1. (d)

Sol. As collision is elastic, freely suspended mass moves acquiring velocity of colliding mass after the collision. Also acquired velocity must be equal to $\sqrt{5gL}$ to complete the circular motion.

Hence, $mgL = \frac{1}{2}mu^2 = \frac{1}{2}m(5gl)$

$u = \sqrt{3gL}$.

2. (c)

Sol. $\because F = \frac{K}{v}$

$\therefore m\frac{dv}{dt} = \frac{K}{v} \Rightarrow vdv = \frac{K}{m}dt$

$\Rightarrow \int vdv = \frac{K}{m}\int dt$

$\Rightarrow \frac{v^2}{2} = \frac{K}{m}t$

$\Rightarrow \frac{1}{2}mv^2 = Kt \Rightarrow W = Kt$

3. (c)

Sol. Spring energy = kinetic energy

i.e., $\frac{1}{2}kx^2 = \frac{1}{2}mv^2$ or $v = x\sqrt{\frac{k}{m}}$

Time taken by ball to reach ground, t

$= \sqrt{\frac{2h}{g}}$ (from $S = ut + \frac{1}{2}at^2$)

$\therefore$ Horizontal distance covered = vt

$= x\sqrt{\frac{k}{m}}\sqrt{\frac{2h}{g}} = x\sqrt{\frac{2kh}{mg}}$

4. (b)

Sol. Potential energy is minimum if equilibrium is stable.

$\frac{d}{dx}[P.E.(x)] = 0$

i.e., $\frac{d}{dx}\left[\frac{\alpha}{x^{12}} - \frac{\beta}{x^6}\right] = 0$

i.e., $\frac{-12\alpha}{x^{13}} + \frac{6\beta}{x^7} = 0$

i.e., $[-2\alpha + \beta x^6] \frac{6}{x^{13}} = 0$

i.e., $(-2\alpha + \beta x^6) = 0$

i.e., $x = \left(\frac{2\alpha}{\beta}\right)^{1/6}$

5. (d)

Sol. Note $\frac{1}{2}kd^2 = mg(H + d)$

or $k = \frac{2mg(H+d)}{d^2}$

6. (d)

Sol. $x = x_1$ and $x = x_3$ are not equilibrium positions because $\frac{dU}{dx} \neq 0$ at these points. $x = x_2$ is unstable, as U is maximum at this point.

7. (d)

Sol. The weight of hanging part $\left(\frac{L}{3}\right)$ of chain is $\left(\frac{1}{3}mg\right)$. This weight acts at centre of gravity of the hanging part, which is at a distance of $\left(\frac{L}{6}\right)$ from the table.

As work done = force × distance

$\therefore W = \frac{Mg}{3} \times \frac{L}{6} = \frac{MgL}{18}$

8. (b)

Sol. Since the particle is moving in horizontal circle, centripetal force,

$F = \frac{mv^2}{r} = \frac{k}{r^2}$

$mv^2 \frac{k}{r}$ .....(i)

Kinetic energy of the particle,

$k = \frac{1}{2}mv^2 = \frac{k}{2r}$ (using (i))

As $F = \frac{-du}{dr}$

$\therefore$ potential energy,

$U = \int_{\infty}^{r} F dr = -\int_{\infty}^{r}\left(\frac{-k}{r^2}\right)dr = k\int_{\infty}^{r} r^{-2} dr = \frac{-k}{r}$

$\therefore$ total energy = $K+U=\frac{k}{2r}-\frac{k}{r}=\frac{-k}{2r}$

9. (a)

Sol. Here, m = 60 + 20 = 80 kg

h = 20 × 0.2 = 4 m

$g = 9.8\,ms^{-2}, t = 10s$

$$p=\frac{W}{t}=\frac{mgh}{t}=\frac{80\times9.8\times4}{10}=\frac{3136}{10}=313.6W.$$

10. (b)

Sol. Using v = u + at

$\therefore v = at \qquad (\because u = 0)$

As power,

$p = F \times v \qquad \therefore p = (ma)\times at = ma^2t$

As m and a are constants

$\therefore p \propto t$

11. (d)

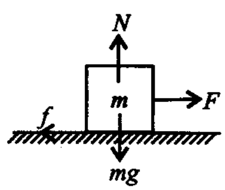
Sol. As the earth moves once around the sun is its elliptical orbit, its kinetic energy is maximum when it is farthest from the sun. As kinetic energy is never zero during its motion, hence option (d) is correct.

12. (c)

Sol. When a pendulum is oscillating in air, its total mechanical energy decreases exponentially with time. Hence, option (c) represents correct diagram.

13. (c)

Sol. The various forces acting on the block is as Shown in the figure.



Here, $m = 2kg, \mu = 0.1, F = 6N, g = 10ms^{-2}$

Force of friction,

$f = \mu N = 0.1\times2kg\times10ms^{-2} = 2N$

Net force with which the block moves

$F' = F - f = 6N - 2N = 4N$

Net acceleration with which the block moves

$$a=\frac{F'}{m}=\frac{4N}{2kg}=2ms^{-2}$$

Distance travelled by the block in 10 s is

$$d=\frac{1}{2}at^2=\frac{1}{2}\times2ms^{-2}(10s)^2=100m \qquad (\therefore u=0)$$

As the applied force and displacement are in the same direction, therefore angle between the applied force and the displacement is $\theta = 0^0$

Hence,
Work done by the applied force,

$W_F = Fd\cos\theta(6N)(100m)\cos 0^0 = 600J$

14. (b)

Sol. Here, $\vec{F}_1 = 4\hat{i} + \hat{j} - 3\hat{k}$

$\vec{F}_2 = 3\hat{i} + \hat{j} - \hat{k}$

$\hat{r}_1 = \hat{i} + 2\hat{j} + 3\hat{k}$

$\vec{r}_2 = 5\hat{i} + 4\hat{j} + \hat{k}$

Displacement, $\vec{r} = \vec{r}_2 - \vec{r}_1$

$= (5\hat{i} + 4\hat{j} + \hat{k}) - (\hat{i} + 2\hat{j} + 3\hat{k}) = 4\hat{i} + 2\hat{j} - 2\hat{k}$

Work done by the forces,

$W = \left[\vec{F}_1 + \vec{F}_2\right].\vec{r}$

$= \left[(4\hat{i} + \hat{j} - 3\hat{k}) + (3\hat{i} + \hat{j} - \hat{k})\right].(4\hat{i} + 2\hat{j} - 2\hat{k})$

$= (7\hat{i} + 2\hat{j} - 4\hat{k}).(4\hat{i} + 2\hat{j} - 2\hat{k}) = 28 + 4 + 8 = 40J$

15. (c)

Sol. kinetic energy of the body is

$$k = \frac{p^2}{2m}$$

Where p is the momentum and m is the mass of a body respectively.

$\therefore k \propto p^2$

When the momentum of a body is increased by 25%, its momentum will become

$$p' = p + \frac{25}{100}p = \frac{125}{100}p = \frac{5}{4}p$$

$$\therefore \frac{k'}{k} = \frac{p'^2}{p^2} = \left(\frac{5}{4}\right)^2 = \frac{25}{16}$$

Or $k' = \frac{25}{16}k$

Percentage increase in the kinetic energy of the body

$$= \frac{k' - k'}{k} \times 100$$

$$= \frac{(5/16)k - k}{k} \times 100$$

$$= \frac{9}{16} \times 100 = 56\%$$

16. (c)

Sol. $\vec{F} = 3x^2\hat{i} + 4\hat{j}$

$\vec{r} = x\hat{i} + y\hat{i} \quad \therefore d\vec{r} = dx\hat{i} + dy\hat{j}$

Work done, $W = \int \vec{F}.d\vec{r}$

$$= \int_{(2,3)}^{(3,0)} (3x^2\hat{i} + 4\hat{j}).(dx\hat{i} + dy\hat{j})$$

$$= \int_{(2,3)}^{(3,0)} 3x^2 dx + 4dy = \int_{(2,3)}^{(3,0)} d(x^3 + 4y)$$

$$= \left[x^3 + 4y\right]_{(2,3)}^{(3,0)} = 3^3 + 4\times 0 - (2^3 + 4\times 3)$$

$$= 27 + 0 - (8 + 12) = 27 - 20 = +7J$$

According to work-energy theorem.

Change in the kinetic energy = work done, W = +7J

17. (a)

Sol. Potential energy

$$U = \frac{1}{2}kx^2 = \frac{1}{2}k\left(\frac{F}{k}\right)^2 = \frac{F^2}{2k}$$

$$U_1 \times k_1 = U_2 \times k_2 \quad \text{or} \quad \frac{U_1}{U_2} = \frac{k_2}{k_1} = \frac{2000}{1000} = \frac{2}{1}$$

18. (c)

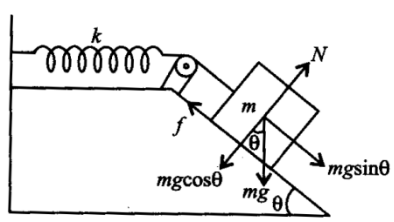
Sol. Here, $R_{max} = \frac{u^2}{g} = \frac{1}{2}mu^2 \times \frac{2}{mg}$

But $\frac{1}{2}mu^2 = \frac{1}{2}kx^2$

$$\therefore R_{max} = \frac{1}{2}kx^2 \times \frac{2}{mg} = \frac{kx^2}{mg} = \frac{600\times(0.05)^2}{0.015\times 10} = 10m$$

19. (b)

Sol.



Here, m = 1 kg, $\theta = 45^0$, $k = 100 N m^{-1}$

From figure,

$N = mg\cos\theta$

$f = \mu N = \mu mg\cos\theta$

Where μ is the coefficient between the block and the incline.

Net force on the block down the incline,

$= mg\sin\theta - f$

$= mg\sin\theta - \mu mg\cos\theta = mg(\sin\theta - \mu\cos\theta)$

Distance moved, x =10 cm = 10 × 10^{-2}m
In equilibrium.
Work done = potential energy of stretched spring

$$mg(\sin\theta - \mu\cos\theta)x = \frac{1}{2}kx^2 \quad 2mg(\sin\theta - \mu\cos\theta) = kx$$

$$2\times1\times10\times(\sin 45^0 - \mu\cos 45^0) = 100\times10\times10^{-2}$$

$$\sin 45^0 - \mu\cos 45^0 = \frac{1}{2}$$

$$\frac{1}{\sqrt{2}} - \frac{\mu}{\sqrt{2}} = \frac{1}{2}$$

$$1-\mu = \frac{\sqrt{2}}{2} = \frac{1}{\sqrt{2}} \qquad \Rightarrow \mu = 1 - \frac{1}{\sqrt{2}} = \frac{\sqrt{2}-1}{\sqrt{2}}$$

$$\mu = 0.3$$

20. (b)
Sol. potential energy in a stretched spring is given by $v = \frac{1}{2}kx^2$

$$\therefore \frac{v_1}{v_2} = \left(\frac{x_1}{x_2}\right) \qquad \therefore \frac{v_1}{v_2} = \left(\frac{0.02}{0.1}\right) = \frac{1}{25}$$

$$v_2 = 25V_1 = 25V$$

21. (b)
Sol. Given: $m = 0.5kg,\ v = kx^{3/2}$
Where, $k = 5m^{-1/2}s^{-1}$

Acceleration, $A = \frac{dv}{dt} = \frac{dv}{dx}\frac{dx}{dt} = v\frac{dv}{dx}$

$\left(\therefore v = \frac{dx}{dt}\right)$

As $v^2 = k^2x^3$

$\therefore Acceleration,\ a = \frac{3}{2}k^2x^2$

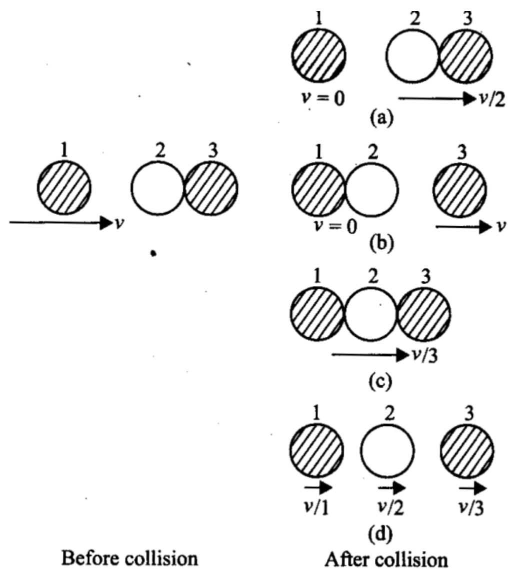
Force, F = Mass × Acceleration $= \frac{3}{2}mk^2x^2$

Work done,

$$W = \int Fdx = \int_0^2 \frac{3}{2}mk^2x^2dx$$

$$w = \frac{3}{2}mk^2\left[\frac{x^3}{3}\right]_0^2 = \frac{3}{6}\times0.5\times5^2\times[2^3-0] = 50J$$

22. (b)
Sol.



Let m be mass of each ball bearing.
Total kinetic energy of the system before collision,

$$= \frac{1}{2}mv^2 + 0 = \frac{1}{2}mv^2$$

In (a), Kinetic energy of the system after collision,

$$K_1 = \frac{1}{2}(2m)\left(\frac{v}{2}\right)^2 = \frac{1}{4}mv^2$$

In (b), kinetic energy of the system after collision.

$$K_2 = \frac{1}{2}(m)(v)^2 = \frac{1}{2}mv^2$$

In (c), kinetic energy of the system after collision

$$k_3 = \frac{1}{2}(3m)\left(\frac{v}{3}\right)^2 = \frac{1}{6}mv^2$$

In (d), kinetic energy of the system after collision,

$$k_4 = \frac{1}{2}mv^2 + \frac{1}{2}m\left(\frac{v}{2}\right)^2 + \frac{1}{2}m\left(\frac{v}{3}\right)^2 = \frac{49}{72}mv^2$$

We see that kinetic energy is conserved only in (b)
Hence, (b) is the only possibility.

23. (a)
Sol. In presence of friction, both the spring force and the frictional act so as to oppose the compression of the spring.
Work done by the net force

$$W = -\frac{1}{2}kx_m^2 - \mu mgx_m$$

Where X_m is the maximum compression of the spring. Change in kinetic energy.

$$\Delta K = k_f - k_i = 0 - \frac{1}{2}mv^2$$

According to work-energy theorem

$$W = \Delta k$$

$$-\frac{1}{2}kx_m^2 - \mu mgx_m = -\frac{1}{2}mv^2$$

$$\frac{1}{2}kx_m^2 + \mu mgx_m = -\frac{1}{2}mv^2$$

$$kx_m^2 + 2\mu mgx_m - mv^2 = 0$$

$$x_m^2 + \frac{2\mu mgx_m}{k} - \frac{mv^2}{k} = 0$$

It is a quadratic equation in x_m.

Solving this quadratic equation for x_m and taking only positive root since x_m is positive, we get

$$x_m = -\frac{\mu mg}{k} + \frac{1}{k}\sqrt{(\mu mg)^2 + mkv^2}$$

24. (a)

Sol. work done = Area under f-x graph with proper algebraic sign

$$= \frac{1}{2}\times 20\times 4 - \frac{1}{2}\times 20\times 4 = 0J$$

25. (b)

Sol. Given: $V = \frac{20xy}{z}$

For a conservative field

$$\vec{F} = -\nabla V$$

Where, $\nabla - \hat{i}\frac{\partial}{\partial x} + \hat{j}\frac{\partial}{\partial y} + \hat{k}\frac{\partial}{\partial k}$

$$\therefore \vec{F} = -\left[\hat{i}\frac{\partial V}{\partial X} + \hat{j}\frac{\partial V}{\partial Y} + \hat{k}\frac{\partial V}{\partial Z}\right]$$

$$= -\left[i\frac{\partial}{\partial X}\left(\frac{20xy}{z}\right) + \hat{j}\frac{\partial}{\partial y}\left(\frac{20xy}{z}\right) + \hat{k}\frac{\partial}{\partial Z}\left(\frac{20xy}{z}\right)\right]$$

$$= -\left[\left(\frac{20y}{z}\right)\hat{i} + \left(\frac{20x}{z}\right)\hat{j} + \left(-\frac{20xy}{z^2}\right)\hat{k}\right]$$

$$= -\left(\frac{20y}{z}\right)\hat{i} - \left(\frac{20x}{z}\right)\hat{j} + \left(\frac{20xy}{z^2}\right)\hat{k}$$

26. (c)

Sol. There are two external forces on the bob : gravity (mg) and tension (T) in the string. The tension does no work as displacement is always perpendicular to the string. Total mechanical energy (E) of the system is conserved.

If we take potential energy of the system to be zero at the lowest point A. then

$\text{At A}, E = \frac{1}{2}mv_0^2$ ….(i)

Form Newton's second law

$T_A - mg = \frac{mv_0^2}{L}$ …(ii)

Where T_A is the tension in the string at A.

At the highest point C, the string slackens as the tension in the string (T_C) becomes zero.

$\text{At C}, \ E = \frac{1}{2}mv_C^2 + mg(2L)$ …(iii)

From Newton's second law

$mg = \frac{mv_C^2}{L}$ ….(iv)

Where V_C is the velocity at C.

From (iv), $V_C = \sqrt{gL}$

C-q

From (iii), $E = \frac{1}{2}m(gL) + 2mgL = \frac{5}{2}mgL$ …(v)

Using (i), $\frac{1}{2}mv_0^2 = \frac{5}{2}mgL,$

$v_0 = \sqrt{5gL}$ ….(vi)

A – r

$\text{At B}, \ E = \frac{1}{2}mv_B^2 + mg(L)$

Where V_B is the velocity at B.

or $\frac{1}{2}mv_B^2 = Eg(L) = \frac{5}{2}mgL - mgL$ (Using (v))

$\frac{1}{2}mv_B^2 = \frac{3}{2}mgL$

$\therefore \ v_B = \sqrt{3gL}$

B – S

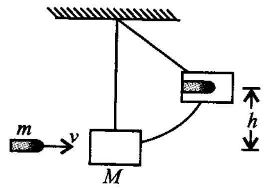
The ratio of kinetic energies at B and C is

$$\therefore \frac{K_B}{K_C} = \frac{\frac{1}{2}mv_B^2}{\frac{1}{2}mv_C^2} = \frac{3gL}{gL} = \frac{3}{1}$$

D – P

27. (a)

Sol. The situation is as shown in the figure.



Let V be velocity of the block-bullet system just after collision. Then by the law of conservation of linear momentum, we get

$mv = (m+M)V$

$V = \frac{mv}{m+M}$ .....(i)

Let the block rises to a height h.

According to law of conservation of mechanical energy,

We get

$\frac{1}{2}(m+M)v^2 = (m+M)gh$

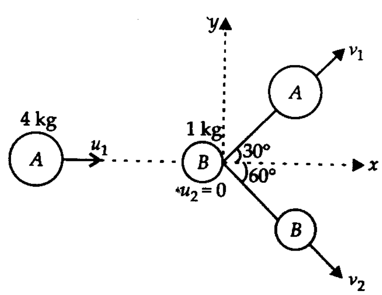
$h = \frac{V^2}{2g}$

$h = \frac{1}{2g}\left(\frac{mv}{m+M}\right)^2$ (Using (i))

$= \frac{v^2}{2g}\left(\frac{m}{m+M}\right)^2$

28. (a)

Sol.



Applying the law of conservation of linear momentum along a direction perpendicular to the direction of motion (i.e. along y - axis), we get

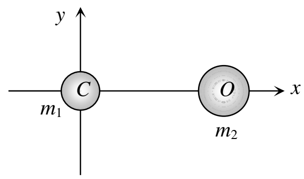
$0 + 0 = 4v_1 \sin 30^0 - v_2 \sin 60^0$

$4v_1 \sin 30^0 = v_2 \sin 60^0$

$\frac{v_1}{v_2} = \frac{\sin 60^0}{4\sin 30^0} = \frac{\sqrt{3}}{4}$

29. (c)

Sol. Let carbon atom is at the origin and the oxygen atom is placed at x-axis



$m_1 = 12$, $m_2 = 16$, $\vec{r}_1 = 0\hat{i} + 0\hat{j}$ and $\vec{r}_2 = 1.1\hat{i} + 0\hat{j}$

$$\vec{r} = \frac{m_1 \vec{r}_1 + m_2 \vec{r}_2}{m_1 + m_2} = \frac{16 \times 1.1}{28}\hat{i}$$

$\vec{r} = 0.63\hat{i}$ i.e. 0.63 Å from carbon atom.

30. (c)

Sol. $m_1 = 7\,gm$, $m_2 = 4\,gm$, $m_3 = 10\,gm$

and $\vec{r}_1 = (\hat{i} + 5\hat{j} - 3\hat{k}),\ r_2 = (2i + 5j + 7k),\ r_3 = (3\hat{i} + 3\hat{j} - \hat{k})$

Position vector of center mass

$$\vec{r} = \frac{7(\hat{i} + 5\hat{j} - 3\hat{k}) + 4(2\hat{i} + 5\hat{j} + 7\hat{k}) + 10(3\hat{i} + 3\hat{j} - \hat{k})}{7 + 4 + 10} = \frac{(45\hat{i} + 85\hat{j} - 3\hat{k})}{21}$$

$\Rightarrow \vec{r} = \frac{15}{7}\hat{i} + \frac{85}{21}\hat{j} - \frac{1}{7}\hat{k}$. So coordinates of centre of mass $\left[\frac{15}{7}, \frac{85}{21}, \frac{-1}{7}\right]$.

31. (a)

Sol. $x_{cm} = \dfrac{\int x\,dm}{\int dm} \quad \dfrac{\int_0^L \frac{kx^2}{L} dx \times x}{\int_0^L \frac{kx^2}{L} dx}$

32. (b)

Sol. $y_{cm} = \dfrac{m_1 x_1 + m_2 x_2}{m_1 + m_2}$, $m_1 = \rho \frac{1}{3} \pi r^2 h$

$m_2 = \rho\left(\frac{2}{3}\pi r^3\right)$, $0 = \dfrac{m_1 \frac{h}{4} - m_2 \frac{3r}{8}}{m_1 + m_2}$, $h = \sqrt{3}\,r$

$TE = KE + PE = \frac{1}{2}mv^2 + \frac{1}{2}Kx^2$

33. (b)

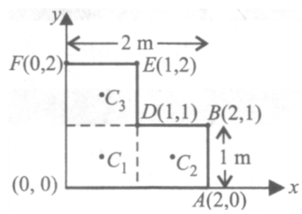
Sol. $a = \frac{(M-m)g}{M+m}$, $a_{cm} = \frac{Ma+ma}{M+m}$

34. (c)

Sol. $a_{cm} = \frac{m_1a_1+m_2a_2}{m_1+m_2} = \frac{m(0)+m(a)}{m+m} = a/2$

35. (a)

Sol. Choosing the x and y axes as shown in the figure. The coordinates of the vertices of the L – shaped lamina is as shown in the figure.



Divide the L-shaped lamina into three squares each of side 1m and mass 1 kg ($\because$ the lamina is uniform) by symmetry, the centres of mass C_1, C_2 and C_3 of the squares are their geometric centres and have coordinates $C_1\left(\frac{1}{2},\frac{1}{2}\right), C_2\left(\frac{3}{2},\frac{1}{2}\right)$ and $C_3\left(\frac{1}{2},\frac{3}{2}\right)$ respectively.

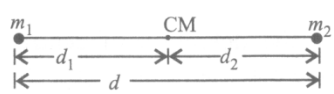
The coordinates of the centre of mass of the L-shaped lamina is

$$X_{CM} = \frac{m_1x_1+m_2x_2+m_3x_3}{m_1+m_2+m_3} = \frac{1\times\frac{1}{2}+1\times\frac{3}{2}+1\times\frac{1}{2}}{1+1+1} = \frac{5}{6}\text{m} \quad Y_{CM} = \frac{m_1y_1+m_2y_2+m_3y_3}{m_1+m_2+m_3}$$

$$= \frac{1\times\frac{1}{2}+1\times\frac{1}{2}+1\times\frac{3}{2}}{1+1+1} = \frac{5}{6}\text{m}$$

36. (a)

Sol.



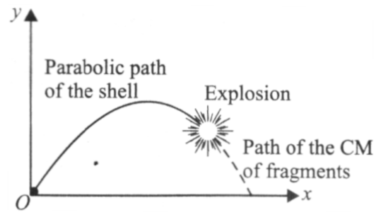
Refer figure.

The distances of centre of mass CM form masses m_1 and m_2 are

$d_1 = \frac{m_2d}{m_1+m_2}$ and $d_2 = \frac{m_1d}{m_1+m_2}$ $\quad \therefore \frac{d_1}{d_2} = \frac{m_2}{m_1}$

37. (b)

Sol. The forces leading to the explosion are internal force. They contribute noting to the motions of the centre of mass. The total external force, namely the force of gravity acting on the shell is the same before and after the explosion. Therefore, the centre of mass of the fragments of the shell continues along the same of the fragments of the shell continues along the same parabolic as it would have followed. If there were no explosion as shown in figures



38. (a)

Sol. Here, $\vec{r} = \hat{i} - \hat{j} + \hat{k}$

$\vec{F} = 7\hat{i} + 3\hat{j} - 5\hat{k}$

Torque, $\vec{\tau} = \vec{r} \times \vec{F}$

$$\vec{\tau} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 1 & -1 & 1 \\ 7 & 3 & -5 \end{vmatrix} = \hat{i}(5-3) + \hat{j}(7-(-5)) + \hat{k}(3-(-7)) \text{ or } \vec{\tau} = 2\hat{i} + 12\hat{j} + 10\hat{k}$$

39. (d)

Sol. For translations equilibrium, $\sum \vec{F} = 0$ A – R

For rotational equilibrium,

$\sum \vec{\tau} = 0$

B – S

Moment of inertial of a body = MK^2

C – P

Torque is required to produce angular accelerations.

D – q

40. (a)

Sol. Given: $\theta(t) = 2t^3 - 6t^2$

$\therefore \frac{d\theta}{dt} = 6t^2 - 12t$

$\frac{d^2\theta}{dt^2} = 12t - 12$

Angular acceleration,

$\alpha = \frac{d^2\theta}{dt^2} = 12t - 12$

When angular acceleration (α) is zero, then the torque on the wheel becomes zero ($\because \tau = \alpha$)

$\Rightarrow 12t - 12 = 0$ or $t = 1$ s

41. (d)

Sol. Here, $m_1 = 1\text{kg}, m_2 = 3\text{kg}$

$\vec{r}_1 = 2\hat{i} + 3\hat{j} + 4\hat{k}, r_2 = -2\hat{i} + 3\hat{j} - 4\hat{k}$

The position vector of the centre of mass is

$$\vec{r}_{CM} = \frac{m_1\vec{r}_1 + m_2\vec{r}_2}{m_1+m_2} = \frac{(1)(2\hat{i}+3\hat{j}+4\hat{k})+(3)(-2\hat{i}+3\hat{j}-4\hat{k})}{1+3} = \frac{2\hat{i}+3\hat{j}+4\hat{k}-6\hat{i}+9\hat{j}-12\hat{k}}{4}$$

$$= \frac{-4\hat{i}+12\hat{j}-8\hat{k}}{4} = -\hat{i}+3\hat{j}-2\hat{k}$$

42. (a)

Sol. Here, $\vec{v}_1 = 2\hat{i}ms^{-1}, \vec{v}_2 = 2\hat{j}ms^{-1}$.

$\vec{a}_1 = (3\hat{i}+3\hat{j})ms^{-2}, \vec{a}_2 = 0ms^{-2}$

$$\therefore \vec{v}_{CM} = \frac{m_1\vec{v}_1 + m_2\vec{v}_2}{m_1+m_2} = \frac{\vec{v}_1+\vec{v}_2}{2} = \frac{2\hat{i}+2\hat{j}}{2} = (\hat{i}+\hat{j})ms^{-1}$$

$(\because m_1 = m_2)$

Similarly,

$$\vec{a}_{CM} = \frac{\vec{a}_1+\vec{a}_2}{2} = \frac{3\hat{i}+3\hat{j}+0}{2} = \frac{3}{2}(\hat{i}+\hat{j})ms^{-2}$$

Since, $\vec{v}_{CM}$ is parallel to $\vec{a}_{CM}$ The path will be a straight line

43. (d)

Sol. According to the definition of centre of mass, we can imagine one particle of mass (1+2+3) kg at (1,2,3) ; another particle of mass (2 + 3) kg at (-1, 3, -2).

Let the third particle of mass 5 kg put at (x_3, y_3, z_3) i.e.,

$m_1 = 6kg, (x_1, y_1, z_1) = (1,2,3)$

$m_2 = 5kg, (x_2, y_2, z_2) = (-1,3,-2)$

$m_3 = 5kg, (x_3, y_3, z_3)$ **=?**

Given, $(X_{CM}, Y_{CM}, Z_{CM}) = (1,2,3)$

Using $X_{CM} = \dfrac{m_1x_1 + m_2x_2 + m_3x_3}{m_1+m_2+m_3}$

$$1 = \frac{6\times1 + 5\times(-1) + 5x_3}{6+5+5}$$

$5x_3 = 16 - 1 = 15 \text{ or } x_3 = 3$

Similarly, $y_3 = 1$ and $z_3 = 3$

44. (b)

Sol. We know that second's hand completes its revolution (2π) in 60 sec $\therefore\ \omega = \frac{\theta}{t} = \frac{2\pi}{60} = \frac{\pi}{30}\ rad/sec$

45. (d)

Sol. Conceptual

46. (d)

Sol. May lie within or outside the body.

47. (c)

Sol. A rigid body is said to be in partial equilibrium when it is in translational equilibrium but not in rotational equilibrium or when it is in rotational equilibrium but not in translational equilibrium.

48. (d)

Sol. $E = \frac{P^2}{2m} \Rightarrow \frac{E_2}{E_1} = \left(\frac{P_2}{P_1}\right)^2 = \left(\frac{2P}{P}\right)^2 = 4$

$E_2 = 4E_1 = E_1 + 3E_1 = E_1 + 300$ % of E_1.

49. (b)

Sol. When the rod is lying on a horizontal table, its potential

energy = 0

But when we make its stand vertical its centre of mass rises upto high $\frac{l}{2}$. So it's potential energy $= \frac{mgl}{2}$

$\therefore$ Work done = charge in potential energy

$= mg\frac{l}{2} - 0 = \frac{mgl}{2}$.

50. (c)

Sol. $P = \vec{F}.\vec{v}$

$= (10\hat{i} + 10\hat{j} + 20\hat{k}).(5\hat{i} - 3\hat{j} + 6\hat{k}) = 50 - 30 + 120 = 140\ J\text{-}s^{-1}$

51. (c)
Sol. Since the IV, I.E. is very high. Thus electron is to be removed from stable configuration.

52. (a)
Sol. EKa -aluminium $\Rightarrow$ Ga

EKa -silicon $\Rightarrow$ Ge

53. (a)
Sol. Coinage metal $\rightarrow$ (Cu, Ag, Au)

54. (c)
Sol. Atomic Number

55. (c)
Sol. I.P. of $\boxed{N > O}$

Half filled p-orbitals has extra stability

56. (a)
Sol. $L \xrightarrow{\text{I.P.}\uparrow} R$

57. (c)
Sol. Atomic Mass

58. (b)
Sol. G.E.C. of d-block = $(n-1)d^{1-10}\ ns^{1-2}$

59. (c)
Sol. 3d – series $\Rightarrow$ $_{21}Sc$ ———————— $_{30}Zn$

60. (a)
Sol. Size of isoelectronic decreases with increase in atomic number.

61. (b)
Sol. As we move in a group from top to bottom, electron gain enthalpy becomes less negative because the size of the atom increases and the added electron would be at larger distance from the nucleus.

Negative electron gain enthalpy of F is less than Cl. This is due to the fact that when an electron is added to F, the added electron goes to the smaller n = 2 energy level and experiences significant repulsion from the other electrons present in this level. In Cl, the electron goes to the larger n = 3 energy level and consequently occupies a larger region of space leading to much less electron-electron repulsion. So the correct order is
Cl > F > Br > I.

62. (b)

Sol. 2^{nd} Period Li Be B C N O F

3^{rd} Period Na Mg Al Si P S Cl

63. (b)

Sol. Non-metals present in p-Block

64. (a)

Sol.

	F	Cl	Br	I	At
Z =	9	17	35	53	85

65. (a)

Sol. Lanthanide series $\Rightarrow 4f^{1-14} \Rightarrow 6^{th}$ period.

66. (d)

Sol. Down the group I.P. decreases.

So minimum I.P. = Rb

67. (c)

Sol. Cl, Br, I

68. (c)

Sol. Oxygen family elements also called chalcogens

69. (d)

Sol. Z = 118 $[Rn]^{86}\ 5f^{14}\ 6d^{10}\ 7s^{2}\ 7p^{6}$; as last electron enters in p-subshell, it belongs to p-block. Thus its group number will be 10 + 2 + 6 = 18. Hence the element is a noble gas.

70. (d)

Sol. CO is a neutral oxide. SrO is a basic oxide. Al_2O_3 is an amphoteric oxide while CO_2 is an acidic oxide.

71. (d)

Sol. Terbium (Z = 65) is a lanthanoid and all others are actinoids.

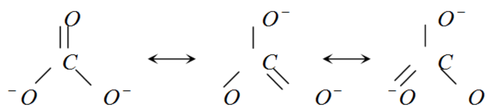
72. (a)

Sol. According to the law of octaves, every eighth element had properties similar to the first element like eight note of music.

73. (b)
Sol. Same number of valence electrons

74. (a)
Sol. In sp^3 –hybridisation each sp^3 hybridised orbital has 1/4 s-character.

75. (b)
Sol. There are three resonance structure of CO_3^{2-} ion.



(I) (II) (III)

76. (c)
Sol. In solid state, ionic compounds are bad conductor of
Electricity

77. (c)
Sol. $\left[\text{Polarising Power} \propto \frac{1}{\text{size of cation}}\right]$

78. (c)
Sol. RbCl and $BeCl_2$

79. (d)
Sol. Both

$$\boxed{\text{Lattice Energy} \propto \frac{q_1 q_2}{r_c + r_a}}$$

80. (b)
Sol. The conditions required for the formation of an ionic bond.

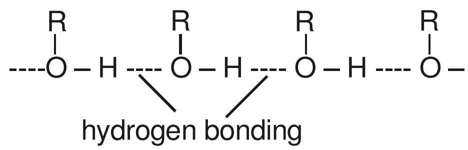
(i) Ionization enthalpy [$M(g) \rightarrow M^+(g) + e^-$] of electropositive element must be low.

(ii) Negative value of electron gain enthalpy [$X(g) + e^- \rightarrow X^-(g)$] of electronegative element should be high.

81. (b)
Sol. Cs has lowest IE_1 amongst the metals and F has higher electron affinity. So Cs and F form most ionic compound.

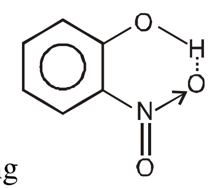
82. (d)
Sol. In SF_6, PCl_5 and IF_7 the valence shell has 12, 10 and 14 electrons. As all contain more than 8 electrons in their valence shell they are example of super octet molecules.

83. (d)
Sol. The reason for the lesser volatility of alcohol than ethers is the intermolecular association of a large number of molecules due to hydrogen bonding as – OH group is highly polarised.



No such hydrogen bonding is present in ethers.

84. (b)
Sol.



It has intra molecular H-bonding

85. (a)`
Sol. Strength of H-bond depends on following factors.
(i) Electronegativity of element covalently bonded to hydrogen atom.
(ii) Size of electronegative element.
(iii) Ease of donation of lone pair of electrons by electronegative element.

86. (c)
Sol. $O_2^+ \Rightarrow$ B.O. = 2.5
$O_2^- \Rightarrow$ B.O. = 1.5
$O_2 \Rightarrow$ B.O. = 2

87. (a)
Sol. Step I : Skeleton OCO
Step II : A = 1×4 for C + 2×6 for O = 4 + 12 = 16 electrons
Step III : Total no. of electrons needed to achieve noble gas configuration (N)
N = $1 \times 8 + 2 \times 8 = 24$
Step IV : Shared electrons, S = N – A = 24 -16 =8 electrons
Step V : O :: C :: O
Step VI : $:\ddot{O}::C::\ddot{O}: \equiv :\ddot{O}=C=\ddot{O}:$

88. (d)

Sol. $\left[\begin{array}{c} \quad\ \ H \\ \quad\ \ | \\ H - N \rightarrow H \\ \quad\ \ | \\ \quad\ \ H \end{array}\right]^{+}$ or $\left[\begin{array}{c} H \\ H:\ddot{N}:H \\ \ddot{H} \end{array}\right]^{+}$

89. (d)

Sol. $\dot{\ddot{N}} = \ddot{\underset{..}{O}}$

For NO, the octet rule is not followed due to the present of odd electrons on N.

90. (d)

Sol. $:N\vdots\vdots N:$

Number of electrons involved in bonding is 6.

91. (a)

$$\begin{array}{c} \qquad\qquad\quad H \\ \qquad\qquad\quad | \\ H - C \equiv C - C - H \\ \qquad\qquad\quad | \\ \qquad\qquad\quad H \end{array}$$

Sol.

No. of sigma bonds = 6, No. of pi bonds = 2

92. (a)

Sol. Electronic configuration of atom : $1s^2\,2s^2\,2p^5$

M.O. configuration :

$(\sigma 1s^2)(\sigma^* 1s^2)(\sigma 2s^2)(\sigma^* 2s^2)(\sigma 2p_z^2)$

$(\pi 2p_x^2 = \pi 2p_y^2)\ (\pi^* 2p_x^2 = \pi^* 2p_y^2)$

$\text{B.O.} = \frac{1}{2} \times (10 - 8) = 1$

93. (b)

Sol. The angle corresponds to sp^2 hybridisation triangular planar is 120^0

94. (a)

Sol. Cation size is decreasing in the order :

$Na^{+} > Mg^{2+} > Al^{3+}$

Al^{3+} has maximum polarization effect and Na^{+} has minimum polarization effect.

The covalent nature is in the order:

$AlCl_3 > MgCl_2 > NaCl$

95. (c)

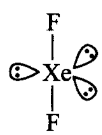
Sol. *lp* –*lp* repulsions > *lp* – *bp* repulsions > *bp* – *bp* repulsions

96. (b)

Sol. The percentage of s-d character in sp^3, sp^2 and sp is 25% 33% and 50% respectively. Order of size of orbitals is $sp < sp^2 < sp^3$.

97. (b)

Sol. $XeF_2 - sp^3d$



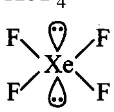
Total no. of valence electrons = 22

$\frac{22}{8} = 2(Q) + 6(R), \frac{6}{2} = 3(Q)$

X = 2 +3 = 5

Hybridisation is sp^3d.

$XeF_4 -$



Hybridisation is sp^3d^2

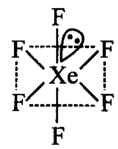
Total no. of electrons in outermost shells = 8 +28 =36

$\frac{36}{8} = 4(Q) + 4(R), \frac{4}{2} = 2(Q) + 0(R)$

X = 4 + 2 +0 =6

Hybridisation is Sp^3d^2

XeF_6



Total no. of valence electrons = 8+ 42 = 50

$\frac{50}{8} = 6(Q) + 2(R), \frac{2}{2} = 1(Q)$

X= 6+ 1 = 7

Hybridisation is Sp^3d^3.

98. (c)

Sol. A molecule exists only if the bond order is positive. If bond order is zero or negative, the molecule does not exist.

99. (b)

Sol. Density of ice is less than water due to an open-cage structure formed by hydrogen bonding.

100. (b)

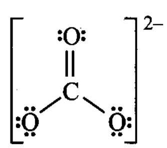
Sol. $:\ddot{S} = C = \ddot{S}:$

Formal charge on C atom = Valence electrons

- Lone pair of electrons $-\frac{1}{2} \times$ Bonding electrons

$= 4 - 0 - \frac{1}{2} \times 8 = 0$

Formal charge on C atom = 0



BOTANY									
Q.	ANS.	Q.	ANS.	Q.	ANS.	Q.	ANS.	Q.	ANS.
101	C	113	D	125	B	136	C	148	C
102	D	114	C	126	B	137	D	149	B
103	A	115	B	127	A	138	D	150	A
104	D	116	B	128	B	139	A		
105	A	117	D	129	B	140	D		
106	B	118	C	130	D	141	B		
107	C	119	A	131	B	142	C		
108	C	120	C	132	B	143	C		
109	C	121	A	133	B	144	C		
110	C	122	C	134	D	145	C		
111	C	123	C	135	A	146	A		
112	B	124	C			147	B		

ZOOLOGY									
Q.	ANS.	Q.	ANS.	Q.	ANS	Q.	ANS.	Q.	ANS
151	C	163	B	175	B	186	B	198	A
152	D	164	C	176	B	187	B	199	C
153	A	165	C	177	B	188	D	200	B
154	B	166	A	178	D	189	C		
155	B	167	B	179	A	190	A		
156	C	168	D	180	C	191	C		
157	C	169	A	181	B	192	C		
158	D	170	B	182	B	193	D		
159	A	171	B	183	C	194	A		
160	D	172	C	184	A	195	B		
161	C	173	A	185	C	196	C		
162	C	174	C			197	A		