

Test **RIDER**

JEE Advanced

A Single Door Entry to the Various IITs...

Paper 1

Duration : 3 Hours

Max. Marks : 180

Please read the instructions carefully. You are allotted 5 minutes specially for this purpose.

- ▶ This booklet is your question paper. Attempt all the questions.
- ▶ Blank papers, clipboards, log tables, slide rules, calculators, cameras, cellular phones, pagers and electronic gadgets are not allowed.
- ▶ Write your name and roll number in the space provided on the bottom of this page.

Question Paper Format

- ▶ The question paper consists of three parts (Physics, Chemistry and Mathematics). Each part consists of three sections.
- ▶ **Section 1** contains 10 multiple choice questions. Each question has four choices (a), (b), (c) and (d) out of which only one is correct.
- ▶ **Section 2** contains 5 multiple choice questions. Each question has four choices (a), (b), (c) and (d) out of which one or more than one is/are correct.
- ▶ **Section 3** contains 5 questions. The answer to each question is a single-digit integer, ranging from 0 to 9 (both inclusive)

Marking Scheme

- ▶ For each question in Section 1, you will be awarded **2 marks** for correct answer and zero mark for unattempted questions. No negative marks will be awarded for incorrect answers in this section.
- ▶ For each question in Section 2, you will be awarded **4 marks** for correct answer(s) and zero mark for unattempted questions. In all other cases, minus one (–1) mark will be awarded.
- ▶ For each question in Section 3, you will be awarded **4 marks** for the correct answer and zero mark for unattempted questions. In all other cases, minus one (–1) mark will be awarded.

Name of the Candidate (in capital letters) _____

Roll Number (in figures)

_____ (in words) _____

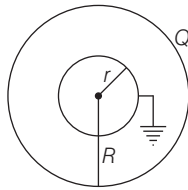
Practice Set 1

Part I

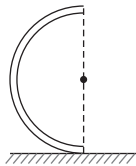
Section 1 Single Correct Option Type

This section contains **10 multiple choice questions**. Each question has four choices, (a), (b), (c) and (d) out of which **only one** is correct.

1. A conducting sphere is connected with earth and a concentric spherical shell is given a charge Q . Choose the correct option.

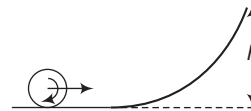


- a. the charge on the sphere must be zero.
 b. the charge on the sphere must be positive.
 c. the magnitude of charge on the inner sphere is $\frac{Qr}{R}$
 d. None of the above
2. A half section of thin uniform pipe of mass m and radius r is released from rest. Pipe rolls without slipping. The change in PE of pipe when it has rolled through 90° .

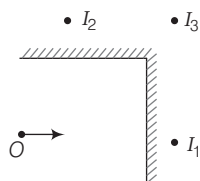


- a. $\frac{4mgr}{\pi}$ b. $\frac{2mgr}{\pi}$ c. mgr d. $\sqrt{2} mgr$
3. A potentiometer has an uncertainty of ± 0.0001 V. If it is used to measure current through a standard resistance of $0.1 \pm 0.1\% \Omega$ (uncertainty). The voltage across the resistance is measured to be 0.2514 V. What is the percentage uncertainty in the measurement of current?
- a. 1.04% b. 2.01% c. 2.08% d. 0.08%

4. A ball rolls without slipping on horizontal surface and then moves up the inclined shown if height attained is h_1 and h_2 with sufficiently rough track and with smooth track then.

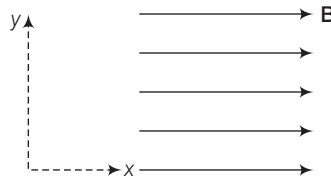


- a. $h_1 = h_2$ b. $h_1 < h_2$ c. $h_1 > h_2$ d. $h_2 = 2h_1$
5. The object O is placed in front of mirrors as given. If the velocity of image I_3 is v (magnitude), then what will be speed of object?

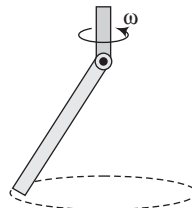


- a. v b. $\sqrt{2} v$ c. $\sqrt{3} v$ d. $\sqrt{5} v$

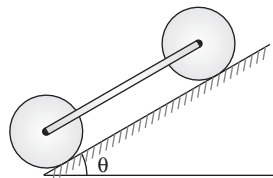
6. A uniform magnetic field exists in the space along the x -axis as shown in the figure. A rectangular loop of sides $(a \times b)$ is rotated in magnetic field about an axis passing through the mid-point of side a and parallel to side b with angular speed ω (this axis is parallel to direction of \mathbf{B}). The induced current in the loop if the resistance of loop is R , is



- a. $B\omega^2 b/2R$ b. $B\omega^2 a/2R$ c. zero d. None of these
7. Three point charges q , $2q$ and $8q$ are to be placed on a 9 cm long straight line. Find the position where the charges should be placed such that the potential energy of this system is minimum. In this situation, what is the electric field at the position of the charge q due to the other two charges?
- a. 20 cm, 24 N/C b. 12 cm, 2 N/C c. 3 cm, zero d. 9 cm, zero
8. A conical pendulum consists of a slender bar AB of length L and mass M . If it rotates with constant angular velocity ω , then value of $\cos \alpha$ will be



- a. $\cos \alpha = \frac{g}{\omega^2 L}$ b. $\cos \alpha = \frac{2g}{\omega^2 L}$
 c. $\cos \alpha = \frac{3g}{2\omega^2 L}$ d. $\cos \alpha = \frac{3g}{\omega^2 L}$
9. A solid sphere and a thin loop of equal masses m and radius R are harnessed together by rigging and free to roll without slipping down the incline plane. Neglect the mass of rigging, then compressive force in rigging will be

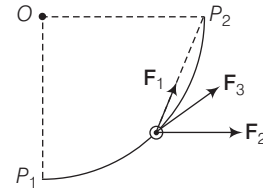


- a. $\frac{3}{17} mg \sin \theta$ b. $\frac{mg \sin \theta}{17}$
 c. $3mg \sin \theta$ d. $\frac{2 mg \sin \theta}{17}$
10. An electron and a proton are separated by a large distance. The electron starts approaching the proton with energy 2 eV. The proton captures the electron and forms a hydrogen atoms in first excited state. The resulting photon is incident on a photosensitive metal of threshold wavelength 4600 Å. The maximum KE of the emitted photoelectron is
- a. 2.4 eV b. 2.7 eV c. 2.9 eV d. 5.4 eV

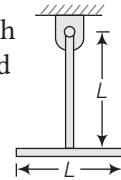
Section 2 More Than One Correct Option

This section contains 5 multiple choice questions. Each question has four choices, (a), (b), (c) and (d) out of which one or more than one is/are correct.

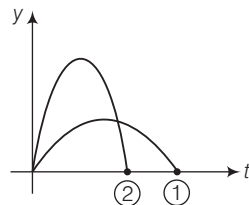
- 11.** A smooth track in form of a quarter circle of radius 6 m lies in vertical plane. A particle moves from P_1 to P_2 under action of force F_1 , F_2 and F_3 . Force F_1 is always towards P_2 and is always 20 N in magnitude. Force F_2 is always act horizontally and is always 30 N in magnitude. F_3 acts tangentially and has magnitude 15 N. Select the correct options.



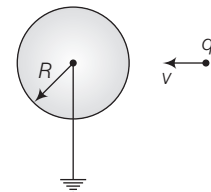
- a. work done by F_1 is $120\sqrt{2}$ J
 b. work done by F_2 is 180 J
 c. work done by $F_3 = 45\pi$ J
 d. F_3 is conservation in nature
- 12.** A pendulum is constructed from two identical uniform thin rods A and B each of length L and mass m connected at right angle forming T shape. It suspended free end and swings in vertical plane.



- a. moment of inertia of the T about axis of rotation is $\frac{17}{12} ml^2$
 b. moment of inertia a of T about axis of rotation is $13/12 ml^2$
 c. time period of small angular oscillation of T is $2\pi\sqrt{\frac{17l}{18g}}$
 d. angular frequency of T for small oscillation is $\sqrt{\frac{18g}{17l}}$
- 13.** Variation of y -coordinate of two projectiles with time is given in figure. If initial speed of both is same then

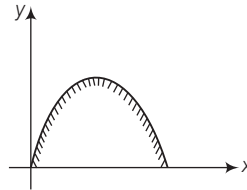


- a. horizontal speed of 1 is less than 2
 b. horizontal speed of 1 is greater than 2
 c. horizontal range of 1 is greater than 2
 d. Both has same horizontal range
- 14.** A charged particle having a positive charge q approaches a grounded metallic neutral sphere of radius R with a constant speed v as shown in figure. Now, choose the correct alternative (s).



- a. As the charged particle draws nearer to the surface of the sphere, a current flows into the ground
 b. As the charged particle draws nearer to the surface of the sphere, a current flows out of the ground into the sphere
 c. As the charged particle draw nearer, the magnitude of current flowing in the connector joining the shell to the ground increases
 d. As the charged particle draws nearer, the magnitude of current flowing in the connector joining the sphere shell to the ground decreases

15. A reflecting surface is represented by the equation $y = \frac{2L}{\pi} \sin\left(\frac{\pi}{L}x\right)$, $0 \leq x \leq L$. A ray of light moving horizontally becomes vertical after reflecting. Find coordinates of points where ray is incident.



- a. $\left(\frac{L}{4}, \frac{\sqrt{2}L}{\pi}\right)$ b. $\left(\frac{L}{3}, \frac{\sqrt{3}L}{\pi}\right)$ c. $\left(\frac{3L}{4}, \frac{\sqrt{2}L}{\pi}\right)$ d. $\left(\frac{2L}{3}, \frac{\sqrt{3}L}{\pi}\right)$

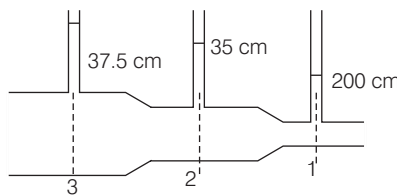
Section 3 Integer Answer Type

This section contains 5 multiple choice questions. The answer to each question is a single-digit integer, ranging from 0 to 9 (both inclusive).

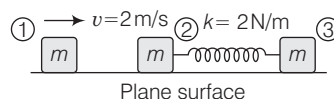
16. A classroom is maintained at 20°C by a heater of resistance 20Ω connected to 200 V mains. The temperature is uniform throughout the classroom and heat is transmitted through a glass window of area is $A \text{ m}^2$ and thickness 0.2 cm . So, outside temperature maintained is 15.24°C . Find the value of A .

[Given Thermal conductivity of glass is $0.2 \text{ cal m}^{-1}\text{s}^{-1}(\text{C}^\circ)^{-1}$ and mechanical equivalent of heat is 4.2 J/cal .]

17. Water is flowing in varying cross-section pipe. The areas of cross-sections 1, 2 and 3 are 1 cm^2 , 2 cm^2 and $A \text{ cm}^2$ respectively. Water levels are shown in different vertical tubes. The speed of water at cross-section 3 is $\frac{1}{\sqrt{x}} \text{ m/s}$. The value of x is



18. A block is moving with speed v towards a system of two blocks system. The first block hits the second block elastically. What will be the common velocity by which two blocks system will move together after some time. If the maximum compression is $x = 1 \text{ m}$.



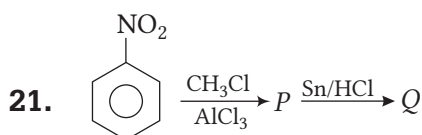
19. If the K_α radiation of Mo ($Z = 42$) has a wavelength of 0.71 \AA , calculate wavelength of the corresponding radiation of Cu , i.e., K_α for Cu ($Z = 29$). Find the value of nearest integer value (in Å) of wavelength.

20. The mean lives of a radioactive substance are 1000 and 400 years for α -emission and β -emission respectively. Find out the time during which three fourth of a sample will decay if it is decaying both by α -emission and β -emission simultaneously and fill the number of significant digits of your answer in OMR.

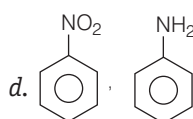
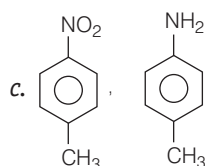
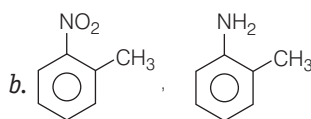
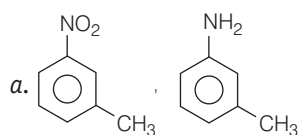
Part II

Section 1 Single Correct Option Type

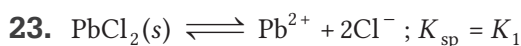
This section contains 10 multiple choice questions. Each question has four choices, (a), (b), (c) and (d) out of which only one is correct.



P and Q are respectively



22. Boron differs from other members of group 13 elements on reaction with carbon it forms carbides, reaction of boron with metals, oxygen etc., are only due to its small size and high electronegativity. Which of the following statement is/are incorrect?
- Carbides of boron are abrasive
 - Boron show diagonal relationship with silicon due to smaller size and dissimilar e/r ratio
 - Boron on reaction with metals forms metal borides
 - Boron forms only covalent compounds



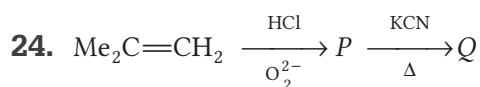
If a constant concentration of $[\text{Cl}^-] = x\text{M}$ is maintained in a solution in which the initial $[\text{Pb}^{2+}] = y\text{M}$, what % of original $[\text{Pb}^{2+}]$ will remain unprecipitated?

a. $\frac{K_1 \times 100}{x^2 \cdot y}$

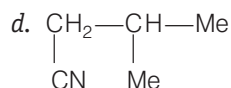
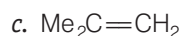
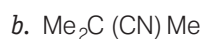
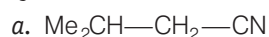
b. $\frac{yK_1 \times 100}{x^2}$

c. $\frac{x^2 - y}{K_1} \times 100$

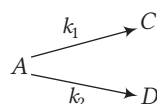
d. None of these



Q will be



25. Consider the following case of competing 1st order reaction.



After the start of reaction at $t=0$ with only A, the C is equal to the D at all times. The time in which all three concentrations will be equal is given by

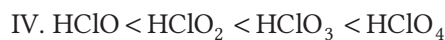
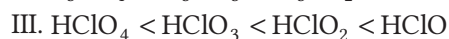
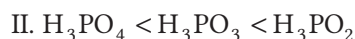
a. $t = \frac{1}{2k_1} \ln 3$

b. $t = \frac{1}{2k_2} \ln 3$

c. $t = \frac{1}{3k_1} \ln 2$

d. $t = \frac{1}{3k_2} \ln 2$

26. Which of the following order of acidic strength of oxoacids of phosphorous and oxoacids of chlorine is/are correct? Choose the correct option.



a. I and III are correct

b. II and III are correct

c. I and IV are correct

d. II and IV are correct

27. What is the reaction intermediate involved in Balz-Schiemann reaction?

a. Carbocation

b. Carbanion

c. Free radical

d. Carbene

28. Which of the following occur as sulphide ores?

Ag, Hg, Pb, Au, Sn, Mg, Al, Fe

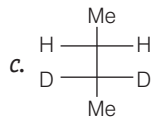
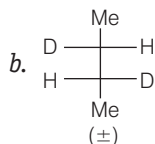
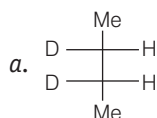
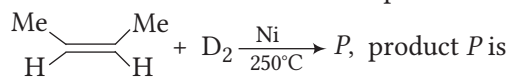
a. Ag, Hg, Pb and Fe

b. Hg, Pb, Fe and Mg

c. Hg, Pb, Au and Fe

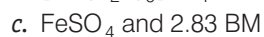
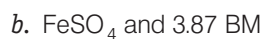
d. Sn, Mg, Hg and Ag

29. There are some chemical reaction which produces only one product in large extent and are in minor amount. These reaction are known as stereoselective reaction and if only product is obtained as more than 98% reaction is said to be stereospecific reaction.



d. None of these

30. Reagent used during brown ring test of nitrate and the magnetic moment of brown ring complex formed during the reaction is



Section 2 More Than One Correct Option

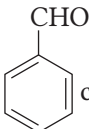
This section contains 5 multiple choice questions. Each question has four choices, (a), (b), (c) and (d) out of which one or more than one is/are correct.

31. Which of the following pair of compounds cannot exist together in aqueous solution?

- a. NaH_2PO_4 and Na_2HPO_4 b. Na_2CO_3 and NaHCO_3
 c. NaOH and NaH_2PO_4 d. NaHCO_3 and NaOH

32. Identify the wrong statement.

- a. Lower the packing fraction, more the stability
 b. Lower the packing fraction, lesser the binding energy
 c. Lower the packing fraction, more will be binding energy per nucleon, hence greater is stability
 d. Higher the packing fraction, more the stability

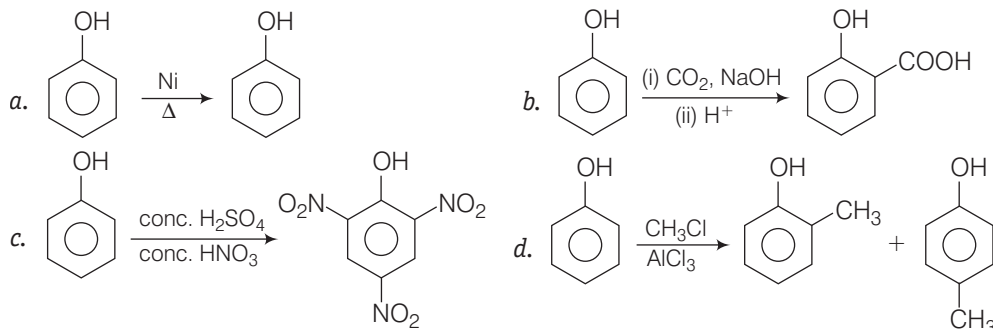
33. CH_3CHO and  can be distinguished by

- a. Tollen's reagent b. Fehling solution c. 2, 4 DNP d. KCN (alcohol)

34. Which of the following statements is/are incorrect?

- a. N_2O_5 and N_2O_4 contain one N—N bond each
 b. Hybridisation of $\text{N}(\text{SiH}_3)_3$ is sp^3
 c. Bond angle of H_2O is lower than O_2S
 d. $\text{H}_2\text{S}_2\text{O}_7$ contain no S—S bond

35. In which of the following reaction(s), which product is more acidic than phenol?



Section 3 Integer Answer Type

This section contains 5 multiple choice questions. The answer to each question is a single-digit integer, ranging from 0 to 9 (both inclusive).

36. Number of total possible stereoisomers of $\text{Pd}[\text{NH}_2\text{—CH}(\text{CH}_3)\text{—CO}_2^-]$ is

37. If pd versus p (where p in atm and d in g/L) is plotted for He gas at a particular temperature. If

$$\left[\frac{d}{dp}(pd) \right]_{p=8.21 \text{ atm}} = 5, \text{ what is the temperature?}$$

- a. ${}^n C_{m+1}$ b. ${}^n C_m$ c. ${}^{n+1} C_{m+1}$ d. None of these
46. If $P = \int_0^\infty \frac{x^2}{x^4 + 1} dx$, $Q = \int_0^\infty \frac{x dx}{x^4 + 1}$ and $R = \int_0^\infty \frac{dx}{x^4 + 1}$, then find the value of $P - \sqrt{2}Q + R$.
- a. $\frac{\pi}{2}$ b. $\frac{\pi}{2\sqrt{2}}$ c. $\frac{\pi}{\sqrt{2}}$ d. $\frac{\pi}{3\sqrt{2}}$
47. If $f(x) = ax^7 + bx^3 + cx - 5$, a, b and c are real constants and $f(-7) = 7$, then the range of $f(7) + 17 \cos x$ is
- a. $[-34, 0]$ b. $[0, 34]$ c. $[-34, 34]$ d. None of these
48. PQ is a chord of the parabola $x^2 + 2x + 12y - 11 = 0$ through $(-1, -2)$ and a circle is drawn on PQ as diameter, then the circle touches the
- a. directrix of the parabola
b. tangent at the vertex of the parabola
c. latus rectum of the parabola
d. axis of the parabola
49. The solution of differential equation
- $$x^2 + 3 = 1 + \left(\frac{2x}{y}\right)^{-1} \frac{dy}{dx} + \frac{\left(\frac{2x}{y}\right)^{-2} \left(\frac{dy}{dx}\right)^2}{2!} + \frac{\left(\frac{2x}{y}\right)^{-3} \left(\frac{dy}{dx}\right)^3}{3!} + \dots$$
- a. $(x^2 + 3) \log_e \left(\frac{x^2 + 3}{e}\right) = y + c$ b. $(x^2 + 3) \log_e \left(\frac{x^2 + 3}{e}\right) = \frac{y^2}{2} + c$
c. $(x^2 - 3) \log_e \left(\frac{x^2 - 3}{e}\right) = \frac{y^2}{2} + c$ d. $(x^2 - 3) \log_e \left(\frac{x^2 + 3}{2}\right) = \frac{y^2}{2} + c$
50. If $z = a + ib$ where $a > 0, b > 0$, if $b = 0$, z is called purely real and if $a = 0$, z is called purely imaginary, then
- a. $|z| \geq \frac{1}{\sqrt{2}}(a - b)$ b. $|z| \geq \frac{1}{\sqrt{2}}(a + b)$ c. $|z| < \frac{1}{\sqrt{2}}(a + b)$ d. None of these

Section 2 More Than One Correct Option

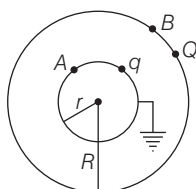
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51. $\mathbf{a}, \mathbf{b}, \mathbf{c}$ are three coplanar unit vectors such that $\mathbf{a} + \mathbf{b} + \mathbf{c} = 0$. If three vectors \mathbf{p}, \mathbf{q} and \mathbf{r} are parallel to \mathbf{a}, \mathbf{b} and \mathbf{c} respectively and have integral but different magnitudes, then $|\mathbf{p} + \mathbf{q} + \mathbf{r}|$ can take a value equal to
- a. $\sqrt{3}$ b. 2 c. 1 d. 0
52. If $f(x - y), f(x) f(y)$ and $f(x + y)$ are in AP for all x, y and $f(0) \neq 0$, then
- a. $f'(2) = f'(-2)$ b. $f(2) + f(-2) = 0$

Analytical Explanations

1. (c) **Idea** The problem is based on conducting sphere when it is earthed it means that the **net** potential on it is zero, it does not necessarily means that the charge on it must be zero.
 ⇒ Here **net** potential refers to the total potential due to all the charges present in the vicinity.

As the sphere is earthed the net potential on it must be zero. To make potential zero on the sphere some electrons will flow from earth to sphere.



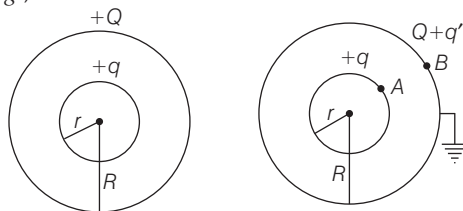
$$\begin{aligned} \therefore (V_{\text{net}})_A &= 0 \\ \Rightarrow (V_A)_r + (V_A)_R &= 0 \\ \Rightarrow \frac{1}{4\pi\epsilon_0} \frac{q}{r} + \frac{1}{4\pi\epsilon_0} \frac{Q}{R} &= 0 \end{aligned}$$

[Potential due to Q on shell and on sphere will be same]

$$\Rightarrow q = \frac{-QR}{R}$$

TEST Edge Different types of questions could be asked on the similar concept of earthing by just making different spheres or shells earthed or by increasing the number of shells.

e.g.,

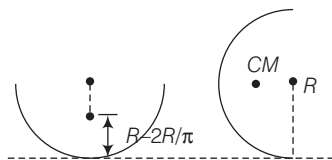


For the above system of conducting sphere and shell if the outer sphere is earthed, then suppose q' charge flows from earth to the shell.

So, net charge on conducting sphere flow from earth to the shell.

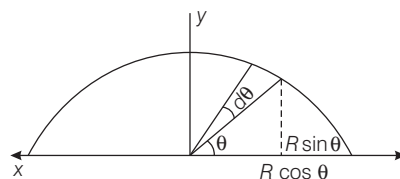
$$\text{i.e., } q' = -(q + Q)$$

2. (b) **Idea** Here the problem is based on centre of mass of a uniform semicircular pipe and conservation of total mechanical energy.
 A half section of thin uniform pipe carrying mass m and radius r is released from rest.



$$\begin{aligned} \therefore \Delta PE_{\text{max}} &= mgR - \left[mg \left(R - \frac{2R}{\pi} \right) \right] \\ &= mgR - mgR + mg \left(\frac{2R}{\pi} \right) \\ \Rightarrow \Delta PE_{\text{max}} &= mg \left(\frac{2R}{\pi} \right) \end{aligned}$$

TEST Edge In every year, one question is asked in JEE Advanced/IIT. Students should concentrate on this idea and relate with centre of mass, linear momentum and collision. Suppose m be the mass and R is the radius of a uniform semicircular wire. Take its centre as the origin, the line joining the ends as the x -axis and y -axis in the plane of wire as shown in figure.



As the wire is uniform, the mass per unit length of the wire is $\frac{M}{\pi R}$.

The mass of the element is

$$dm = \frac{M}{\pi R} (R d\theta) = \frac{M}{\pi} d\theta$$

$$\text{So, } y = \frac{1}{M} \int y dm = \frac{1}{M} \int_0^\pi (R \sin \theta) \left(\frac{M}{\pi} \right) d\theta = \frac{2R}{\pi}$$

∴ The coordinates value of the centre of mass along y -axis = $\frac{2R}{\pi}$.

3. (a) **Idea** Here, the solution is based on percentage of fractional error.

$$\text{i.e., } \frac{\Delta Z}{Z} \times 100 = \pm \left[\frac{\Delta A}{A} + \frac{\Delta B}{B} \right] \times 100$$

Fractional error in current is

$$\frac{\Delta I}{I} = \pm \left[\frac{\Delta V}{V} + \frac{\Delta R}{R} \right]$$

$$\begin{aligned} \text{or } &= \pm \left[\frac{0.0001}{0.2514} + \frac{0.001}{0.1} \right] \\ &= \pm [3.977 \times 10^{-4} + 0.01] \\ &= \pm [0.0103977] \end{aligned}$$

Percentage of uncertainty in the measurement of current i.e., $\frac{\Delta I}{I} \times 100 = \pm 0.0103977 \times 100$

$$\frac{\Delta I}{I} \times 100 = 1.039\% \approx 1.04\%$$

TEST Edge This Idea is important according to JEE Advanced. Students should focus on errors in measurement along with significant figures.

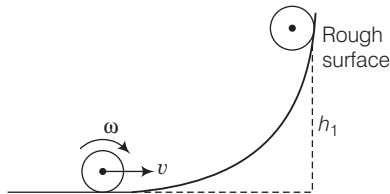
(i) **In product** If $Z = AB$, then maximum fractional error is

$$\frac{\Delta Z}{Z} = \pm \left[\frac{\Delta A}{A} + \frac{\Delta B}{B} \right]$$

(ii) **In division** If $Z = A/B$, then maximum fractional error

$$\frac{\Delta Z}{Z} = \pm \left[\frac{\Delta A}{A} + \frac{\Delta B}{B} \right] \approx 1.04\%$$

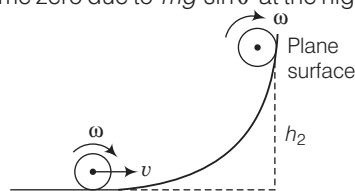
4. (c) **Idea** This problem is based on the concept of a rolling body trying to rolling up the incline plane, ' $mg \sin \theta$ ' reduce the linear velocity and ' f_s ' will provide the torque to reduce the angular velocity. But for plane surface friction is absent so the angular velocity of rolling body will not change.



A ball rolls for rough surface, the linear and angular both the velocities reduce and at the highest point ball will come at momentarily rest.

$$\text{So, } \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2 = mgh_1 \quad \dots(i)$$

For plane surface, only the linear velocity of the ball will become zero due to ' $mg \sin \theta$ ' at the highest point.



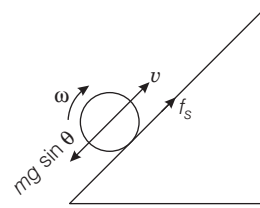
$$\text{So, } \frac{1}{2}mv^2 = mgh_2 \quad \dots(ii)$$

So, from Eqs. (i) and (ii), we get $h_1 > h_2$

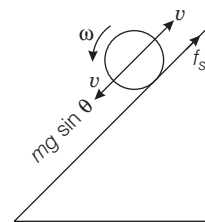
TEST Edge This concept is important according to JEE Advanced. Students should focus on this idea and relate with laws of motion and friction.

Note When the ball is placed on an inclined plane, then

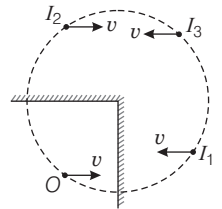
Case I When a ball is rolling upward,



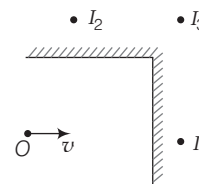
Case II When a ball is rolling downward,



5. (a) **Idea** This problem is based on the concept on reflection of light. When magnitude of speed of three images is same then speed of object will be same.

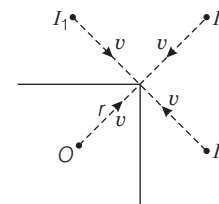


Let say object moves with speed u image I_1 moves with same speed u towards mirror. Image I_2 will move horizontally with object with same speed in same direction. As we know that during that image formation all four (images and object) will lie on the corners of a rectangle so like other three points, fourth point will have to move with same speed so speed of image I_3 will be equal to object.



TEST Edge According to JEE Advanced, students should focus on above idea and relate with refraction of light and YDSE

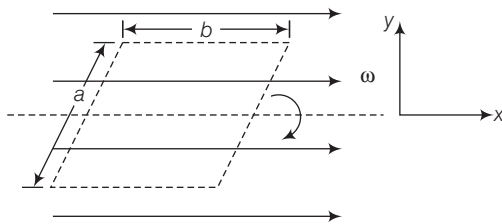
Note



In the above case, the forming of locus point by joining I_1, I_2, I_3 and O then it will be a square.

6. (c) **Idea** It is based on induced emf when magnetic field is perpendicular to the surface area ds , then, induced emf $\phi = Bds \cos 90^\circ$
 $\phi = \text{zero}$

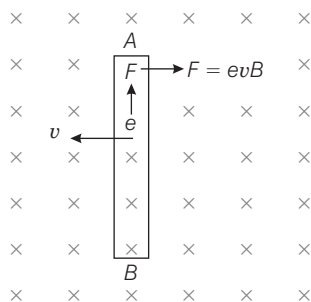
A rectangular loop of $(a \times b)$ is rotated in magnetic field about an axis passing through the mid-point of side a and parallel to side b with angular speed ω , we get



Don't be confused see clearly that the angle between the area vector of loop and \mathbf{B} will always remain constant (90°).

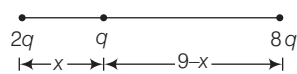
- \Rightarrow Induced emf = $Ba \cos 90$ (no change in flux)
- \Rightarrow Induced current = 0

TEST Edge Know exactly how emf is induced?



As the conducting rod is moving in the magnetic field, it's free electrons are also moving in the magnetic field. There will be a magnetic force on the electrons due to which they will drift towards the end 'A' and excess positive charge will remain at end 'B'. Due to this an emf will induce in the conducting rod.

7. (c) **Idea** The problem is based on potential energy and electric field between point charges. So, potential energy of the system i.e., $U(r) = K \frac{q_1 q_2}{r}$ and electric field between point charges $E(r) = \frac{K q_1}{r^2}$



For potential energy to be minimum, the bigger charges should be farthest.

Suppose x be the distance of q to $2q$. Then, potential energy of the system is shown in figure would be

$$U = K \left[\frac{(2q)(q)}{x} + \frac{(8q)(q)}{(9-x)} + \frac{(8q)(2q)}{9} \right]$$

Here, $K = \frac{1}{4\pi\epsilon_0}$

For U to be minimum $\frac{2}{x} + \frac{8}{9-x}$ should be minimum.

$$\frac{d}{dx} \left[\frac{2}{x} + \frac{8}{9-x} \right] = 0$$

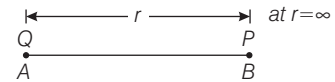
$$\therefore \frac{-2}{x^2} + \frac{8}{(9-x)^2} = 0 \Rightarrow x = 3$$

i.e., distance of charge q from $2q$ should be 3 cm.

So, electric field at q

$$E = \frac{K(2q)}{(3 \times 10^{-2})^2} - \frac{K(8q)}{(6 \times 10^{-2})^2} = \text{zero}$$

TEST Edge This concept is important according to JEE Advanced. Every year one or two questions are asked in JEE Advanced/IIT. So, students should focus on this concept and relate with equipotential surface and electric dipole moment. Such as



Suppose a point charge Q placed at a point A as shown in figure. We have to find the electric potential at a point P where $AP = r$. Then, take another charge q is moved from $r = \infty$ to the point P .

Then, electric potential energy of the system is

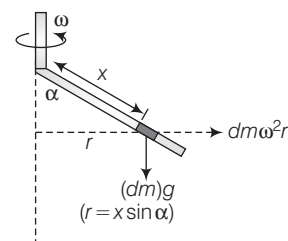
$$U_p - U_\infty = \frac{Qq}{4\pi\epsilon_0 r}$$

8. (c) **Idea** The problem is based on concept of equilibrium, net torque on the system must be zero. So, net torque due to mg and torque due to centrifugal force must be zero.

For equilibrium of rigid body net torque acting on body should be zero.

Here only two forces, one is gravity force and other is centrifugal force (if rod is considered as frame of reference).

Here notice that centrifugal force is variable because distance of mass from axis is variable that's why radius is variable and because of that centrifugal force is variable.



Torque due to centrifugal force
 = Torque due to weight

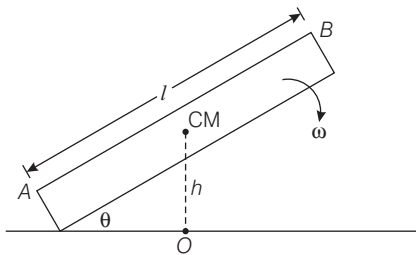
$$(dm\omega^2 r)(x \cos \alpha) = (dm)g \times \sin \alpha$$

$$\omega^2 (x^2 \sin \alpha \cos \alpha) = gx \sin \alpha$$

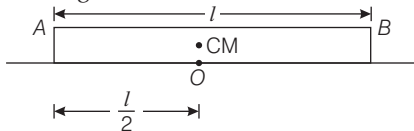
$$\cos \alpha (\omega^2 \int_0^L x^2 dx) = g \int_0^L x dx$$

$$\cos \alpha \frac{\omega^2 L^3}{3} = \frac{gL^2}{2} \Rightarrow \cos \alpha = \frac{3g}{2\omega^2 L}$$

TEST Edge Student should relate above concept with centre of mass and rotational motion as a rod is falling downwards on a plane surface as shown in the figure. The position of end 'A' from point 'O' when it will completely fall down on the plane surface.



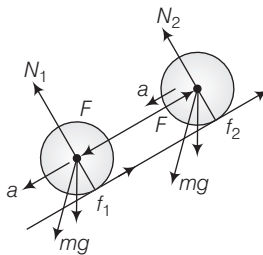
Here the simple point is that there is no force in the horizontal direction, so horizontal position of CM will not change.



9. (a) Idea The pure accelerated rolling is possible due to friction (static) but as the sphere and ring are attached then stress in the rod will be adjusted to keep the pure accelerated rolling in both the rolling bodies.

In FBD arrangement, we have
 $F =$ force in agging.

So, force for ring,



$$mg \sin \theta - f_1 + F = ma \quad \dots(i)$$

$$f_1 r = mr^2 \alpha \quad \dots(ii)$$

Force equation for sphere

$$mg \sin \theta - f_2 - F = ma \quad \dots(iii)$$

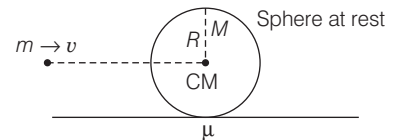
$$f_2 r = \frac{2}{5} mr^2 \alpha \quad \dots(iv)$$

[$a = r\alpha$ for pure rolling]
 Solve all equations

$$F = \frac{3}{17} mg \sin \theta$$

TEST Edge Rolling is a very complicated and vast topic so different types of questions could be asked on it, let us consider more example.

e.g., When the particle hits the sphere and if it sticks to sphere, we can find the linear velocity of sphere-particle system (as, particle will provide it only linear velocity)



Then due to f_k (backward direction), the sphere-particle system will start gaining the angular velocity. When the condition of pure rolling $v = R\omega$ is fulfilled then f_k will stop acting.

10. (b) Idea The basis of the problem in frequency dependence of photoelectric emission. The problem based on emission of electron when incident light with certain frequency (greater than on the threshold frequency) is focused on a metal surface then some electrons are emitted from the metal with substantial initial speed.

Initial energy of electrons = 2 eV

Energy of electron in 1st excited state

$$(i.e., n = 2) = -13.6 \times \frac{1^2}{2^2} = -3.4 \text{ eV}$$

Photon of energy = 2 - (-3.4) = 5.4 eV will be emitted.

$$\Rightarrow KE_{\max} = E_{\text{Photon}} - W_0 = 5.4 - \frac{12400}{4600}$$

$$= 5.4 - 2.7 = 2.7 \text{ eV}$$

TEST Edge The minimum energy is required to extract electron from the surface, they will have the maximum kinetic energy.

i.e. $KE_{\max} = E - W_0$

$$KE_{\max} = h\nu - W_0$$

This equation is known as Einstein's photoelectric equation.

Note At a certain potential V_0 having maximum kinetic energy (K_{\max}) also get stopped and current in the circuit becomes zero. This is called stopping potential.

11. (a, b, c) Idea The work done due to variable force
 $= \int F ds \cos \theta$
 i.e., The work done due to a constant force
 $= F_s$ [$\therefore \theta = 0^\circ$]

Work done by a constant force is equal to
 $= \text{Force} \times (\text{displacement in the direction of force})$

So, $W_{F_1} = F_1 \times \sqrt{2}R = 20 \times \sqrt{2} \times 6 = 120\sqrt{2} \text{ J}$

$W_{F_2} = F_1 \times R = 30 \times 6 = 180 \text{ J}$

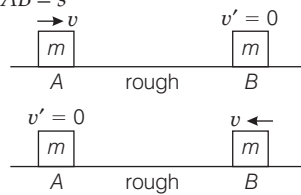
F_3 is a variable in direction only so work done in small tangential displacement

$$W = \int F_3 ds = \int F_3 R d\theta = F_3 R (\pi/2)$$

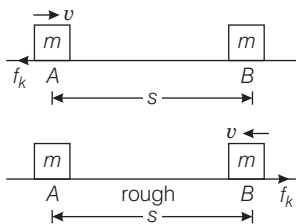
$$= 15 \times 6 \times \pi/3 = 45 \pi \text{ J}$$

TEST Edge These type of problems are generally asked in JEE Advanced/IIT. So, student should relate this concept with potential energy and work energy theorem.

For the process from $A \rightarrow B \rightarrow A$, find the work done. $AB = s$



Don't be confused with $s = 0$, here kinetic friction is variable.



$$\Rightarrow W_{A \rightarrow B} = -f_k s$$

$$W_{B \rightarrow A} = -f_k s$$

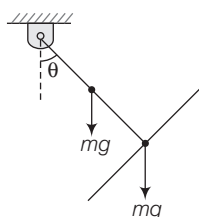
$$W_{\text{net}} = -f_k s - f_k s = -2f_k s$$

12. (a,c) **Idea** The basic idea is same as of simple pendulum. It's just there are two forces, one weight of vertical rod and other weight of horizontal rod due to which torque will be produced.

Moment of inertia for AB rod about A is $ml^2/3$ and of rod CD about A is

$$= \frac{Ml^2}{12} + ml^2 = \frac{13ml^2}{12}$$

Total moment of inertia is $\frac{17ml^2}{12}$



Restoring about A

$$\tau_R = mg \sin \theta \frac{l}{2} + mg l \sin \theta$$

$$= \frac{3mg l}{2} \sin \theta$$

Small value of θ

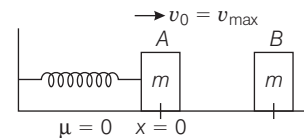
$$\tau_R = \left(\frac{3mg l}{2} \right) \theta$$

$$T = 2\pi \sqrt{\frac{I}{K}}$$

$$= 2\pi \sqrt{\frac{17ml^2 \times 2}{12 \times 3mg l}} = 2\pi \sqrt{\frac{17l}{18g}}$$

$$T = 2\pi \sqrt{\frac{17l}{18g}}$$

TEST Edge On SHM different types of questions could be asked e.g.,



A box is in SHM on a horizontal plane. Another box is placed at the positive extreme. The oscillating box hits the box which was at rest and sticks to it. The new amplitude of oscillation can be find out as.

When it hits the box B , then the mass at the system will become ' $2m$ '. So at the equilibrium position, the KE conservation could be applied.

$$\frac{1}{2}mv_0^2 = \frac{1}{2}(2m)v^2 \Rightarrow v = v_0/\sqrt{2}$$

But concentrate on the fact that it is the maximum speed at the boxes that changed not the KE of the system. So, the amplitude will not change by mechanical energy conservation.

13. (b,c) **Idea** The idea is that by comparing the ' $u \sin \theta$ ' and ' $u \cos \theta$ ' of two projectile motions, we can solve this question easily.

Slope at $t = 0$ gives initial vertical speed. So,

$$\left(\frac{dy}{dt} \right)_{1 \text{ at } t=0} < \left(\frac{dy}{dt} \right)_{2 \text{ at } t=0}$$

$$u \sin \theta_1 < u \sin \theta_2$$

$$\theta_1 < \theta_2 \text{ (angle of projection)}$$

$$\theta_1 < \theta_2$$

$$\text{So, } \cos \theta_1 > \cos \theta_2$$

$$u \cos \theta_1 > u \cos \theta_2$$

\therefore From graph we can see that

$$T_1 > T_2$$

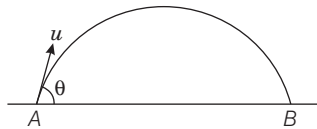
$$\text{So, } u \cos \theta_1 T_1 > u \cos \theta_2 T_2$$

$$R_1 > R_2.$$

TEST Edge These concepts are generally asked in JEE Advanced/ IIT. In every year, one or two problems are based on this idea. So, students should concentrate on projectile motion along with circular motion. Let us consider another example of projectile motion.

The average velocity of the projectile between the points A and B.

We know $\mathbf{v} = \frac{\Delta \mathbf{r}}{\Delta t} = \frac{\Delta \mathbf{r}}{T}$ [Here, $\Delta t = T$]



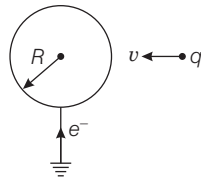
For $A \rightarrow B \Delta \mathbf{r} = \Delta x \hat{i} + \Delta y \hat{j}$
But here for $A \rightarrow B, \Delta y = 0$

So, there is no displacement along the y-axis.

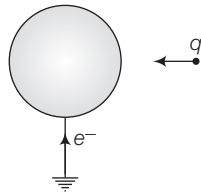
So, $\bar{\mathbf{v}} = (\bar{\mathbf{v}})_x = u \cos \theta$ (as component of velocity along x-axis is not changing).

14. (a,c)

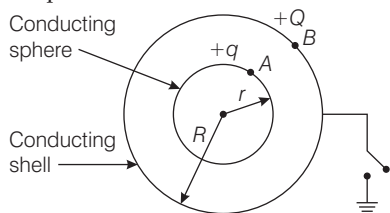
Idea It is based on an electric potential energy of a uniformly charged sphere. When the potential on the surface of earth has to be zero, so sphere must get some electrons from the earth to keep the potential on it to be zero.



The potential of the grounded sphere has to be zero, due to the positive charge the potential of the sphere is positive so negative charge must be possessed by the sphere so that the total potential of the sphere becomes zero. This negative charge is acquired by the sphere from the ground, hence current flows into the ground. As the charged particle comes nearer to the sphere the potential of the sphere due to the positive charge increases and hence more electrons per unit time will flow from the ground to the sphere and thus the magnitude of the current increases.

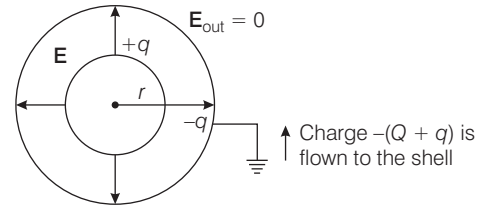


TEST Edge According to JEE Advanced, this concept is important and students should relate it with spherical charge distribution and earthing a conductor. Let us consider an example based on the same concept.



In the above system, if the shell is earthed, then the change in the potential of point A can be found out as

Here is the condition after earthing.

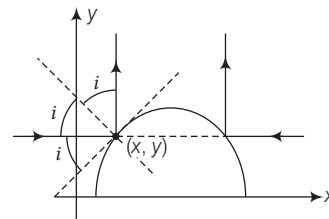


i.e., $(\Delta V)_A = \frac{KQ}{R}$

15. (b,d) **Idea** The problem is based on the reflection of light at a smooth surface.

- (i) The angle of incidence is equal to the angle of reflection.
- (ii) The incident ray, the reflected ray and the normal to the reflecting surface are coplanar.

For reflection at general point A



$2i = 90^\circ$

So, $i = 45^\circ$

So, dy/dx at A should be 45°

$y = \frac{2L}{\pi} \sin\left(\frac{\pi x}{L}\right)$

$\frac{dy}{dx} = \frac{2L}{\pi} \cos\left(\frac{\pi x}{L}\right) \times \frac{\pi}{L} = 2 \cos\left(\frac{\pi x}{L}\right)$

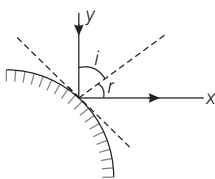
$1 = 2 \cos\left(\frac{\pi x}{L}\right)$

$\frac{\pi x}{L} = \frac{\pi}{3} \Rightarrow x = L/3, y = \frac{\sqrt{3}L}{\pi}$

and another point will be the just opposite point so, its coordinates will be $\left(2L/3, \frac{\sqrt{3}L}{\pi}\right)$

TEST Edge In every year, one question is asked in JEE Advanced/IIT. So, students should focus on this idea and relate it with Snell's law and refraction through a glass slab. According to the basic laws of reflection, they are the same for a plane curved surface. A normal can be drawn from any point of the curve by first drawing the tangent plane from that point and then drawing the line perpendicular to that plane.

- (i) angle of incidence and reflection are defined from this normal as shown in figure.
- (ii) the angle incident (i) is equal to the angle of reflection (r). The incident ray, the normal and the reflected ray are in the same plane.



16. (1) **Idea** The problem is based on thermal conductivity of the material.

$$\text{i.e., } \frac{\Delta Q}{\Delta t} = K \frac{A(T_1 - T_2)}{x} = \frac{T_1 - T_2}{x/KA}$$

where K is constant for the material of the slab, and x/KA is a thermal resistance. The idea is that by comparing the power produced by heater and rate of heat flow through window.

Power produced by heater = rate of heat flow through window.

$$\therefore \frac{V^2}{R} = \frac{\text{Temperature difference}}{\text{Thermal resistance}} = \frac{(20 - Q)}{l/KA}$$

$$\Rightarrow Q = 20 - \frac{V^2 l}{RKA}$$

Substituting the values, we get

$$Q = 20 - \frac{(200)^2 \times (0.2 \times 10^{-2})}{0.2 \times 4.2 \times A \times 20}$$

$$\Rightarrow 15.24 = 20 - \frac{(200)^2 \times (0.2 \times 10^{-2})}{(0.2 \times 4.2) \times A \times 20}$$

$$\Rightarrow A = 1.0004 \text{ m}^2 \approx 1 \text{ m}^2$$

TEST Edge According to JEE Advanced, students should relate this idea with heat transfer through conduction, convection and radiation of a body. If the area of cross-section is not uniform or if the steady-state conditions are not reached, the equation can only be applied to an thin layer of material perpendicular to the heat flow.

If A be area of cross-section, dx be small thickness and dT be temperature difference across the layer, then heat current through this cross-section is

$$\frac{\Delta Q}{\Delta t} = -KA \frac{dT}{dx}$$

17. (2) **Idea** It is based on Bernoulli's equation for flowing liquid for steady or streamline flow.

$$\text{i.e., } p + \frac{1}{2} \rho v^2 + \rho gh = \text{constant}$$

where p is pressure energy, $\frac{1}{2} \rho v^2$ is kinetic energy per unit volume and ρgh is the potential energy per unit volume.

Apply Bernoulli's equations at pipe (1), (2) and (3)

$$p_3 + \frac{1}{2} \rho v_3^2 = p_2 + \frac{1}{2} \rho v_2^2 = p_1 + \frac{1}{2} \rho v_1^2$$

$$p_0 + \rho gh_3 + \frac{1}{2} \rho v_3^2 = p_0 + \rho gh_2 + \frac{1}{2} \rho v_2^2$$

$$= p_0 + \rho gh_1 + \frac{1}{2} \rho v_1^2$$

$$gh_3 + \frac{v_3^2}{2} = gh_2 + \frac{v_2^2}{2} = gh_1 + \frac{v_1^2}{2} \quad \dots(i)$$

Equations of continuity at (3) and (2) are

$$v_3 A_3 = v_2 A_2$$

$$v_3 \times A = v_2 \times 2 \quad \dots(ii)$$

$$v_2 \times 2 = v_1 \times 1 \quad \dots(iii)$$

From Eq. (i), we get

$$gh_2 + \frac{v_2^2}{2} = gh_1 + \frac{v_1^2}{2}$$

$$10 \times \frac{35}{100} + \frac{v_2^2}{2} = 10 \times \frac{20}{100} + \frac{v_1^2}{2}$$

$$\frac{15}{10} = \frac{v_1^2 - v_2^2}{2} = \frac{4v_2^2 - v_2^2}{2} = \frac{3v_2^2}{2}$$

$$v_2 = 1 \text{ m/s, } v_1 = 2 \text{ m/s}$$

From Eq. (i), we get

$$gh_3 + \frac{v_3^2}{2} = gh_2 + \frac{v_2^2}{2}$$

$$= 10 \times \frac{37.5}{100} + \frac{v_3^2}{2} = 10 \times \frac{35}{100} + \frac{1}{2}$$

$$\frac{v_3^2}{2} = \frac{1}{2} + \frac{35}{10} - \frac{37.5}{10} = \frac{1}{2} - \frac{2.5}{10} = \frac{1}{2} - \frac{25}{100}$$

$$\frac{v_3^2}{2} = \frac{1}{4} \Rightarrow v_3^2 = \frac{1}{2} \Rightarrow v_3 = \frac{1}{\sqrt{2}}$$

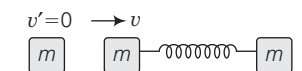
$$X = 2$$

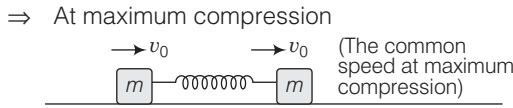
TEST Edge According to the property of fluids, if the speed of the fluid is zero everywhere, we get the situation of hydrostatics. Putting $v_1 = v_2 = 0$ in the Bernoulli's equation, we get

$$p_1 - p_2 = \rho g(h_2 - h_1)$$

18. (1) **Idea** The problem is based on the conservation of mechanical energy in elastic collision. First the collision occurred and then the spring starts compressing will reduce the velocity of 1st block and increase the velocity of 2nd block until the velocities at both the blocks become same and it will be the condition of maximum stretch.

As the collision is elastic the first block will transfer its speed completely to second block. So, initial scenerio will be like this





Let the maximum compression is 'x'.
 ⇒ So, by mechanical energy conservation
 ⇒ $\frac{1}{2}mv^2 = 2\left(\frac{1}{2}mv_0^2\right) + \frac{1}{2}kx^2$
 ⇒ $mv^2 = 2mv_0^2 + kx^2$
 ⇒ $mv^2 - kx^2 = 2mv_0^2$
 ⇒ $v_0 = \sqrt{\frac{mv^2 - kx^2}{2m}} = \sqrt{\frac{1 \times 4 - 2 \times 1}{2 \times 1}}$
 $v_0 = 1 \text{ m/s}$

TEST Edge It is important according to JEE Advanced. So, students should focus on collision and try to relate with potential energy of a spring. If the collision would be inelastic then you have to find the velocity at 2nd block then apply the same concept of maximum compression.

19. (2) **Idea** This problem is based on Moseley's observation can be mathematically expressed as

$$\sqrt{\nu} = a(Z - b)$$

where ν is frequency, Z is atomic number and a, b are constants. This relation is known as Moseley's law.

According to Moseley's law K_{α} X-rays emission

$$\sqrt{\nu} = a(Z - 1)$$

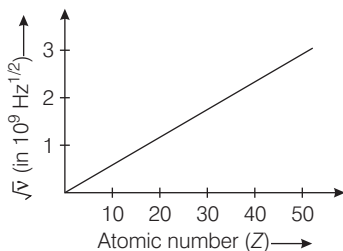
$$\Rightarrow (Z - 1)^2 \propto \nu \text{ or } (Z - 1)^2 \propto \frac{1}{\lambda}$$

$$\Rightarrow \frac{(Z_{Mo} - 1)^2}{(Z_{Cu} - 1)^2} = \frac{\lambda_{Cu}}{\lambda_{Mo}}$$

$$\Rightarrow \lambda_{Cu} = \lambda_{Mo} \frac{(Z_{Mo} - 1)^2}{(Z_{Cu} - 1)^2} = 0.71 \times \left(\frac{41}{28}\right)^2 = 1.52 \text{ \AA}$$

$[\lambda] = 2 \text{ \AA}$

TEST Edge According to Moseley, that there must be a fundamental property of the atom which increased by regular steps as one moves from one element to the other, there is increase in the number of proton in the nucleus and was referred as atomic number as shown in figure.



20. (4) **Idea** This problem is based on law of radioactivity decay law i.e., mean life. The average or mean life (t_{av}) is the reciprocal of the decay constant (λ).

i.e., $t_{av} = \frac{1}{\lambda}$

Let the element be X



When a substance decays by α and β -emissions simultaneously, the average rate disintegration $\lambda_{overall}$ is given by

$$\lambda_{overall} = \lambda_{\alpha} + \lambda_{\beta}$$

where λ_{α} = disintegration constant for α -emission only and λ_{β} = disintegration constant for β -emission only.

Mean life is given by $\tau = \frac{1}{\lambda}$

$$\Rightarrow \lambda_{overall} = \lambda_{\alpha} + \lambda_{\beta} = \frac{1}{(\tau)_{overall}} = \frac{1}{\tau_{\alpha}} + \frac{1}{\tau_{\beta}}$$

$$= \frac{1}{1600} + \frac{1}{400} = 3.125 \times 10^{-3} \text{ year}^{-1}$$

$$\lambda_{overall} t = 2.303 \log_{10} \frac{N_0}{N_t}$$

$$\Rightarrow (3.125 \times 10^{-3})t = 2.303 \log_{10} \frac{100}{25}$$

$$\Rightarrow t = 2.303 \times \frac{1}{3.125 \times 10^{-3}} \log_{10} 4 = 443.5 \text{ year}$$

Number of significant digit = 4

TEST Edge This problem is deal with activity of a radioactive substance and relate with equivalence of mass, energy and binding energy per nucleon. According to the radioactive decay law, when there is a nuclei in a sample, the rate of decay is proportional to the number of a nuclei.

i.e., $\left(-\frac{dN}{dt}\right) \propto N$

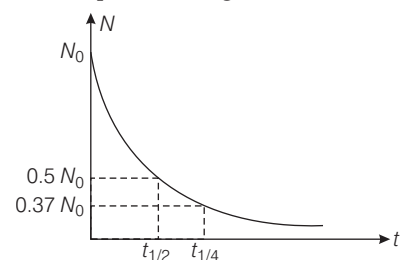
where λ is the decay constant.


or $\ln\left(\frac{N}{N_0}\right) = -\lambda t$

At $t = 0$, then N_0 is the initial number of parent nuclei, then number of nuclei survive at time t ,

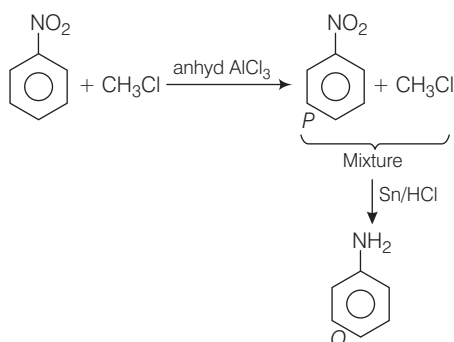
i.e., $N = N_0 e^{-\lambda t}$

This function is plotted in figure.




21. (d)  **Idea** This problem is based on chemical properties of aromatic nitro compound towards Friedal Craft reaction and reduction of aromatic nitro compound. While solving this problem, students are advised to use both the concepts notified and suggested to be careful while solving such problems.

As nitrobenzene does not give Friedal Craft reaction hence reaction medium contain mixture of nitrobenzene and alkyl halide and when this mixture undergo reduction with Sn/HCl, it produces aniline. The reaction sequence is as follows



Difficulty of this question is due to reactivity of nitrobenzene towards Friedal Craft alkylation.

TEST Edge Similar problem based on chemical reactivity of phenol, aromatic aldehyde etc., can also be asked with conceptual mixing of comparative study of basicity or a acidity of product, so students are advised to go through these topics as well.

22. (b)  **Idea** This problem includes concept of properties of boron and compounds of boron.

To solve this problem, students must have knowledge of chemical and physical properties of boron compounds as well as uses of them.

Boron show diagonal relation with aluminium due to small size and similar e/r ratio while all other statements are correct.

TEST Edge Similar types of problems based on chemical properties and uses of silicon and their compounds such as silicones, silicates can be asked in JEE Advanced so students must have in depth knowledge of properties and nature bonding and structure of silicones and silicates. Sometimes, questions from this segments are asked directly on general formulae and net charge calculation of various silicates hence students must be familiar with these topics. A ready reference between formulae & charges of silicates is given below

Types of Silicate	Structural Formula	Number of Oxygen Atom(s) Shared	Net charge	Example of Minerals
Island (Orthosilicate)	$(\text{SiO}_4)^{4-}$	0	Si = + 4 O = - 8 <hr/> Net = - 4	Fenacite (Be_2SiO_4) Zircon (ZrSiO_4), Forestrite (Mg_2SiO_4)
Island (Pyrosilicate)	$(\text{Si}_2\text{O}_7)^{6-}$	1	Si = + 8 O = - 14 <hr/> Net = - 6	Hemimorphite $\text{Zn}_4\text{Si}_2\text{O}_7(\text{OH})_2$ Thortveitite, $\text{Se}_2(\text{Si}_2\text{O}_7)$
Single chain	$(\text{SiO}_3)^{2-}$	2	Si = + 4 O = - 6 <hr/> Net = - 2	Enstatite, MgSiO_3 Wollastonite, $\text{Ca}_3(\text{Si}_3\text{O}_9)$
Ring	$(\text{SiO}_3)^{2-}$	2	Si = + 4 O = - 6 <hr/> Net = - 2	Beryl, $\text{Be}_3\text{Al}_2(\text{SiO}_3)_6$
Double chain	$(\text{Si}_4\text{O}_{11})^{6-}$	$2\frac{1}{2}$	Si = + 16 O = - 22 <hr/> Net = - 6	Tremolite (Asbestos), $\text{Ca}_2\text{Mg}_5(\text{OH})_2(\text{Si}_4\text{O}_{11})_2$
Sheet silicate	$(\text{Si}_2\text{O}_5)^{2-}$	3	Si = + 8 O = - 10 <hr/> Net = - 2	Muscovite (Mica), $\text{KAl}_2(\text{OH})_2\text{Si}_3\text{AlO}_{10}$
Three dimensional	$(\text{SiO}_2)^0$	4	Si = + 4 O = - 4 <hr/> Net = 0	Quartz, SiO_2

23. (a) **Idea** This problem is based on concept of solubility product and equilibrium constant. To solve this problem, students are advised to calculate K_{sp} and correlate this with total concentration of cation in order to calculate % of original cation.

$$K_1 = (\text{Pb}^{2+})(x)^2 \Rightarrow (\text{Pb}^{2+})_R = \frac{K_1}{x^2}$$

$$\% (\text{Pb}^{2+})_R = \frac{K_1/x^2}{y} \times 100 = \frac{K_1 \times 100}{x^2 y}$$

TEST Edge Similar problems based on conceptual mixing of solubility product and equilibrium constant along with standard electrode potential of electrochemical cell can be asked in JEE Advanced such as for a spontaneous reaction occurring at 25°C $\text{Ag} | \text{AgCl}(s); \text{KCl}(0.2\text{M}) || \text{KBr}(0.001\text{M}); \text{AgBr}(s) | \text{Ag}(s)$, calculate emf generated.

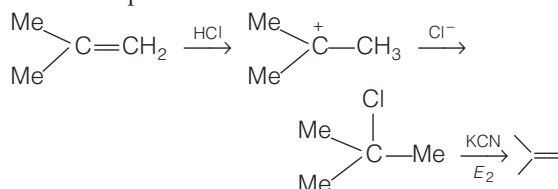
Given, $K_{sp}(\text{AgCl}) = 2.88 \times 10^{-10}$

$K_{sp}(\text{AgBr}) = 3.3 \times 10^{-13}$ after solving this question, you will get answer $E = 0.037\text{ V}$.

Use formula

$$E = E^\circ - \frac{0.059}{n} \log \left[\frac{\text{Products}}{\text{Reactants}} \right]$$

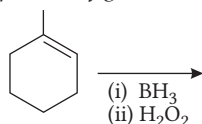
24. (c) **Idea** This problem is based on concept of Markonikov's addition reaction of HCl to alkene and E_2 elimination. Keep in mind the concept of above two concepts while solving the problem.



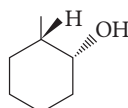
Here, presence of peroxide ion in step 1 will not affect the product.

TEST Edge Similar problem including concept of markonikov's type addition of water to alkene can also be asked in JEE Advanced so students are advised to go through these topics problem such as

What will be the product of given reaction?



You can get answer as



Here, note that above addition is markonikov's of which looks like anti-markonikov's due to the presence of H^- in the reagent.

25. (b) **Idea** This problem is based on concept of kinetics of parallel reaction which can be solved by using the expression of rate constant obtained for parallel reaction. While solving this problem, students are suggested to be careful that reaction concentration is distributed towards two pathway parallelly.

$$k_1 = k_2$$

$$\Rightarrow \frac{2}{3} \text{ rd of A has reaction for } [A] = [C] = [D]$$

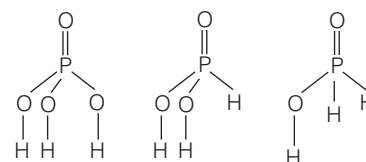
$$\therefore k_1 + k_2 = \frac{1}{t} \ln \frac{[A_0]}{\frac{1}{3}[A_0]}$$

$$\Rightarrow t = \frac{1}{k_1 + k_2} \ln 3 = \frac{1}{2k_1} \ln 3 = \frac{1}{2k_2} \ln 3$$

TEST Edge In JEE Advanced, these types of problem are asked to judge the knowledge of students regarding kinetic study of chemical reaction and mathematics involved in calculation. Similar problems based on half-life, quarter life, can also be asked.

26. (d) **Idea** The acidic character of oxy acids of phosphorus and halogen can be explained on the basis of polarity of O—H bond, which is dependent on number of P=O and other elements P—OH bond. While in the case of oxo acids of other elements, it depends on number of O atom.

Let us see the number of P=O and P—OH bond



Number of P=O bond

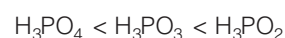
1 1 1

Number of P—OH bond

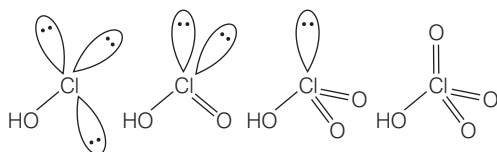
3 2 1

Polarity of OH bond is minimum when number of P—OH bond is maximum because the effect of P=O bond is distributed among all the three P—OH bond.

We may say as the number of P—OH bond increases the acidity of species decreases. The correct order of acidic strength is



In case of oxy acids of chlorine as number of oxygen atom increases, number of Cl=O bond increases finally acidic order increases as



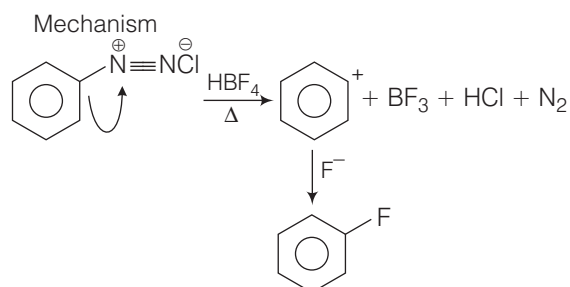
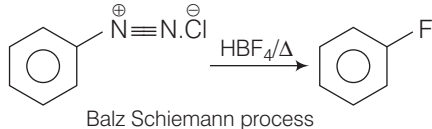
No. of O—H bond	1	1	1	1
No. of O atom	1	2	3	4
No. of Cl=O bond	0	1	2	3

—————> Polarity of O—H increases

TEST Edge Similar trend related problems regarding oxidising capacity of oxyacids of chlorine, sulphur etc., can also be asked in JEE Advanced. So, students are advised to go through understanding of oxidising, reducing capacity of oxyacids of chlorine and sulphur, questions including concept of equivalent weight of oxoacids of sulphur, chlorine can also be asked.

27. (a) **Idea** This problem is based on concept of mechanism involved in Balz Schiemann reaction. To solve the problem, students must have a clear idea about mechanism of conversion of diazonium salt to fluorobenzene. *i.e.*, Balz Schiemann reaction.

Chemical conversion of benzene diazonium chloride to fluorobenzene is known as Balz Schiemann process. This conversion can be made by heating HBF_4 with benzene diazonium chloride.



TEST Edge Similar problem based on conceptual mixing of chemical conversion, name of particular reaction and intermediate involved in given conversion can also be asked in JEE Advanced. Students are advised to read any of chemical reaction with proper mechanism of reaction.

What is the name of reaction which involves conversion of benzene diazonium salt to chlorobenzene and what is the intermediate involved in the reaction?

After undergoing proper mechanism of above conversion one can get the answer as

Intermediate = free radical

Reagent = CuCl/HCl

Name = Sandmeyer process

28. (a) **Idea** This question is based on occurrence of element as sulphide ore so students are advised to solve this problem by using concept of stability of sulphide of metals.

Ag occurs as Ag_2S

Hg occurs as HgS (cinnabar)

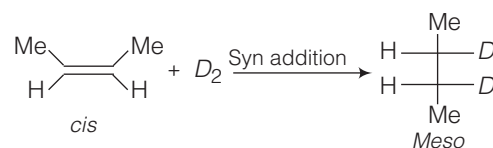
Pb occurs as PbS (galena)

Fe occurs as FeS_2 (iron pyrite)

TEST Edge Problems based on concept of concentration, reduction and roasting of ore can also be asked so students are advised to go through clear understanding of each term.

29. (a) **Idea** This problem is based on conceptual mixing of stereochemistry of reaction and addition of D_2 to alkene. While solving these types of problem, students must be clear about stereochemistry of addition of deuterium to alkene.

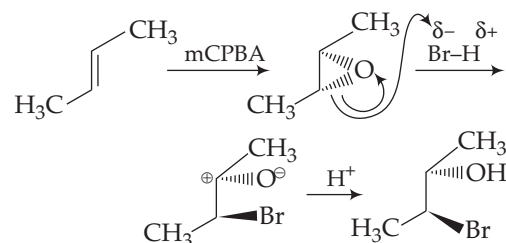
Cis alkene + $\text{D}_2 \xrightarrow[250^\circ\text{C}]{\text{Ni}}$ Meso compound.
(Syn addition)



TEST Edge The problem based on stereochemical approach of reagent and mechanism of product formation can also be asked in JEE Advanced. Students are advised to go through study of stereospecific and stereoselective reaction. To solve these types of problems such as

What will be the product when *trans* 2 butene undergo reaction with *m*CPBA followed by Br_2 ?

By undergoing proper mechanistic step one can get answer as *trans* 2-hydroxy 2-bromobutane use concept of epoxide ring formation & ring opening from least hindered side.




Here, the concept of CAR can be very useful *i.e.*, for stereoselective reactions

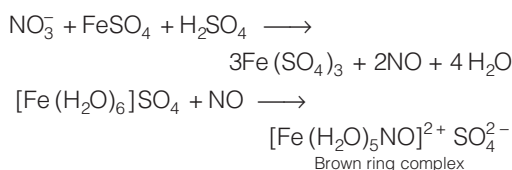
cis alkene + anti addition \longrightarrow Racemic Mixture

trans alkene + anti addition \longrightarrow Meso compound

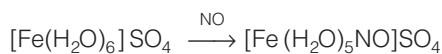
cis alkene + syn addition \longrightarrow Racemic mixture

30. (b)  **Idea** This problem involves reagent used in brown ring test and magnetic moment of brown ring complex. While solving the problem, students are advised to complete the chemical reaction involved in formation of brown ring complex then determination of magnetic moment of complex formed.

Brown ring test When the freshly prepared FeSO_4 solution is added to the solution containing nitrate ion along with the conc. H_2SO_4 added by the side of test tube, a brown ring of $[\text{Fe}(\text{H}_2\text{O})_5\text{NO}]\text{SO}_4$ is generated between the junction of two liquids.



Fe has +1 oxidation state due to addition of single electron from NO to Fe^{2+} .

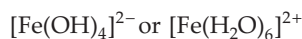


$$n = 3$$


$$\begin{aligned} \mu &= \sqrt{n(n+2)} \text{ BM} = \sqrt{3(3+2)} \text{ BM} \\ &= \sqrt{15} = 3.87 \text{ BM} \end{aligned}$$

TEST Edge Similar problems based on conceptual mixing of magnetic moment of coordination compounds and intensity of colour produces by different coordination compound by absorption of light can also be asked in JEE Advanced so students are advised to undergo study of properties and analytical use of coordination compound, stability of coordination compound in detail to tackle question like

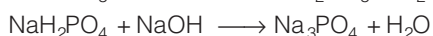
Which of the following has lowest negative value of CFSE?



Students can solve this question using above relations $\Delta t = 0.45 \Delta_0$

31. (c,d)  **Idea** This problem involves chemical properties of sodium biphosphate and sodium bicarbonate with NaOH.

The reaction in NaOH with NaHCO_3 & NaH_2PO_4 is as follows




Since both of them form salt so they cannot exist together.

TEST Edge Problems based on concept of hydroxides, bicarbonates, carbonates, chloride, sulphates of sodium, potassium, magnesium and

calcium can also be asked. So, students are advised to study the preparation, physical and chemical properties of these compounds which can be asked in JEE Advanced.

What is the difference between molecular mass of plaster of Paris and dead burnt? After calculating you will get answer as 9.

32. (a,c)  **Idea** While solving these types of problems which is based on packing fraction, students are advised to relate packing fraction with stability, binding energy and binding energy per nucleon.

Packing fraction

$$= \frac{\text{Actual isotopic mass} - \text{mass number}}{\text{Mass number}} \times 10^4$$

As we know from characteristics of packing fraction value that lower the packing fraction, greater is the packing fraction per nucleon, and hence greater is the stability. Hence, options a and c are correct

TEST Edge Similar types of problems including concept of kinetics of radioactive decay, carbon dating, nuclear fusion, nuclear fission can also be asked so students are advised to go through study of these topics. One of such problems is

What will be the value of α activity in terms of dpm of 0.001 g sample of Pu^{239} ?

$$(+ 1/2 = 24300 \text{ yrs})$$


$$\text{and } 1 \text{ yr} = 3.15 \times 10^7 \text{ seconds}$$

After solving the question by using formulae

$$\lambda = \frac{0.693}{t_{1/2}}, \text{ where } \lambda = \text{disintegration constant and}$$

$$N\lambda = \frac{-dN}{dt} \text{ one can get answer}$$


$$= 1.43 \times 10^8 \text{ dpm}$$

33. (b,d)  **Idea** This problem is based on concept of test of aldehyde and characteristics of benzoin condensation.

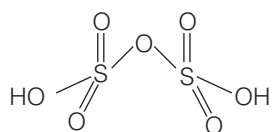
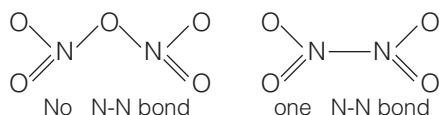
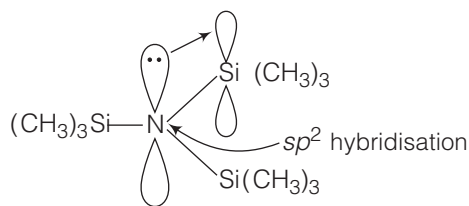
While solving this problem, students must have knowledge of benzoin condensation and test to distinguish aldehyde and ketones.

Aromatic aldehyde does not reduce Fehling solution. Aromatic aldehyde form benzoin with KCN.

TEST Edge In JEE Advanced, these types of problems are asked to judge the knowledge of students regarding chemical characteristics of aldehyde and ketone.

34. (a,b)  **Idea** This problem includes concept of $d_\pi - p_\pi$ bonding, bent rule, structure of oxyacids of sulphur, oxyacids of nitrogen. So students are advised to go through structural characteristic of these compounds.

Hybridisation of $\text{N}(\text{SiH}_3)$ is sp^2 due to back bonding.



Structure of $\text{H}_2\text{S}_2\text{O}_7$
No S-S bond



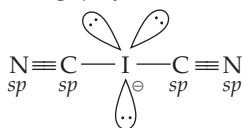
TEST Edge Problems based on structure, hybridisation, bond angles, stability of inorganic compounds usually asked in JEE Advanced

In $[\text{ICN}_2]^-$, how many atoms are in plane and how many atoms are sp hybridised?

After drawing structure using concept of VSEPR one can get answer as

Atoms in plane = 5

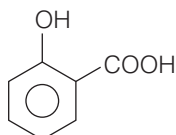
atoms having sp hybridised = 4



35. (b,c)

Idea This problem involves various chemical properties of phenols. These types of problem can be solved by completing all chemical conversions and then comparing acidic strength of product with reactant.

(i)



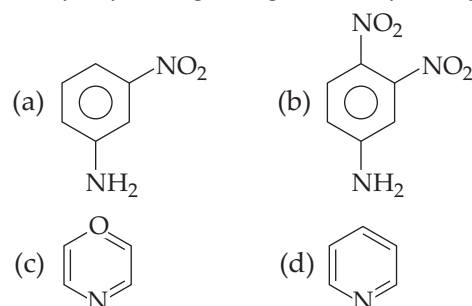
Salicylic acid is a carboxylic acid which is a stronger acid than phenol.

(ii) In picric acid three strong $-M$ group increases acidic strength of phenol.

TEST Edge Problems based on concept of acidic strength of substituted carboxylic acid, basic strength of substituted amine can also be asked in JEE Advanced so students must be careful during

solving such problems. Students are advised to use concept of *ortho* effect also like

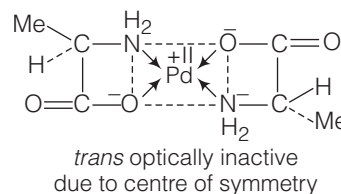
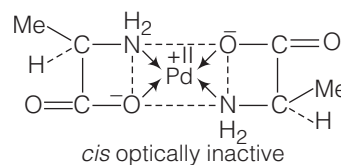
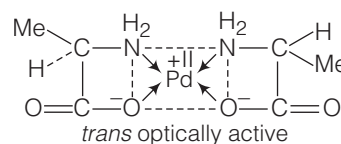
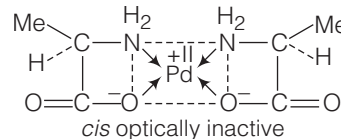
Which of the following has highest value of basicity?



After comparing, one can get (d) as an answer.

36. (6) **Idea** This problem is based on structure and isomerism of coordination compound while solving the problem students are advised to draw the structure of coordination compound then draw the possible isomers of coordination compound. Students are advised to keep in mind the concept of geometrical and optical isomerism.

Every optically active isomer must have a mirror image isomer. *i.e.*, enantiomer of optically active isomer.



The two more optical isomers are mirror image of optically active isomer *i.e.*, enantiomeric form of optical isomer.


Due to centre of symmetry. Total number of space isomers = 6.

TEST Edge Problems based on calculation of numbers of stereoisomers; geometrical isomers, optical isomers etc., can also be asked in JEE

Advanced so students are advised to go through in depth study of number of possible isomers. vant Hoff factor of coordination compound, conductivity of coordination compound can also be asked hence students are suggested to go through of these types of problems.

What is the value of vant Hoff factor for brown ring complex

One can get answer as 3.

- 37.** (160)  **Idea** This problem is based on concept of ideal gas equation and their interconversion into pd vs p equation. To solve the problem, students must apply the creative idea regarding relation between p and d .

As we know

$$pV = nRT$$

$$\Rightarrow p = \frac{n}{V} RT$$

$$\Rightarrow p = \frac{\left(\frac{w}{M}\right)RT}{V} \quad \therefore n = \frac{w}{M}$$

$$\Rightarrow p = \frac{w \cdot RT}{V \cdot M} = \frac{w}{V} \times \frac{RT}{M}$$

$$\Rightarrow p = d \cdot \frac{RT}{M} \quad \left(\because \frac{w}{V} = d\right)$$

$$\Rightarrow d = \frac{pM}{RT}$$

Multiply both sides by p

$$\Rightarrow pd = p \times \frac{pM}{RT} = \frac{p^2 M}{RT} \quad \dots(i)$$

On differentiating Eq. (i) w.r.t. p , we will get


$$\frac{d(p \cdot d)}{dp} = \frac{d}{dp} \left(\frac{p^2 M}{RT} \right) = \frac{2pM}{RT}$$

$$5 = \frac{2pM}{RT}$$

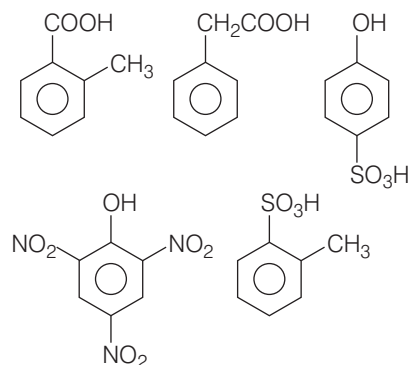
$$T = \frac{2pM}{5R} = \frac{2 \times 8.21 \times 4}{5 \times 0.0821} \quad [\text{for He, } M=4]$$

$$T = 160 \text{ K}$$

TEST Edge Problem based on various possible representation of ideal gas equation, gas laws etc; can be asked in JEE Advanced, Hence, it is advisable to learn the equation and their representation in various form.


- 38.** (5)  **Idea** This problem can be solved by using the concept of acidic strength of organic compound and reactivity of the organic compounds with base.

All those acids which are stronger acid than H_2CO_3 gives the NaHCO_3 test.



These 5 organic compounds will give NaHCO_3 test.

TEST Edge Similar problems based on relative acidic/basic strength of organic compound can also be asked so students are advised to go through study of factors affecting acidic and basic strength of organic compound. Such as I effect, M effect, R effect, hyperconjugation etc.

- 39.** (3)  **Idea** Problem is based on concept of first law of thermodynamics. Students are advised to write equation derived from first law of thermodynamics then calculate value of molar heat capacity (c).

$$dQ = dE + (-dW)$$

$$Q = nC_V dT - \left(-\frac{Q}{2}\right)$$

$$n \Delta T = \frac{Q}{2C_V}$$

$$C = \frac{Q}{n \Delta T}$$

$$= \frac{Q}{Q/2C_V} = 2C_V$$

$$C = 2 \times \frac{3}{2} R = 3R$$


TEST Edge Similar problem based on conceptual mixing of work done in various thermodynamic processes such as adiabatic, isochoric, isobaric, isothermal and internal energy can also be asked in JEE Advanced, student must go through study of criterion of spontaneity and entropy of system just like

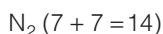
Calculate the enthalpy change of process when a sample of argon gas at 1 atm pressure and 27°C expands reversibly and adiabatically from 1.25 dm^3 to 2.50 dm^3 .

After solving the question by using ideal gas equation, and temperature volume relation for adiabatic expansion.

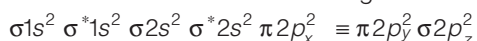
$$\text{i.e., } \frac{T_1}{T_2} = \left(\frac{V_2}{V_1}\right)^{\gamma-1} \quad \text{and } \Delta H = n C_p dT. \quad \text{One can get}$$

$$\text{answer} = -117.65$$

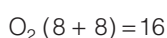
40. (2)  **Idea** This problem is based on concept of molecular orbital theory and molecular orbital electronic configuration of diatomic molecules. Students are advised to write molecular orbital electronic configuration of N_2 and NO so that they will be able to compare their bond order after removing one electron from NO .



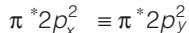
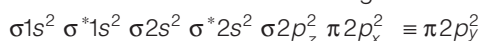
Molecular orbital electronic configuration of N_2



$$\text{Bond order} = \frac{10 - 4}{2} = 3$$



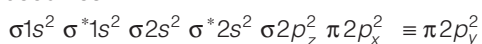
Molecular orbital electronic configuration of O_2



$$\text{Bond order} = \frac{10 - 6}{2} = 2$$


This is only possible if 2 electrons are removed from π antibonding molecular orbital.

The Molecular orbital electronic configuration of O_2^{2+} becomes



$$\text{Bond order} = \frac{10 - 4}{2} = 3$$

TEST Edge Similar problems based on conceptual mixing of molecular orbital theory, reducing, oxidising, nature of homonuclear as well as heteronuclear diatomic molecule can also be asked so students are advised to go through in depth study of information provided by molecular orbital electronic configuration of homonuclear and heteronuclear diatomic molecules.

41. (a)  **Idea** Here, we use to the concepts of progression AP and GP to find the value of a and b in terms of c which substitute in the trigonometric relation $\cos A = \frac{b^2 + c^2 - a^2}{2bc}$ to obtain the result. If $\cos A > 0$, then angle is acute and if $\cos A < 0$, then angle is obtuse.

$$\text{We have } b^2 = ac \quad \dots(i)$$

($\because a, b, c$ are in GP)

$$2(\log 2b - \log 3c) = \log a - \log 2b \\ + \log 3c - \log a \quad (\text{AP})$$

$$\Rightarrow 2 \log 2b - 2 \log 3c = \log 3c - \log 2b$$

$$\Rightarrow 3 \log 2b = 3 \log 3c$$

$$\Rightarrow 2b = 3c \quad \dots(ii)$$


From Eqs. (i) and (ii), we get

$$c = 4a/9$$

$$\text{Now, } \cos A = \frac{b^2 + c^2 - a^2}{2bc} \\ = \frac{\left(\frac{3c}{2}\right)^2 + c^2 - \left(\frac{9c}{4}\right)^2}{2 \times \frac{3}{2} c \times c} = \frac{-29}{48} < 0.$$

A is obtuse.

TEST Edge In JEE Advanced, the questions based on relation of the terms of AP, GP and HP and the sum of n terms are asked. So, to solve such types of questions you should learn concepts of AP, GP and HP and also acquainted yourself with properties of trigonometry, algebra, logarithm, etc. e.g., if x^3, y^3, z^3 are in AP and $\log_x y, \log_z x, \log_y z$ in GP also $xyz = 64$, then use the above concept to get $x = y = z = 4$.

42. (b)  **Idea** Here, we use the concept of greatest integer function i.e., $[x] = n$ if $n \leq x < n + 1$ to get integer less than or equal to the number from the given equation and find the values of x which satisfies the equation.

$$\text{Given equation is } \left[\frac{x}{2}\right] + \left[\frac{x}{3}\right] + \left[\frac{x}{5}\right] = \frac{31}{30}x \quad \dots(i)$$

$$\text{Now, } \frac{x}{2} + \frac{x}{3} + \frac{x}{5} = \frac{15x + 10x + 6x}{30} = \frac{31}{30}x \quad \dots(ii)$$

Also LHS of given Eq. (i) is integer

\therefore RHS is an integer

As evident from Eq. (ii) sum of $\frac{x}{2} + \frac{x}{3} + \frac{x}{5}$ is equal to


$$\frac{31}{30}x.$$

$\therefore \frac{x}{2}, \frac{x}{3}, \frac{x}{5}$ are all integers and $\frac{31}{30}x$ is also an integer

$\therefore x = \text{multiple of } 2, 3, 5 \text{ and } 30$

Thus, $x = 30 \times 1, 30 \times 2, \dots, 30 \times 33$

TEST Edge In JEE Advanced, question based on different type of functions such as smallest integer, modulus, even function, etc., are asked in terms of equation. So, to solve such types of question, acquainted yourself with the definition of different types of function and utilise it to solve the equation e.g., if $f(x) = \cos[\pi^2]x + \cos[-\pi^2]x$, then to evaluate $f\left(\frac{\pi}{2}\right)$ we utilise the concept of greatest integer function to obtain $[\pi^2] = 9$ and $[-\pi^2] = -10$ and get $f\left(\frac{\pi}{2}\right) = -1$.

43. (a)  **Idea** Here, we use the concept of arrangements to obtain different observations or results whose sum can be obtained by the sum of n terms of GP and equate it with the given sum to get the value of n .

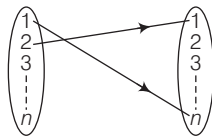
Given 2^{n-i} students gave wrong answer to atleast i questions.
 2^{n-1} students gave wrong answer to atleast 1 questions.
 2^{n-2} students gave wrong answer to atleast 2 questions.
 $2^{n-1} - 2^{n-2}$ students gave wrong answer to exactly one equation.

$$\begin{aligned} &(\text{exactly 1 wrong}) + (\text{exactly 2 wrong}) + \dots \\ &\quad + (\text{exactly } n \text{ wrong}) = 2047 \\ &1(2^{n-1} - 2^{n-2}) + 2[2^{n-2} - 2^{n-3}] + \dots \\ &\quad + (n-1)[2^1 - 2^0] + n(1) = 2047 \\ &1 \cdot 2^{n-1} + 1 \cdot 2^{n-2} + 1 \cdot 2^{n-3} + \dots + 1 \cdot 2^0 = 2047 \\ &\Rightarrow \frac{2^n - 1}{2 - 1} = 2047 \Rightarrow 2^n - 1 = 2047 \\ &\Rightarrow 2^n = 2048 \\ &\quad 2^n = 2^{11} \Rightarrow n = 11 \end{aligned}$$

TEST Edge The question based on fundamental theorem of arrangements are asked. So, to solve such types of questions we need to deduce various observations whose sum of n terms are in AP, GP and HP. So, students acquainted themselves with the concepts of arrangement and sum of series to get the desired result e.g., the value of the sum $\sum_{i=1}^{13} (i^n + i^{n+1})$, where $i = \sqrt{-1}$ can be obtain by the sum of GP and answer will get i.e., $i - 1$.

44. (c) **Idea** The number of mapping of a function having n elements is n^n and its one-one mappings is $n!$. According to the definition of probability $P(X) = \frac{\text{Favourable outcomes}}{\text{Total outcomes}}$.
 We get the probability that the mapping is one-one and equate it with given probability to get the value of n .

Total number of mappings = n^n
 We also know, number of one-one mappings = $n(n-1)(n-2)\dots, 3 \cdot 2 \cdot 1 = n!$



$$\begin{aligned} \therefore \text{ Required probability} &= \frac{n!}{n^n} \\ \Rightarrow \frac{3}{32} &= \frac{n!}{n^n} \\ \Rightarrow \frac{3}{2^5} &= \frac{n!}{n^n} \Rightarrow \frac{24}{2^8} = \frac{n!}{n^n} \\ \Rightarrow \frac{4!}{4^4} &= \frac{n!}{n^n} \Rightarrow n = 4 \end{aligned}$$

TEST Edge There are various types of mapping one-one onto, into, etc., of functions are asked. So, to solve such types of questions, students are advised to learn various types of function mappings and formula to get number of mappings and basics concept of probability to get the desired result e.g., If A is non-empty set in which number of elements is n , then

- (i) Number of functions from A to $A = n^n$
- (ii) Number of one-one function = $n!$
- (iii) Number of onto function = $\sum_{r=1}^n (-1)^{n-r} {}^n C_r r^n$

45. (c) **Idea** To solve this question, we first write the series in terms of binomial coefficients of $(1+x)^n$ and using the formula of sum of n terms of GP i.e., $S_n = a \left(\frac{r^n - 1}{r - 1} \right)$. [$\therefore r > 1$]

$$\begin{aligned} \text{Now, } \binom{n}{m} + \binom{n-1}{m} + \binom{n-2}{m} + \dots + \binom{m}{m} &\text{ can be written} \\ \text{as } {}^n C_m + {}^{n-1} C_m + {}^{n-2} C_m + \dots + {}^m C_m & \\ \text{We know } {}^n C_r &= \text{coefficient of } x^r \text{ in } (1+x)^n \\ \therefore {}^n C_m + {}^{n-1} C_m + \dots + {}^m C_m & \\ = \text{coefficient of } x^m \text{ in } (1+x)^n + \text{coefficient of } x^m &\text{ in } \\ (1+x)^{n-1} + \dots + \text{coefficient of } x^m \text{ in } (1+x)^m & \\ = \text{coefficient of } x^m \text{ in} & \\ [(1+x)^n + (1+x)^{n-1} + \dots + (1+x)^m] & \\ = \text{coefficient of } x^m \text{ in } (1+x)^n \left[\frac{(1+x)^{n-m+1} - 1}{1+x-1} \right] & \\ \text{[using sum of } n \text{ terms of GP]} & \\ = \text{coefficient of } x^{m+1} \text{ in } [(1+x)^{n+1} - (1+x)^m] & \\ = \text{coefficient of } x^{m+1} \text{ in } (1+x)^{n+1} & \\ = {}^{n+1} C_{m+1} & \end{aligned}$$

TEST Edge In JEE Advanced, questions based on binomial series and properties of binomial coefficient and sum of n terms of AP, GP and HP are asked. So, students are advised to learn important terms in binomial expansion such as general term, middle term, etc., and properties of binomial coefficients such as ${}^2 C_0 + {}^2 C_1 + {}^2 C_2 + \dots + {}^2 C_n = 2^n C_n$, etc. and formula to find sum of n terms of AP, GP and HP. e.g., $a, a+d, a+2d, \dots$ are in AP then $S_n = \frac{n}{2}[2a + (n-1)d]$.

46. (b) **Idea** We obtain the integral in the form of $\int \frac{px+q}{ax^2+bx+c} dx$ on substituting the value of P, Q, R in $P - \sqrt{2Q} + R$, express $ax^2 + bx + c$ as sum or difference of two squares and use substitution to convert it to standard integral form then apply limit to get desired result.

$$P - \sqrt{2}Q + R = \int_0^\infty \frac{x^2}{x^4 + 1} dx - \sqrt{2} \int_0^\infty \frac{x dx}{x^4 + 1} + \int_0^\infty \frac{dx}{x^4 + 1}$$

$$\Rightarrow \int_0^\infty \frac{x^2 - \sqrt{2}x + 1}{x^4 + 1} dx$$

$$\Rightarrow \int_0^\infty \frac{x^2 + 1}{x^4 + 1} dx - \sqrt{2} \int_0^\infty \frac{x dx}{x^4 + 1} \quad \dots(i)$$

$$I_1 = \int_0^\infty \frac{x^2 + 1}{x^4 + 1} dx, I_2 = \sqrt{2} \int_0^\infty \frac{x dx}{x^4 + 1}$$

$$\Rightarrow I_1 = \int_0^\infty \frac{x^2 \left(1 + \frac{1}{x^2}\right)}{x^2 \left[\left(x^2 + \frac{1}{x^2} - 2\right) + 2\right]} dx$$

$$\Rightarrow \int_0^\infty \frac{1 + \frac{1}{x^2}}{\left(x - \frac{1}{x}\right)^2 + 2} dx$$

$$\Rightarrow x - \frac{1}{x} = t$$

Differentiate on both sides

$$\left(1 + \frac{1}{x^2}\right) dx = dt$$

When $x = 0$ then $t = -\infty$

and $x = \infty$ then $t = \infty$

$$\int_{-\infty}^\infty \frac{dt}{t^2 + (\sqrt{2})^2}$$

$$\Rightarrow \frac{1}{\sqrt{2}} \left[\tan^{-1} \frac{t}{\sqrt{2}} \right]_{-\infty}^\infty \Rightarrow \frac{1}{\sqrt{2}} \left[\frac{\pi}{2} - \left(-\frac{\pi}{2}\right) \right]$$

$$\Rightarrow \frac{\pi}{\sqrt{2}}$$

Now, $I_2 = \sqrt{2} \int_0^\infty \frac{x dx}{1 + x^4}, x^2 = t$

$$2x dx = dt$$

$$x dx = \frac{dt}{2}$$

When $x = 0$ then $t = 0$

and $x = \infty$ then $t = \infty$

$$\Rightarrow \frac{1}{\sqrt{2}} \int_0^\infty \frac{dt}{1 + t^2}$$


$$\Rightarrow \frac{1}{\sqrt{2}} [\tan^{-1} t]_0^\infty$$

$$= \frac{1}{\sqrt{2}} \left[\frac{\pi}{2} - 0 \right] = \frac{\pi}{2\sqrt{2}}$$

Substituting values of I_1 and I_2 in Eq. (i) we get

$$\Rightarrow \frac{1}{\sqrt{2}} \left[\pi - \frac{\pi}{2} \right] \Rightarrow \frac{\pi}{2\sqrt{2}}$$

TEST Edge In JEE Advanced, integration of various types of functions such as trigonometric, exponential, etc based questions are asked. So, to solve such types of questions, students are advised to understand methods to convert different types of integrals of form $\int \frac{px + q}{ax^2 + bx + c} dx, \int \frac{px + q}{\sqrt{ax^2 + bx + c}},$ etc., into standard form by substitution and use standard formula of integration to get the result e.g., $\int \frac{1}{x^2 + a^2} dx = \frac{1}{a} \tan^{-1} \frac{x}{a}$ is one such standard result.

47. (a)  **Idea** To get the range of $f(7) + 17\cos x$ which involves different types of functions, we firstly obtain value of $f(7)$ from the equation of $f(x)$ and $f(-7)$ and use the principal value of $\cos x$ function i.e., $\cos x \in [-1, 1]$ to calculate the range of the given function.

$$f(7) = a(7)^7 + b(7)^3 + c(7) - 5$$

$$f(-7) = a(-7)^7 + b(-7)^3 + c(-7) - 5$$

$$f(7) + f(-7) = -10$$

and $f(-7) = 7$

$$\Rightarrow f(7) + 7 = -10 \Rightarrow f(7) = -17$$

$$\therefore f(7) + 17 \cos x = -17 + 17 \cos x = +17(\cos x - 1)$$

Now, $\cos x \in [-1, 1]$

$$\cos x - 1 \in [-2, 0]$$

$$17(\cos x - 1) \in [-34, 0]$$

TEST Edge The questions are asked to find domain and range of function which can be combination of various types of functions such as trigonometric function, algebraic function, etc. So, to solve such types of questions, students are advised to understand the concept of range and domain of the functions.

48. (a)  **Idea** Standard equation of the parabola is $y^2 = 4ax$.

Firstly, we convert given general equation into standard form and find the focus and use the concept of circle having focal chord as a diameter always touches the directrix of parabola.

Given parabola is $x^2 + 2x + 12y - 11 = 0$

$$\Rightarrow (x + 1)^2 = -12(y - 1)$$

Vertex $\equiv (-1, 1)$

Here, $4a = 12 \Rightarrow a = 3$

\therefore For focus, $x + 1 = 0, y - 1 = -3$

$$x = -1, y = -2$$

Focus $\equiv (-1, -2)$

Thus, the chord passing through the point $(-1, -2)$ is a focal chord of the parabola.

\therefore Circle having focal chord of a parabola as diameter always touches the directrix of parabola.

TEST Edge In JEE Advanced, questions based on basic properties of parabola and circle are asked. So, students are advised to understand all concepts related to parabola and properties of circle respective of parabola and also learn to deduce information from the general equation of parabola *i.e.*, focal chord, directrix, latus rectum, etc.

49. (b) **Idea** In this question, differential equation is given in exponential series form, so we first reduce it to exponential function then find the solution by the method of variable separation and concept of integration by substitution.

$$x^2 + 3 = 1 + \left(\frac{2x}{y}\right)^{-1} \frac{dy}{dx} + \frac{\left(\frac{2x}{y}\right)^{-2} \left(\frac{dy}{dx}\right)^2}{2!} + \frac{\left(\frac{2x}{y}\right)^{-3} \left(\frac{dy}{dx}\right)^3}{3!} + \dots$$

$$\Rightarrow x^2 + 3 = 1 + \frac{\left(\frac{y}{2x}\right) \left(\frac{dy}{dx}\right)}{1!} + \frac{\left(\frac{y}{2x}\right)^2 \left(\frac{dy}{dx}\right)^2}{2!} + \frac{\left(\frac{y}{2x}\right)^3 \left(\frac{dy}{dx}\right)^3}{3!} + \dots$$

$$\Rightarrow x^2 + 3 = e^{\left(\frac{y}{2x}\right) \left(\frac{dy}{dx}\right)} \left[\because e^x = 1 + \frac{x}{1!} + \frac{x^2}{2!} + \dots \right]$$

$$\Rightarrow \log_e (x^2 + 3) = \left(\frac{y}{2x}\right) \frac{dy}{dx}$$

Separating the variables, we get

$$\Rightarrow 2x \log_e (x^2 + 3) dx = y dy$$

On integrating both sides, we get

$$\Rightarrow \int 2x \log_e (x^2 + 3) dx = \int y dy$$

$$\text{Put, } x^2 + 3 = t \Rightarrow 2x dx = dt$$

$$\Rightarrow \int \log_e t dt = \int y dy$$

$$\Rightarrow t \cdot \log_e (t) - t = \frac{y^2}{2} + C$$

$$\Rightarrow (x^2 + 3) \log_e (x^2 + 3) - (x^2 + 3) = \frac{y^2}{2} + C$$

$$\Rightarrow (x^2 + 3) (\log_e (x^2 + 3) - 1) = \frac{y^2}{2} + C$$

$$\Rightarrow (x^2 + 3) \left(\log_e \left(\frac{x^2 + 3}{e} \right) \right) = \frac{y^2}{2} + C$$

TEST Edge In JEE Advanced, question based on solution of differential equation in combination with its representation in various mathematical series form *i.e.*, logarithmic, sine function, etc., are asked. So, students are advised to learn various types of mathematical series and concept of integration by substitution, partial method and method to find the solution of differential equation.

50. (b) **Idea** This question involves the concept of modulus of the complex number. To solve it apply the basic algebraic formula to deduce the desired result.

Given, $z = a + i b$
 $|z| = \sqrt{a^2 + b^2}$
 $|z|^2 = a^2 + b^2 \dots(i)$

Now, $(a - b)^2 \geq 0 \Rightarrow a^2 + b^2 - 2ab \geq 0$
 $\Rightarrow a^2 + b^2 \geq 2ab \dots(ii)$

From Eqs. (i) and (ii), we get

$$|z|^2 \geq 2ab$$

Also, $|z|^2 + a^2 + b^2 \geq a^2 + b^2 + 2ab$

$$|z|^2 + |z|^2 \geq (a + b)^2$$

$$2|z|^2 \geq (a + b)^2$$

$$|z| \geq \frac{1}{\sqrt{2}} (a + b)$$

TEST Edge The questions based on properties of modulus are asked to prove or find any algebraic relations. So, students are advised to understand algebra of complex number, its polar representation and properties of modulus and basic formula of algebra.

$$\text{Such as } |z_1 z_2| = |z_1| |z_2|$$

51. (a,b) **Idea** Three coplanar vectors **a**, **b** and **c** and relation of its sum and with other vectors **p**, **q**, **r** are given in the question. Firstly, we take vectors **p**, **q**, **r** values which satisfy the given relation and equate it with vectors **p**, **q**, **r** and take modulus of sum of vectors. Then, we use the concept of $AM \geq GM$ to get the result.

Let **a**, **b**, **c** lie in the *xy*-plane.

$$\text{Let } \mathbf{a} = -1/2 \hat{i} + \frac{\sqrt{3}}{2} \hat{j}, \mathbf{b} = -\frac{1}{2} \hat{i} - \frac{\sqrt{3}}{2} \hat{j} \text{ and } \mathbf{c} = \hat{i}$$

$$\text{Then, } |\mathbf{p} + \mathbf{q} + \mathbf{r}| = |\lambda \mathbf{a} + \mu \mathbf{b} + r \mathbf{c}|$$

$$= \left| \lambda \left(-\frac{1}{2} \hat{i} + \frac{\sqrt{3}}{2} \hat{j} \right) + \mu \left(-\frac{1}{2} \hat{i} - \frac{\sqrt{3}}{2} \hat{j} \right) + r \hat{i} \right|$$

$$= \left| \hat{i} \left(-\frac{1}{2} \lambda - \frac{\mu}{2} + r \right) + \hat{j} \left(\frac{\sqrt{3}}{2} \lambda - \frac{\sqrt{3}}{2} \mu \right) \right|$$

$$= \sqrt{\left(-\frac{\lambda}{2} - \frac{\mu}{2} + r \right)^2 + \left(\frac{\sqrt{3}}{2} \lambda - \frac{\sqrt{3}}{2} \mu \right)^2}$$

$$= \sqrt{\frac{\lambda^2}{4} + \frac{\mu^2}{4} + r^2 + 2 \left(\frac{-\lambda}{2} \right) \left(\frac{-\mu}{2} \right)}$$


$$+ 2 \left(\frac{-\lambda}{2} \right) (r) + 2 \left(\frac{-\mu}{2} \right) r + \frac{3}{4} (\lambda^2 + \mu^2 - 2\lambda\mu)$$

$$= \sqrt{\lambda^2 + \mu^2 + r^2 - \lambda\mu - \lambda r - \mu r}$$

$$= \frac{1}{\sqrt{2}} \sqrt{(\lambda - \mu)^2 + (\mu - r)^2 + (r - \lambda)^2} \geq \frac{1}{\sqrt{2}} \sqrt{1+1+4} = \sqrt{3}$$

$$\Rightarrow |\mathbf{p} + \mathbf{q} + \mathbf{r}| \text{ can take values equal to } \sqrt{3} \text{ and } 2.$$

TEST Edge In JEE Advanced, questions based on different types of vectors and its relation and combination with arithmetic and geometric mean are asked. So, students are advised to learn about different types of vectors, calculate magnitude of vectors and properties of arithmetic and geometric progression.

52. (c,d)  **Idea** As functions are in AP, so we use the formula such as $2b = a + c$, first we find the relation between terms of AP and then its derivative to get the desired result.

Since $f(x - y), f(x) f(y), f(x + y)$ are in AP.

$$\Rightarrow f(x - y) + f(x + y) = 2f(x) f(y) \quad \forall x, y \quad \dots(i)$$

Putting $x = 0 = y$

We have

$$f(0) + f(0) = 2[f(0)]^2$$

$$2f(0) = 2[f(0)]^2$$

$$\Rightarrow f(0) = 1 \quad [\because f(0) \neq 0]$$

Putting $x = 0, y = x$ in (i), we have

$$f(-x) + f(x) = 2f(0) f(x)$$

$$f(-x) + f(x) = 2f(x)$$

$$\Rightarrow f(-x) = f(x) \quad \dots(ii)$$

$$\therefore f(-4) = f(4)$$


Differentiating of Eq. (ii) w.r.t x , we have

$$-f'(-x) = f'(x)$$

$$\Rightarrow f'(x) + f'(-x) = 0$$

$$\therefore f'(4) + f'(-4) = 0$$

TEST Edge In JEE Advanced, questions based on different progression i.e., AP, GP and HP and basic rule of derivatives are asked to prove certain results. So, students should acquainted themselves with the information and properties of progression and basic formulae of derivatives of function to solve these questions.

53. (a,b,c,d)  **Idea** Given three numbers a, b, c are in HP and we need to prove the relations among them given in the options are true or false. So, we know the relationship between AM, GM and HM combining all relations, we deduce the correctness of the options.

b is the harmonic mean of a and c

We know $GM > HM$

$$\sqrt{ac} > b$$

also AM of a^n and $c^n > GM$ of a^n and c^n .

Interval	value in the interval	value of $f'(x)$	sign of $f'(x)$
$(0, \infty)$	1	$3 + 2(p^2 + q^2 + r^2)$	positive
$\left(\frac{-2(p^2 + q^2 + r^2)}{3}, 0\right)$	$-\frac{1}{3}(p^2 + q^2 + r^2)$	$-\frac{5}{9}(p^2 + q^2 + r^2)$	negative
$\left(-\infty, -\frac{2}{3}(p^2 + q^2 + r^2)\right)$	$-(p^2 + q^2 + r^2)$	$(p^2 + q^2 + r^2)^2$	positive


$$\frac{a^n + c^n}{2} > \sqrt{a^n c^n}$$

$$\Rightarrow a^n + c^n > 2(\sqrt{ac})^n > 2b^n.$$

Putting $n = 4, 5, 100, 3$

We get the required options.

TEST Edge Questions based on different progression i.e., AP, GP and HP are asked on the basis of it we need to find some relation. So, it is advisable to the students to understand these progressions and relationships of its mean and various results which can be deduce by their combinations, e.g. if A, G, H are AM, GM, HM of two positive numbers then $A \geq G \geq H$ and $G^2 = AH$.

54. (a,b,c)  **Idea** This question involves the concept of determinants and application of derivatives. Differentiate the given function $f(x)$ and equate $f'(x) = 0$ to find point of maxima or minima and interval in which $f(x)$ is increasing and decreasing.

$$f(x) = \begin{vmatrix} x + p^2 & pq & pr \\ pq & x + q^2 & qr \\ pr & qr & x + r^2 \end{vmatrix}$$

$$f'(x) = \begin{vmatrix} 1 & 0 & 0 \\ pq & x + q^2 & qr \\ pr & qr & x + r^2 \end{vmatrix}$$

$$+ \begin{vmatrix} x + p^2 & pq & pr \\ 0 & 1 & 0 \\ pr & qr & x + r^2 \end{vmatrix}$$

$$+ \begin{vmatrix} x + p^2 & pq & pr \\ pq & x + q^2 & qr \\ 0 & 0 & 1 \end{vmatrix}$$

$$= 3x^2 + 2(p^2 + q^2 + r^2)x$$

Putting $f'(x) = 0$


$$\Rightarrow x = 0, x = -\frac{2(p^2 + q^2 + r^2)}{3}$$

Clearly, $f'(x) > 0$ for $x \in (0, \infty)$

$$f'(x) < 0 \text{ for } x \in \left(-\frac{2}{3}(p^2 + q^2 + r^2), 0\right)$$

$$f'(x) > 0 \text{ for } x \in \left(-\infty, -\frac{2}{3}(p^2 + q^2 + r^2)\right)$$

TEST Edge In JEE Advanced, questions based on properties of determinants and application of derivatives are asked. To solve such types of questions, students are advised to learn properties of determinants and also acquainted yourself with the concept of increasing and decreasing functions with the use of derivatives and basic theorem such as $f(x)$ is increasing in (a, b) , if $f'(x) > 0 \forall x \in (a, b)$.

55. (a, c)  **Idea** To solve this question, students are advised to use the quadratic formula, If $ax^2 + bx + c = 0$, then $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$ to find the root of the equation and use trigonometric relation $\sin 2x = 2 \sin x \cos x$.

It is given that $\cos \alpha$ is root of equation $25x^2 + 5x - 12 = 0, -1 < x < 0$

Now, $25x^2 + 5x - 12 = 0$

$$x = \frac{-5 \pm \sqrt{25 + 1200}}{50}$$

$$= \frac{-5 \pm \sqrt{1225}}{50}$$

$$x = \frac{-5 \pm 35}{50} \Rightarrow x = \frac{30}{50}, \frac{-40}{50}$$


$$x = \frac{15}{25}, \frac{-20}{25}$$

$$-1 < x < 0$$

$$\cos \alpha = \frac{-20}{25}$$

$$\sin 2\alpha = 2 \sin \alpha \cos \alpha = \frac{24}{25}, \text{ or } \frac{-24}{25}$$

TEST Edge Questions based on quadratic formula and basic trigonometric relations are asked. To solve such types of questions, students are advised to understand the concept quadratic formula and its various roots *i.e.*, real, complex and also learn basic formulae of trigonometry such as $\sin^2 x + \cos^2 x = 1, 1 + \tan^2 x = \sec^2 x$ etc.

56. (1)  **Idea** This question involves the concept of dot product of vectors *i.e.*, $\mathbf{a} \cdot \mathbf{b} = |\mathbf{a}| |\mathbf{b}| \cos \theta$ and Geometric Progression (GP) *i.e.*, $b^2 = ac$ if a, b, c are in GP, Now applying both the concepts to get the magnitude of vector $|\mathbf{u}|$.

Given, the angle between \mathbf{u} and $\hat{\mathbf{i}}$ is 60°

$$\therefore \mathbf{u} \cdot \hat{\mathbf{i}} = |\mathbf{u}| |\hat{\mathbf{i}}| \cos 60^\circ = \frac{|\mathbf{u}|}{2}$$

We are also given that

$|\mathbf{u} - \hat{\mathbf{i}}|$ is the geometric mean of $|\mathbf{u}|$ and $|\mathbf{u} - 2\hat{\mathbf{i}}|$

$$\therefore |\mathbf{u} - \hat{\mathbf{i}}|^2 = |\mathbf{u}| |\mathbf{u} - 2\hat{\mathbf{i}}|$$

Squaring both sides, we have

$$[|\mathbf{u}|^2 + |\hat{\mathbf{i}}|^2 - 2\mathbf{u} \cdot \hat{\mathbf{i}}]^2 = |\mathbf{u}|^2 [|\mathbf{u}|^2 + 4|\hat{\mathbf{i}}|^2 - 4\mathbf{u} \cdot \hat{\mathbf{i}}]$$

$$\left[|\mathbf{u}|^2 + 1 - \frac{2|\mathbf{u}|}{2} \right]^2 = |\mathbf{u}|^2 \left[|\mathbf{u}|^2 + 4 - 4 \frac{|\mathbf{u}|}{2} \right]$$

$$|\mathbf{u}|^4 + 1 + |\mathbf{u}|^2 + 2|\mathbf{u}|^2 - 2|\mathbf{u}|^3 - 2|\mathbf{u}|$$


$$= |\mathbf{u}|^4 + 4|\mathbf{u}|^2 - 2|\mathbf{u}|^3$$

$$|\mathbf{u}|^2 + 2|\mathbf{u}| - 1 = 0$$

$$\Rightarrow |\mathbf{u}| = \frac{-2 \pm 2\sqrt{2}}{2} \Rightarrow |\mathbf{u}| = \sqrt{2} - 1$$

$$\therefore (\sqrt{2} + 1)|\mathbf{u}| = (\sqrt{2} + 1)(\sqrt{2} - 1) = 2 - 1 = 1$$

TEST Edge Dot and cross product based questions of vectors and sequence and series, its properties are asked. So, students are advised to understand the basic concept of vectors algebra, scalar triple products etc., and also acquainted yourself with the properties of sequence and series. For *e.g.*, if V be the volume of paralleloiped formed by the vectors $\mathbf{a} = a_1\hat{\mathbf{i}} + a_2\hat{\mathbf{j}} + a_3\hat{\mathbf{k}}, \mathbf{b} = b_1\hat{\mathbf{i}} + b_2\hat{\mathbf{j}} + b_3\hat{\mathbf{k}}$ and $\mathbf{c} = c_1\hat{\mathbf{i}} + c_2\hat{\mathbf{j}} + c_3\hat{\mathbf{k}}$ and $\sum_{r=1}^3 (a_r + b_r + c_r) = 3L$, then to prove $V \leq L^3$. We use the concept of scalar product and $AM \geq GM$.

57. (0)  **Idea** Firstly, we apply the concept of AP to reduce the given series as $a_n = a + (n-1)d$, is the n th term of AP. Then, the concept of binomial expansion $(x+y)^n = {}^nC_0 x^n + {}^nC_1 x^{n-1}y + {}^nC_2 x^{n-2}y^2 + \dots + {}^nC_r x^{n-r}y^r + \dots + {}^nC_n y^n = \sum_{r=0}^n {}^nC_r x^{n-r}y^r$ and properties of binomial concept such as $r^n C_r = n^{n-1} C_{r-1}$ to solve the question.

Consider the given series

$${}^{2013}C_0 - 8 {}^{2013}C_1 + 15 {}^{2013}C_2 - 22 {}^{2013}C_3 + \dots$$

upto 2014 terms

$$\text{Clearly, sum of series} = \sum_{r=0}^{2013} (-1)^r (7r + 1) {}^{2013}C_r$$

$$= 7 \sum_{r=0}^{2013} (-1)^r {}^{2013}C_r r + \sum_{r=0}^{2013} (-1)^r {}^{2013}C_r$$

$$= 7 \left(0 + \sum_{r=0}^{2013} (-1)^r {}^{2013}C_r r \right) + \sum_{r=0}^{2013} (-1)^r {}^{2013}C_r$$


$$= 7 \left(\sum_{r=0}^{2013} (-1)^r {}^{2013} {}^{2012}C_{r-1} \right) + \sum_{r=0}^{2013} (-1)^r {}^{2013}C_r$$

$$[\because r {}^n C_r = n {}^{n-1} C_{r-1}]$$

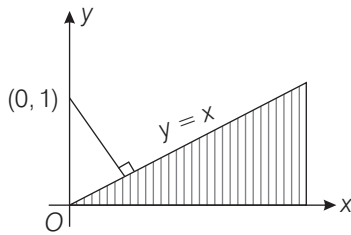
$$= 7 \times 2013 \left(\sum_{r=0}^{2013} (-1)^r (-1)^r {}^{2012}C_{r-1} \right) + \sum_{r=0}^{2013} (-1)^r {}^{2013}C_r$$

$$= 7 \times 2013 \times 0 + 0 = 0$$

TEST Edge In JEE Advanced, questions based on binomial expansion and properties of binomial coefficient are asked. To solve such types of questions, students are advised to understand binomial theorem, important terms in the binomial expansions and properties of binomial coefficients such as $C_0 + C_1 + C_2 + \dots + C_n = 2^n, C_0 + C_2 + C_4 + \dots = C_1 + C_3 + C_5 + \dots = 2^{n-1}$, etc.

58. (1)  **Idea** Represent the locus of $z - i$ in the arg and plane such that $0 \leq \arg z \leq \frac{\pi}{4}$ and use the formula $\frac{a\bar{z}_1 + \bar{a}z_2 + b}{z|a|}$ to find the length of perpendicular from a point z_1 to the line $a\bar{z} + \bar{a}z + b = 0$

The shaded region represent




$$0 \leq \arg z \leq \pi/4$$

The least value of $|z - i|$ is the length of perpendicular from $(0, 1)$ to the line $y = x$ i.e., $x - y = 0$

$$\perp \text{ distance} = \left| \frac{0 - 1}{\sqrt{1 + 1}} \right| = \frac{1}{\sqrt{2}}$$

$$\therefore \sqrt{2} |z - i| = \sqrt{2} \left(\frac{1}{\sqrt{2}} \right) = 1$$

TEST Edge The question based on geometrical representation of complex numbers on the arg and plane are asked in JEE Advanced. To solve such types of questions, students are advised to learn geometrical representation of complex number and its interpretation a line and circle. For e.g., equation of circle having centre z_0 and radius r is $|z - z_0| = r$ or $z\bar{z} - z_0\bar{z} + z_0z - r^2 = 0$

59. (6)  **Idea** Nature of roots of the quadratic equation is found by the value of discriminant i.e., $D \geq 0$ for real roots and concept of AP whose terms are $a, a + d, a + 2d \dots$ if series is increasing are used to find ratio of $\frac{d}{a}$.

$$ax^2 + (a + d)x + (a + 2d) = 0$$

Given, $a, a + d, a + 2d$ are in increasing AP ($d > 0$).

\therefore For real roots $D \geq 0$.

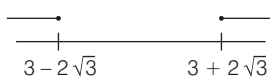
$$\Rightarrow (a + d)^2 - 4a(a + 2d) \geq 0.$$

$$\Rightarrow d^2 - 6ad - 3a^2 \geq 0.$$

$$\Rightarrow (d - 3a)^2 - 12a^2 \geq 0$$

$$\Rightarrow (d - 3a + 2\sqrt{3}a)(d - 3a - 2\sqrt{3}a) \geq 0$$


$$\Rightarrow \left[\frac{d}{a} - (3 + 2\sqrt{3}) \right] \left[\frac{d}{a} - (3 - 2\sqrt{3}) \right] \geq 0$$

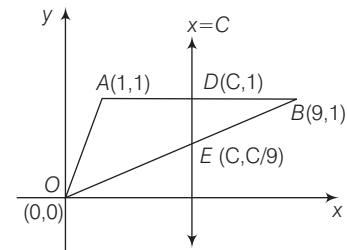


$$\text{Min value of } \frac{d}{a} = 3 + 2\sqrt{3} \quad (d > 0)$$

$$\Rightarrow \text{least integral value of } d/a = 6$$

TEST Edge In JEE Advanced, questions based on nature of roots of quadratic equations and also related to the terms of AP, GP and HP are asked. So, students are advised to understand the different roots of quadratic equation, i.e., real, equal or complex roots and also acquainted yourself with the concept of progression such as sum of n terms, n^{th} term of AP, GP or HP etc.

60. (3)  **Idea** Represent the given vertices of triangle on Cartesian plane and use the formula, Area of triangle = $\frac{1}{2} \times \text{Base} \times \text{Altitude}$. To find the area of the region formed by the line $x = C$ cuts this triangle.



$$\text{ar}(\Delta OAB) = \frac{1}{2} (8)(1).$$

$$= 4 \text{ sq. units}$$

Equation of OB ,

$$y - 0 = \frac{1}{9}(x - 0)$$

$$y = \frac{1}{9}x$$

Hence, point E is $\left(C, \frac{1}{9}C \right)$

Now, area $(\Delta BDE) = 2$

$$\Rightarrow \frac{1}{2} \left(1 - \frac{C}{9} \right) (9 - C) = 2$$

$$\Rightarrow (9 - C)^2 = 36$$

$$\Rightarrow 9 - C = \pm 6$$

$$\Rightarrow 9 \mp 6 = C$$

$$\Rightarrow C = 3$$

$$C = 15$$

$$\Rightarrow C = 3$$

TEST Edge In JEE Advanced, question based on equation of straight line in various forms and area of the region formed on its representation on Cartesian plane are asked.

So, to solve such types of questions, learn equation of straight lines in various forms such as parametric form, slope-intercept form, etc., and its representation on Cartesian plane. For e.g., equation of a straight line in perpendicular form as $x \cos p + y \sin p = \alpha$.