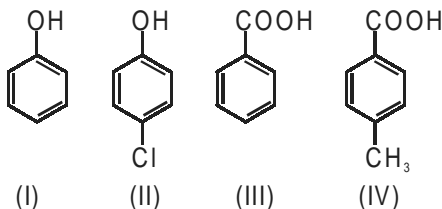


Part – I
Section – I
Single Correct Choice Type

Chemistry

This section contains 8 multiple choice questions. Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which **ONLY ONE** is correct.

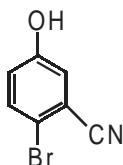
1. Among cellulose, poly(vinyl chloride), nylon and natural rubber, the polymer in which the intermolecular force of attraction is weakest is
(A) Nylon (B) Poly (vinyl chloride)
(C) Cellulose (D) Natural Rubber
2. The reaction of P_4 with X leads selectively to P_4O_6 . The X is
(A) Dry O_2 (B) A mixture of O_2 and N_2
(C) Moist O_2 (D) O_2 in the presence of aqueous NaOH
3. The Henry's law constant for the solubility of N_2 gas in water at 298 K is 1.0×10^5 atm. The mole fraction of N_2 in air is 0.8. The number of moles of N_2 from air dissolved in 10 moles of water at 298 K and 5 atm pressure is
(A) 4.0×10^{-4} (B) 4.0×10^{-5} (C) 5.0×10^{-4} (D) 4.0×10^{-6}
4. Among the electrolytes Na_2SO_4 , $CaCl_2$, $Al_2(SO_4)_3$ and NH_4Cl , the most effective coagulating agent for Sb_2S_3 sol is
(A) Na_2SO_4 (B) $CaCl_2$ (C) $Al_2(SO_4)_3$ (D) NH_4Cl
5. The correct acidity order of the following is



- (A) (III) > (IV) > (II) > (I) (B) (IV) > (III) > (I) > (II)
(C) (III) > (II) > (I) > (IV) (D) (II) > (III) > (IV) > (I)
6. The term that corrects for the attractive forces present in a real gas in the van der Waals equation is
(A) nb (b) $\frac{an^2}{V^2}$ (C) $-\frac{an^2}{V^2}$ (d) -nb

Chemistry

7. The IUPAC name of the following compound is



- (A) 4-Bromo-3-cyanophenol (B) 2-Bromo-5-hydroxybenzonitrile
(C) 2-Cyano-4-hydroxybromobenzene (D) 6-Bromo-3-hydroxybenzonitrile
8. Given that the abundances of isotopes ^{54}Fe , ^{56}Fe and ^{57}Fe are 5%, 90% and 5%, respectively, the atomic mass of Fe is
(A) 55.85 (B) 55.95 (C) 55.75 (D) 56.05

Section – II Multiple Correct Choice Type

This section contains 4 multiple choice questions. Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which **ONE OR MORE** is/are correct.

9. The correct statement(s) regarding defects in solids is(are)
(A) Frenkel defect is usually favoured by a very small difference in the sizes of cation and anion.
(B) Frenkel defect is a dislocation defect.
(C) Trapping of an electron in the lattice leads to the formation of F-center.
(D) Schottky defects have no effect on the physical properties of solids.
10. The correct statement(s) about the compound $\text{H}_3\text{C}(\text{HO})\text{HC}-\text{CH}=\text{CH}-\text{CH}(\text{OH})\text{CH}_3$ (X) is (are)
(A) The total number of stereoisomers possible for X is 6.
(B) The total number of diastereomers possible for X is 3.
(C) If the stereochemistry about the double bond in X is *trans*, the number of enantiomers possible for X is 4.
(D) If the stereochemistry about the double bond in X is *cis*, the number of enantiomers possible for X is 2.
11. The compound(s) formed upon combustion of sodium metal in excess air is(are)
(A) NaO_2 (B) Na_2O (C) NaO (D) NaOH
12. The compound(s) that exhibit(s) geometrical isomerism is(are)
(A) $[\text{Pt}(\text{en})\text{Cl}_2]$ (B) $[\text{Pt}(\text{en})_2]\text{Cl}_2$ (C) $[\text{Pt}(\text{en})_2\text{Cl}_2]\text{Cl}_2$ (D) $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$

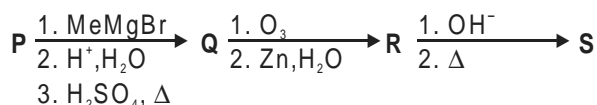
Section – III
Comprehension Type

Chemistry

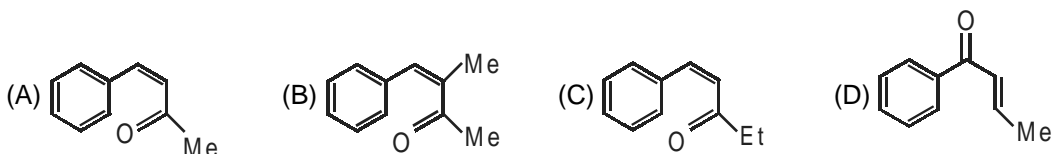
This section contains 2 groups of questions. Each group has 3 multiple choice questions based on a paragraph. Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which **ONLY ONE** is correct.

Paragraph for Question Nos. 13 to 15

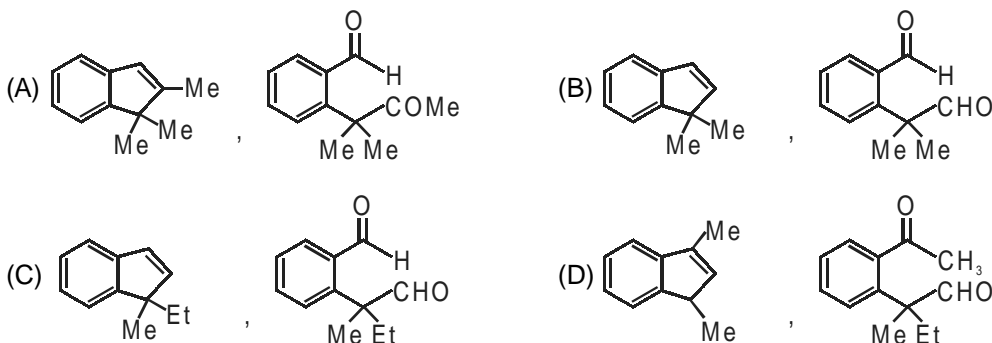
A carbonyl compound **P**, which gives positive iodoform test, undergoes reaction with MeMgBr followed by ehydration to give an olefin **Q**. Ozonolysis of **Q** leads to a dicarbonyl compound **R**, which undergoes intramolecular aldol reaction to give predominantly **S**.



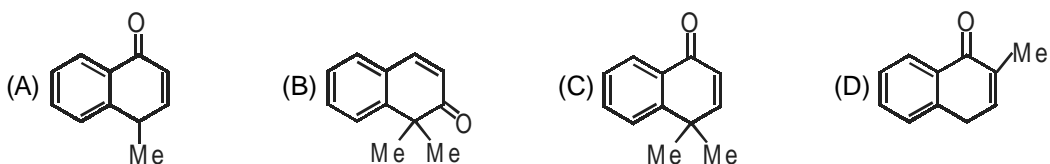
13. The structure of the carbonyl compound **P** is



14. The structures of the products **Q** and **R**, respectively, are



15. The structure of the product **S** is



Chemistry

Passage for Questions Nos. 16 to 18

p-Amino-*N*, *N*-dimethylaniline is added to a strongly acidic solution of **X**. The resulting solution is treated with a few drops of aqueous solution of **Y** to yield blue coloration due to the formation of methylene blue. Treatment of the aqueous solution of **Y** with the reagent potassium hexacyanoferrate (II) leads to the formation of an intense blue precipitate. The precipitate dissolves on excess addition of the reagent. Similarly, treatment of the solution of **Y** with the solution of potassium hexacyanoferrate(III) leads to a brown coloration due to the formation of **Z**.

16. The compound **X** is
(A) NaNO_3 (B) NaCl (C) Na_2SO_4 (D) Na_2S
17. The compound **Y** is
(A) MgCl_2 (B) FeCl_2 (C) FeCl_3 (D) ZnCl_2
18. The compound **Z** is
(A) $\text{Mg}_2[\text{Fe}(\text{CN})_6]$ (B) $\text{Fe}[\text{Fe}(\text{CN})_6]$ (C) $\text{Fe}_4[\text{Fe}(\text{CN})_6]_3$ (D) $\text{K}_2\text{Zn}_3[\text{Fe}(\text{CN})_6]_2$

Section – IV Matrix-Match Type

This section contains 2 questions. Each question contains statements given in two columns, which have to be matched. The statements in **Column I** are labelled A, B, C and D, while the statements in **Column II** are labelled p, q, r, s and t. Any given statement in **Column I** can have correct matching with **ONE OR MORE** statement(s) in **Column II**. The appropriate bubbles corresponding to the answers to these questions have to be darkened as illustrated in the following example :

If the correct matches are A–p, s and t; B – q and r; C – p and q; and D – s and t; then the correct darkening of bubbles will look like the following :

	p	q	r	s	t
A	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input checked="" type="radio"/>
B	<input type="radio"/>	<input checked="" type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
C	<input checked="" type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
D	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input checked="" type="radio"/>

19. Match each of the compounds in **Column I** with its characteristic reaction(s) in **Column II**.

Column I

- a. $\text{CH}_3\text{CH}_2\text{CH}_2\text{CN}$
- b. $\text{CH}_3\text{CH}_2\text{OCOCH}_3$
- c. $\text{CH}_3 - \text{CH} = \text{CH} - \text{CH}_2\text{OH}$
- d. $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{NH}_2$

Column II

- p. Reduction with $\text{Pd} - \text{C}/\text{H}_2$
- q. Reduction with SnCl_2/HCl
- r. Development of foul smell on treatment with chloroform and alcoholic KOH .
- s. Reduction with diisobutylaluminium hydride (DIBAL-H)
- t. Alkaline hydrolysis

20. Match each of the diatomic molecules in **Column I** with its property/properties in **Column II**.

Column I

- a. B_2
- b. N_2
- c. O_2^-
- d. O_2

Column II

- p. Paramagnetic
- q. Undergoes oxidation
- r. Undergoes reduction
- s. Bond order ≥ 2
- t. Mixing of 's' and 'p' orbitals

This section contains 8 multiple choice questions. Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which **ONLY ONE** is correct.

21. Tangents drawn from the point $P(1, 8)$ to the circle $x^2 + y^2 - 6x - 11 = 0$ touch circle at the points A and B. The equation of the circumcircle of the triangle PAB is.
 (A) $x^2 + y^2 + 4x - 6y + 19 = 0$ (B) $x^2 + y^2 - 4x - 10y + 19 = 0$
 (C) $x^2 + y^2 + 2x + 6y - 29 = 0$ (D) $x^2 + y^2 + 6x - 4y + 19 = 0$
22. The number of seven digit integers, with sum of the digits equal to 10 and formed by using the digits 1, 2 and 3 only, is
 (A) 55 (B) 66 (C) 77 (D) 88
23. Let $P(3, 2, 6)$ be a point in space and Q be point on the line $\vec{r} = (\hat{i} - \hat{j} + 2\hat{k}) + \mu(-3\hat{i} + \hat{j} + 5\hat{k})$
 Then the value of μ for which the vector \overrightarrow{PQ} is parallel to the plane $x - 4y + 3z = 1$ is
 (A) $\frac{1}{4}$ (B) $-\frac{1}{4}$ (C) $\frac{1}{8}$ (D) $-\frac{1}{8}$
24. Let $z = \cos \theta + i \sin \theta$. Then the value of $\sum_{m=1}^{15} \operatorname{Im}(z^{2m-1})$ at $\theta = 2^\circ$ is
 (A) $\frac{1}{\sin 2^\circ}$ (B) $\frac{1}{3 \sin 2^\circ}$ (C) $\frac{1}{2 \sin 2^\circ}$ (D) $\frac{1}{4 \sin 2^\circ}$
25. Let $z = x + iy$ be a complex number where x and y are integers. Then the area of the rectangle whose vertices are the roots of the equation $zz + \bar{z}z^3 = 350$ is
 (A) 48 (B) 32 (C) 40 (D) 80
26. IF $\vec{a}, \vec{b}, \vec{c}$ and \vec{d} are unit vectors such that $(\vec{a} \times \vec{b}) \cdot (\vec{c} \times \vec{d}) = 1$ and $\vec{a} \cdot \vec{b} = \frac{1}{2}$, then
 (A) $\vec{a}, \vec{b}, \vec{c}$ are non-coplanar (B) $\vec{a}, \vec{c}, \vec{d}$ are non-coplanar
 (C) \vec{b}, \vec{d} are non-parallel (D) \vec{a}, \vec{d} are parallel; and \vec{b}, \vec{c} are parallel.

27. Let f be a non-negative function defined on the interval $[0, 1]$. If $\int_0^x \sqrt{1 - (f'(t))^2} dt = \int_0^x f(t) dt, 0 \leq x \leq 1$,

and $f(0) = 0$, then

(A) $f\left(\frac{1}{2}\right) < \frac{1}{2}$ and $f\left(\frac{1}{3}\right) > \frac{1}{3}$

(B) $f\left(\frac{1}{2}\right) > \frac{1}{2}$ and $f\left(\frac{1}{3}\right) > \frac{1}{3}$

(C) $f\left(\frac{1}{2}\right) < \frac{1}{2}$ and $f\left(\frac{1}{3}\right) < \frac{1}{3}$

(D) $f\left(\frac{1}{2}\right) > \frac{1}{2}$ and $f\left(\frac{1}{3}\right) < \frac{1}{3}$

28. The line passing through the extremity A of the major axis and extremity B of the minor axis of the ellipse $x^2 + 9y^2 = 9$ meets its auxiliary circle at the point M. Then the area of the triangle with vertices at A, M and the origin O is

(A) $\frac{31}{10}$

(B) $\frac{29}{10}$

(C) $\frac{21}{10}$

(D) $\frac{27}{10}$

SECTION - II

Multiple Correct Choice Type

This section contains 4 multiple choice questions. Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which ONE OR MORE is/are correct.

29. In a triangle ABC with fixed base BC, the vertex A moves such that $\cos B + \cos C = 4 \sin^2 \frac{A}{2}$. If a,

b and c denote the lengths of the sides of the triangle opposite to the angles a, B and C, respectively, then

(A) $b + c = 4a$

(B) $b + c = 2a$

(C) locus of point A is an ellipse

(D) locus of point A is a pair of straight lines.

30. Area of the region bounded by the curve $y = e^x$ and lines $x = 0$ and $y = e$ is

(A) $e - 1$

(B) $\int_1^e \ln(e+1-y) dy$

(C) $e - \int_1^e e^x dx$

(D) $\int_1^e \ln y dy$

31. Let $L = \lim_{x \rightarrow 0} \frac{a - \sqrt{a^2 - x^2} - \frac{x^2}{4}}{x^4}, a > 0$. If L is finite, then

(A) $a = 2$

(B) $a = 1$

(C) $L = \frac{1}{64}$

(D) $L = \frac{1}{32}$

Mathematics

32. If $\frac{\sin^4 x}{2} + \frac{\cos^4 x}{3} = \frac{1}{3}$ then

(A) $\tan^2 x = \frac{2}{3}$

(B) $\frac{\sin^8 x}{8} + \frac{\cos^8 x}{27} = \frac{1}{125}$

(C) $\tan^2 x = \frac{1}{3}$

(D) $\frac{\sin^8 x}{8} + \frac{\cos^8 x}{27} = \frac{2}{125}$

SECTION - III Comprehension Type

This section contains 2 groups of questions. Each group has 3 multiple choice questions based on a paragraph. Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which **ONLY ONE** is correct.

Directions paragraph for questions nos. 33 to 35:

Let A be the set of all 3×3 symmetric matrices all of whose entries are either 0 or 1. Five of these entries are 1 and four of them are 0.

33. The number of matrices in A is

(A) 12

(B) 6

(C) 9

(D) 3

34. The number of matrices A in A for which the system of linear equations $A \begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix}$ has a unique

solution, is

(A) less than 4

(B) at least 4 but less than 7

(C) at least 7 but less than 10

(D) at least 10

35. The number of matrices A in A for which the system of linear equations $A \begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix}$ is inconsistent,

is

(A) 0

(B) More than 2

(C) 2

(D) 1

Direction paragraph for questions nos. 36 to 38:

A fair die is tossed repeatedly until a six is obtained. Let X denote the number of tosses required.

36. The probability that $X = 3$ equals.

- (A) $\frac{25}{216}$ (B) $\frac{25}{36}$ (C) $\frac{5}{36}$ (D) $\frac{125}{216}$

37. The probability that $x \geq 6$ given $x > 3$ equals

- (A) $\frac{125}{216}$ (B) $\frac{25}{36}$ (C) $\frac{5}{36}$ (D) $\frac{25}{216}$

38. The conditional probability that $x \geq 6$ given $X > 3$ equals

- (A) $\frac{125}{216}$ (B) $\frac{125}{216}$ (C) $\frac{5}{36}$ (D) $\frac{25}{36}$

SECTION - IV

Matrix - Match Type

This section contains 2 questions. Each question contains statements given in two columns which have to be matched. The statements in **Column I** are labelled A, B, C and D, while the statements in **Column II** are labelled p, q, r, s and t. Any given statement in Column I can have correct matching with **ONE OR MORE** statement(s) in **Column II**. The appropriate bubbles corresponding to the answers to these questions have to be darkened as illustrated in the following example:

If the correct matches are A – p, s and t; B – q and r; C – p and q; and D – s and t; then the correct darkening of bubbles will look like the following.

	p	q	r	s	t
A	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input checked="" type="radio"/>
B	<input type="radio"/>	<input checked="" type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
C	<input checked="" type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
D	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input checked="" type="radio"/>

Mathematics

39. Match the statements/expressions in Column I with the open intervals in Column - II

(A) Interval contained in the domain of definition of non-zero solutions of the differential equations $(x - 3)^2 y'' + y = 0$

(p) $\left(-\frac{\pi}{2}, \frac{\pi}{2}\right)$

(B) Interval containing the value of the integral

(q) $\left(0, \frac{\pi}{2}\right)$

$$\int_1^5 (x-1)(x-2)(x-4)(x-5) dx$$

(r) $\left(\frac{\pi}{8}, \frac{5\pi}{4}\right)$

(C) Interval in which at least one of the points of local maximum of $\cos^2 x + \sin x$ lies

(s) $\left(0, \frac{\pi}{8}\right)$

(D) Interval in which $\tan^{-1}(\sin x + \cos x)$ is increasing

(t) $(-\pi, \pi)$

40. Match the conics in Column I with the statements/expressions in Column - II

Column I

Column - II

(A) Circle

(p) The locus of the point (h, k) for which the line $hx + ky = 1$ touches the circle $x^2 + y^2 = 4$

(B) Parabola

(q) Points z in the complex plane satisfying $|z + 2| - |z - 2| = \pm 3$

(C) Ellipse

(r) Points of the conic have parametric representation

$$x = \sqrt{3} \left(\frac{1-t^2}{1+t^2} \right), y = \frac{2t}{1+t^2}$$

(D) Hyperbola

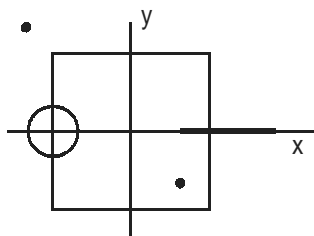
(s) The eccentricity of the conic lies in the interval $1 \leq e < \infty$.

(t) Points z in the complex plane satisfying $\operatorname{Re}(z + 1)^2 = |z|^2 + 1$

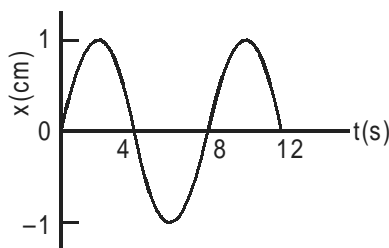
Part – III
Section – I
Single Correct Choice Type

Thus section contains 8 multiple choice questions. Each questions has 4 choices (A), (B), (C) and (D) for its answer, out of which **ONLY ONE** is correct.

41. A disk of radius $a/4$ having a uniformly distributed charge $6C$ is placed in the x - y plane with its centre at $(-a/2, 0, 0)$. A rod of length a carrying a uniformly distributed charge $8C$ is placed on the x -axis from $x = a/4$ to $x = 5a/4$. Two point charges $-7C$ and $3C$ are placed at $(a/4, -a/4, 0)$ and $(-3a/4, 3a/4, 0)$, respectively. Consider a cubical surface formed by six surfaces $x = \pm a/2, y = \pm a/2, z = \pm a/2$. The electric flux through this cubical surface is



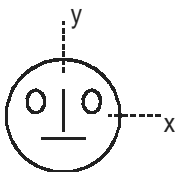
- (A) $\frac{-2C}{\epsilon_0}$ (B) $\frac{2C}{\epsilon_0}$ (C) $\frac{10C}{\epsilon_0}$ (D) $\frac{12C}{\epsilon_0}$
42. The x - t graph of a particle undergoing simple harmonic motion is shown below. The acceleration of the particle at $t = 4/3$ s is



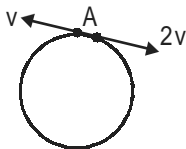
- (A) $\frac{\sqrt{3}}{32} \pi^2 \text{ cm/s}^2$ (B) $\frac{-\pi^2}{32} \text{ cm/s}^2$ (C) $\frac{\pi^2}{32} \text{ cm/s}^2$ (D) $-\frac{\sqrt{3}}{32} \pi^2 \text{ cm/s}^2$
43. Three concentric metallic spherical shells of radii $R, 2R, 3R$ are given charges Q_1, Q_2, Q_3 , respectively. It is found that the surface charge densities on the outer surfaces of the shells are equal. Then, the ratio of the charges given to the shells, Q_1, Q_2, Q_3 , is
- (A) $1 : 2 : 3$ (B) $1 : 3 : 5$ (C) $1 : 4 : 9$ (D) $1 : 8 : 18$

Physics

44. A ball is dropped from a height of 20 m above the surface of water in a lake. The refractive index of water is $\frac{4}{3}$. A fish inside the lake, in the line of fall of the ball, is looking at the ball. At an instant, when the ball is 12.8 m above the water surface, the fish sees the speed of ball as [Take $g = 10 \text{ m/s}^2$]
 (A) 9 m/s (B) 12 m/s (C) 16 m/s (D) 21.33 m/s
45. Look at drawing given in the figure which has been drawn with ink of uniform line-thickness. The mass of ink used to draw each of the two inner circles, and each of the two line segments is m . The mass of the ink used to draw the outer circle is 6 m. The coordinates of the centres of the different parts are: outer circle (0, 0), left inner circle ($-a$, a), right inner circle (a , a), vertical line (0, 0) and horizontal line (0, $-a$). The y-axis coordinate of the centres of mass of the ink in this drawing is

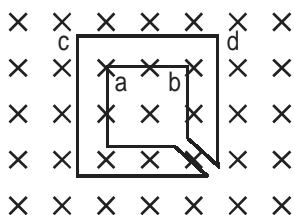


- (A) $\frac{a}{10}$ (B) $\frac{a}{8}$ (C) $\frac{a}{12}$ (D) $\frac{a}{3}$
46. A block of base $10 \text{ cm} \times 10 \text{ cm}$ and height 15 cm is kept on an inclined plane. The coefficient of friction between them is $\sqrt{3}$. The inclination θ of this inclined plane from the horizontal plane is gradually increased from 0° . Then
 (A) at $\theta = 30^\circ$, the block will start sliding down the plane
 (B) the block will remain at rest on the plane up to certain θ and then it will topple
 (C) at $\theta = 60^\circ$, the block will start sliding down the plane and continue to do so at higher angles
 (D) at $\theta = 60^\circ$, the block will start sliding down the plane and on further increasing θ , it will topple at certain θ
47. Two small particles of equal masses start moving in opposite directions from a point A in a horizontal circular orbit. Their tangential velocities are v and $2v$, respectively, as shown in the figure. Between collisions, other than that at A, these two particles will again reach the point A?



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

48. The figure shows certain wire segments joined together to form a coplanar loop. The loop is placed in a perpendicular magnetic field in the direction going into the plane of the figure. The magnitude of the field increases with time. I_1 and I_2 are the currents in the segments **ab** and **cd**. Then,



- (A) $I_1 > I_2$
 (B) $I_1 < I_2$
 (C) I_1 is in the direction **ba** and I_2 is in the direction **cd**
 (D) I_1 is in the direction **ab** and I_2 is in the direction **dc**

Section – II

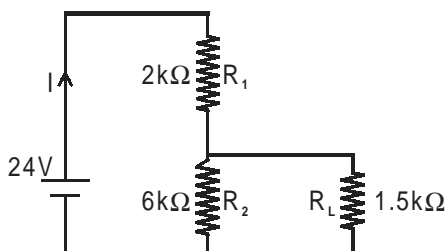
Multiple Correct Choice Type

This section contains 4 multiple choice questions. Each questions has 4 choices (A), (B), (C) and (D) for its answer, out which **ONE OR MORE** is/are correct.

49. A student performed the experiment of determination of focal length of a concave mirror by u-v method using an optical bench of length 1.5 meter. The focal length of the mirror used is 24 cm. The maximum error in the location of the image can be 0.2 cm. The 5 sets of (u, v) values recorded by the student (in cm) are: (42 : 56), (48 : 48), (60 : 40), (66 : 33), (78 : 39). The data set(s) that **cannot** come from experiment and is (are) incorrectly recorded, is (are)
- (A) (42, 56) (B) (48, 48) (C) (66, 33) (D) (78, 39)
50. If the resultant of all the external forces acting on a system of particles is zero, then from an inertial frame, one can surely say that
- (A) linear momentum of the system does not change in time
 (B) Kinetic energy of the system does not change in time
 (C) angular momentum of the system does not change in time
 (D) potential energy of the system does not change in time
51. C_v and C_p denote the molar specific heat capacities of a gas at constant volume and constant pressure, respectively. Then
- (A) $C_p - C_v$ is larger for a diatomic ideal gas than for a monoatomic ideal gas
 (B) $C_p + C_v$ is larger for a diatomic ideal gas than for a monoatomic ideal gas
 (C) C_p / C_v is larger for a diatomic ideal gas than for a monoatomic ideal gas
 (A) $C_p \cdot C_v$ is larger for a diatomic ideal gas than for a monoatomic ideal gas

Physics

52. For the circuit shown in the figure



- (A) the current I through the battery is 7.5 mA
- (B) the potential difference across R_L is 18V
- (C) ratio of powers dissipated in R_1 and R_2 is 3
- (D) if R_1 and R_2 are interchanged, magnitude of the power dissipated in R_L will decrease by a factor of 9

Section – III Comprehension Type

This section contains 2 groups of questions. Each group has 3 multiple choice questions based on a paragraph. Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which **ONLY ONE** is correct.

Passage for Questions Nos. 53 to 55

Scientists are working hard to develop nuclear fusion reactor. Nuclei of heavy hydrogen, ${}^2_1\text{H}$, known as deuteron and denoted by D, can be thought of as a candidate for fusion reactor. The D-D reaction is ${}^2_1\text{H} + {}^2_1\text{H} \rightarrow {}^3_2\text{He} + n + \text{energy}$. In the core of fusion reactor, a gas of heavy hydrogen is fully ionized into deuteron nuclei and electrons. This collection of ${}^2_1\text{H}$ nuclei and electrons is known as plasma. The nuclei move randomly in the reactor core and occasionally come close enough for nuclear fusion to take place. Usually, the temperatures in the reactor core are too high and no material wall can be used to confine the plasma. Special techniques are used which confine the plasma for a time t_0 before the particles fly away from the core. If n is the density (number/volume) of deuterons, the product nt_0 is called Lawson number. In one of the criteria, a reactor is termed successful if Lawson number is greater than $5 \times 10^{14} \text{ s/cm}^3$.

It may be helpful to use the following: Boltzman constant $K = 8.6 \times 10^{-5} \text{ eV/K}$; $\frac{e^2}{4\pi\epsilon_0} = 1.44 \times 10^{-9} \text{ eVm}$.

53. In the core of nuclear fusion reactor, the gas becomes plasma because of
- (A) strong nuclear force acting between the deuterons
 - (B) Coulomb force acting between the deuterons
 - (C) Coulomb force acting between deuterons-electrons pairs
 - (D) the high temperature maintained inside the reactor core

54. Assume that two deuteron nuclei in the core of fusion reactor at temperature T are moving towards each other, each with kinetic energy $1.5 T$, when the separation between them is large enough to neglect Coulomb potential energy. Also neglect any interaction from other particles in the core. The minimum temperature T required for them to reach a separation of 4×10^{-15} m in the range.
 (A) $1.0 \times 10^9 \text{ K} > T < 2.0 \times 10^9 \text{ K}$ (B) $2.0 \times 10^9 \text{ K} < T < 3.0 \times 10^9 \text{ K}$
 (C) $3.0 \times 10^9 \text{ K} < T < 4.0 \times 10^9 \text{ K}$ (D) $4.0 \times 10^9 \text{ K} < T < 5.0 \times 10^9 \text{ K}$
55. Results of calculations for four different designs of a fusion reactor using D-D reaction are given below. Which of these is most promising based on Lawson criterion?
 (A) deuteron density = $2.0 \times 10^{12} \text{ cm}^{-3}$, confinement time = $5.0 \times 10^{-3} \text{ s}$
 (B) deuteron density = $8.0 \times 10^{14} \text{ cm}^{-3}$, confinement time = $9.0 \times 10^{-1} \text{ s}$
 (C) deuteron density = $4.0 \times 10^{23} \text{ cm}^{-3}$, confinement time = $1.0 \times 10^{-11} \text{ s}$
 (D) deuteron density = $1.0 \times 10^{24} \text{ cm}^{-3}$, confinement time = $4.0 \times 10^{-12} \text{ s}$

Passage for Questions 56 to 58

When a particle is restricted to move along x-axis between $x = 0$ and $x = a$, where a is of nanometer dimension, its energy can take only certain specific values. The allowed energies of the particle moving in such a restricted region, correspond to the formation of standing waves with nodes at its ends $x = 0$ and $x = a$. The wavelength of this standing wave is related to the linear momentum p of the particle according to the de-Broglie relation. The energy of the particle of mass m is related to its linear momentum as

$E = \frac{p^2}{2m}$. Thus, the energy of the particle can be denoted by a quantum number n taking values 1, 2, 3....., ($n = 1$, called the ground state) corresponding to the number of loops in the standing wave.

Use the model described above to answer the following three questions for a particles moving in the line $x = 0$ to $x = a$. Take $h = 6.6 \times 10^{-34} \text{ J s}$ and $e = 1.6 \times 10^{-19} \text{ C}$.

56. The allowed energy for the particle for a particular value of n is proportional to :
 (A) a^{-2} (B) $a^{-3/2}$ (C) a^{-1} (D) a^2
57. If the mass of the particle is $m = 1.0 \times 10^{-30} \text{ kg}$ and $a = 6.6 \text{ nm}$, the energy of the particle in its ground state is closest to :
 (A) 0.8 meV (B) 8 meV (C) 80 meV (D) 800 meV
58. The speed of the particle, that can take discrete values, is proportional to:
 (A) $n^{-3/2}$ (B) n^{-1} (C) $n^{1/2}$ (D) n

Physics

Section – IV Matrix-Match Type

This section contains 2 questions. Each question contains statements given in two columns which have to be matched. The Statements in **Column-I** are labelled A, B, C, while the statements in **Column-II** are labelled p, q, r, s and t. Any given statement in **Column-I** can have correct matching with **ONE OR MORE** statement(s) **Column-II**. The appropriately bubbles corresponding to the answers to these questions have to be darkened as illustrated in the following examples:

If the correct matches A–p, s and t; B–q, and r; C–p, and q and D–s and t; then the correctly darkening of bubbles will look the following.

	p	q	r	s	t
A	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input checked="" type="radio"/>
B	<input type="radio"/>	<input checked="" type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
C	<input checked="" type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
D	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input checked="" type="radio"/>

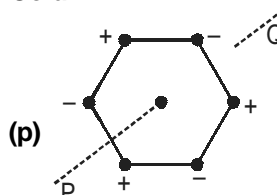
59. Six point charges, each of the same magnitude q , are arranged in different manners as shown in **Column-II**. In each case, a point M and a line PQ passing through M are shown. Let E be the electric field and V be the electric potential at M (potential at infinity is zero) due to the given charge distribution when it is at rest. Now, the whole system is set into rotation with a constant angular velocity about the line PQ. Let B be the magnetic field at M and μ be the magnetic moment of the system in this condition. Assume each rotating charge to be equivalent to a steady current.

Column-I

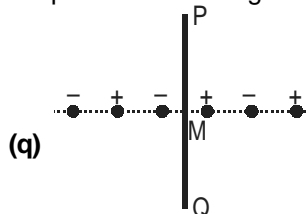
(A) $E = 0$

(B) $V \neq 0$

Column-II

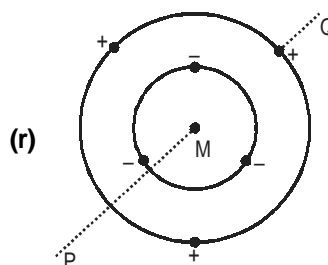


Charges are at the corners of a regular hexagon. M is at the centre of the hexagon. PQ is perpendicular to the plane of the hexagon.



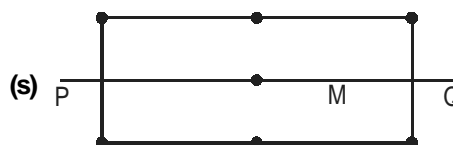
Charges are on a line perpendicular to PQ at equal intervals. M is the midpoint between the two innermost charges.

(C) $B = 0$

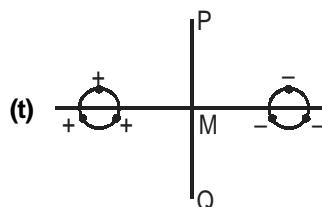


Charges are placed on two coplanar insulating rings at equal intervals. M is the common centre of the rings. PQ is perpendicular to the plans of rings.

(D) $\mu \neq 0$



Charges are placed at the corners of a rectangle of sides a and $2a$ and at the mid-points of the longer sides. M is at the rectangular. PQ is parallel to the longer sides.



Charges are placed on two coplanar identical insulating rings at equal intervals. M is the mid-point between the centres of the rings. PQ is perpendicular to the line joining the centres and coplanar to the rings.

Mathematics

60. **Column II** shows five systems in which two objects are labelled as X and Y. Also in each case a point P is shown. **Column II** gives some statements about X and and/or Y. Match these statements to the appropriate system(s) from **Column II**.

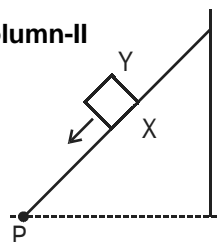
Column - I

- (A) The force exerted by X on Y has a magnitude Mg .

- (B) The gravitational potential energy of X is continuously increasing.

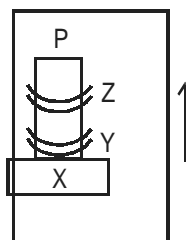
- (C) Mechanical energy of the system X + Y is continuously decreasing.

Column-II (p)



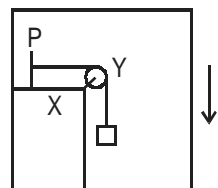
Block Y of mass M left on a fixed inclined plane X, slides on it with a constant velocity.

(q)



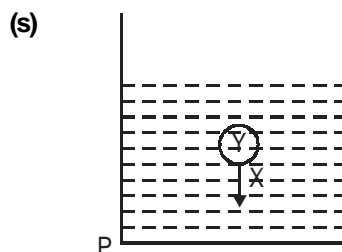
Two ring magnets Y and Z, each of mass M , are kept in frictionless vertical plastic stand so that they repel each other. Y rests on the base X and Z hangs in air in equilibrium. P is the topmost point of the stand on the common axis of the two rings. The whole system up with a constant velocity.

(r)

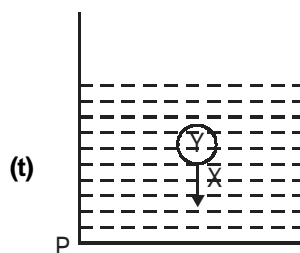


A pulley Y of mass m_0 is fixed to a table through a clamp X. A block of mass M hangs from a string that goes over the pulley and is fixed at Point P of the table. The whole is systems is kept in a lift that is going down with a constant velocity.

- (D) The torque of the weight of Y about point P is zero.



A sphere Y of mass M is put in a nonviscous liquid X kept in a container at rest. The sphere is released and it moves down in the liquid



A sphere Y of mass M is falling with its terminal velocity in a viscous liquid X kept in a container.