in diameter, with a slider wire on it, is in a horizontal plane. A liquid film is formed, bounded by the wires, on the left side of the slider, as shown in figure. The surface tension of the liquid is 0.1Nm^{-1}. An applied force of 16 mN, perpendicular to the slider, maintains the film in equilibrium. Ignore the sag in the film. What can be the distance between point P and the slider?



A) 8 cm
B) 2 cm
C) 5 cm
D) slider cannot be in equilibrium

12. Two separate soap bubbles (radii 0.002 m and 0.004 m) formed of the same soap solution (surface tension 0.07 Nm^{-1}) comes together to form a double bubble. The internal film common to both the bubbles has radius R. Then,

A) R = 0.004 m

B) R = 0.003 m

C) internal film is concave towards smaller bubble

D) internal film is concave towards bigger bubble

13. What is the excess pressure inside a bubble of soap solution of radius 5.0 mm, given that the surface tension of soap solution is $2.5\times10^{-2}\text{N}/\text{m}$.

[Atmospheric pressure is $1\text{atm}=1.0100\times10^{5}\text{N}/\text{m}^2$, $g=10ms^{-2}$

A) $10Nm^{-2}$
B) $20Nm^{-2}$
C) If an air bubble of the same dimension were formed at a depth of 40.0 cm inside a container containing the soap solution (of relative density 1.2) pressure inside the bubble would be $1.0582atm$
D) If an air bubble of the same dimension were formed at a depth of 40.0 cm inside a container containing the soap solution (of relative density 1.2) pressure inside the bubble would be $1.0581atm$

14. Two soap bubbles ($\sigma -$ surface tension) of radii a and b are given $(a<b)$;

A) The radius of the common surface $\frac{1}{r}=\frac{1}{a}-\frac{1}{b}$

B) The radius on merging them is $r=\sqrt{a^2+b^2}$ under isothermal conditions

C) The new radius depends on atmospheric pressure

D) The radius on merging them is $r=\sqrt{\left(\frac{a^2+b^2}{\sigma}\right)}$

SECTION – III
(PARAGRAPH TYPE)

This section contains **2 groups of questions.** Each group has 2 multiple choice questions based on a paragraph. Each question has 4 choices A), B), C) and D) for its answer, out of which **ONLY ONE** is **correct.**
Marking scheme: +3 for correct answer, 0 if not attempted and 0 in all other cases.

Paragraph For Questions 15 and 16

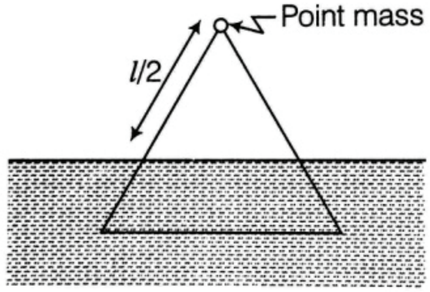
A prism shaped Styrofoam of density $\rho_{\text{styrofoam}} < \rho_{\text{water}}$ is held completely submerged in water. It lies with its base (i.e. rectangular face) horizontal. The base of foam is at a depth H below water surface and atmospheric pressure is p_0. Surface of water is opened to atmosphere. Styrofoam prism is held in equilibrium by the string attached symmetrically. (where, $\rho_{\text{styrofoam}}=\rho_{\text{sf}}$ and $\rho_{\text{water}}=\rho_{\text{w}}$, length of prism = L and side of equilateral triangular base $=\ell$, atmospheric pressure $=p_0$, surface tension of water $=T$ and contact angle $=0°$)

15. Magnitude of force on any one of the slant faces of styrofoam is

A) $\left[p_0+\rho_w g\left(H-\sqrt{\frac{2}{3}}\ell\right)\right]L\ell$ B) $\left[p_0+\rho_w g\left(H-\frac{\ell}{\sqrt{2}}\right)\right]L\ell$

C) $\left[p_0-\rho_w g\left(H-\frac{\ell}{\sqrt{2}}\right)\right]L\ell$ D) $\left[p_0+\rho_w g\left(H-\frac{\sqrt{3}}{4}\ell\right)\right]L\ell$

16. Now string is cut and Styrofoam is allowed to come to surface. A point mass is to be placed symmetrically on the upper surface of Styrofoam such that it is in equilibrium with its base in horizontal plane. In equilibrium position Styrofoam has half of its slant height submerged. Determine mass m to achieve equilibrium.



A) $\frac{L\ell^2\sqrt{3}}{4}\left[\frac{3}{4}\rho_w - \rho_{sf}\right] - (2L+\ell)\frac{T}{g}$ B) $\frac{L\ell^2\sqrt{3}}{2}\left[\frac{3}{2}\rho_w - \rho_{sf}\right] - (2L+\ell)\frac{T}{g}$

C) $\frac{L\ell^2\sqrt{3}}{4}\left[\frac{3}{4}\rho_w - \rho_{sf}\right] - (\sqrt{3}L+\ell)\frac{T}{g}$ D) $\frac{L\ell^2\sqrt{3}}{2}\left[3\rho_w - \frac{\rho_{sf}}{2}\right] - (L+\ell)\frac{T}{g}$

Paragraph For Questions 17 and 18

In a model of Surface Tension, an elastic film is modeled as a square grid formed by very small springs each of stiffness k. For example a square film of side l can be treated as a square mesh made from springs of length 'a' ($l >> a$) with the springs parallel to either $x-axis$ or $y-axis$ of a coordinate system. For infinitely small springs $a \to 0$ gives us the necessary results. If S_0 is the area of the unstretched film, S is area of the stretched film

17. Potential energy U of the film if stretched uniformly and isotropically can be given by

A) $U = \frac{1}{2}k\left(\sqrt{S}-\sqrt{S_0}\right)^2$ B) $U = k\left(\sqrt{S}-\sqrt{S_0}\right)^2$

C) $U = \frac{1}{2}k\left(\sqrt{S-S_0}\right)^2$ D) $U = k\left(\sqrt{S-S_0}\right)^2$

18. If an elastic film is used to fabricate a spherical balloon of radius r_0 in relaxed state, the dependence of air pressure p inside the balloon on its radius r is (assume vacuum outside the balloon)

A) $k\left(\frac{r-r_0}{r^2}\right)$ B) $k\left(\frac{r-r_0}{r_0^2}\right)$ C) $2k\left(\frac{r-r_0}{r^2}\right)$ D) $2k\left(\frac{r-r_0}{r_0^2}\right)$

Sri Chaitanya IIT Academy., India

A.P, TELANGANA, KARNATAKA, TAMILNADU, MAHARASHTRA, DELHI, RANCHI

A right Choice for the Real Aspirant

ICON CENTRAL OFFICE, MADHAPUR - HYD

Sec: Sri Chaitanya-Jr.Chaina-I | WTA-17 | Date:27-10-19
Time: 09:00 AM to 12:00 Noon | 2017_P2 | Max.Marks:183

KEY SHEET

PHYSICS

1	**B**	2	**A**	3	**D**	4	**B**	5	**C**
6	**A**	7	**A**	8	**B**	9	**ABC**	10	**AC**
11	**AB**	12	**AC**	13	**BD**	14	**AC**	15	**D**
16	**C**	17	**B**	18	**C**				

CHEMISTRY

19	**B**	20	**C**	21	**D**	22	**B**	23	**B**
24	**A**	25	**D**	26	**ABC**	27	**AC**	28	**BCD**
29	**BC**	30	**B**	31	**ACD**	32	**ABD**	33	**A**
34	**C**	35	**B**	36	**C**				

MATHS

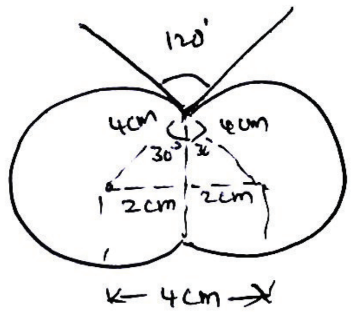
37	**B**	38	**D**	39	**A**	40	**C**	41	**C**
42	**B**	43	**D**	44	**ABC**	45	**ACD**	46	**ACD**
47	**CD**	48	**AB**	49	**ABCD**	50	**B**	51	**C**
52	**C**	53	**C**	54	**D**				

SOLUTIONS

PHYSICS

1. In equilibrium conditions, lateral pull of the soap film on the thread due to surface tension must everywhere be normal to the thread.

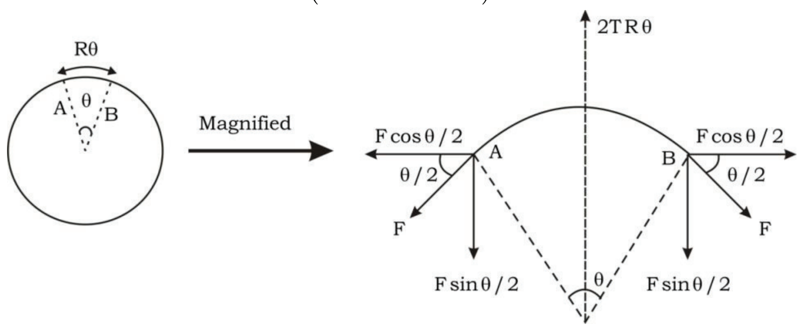
2.



3. $$W_{app} = mg - f_B + 2T(\ell + t) = 8\times10^{-3}\times10 - \frac{0.1\times15\times10^{-3}\times2\times10^{-3}}{2}$$

$$\times10^{3}\times10 + 2\times72\times10^{-3}\left(0.1+2\times10^{-3}\right) = 79.4\times10^{-3}\,N$$

4.



Force due to tension in the wire, on the element is $F_1 = 2F\sin\left(\frac{\theta}{2}\right)\downarrow$

Force on the element due to surface tension of soap film is $F_2 = 2(TR\theta)\uparrow$

$\because$ The wire is in contact with the soap film along upper length $R\theta$ and along lower length $R\theta$ both of the element AB.

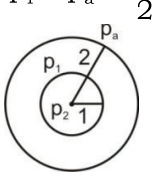
For equilibrium, $F_2 = F_1$ $\quad 2(TR\theta) = 2F\sin\left(\frac{\theta}{2}\right)$

$2(TR\theta) = 2F\left(\frac{\theta}{2}\right)$ $\quad \left(\because \theta \text{ is small, } \sin\frac{\theta}{2} \simeq \frac{\theta}{2}\right)$

$F = 2TR$ $\quad Y = \frac{FL}{A\Delta L} = \frac{FR}{A\Delta R}$

$\Rightarrow \Delta R = \frac{FR}{AY} = (2TR)\frac{R}{AY}$ $\quad \Delta R = \frac{2TR^2}{AY}$

5. $p_1 = p_a + \frac{4T}{2} = p_a + 2T$ $\qquad p_2 = p_1 + \frac{4T}{1}$



$p_2 = p_a + 2T + 4T$

$p_2 - p_a = 6T$ $\qquad \frac{4T}{r} = 6T$

$r = 4/6\,cm = 0.0067\,m$

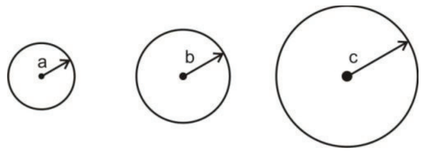
6. The net force between the drop and a glass plate results from the force of surface tension and the force of excess pressure inside the drop.

7. Let (a) and (b) coalesce to form (c).

By mole conservation:

$P_a.a^3 + P_b.b^3 = P_c.c^3$ ....(i)

also $P_a = P_0 + \frac{4\gamma}{a}$ ....(ii)



$P_b = P_0 + \frac{4\gamma}{b}$ ......(iii)

$P_c = P_0 + \frac{4\gamma}{c}$ .....(iv)

Putting there values:

$$\left(P_0 + \frac{4\gamma}{a}\right)a^3 + \left(P_0 + \frac{4\gamma}{b}\right)b^3 = \left(P_0 + \frac{4\gamma}{c}\right)c^3 \Rightarrow P_0\left[a^3 + b^3 - c^3\right] + 4\gamma\left[a^2 + b^2 - c^2\right] = 0$$

also $c^3 - \left(b^3 + a^3\right) = \frac{3v}{4\pi}$ and $c^2 - \left(a^2 + b^2\right) = \frac{s}{4\pi}$.

Putting their values: $P_0\left(\frac{-3v}{4\pi}\right) + 4T\left(\frac{-S}{4\pi}\right) = 0 \Rightarrow 3P_0V + 4ST = 0$

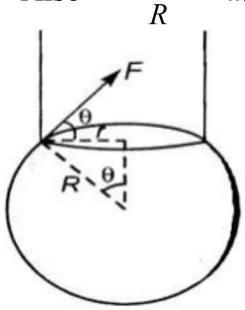
8. Note that cohesive force among mercury molecules is greater than adhesive force between glass and mercury molecules, Also, adhesive force between water and glass molecule is greater than cohesive force among water molecules.

9. Conceptual.

10. Vertical force due to surface tension,

$F_v = F\sin\theta = (T2\pi r)(r/R) \qquad = \frac{2\pi r^2 T}{R}$ so a is correct

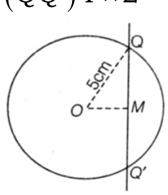
Also $\frac{2\pi r^2 T}{R} = mg = \frac{4}{3}\pi R^3 \cdot \rho \cdot g$



$\therefore R^4 = \frac{3r^2 T}{2\rho g} = \frac{3\times\left(5\times10^{-4}\right)^2(0.11)}{2\times10^3\times10} \quad = 4.125\times10^{-12}\,m^4 \qquad \therefore R = 1.425\times10^{-3}\,m = 1.4\times10^{-3}\,m$

So C is correct.

11. $(QQ')T\times2 = F$

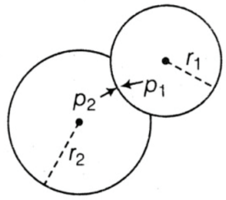


$\therefore QQ' = \dfrac{F}{2T} = \dfrac{16\times10^{-3}}{2(0.1)} = 0.08\,m = 8cm \qquad \therefore\ QM = 4cm$

$\therefore OM = \sqrt{5^2-4^2} = 3cm$ Required distance $=(5+3)cm$ or $(5-3)cm$

i.e., $8cm$ or $2cm$

12. $r_1 < r_2 \quad p_1 > p_2$



Excess pressure is always present on concave side. So, interface is concave towards small bubble. $p_1 = p_0 + \dfrac{4T}{r_1}\ p_2 = p_0 + \dfrac{4T}{r_2}$

Excess pressure $= p_1 - p_2 = 4T\left[\dfrac{1}{r_1} - \dfrac{1}{r_2}\right]$

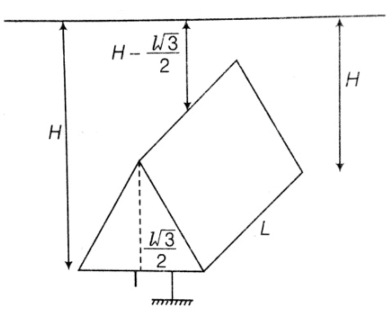
This excess pressure for the interface is also equal to $\dfrac{4T}{R}$.

$\therefore\ 4T\left(\dfrac{1}{r_1} - \dfrac{1}{r_2}\right) = \dfrac{4T}{R} \quad R = \dfrac{r_1r_2}{r_2 - r_1} = \dfrac{(0.002)(0.004)}{0.004-0.002} = 0.004m$

13. Conceptual

14. Conceptual

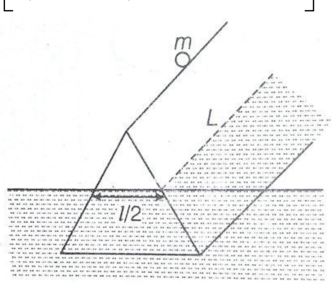
15. $p_{av} = \dfrac{\left[p_0 + \rho_w g\left(H - \dfrac{\ell\sqrt{3}}{2}\right)\right] + [p_0 + \rho gH]}{2} \qquad = p_0 + \rho_w g\left(H - \dfrac{\ell\sqrt{3}}{4}\right)$



On slant face, $F_{net} = p_{av} \times \text{Area} = \left[p_0 + \rho_w g\left(H - \dfrac{\ell\sqrt{3}}{4}\right)\right]L\ell$

16. $\left[M_{styrofoam} + m\right]g + F_{surfacetension} =$ Buoyant force

$\left[\dfrac{1}{2}\times\ell\times\dfrac{\ell\sqrt{3}}{2}\times L\times\rho_{sf} + m\right]g + \left[2L.\cos30^0 + 2.\dfrac{\ell}{2}\right]T = \left[\dfrac{1}{2}\times\ell\times\dfrac{\ell\sqrt{3}}{2} - \dfrac{1}{2}\times\dfrac{\ell}{2}\times\dfrac{\ell}{2}\dfrac{\sqrt{3}}{2}\right]\times L\rho_w g$



$$\frac{\ell^2\sqrt{3}}{4}L\rho_{sf}+m=\frac{3\sqrt{3}\ell^2}{16}L\rho_w-(2L+\ell)\frac{T}{g}$$

$$m=\frac{\ell^2 3\sqrt{3}}{16}L\rho_w-\frac{\ell^2\sqrt{3}}{4}L\rho_{sf}-(2L+\ell)\frac{T}{g} \qquad =\frac{L\ell^2\sqrt{3}}{4}\left[\frac{3}{4}\rho_w-\rho_{sf}\right]-(2L+\ell)\frac{T}{g}$$

17. Let the extension in each spring be x. Total number of springs is approximately $2\left(\frac{\ell_0}{L}\right)^2$, where ℓ_0 is the initial edge length of the square grid and a is the length of each spring

$\therefore$ Energy of the film (E) $=N\times\frac{1}{2}kx^2$

$$=2\left(\frac{\ell_0}{L}\right)^2\times\frac{1}{2}kx^2 \qquad =k\left(\frac{\ell_0 x}{L}\right)^2$$

New edge length $\ell=\ell_0+\left(\frac{\ell_0}{a}\right)x$

$$\Rightarrow E=k(\ell-\ell_0)^2 \qquad =k\left(\sqrt{s}-\sqrt{s_0}\right)^2$$

18. Considering a "small" square patch on the spherical film of unstrethed edge length ℓ_0,

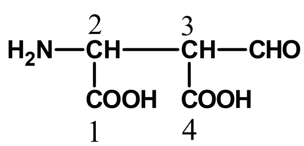
$$2T\left(\ell_0+\frac{\ell_0}{a}.x\right)=\left(\frac{\ell_0}{a}\right)kx \qquad \Rightarrow 2T=\frac{kx/a}{1+x/a}$$

Also $2\pi r=2\pi r_0+\frac{2\pi r_0}{a}x \qquad \Rightarrow r=r_0+\frac{r_0 x}{a}$

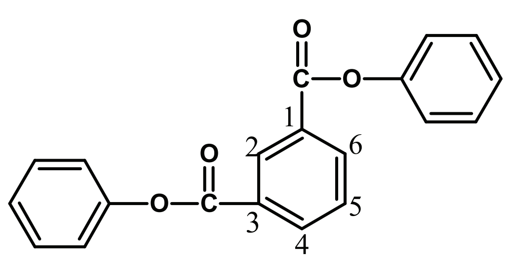
$$\therefore P=\frac{4T}{r}=\frac{2kx/a}{(1+x/a)r}=\frac{2k\left(\frac{r-r_2}{r_0}\right)}{\left(1+\frac{r+r_0}{r_0}\right)r} \qquad =\frac{2k(r-r_0)}{r^2}$$

CHEMISTRY

19.



20.



Diphenylbenzene – 1, 3 – ducarvixtkate

21. In (A) double bond should be allotted lower number.
(B) Functional groups should have lowest set of locant.
(C) Name of complex side chain is beginning from first alphabet of its complete name.
(D) Ethanoyloxy comes first than methoxy carbonyl.

22.

Final Key

S.NO	SUB	Q.NO	GIVEN KEY	FINALIZED KEY	EXPLANATION
1	PHY	8	**B**	**Delete**	Adhesive and cohesive forces were not there in this week syllabus
2	PHY	13	**BD**	**A or B**	It is not mentioned whether soap bubble is in soap solution (or) water. We get 1.049 atm in option D
3	PHY	14	**AC**	**AC or A**	In option C, there was no clarity(either it is about interface radius (or) merging radius) In option A the position of bubbles is not mentioned(Either it is one inside other (or) out side)