MATHEMATICS

SECTION-I

Section I contains 6 multiple choice questions. Each question has 4 choices A), B), C) and D), out of which only one is correct. For each question in Section –I , you will be awarded 3 marks if you have darkened only the bubble corresponding to the correct answer and zero marks if no bubble is darkened. In all other cases, minus one (-1) will be awarded

1. $\vec{a}\times(\vec{b}\times\vec{c})$, $\vec{b}\times(\vec{c}\times\vec{a})$ and $\vec{c}\times(\vec{a}\times\vec{b})$ are

A) Linearly dependent
B) equal vectors
C) Parallel vectors
D) Linearly independent

2. $[\vec{b}\ \vec{c}\ \vec{b}\times\vec{c}]+(\vec{b}.\vec{c})^2$ is equal to

A) $|\vec{b}|^2|\vec{c}|^2$ B) $(\vec{b}+\vec{c})^2$ C) $|\vec{b}|^2+|\vec{c}|^2$ D) $|\vec{b}|^2-|\vec{c}|^2$

3. Let $\vec{a}$ and $\vec{b}$ be two non-collinear unit vectors. If $\vec{u}=\vec{a}-(\vec{a}.\vec{b})\vec{b}$ and $\vec{v}=\vec{a}\times\vec{b}$ then $|\vec{v}|$ is

A) $|\vec{u}|$ B) $|\vec{u}|+|\vec{u}.\vec{a}|$ C) $|\vec{u}|+|\vec{u}\times\vec{b}|$ D) $|\vec{u}|+\vec{u}.(\vec{a}+\vec{b})$

4. Let $\vec{r}$ be a vector perpendicular to $\vec{a}+\vec{b}+\vec{c}$, where $[\vec{a}\ \vec{b}\ \vec{c}]=2$. If $\vec{r}=\ell(\vec{b}\times\vec{c})+m(\vec{c}\times\vec{a})+n(\vec{a}\times\vec{b})$ then $\ell+m+n$ is

A) 2 B) 1 C) 0 D) – 2

5. Let $\vec{a}=\hat{i}+\hat{j}+\hat{k}$, $\vec{c}=\hat{j}-\hat{k}$. If $\vec{b}$ is a vector satisfying $\vec{a}\times\vec{b}=\vec{c}$ and $\vec{a}.\vec{b}=3$ then $\vec{b}$ is

A) $\frac{1}{3}(5\hat{i}+2\hat{j}+2\hat{k})$ B) $\frac{1}{3}(5\hat{i}-2\hat{j}-2\hat{k})$ C) $3\hat{i}-\hat{j}-\hat{k}$ D) $\frac{1}{5}\left(\hat{i}+\hat{j}+\hat{k}\right)$

6. Let $\vec{a}=\hat{i}-2\hat{j}+3\hat{k}$, $\vec{b}=2\hat{i}+3\hat{j}-\hat{k}$, $\vec{c}=\lambda\hat{i}+\hat{j}+(2\lambda-1)\hat{k}$. If $\vec{c}$ is parallel to the plane of the vectors $\vec{a}$ and $\vec{b}$ then λ is

A) 1 B) 0 C) –1 D) 2

SECTION-II

Section II contains 4 multiple correct answer type questions. Each question has 4 choices A), B), C) and D), out of which **one or more answers** are correct. For each question in Section –II , you will be **awarded 4 marks** if you have darkened only the bubble corresponding to the correct answer and **zero marks** if no bubble is darkened. In all other cases, **no negative marking for wrong answer.**

7. $(\vec{a}\times\vec{b}).(\vec{c}\times\vec{d})$ is equal to

A) $\vec{a}\left\{\vec{b}\times(\vec{c}\times\vec{d})\right\}$ B) $\left\{(\vec{a}\times\vec{b})\times\vec{c}\right\}.\vec{d}$ C) $(\vec{a}.\vec{c})(\vec{b}.\vec{d})-(\vec{a}.\vec{d})(\vec{b}.\vec{c})$ D) $(\vec{d}\times\vec{c}).(\vec{b}\times\vec{a})$

8. If $\vec{x}\times\vec{b}=\vec{c}\times\vec{b}$ and $\vec{x}\perp\vec{a}$ then $\vec{x}$ is equal to

A) $\frac{\vec{b}\times(\vec{a}\times\vec{c})}{\vec{b}.\vec{c}}$ B) $\frac{(\vec{b}\times\vec{c})\times\vec{a}}{\vec{b}.\vec{a}}$ C) $\frac{\vec{a}\times(\vec{c}\times\vec{b})}{\vec{a}.\vec{b}}$ D) $\frac{(\vec{a}-\vec{b})\times\vec{c}}{\vec{b}.\vec{c}}$

9. Three points whose position vectors are $\vec{a}$, $\vec{b}$, $\vec{c}$ will be collinear if

A) $\lambda\vec{a}+\mu\vec{b}=(\lambda+\mu)\vec{c}$
B) $[\vec{a}\ \vec{b}\ \vec{c}]=0$
C) $\vec{a}\times\vec{b}+\vec{b}\times\vec{c}+\vec{c}\times\vec{a}=0$
D) $\vec{a}.\vec{b}=0$

10. If $\vec{a}$, $\vec{b}$, $\vec{c}$ are non-coplanar vectors such that $\vec{b}\times\vec{c}=\vec{a}$, $\vec{a}\times\vec{b}=\vec{c}$ and $\vec{c}\times\vec{a}=\vec{b}$ then

A) $|\vec{a}|=1$ B) $|\vec{b}|=1$ C) $|\vec{a}|+|\vec{b}|+|\vec{c}|=3$ D) $|\vec{a}+\vec{b}+\vec{c}|=0$

SECTION-III

Section III contains 4 Reasoning type questions. Each question contains STATEMENT–1 and STATEMENT–2.

Bubble A) if both the statements are TRUE and STATEMENT-2 is the correct explanation of STATEMENT-1

Bubble B) if both the statements are TRUE but STATEMENT-2 is NOT the correct explanation of STATEMENT- 1

Bubble C) if STATEMENT-1 is TRUE and STATEMENT-2 is FALSE.

Bubble D) if STATEMENT-1 is FALSE and STATEMENT-2 is TRUE.

For each question in Section –III , you will be **awarded 3 marks** if you have darkened only the bubble corresponding to the correct answer and **zero marks** if no bubble is darkened. In all other cases, **minus one (-1)** will be awarded

11. STATEMENT-1: $\vec{a} = \hat{i} + p\hat{j} + 2\hat{k}$ and $\vec{b} = 2\hat{i} + 3\hat{j} + q\hat{k}$ are parallel vectors if p = 3/2 , q = 4

    STATEMENT-2: If $\vec{a} = a_1\hat{i} + a_2\hat{j} + a_3\hat{k}$ and $\vec{b} = b_1\hat{i} + b_2\hat{j} + b_3\hat{k}$ are parallel if $\frac{a_1}{b_1} = \frac{a_2}{b_2} = \frac{a_3}{b_3}$

12. STATEMENT-1: If $\vec{a} = 2\hat{i} + \hat{k}$, $\vec{b} = 3\hat{j} + 4\hat{k}$ and $\vec{c} = 8\hat{i} - 3\hat{j}$ are coplanar then $\vec{c} = 4\vec{a} - \vec{b}$

    STATEMENT-2: A set of vectors $\overrightarrow{a_1}$, $\overrightarrow{a_2}$, $\overrightarrow{a_3}$, ….., $\overrightarrow{a_n}$ is said to be linearly independent if every relation of the form $\ell_1\overrightarrow{a_1} + \ell_2\overrightarrow{a_2} + ... + \ell_n\overrightarrow{a_n} = 0$ implies that $\ell_1 = \ell_2 = \ell_3 .... \ell_n = 0$

13. STATEMENT-1: The position vectors of three points are $2\vec{a} - \vec{b} + 3\vec{c}$, $\vec{a} - 2\vec{b} + \lambda\vec{c}$ and $\mu\vec{a} - 5\vec{b}$ where $\vec{a}$, $\vec{b}$, $\vec{c}$ are non-coplanar vectors. If the points are collinear then $\lambda = \frac{9}{4}$ and $\mu = -2$

    STATEMENT-2: Two vectors are said to be collinear if $\vec{x} = \lambda\vec{y}$

14. STATEMENT-1: If I is the incentre of Δ ABC then $|\overrightarrow{BC}|\overrightarrow{IA} + |\overrightarrow{CA}|\overrightarrow{IB} + |\overrightarrow{AB}|\overrightarrow{IC} = 0$

    STATEMENT-2: The position vectors of centroid of Δ ABC is $\frac{\overrightarrow{OA} + \overrightarrow{OB} + \overrightarrow{OC}}{3}$

SECTION-IV

Section IV contains 3 sets of Linked Comprehension type questions. Each set consists of a paragraph followed by 3 questions. Each question has 4 choices A), B), C) and D), out of which **only one** is correct.

For each question in Section –IV , you will be **awarded 4 marks** if you have darkened only the bubble corresponding to the correct answer and **zero mark** if no bubble is darkened. In all other cases, **minus one (-1)** will be awarded

Paragraph for Question Nos.15 to 17

PASSAGE – I :

Let $\vec{x}$, $\vec{y}$, $\vec{z}$ be the vectors, such that $|\vec{x}| = |\vec{y}| = |\vec{z}| = \sqrt{2}$ and $\vec{x}$, $\vec{y}$, $\vec{z}$ make angles of 60^0 with each other also $\vec{x} \times (\vec{y} \times \vec{z}) = \vec{a}$, $\vec{y} \times (\vec{z} \times \vec{x}) = \vec{b}$ and $\vec{x} \times \vec{y} = \vec{c}$, then

15. The value of $\vec{x}$ is

A) $\left\{(\vec{a}+\vec{b})\times\vec{c}-(\vec{a}+\vec{b})\right\}$ B) $\left\{(\vec{a}+\vec{b})-(\vec{a}+\vec{b})\times\vec{c}\right\}$

C) $\frac{1}{2}\left\{(\vec{a}+\vec{b})\times\vec{c}-(\vec{a}+\vec{b})\right\}$ D) $\frac{1}{2}\left\{(\vec{a}+\vec{b})-(\vec{a}+\vec{b})\times\vec{c}\right\}$

16. The value of $\vec{y}$ is

A) $\frac{1}{2}\left\{(\vec{a}+\vec{b})+(\vec{a}+\vec{b})\times\vec{c}\right\}$ B) $2\left\{(\vec{a}+\vec{b})+(\vec{a}+\vec{b})\times\vec{c}\right\}$

C) $4\left\{(\vec{a}+\vec{b})+(\vec{a}+\vec{b})\times\vec{c}\right\}$ D) $\left\{(\vec{a}+\vec{b})+(\vec{a}+\vec{b})\times\vec{c}\right\}$

17. The value of $\vec{z}$ is

A) $\frac{1}{2}\left\{(\vec{b}-\vec{a})\times\vec{c}+(\vec{a}+\vec{b})\right\}$ B) $\frac{1}{2}\left\{(\vec{b}-\vec{a})+(\vec{a}+\vec{b})\times\vec{c}\right\}$

C) $\left\{(\vec{b}-\vec{a})\times\vec{c}+(\vec{a}+\vec{b})\right\}$ D) $\left\{(\vec{b}-\vec{a})+(\vec{a}+\vec{b})\times\vec{c}\right\}$

Paragraph for Question Nos.18 to 20

PASSAGE – II :

If $\vec{a}$, $\vec{b}$, $\vec{c}$ are three given non-coplanar vectors and any arbitrary vector $\vec{r}$ in space where

$$\Delta_1=\begin{vmatrix}\vec{r}.\vec{a} & \vec{b}.\vec{a} & \vec{c}.\vec{a}\\ \vec{r}.\vec{b} & \vec{b}.\vec{b} & \vec{c}.\vec{b}\\ \vec{r}.\vec{c} & \vec{b}.\vec{c} & \vec{c}.\vec{c}\end{vmatrix},\ \Delta_2=\begin{vmatrix}\vec{a}.\vec{a} & \vec{r}.\vec{a} & \vec{c}.\vec{a}\\ \vec{a}.\vec{b} & \vec{r}.\vec{b} & \vec{c}.\vec{b}\\ \vec{a}.\vec{c} & \vec{r}.\vec{c} & \vec{c}.\vec{c}\end{vmatrix},\ \Delta_3=\begin{vmatrix}\vec{a}.\vec{a} & \vec{b}.\vec{a} & \vec{r}.\vec{a}\\ \vec{a}.\vec{b} & \vec{b}.\vec{b} & \vec{r}.\vec{b}\\ \vec{a}.\vec{c} & \vec{b}.\vec{c} & \vec{r}.\vec{c}\end{vmatrix},\ \Delta=\begin{vmatrix}\vec{a}.\vec{a} & \vec{b}.\vec{a} & \vec{c}.\vec{a}\\ \vec{a}.\vec{b} & \vec{b}.\vec{b} & \vec{c}.\vec{b}\\ \vec{a}.\vec{c} & \vec{b}.\vec{c} & \vec{c}.\vec{c}\end{vmatrix}$$

Answer the following questions

18. The vector $\vec{r}$ is expressible in the form

A) $\vec{r}=\frac{\Delta_1}{2\Delta}\vec{a}+\frac{\Delta_2}{2\Delta}\vec{b}+\frac{\Delta_3}{2\Delta}\vec{c}$ B) $\vec{r}=\frac{2\Delta_1}{\Delta}\vec{a}+\frac{2\Delta_2}{\Delta}\vec{b}+\frac{2\Delta_3}{\Delta}\vec{c}$

C) $\vec{r}=\frac{\Delta}{\Delta_1}\vec{a}+\frac{\Delta}{\Delta_2}\vec{b}+\frac{\Delta}{\Delta_3}\vec{c}$ D) $\vec{r}=\frac{\Delta_1}{\Delta}\vec{a}+\frac{\Delta_2}{\Delta}\vec{b}+\frac{\Delta_3}{\Delta}\vec{c}$

19. The vector $\vec{r}$ is expressible as:

A) $\vec{r}=\frac{[\vec{r}\ \vec{b}\ \vec{c}]}{2[\vec{a}\ \vec{b}\ \vec{c}]}\vec{a}+\frac{[\vec{r}\ \vec{c}\ \vec{a}]}{2[\vec{a}\ \vec{b}\ \vec{c}]}\vec{b}+\frac{[\vec{r}\ \vec{a}\ \vec{b}]}{2[\vec{a}\ \vec{b}\ \vec{c}]}\vec{c}$ B) $\vec{r}=\frac{2[\vec{r}\ \vec{b}\ \vec{c}]}{[\vec{a}\ \vec{b}\ \vec{c}]}\vec{a}+\frac{2[\vec{r}\ \vec{c}\ \vec{a}]}{[\vec{a}\ \vec{b}\ \vec{c}]}\vec{b}+\frac{2[\vec{r}\ \vec{a}\ \vec{b}]}{[\vec{a}\ \vec{b}\ \vec{c}]}\vec{c}$

C) $\vec{r}=[\vec{a}\ \vec{b}\ \vec{c}]\left(\frac{\vec{a}}{[\vec{r}\ \vec{b}\ \vec{c}]}+\frac{\vec{b}}{[\vec{r}\ \vec{c}\ \vec{a}]}+\frac{\vec{c}}{[\vec{r}\ \vec{a}\ \vec{b}]}\right)$ D) $\vec{r}=\left(\frac{[\vec{r}\ \vec{b}\ \vec{c}]\vec{a}}{[\vec{a}\ \vec{b}\ \vec{c}]}+\frac{[\vec{r}\ \vec{c}\ \vec{a}]\vec{b}}{[\vec{a}\ \vec{b}\ \vec{c}]}+\frac{[\vec{r}\ \vec{a}\ \vec{b}]\vec{c}}{[\vec{a}\ \vec{b}\ \vec{c}]}\right)$

20. If vector $\vec{r}$ is expressible as $\vec{r}=x\vec{a}+y\vec{b}+z\vec{c}$, then

A) $\vec{a}=\frac{\vec{a}.\vec{a}}{[\vec{a}\ \vec{b}\ \vec{c}]}(\vec{b}\times\vec{c})+\frac{\vec{a}.\vec{b}}{[\vec{a}\ \vec{b}\ \vec{c}]}(\vec{c}\times\vec{a})+\frac{\vec{c}.\vec{a}}{[\vec{a}\ \vec{b}\ \vec{c}]}(\vec{a}\times\vec{b})$

B) $\vec{a}=\vec{a}.\vec{a}(\vec{b}\times\vec{c})+\vec{a}.\vec{b}(\vec{c}\times\vec{a})+\vec{c}.\vec{a}(\vec{a}\times\vec{b})$

C) $\vec{a}=[\vec{a}\ \vec{b}\ \vec{c}](\vec{b}\times\vec{c})+[\vec{a}\ \vec{b}\vec{c}](\vec{c}\times\vec{a})+[\vec{a}\ \vec{b}\ \vec{c}](\vec{a}\times\vec{b})$

D) $\vec{a} = \frac{(\vec{b}\times\vec{c})}{[\vec{a}\,\vec{b}\,\vec{c}]} + \frac{(\vec{c}\times\vec{a})}{[\vec{a}\ \vec{b}\ \vec{c}]} + \frac{(\vec{a}\times\vec{b})}{[\vec{a}\ \vec{b}\ \vec{c}]}$

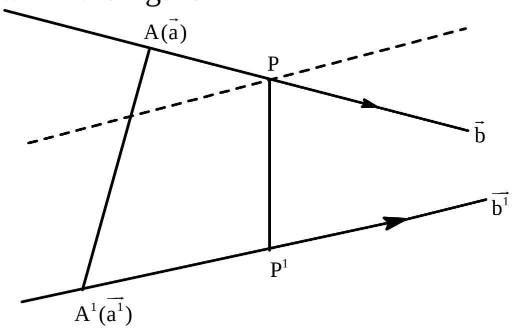
Paragraph for Question Nos.21 to 23

PASSAGE – III :

Two straight lines in space are called coplanar if they are parallel or they intersect, other wise the lines are called non-coplanar or skew lines. Let the equation of two skew lines in vector from be

$$\vec{r} = \vec{a} + t\vec{b} \text{ and } \vec{r} = \vec{a^1} + s\vec{b^1}$$

The vector $\vec{n} = \vec{b}\times\vec{b^1}$ is perpendicular to both lines and there fore parallel to their common perpendicular PP^1 as shown in the figure



The length d of this common perpendicular equal to the length of the projection of AA^1 and $\vec{n}$

$$d = \frac{|\vec{n}.(\vec{a}-\vec{a^1})|}{|\vec{n}|} = \frac{|(\vec{b}\times\vec{b^1}).(\vec{a}-\vec{a^1})|}{|\vec{b}\times\vec{b^1}|} = \frac{[\vec{b}\,\vec{b^1}.(\vec{a}-\vec{a^1})]}{|\vec{b}\times\vec{b^1}|}$$

This distance d represents the shortest distance between these lines. The condition that above lines as intersecting if $d = 0 \Rightarrow [\vec{b}\ \vec{b^1}(\vec{a}-\vec{a^1})] = 0$.The equation of the plane containing the first line and the common perpendicular to the two lines is $\left[\vec{r}-\vec{a}, \vec{b}, \vec{b}\times\vec{b^1}\right] = 0$. The point P^1 is that in which the 2nd the line meets this plane. Similarly the equation of the plane containing the 2nd line and the common perpendicular is $\left[(\vec{r}-\vec{a^1}), \vec{b}, \vec{b^1}\times\vec{b^1}\right] = 0$. The point P is that in which the first line meets this plane. These two planes simultaneously determine the PP^1.

Answer the following questions

21. A line is drawn through $A(6,2,2)$ in the direction of the vector $(\hat{i}-2\hat{j}+2\hat{k})$ and another line through a point $A^1(-4,0,-1)$ in the direction of the vector $3\hat{i}-2\hat{j}-2\hat{k}$. Then a unit vector in direction of the common perpendicular to two line is

A) $\frac{1}{\sqrt{3}}(\hat{i}+\hat{j}-\hat{k})$ B) $\frac{1}{3}(2\hat{i}+2\hat{j}+\hat{k})$ C) $\frac{1}{3}(2\hat{i}-2\hat{j}-\hat{k})$ D) $\frac{1}{\sqrt{3}}(\hat{i}+\hat{j}+\hat{k})$

22. A rectangular parallelepiped has sides of length a, b, c. The shortest distance of the edge of length 'a' from the diagonal not meeting it is

A) $\frac{a^2}{\sqrt{a^2+b^2+c^2}}$ B) $\frac{a(b+c)}{\sqrt{a^2+b^2+c^2}}$ C) $\frac{bc}{\sqrt{b^2+c^2}}$ D) $\frac{a^2}{\sqrt{b^2+c^2}}$

23. The shortest distance between two opposite sides of a regular tetrahedron of edge length ‘d’ is

A) d B) $\sqrt{2}$d C) $\frac{d}{\sqrt{2}}$ D) $\sqrt{3}$d

PHYSICS

SECTION-I

Section I contains 6 multiple choice questions. Each question has 4 choices (A), (B), (C) and (D), out of which only one is correct. For each question in Section –I , you will be awarded 3 marks if you have darkened only the bubble corresponding to the correct answer and zero marks if no bubble is darkened. In all other cases, minus one (-1) will be awarded

24. The moment of inertia of a uniform disc of radius R from which a circular portion of radius *r* is removed from the periphery, about a tangent in the plane at the point of removal, if the remaining mass is *m*, is

A) $\frac{5}{4}m(R^2+r^2)$ B) $\frac{5}{4}m(R^2-r^2)$ C) $\frac{5}{4}\frac{m(R^4+r^4)}{(R^2-r^2)}$ D) $\frac{5}{4}\frac{m(R^4-r^4)}{(R^2+r^2)}$

25. The angular momentum of a particle of mass $1/(3a+4b+5)$, moving with a magnitude of velocity 5 along $3x+4y+5=0$ about an axis passing through $(a,b,0)$ and normal to (x,y) plane is

A) zero B) $\frac{3a+4b+5}{5}$ C) 1 D) $3a+4b+5$

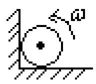
26. On a disc of radius R free to rotate about its center, an insect of same mass as that of disc starts to move with a velocity *u* relative to the disc on its periphery. The angular velocity of the system is

A) $\frac{v}{R}$ B) $\frac{2v}{3R}$ C) $\frac{v}{3R}$ D) $\frac{v}{2R}$

27. The time taken for a disc of radius R to reduce its angular velocity from ω_0 to $\omega_0/3$ when placed over a rough horizontal surface of coefficient of friction μ , is

A) $\frac{2R\omega_0}{3\mu g}$ B) $\frac{R\omega_0}{3\mu g}$ C) $\frac{R\omega_0}{2\mu g}$ D) $\frac{R\omega_0}{\mu g}$

28. The time taken for a disc of radius R and rotating about its center with ω_0 to stop when placed on the corner of a room such that the wall (coefficient of friction μ_1) and the horizontal floor (coefficient of friction μ_2) retard the disc, is



A) $\frac{\omega_0 R(1+\mu_1\mu_2)}{2\mu_2(1+\mu_1)g}$ B) $\frac{\omega_0 R(1-\mu_1\mu_2)}{2\mu_1(1+\mu_2)g}$ C) $\frac{(1+\mu_1)\omega_0 R\mu_2}{2(1+\mu_1\mu_2)g}$ D) $\frac{\omega_0 R(1+\mu_2)\mu_1}{2g(1-\mu_1\mu_2)}$

29. A body of mass $M/2$ strikes a thin rod AB of mass M and length ‘*l*’ with a velocity $'u'$ in a direction normal to the rod on a smooth horizontal surface at A and stops. The point on the rod at momentary rest just after the collision is at a distance ‘*x*’ from center of rod, *x* =

A) $\frac{l}{3}$ towards A B) $\frac{l}{3}$ towards B C) $\frac{l}{6}$ towards B D) No such point exists

SECTION-II

Section II contains 4 multiple correct answer type questions. Each question has 4 choices (A), (B), (C) and (D), out of which **one or more answers** are correct. For each question in Section –II , you will be **awarded 4 marks** if you have darkened only the bubble corresponding to the correct answer and **zero marks** if no bubble is darkened. In all other cases, **no negative marking for wrong answer.**

30. A uniform thin vertical rod of mass M and length 'l' is pivoted at the top and a small body of same mass collides the bottom edge horizontally with a velocity 'u' and gets stuck to it. Then
A) Angular momentum is conserved about the pivot throughout its subsequent motion.
B) The torque due to gravity acts about pivot during the subsequent motion except when it passes through the original position.
C) The immediate angular velocity of the system is $3u/4l$.
D) The center of mass has a maximum vertical displacement of $3u^2/16g$.

31. On a smooth horizontal circular plate a bead of mass 'm' tied to a string, the other end of which passes through a hole at the center 'O' of plate, moves with certain angular velocity. The string is pulled further to bring the radius to one fourth of its initial value. Then
A) The angular momentum is conserved about vertical axis passing through center 'O'
B) The angular velocity becomes 16 times its initial value
C) The tension becomes 64times its initial value
D) The tension falls to one fourth of its initial value

32. A body of mass 'M' is attached to the top of a disc of mass M and radius R, Pivoted at its center and the system lies in vertical plane. The system is released and no friction is involved and 'g' is acceleration due to gravity. Then
A) The maximum change in potential energy is $2MgR$
B) The maximum angular velocity of the system is $\sqrt{8g/3R}$
C) The maximum angular velocity of the system is $\sqrt{4g/3R}$
D) The maximum linear velocity of the body is $\sqrt{8gR/3}$

33. A thin rod of mass 'm' and length 'l' rotates freely about one of its ends. The other end held upwards and released when it makes an angle $'\theta'$ with the vertical and top edge acquires a maximum velocity of $u\,ms^{-1}$. Then
A) The maximum change in PE is $mg\frac{l}{2}(1-\cos\theta)$
B) The angle (θ) from which it released is $\cos^{-1}\left[\frac{u^2}{3gl}-1\right]$
C) The angle (θ) from which it released is $\cos^{-1}\left[\frac{u^2}{3gl}+1\right]$
D) The maximum change in PE is $mg\frac{l}{2}(1+\cos\theta)$

<u>SECTION-III</u>

Section III contains 4 Reasoning type questions. Each question contains STATEMENT–1 and STATEMENT–2.
Bubble (A) if both the statements are TRUE and STATEMENT-2 is the correct explanation of STATEMENT-1
Bubble (B) if both the statements are TRUE but STATEMENT-2 is NOT the correct explanation of STATEMENT- 1

Bubble (C) if STATEMENT-1 is TRUE and STATEMENT-2 is FALSE.
Bubble (D) if STATEMENT-1 is FALSE and STATEMENT-2 is TRUE.
For each question in Section –III , you will be **awarded 3 marks** if you have darkened only the bubble corresponding to the correct answer and **zero marks** if no bubble is darkened. In all other cases, **minus one (-1)** will be awarded

34. **Statement I :** When a body is in translational equilibrium net torque computed about any point is same as that about centre of mass.
Statement II : The additional torque due to shift of origin to a constant displacement from centre of mass amounts to zero since $\sum \vec{F} = 0$.

35. **Statement I :** For a body in simultaneous rotatory and translatory motion angular momentum can't be zero.
Statement II : Orbital angular momentum and spin angular momentum may or may not act in opposite sense.

36. **Statement I :** Geometrically orbital angular momentum of a body can be interpred as twice the rate of change area swept by position vector multiplied by its mass.
Statement II: Moment of linear momentum is taken as orbital angular momentum..

37. **Statement I :** For a given system angular momentum may be conserved about one point and may not be conserved simultaneously about some other point.
Statement II : Net torque is zero about one point and can't be non zero about another point at the same time for a given system.

SECTION-IV

Section IV contains 3 sets of Linked Comprehension type questions. Each set consists of a paragraph followed by 3 questions. Each question has 4 choices (A), (B), (C) and (D), out of which **only one** is correct.
For each question in Section –IV , you will be **awarded 4 marks** if you have darkened only the bubble corresponding to the correct answer and **zero mark** if no bubble is darkened. In all other cases, **minus one (-1)** will be awarded

P_{38-40} ***: Paragraph for Question Nos.38 to 40***

PASSAGE - 1 :

A point mass of mass '*m*' is tied to one end of a string of length '*l*'. By holding the other end of the string the bob is made to be in horizontal circular motion with a uniform angular velocity 'ω'. This is called as conical pendulum. Let the center of circle be 'O'. Let the point of holding the thread be 'A', and let the radius of circle be *r*. Let the angular momentum of the mass be L_0 with 'O' as origin and L_A with '*A*' as origin. Let the string make a constant angle $'\theta'$ with vertical.
Answer the following questions.

38. L_0 is

A) $\omega ml^2 \sin^2\theta$ along the vertical
B) $\omega mr^2 \sin^2\theta$ along horizontal
C) $\omega ml^2 \sin^2\theta$ making an angle $'\theta'$ with the vertical
D) Data not sufficient

39. Choose the wrong statement

A) The horizontal component of L_A is variable and the vertical component of L_A is constant
B) Both horizontal and vertical components of L_A are variables

C) The magnitudes of both horizontal and vertical components of L_A are constant

D) The vertical component of L_A is constant in direction as well as magnitude while the horizontal component of L_A is constant in magnitude but not in direction.

40. The torque about A is

A) $l^2 M\omega^2 \sin^2\theta$ B) $Mgl\sin^2\theta$ C) $\frac{1}{2}Ml^2\omega^2\sin 2\theta$ D) $mgl\cos\theta$

P_{41-43}***: Paragraph for Question Nos.41 to 43***

PASSAGE - 2 :

The linear density of a thin rod 'AB' of length '*l*' varies as Kx where *x* is counted from A. Let its mass be *M*. Then answer the following

41. The moment of inertia of the rod about 'A' and normal to the rod is

A) $\frac{Ml^2}{3}$ B) $\frac{Ml^2}{2}$ C) zero D) $\frac{Ml^2}{6}$

42. The moment of inertia of the rod about 'B' and normal to the rod is

A) $\frac{3Ml^2}{2}$ B) $\frac{Ml^2}{3}$ C) $\frac{Ml^2}{6}$ D) $\frac{2Ml^2}{3}$

43. The moment of inertia about midpoint of the rod normal to the rod is

A) $\frac{Ml^2}{18}$ B) $\frac{Ml^2}{12}$ C) $\frac{Ml^2}{24}$ D) $\frac{Ml^2}{36}$

P_{44-46}***: Paragraph for Question Nos.44 to 46***

PASSAGE - 3 :

A uniform rod of mass '*m*', length '*l*' rests on a horizontal smooth surface. An impulse J is provided at one edge normal to the rod and it acquires a linear momentum 'P' and angular velocity ω. Let *I* be the moment of inertial about the edge normal to the rod.
Answer the following questions.

44. Angular velocity of rod just after receiving impulse is

A) $\frac{3J}{2ml}$ B) $\frac{6J}{ml}$ C) $\frac{2J}{ml}$ D) $\frac{J}{2ml}$

45. The force exerted by one half of the rod on the other half during its subsequent motion is

A) $\frac{9J^2}{2ml}$ B) $\frac{36J^2}{5ml}$ C) $\frac{9J}{4ml}$ D) $\frac{3J^2}{2ml}$

46. Choose the most correct statement

A) $J = P$ B) $J = \frac{2}{l}\left(I - \frac{ml^2}{4}\right)\omega$ C) neither A nor B D) both A and B

CHEMISTRY

SECTION-I

Section I contains 6 multiple choice questions. Each question has 4 choices (A), (B), (C) and (D), out of which **only one** is correct. For each question in Section –I , you will be **awarded 3 marks** if you have darkened only the bubble corresponding to the correct answer and **zero marks** if no bubble is darkened. In all other cases, **minus one (-1)** will be awarded

47. A mixture containing solid $KMnO_4$ and solid $K_2Cr_2O_7$ is strongly heated. Then it is heated with excess water and filtered .The composition of the ppt. is
A) only $Cr_2O_3.XH_2O$ B) K_2MnO_4 only C) $MnO_2.XH_2O$ only D)A mixture of (A)and (C)

48. $FeCl_3$ solution is treated with excess $NaOH$. A brown ppt. is formed. The ppt is filtered and dried finally heated with carbon monoxide at approximately 700^0C the products of the reaction is /are.
A) $FeO+CO_2$ B) $Fe_3O_4+CO_2$ C) only Fe D) $Fe+CO_2$

49. Two flasks 'X' and 'Y' of volumes 250ml and 300ml respectively at the same temperature are connected by a stop cock of negligible volume. The flask 'X' contains N_2 gas at a pressure of 660torr and the flask 'Y' contains Ne at a pressure of 825 torr. If the stop cock is opened to allow the two gases to mix, the partial pressure of Ne and total pressure of the system will be:
A)300torr, 700torr B)400torr,700torr C)450torr,750torr D)300torr,750torr

50. Under identical conditions of pressure and temperature 2lit.of gaseous mixture (H_2 and CH_4) effuses through a hole in 5 minutes where as a 2 lit of a gas 'X' of molecular mass 36 takes 10 minutes to effuse through the same hole. The mole ratio of $H_2:CH_4$ in the mixture is
A)1:2 B)2:1 C)2:3 D)1:1

51. A graph is drawn between volume (V) of a gas on Y-axis and temperature $\left(t^0c\right)$ on X-axis at constant pressure gives a straight line the value of slope/intercept will be:
A)273 B)1/273 C)100 D)546

52. An open vessel at 27^0c heated until 2/5 of the air in it has been expelled. Assuming that the volume of the vessel remains constant. Find the temperature to which the vessel has been heated?
A) 227^0c B) 477^0c C) 750K D) 500^0c

SECTION-II

Section II contains 4 multiple correct answer type questions. Each question has 4 choices (A), (B), (C) and (D), out of which **one or more answers** are correct. For each question in Section –II , you will be **awarded 4 marks** if you have darkened only the bubble corresponding to the correct answer and **zero marks** if no bubble is darkened. In all other cases, no negative marking for wrong answer**.**

53. The Compounds which can give element on strong heating is / are :
A) $AgNO_3$ B) $Cu(NO_3)_2$ C) $Co(NO_3)_2$ D) Ag_2CO_3

54. The reaction which can be used to prepare anhydrous ferric chloride are :
A) Dissolving ferric hydroxide in conc HCl
B) Heating hydrated ferric chloride $\left(FeCl_3.6H_2O\right)$ with thionyl chloride.
C) Heating hydrated ferric chloride.
D) Heating iron powder with dry Cl_2 gas.

55. Which of the following statements are correct?
A) Helium diffuses at a rate 8.65 times as much as CO does
B) Helium escapes at a rate 2.65 times as fast as CO does
C) Helium escapes at a rate 4 times as fast as CO_2 does
D) Helium escapes at a rate 4 times as fast as SO_2 does

56. If pressure of a gas is increased by 1% when heated by 1^0C., its initial temperature must be(if volume remains constant):
A)100K B) 100^0c C) -173^0c D)373K

SECTION-III

Section III contains 4 Reasoning type questions. Each question contains STATEMENT–1 and STATEMENT–2.
Bubble (A) if both the statements are TRUE and STATEMENT-2 is the correct explanation of STATEMENT-1
Bubble (B) if both the statements are TRUE but STATEMENT-2 is NOT the correct explanation of STATEMENT- 1
Bubble (C) if STATEMENT-1 is TRUE and STATEMENT-2 is FALSE.
Bubble (D) if STATEMENT-1 is FALSE and STATEMENT-2 is TRUE.
For each question in Section –III , you will be **awarded 3 marks** if you have darkened only the bubble corresponding to the correct answer and **zero marks** if no bubble is darkened. In all other cases, **minus one (-1)** will be awarded

57. Statement – I : Copper sulphate solution when treated with KI solution, a brown ppt, is formed. When hypo solution is added over this ppt. brown ppt. changes to white ppt.
Statement – II : Hypo dissolves only iodine to form Na I and $Na_2S_4O_6$ which are colourless.only Cu_2I_2 is left behind which is a white ppt.

58. Statement – I : An aqueous solution containing $K\left[Ag\left(CN\right)_2\right]$ when treated with zinc metal, a black ppt. is formed.
Statement –II : Zinc is less electropositive than silver.

59. Statement-I:- A lighter gas diffuse more rapidly than a heavier gas.
Statement-II:- At a given temperature, the rate of diffusion of a gas is inversely proportional to the density

60. Statement-I:- The plot of volume (v) versus pressure(p) at constant temperature is a hyperbola in the first quadrant.
Statement-II:- $V \propto 1/p$ at constant temperature.

SECTION-IV

Section IV contains 3 sets of Linked Comprehension type questions. Each set consists of a paragraph followed by 3 questions. Each question has 4 choices (A), (B), (C) and (D), out of which **only one** is correct.

For each question in Section –IV , you will be **awarded 4 marks** if you have darkened only the bubble corresponding to the correct answer and **zero mark** if no bubble is darkened. In all other cases, **minus one (-1)** will be awarded

Paragraph for Question Nos.61 to 63

Passage – I

Most of the d-block elements exhibit variable oxidation numbers using (n-1)d and ns electrons. The Compounds formed by many d-block elements are coloured, due to d-d transition in which unpaired electrons from the lower energy d-orbitals are transferred to higher energy d-orbitals. Most of the d-block elements and their Compounds are paramagnetic. In general more the number of unpaired electrons more will be the magnetic moments.

61. An element with $(n-1)d^2ns^2$ configuration does not exhibit +1 oxidation number because :

A) of poor shielding nature of $(n-1)d$ electrons.

B) ns^2 electrons will be weakly attracted toward nucleus.

C) available energy is enough to use both the s-electrons

D) none of the above.

62. Which of the compounds likely to be coloured ?

A) $TiCl_3$ B) $Ti(SO_4)_2$ C) Cu_2Cl_2 D) $ScCl_3$

63. The compound which have the same magnetic moment like that of $FeCl_2$.

A) $CrCl_3$ B) $MnCl_2$ C) $CoCl_3$ D) $NiCl_2$

Paragraph for Question Nos.64 to 66

Passage – II

Dalton's law of partial pressures states that the total pressure exerted by a gaseous mixture is equal to the sum of the partial pressures of each individual component in a gas mixture. It is assumed that the gases do not react with each other. Mathematically, the pressure P of a mixture of *n* gases can be defined as the summation.

$$P_{total} = \sum_{i=1}^{n} Pi \text{ or } P_{total} = p_1 + p_2 + ... + p_n$$

where p_1, p_2, p_n represent the partial pressure of each component. Air, for example, is composed primarily of nitrogen and oxygen. In a given sample of air, total number of moles in air can be approximated as : $n = n_{nitrogen} + n_{oxygen}$

Now, according to ideal gas law, $PV = nRT$ or $PV = (n_{nitrogen} + n_{oxygen})RT$

All molecules in the gas have access to the entire volume of the system, thus V is same for both nitrogen and oxygen.

$$P = n_{nitrogen}RT/V + n_{oxygen}RT/V$$

$$P = p_{nitrogen} + p_{oxygen}$$

The above equation is Dalton's Law of Partial Pressure. $p_{nitrogen}$ is the partial pressure of the nitrogen and p_{oxygen} is the partial pressure of oxygen.

64. In what ratio by mass carbon monoxide and nitrogen should be mixed so that partial pressure exerted by each gas is same?

A) 1:1 B) 1:2 C) 2:1 D) 3:4

65. Equal weights of two gases of molecular weight 4 and 40 are mixed. The pressure of the mixture is 1.1 atm. The partial pressure of the lighter gas in this mixture is

A) 0.55 B) 0.11 C) 1 D) 11

66. In a flask of volume V liters, 0.2 mol of oxygen, 0.4 mol of nitrogen, 0.1 mol of ammonia and 0.3 mol of helium are enclosed at 27^0C. If the total pressure exerted by these non-reacting gases is one atmosphere, the partial pressure exerted by nitrogen is

A) 1 atm B) 0.1 atm C) 0.2 atm D) 0.4 atm

Paragraph for Question Nos.67 to 69

Passage – III

Density of a gas is inversely proportional to temperature and directly proportional to pressure

$\Rightarrow d \propto \frac{p}{T}$ $\Rightarrow \frac{dT}{p}$ =constant

$\Rightarrow \frac{d_1T_1}{p_1} = \frac{d_2T_2}{p_2}$

Density at a particular temperature and pressure can be calculated by using ideal gas equation

$$PV = nRT \Rightarrow PV = \frac{mass}{molarmass(M)} \times RT$$

$$P \times M = \frac{mass}{Volume} \times RT$$

$$P \times M = d \times RT$$

$$d = \frac{PM}{RT}$$

67. Which of the following has maximum density

A) O_2 at 25^0C and 1atm

B) O_2 at 0^0C and 2 atm

C) O_2 at 273^0C and 1 atm

D) O_2 at 0^0C and 1 atm

68. The density of CO_2 at 1 atm and 273K is

A) $1.96\,g\,L^{-1}$ B) $2.12\,g\,L^{-1}$ C) $1.09\,g\,L^{-1}$ D) $2.02\,g\,L^{-1}$

69. The density of gas is $3.8\,gL^{-1}$ at STP. The density at 27^0C and 700 mm Hg pressure will be:

A) $3.185g\,L^{-1}$ B) $3.185g\,ml^{-1}$ C) $3.185kg\,L^{-1}$ D) $3.185kg\,ml^{-1}$