MELUHA INTERNATIONAL SCHOOL
HYDERABAD

OUTGOING SR
Time: 3 Hours

JEE MAINS UNIT TEST -VII

Date: 25-06-2020
Max. Marks: 300 M

JEE MAIN MODEL

MATHEMATICS

Section	Question type	+Ve Marks	- Ve Marks	No.of Qs	Total marks
Sec – I(Q.N : 01 – 20)	Questions with Single Answer Type	4	-1	20	80
Sec – II(Q.N : 21 – 25)	Questions with Numerical Answer Type (+/ - Decimal Numbers)	4	0	5	20
Total				25	100

PHYSICS

Section	Question type	+Ve Marks	- Ve Marks	No.of Qs	Total marks
Sec – I(Q.N : 26 – 45)	Questions with Single Answer Type	4	-1	20	80
Sec – II(Q.N : 46 – 50)	Questions with Numerical Answer Type (+/ - Decimal Numbers)	4	0	5	20
Total				25	100

CHEMISTRY

Section	Question type	+Ve Marks	- Ve Marks	No.of Qs	Total marks
Sec – I(Q.N : 51 – 70)	Questions with Single Answer Type	4	-1	20	80
Sec – II(Q.N : 71 – 75)	Questions with Numerical Answer Type (+/ - Decimal Numbers)	4	0	5	20
Total				25	100

SECTION – I
(SINGLE CORRECT ANSWER TYPE)

This section contains 20 multiple choice questions. Each question has 4 options (A), (B), (C) and (B) for its answer, out of which **ONLY ONE** option can be correct.

Marking scheme: +4 for correct answer, 0 if not attempted and -1 if not correct.

MATHEMATICS

SYLLABUS: **Complex Numbers, Trigonometry UptoTransformations, Trignometric Equations, Inverse Trignometric Functions, Properties of Triangles, Heights & Distances**

1. **If** $i^{i^{\cdots\cdots\infty}} = x + iy$ **then** $x^2 + y^2 =$

A) $e^{-\pi y}$ B) $e^{\pi y}$ C) $e^{\pi x}$ D) $e^{-\pi x}$

2. **If** $\theta = \frac{2\pi}{2009}$ **then** $\cos\theta\cos 2\theta\cos 3\theta.....\cos 1004\theta$ **is equal to**

A) 0 B) $\frac{1}{2^{2008}}$ C) $\frac{1}{2^{1004}}$ D) $-\frac{1}{2^{1004}}$

3. $\frac{1}{2}\tan\frac{\theta}{2} + \frac{1}{4}\tan\frac{\theta}{4}$ **is equal to**

A) $4\cot\frac{\theta}{4} - \cot\theta$ B) $\cot\frac{\theta}{4} - \cot\theta$ C) $\frac{1}{4}\cot\frac{\theta}{4} - \cot\theta$ D) $\cot\frac{\theta}{4} - 4\cot\theta$

4. **The value of the expression** $\sum_{n=1}^{\infty} \frac{\tan\frac{(2n-1)\pi}{4}}{2^{n+1}}$ **is**

A) $\frac{1}{2}$ B) $\frac{1}{3}$ C) $\frac{1}{6}$ D) $\frac{2}{3}$

5. **For** $\alpha = \frac{\pi}{7}$ **which of the following is false**

A) $\tan\alpha\tan 2\alpha\tan 3\alpha = \tan 3\alpha - \tan 2\alpha - \tan\alpha$ B) $\operatorname{cosec}\alpha = \operatorname{cosec}2\alpha + \operatorname{cosec}4\alpha$

C) $\cos\alpha - \cos 2\alpha + \cos 3\alpha = \frac{1}{2}$ D) $8\cos\alpha\cos 2\alpha\cos 4\alpha = 1$

6. **General solution of the equation** $\sin x + \cos x = \min_{a\in R}\{1, a^2 - 4a + 6\}$ **is.**

A) $\frac{n\pi}{2} + (-1)^n\frac{\pi}{4}$ B) $2n\pi + (-1)^n\frac{\pi}{4}$ C) $n\pi + (-1)^{n+1}\frac{\pi}{4}$ D) $n\pi + (-1)^n\frac{\pi}{4} - \frac{\pi}{4}$

7. **If** $|z_1 - 1| < 1, |z_2 - 2| < 2, |z_3 - 3| < 3$ **then** $|z_1 + z_2 + z_3|$ **is**

A) < 12 B) > 12 C) ≤ 12 D) ≥ 12

8. **Number of solution of** $\tan(2x) = \tan(6x)$ **in** $(0, 3\pi)$ **is.**

A) 4 B) 5 C) 3 D) 6

9. **The number of values of** x **in the interval** $[0, 5\pi]$ **satisfying the equation** $3\sin^2 x - 7\sin x + 2 = 0$ **is**

A) 0 B) 2 C) 6 D) 8

10. **If** $\sin^{-1} x \in \left(0, \frac{\pi}{2}\right)$, **then the value of** $\tan\left(\frac{\cos^{-1}(\sin)(\cos^{-1} x) + \sin^{-1}(\cos(\sin^{-1} x))}{2}\right)$ **is.**

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

11. **The solution set of** $\left(\cot^{-1}x\right)\left(\tan^{-1}x\right)+\left(2-\frac{\pi}{2}\right)\cot^{-1}x-3\tan^{-1}x-3\left(2-\frac{\pi}{2}\right)>0,$ **is.**

A) $x\in\left(\tan 2,\tan 3\right)$

B) $x\in\left(\cot 3,\cot 2\right)$

C) $x\in\left(-\infty\tan 3\cup\tan 3,\infty\right)$

D) $x\in\left(-\infty,\cot 3\right)\cup\left(\cot 2,\infty\right)$

12. **The value of** $\sec^2\left(\tan^{-1}2\right)+\cos ec^2\left(\cot^{-1}3\right)$ **is.**

A) 14 B) 15 C) 16 D) 17

13. **If** z,w **are two non-zero complex numbers such that** $|zw|=1$ **and** $\arg(z)-\arg(w)=\frac{\pi}{2}$ **then** $\bar{z}w$ **is**

A) 1 B) -1 C) i D) –i

14. $\cot^{-1}\left(\sqrt{\cos\alpha}\right)-\tan^{-1}\left(\sqrt{\cos\alpha}\right)=x,$ **then** $\sin x=$

A) $\tan^2\left(\frac{\alpha}{2}\right)$ B) $\cot^2\left(\frac{\alpha}{2}\right)$ C) $\tan\alpha$ D) $\cot\left(\frac{\alpha}{2}\right)$

15. **In a** ΔABC **if** $9\left(a^2+b^2\right)=17c^2$ **then the value of the expression** $\frac{\cot A-\cot B}{\cot C}$ **is.**

A) $\frac{13}{4}$ B) $\frac{7}{4}$ C) $\frac{5}{4}$ D) $\frac{9}{4}$

16. **Circum radius of a** ΔABC **is 3 units; let O be the circum centre and H be the orthocentre then the value of** $\frac{1}{64}\left(AH^2+BC^2\right)\left(BH^2+AC^2\right)\left(CH^2+AB^2\right)$ **equals.**

A) 3^4 B) 9^3 C) 27^6 D) 81^4

17. **In a triangle ABC, if** $\tan\frac{A}{2}\tan\frac{C}{2}=\frac{1}{3}$ **and** $ac=4,$ **then the least value of b is.**

(notation have their usual meaning)

A) 1 B) 2 C) 4 D) 6

18. **In a triangle ABC the expression** $a\cos B\cos C+b\cos C\cos A+c\cos A\cos B$ **equals to.**

A) $\frac{rs}{R}$ B) $\frac{r}{sR}$ C) $\frac{R}{rs}$ D) $\frac{Rs}{r}$

19. **A bird is sitting on the top of a vertical pole 20 m high and its elevation from a point O on the ground is** 45^0. **It flies off horizontally straight away from the point O. After one second, the elevation of the bird from O is reduced to** 30^0. **Then the speed (in m/s) of the bird is**

A) $20\sqrt{2}$ B) $40\left(\sqrt{2}-1\right)$ C) $40\left(\sqrt{2}-1\right)$ D) $40\left(\sqrt{3}-\sqrt{2}\right)$

20. **A man observes a tower AB of height h from a point P on the ground. He moves a distance 'd' towards the foot of the tower and finds that the angle of elevation is doubled. He further moves a distance 3d/4 in the same direction and the angle of elevation is three times that at P. Then** $36h^2=$

A) $32d^2$ B) $35d^2$ C) $40d^2$ D) $42d^2$

SECTION-II
(Numerical Value Answer Type)

This section contains 5 questions. The answer to each question is a Numerical values comprising of positive or negative decimal numbers. Each question has 4 options (1), (2), (3) and (4) for its answer, out of which **ONLY ONE** option can be correct.
Marking scheme: +4 for correct answer, 0 in all other cases.

21. **A vertical lamp-post 6 m height stands at a distance of 2m from a wall, 4m high. A 1.5m tall man starts to walk away from the wall on the other side of the wall in line with the lamp post. The maximum distance to which the man can walk, remains in the shadow is**

22. **If** $\cot(\theta-\alpha), 3\cot\theta, \cot(\theta+\alpha)$ **are in A.P. and** θ **is not an integral multiple of** $\frac{\pi}{2}$, **then** $\frac{4\sin^2\theta}{\sin^2\alpha}$ **is equal to**

23. **Number of roots of the equation** $\cos(\sin x) = \frac{1}{\sqrt{2}}(0 < x < \pi)$ **is**

24. **Let** $\omega = \frac{\sqrt{3}+i}{2}$ **and** $P = \{w^n : n = 1,2,3,....\}$. **Further** $H_1 = \left\{z \in C : \operatorname{Re} z > \frac{1}{2}\right\}$ **and** $H_2 = \left\{z \in C : \operatorname{Re} z < -\frac{1}{2}\right\}$ **where C is the set of all complex numbers. If** $z_1 \in P \cap H_1, z_2 \in P \cap H_2$ **and O represents the origin, then** $\angle z_1 O z_2 = \frac{5\pi}{k}, \frac{2\pi}{m}$. **Find the value of** $(k+m)$.

25. **Let** α^k, **where** $k = 0,1,2,....,2013$ **are the** 2014^{th} **roots of unity. If** z_1 **and** z_2 **be any two complex number such that** $|z_1| = |z_2| = \frac{1}{\sqrt{2014}}$, **then the value of** $\sum_{k=0}^{2013} |z_1 + \alpha^k z_2|^2$, **is equal to**

SECTION – I
(SINGLE CORRECT ANSWER TYPE)

This section contains 20 multiple choice questions. Each question has 4 options (A), (B), (C) and (D) for its answer, out of which **ONLY ONE** option can be correct.
Marking scheme: +4 for correct answer, 0 if not attempted and -1 if not correct.

PHYSICS

SYLLABUS: Rotational dynamics

26. **The moment of inertia of a body about a given axis is** $1.2\, kg\, m^2$. **Initially, the body is at rest. In order to produce a rotational kinetic energy of 1500 joule, an angular acceleration of 25 radian/sec^2 must be applied about that axis for a duration of**

A) 4 seconds B) 2 seconds C) 8 seconds D) 10 seconds

27. **A pulley of radius 2 m is rotated about its axis by a force** $F = (20t - 5t^2)$ **newton (where t is measured in seconds) applied tangentially. If the moment of inertia of the pulley about its axis of rotation is 10 kg-m^2 the number of rotations made by the pulley before its direction of motion is reversed, is.**

A) more than 3 but less than 6 B) more than 6 but less than 9

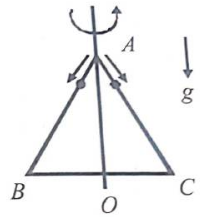
C) more than 9 D) less than 3

28. A gymnast takes turns with her arms and legs stretched. When she pulls her arms and legs in

A) the angular velocity decreases B) the moment of inertia decreases

C) the angular velocity stays constant D) the angular momentum increases

29. An equilateral triangle ABC formed from a uniform wire has two small identical beads initially located at A. The triangle is set rotating about the vertical axis AO. Then the beads are released from rest simultaneously and allowed to slide down, one along AB and the other along AC as shown. Neglecting frictional effects, the quantities that are conserved as the beads slide down, are



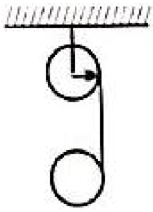
A) angular velocity and total energy (kinetic and potential)

B) total angular momentum and total energy

C) angular velocity and moment of inertia about the axis of rotation

D) total angular momentum and moment of inertia about the axis of rotation

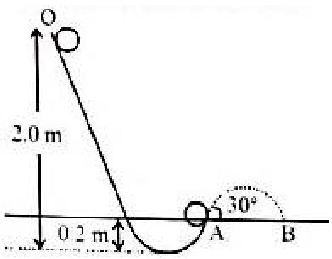
30. Two identical discs of mass m and radius are arranged as shown in the figure. If α is the angular acceleration of the lower disc and a_{cm} is acceleration of centre of mass of the lower disc, then relation between a_{cm}, α and r is



A) $a_{cm} = \alpha/r$ B) $a_{cm} = 2\alpha r$ C) $a_{cm} = \alpha r$ D) $a_{cm} = 2\alpha r$

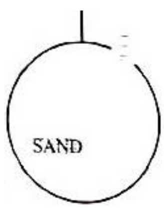
31. A tennis ball (treated as hollow spherical shell) starting from O rolls down a hill. At point A the ball becomes air borne leaving at an angle of 30^0 with the horizontal. The ball strikes the ground at B. What is the value of the distance AB?

(Moment of inertia of a spherical shell of mass m and radius R about its diameter $= \frac{2}{3}mR^2$)



A) 1.87 m B) 2.08 m C) 1.57 m D) 1.77 m

32. A hollow sphere is held suspended. Sand is now poured into it in stages. The centre of mass of the sphere with the sand

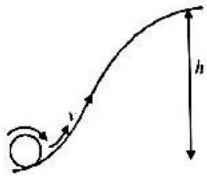


A) rises continuously
B) remains unchanged in the process
C) first rises and then falls to the original position
D) first falls and then rises to the original position

33. From a solid sphere of mass M and radius R a cube of maximum possible volume is cut. Moment of inertia of cube about an axis passing through its center and perpendicular to one of its faces is.

A) $\frac{4MR^2}{9\sqrt{3}\pi}$ B) $\frac{4MR^2}{3\sqrt{3}\pi}$ C) $\frac{4MR^2}{3\sqrt{3}\pi}$ D) $\frac{MR^2}{16\sqrt{2}\pi}$

34. A solid sphere is rolling on a surface as shown in figure, with a translational velocity v ms^{-1}. If it is to climb the inclined surface continuing to roll without slipping, then minimum velocity for this to happen is

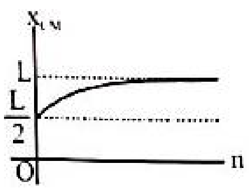


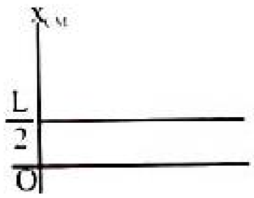
A) $\sqrt{2gh}$ B) $\sqrt{\frac{7}{5}gh}$ C) $\sqrt{\frac{7}{2}gh}$ D) $\sqrt{\frac{10}{7}gh}$

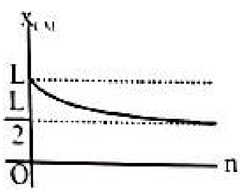
35. A loop of radius r and mass m rotating with an angular velocity ω_0 is placed on a rough horizontal surface. The initial velocity of the centre of the hoop is zero. What will be the velocity of the centre of the hoop when it ceases to slip?

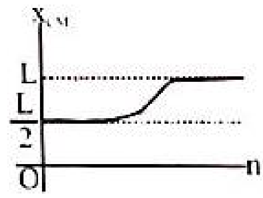
A) $\frac{r\omega_0}{4}$ B) $\frac{r\omega_0}{3}$ C) $\frac{r\omega_0}{2}$ D) $r\omega_0$

36. A thin rod of length 'L' is lying along the $x-$axis with its ends at $x=0$ and $x=L.$ Its linear density (mass length) varies with x as $k\left(\frac{x}{L}\right)^n$, where n can be zero or any positive number. If the position x_{CM} of the centre of mass of the rod is plotted against 'n', which of the following graphs best approximates the dependence of x_{CM} on n?

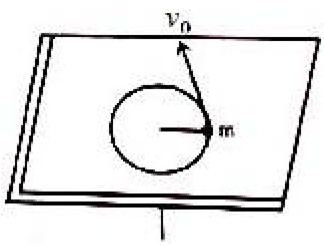
A) 

B) 

C) 

D) 

37. A mass m moves in a circle on a smooth horizontal plane with velocity v_0 at a radius R_0. The mass is attached to string which pass through a smooth hole in the plane as shown. The tension in the string is increased gradually and finally m moves in a circle of radius $\frac{R_0}{2}$. The final value of the kinetic energy is



A) $\frac{1}{4}mv_0^2$ B) $2mv_0^2$ C) $\frac{1}{2}mv_0^2$ D) mv_0^2

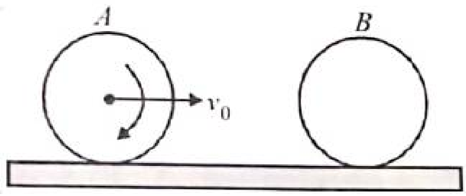
38. A ball rolls without slipping. The radius of gyration of the ball about an axis passing through its centre of mass is K. If radius of the ball be R, then the fraction of total energy associated with its rotational energy will be

A) $\frac{K^2}{R^2}$ B) $\frac{K^2}{K^2+R^2}$ C) $\frac{R^2}{K^2+R^2}$ D) $\frac{K^2+R^2}{R^2}$

39. A ring of mass M and radius R is rotating its axis with angular velocity ω. Two identical bodies each of mass m are now gently attached at the two ends of a diameter of the ring. Because of this, the kinetic energy loss will be.

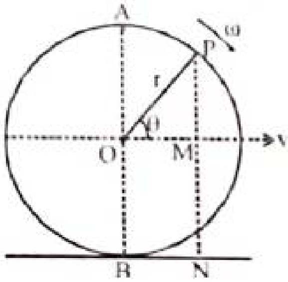
A) $\frac{m(M+2m)}{M}\omega^2R^2$ B) $\frac{Mm}{(M+m)}\omega^2R^2$ C) $\frac{Mm}{(M+2m)}\omega^2R^2$ D) $\frac{(M+m)M}{(M+2m)}\omega^2R^2$

40. A hollow smooth uniform sphere A of mass m rolls without sliding on a smooth horizontal surface. It collides head on elastically with another stationary smooth solid sphere B of the same mass m and same radius. The ratio of kinetic energy of B to that of A just after the collision is



A) 1 : 1 B) 2 : 3 C) 3 : 2 D) None of these

41. Figure shows a disc rolling on a horizontal plane with linear velocity v. Its linear velocity is v and angular velocity is ω. Which of the following gives the velocity of the particle P on the rim of the disc?

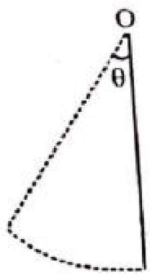


A) $v(1+\cos\theta)$ B) $v(1-\cos\theta)$ C) $v(1+\sin\theta)$ D) $v(1-\sin\theta)$

42. A couple produces

A) purely linear motion B) purely rotational motion
C) linear and rotational motion D) no motion

43. A uniform rod of length l is free to rotate in a vertical plane about a fixed horizontal axis through O. The rod begins rotating from rest from its unstable equilibrium position. When it has turned through an angle θ, its angular velocity ω is given as



A) $\sqrt{\frac{6g}{l}}\sin\theta$ B) $\sqrt{\frac{6g}{l}}\sin\frac{\theta}{2}$ C) $\sqrt{\frac{6g}{l}}\cos\frac{\theta}{2}$ D) $\sqrt{\frac{6g}{l}}\cos\theta$

44. **A rod PQ of length L revolves in a horizontal plane about the axis YY'. The angular velocity of the rod ω. If A is the area of cross-section of the rod and ρ be its density, its rotational kinetic energy is**

A) $\frac{1}{3}AL^3\rho\omega^3$ B) $\frac{1}{2}AL^3\rho\omega^2$ C) $\frac{1}{24}AL^3\rho\omega^2$ D) $\frac{1}{18}AL^3\rho\omega^2$

45. **A wooden cube is placed on a rough horizontal table, a force is applied to the cube. Gradually the force is increased. Whether the cube slides before toppling or topples before sliding is independent of.**

A) the position of point of application of the force B) the length of the edge of the cube

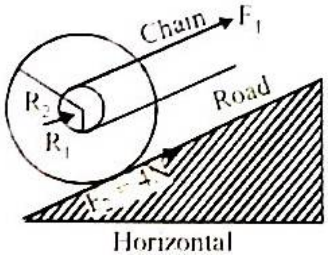
C) mass of the cube

D) coefficient of friction between the cube and the table

SECTION- II
(Numerical Value Answer Type)

This section contains 5 questions. The answer to each question is a Numerical values comprising of positive or negative decimal numbers. Each question has 4 options (A), (B), (C) and (D) for its answer, out of which **ONLY ONE** option can be correct.
Marking scheme: +4 for correct answer, 0 in all other cases.

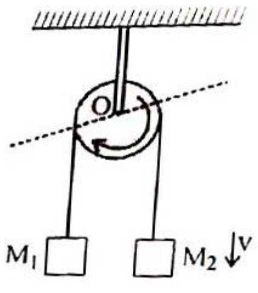
46. **A certain bicycle can go up a gentle incline with constant speed when the frictional force of ground pushing the rear wheel is $F_2 = 4N$. With what force F_1 (in newton) must the chain pull on the sprocket wheel if $R_1 = 5$ cm and $R_2 = 30$ cm?**



47. **From a circular ring of mass M and radius R, an arc corresponding to a 90^0 sector is removed. The moment of inertia of the remaining part of the ring about an axis passing through the centre of the ring and perpendicular to the plane of the ring is k times MR^2. Then what is the value of k?**

48. **A solid sphere of mass 2 kg rolls on a smooth horizontal surface at 10 m/s. It then rolls up a smooth inclined plane of inclination 30^0 with the horizontal. Then what is the height (in meter) attained by the sphere before it stops?**

49. **A pulley is in the form of a disc of mass M and radius R. In following figure two masses M_1 and M_2 are connected by a light inextensible string which passes over the pulley. Assuming that the string does not slip over the pulley, the angular momentum of system at the instant shown, about axis of rotation of pulley is $\left[M_2 + M_1 + \frac{1}{k}M\right]vR$ then find the value of k.**



50. **The moment of inertia of a uniform semicircular wire of mass m and radius r, about an axis passing through its centre of mass and perpendicular to its plane is $mr^2\left(1-\frac{k}{\pi^2}\right)$. Find the value of k.**

SECTION – I
(SINGLE CORRECT ANSWER TYPE)

This section contains 20 multiple choice questions. Each question has 4 options (A), (B), (C) and (D) for its answer, out of which **ONLY ONE** option can be correct.
Marking scheme: +4 for correct answer, 0 if not attempted and -1 if not correct.

CHEMISTRY

***SYLLABUS:* Mole Concept, Titrations, Atomic structure, Classification of elements, Chemical bonding, Coordination compounds, Group 14, 18, Hydrogen & its Compounds**

51. **The ratio mass of oxygen and nitrogen of a particular gaseous mixture is 1:4. The ratio of number of their molecule is**
A) 1 : 4 B) 7 : 32 C) 1 : 8 D) 3 : 16

52. **The molarity of a solution obtained by mixing 750 mL of 0.5 M HCl with 250 mL of 2 M HCl will be**
A) 0.875 M B) 1.00 M C) 1.75 M D) 0.0975 M

53. **The largest number of molecules is in**
A) 36 g of water B) 28 g of CO
C) 46 g of ethyl alcohol D) 54 g of nitrogen pentaoxide (N_2O_5)

54. **What is the work function of the metal, if the light of wavelength** $4000\ \overset{0}{A}$ **generates photoelectron of velocity** $6\times10^5 ms^{-1}$ **from it?**
(Mass of electron = $9\times10^{-31}kg$
Velocity of light $=3\times10^8 ms^{-1}$
Planck's constant $=6.626\times10^{-34} Js$
Charge of electron $=1.6\times10^{-19} JeV^{-1}$)
A) 4.0 eV B) 2.1 eV C) 0.9 eV D) 3.1 eV

55. **The ground state energy of hydrogen atom is -13.6 eV. The energy of second excited state of** He^+ **ion in eV is**
A) -54.4 B) -3.4 C) -6.04 D) -27.2

56. **The increasing order (lowest first) for the values of e/m (charge/mass) for electron (e), proton (p), neutron (n) and alpha particle** (α) **is**
A) e, p, n, α B) n, p, e, α C) n, p, α, e D) n, α, p, e

57. **The set representing the correct order of first ionization potential is**
A) $K > Na > Li$ B) $Be > Mg > Ca$ C) $B > C > N$ D) $Ge > Si > C$

58. **The correct order of radii is**
A) $N < Be < B$ B) $F^- < O^{2-} < N^{3-}$ C) $Na < Li < K$ D) $Fe^{3+} < Fe^{2+} < Fe^{4+}$

59. **The hydration energy of** Mg^{2+} **is larger than that of**
A) Al^{3+} B) Na^+ C) Be^{2+} D) Mg^{3+}

60. **The correct order of hybridization of the central atom in the following species** $NH_3, [PtCl_4]^{2-}, PCl_5$ **and** BCl_3 **is**

A) dsp^2, dsp^3, sp^2 and sp^3
B) sp^3, dsp^2, sp^3d and sp^2
C) dsp^2, sp^2, sp^3 and dsp^3
D) dsp^2, sp^3, sp^2 and dsp^3

61. In compounds of type ECl_3, where $E = B, P, As$ or Bi, the angles $Cl-E-Cl$ is in order.

A) $B > P = As = Bi$ B) $B > P > As > Bi$ C) $B < P = As = Bi$ D) $B < P < As < Bi$

62. The correct order of increasing $C-O$ bond length of CO, CO_3^{2-}, CO_2 is

A) $CO_3^{2-} < CO_2 < CO$ B) $CO_2 < CO_3^{2-} < CO$ C) $CO < CO_3^{2-} < CO_2$ D) $CO < CO_2 < CO_3^{2-}$

63. The correct statement among the following is

A) $(SiH_3)_3N$ is planar and less basic than $(CH_3)_3N$.

B) $(SiH_3)_3N$ is pyramidal and more basic than $(CH_3)_3N$.

C) $(SiH_3)_3N$ is pyramidal and less basic than $(CH_3)_3N$.

D) $(SiH_3)_3N$ is planar and more basic than $(CH_3)_3N$.

64. The number of pentagons in C_{60} and trigons (triangles) in white phosphorus, respectively, are

A) 20 and 3 B) 12 and 4 C) 20 and 4 D) 12 and 3

65. The type of hybridization and number of lone pair(s) of electrons of Xe in $XeOF_4$, respectively, are

A) sp^3d^2 and 1 B) sp^3d and 2 C) sp^3d and 1 D) sp^3d^2 and 2

66. The crystal field stabilization energy (CFSE) of $\left[Fe(H_2O)\right]Cl_2$ and $K_2[NiCl_4]$, respectively, are

A) $-0.4\Delta_0$ and $-1.2\Delta_t$
B) $-0.4\Delta_0$ and $-0.8\Delta_t$
C) $-2.4\Delta_0$ and $-1.2\Delta_t$
D) $-0.6\Delta_0$ and $-0.8\Delta_t$

67. The pair of metal ions that can given a spin-only magnetic moment of 3.9 BM for the complex $\left[M(H_2O)_6\right]Cl_2$, is

A) Co^{2+} and Fe^{2+} B) Cr^{2+} and Mn^{2+} C) V^{2+} and Co^{2+} D) V^{2+} and Fe^{2+}

68. The metal d-orbitals that are directly facing the ligands in $K_3\left[Co(CN)_6\right]$ are

A) d_{xz}, d_{yz} and d_{z^2} B) $d_{x^2-y^2}$ and d_{z^2} C) d_{xy}, d_{xz} and d_{yz} D) d_{xz} and $d_{x^2-y^2}$

69. The IUPAC name of $\left[Ni(NH_3)_4\right][NiCl_4]$ is

A) Tetrachloronickel (II)-tetraamminenickel (II) B) Tetraamminenickel (II)-tetrachloronickel (II)
C) Tetraamminenickel (II)-tetrachloronickelate(II)
D) Tetrachloronickel (II) –tetraamminenickelate (0)

70. The volume strength of 1.5 $N\,H_2O_2$ is

A) 4.8 B) 8.4 C) 3.0 D) 8.0

SECTION-II
(Numerical Value Answer Type)

This section contains 5 questions. The answer to each question is a Numerical values comprising of positive or negative decimal numbers. Each question has 4 options (A), (B), (C) and (D) for its answer, out of which **ONLY ONE** option can be correct.
Marking scheme: +4 for correct answer, 0 in all other cases.

71. **Not considering the electronic spin, the degeneracy of the second excited state $(n=3)$ of H-atom is 9, while the degeneracy of the second excited state of H^- is**

72. **Among $H_2, He_2^+, Li_2, Be_2, B_2, C_2, N_2, O_2^-$ and $F_2,$ the number of diamagnetic species is**
(Atomic numbers : $H=1, He=2, Li=3, Be=4, B=5, C=6, N=7, O=8, F=9$)

73. **Among the following, the number of elements showing only one non-zero oxidation state is** $O, Cl, F, N, P, Sn, Tl, Na, Ti$

74. $EDTA^{4-}$ **is ethylenediaminetetraacetate ion. The total number of N-Co-O bond angles in** $\left[Co(EDTA)\right]^-$ **complex ion is**

75. **The sum of the number of lone pairs of electrons on each central atom in the following species is** $\left[TeBr_6\right]^{2-}, \left[BrF_2\right]^+, SNF_3$ and $\left[XeF_3\right]^-$
(Atomic numbers: $N=7, F=9, S=16, Br=35, Te=52, Xe=54$)

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MELUHA INTERNATIONAL SCHOOL
HYDERABAD

OUTGOING SR
Time: 3 Hours

JEE MAINS UNIT TEST-VII

Date: 25-06-2020
Max. Marks: 300 M

KEY SHEET

MATHEMATICS

1) **A**	2) **C**	3) **C**	4) **C**	5) **D**	6) **D**	7) **A**	8) **B**	9) **C**	10) **A**
11) **B**	12) **B**	13) **D**	14) **A**	15) **D**	16) **B**	17) **B**	18) **A**	19) **B**	20) **B**
21) **2.5**	22) **6**	23) **2**	24) **7**	25) **2**					

PHYSICS

26) **B**	27) **A**	28) **B**	29) **B**	30) **B**	31) **B**	32) **D**	33) **A**	34) **D**	35) **C**
36) **A**	37) **B**	38) **B**	39) **C**	40) **C**	41) **C**	42) **B**	43) **C**	44) **C**	45) **C**
46) **24**	47) **0.75**	48) **7.1**	49) **2**	50) **4**					

CHEMISTRY

51) **B**	52) **A**	53) **A**	54) **B**	55) **C**	56) **D**	57) **B**	58) **B**	59) **B**	60) **B**
61) **B**	62) **A**	63) **A**	64) **B**	65) **A**	66) **B**	67) **C**	68) **B**	69) **C**	70) **B**
71) **3**	72) **6**	73) **2**	74) **8**	75) **6**					

Paper Setters:

SNO	Subject	Name of the Paper Setter	Phone No	Branch
1	MATHS	SUDHAKAR SIR	9440260683	CO ICC
3	PHYSICS	BHARGAV SHARMA SIR	9618550817	CO ICC
4	CHEMISTRY	KATAMAIAH SIR	9948729934	CO ICC

HINTS & SOLUTIONS

MATHS SOLUTIONS

1. $x+iy=i^{i.....i.....\infty}$

$x+iy=i^{x+iy}$

Take $x+iy=re^{i\theta}$

$r=\sqrt{x^2+y^2}\quad d=\tan^{-1}\left(\frac{y}{x}\right)$

$r.e^{id}=i^{rei\theta}$

Apply 'log' on b.s

$\log r+\log\left(e^{i\theta}\right)=r.e^{i\theta}\log_i$

$\log\sqrt{x^2+y^2}+i\theta\log e=r.e^{i\theta}\left(\log\left(e^{\frac{i\pi}{2}}\right)\right)$

$\log\left(x^2+y^2\right)+i\tan^{-1}\left(\frac{y}{x}\right)=\left(x+iy\right)\left(i\frac{\pi}{2}\right)$

R.P $\log\sqrt{x^2+y^2}=\frac{-\pi}{2}y$

I.P $\tan^{-1}\left(\frac{y}{x}\right)=\frac{\pi}{2}x$

$x^2+y^2=\frac{4}{\pi^2}\left[\left(\tan^{-1}\right)\left(\frac{y}{x}\right)^{-2}+\left(\log\sqrt{x^2+y^2}\right)\right]$

2. $P=\cos\theta\cos2\theta\cos3\theta.....\cos1004\theta$

$Q=\sin\theta\sin2\theta.....\sin1004\theta$

Then $2^{1004}PQ=\sin2\theta\sin4\theta.....\sin2008\theta$

$=\left(\sin2\theta=\sin1004\theta\right)\left[\sin\left(2\pi-1003\theta\right)\sin\left(2\pi-1001\theta\right).....\sin\left(2\pi-\theta\right)\right]$

$=\left(\sin2\theta\sin4\theta.....\sin1004\theta\right)\left(-\sin1003\theta\right).....\left(-\sin\theta\right)=Q$

$\Rightarrow p=\frac{1}{2^{1004}}$

3. As $\cot\theta-\tan\theta=2\cot2\theta$

$\Rightarrow\tan\theta=\cot\theta-2\cot2\theta$

$\Rightarrow\frac{1}{2}\tan\frac{\theta}{2}+\frac{1}{4}\tan\frac{\theta}{4}=\frac{1}{4}\cot\frac{\theta}{4}-\cot\theta$

4. $S=\frac{\tan\frac{\pi}{4}}{4}+\frac{\left(\tan\frac{3\pi}{4}\right)}{8}+\frac{\left(\tan\frac{5\pi}{4}\right)}{16}+\frac{\left(\tan\frac{7\pi}{4}\right)}{32}+...$

$=\frac{1}{4}-\frac{1}{8}+\frac{1}{16}-\frac{1}{32}+...$

$\frac{\frac{1}{4}}{1+\frac{1}{2}}=\frac{1}{4}\times\frac{2}{3}=\frac{1}{6}.$

5. (a) $3\alpha=2\alpha+\alpha$

$\Rightarrow\tan3\alpha=\tan\left(2\alpha+\alpha\right)$

$\Rightarrow\tan3\alpha-\tan\alpha-\tan\alpha=\tan\alpha\tan2\alpha\tan3\alpha$

(b) R.H.S $=\frac{\sin4\alpha+\sin2\alpha}{\sin2\alpha\sin4\alpha}=\frac{2\sin3\alpha\cos\alpha}{\sin2\alpha\sin4\alpha}$

$=\frac{2\sin\frac{3\pi}{7}\cos\frac{\pi}{7}}{\sin\frac{2\pi}{7}\sin\frac{4\pi}{7}}=\frac{1}{\sin\alpha}=\cos ec\alpha$

(c) $\cos\alpha-\cos2\alpha+\cos3\alpha=\cos\frac{\pi}{7}-\cos\frac{2\pi}{7}+\cos\frac{3\pi}{7}$

$=1/2$

(d) $8\cos\alpha\cos2\alpha\cos4\alpha=-1$

6. $\sin x+\cos x=1$

$\sin\left(x+\frac{\pi}{4}\right)=\frac{1}{\sqrt{2}}$

$x=n\pi+\left(-1\right)^n\frac{\pi}{4}-\frac{\pi}{4}$

7. $\left|z_1-1\right|<1\Rightarrow0<\left|z_1\right|<2$

$\left|z_1-2\right|<2\Rightarrow0<\left|z_2\right|<4$

$\left|z_3-3\right|<3\Rightarrow0<\left|z_3\right|<6$

Now $\left|z_1+z_2+z_3\right|\le\left|z_1\right|+\left|z_2\right|+\left|z_3\right|$

$<2+4+6=12$

$\therefore\left|z_1+z_2+z_3\right|<12$

8. $\tan2x=\tan6x\Rightarrow\sin4x=0$

$4x=\pi,2\pi,3\pi,....,11\pi$

$x=\frac{\pi}{4},\frac{2\pi}{4},\frac{3\pi}{4},.....,\frac{11\pi}{4}$

But $\frac{\pi}{4},\frac{3\pi}{4},\frac{5\pi}{4},\frac{7\pi}{4},\frac{9\pi}{4},\frac{11\pi}{4}$ are rejected.

So number of solutions =5.

9. $3\sin^2x-6\sin x-\sin x+2=0$

$\left(3\sin x-1\right)\left(\sin x-2\right)=0$

$\sin x\ne2$, then $\sin x=\frac{1}{3}$

10. Conceptual

11. $\left(\cot^{-1}x\right)\left(\frac{\pi}{2}-\cot^{-1}x\right)+2\cot^{-1}x-\frac{\pi}{2}\cot^{-1}x+3$

$\left(\frac{\pi}{2}-\tan^{-1}x\right)-6>0$

$-\left(\cot^{-1}x\right)^2+5\cot^{-1}x-6>0$

$\left(\cot^{-1}x\right)^2-5\left(\cot^{-1}x\right)+6<0$

$\left(\cot^{-1}x-3\right)\left(\cot^{-1}x-2\right)<0$

$2<\cot^{-1}x<3$

$\cot3<x<\cot2\quad\left(\because\cot^{-1}x\text{ is decreasing}\right)$

12. $1+\tan^2\left(\tan^{-1}2\right)+1+\cot^2\left(\cot^{-1}3\right)$

$=1+2^2+1+3^2=15$

13. Given $|zw|=1 \Rightarrow |z\overline{w}|=1$

also, $\arg(z)-\arg(w)=\dfrac{\pi}{2}$

$\Rightarrow \arg\left(z\overline{w}\right)=\dfrac{\pi}{2}$ and $\left(z\overline{w}\right)=1$

hence $z\overline{w}=i \Rightarrow \overline{\left(z\overline{w}\right)}=\overline{i} \Rightarrow \overline{z}w=-i$

14. $\cot^{-1}\left(\sqrt{\cos\alpha}\right)-\tan^{-1}\left(\sqrt{\cos\alpha}\right)=x$

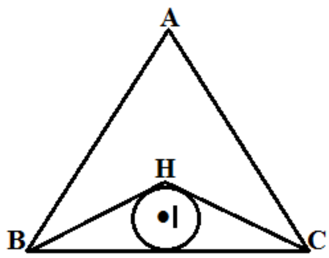
$\dfrac{\pi}{2}-2\tan^{-1}\sqrt{\cos\alpha}=x$

15. $\dfrac{\cot A+\cot B}{\cot C}=\dfrac{\cos A\sin B+\cos B\sin A}{\left(\sin A\sin B\right)\dfrac{\cos C}{\sin C}}$

$=\dfrac{\sin^2 C}{\left(\sin A\sin B\right)\cos C}=\dfrac{c^2}{ab.\dfrac{a^2+b^2-c^2}{2ab}}$

$=\dfrac{2c^2}{\left(\dfrac{17}{9}-1\right)c^2}=\dfrac{18}{8}$

16. $\dfrac{1}{64}\left[(2R\cos A)^2+a^2\right]\left[(2R\cos B)^2+b^2\right]\left[(2R\cos C)^2+c^2\right]$



$\dfrac{1}{64}\left[(2R\cos A)^2+(2R\sin A)^2\right]\left[(2R\cos B)^2+(2R\sin B)^2\right]\left[(2R\cos C)^2+(2R\sin C)^2\right]$

$=R^6$

17. $\tan\dfrac{A}{2}\tan\dfrac{C}{2}=\dfrac{1}{3}$

$\dfrac{s-b}{s}=\dfrac{1}{3}\Rightarrow b=\dfrac{2}{3}s\Rightarrow \dfrac{a+c}{2}=b\Rightarrow b\geq 2$

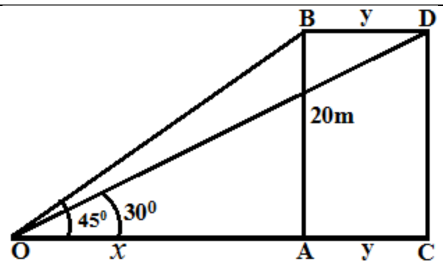
(A.M. $\geq$G.M.)

18. $\cos A\cos B\cos C\sum\dfrac{a}{\cos A}$

$=2R\cos A\cos B\cos C\sum\tan A$

$=2R\cos A.\cos B.\cos C.\pi\left(\tan A\right)$

19. Let x be the distance travelled by the bird in one second.



Here $AB=20, \angle AOB=45, BD=x, \angle COD=30^0$

$\tan 45^0=\dfrac{AB}{OA}=\dfrac{20}{x}\Rightarrow x=20$

$\tan 30^0=\dfrac{20}{x+y}\Rightarrow x+y=20\sqrt{3}\Rightarrow 20+y=20\sqrt{3}$

$\Rightarrow y=20\sqrt{3}-20=20\left(\sqrt{3}-1\right).$

$\therefore$ Speed = $20\left(\sqrt{3}-1\right)$ m/s.

20. Let AB = Tower, with foot at A

P = First point observation

Q = Second point observation

R = Third point observation

Given $AB=h, PQ=d, QR=3d/4$

Exterior angle = Sum of the opposite interior angles.

$\angle AQB=\angle QPB+\angle PBQ$ and

$\angle ARB=\angle RQB+\angle QBR$

$\therefore\ PQ=d=BQ.$

Applying sine rule to ΔBQR, we get

$\dfrac{BQ}{\sin\angle BRQ}=\dfrac{RQ}{\sin\angle RBQ}\Rightarrow\dfrac{d}{\sin\left(180^0-3\theta\right)}$

$=\dfrac{3d/4}{\sin\theta}$

$\Rightarrow\dfrac{1}{3/4}=\dfrac{\sin 3\theta}{\sin\theta}\Rightarrow\dfrac{4}{3}=\dfrac{3\sin\theta-4\sin^3\theta}{\sin\theta}$

$=3-4\sin^2\theta\Rightarrow 4\sin^2\theta=3-\dfrac{4}{3}=\dfrac{5}{3}\Rightarrow\sin^2\theta=\dfrac{5}{12}.$

$\therefore\cos^2\theta=1-\sin^2\theta=1-\dfrac{5}{12}=\dfrac{7}{12}$

From $\Delta ABQ, \sin 2\theta=\dfrac{h}{d}\Rightarrow 2\sin\theta\cos\theta$

$=\dfrac{h}{d}4\sin^2\theta.\cos^2\theta$

$=\dfrac{h^2}{d^2}\Rightarrow 4\left(\dfrac{5}{12}\right)\left(\dfrac{7}{12}\right)=\dfrac{h^2}{d^2}\Rightarrow\dfrac{h^2}{d^2}=\dfrac{35}{36}$

21. Conceptual

22. $6\cot\theta=\cot\left(\theta-\alpha\right)+\cot\left(\theta+\alpha\right)$

$=\dfrac{\sin 2\theta}{\sin\left(\theta+\alpha\right)\sin\left(\theta-\alpha\right)}$

$\Rightarrow\dfrac{3\cos\theta}{\sin\theta}=\dfrac{2\sin\theta\cos\theta}{\cos 2\theta-\cos 2\theta}$

$\Rightarrow 4\sin^2\theta = 6\sin^2\alpha$

$\therefore \dfrac{2\sin^2\theta}{\sin^2\alpha} = 3$

23. Conceptual

24. $w = \dfrac{\sqrt{3}+i}{2} \quad p = \{w^n, n = 1,2,3...\}$

$H_1 = \left\{z \in C, \text{Re}\, z > \dfrac{1}{2}\right\} \quad |w| = 1$

$H_2 = \left\{z \in C, \text{Re}\, z < -\dfrac{1}{2}\right\} \quad |w^2| = 1$

$|w^3| = 1$

$z = x + iy \quad \text{Re}\, z = x$

$\text{Re}\, z > \dfrac{1}{2} \Rightarrow x > \dfrac{1}{2}$

$\text{Re}\, z < \dfrac{1}{2} \Rightarrow x < -\dfrac{1}{2}$

$z_1 \in P \cap H_1 \quad z_2 \in P \cap H_2 \quad O = (0,0)$

$\angle z_1 o z_2 = 0, \pi$

So $\dfrac{5\pi}{k} = \pi \Rightarrow k = 5$

$\dfrac{2\pi}{m} = \pi \Rightarrow m = 2$

$k + m = 7$

25. Let $1, \omega, \omega^2$ are cube roots of unity

$\alpha^0, \alpha^1, \alpha^2$

$|z_1| = |z_2| = \dfrac{1}{\sqrt{3}}$

$\sum_{k=0}^{2} |z_1 + \alpha^k z_2|^2$

$\sum_{k=0}^{2} (z_1 + \alpha^k z_2).(\overline{z_1 + \alpha^k z_2})$

$\sum_{k=0}^{2} (z_1 + \alpha^k z_2).(\overline{z}_1 + \overline{\alpha}^k \overline{z}_2)$

$\sum_{k=0}^{2} z_1\overline{z}_1 + \overline{\alpha^k} z_1\overline{z}_2 + \alpha^k z_2\overline{z}_1 + \overline{\alpha^k}.\alpha^k \overline{z}_2 z_2$

$= \sum_{k=0}^{2} \left(\dfrac{1}{3} + z_1\overline{z}_2\overline{\alpha^k} + \alpha^k (z_2\overline{z}_1) + \dfrac{1}{3}\right)$

$= \dfrac{1}{3}(1+1+1) + z_1\overline{z}_2\left(\overline{\alpha^0} + \overline{\alpha^1} + \overline{\alpha^2}\right)$

$+ (z_2\overline{z}_1)(\alpha^0 + \alpha^1 + \alpha^2) + \dfrac{1}{3}(1+1+1)$

$= \dfrac{1}{3} \times 3 + 0 + 0 + \dfrac{3}{3} = 2$

PHYSICS

26. $I = 1.2\, kg\, m^2, E_t = 1500\, t.$

$\alpha = 25 \text{ rad sec}^2, \omega_t = 0.1 = ?$

As $E_t = \dfrac{1}{2} l\omega^2,$

$\omega = \sqrt{\dfrac{2E_r}{l}} = \sqrt{\dfrac{2 \times 1500}{1.2}} = 50 \text{ rad/sec}$

From $\omega_2 = \omega_1 + \alpha t$

$50 = 0 + 25t, \quad \therefore t = 2$ seconds

27. $F = 20t - 5t^2$

$\therefore \alpha = \dfrac{FR}{I} = 4t - t^2$

$\Rightarrow \dfrac{d\omega}{dt} = 4t - t^2$

$\Rightarrow \int_0^{\omega} d\omega = \int_a^t (4t - t^2) dt$

$\Rightarrow \omega = 2t^2 - \dfrac{t^3}{3} (\text{as } \omega = 0 \text{ at } t = 0, 6s)$

$\int_0^0 d\theta = \int_0^6 \left(2t^2 - \dfrac{t^3}{3}\right) dt \quad \Rightarrow \theta = 36 \text{ rad}$

$\Rightarrow n = \dfrac{36}{2\pi} < 6$

28. Since no external torque act on gymnast, so angular momentum $(L = L\omega)$ is conserved.

After pulling her arms & legs, the angular velocity increases but moment of inertia of gymnast, decreases in, such a way that angular momentum remains constant.

29. The M.I. about the axis of rotation is not constant as the perpendicular distance of the bead with the axis of rotation increases. Also since no external torque is acting.

$\therefore \tau_{ext} = \dfrac{dL}{dt} \Rightarrow L = \text{constant}$

$\Rightarrow I\omega = \text{constant}$

Since, I increases, ω decreases.

30. $Tr = \dfrac{mr^2}{2}\alpha_1 \quad ...(1)$

$Tr = \dfrac{mr^2}{2}\alpha \quad ....(2)$

$\alpha_1 = \alpha \quad ....(3)$

Acceleration of point b=acceleration of point a $r\alpha_1 = a_{\cos} - ra \quad ...(4)$

Hence, $2r\alpha - a_{\cos}$

31. Velocity of the tennis ball on the surface of the earth or ground

$v=\sqrt{\dfrac{2gh}{1+\dfrac{k^2}{R^2}}}$ (where $k=$radius of gyration of

spherical shell $=\sqrt{\dfrac{2}{3}}R$)

Horizontal range $AB=\dfrac{v^2\sin 2\theta}{g}$

$$=\frac{\left(\sqrt{\dfrac{2gh}{1+k^2/R^2}}\right)^2\sin\left(2\times 30^0\right)}{g}$$

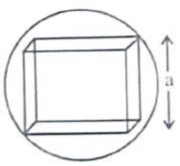
Solving we get $AB=2.08\,m$

32. Initially centre of mass is at the centre. When sand is poured it will tall and again after a limit, centre of mass will rise.

33. Here $a=\dfrac{2}{\sqrt{3}}R$

Now, $\dfrac{M}{M}=\dfrac{\dfrac{4}{3}\pi R^3}{a^3}$

$$=\frac{\dfrac{4}{3}\pi R^3}{\left(\dfrac{2}{\sqrt{3}}R\right)^3}=\frac{\sqrt{3}}{2}\pi.\quad M'=\frac{2M}{\sqrt{3}\pi}$$



Moment of inertia of the cube about the given axis.

$$I=\frac{M'a^2}{6}=\frac{\dfrac{2M}{\sqrt{3}\pi}\times\left(\dfrac{2}{\sqrt{3}}R\right)^2}{6}=\frac{4MR^2}{9\sqrt{3}\pi}$$

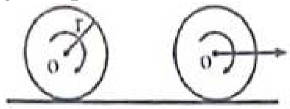
34. Minimum velocity for a body rolling without slipping

$$v=\frac{2gh}{\sqrt{1+\dfrac{K^2}{R^2}}}$$

For solid sphere, $\dfrac{K^2}{R^2}=\dfrac{2}{5}$

$$\therefore\quad v=\frac{2gh}{\sqrt{1+\dfrac{K^2}{R^2}}}=\sqrt{\frac{10}{7}gh}$$

35. From conservation of angular momentum about any fix point on the surface,



$mr^2\omega_0=2mr^2\omega$

$\Rightarrow\omega=\omega_0/2\Rightarrow v=\dfrac{\omega_0 r}{2}\ [\because v=r\omega]$

36. When $n=0,x=k$ where k is a constant. This means that the linear mass density is constant, In this case the centre of mass will be at the middle of the rod i.e., at $L/2$. Therefore (c) is ruled out

n is positive and as its value increases, the rate of increase of linear mass density with increase in x increases. This shows that the centre of mass will shift towards that end of the rod where $n=L$ as the value of n increases. Therefore graph (b) is ruled out.

The linear mass density $\lambda=k\left(\dfrac{x}{L}\right)^n$

Here $\dfrac{x}{L}\le 1$

With increase in the value of n, the centre of mass shift towards the end $x=L$ such that first the shifting is at a higher rate with increase in the value of n and then the rate decreases with the value of n.

These characteristics are represented by graph (a).

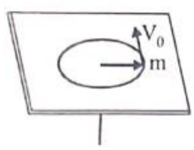
$$x_{CM}=\frac{\int_0^L x\,dm}{\int_0^L dm}=\frac{\int_0^L x(\lambda dx)}{\int_0^L \lambda dx}=\frac{\int_0^L x\left(\dfrac{x}{L}\right)^n xdx}{\int_0^L k\left(\dfrac{x}{L}\right)^n dx}$$

$$=\frac{k\left[\dfrac{x^{n+2}}{(n+2)L^n}\right]_0^L}{\left[\dfrac{kx^{n+1}}{(n+1)L^n}\right]_0^L}=\frac{L(n+1)}{n+2}$$

For $n=0, x_{CM}=\dfrac{L}{2}; n=1,$

$x_{CM}=\dfrac{2L}{3}; n=2, x_{CM}=\dfrac{3L}{4};...$

37. Applying angular momentum conservation



$mV_0R_0 = (m)(V^1)\left(\frac{R_0}{2}\right)$

$\therefore v^1 = 2V_0$

Therefore, new $KE = \frac{1}{2}m(2V_0)^2 = 2mv_0^2$

38. $\frac{\text{Rotational KE}}{\text{Total KE}} = \frac{\frac{1}{2}mv^2\left(\frac{K^2}{R^2}\right)}{\frac{1}{2}mv^2\left(1+\frac{K^2}{R^2}\right)} = \frac{K^2}{K^2+R^2}$

39. Kinetic energy $_{(\text{rotational})}K_R = \frac{1}{2}I\omega^2$

Kinetic energy $_{(\text{translational})}K_T = \frac{1}{2}Mv^2$

$(v = R\omega)$

$M.I._{(\text{initial})}I_{ring} = MR^2; \omega_{\text{initial}} = \omega$

$M.I._{(\text{new})}I'_{(\text{system})} = MR^2 + 2mR^2$

$\omega'_{(\text{system})} = \frac{M\omega}{M+2m}$

Solving we get loss in $K.E. = \frac{Mm}{(M+2m)}\omega^2R^2$

40. After collision velocity of COM of A becomes zero and that of B becomes equal to initial velocity of COM of A. But angular velocity of A remains unchanged as the two spheres are smooth.

41. Velocity of $P = (NP)\omega = (NM + MP)\omega$

$= r(r + \sin\theta)\omega = v(l + \sin\theta)$

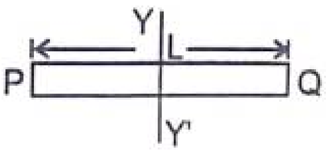
42. Couple produces purely rotational motion.

43. $\frac{1}{2}I\omega^2 =$ Loss of potential energy

$\frac{1}{2}\times\frac{ml^2}{3}\omega^2 = \frac{mgl}{2}(1+\cos\theta)$

$\Rightarrow \omega^2 = \frac{3g}{l}\left(2\cos^2\frac{\theta}{2}\right) \Rightarrow \omega = \sqrt{\frac{6g}{l}}\cos\frac{\theta}{2}$

44. If rotation axis is passing through its middle point & is $\perp$ to its plane, then moment of inertia about YY' is



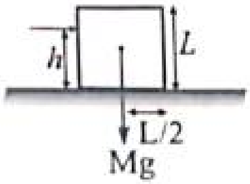
$I = \frac{ML^2}{12}$ where $M =$ volume $\times$ density

$= (L \times A) \times \rho$

so $I = \frac{L^3Ap}{12}$

so rotational $K.E = \frac{1}{2}I\omega^2 = \frac{L^3A\rho\omega^2}{24}$

45. For toppling $Mg\frac{L}{2} = F_1 \times h$



For sliding

$\mu Mg = F_2$

For sliding to occur first

$F_1 > F_2$

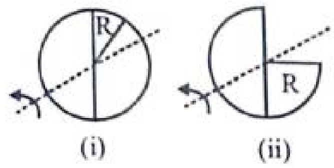
or $\frac{mgL}{2} > \mu Mg$ or $L > 2\mu h$

46. For no angular acceleration $\tau_{net} = 0$

$\Rightarrow F_1 \times 5 = F_2 \times 30$ (Given $F_2 = 4N$)

$\Rightarrow F_1 = 24N$

47. Moment of inertia of a ring about a given axis is $I = MR^2$



Mass of the remaining portion of the ring $= \frac{3M}{4}$

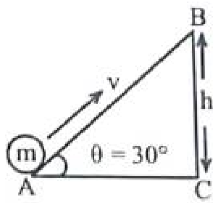
Moment of inertia of the remaining portion of the ring $r = \frac{3}{4}MR^2$

Given $I' = kMR^2$

$\therefore k = 3/4 = 0.75$

48. If a body rolls on a horizontal surface, it possesses both translational and rotational kinetic energies. The net kinetic energy is given by

$K_{net} = \frac{1}{2}mv^2\left(1+\frac{K^2}{R^2}\right).$



Where K is the radius of gyration.

So from law of conservation of energy.

$$\frac{1}{2}mv^2\left(1+\frac{K^2}{R^2}\right)=mgh,$$

Where h is the height attained by the sphere.

$$i.e, \frac{1}{2}\times 2\times (10)^2\left(1-\frac{2}{5}\right)=2\times 9.8\,zh$$

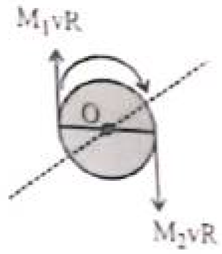
$$i.e, \frac{1}{2}\times 100\times\left(\frac{7}{5}\right)=9.8\,h$$

or $h=\frac{700}{98}=7.1\,m$

49. Angular momentum of M_2 about O is

$L_2=M_2vR$ clockwise $\quad M_1vR$

Angular momentum of M_1 about O is



$L_1=M_1vR$ clockwise

$L_{disc}=1\omega$ clockwise

$\therefore L_{total}=L_1+L_2+L_{disc}$

$$=M_2vR+M_1vR+\frac{1}{2}MR^2\omega$$

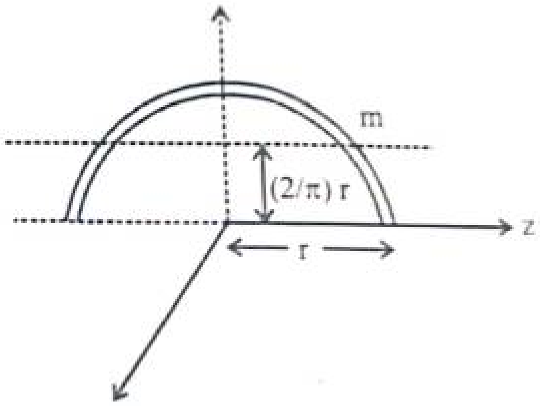
Now, $v=R\omega$ as rope does not slip

$$\therefore L=\left[M_2+M_1+\frac{1}{2}M\right]vR$$

Therefore $k=2$

50. Moment of inertia about z-axis, $I_2=mr^2$ (about centre of mass)

Applying parallel axes theorem,



$I_z=I_{cm}+mk^2$

$$I_{cm}=I_z-m\left(\frac{2}{\pi}r\right)^2=mr^2-\frac{m4r^2}{\pi^2}=mr^2\left(1-\frac{4}{\pi^2}\right)$$

i.e., $k=4$

CHEMISTRY

51. $$\frac{{}^{n}O_2}{{}^{n}N_2}=\frac{\left(\frac{{}^{m}O_2}{{}^{M}O_2}\right)}{\left(\frac{{}^{m}N_2}{{}^{M}N_2}\right)}$$

where, m_{O_2} = given mass of O_2, m_{N_2} = given mass of N_2,
M_{O_2} = molecular mass of O_2, M_{N_2} = molecular mass of N_2,
n_{O_2} = number of moles of O_2, n_{N_2} = number of moles of N_2

$$=\left[\frac{m_{O_2}}{m_{N_2}}\right]\frac{28}{32}=\frac{1}{4}\times\frac{28}{32}=\frac{7}{32}$$

52. From the formula, $M_f=\frac{M_1V_1+M_2V_2}{V_1+V_2}$

Given, V_1 = 750 mL, M_1 = 0.5 M

V_2 = 250 mL, M_2 = 2 M

$$=\frac{750\times 0.5+250\times 2}{750+250}=\frac{875}{1000}=0.875\text{ M}$$

53. Number of molecules present in 36g of water

$$=\frac{36}{18}\times N_A=2N_A$$

Number of molecules present in 28 g of CO $=\frac{28}{28}\times N_A=N_A$

Number of molecules present in 46 g of $C_2H_5OH=\frac{46}{46}\times N_A=N_A$

Number of molecules present in 54 g of $N_2O_5=\frac{54}{108}\times N_A=0.5\,N_A$

Here, N_A is Avogadro's number. Hence, 36 g of water contain the largest $(2N_A)$ number of molecules.

54. Work function of metal $(\phi)=hv_0$ where,

v_0 = threshold frequency

Also, $\frac{1}{2}m_ev^2=hv-hv_0$

or $\frac{1}{2}m_ev^2=hv-\phi \qquad$ ...(i)

$\frac{1}{2}m_ev^2=\frac{hc}{\lambda}-\phi \qquad$ ...(ii)

Given: $\lambda=4000\overset{0}{\text{A}}=4000\times 10^{-10}m$

$v=6\times 10^5\text{ms}^{-1}$,

$m_e=9\times 10^{-31}kg, c=3\times 10^8\,ms^{-1}$

$h=6.626\times 10^{-34}\,Js$

Thus, on substituting all the given values in Eq. (i), we get $\frac{1}{2}\times 9\times 10^{-31}kg\times\left(6\times 10^{5}\,ms^{-1}\right)^{2}$

$$=\frac{6.626\times 10^{-34}\,Js\times 3\times 10^{8}\,ms^{-1}}{4000\times 10^{-10}\,m}-\phi$$

$$\therefore \phi = 1.62\times 10^{-21}\,kgm^{2}s^{-2}-4.96\times 10^{-19}\,J$$

$$=3.36\times 10^{-19}\,J \quad \left[1kg\,m^{2}s^{-2}=1J\right]$$

$$=2.1eV$$

55. The ground state energy of H-atom is +13.6 eV.
For second excited state, $n = 2+1 = 3$

$$\therefore E_3\left(He^{+}\right) = -13.6\times\frac{Z^2}{n^2}eV \quad \left[\because \text{for } He^{+}, Z=2\right]$$

$$=-13.6\times\frac{2^2}{3^2}eV = -6.04eV$$

56. Neutron has no charge, hence e/m is zero for neutron. Next, $\alpha-$particle $\left(He^{2+}\right)$ has very high mass compared to proton and electron, therefore very small e/m ratio. Proton and electron have same charge (magnitude) but former is heavier, hence has smaller value of e/m.

57. In a group, ionization energy decreases down the group

$$Be > Mg < Ca$$

58. Among isoelectronic species, greater the negative charge, greater the ionic size, hence $F^{-} < O^{2-} < N^{3-}$.

59. Hydration energy depends on charge of ion and ionic radius. Higher the charge, greater the hydration energy. On the other hand, smaller the size, greater the hydration energy. Charge is considered first for comparison. Hence, Mg^{2+} has higher hydration energy than Na^{2}.

60. $NH_3 = sp^3, \left[PtCl_4\right]^{2-} = dsp^2, PCl_5 = sp^3d, BCl_3 = sp^2$

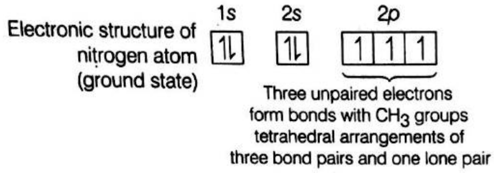
61. When $E = B$ in BCl_3, bond angle is 120^0. When $E = P$, As or Bi in ECl_3, hybridization at E will be sp^3. Also, if central atoms are from same group, bond angle decreases down the group provided all the things are similar. Hence, the order of bond angles is $BCl_3 > PCl_3 > AsCl_3 > BiCl_3$

62. Bond length $\propto \frac{1}{\text{Bond order}}$

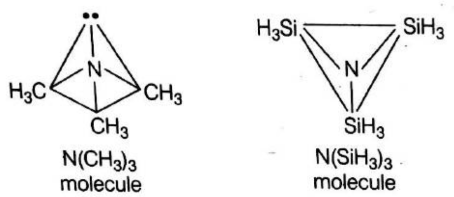
Bond order : $CO_2 = 2, CO = 3, CO_3^{2-} = 1+\frac{1}{3}=\frac{4}{3}$

Therefore, order of bond length is $CO_3^{2-} < CO_2 < CO$

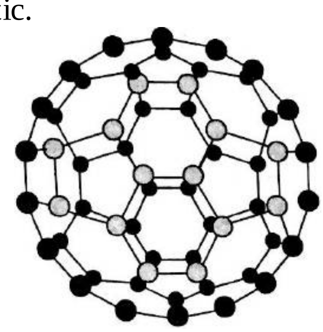
63. The correct statement is that $\left(SiH_3\right)_3 N$ is planar and less basic than $\left(CH_3\right)_3 N$. The compounds trimethylamine $\left(CH_3\right)_3 N$ and trisilylamine $\left(SiH_3\right)_3 N$ have similar formulae, but have totally different structures. In trimethylamine the arrangement of electrons is as follows:



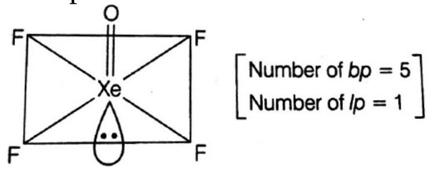
In trisilylamine, three sp^2 orbitals are used for σ-bonding, giving a plane triangular structure.



64. In C_{60} (Buckminster fullerene) twenty hexagons and twelve pentagons are present which are interlocked resulting a shape of soccer ball. Every ring in this structure is aromatic.

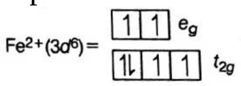


65. In $XeOF_4, Xe$ is sp^3d^2-hybridized. Geometry of the molecule is octahedral, but shape of the molecule is square pyramidal. According to VSEPR, theory it has one π bond. Remaining six electron pairs from an octahedron with one position occupied by a lone pair.



Here, Xe contains are lone pair of electrons.

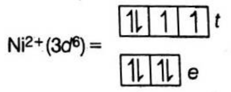
66. In $\left[Fe\left(H_2O\right)_6\right]Cl_2, H_2O$ is a weak field ligand, so it is a high spin (outer orbital) octahedral complex of Fe^{2+}.



$\therefore$ CFSE $= (-0.4x + 0.6y)\Delta_o$

$= [-0.4 \times 4 + 0.6 \times 2]\Delta_o = -0.4\Delta_o$

In $K_2[NiCl_4]$, Cl^- is a weak field ligand, so it is a high spin tetrahedral complex of Ni^{2+}.



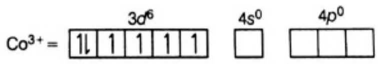
$\therefore$ CFSE $= (-0.6 \times 4 + 0.4 \times 4)\Delta_t = -0.8\Delta_t$

67. As H_2O is a weak field ligand. It readily forms high spin complexes. In $\left[M\left(H_2O\right)_6\right]Cl_2, M$ exist in +2 oxidation state. The arrangement of electrons in the given metal ions are as follows.

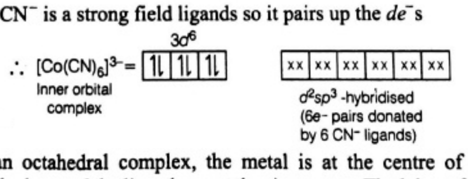
Metal ions	Configuration	Number of unpaired electrons	Spin only Magnetic moment (in BM) $= \sqrt{n(n+2)}$
Co^{2+}	$(d^7) = t_{2g}^5 e_g^2$	3	3.9
Fe^{2+}	$(d^6) = t_{2g}^4 e_g^2$	4	4.9
Cr^{2+}	$(d^4) = t_{2g}^3 e_g^1$	4	4.9
Mn^{2+}	$(d^5) = t_{2g}^3 e_g^2$	5	5.9
V^{2+}	$(d^3) = t_{2g}^3 e_g^0$	3	3.9

Therefore, Co^{2+} and V^{2+} contains same value of magnetic moment (3.9 BM).

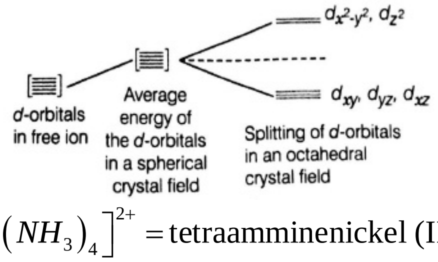
68. In $K_3\left[Co\left(CN\right)_6\right], Co$ have +3 oxidation state and electronic configuration of Co^{3+} is $\left[Ar\right]_{18} 3d^6$.



As, CN^- is a strong field ligands so it pairs up the de^-s



In an octahedral complex, the metal is at the centre of the octahedron and the ligands are at the six corners. The lobes of the e_g orbitals ($d_{x^2-y^2}$ and d_{z^2}) point along the axes x, y and z under the influence of an octahedral field, the d- orbitals split as follow.



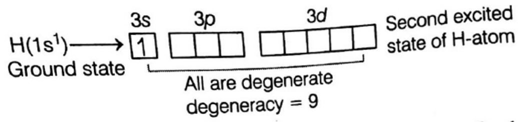
69. $\left[Ni\left(NH_3\right)_4\right]^{2+}$ = tetraamminenickel (II)

$\left[NiCl_4\right]^{2-}$ = tetrachloronickelate (II)

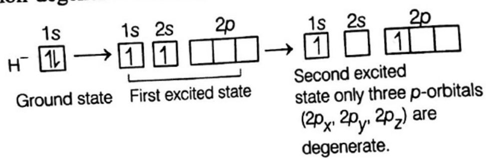
Cationic part is named first, hence : tetraamminenickel (II) -tetrachloronickelate(II)

70. Volume strength of H_2O_2 = Normality$\times 5.6 = 1.5 \times 5.6 = 8.4V$

71. In an one electron (hydrogenic) system, all orbtials of a shell remains degenerate, hence in second excited state, the degeneracy of H-atom is nine



In case of many electrons system, different orbitals of a shell are non-degenerate. Hence,



72. Conceptual
73. Conceptual
74. Conceptual
75. Conceptual