WEEKLY TEST TARGET - JEE -01 TEST - 11
SOLUTION Date 21-07-2019

[PHYSICS]

1. The centre of mass of a body is independent of the choice of co-ordinate system, *e.g.*, the centre of mass of a ring is at its centre whatever may be the co-ordinate system.

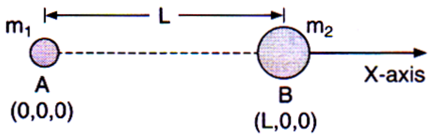
2. 

Fig. S-6.1

It follows from the figure that,

$$X_{CM} = \frac{m_1 \times 0 + m_2 L}{m_1 + m_2} = \frac{m_2}{m_1 + m_2} L$$

$$Y_{CM} = \frac{m_1 \times 0 + m_2 \times 0}{m_1 + m_2} = 0$$

$$Z_{CM} = \frac{m_1 \times 0 + m_2 \times 0}{m_1 + m_2} = 0$$

i.e., the centre of mass is at a distance $[m_2 L/(m_1 + m_2)]$ from m_1 internally on the line joining the two particles.

3. We know that for a square plate, the centre of mass lies at the point of intersection of diagonals. Moreover we also know that the two diagonals of a square bisect each other.

∴ Co-ordinates of the centre of mass

$$= \left(\frac{x_1 + x_2}{2}, \frac{y_1 + y_2}{2}\right) = \left(\frac{-2 + 2}{2}, \frac{0 + 2}{2}\right) = (0, 1).$$

4. The two bodies will move towards their common centre of mass but the location of the centre of mass will remain unchanged, *i.e.*, CM remains at rest w.r.t. *A* as well as *B*.

5. As seen in question 29, two particles will meet at their centre of mass

∴ Distance of the centre of mass from 8 kg mass

$$= \frac{8 \times 0 + 4 \times 12}{8 + 4} = 4 \text{ m}.$$

6. Under mutual attraction, the centre of mass remains at rest.

7. $m_1 = 10$ kg, $m_2 = 2$ kg

$\vec{v}_1 = 2\hat{i} - 7\hat{j} + 3\hat{k}$

$\vec{v}_2 = -10\hat{i} + 35\hat{j} - 3\hat{k}$

$$\vec{v}_{CM} = \frac{m_1\vec{v}_1 + m_2\vec{v}_2}{m_1 + m_2}$$

$$= \frac{10(2\hat{i} - 7\hat{j} + 3\hat{k}) + 2(-10\hat{i} + 35\hat{j} - 3\hat{k})}{10 + 2} = 2\hat{k} \text{ m/s}$$

8. $$a_{CM} = \frac{m_1a_1 + m_2a_2}{m_1 + m_2}$$

$m_1 = m_2 = m$; $a_1 = 0$; $a_2 = a$

$$\therefore \quad a_{CM} = \frac{ma}{2m} = \frac{a}{2}.$$

9. Unless $m_1 = m_3$, the centre of mass of all the four particles can never be at the centre of the square.

10. According to question 167, $|\vec{V}| = \frac{m}{M}|\vec{v}|$

Given: $|\vec{V}| = 1 \text{ m s}^{-1}$, $m = 50$ gm, $|\vec{v}| = 30$ m/s

$$\therefore \quad M = \frac{m|\vec{v}|}{|\vec{V}|} = \frac{50 \times 30}{1} \text{ g} = 1500 \text{ g} = 1.5 \text{ kg}.$$

11. According to law of conservation of momentum

$\vec{p}_s$ = constant or $\vec{p}_{\text{spacecraft}} = \vec{p}_{\text{pieces}}$

or

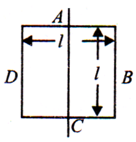
$MV = m \times 0 + (M - m)v$ or $v = \left(\frac{MV}{M - m}\right)$.

12. (c) Let M be the mass of each disc. Let R_A and R_B be the radii of discs A and B, respectively. Then $M = \pi R_A^2 t d_A = \pi R_B^2$ $_B$.
As $d_A = d_B$, so $R_A^2 < R_B^2$. Now,

$I_A = \frac{1}{2}MR_A^2$, $I_B = \frac{1}{2}MR_B^2$

$\frac{I_A}{I_B} = \frac{R_A^2}{R_B^2} < 1$, i.e., $I_A < I_B$

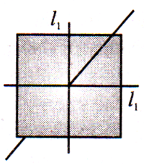
13. (d) $I_{\text{median line}} = I_A + I_B + I_C + I_D$



$$= 2 \times \frac{Ml^2}{12} + 2M\left(\frac{l}{2}\right)^2$$

$$= \frac{Ml^2}{6} + \frac{Ml^2}{2} = \frac{2}{3}Ml^2$$

14. (a)



$$I = I_1 + I_1 = 2 \times \frac{2}{3}Ml^2 = \frac{4}{3}Ml^2$$

15. (a) The moment of inertia about CM system $= \frac{4}{3}Ml^2$

From perpendicular axis theorem,

$$\frac{4}{3}Ml^2 = Id_1 + Id_2 \quad (Id_1 = Id_2)$$

$$Id = \frac{2}{3}Ml^2$$

or $I = 4\frac{Ml^2}{3}(\sin 45°)^2$

16. (d) Mass of disc ∝ area, $M_A = 4M_B$ (as $R_A = 2R_B$)

$$\frac{I_A}{I_B} = \frac{\frac{1}{2}M_A R_A^2}{\frac{1}{2}M_B R_B^2}$$

17. (d) Moment of inertia of discs A and B about the axis through their centre of mass and perpendicular to the plane will be

$$I_{AA} = I_{BB} = \frac{1}{2}Mr^2$$

Now, moment of inertia of disc A about an axis through B, by theorem of parallel axis will be

$$I_{AA} = I_{BB} + M(2r)^2 = \frac{1}{2}Mr^2 + 4Mr^2 = \frac{9}{2}Mr^2$$

So $I = I_{BB} + I_{AB} = \frac{1}{2}Mr^2 + \frac{9}{2}Mr^2 = 5Mr^2$

18. (a) Mass of each of the four parts $= \frac{M}{3}$

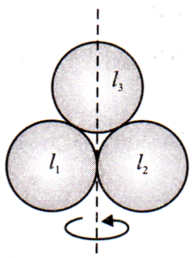
Mass of the plate including the cut piece $= \frac{4M}{3}$

Moment of inertia of the whole plate (including the cut piece) about the said axis $= \left(\frac{4M}{3}\right)\frac{l^2}{6}$

Now moment of inertia of the remaining portion should be 3/4 of the above $= Ml^2/6$.

19. (d) $I = I_1 + I_2 + I_3$

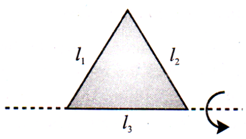
$$I_1 = I_2 = \frac{3}{2}mr^2$$



$$I_1 = I_2 = \frac{3}{2}mr^2$$

$$I = I_1 + I_2 + I_3 = \frac{7}{2}mr^2$$

20. (d) $I = I_1 + I_2 + I_3 = \frac{ml^2}{3} + \frac{ml^2}{3} + 0 = \frac{2ml^2}{3}$



21. (b) MOI is $\Sigma m_i r_i^2$. About BC masses are spread far away than about any other axis.

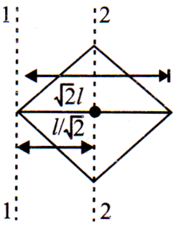
22. (d) Moment of inertia about 2:

$$I_2 = 4\left(\frac{ml^2}{3}\sin^2 45°\right) = \frac{2ml^2}{3}$$

Apply perpendicular axis theorem,

$$I_1 = I_2 + mh^2$$

$$= \frac{2ml^2}{3} + 4m\left(\frac{1}{\sqrt{2}}\right)^2 = \frac{8}{3}ml^2$$



23. (a) $(MI)_{CG} = M\left(\frac{a^2+b^2}{12}\right)$

According to the theorem of parallel axis,

$$(MI)_{\text{required axis}} = (MI)^{CG} + M(OA)^2$$

$$= M\left(\frac{a^2+b^2}{12}\right) + M\left(\frac{a^2+b^2}{4}\right)$$

$$= M\left(\frac{a^2+b^2}{3}\right)$$

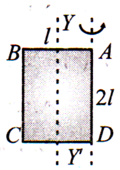
24. (c) The distribution of mass is nearest to axis xx, hence moment of inertia is least about the xx-axis.

25. (b) Moment of inertia of ABC about $AC = \frac{1}{2} \times$ moment of inertia of square sheet $ABCD$ about $AC = \frac{1}{2} \times [2M] \times \frac{l^2}{12} = \frac{Ml^2}{12}$

26. (c) (About YY') $= \frac{ml^2}{12}$

Using parallel axis theorem,

$$I \text{ (about } AD) = \frac{ml^2}{12} + \frac{ml^2}{4} = \frac{ml^2}{3}$$



27. ***(a)*** Moment of Inertia of disc $I = \frac{1}{2}MR^2$

$$= \frac{1}{2}(\pi R^2 t\rho)R^2 = \frac{1}{2}\pi t\rho R^4$$

[As $M = V \times \rho = \pi R^2 t\rho$ where t = thickness, ρ = density]

$\therefore \quad \frac{I_y}{I_x} = \frac{t_y}{t_x}\left(\frac{R_y}{R_x}\right)^4$ [If ρ = constant]

$\Rightarrow \quad \frac{I_y}{I_x} = \frac{1}{4}(4)^4 = 64$ [Given $R_y = 4R_x$, $t_y = \frac{t_x}{4}$]

$\Rightarrow \quad I_y = 64I_x$

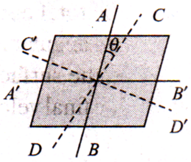
28. ***(a)*** Moment of inertia of rod AB about point $P = \frac{1}{12}Ml^2$

M.I. of rod AB about point $O = \frac{Ml^2}{12} + M\left(\frac{l}{2}\right)^2 = \frac{1}{3}Ml^2$

[by the theorem of parallel axis]

and the system consists of 4 rods of similar type so by the symmetry $I_{System} = \frac{4}{3}Ml^2$.

29. ***Sol. (a)*** Let I_Z is the moment of inertia of square plate about the axis which is passing through the centre and perpendicular to the plane.



$I_Z = I_{AB} + I_{A'B'} = I_{CD} + I_{C'D'}$

[By the theorem of perpendicular axis]

$I_Z = 2I_{AB} = 2I_{A'B'} = 2I_{CD} = 2I_{C'D'}$

[As AB, $A'B'$ and CD, $C'D'$ are symmetric axis]

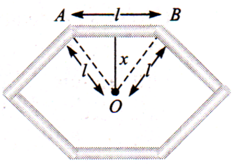
Hence $I_{CD} = I_{AB} = I$

30. ***Sol. (c)*** Moment of inertia of rod AB about its centre and perpendicular to the length $= \frac{ml^2}{12} = I \Rightarrow ml^2 = 12I$

Now moment of inertia of the rod about the axis which is passing through O and perpendicular to the plane of hexagon $I_{rod} = \frac{ml^2}{12} + mx^2$

[From the theorem of parallel axes]

$= \frac{ml^2}{12} + m\left(\frac{\sqrt{3}}{2}l\right)^2 = \frac{5ml^2}{6}$



Now the moment of inertia of system I_{system}

$= 6 \times I_{rod} = 6 \times \frac{5ml^2}{6} = 5ml^2$

$I_{system} = 5\,(12\,I) = 60I$ [As $ml^2 = 12I$]

[CHEMISTRY]

31.

$$N_2O_4 \rightleftharpoons 2NO_2$$

At Eqm. 4.8×10^{-2} mol L^{-1} $\quad$ 1.2×10^{-2} mol L^{-1}

$$K_c = \frac{[NO_2]^2}{[N_2O_4]} = \frac{[1.2\times10^{-2}]^2}{[4.8\times10^{-2}]} = \frac{1.2\times1.2\times10^{-4}}{4.8\times10^{-2}} = \mathbf{3\times10^{-3}\ mol\ L^{-1}}$$

32.

$$COCl_2(g) \rightleftharpoons CO(g) + Cl_2(g)$$

At $t=0$ $\quad$ 450 mm Hg $\quad$ – $\quad$ –

At Eqm. $\quad$ $450-P$ $\quad$ P $\quad$ P

$\Rightarrow \quad 450 + P = 600$

$\Rightarrow \quad P = 150$

$$K_p = \frac{150\times150}{300} = \mathbf{75}$$

33.

$N_2(g) + O_2(g) \rightleftharpoons 2NO(g); \qquad K_1 = 4 \times 10^{-4}$

$2NO(g) \rightleftharpoons N_2(g) + O_2(g); \qquad K_2 = \frac{1}{K_1} = \frac{1}{4 \times 10^{-4}}$

$NO(g) \rightleftharpoons \frac{1}{2} N_2(g) + \frac{1}{2} O_2(g); \qquad K_c = (K_2)^{\frac{1}{2}} = \frac{1}{2 \times 10^{-2}} = \mathbf{50}$

34.

$$NH_4HS(s) \rightleftharpoons NH_3(g) + H_2S(g)$$

	$NH_4HS(s)$	$NH_3(g)$	$H_2S(g)$
At $t = 0$	a moles	0.5 atm	—
At Eqm.	$(a - x)$ mole	$(0.5 + P)$ atm	P atm

When x moles of solid NH_4HS decompose, total pressure $= 0.5 + P + P$
$= (0.5 + 2P)$ atm

$\Rightarrow \quad 0.5 + 2P = 0.84$ (given value)

$\Rightarrow \quad P = 0.17$ atm

$\Rightarrow \quad P_{NH_3} = 0.5 + 0.17 = 0.67$ atm

Eqm. constt. $K_p = P_{NH_3} \times P_{H_2S}$
$= 0.67 \times 0.17$
$= \mathbf{0.1139\ atm}$

35.

$SO_3(g) \rightleftharpoons SO_2(g) + \frac{1}{2} O_2(g); \quad K_c = 4.9 \times 10^{-2}$

$2SO_3(g) \rightleftharpoons 2SO_2(g) + O_2(g); \quad K = K_c^2 = (4.9 \times 10^{-2})^2$

$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g); \quad K' = \frac{1}{K} = \frac{1}{(4.9 \times 10^{-2})^2} = \frac{10000}{(4.9)^2} = \mathbf{416.5}$

The closest choice is **(d).**

36.

	$H_2(g)$	+	$I_2(g)$	$\rightleftharpoons$	$2HI(g)$
At $t = 0$	40 mL		50 mL		—
At Eqm.	30 mL		30 mL		60 mL

	consumed				produced
Ratio of volumes	(40 – 30)	:	(50 – 30)	:	60
Ratio of moles	1	:	2	:	6
(Avogadro's law)					

$$K_c = \frac{C_{HI}^2}{C_{H_2} \times C_{I_2}} = \frac{6 \times 6}{1 \times 2} = \mathbf{18}$$

37.

$H_2 + I_2 \rightleftharpoons 2HI, \ K = 49$

$2HI \rightleftharpoons H_2 + I_2, \ K' = \frac{1}{K} = \frac{1}{49}$

$HI \rightleftharpoons \frac{1}{2} H_2 + \frac{1}{2} I_2,$

$K'' = (K')^{1/2} = \frac{1}{\sqrt{49}} = \frac{1}{7} = \mathbf{0.143}$

38.

$$CO(g) + Cl_2(g) \rightleftharpoons COCl_2(g)$$

$$K_p = K_c (RT)^{\Delta n} = K_c (RT)^{1-(1+1)} = \frac{K_c}{RT}$$

$$\frac{K_p}{K_c} = \frac{\mathbf{1}}{\boldsymbol{RT}}$$

39.

$$K_p = K_c (RT)^{\Delta n}$$

Since, Δn is $[2 + 1 - 2] = 1$, $\boldsymbol{K_p > K_c}$

40.

$$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$$

	PCl_5	PCl_3	Cl_2
At $t = 0$	1 mole	—	—
At Eqm.	$(1 - x)$ moles	x moles	x moles

(x is degree of dissociation of PCl_5)

$$P_{PCl_3} = \frac{n_{PCl_3}}{n_{total}} \times P_{total} = \left(\frac{\boldsymbol{x}}{\mathbf{1}+\boldsymbol{x}}\right)\boldsymbol{P}$$

41.

Δn (gaseous substances) for this equation is zero.

Hence, $K_p = K_c (RT)^{\Delta n} = \boldsymbol{K_c}$.

42.

$$\Delta n = (c + d) - (a + b)$$

$$K_p = K_c (RT)^{\Delta n} = \boldsymbol{K_c (RT)^{(c+d)-(a+b)}}$$

43.

$$SO_2(g) + \frac{1}{2}O_2(g) \rightleftharpoons SO_3(g)$$

$$K_p = K_c (RT)^{\Delta n_g}$$

Here, $\Delta n_g = x = 1 - \left(1 + \frac{1}{2}\right) = -\frac{\mathbf{1}}{\mathbf{2}}$

44.

$$K_c = \frac{K_p}{(RT)^{\Delta n}} = \frac{0.41}{(0.082 \times 300)^{-1}} = 0.41 \times 0.082 \times 300 = \mathbf{10.08\ L\ mol^{-1}}$$

45.

$$X \rightleftharpoons 2Y$$

At $t=0$: X = 1 mole, Y = –

At Eqm.: X = $1-\alpha$, Y = 2α

Total moles $= 1-\alpha+2\alpha = 1+\alpha$

Total pressure $= P_1$

$$K_{p_1} = \frac{P_Y^2}{P_X} = \frac{\left(\frac{2\alpha}{1+\alpha}P_1\right)^2}{\left(\frac{1-\alpha}{1+\alpha}\cdot P_1\right)} = \frac{4\alpha^2 P_1^2(1+\alpha)}{P_1(1+\alpha)(1+\alpha)(1-\alpha)} = \frac{4\alpha^2 P_1}{1-\alpha^2} \quad \text{...(i)}$$

$$Z \rightleftharpoons P + Q$$

At $t=0$: Z = 1 mole, P = –, Q = –

At Eqm.: Z = $1-\alpha$, P = α, Q = α

Total moles $= 1-\alpha+\alpha+\alpha = 1+\alpha$

Total pressure $= P_2$

$$K_{p_2} = \frac{P_P P_Q}{P_Z} = \frac{\left(\frac{\alpha}{1+\alpha}P_2\right)\cdot\left(\frac{\alpha}{1+\alpha}P_2\right)}{\left(\frac{1-\alpha}{1+\alpha}\right)P_2} = \frac{\frac{\alpha^2}{(1+\alpha)^2}\cdot P_2^2}{\left(\frac{1-\alpha}{1+\alpha}\right)P_2} = \frac{\alpha^2 P_2}{1-\alpha^2} \quad \text{...(ii)}$$

From eqns. (i) and (ii)

$$\frac{K_{p_1}}{K_{p_2}} = \frac{4\alpha^2 P_1}{1-\alpha^2} \times \frac{1-\alpha^2}{\alpha^2 P_2} = \frac{4P_1}{P_2} \quad \text{...(iii)}$$

Given, $$\frac{K_{p_1}}{K_{p_2}} = \frac{1}{9} \quad \text{...(iv)}$$

From eqns. (iii) and (iv)

So, $$\frac{4P_1}{P_2} = \frac{1}{9} \Rightarrow \frac{P_1}{P_2} = \mathbf{\frac{1}{36}}$$

46.

$$2AB_2(g) \rightleftharpoons 2AB(g) + B_2(g)$$

(x is degree of dissociation)

At $t = 0$: AB_2 = 2 moles (let), AB = —, B_2 = —

At Eqm.: AB_2 = $(2-2x)$ moles, AB = $2x$ moles, B_2 = x mole

Total $= 2-2x+2x+x = (2+x)$ moles;

Total pressure $= P$

$$K_p = \frac{P_{AB}^2 \cdot P_{B_2}}{P_{AB_2}^2} = \frac{\left(\frac{2x}{2+x}\cdot P\right)^2\left(\frac{x}{2+x}\cdot P\right)}{\left(\frac{2-2x}{2+x}\cdot P\right)^2} = \frac{x^3}{2}\cdot P$$

$$\Rightarrow \quad x = \left[\frac{\mathbf{2K_p}}{\mathbf{P}}\right]^{1/3} \quad (\text{given is } x \ll 1)$$

47.

On adding the first two equations,

$$K = K_1 \cdot K_2 = \mathbf{5 \times 10^{-23}}$$

48.

3rd equation is the sum of first and second equation. Hence, its Eqm. Constt. $= \boldsymbol{K_1 \times K_2}$.

49.

50.

$$N_2 + 3H_2 \overset{K_1}{\rightleftharpoons} 2NH_3$$

$$\Rightarrow \quad 2NH_3 \overset{K'}{\rightleftharpoons} N_2 + 3H_2; \; K' = \frac{1}{K_1}$$

$$N_2 + O_2 \overset{K_2}{\rightleftharpoons} 2NO; \; K_2$$

$$H_2 + \frac{1}{2}O_2 \overset{K_3}{\rightleftharpoons} H_2O$$

$$\Rightarrow \quad 3H_2 + \frac{3}{2}O_2 \overset{K''}{\rightleftharpoons} 3H_2O; \; K'' = K_3^3$$

Adding of eqns. (i), (ii) and (iii)

$$2NH_3 + \frac{5}{2}O_2 \longrightarrow 2NO + 3H_2O; \; K = ?$$

$$K = K' \times K_2 \times K'' = \frac{\boldsymbol{K_2 \cdot K_3^3}}{\boldsymbol{K_1}}$$

* For $4NH_3 + 5O_2 \longrightarrow 4NO + 6H_2O; \quad K = \dfrac{K_2^2 \cdot K_3^6}{K_1^2}$

51.

The reaction is exothermic. So, increase in temperature will not favour forward reaction. Removal of Cl_2, a reactant, will favour backward reaction. Increase in volume, *i.e.*, decrease in pressure, will also favour the backward reaction.

52.

$$k_f = 3k_b \quad \Rightarrow \quad K = \frac{k_f}{k_b} = \mathbf{3}$$

53.

The number of moles of gaseous substances are decreasing as a result of reaction (4 to 2). Increase in pressure will favour the forward reaction.

54.

Catalyst does not affect the equilibrium constant.

55.

Catalyst speeds up forward and backward reactions both equally.

56.

The reaction is exothermic, so it will be favoured in forward direction by lowering of temperature. Since, the number of moles of gaseous substances are decreasing as a result of reaction, high pressure will favour the forward reaction.

57.

Since, the number of moles of gaseous substances on product side is less, increase in pressure will increase the yield. Equilibrium constant will not change because it depends only on temperature (for a specific reaction).

58.

The third equation is obtained by adding the first and second. So, $\boldsymbol{K_3 = K_1 \cdot K_2}$

59.

	$CO_2(g)$ +	$C(s)$ ⇌	$2CO$
At $t = 0$	0.5 atm	—	—
At Eqm.	$0.5 - P$	—	$2P$

Total pressure $0.8 = 0.5 - P + 2P \quad \Rightarrow \quad P = 0.3$

$$K_p = \frac{P_{CO}^2}{P_{CO_2}} = \frac{(0.6)^2}{0.2} = \mathbf{1.8\ atm}$$

60.

The reaction is endothermic. It will be favoured by **increase in temperature.**