



## JEE Main – 2024

### 31<sup>st</sup> JANUARY 2024 (Evening Shift)

#### General Instructions

1. The test is of **3 hours** duration and the maximum marks is **300**.
2. The question paper consists of **3 Subjects** (Subject I: **Mathematics**, Subject II: **Physics**, Subject III: **Chemistry**). Each Part has **two** sections (Section 1 & Section 2).
3. **Section 1** contains **20 Multiple Choice Questions**. Each question has 4 choices (1), (2), (3) and (4), out of which **ONLY ONE CHOICE** is correct.
4. **Section 2** contains **10 Numerical Value Type Questions** Out of which **ONLY 5 (any)** questions have to be attempted. You will **NOT** be allowed to attempt the sixth question. If you wish to attempt any other question apart from the five already attempted, then you will have to delete any one response from the five previously answered and then proceed to answer the new one.  
The answer to each question should be **rounded off to the nearest integer**.
5. No candidate is allowed to carry any textual material, printed or written, bits of papers, pager, mobile phone, any electronic device, etc. inside the examination room/hall.
6. On completion of the test, the candidate must hand over the Answer Sheet to the **Invigilator** on duty in the Room/Hall. **However, the candidates are allowed to take away this Test Booklet with them.**

#### Marking Scheme

1. **Section – 1:** +4 for correct answer, –1 (negative marking) for incorrect answer, 0 for all other cases.
2. **Section – 2:** +4 for correct answer, –1 (negative marking) for incorrect answer, 0 for all other cases.

**SECTION-1**

This section contains 20 Multiple Choice Questions. Each question has 4 choices (1), (2), (3) and (4), out of which ONLY ONE CHOICE is correct.

- The temperature  $T(t)$  of a body at a time  $t=0$  is  $160^\circ\text{F}$  and it decreases continuously as per the differential equation  $\frac{dT}{dt} = -K(T-80)$ , where  $K$  is a positive constant. If  $T(15)=120^\circ\text{F}$ , then  $T(45)$  is equal to :  
 (1)  $85^\circ\text{F}$  (2)  $90^\circ\text{F}$  (3)  $95^\circ\text{F}$  (4)  $80^\circ\text{F}$
- If the function  $f : (-\infty, -1] \rightarrow (a, b]$  defined by  $f(x) = e^{x^3-3x+1}$  is one - one and onto, then the distance of the point  $P(2b+4, a+2)$  from the line  $x + e^{-3}y = 4$  is:  
 (1)  $3\sqrt{1+e^6}$  (2)  $\sqrt{1+e^6}$  (3)  $2\sqrt{1+e^6}$  (4)  $4\sqrt{1+e^6}$
- If  $a = \sin^{-1}(\sin(5))$  and  $b = \cos^{-1}(\cos(5))$ , then  $a^2 + b^2$  is equal to :  
 (1)  $8\pi^2 - 40\pi + 50$  (2)  $4\pi^2 + 25$  (3)  $4\pi^2 - 20\pi + 50$  (4)  $25$
- Let  $P$  be a parabola with vertex  $(2, 3)$  and directrix  $2x + y = 6$ . Let an ellipse  $E: \frac{x^2}{a^2} + \frac{y^2}{b^2} = 1, a > b$ , of eccentricity  $\frac{1}{\sqrt{2}}$  pass through the focus of the parabola  $P$ . Then, the square of the length of the latus rectum of  $E$ , is;  
 (1)  $\frac{512}{25}$  (2)  $\frac{385}{8}$  (3)  $\frac{656}{25}$  (4)  $\frac{347}{8}$
- The number of solutions, of the equation  $e^{\sin x} - 2e^{-\sin x} = 2$ , is:  
 (1) More than 2 (2) 0 (3) 1 (4) 2
- Let the mean and the variance of 6 observations  $a, b, 68, 44, 48, 60$  be 55 and 194, respectively. If  $a > b$ , then  $a + 3b$  is:  
 (1) 210 (2) 180 (3) 200 (4) 190
- A coin is biased so that a head is twice as likely to occur as a tail. If the coin is tossed 3 times, then the probability of getting two tails and one head is:  
 (1)  $\frac{1}{9}$  (2)  $\frac{2}{9}$  (3)  $\frac{2}{27}$  (4)  $\frac{1}{27}$
- If for some  $m, n: {}^6C_m + 2({}^6C_{m+1}) + {}^6C_{m+2} > {}^8C_3$  and  ${}^{n-1}P_3 : {}^nP_4 = 1:8$  then  ${}^nP_{m+1} + {}^{n+1}C_m$  is equal to :  
 (1) 380 (2) 372 (3) 376 (4) 384

9. Let  $f: R \rightarrow (0, \infty)$  be strictly increasing function such that  $\lim_{x \rightarrow \infty} \frac{f(7x)}{f(x)} = 1$ . Then, the value of  $\lim_{x \rightarrow \infty} \left[ \frac{f(5x)}{f(x)} - 1 \right]$  is equal to:
- (1) 0 (2) 1 (3)  $\frac{7}{5}$  (4) 4
10. Let  $A(a, b)$ ,  $B(3, 4)$  and  $C(-6, -8)$  respectively denote the centroid, circumcentre and orthocentre of a triangle. Then, the distance of the point  $P(2a+3, 7b+5)$  from the line  $2x+3y-4=0$  measured parallel to the line  $x-2y-1=0$  is:
- (1)  $\frac{\sqrt{5}}{17}$  (2)  $\frac{17\sqrt{5}}{7}$  (3)  $\frac{15\sqrt{5}}{7}$  (4)  $\frac{14\sqrt{5}}{6}$
11. Let  $f, g: (0, \infty) \rightarrow \mathbb{R}$  be two functions defined by  $f(x) = \int_{-x}^x (|t| - t^2)e^{-t^2} dt$  and  $g(x) = \int_0^{x^2} t^{1/2} e^{-t} dt$ . Then, the value of  $9(f(\sqrt{\log_e 9}) + \sqrt{\log_e 9})$  is equal to :
- (1) 6 (2) 10 (3) 9 (4) 8
12. The shortest distance, between lines  $L_1$  and  $L_2$ , where  $L_1: \frac{x-1}{2} = \frac{y+1}{-3} = \frac{z+4}{2}$  and  $L_2$  is the line, passing through the line, passing through the points  $A(-4, 4, 3)$ ,  $B(-1, 6, 3)$  and perpendicular to the line  $\frac{x-3}{-2} = \frac{y}{3} = \frac{z-1}{1}$  is:
- (1)  $\frac{141}{\sqrt{221}}$  (2)  $\frac{42}{\sqrt{117}}$  (3)  $\frac{24}{\sqrt{117}}$  (4)  $\frac{121}{\sqrt{221}}$
13. The number of ways in which 21 identical apples can be distributed among three children such that each child gets at least 2 apples, is:
- (1) 142 (2) 130 (3) 136 (4) 406
14. Let  $(\alpha, \beta, \gamma)$  be the mirror image of the point  $(2, 3, 5)$  in the line  $\frac{x-1}{2} = \frac{y-2}{3} = \frac{z-3}{4}$ . Then  $2\alpha + 3\beta + 4\gamma$  is equal to :
- (1) 34 (2) 31 (3) 33 (4) 32
15. The area of the region enclosed by the parabolas  $y=4x-x^2$  and  $3y=(x-4)^2$  is equal to :
- (1) 4 (2)  $\frac{32}{9}$  (3)  $\frac{14}{3}$  (4) 6
16. Let  $2^{nd}$ ,  $8^{th}$  and  $44^{th}$  terms of a non-constant A.P. be respectively the  $1^{st}$ ,  $2^{nd}$  and  $3^{rd}$  terms of a G.P.. If the first term of the A.P. is 1, then the sum of its first 20 terms is equal to:
- (1) 980 (2) 970 (3) 960 (4) 990

17. Let  $z_1$  and  $z_2$  be two complex numbers such that  $z_1 + z_2 = 5$  and  $z_1^3 + z_2^3 = 20 + 15i$ . Then,  $|z_1^4 + z_2^4|$  equals:
- (1)  $25\sqrt{3}$                       (2) 75                      (3)  $15\sqrt{15}$                       (4)  $30\sqrt{3}$
18. Consider the function  $f: (0, \infty) \rightarrow \mathbb{R}$  defined by  $f(x) = e^{-|\log_e x|}$ . If  $m$  and  $n$  be respectively the number of points at which  $f$  is **not** continuous and  $f$  is **not** differentiable, then  $m+n$  is:
- (1) 3                      (2) 0                      (3) 1                      (4) 2
19. Let a variable line passing through the centre of the circle  $x^2 + y^2 - 16x - 4y = 0$ , meet the positive co-ordinate axes at the points A and B. Then the minimum value of  $OA + OB$ , where O is the origin, is equal to :
- (1) 18                      (2) 12                      (3) 20                      (4) 24
20. Let A be a  $3 \times 3$  real matrix such that
- $$A \begin{pmatrix} 1 \\ 0 \\ 1 \end{pmatrix} = 2 \begin{pmatrix} 1 \\ 0 \\ 1 \end{pmatrix}, A \begin{pmatrix} -1 \\ 0 \\ 1 \end{pmatrix} = 4 \begin{pmatrix} -1 \\ 0 \\ 1 \end{pmatrix}, A \begin{pmatrix} 0 \\ 1 \\ 0 \end{pmatrix} = 2 \begin{pmatrix} 0 \\ 1 \\ 0 \end{pmatrix}.$$
- Then, the system  $(A - 3I) \begin{pmatrix} x \\ y \\ z \end{pmatrix} = \begin{pmatrix} 1 \\ 2 \\ 3 \end{pmatrix}$  has.
- (1) Exactly two solutions                      (2) Unique solutions
- (3) Infinitely many solutions                      (4) No solution

## SECTION-2

Section 2 contains 10 Numerical Value Type Questions Out of which ONLY 5 (any) questions have to be attempted. The answer to each question should be rounded off to the nearest integer.

21. Let  $a, b, c$  be the lengths of three sides of a triangle satisfying the condition  $(a^2 + b^2)x^2 - 2b(a+c)x + (b^2 + c^2) = 0$ . If the set of all possible values of  $x$  is the interval  $(\alpha, \beta)$  then  $12(\alpha^2 + \beta^2)$  is equal to \_\_\_\_\_.
22. Let  $A = \{1, 2, 3, \dots, 100\}$ . Let  $R$  be a relation on  $A$  defined by  $(x, y) \in R$  if and only if  $2x = 3y$ . Let  $R_1$  be a symmetric relation on  $A$  such that  $R \subset R_1$  and the number of elements in  $R_1$  is  $n$ . Then the minimum value of  $n$  is \_\_\_\_\_.
23. Let  $\vec{a} = 3\hat{i} + 2\hat{j} + \hat{k}$ ,  $\vec{b} = 2\hat{i} - \hat{j} + 3\hat{k}$  and  $\vec{c}$  be a vector such that  $(\vec{a} + \vec{b}) \times \vec{c} = 2(\vec{a} \times \vec{b}) + 24\hat{j} - 6\hat{k}$  and  $(\vec{a} - \vec{b} + \vec{c}) \cdot \vec{c} = -3$ . Then  $|\vec{c}|^2$  is equal to \_\_\_\_\_.
24.  $\left| \frac{120}{\pi^2} \int_0^{\pi} \frac{x^2 \sin x \cos x}{\sin^4 x + \cos^4 x} dx \right|$  is equal to \_\_\_\_\_.
25. If  $\lim_{x \rightarrow 0} \frac{ax^2 e^x - b \log_e(1+x) + cxe^{-x}}{x^2 \sin x} = 1$ , then  $16(a^2 + b^2 + c^2)$  is equal to \_\_\_\_\_.
26. Let  $A(-2, -1)$ ,  $B(1, 0)$ ,  $C(\alpha, \beta)$  and  $D(\gamma, \delta)$  be the vertices of a parallelogram  $ABCD$ . If the point  $C$  lies on  $2x - y = 5$  and the point  $D$  lies on  $3x - 2y = 6$ , then the value of  $|\alpha + \beta + \gamma + \delta|$  is equal to \_\_\_\_\_.
27. A line passes through  $A(4, -6, -2)$  and  $B(16, -2, 4)$ . The point  $P(a, b, c)$ , where  $a, b, c$  are non-negative integers, on the line  $AB$  lies at a distance of 21 units, from the point  $A$ . The distance between the points  $P(a, b, c)$  and  $Q(4, -12, 3)$  is equal to \_\_\_\_\_.
28. Let the coefficient of  $x^r$  in the expansion of  $(x+3)^{n-1} + (x+3)^{n-2}(x+2) + (x+3)^{n-3}(x+2)^2 + \dots + (x+2)^{n-1}$  be  $\alpha_\gamma$ . If  $\sum_{r=0}^n \alpha_\gamma = \beta^n - \gamma^n$ ,  $\beta, \gamma \in \mathbb{N}$ , then the value of  $\beta^2 + \gamma^2$  equals \_\_\_\_\_.
29. Let  $A$  be  $3 \times 3$  matrix and  $\det(A) = 2$ . If  $n = \det \left( \frac{\text{adj}(\text{adj}(\dots(\text{adj } A)))}{2024 - \text{times}} \right)$  remainder when  $n$  is divided by 9 is equal to \_\_\_\_\_.
30. Let  $y = y(x)$  be the solution of the differential equation  $\sec^2 x \, dx + (e^{2y} \tan^2 x + \tan x) \, dy = 0$ ,  $0 < x < \frac{\pi}{2}$ ,  $y\left(\frac{\pi}{4}\right) = 0$ . If  $y\left(\frac{\pi}{6}\right) = \alpha$ , then  $e^{8\alpha}$  is equal to \_\_\_\_\_.

**SECTION-1**

This section contains 20 Multiple Choice Questions. Each question has 4 choices (1), (2), (3) and (4), out of which ONLY ONE CHOICE is correct.

31. A gas mixture consists of 8 moles of argon and 6 moles of oxygen at temperature  $T$ . Neglecting all vibrational modes, the total internal energy of the system is:  
 (1)  $27 RT$  (2)  $21 RT$  (3)  $20 RT$  (4)  $29 RT$
32. Given below are two statements:  
**Statement I** : Electromagnetic waves carry energy as they travel through space and this energy is equally shared by the electric and magnetic fields.  
**Statement II** : When electromagnetic waves strike a surface, a pressure is exerted on the surface.  
 In the light of the above statements, choose the **most appropriate** answer from the options given below :  
 (1) Both Statement I and Statement II are correct.  
 (2) Both Statement I and Statement II are incorrect.  
 (3) Statement I is incorrect but Statement II is correct.  
 (4) Statement I is correct but Statement II is incorrect.
33. In a photoelectric effect experiment a light of frequency 1.5 times the threshold frequency is made to fall on the surface of photosensitive material. Now if the frequency is halved and intensity is doubled, the number of photo electron emitted will be:  
 (1) Zero (2) Quadrupled (3) Halved (4) Doubled
34. The resistance per centimeter of a meter bridge wire is  $r$ , with  $X\Omega$  resistance in left gap. Balancing length from left end is at 40 cm with  $25\Omega$  resistance in right gap. Now the wire is replaced by another wire of  $2r$  resistance per centimeter. The new balancing length for same setting will be at :  
 (1) 20 cm (2) 40 cm (3) 80 cm (4) 10 cm
35. Force between two point charges  $q_1$  and  $q_2$  placed in vacuum at ' $r$ ' cm apart is  $F$ . Force between them when placed in a medium having dielectric constant  $K = 5$  at ' $r/5$ ' cm apart will be:  
 (1)  $25F$  (2)  $F/25$  (3)  $5F$  (4)  $F/5$
36. The mass of the moon is  $\frac{1}{144}$  times the mass of a planet and its diameter is  $\frac{1}{16}$  times the diameter of a planet. If the escape velocity on the planet is  $v$ , the escape velocity on the moon will be:  
 (1)  $\frac{v}{6}$  (2)  $\frac{v}{4}$  (3)  $\frac{v}{3}$  (4)  $\frac{v}{12}$

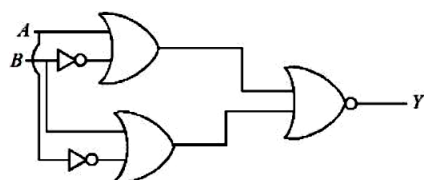
37. A uniform magnetic field of  $2 \times 10^{-3} T$  acts along positive Y-direction. A rectangular loop of sides 20 cm and 10 cm with current of 5A is in Y-Z plane. The current is in anticlockwise sense with reference to negative X axis. Magnitude and direction of the torque is:

- (1)  $2 \times 10^{-4} N-m$  along positive X-direction  
 (2)  $2 \times 10^{-4} N-m$  along positive Y-direction  
 (3)  $2 \times 10^{-4} N-m$  along positive Z-direction  
 (4)  $2 \times 10^{-4} N-m$  along negative Z-direction

38. Consider two physical quantities A and B related to each other as  $E = \frac{B-x^2}{At}$  where E, x and t have dimensions of energy, length and time respectively. The dimension of AB is:

- (1)  $L^0 M^{-1} T^1$  (2)  $L^{-2} M^{-1} T^1$  (3)  $L^{-2} M^1 T^0$  (4)  $L^2 M^{-1} T^1$

39.



The output of the given circuit diagram is:

- |     |   |   |   |     |   |   |   |
|-----|---|---|---|-----|---|---|---|
|     | A | B | Y |     | A | B | Y |
|     | 0 | 0 | 0 |     | 0 | 0 | 0 |
| (1) | 1 | 0 | 1 | (2) | 1 | 1 | 0 |
|     | 0 | 1 | 1 |     | 0 | 1 | 0 |
|     | 1 | 1 | 0 |     | 1 | 1 | 1 |
|     | A | B | Y |     | A | B | Y |
|     | 0 | 0 | 0 |     | 0 | 0 | 0 |
| (3) | 1 | 0 | 0 | (4) | 1 | 0 | 0 |
|     | 0 | 1 | 1 |     | 0 | 1 | 0 |
|     | 1 | 1 | 0 |     | 1 | 1 | 0 |

40. The speed of sound in oxygen at S.T.P. will be approximately :

(given,  $R = 8.3 JK^{-1}$ ,  $\gamma = 1.4$ )

- (1) 333m/s (2) 341m/s (3) 310 m/s (4) 325 m/s

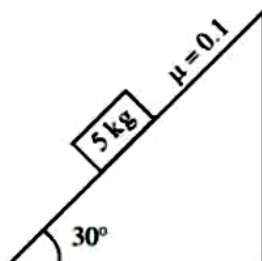
41. If two vectors  $\vec{A}$  and  $\vec{B}$  having equal magnitude R are inclined at an angle  $\theta$ , then :

- (1)  $|\vec{A} + \vec{B}| = 2R \cos\left(\frac{\theta}{2}\right)$  (2)  $|\vec{A} - \vec{B}| = 2R \cos\left(\frac{\theta}{2}\right)$   
 (3)  $|\vec{A} + \vec{B}| = 2R \sin\left(\frac{\theta}{2}\right)$  (4)  $|\vec{A} - \vec{B}| = \sqrt{2}R \sin\left(\frac{\theta}{2}\right)$

42. The mass number of nucleus having radius equal to half of the radius of nucleus with mass number 192 is:

(1) 20                      (2) 32                      (3) 40                      (4) 24

43. A block of mass 5 kg is placed on a rough inclined surface as shown in the figure. If  $\vec{F}_1$  is the force required to just move the block up the inclined plane and  $\vec{F}_2$  is the force required to just prevent the block from sliding down, then the value of  $|\vec{F}_1| - |\vec{F}_2|$  is : [Use  $g = 10 \text{ m/s}^2$ ]

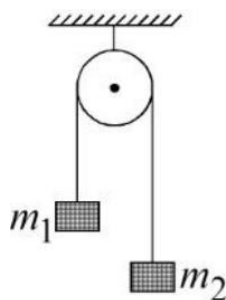


(1)  $25\sqrt{3} \text{ N}$                       (2)  $50\sqrt{3} \text{ N}$                       (3)  $10 \text{ N}$                       (4)  $\frac{5\sqrt{3}}{2} \text{ N}$

44. When unpolarized light is incident at an angle of  $60^\circ$  on a transparent medium from air, the reflected ray is completely polarized. The angle of refraction in the medium is :

(1)  $30^\circ$                       (2)  $45^\circ$                       (3)  $60^\circ$                       (4)  $90^\circ$

45. A light string passing over a smooth light fixed pulley connects two blocks of masses  $m_1$  and  $m_2$ . If the acceleration of the system is  $g/8$ , then the ratio masses is:



(1)  $\frac{9}{7}$                       (2)  $\frac{5}{3}$                       (3)  $\frac{8}{1}$                       (4)  $\frac{4}{3}$

46. AN AC voltage  $V = 20 \sin 200\pi t$  is applied to a series LCR circuit which drives a current  $I = 10 \sin \left( 200\pi t + \frac{\pi}{3} \right)$ . The average power dissipated is:

(1) 21.6 W                      (2) 50 W                      (3) 200 W                      (4) 173.2 W

47. A body of mass 2 kg begins to move under the action of a time dependent force given by  $F = (6t\hat{i} + 6t^2\hat{j}) \text{ N}$ . The power developed by the force at the time  $t$  is given by:

(1)  $(6t^4 + 9t^5) \text{ W}$                       (2)  $(3t^3 + 6t^5) \text{ W}$                       (3)  $(9t^5 + 6t^3) \text{ W}$                       (4)  $(9t^3 + 6t^5) \text{ W}$



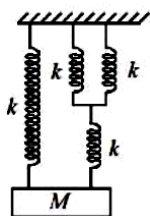
48. By what percentage will the illumination of the lamp decrease if the current drops by 20%?
- (1) 36 %                      (2) 56%                      (3) 46%                      (4) 26%
49. A small spherical ball of radius  $r$ , falling through a viscous medium of negligible density has terminal velocity ' $v$ '. Another ball of the same mass but of radius  $2r$ , falling through the same viscous medium will have terminal velocity:
- (1)  $\frac{v}{4}$                       (2)  $4v$                       (3)  $2v$                       (4)  $\frac{v}{2}$
50. The measured value of the length of a simple pendulum is 20 cm with 2mm accuracy. The time for 50 oscillations was measured to be 40 seconds with 1 second resolution. From these measurements, the accuracy in the measurement of acceleration due to gravity is  $N\%$ . The value of  $N$  is:
- (1) 6                      (2) 8                      (3) 5                      (4) 4

**SECTION-2**

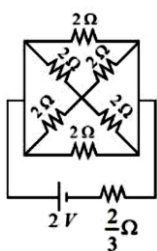
Section 2 contains 10 Numerical Value Type Questions Out of which ONLY 5 (any) questions have to be attempted. The answer to each question should be rounded off to the nearest integer.

51. A nucleus has mass number  $A_1$  and volume  $V_1$ . Another nucleus has mass number  $A_2$  and Volume  $V_2$ . If relation between mass number is  $A_2 = 4A_1$  then  $\frac{V_2}{V_1} = \underline{\hspace{2cm}}$ .
52. Two circular coils P and Q of 100 turns each have same radius of  $\pi \text{ cm}$ . The currents in P and R and 1A and 2A respectively. P and Q are placed with their planes mutually perpendicular with their centres coincide. The resultant magnetic field induction at the centre of the coils is  $\sqrt{x}mT$ , where  $x = \underline{\hspace{2cm}}$ .  
[Use  $\mu_0 = 4\pi \times 10^{-7} TmA^{-1}$ ]

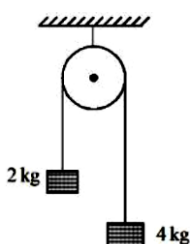
53. The time period of simple harmonic motion of mass  $M$  in the given figure is  $\pi\sqrt{\frac{\alpha M}{5k}}$ , where the value of  $\alpha$  is  $\underline{\hspace{2cm}}$ .



54. Light from a point source in air falls on a convex curved surface of radius 20 cm and refractive index 1.5. If the source is located at 100 cm from the convex surface, the image will be formed at  $\underline{\hspace{2cm}}$  cm from the object.
55. In the following circuit, the battery has an emf 2V and an internal resistance of  $\frac{2}{3}\Omega$ . The power consumption in the entire circuit is  $\underline{\hspace{2cm}}$  W.

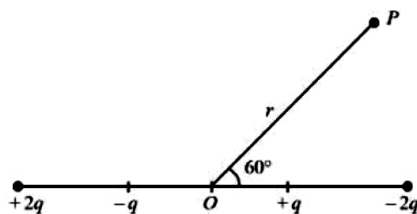


56. Two blocks of mass 2kg and 4 kg are connected by a metal wire going over a smooth pulley as show in figure. The radius of wire is  $4.0 \times 10^{-5} \text{ m}$  and Young's modulus of the metal is  $2.0 \times 10^{11} \text{ N/m}^2$ . The longitudinal strain developed in the wire is  $\frac{1}{\alpha\pi}$ . The value of  $\alpha$  is  $\underline{\hspace{2cm}}$ . [Use  $g = 10 \text{ m/s}^2$ ]



57. The distance between charges  $+q$  and  $-q$  is  $2l$  and between  $+2q$  and  $-2q$  is  $4l$ . The electrostatic potential at point P at a distance  $r$  from centre O is  $-\alpha \left[ \frac{ql}{r^2} \right] \times 10^9 V$ , where the value of  $\alpha$  is \_\_\_\_\_.

[Use  $\frac{1}{4\pi\epsilon_0} = 9 \times 10^9 Nm^2 C^{-2}$ ]



58. A body of mass 'm' is projected with a speed 'u' making an angle of  $45^\circ$  with the ground. The angular momentum of the body about the point of projection, at the highest point is expressed as  $\frac{\sqrt{2}mu^3}{Xg}$ . The value of 'X' is \_\_\_\_\_.
59. Two identical spheres each of mass 2kg and radius 50 cm are fixed at the ends of a light rod so that the separation between the centres is 150 cm. then, moment of inertia of the system about an axis perpendicular to the rod and passing through its middle point is  $\frac{x}{20} kg m^2$ , where the value of x is \_\_\_\_\_.
60. The magnetic flux  $\phi$  (in weber) linked with a closed circuit of resistance  $8\Omega$  varies with time (in seconds) as  $\phi = 5t^2 - 36t + 1$ . The induced current in the circuit at  $t = 2s$  is \_\_\_\_\_ A.

## SECTION-1

This section contains 20 Multiple Choice Questions. Each question has 4 choices (1), (2), (3) and (4), out of which ONLY ONE CHOICE is correct.

61. Given below are two statements :

**Statements I :**  $S_8$  solid undergoes disproportionation reaction under alkaline conditions to form  $S^{2-}$  and  $S_2O_3^{2-}$ .

**Statement II :**  $ClO_4^-$  can undergo disproportionation reaction under acidic condition.

In the light of the above statements, choose the **most appropriate answer** from the options given below:

- (1) Both statement I and statement II are incorrect  
 (2) Statement I is incorrect but statement II is correct  
 (3) Both statement I and statement II are correct  
 (4) Statement I is correct but statement II is incorrect

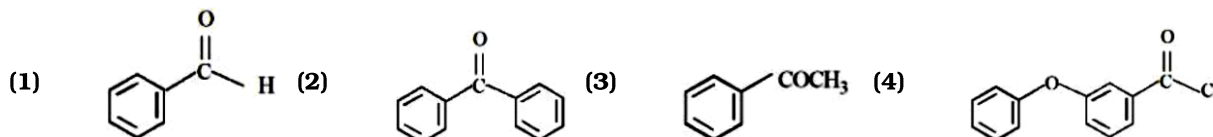
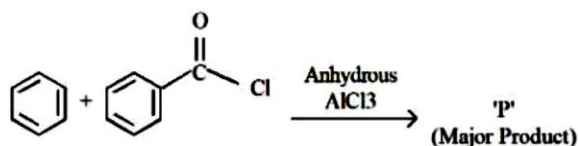
62. Which of the following is least ionic ?

- (1) KCl                      (2)  $CoCl_2$                       (3) AgCl                      (4)  $BaCl_2$

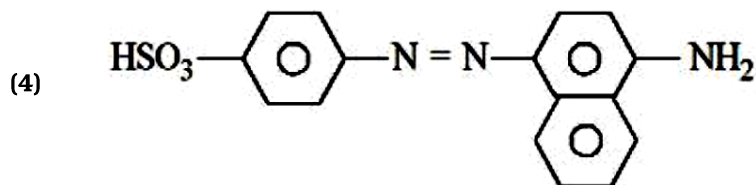
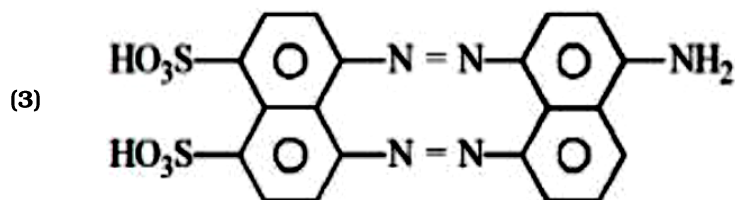
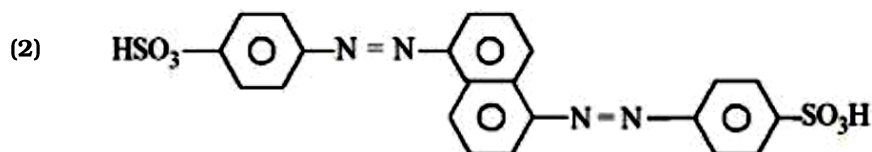
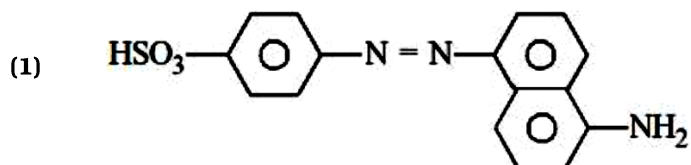
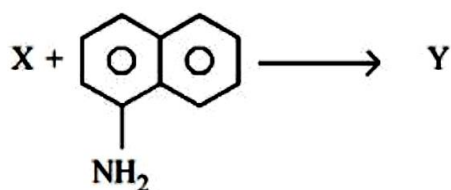
63. The four quantum numbers for the electron in the outer most orbital of potassium (atomic no. 19) are:

- (1)  $n=3, l=0, m=1, s=+\frac{1}{2}$                       (2)  $n=2, l=0, m=0, s=+\frac{1}{2}$   
 (3)  $n=4, l=0, m=0, s=+\frac{1}{2}$                       (4)  $n=4, l=2, m=-1, s=+\frac{1}{2}$

64. Identify major product 'P' formed in the following reaction.



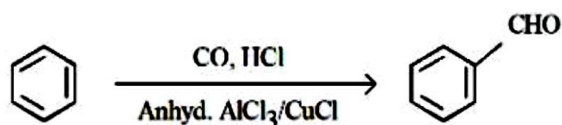
65. The azo-dye (Y) formed in the following reaction is.



66. The fragrance of flowers is due to the presence of some steam volatile organic compounds called essential oils. These are generally insoluble in water at room temperature but are miscible with water vapour in vapour phase. A suitable method for the extraction of these oils from the flower is:

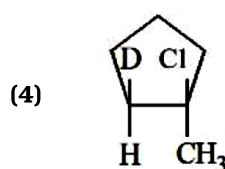
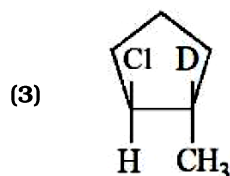
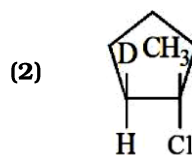
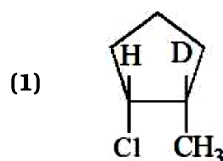
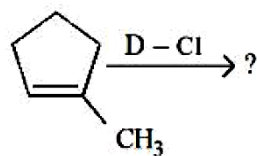
- |   |                        |
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| (1) Crystallisation                     | (2) Steam distillation |
| (3) Distillation under reduced pressure | (4) Distillation       |

67. Identify the name reaction.

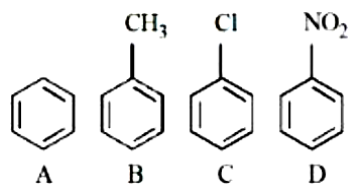


- |                               |                         |
|-------------------------------|-------------------------|
| (1) Gatterman – Koch Reaction | (2) Etard Reaction      |
| (3) Stephen Reaction          | (4) Rosenmund Reduction |

68. Major product of the following reaction is:



69. The correct order of reactivity in electrophilic substitution reaction of the following compounds is:



(1)  $A > B > C > D$  (2)  $B > C > A > D$  (3)  $B > A > C > D$  (4)  $D > C > B > A$

70. Select the option with correct property:

- (1)  $[\text{Ni}(\text{CO})_4]$  and  $[\text{NiCl}_4]^{2-}$  both Paramagnetic  
 (2)  $[\text{NiCl}_4]^{2-}$  Diamagnetic,  $[\text{Ni}(\text{CO})_4]$  Paramagnetic  
 (3)  $[\text{Ni}(\text{CO})_4]$  and  $[\text{NiCl}_4]^{2-}$  both Diamagnetic  
 (4)  $[\text{Ni}(\text{CO})_4]$  Diamagnetic,  $[\text{NiCl}_4]^{2-}$  Paramagnetic

71. Given below are two statements:

**Statement I :** Aniline reacts with con.  $\text{H}_2\text{SO}_4$ , followed by heating at 453–473K gives p-aminobenzene sulphonic acid, which gives blood red colour in the 'Lassaigne's test'

**Statement II :** In Friedel – Craft's alkylation and acylation reactions, aniline forms salt with the  $\text{AlCl}_3$  catalyst. Due to this, nitrogen of aniline acquires a positive charge and acts as deactivating group.

In the light of the above statements, choose the correct answer from the options given below :

- (1) Statement I is false but statement II is true  
 (2) Both statement I and statement II are true  
 (3) Statement I is true but statement II is false  
 (4) Both statement I and statement II are false

72.  $A_{(g)} \rightleftharpoons B_{(g)} + \frac{C}{2}_{(g)}$ . The correct relationship between  $K_P, \alpha$  and equilibrium pressure  $P$  is:

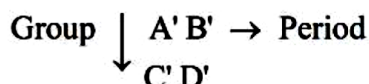
(1)  $K_P = \frac{\alpha^{1/2} P^{3/2}}{(2+\alpha)^{3/2}}$

(2)  $K_P = \frac{\alpha^{1/2} P^{1/2}}{(2+\alpha)^{3/2}}$

(3)  $K_P = \frac{\alpha^{1/2} P^{1/2}}{(2+\alpha)^{1/2}}$

(4)  $K_P = \frac{\alpha^{3/2} P^{1/2}}{(2+\alpha)^{1/2}(1-\alpha)}$

73. Consider the following elements.



Which of the following is/are true about  $A', B', C'$  and  $D'$ ?

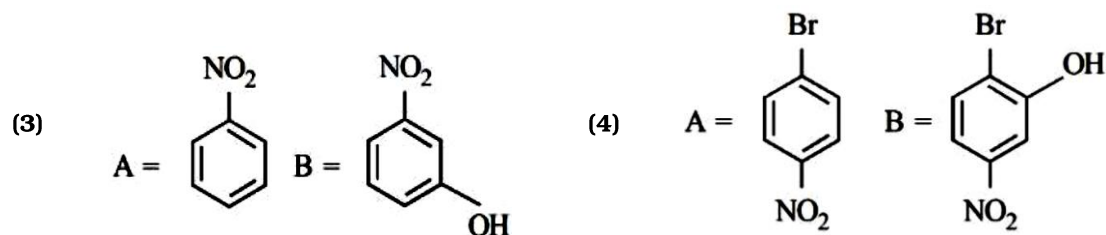
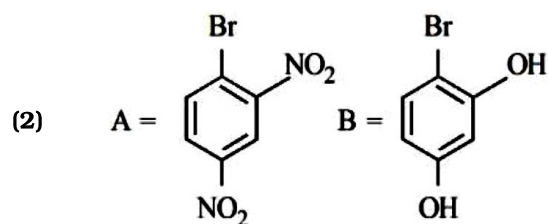
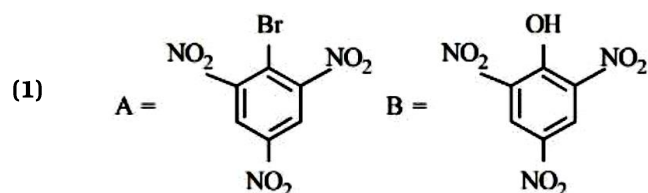
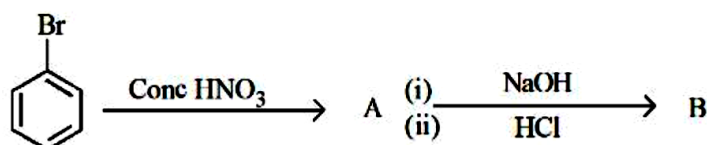
**A** Order of atomic radii :  $B' < A' < D' < C'$       **B** Order of metallic character :  $B' < A' < D' < C'$

**C** Size of the element :  $D' < C' B' < A'$       **D** Order of ionic radii :  $B'^+ < A'^+ < D'^+ < C'^+$

Choose the correct answer from the options given below:

(1) A only      (2) A and B only      (3) A, B and D only      (4) B, C and D only

74. Identify A and B in the following reaction sequence.



75. Given below are two statements :

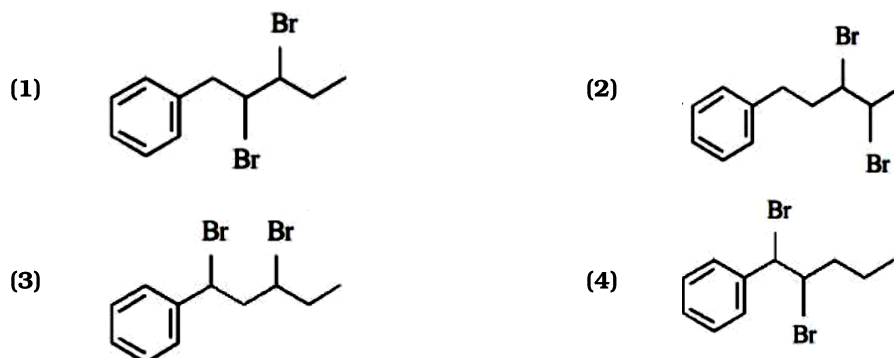
**Statement I :** Group 13 trivalent halides get easily hydrolyzed by water due to their covalent nature.

**Statement II :**  $\text{AlCl}_3$  upon hydrolysis in acidified aqueous solution forms octahedral  $[\text{Al}(\text{H}_2\text{O})_6]^{3+}$  ion.

In the light of the above statements, choose the correct answer from the option below :

- (1) Statement I is false but statement II is true  
 (2) Both statement I and statement II are true  
 (3) Statement I is true but statement II is false  
 (4) Both statement I and statement II are false

76. Identify structure of 2, 3-dibromo-1-phenylpentane.



77. Choose the correct statements from the following.

- A**  $\text{Mn}_2\text{O}_7$  is an oil at room temperature      **B**  $\text{V}_2\text{O}_4$  reacts with acid to give  $\text{VO}_2^{2+}$   
**C**  $\text{CrO}$  is a basic oxide      **D**  $\text{V}_2\text{O}_5$  does not react with acid

Choose the correct answer from the options given below :

- (1) A, B and C only      (2) B and C only      (3) A and C only      (4) A, B and D only

78. Match List I with List II

List I (Complex ion)		List II (Electronic Configuration)	
<b>A.</b>	$[\text{Cr}(\text{H}_2\text{O})_6]^{3+}$	<b>I.</b>	$t_{2g}^2 e_g^0$
<b>B.</b>	$[\text{Fe}(\text{H}_2\text{O})_6]^{3+}$	<b>II.</b>	$t_{2g}^3 e_g^0$
<b>C.</b>	$[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$	<b>III.</b>	$t_{2g}^3 e_g^2$
<b>D.</b>	$[\text{V}(\text{H}_2\text{O})_6]^{3+}$	<b>IV.</b>	$t_{2g}^6 e_g^2$

Choose the correct answer from the options given below :

- (1) A – III, B – II, C – IV, D – I      (2) A – IV, B – III, C – I, D – II  
 (3) A – IV, B – I, C – II, D – III      (4) A – II, B – III, C – IV, D – I



79. Choose the correct statement from the following .

- A All group 16 elements form oxides of general formula  $\text{EO}_2$  and  $\text{EO}_3$  where E = S, Se, Te and Po. Both the types of oxides are acidic in nature.
- B  $\text{TeO}_2$  is an oxidising agent while  $\text{SO}_2$  is reducing in nature.
- C The reducing property decreases from  $\text{H}_2\text{S}$  to  $\text{H}_2\text{Te}$  down the group.
- D The ozone molecule contains five lone pairs of electrons.

Choose the correct answer from the option given below :

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

80. A sample of  $\text{CaCO}_3$  and  $\text{MgCO}_3$  weighed 2.21 g is ignited to constant weight of 1.152 g. The composition of mixture is:

(Given molar mass in  $\text{g mol}^{-1}$   $\text{CaCO}_3$  :100,  $\text{MgCO}_3$  :84)

- |  |  |
|--|--|
| (1) 1.187g $\text{CaCO}_3$ +1.023g $\text{MgCO}_3$ | (2) 1.023g $\text{CaCO}_3$ +1.187g $\text{MgCO}_3$ |
| (3) 1.187g $\text{CaCO}_3$ +1.187g $\text{MgCO}_3$ | (4) 1.023g $\text{CaCO}_3$ +1.023g $\text{MgCO}_3$ |

**SECTION-2**

Section 2 contains 10 Numerical Value Type Questions Out of which ONLY 5 (any) questions have to be attempted. The answer to each question should be rounded off to the nearest integer.

81. If 5 moles of an ideal gas expands from 10 L to a volume of 100 L at 300 K under isothermal and reversible condition then work,  $w$ , is  $-xJ$ . The value of  $x$  is \_\_\_\_\_.  
(Given  $R = 8.314 JK^{-1}mol^{-1}$ )
82. From the vitamins  $A, B_1, B_6, B_{12}, C, D, E$  and  $K$ , the number of vitamins that can be stored in our body is \_\_\_\_\_.
83. Number of moles of  $H^+$  ions required by 1 mole of  $MnO_4^-$  to oxidise oxalate ion to  $CO_2$  is \_\_\_\_\_.
84. The molarity of 1 L orthophosphoric acid ( $H_3PO_4$ ) having 70% purity by weight (specific gravity 1.54 g  $cm^{-3}$ ) is \_\_\_\_\_. M.  
(Molar mas of  $H_3PO_4 = 98 g mol^{-1}$ )
85. A diatomic molecule has a dipole moment of 1.2 D. If the bond distance is 1 Å, then fractional charge on each atom is \_\_\_\_\_  $\times 10^{-1}$  esu.  
(Given  $1 D = 10^{-18}$  esucm)
86. The value of conductivity of some materials at 298.15 K in  $S m^{-1}$  are  $2.1 \times 10^3$ ,  $1.0 \times 10^{-16}$ ,  $1.2 \times 10$ ,  $3.191$ ,  $1.5 \times 10^{-2}$ ,  $1 \times 10^{-7}$ ,  $1.0 \times 10^3$ . The number of conductors among the materials is \_\_\_\_\_.
87.  $r = k[A]$  for a reaction, 50% of A is decomposed in 120 minutes. The time taken for 90% decomposition of A is \_\_\_\_\_ minutes.
88. Number of isomeric products formed by monochlorination of 2-methylbutane in presence of sunlight is \_\_\_\_\_.
89. A compound (x) with molar mass  $108 g mol^{-1}$  undergoes acetylation to give product with molar mass  $192 g mol^{-1}$ . The number of amino groups in the compound (x) is \_\_\_\_\_.
90. In the reaction of potassium dichromate, potassium chloride and sulfuric acid (conc.), the oxidation state of the chromium in the product is (+) \_\_\_\_\_.