

# JEE Main 2025 Paper 1 (B.E./B.Tech) 4 April 2025 Shift 1 Question Paper



Conducted by the National Testing Agency (NTA)

Time Allowed: 3 Hours

Paper 1: B.E./B.Tech.

Maximum Marks: 300

## General Instructions

- (i) This paper is **Paper 1 (B.E./B.Tech.)** of **JEE (Main) 2025 - Session 2**, conducted by the National Testing Agency (NTA) in Computer Based Test (CBT) mode on 4 April 2025, Shift 1. The total duration is **3 hours**.
- (ii) The paper has **75 questions** and a maximum of **300 marks**: Mathematics, Physics and Chemistry carry 25 questions (100 marks) each, in that order.
- (iii) Each subject has **two sections**. **Section A** has **20 multiple choice questions** (MCQs) with four options each. Select the most appropriate answer. **Section B** has **5 numerical value questions**.
- (iv) **All questions are compulsory**. For Section B, the answer is an integer value; the answer should be **rounded off to the nearest integer**. Use only the constants given in the question while calculating.
- (v) **Marking scheme** (Sections A and B): **+4** for a correct answer, **-1** for an incorrect answer, and **0** for an unanswred or marked-for-review question.
- (vi) All calculations and rough work are to be done on the rough sheets only. Calculators, log tables, slide rules and electronic gadgets are not allowed.

1. Let  $f : \mathbb{R} \rightarrow \mathbb{R}$  be a continuous function satisfying  $f(0) = 1$  and  $f(2x) - f(x) = x$  for all  $x \in \mathbb{R}$ . If  $\lim_{n \rightarrow \infty} \left\{ f(x) - f\left(\frac{x}{2^n}\right) \right\} = G(x)$ , then  $\sum_{r=1}^{10} G(r^2)$  is equal to

- (A) 215 (B) 420  
(C) 385 (D) 540

2. Let the shortest distance between the lines  $\frac{x-3}{3} = \frac{y-\alpha}{-1} = \frac{z-3}{1}$  and  $\frac{x+3}{-3} = \frac{y+7}{2} = \frac{z-\beta}{4}$  be  $3\sqrt{30}$ . Then the positive value of  $5\alpha + \beta$  is

- (A) 42 (B) 40  
(C) 48 (D) 46

3. Let  $A = \{1, 6, 11, 16, \dots\}$  and  $B = \{9, 16, 23, 30, \dots\}$  be the sets consisting of the first 2025 terms of two arithmetic progressions. Then  $n(A \cup B)$  is

- (A) 3814 (B) 4003  
(C) 4027 (D) 3761

4. The length of the latus-rectum of the ellipse, whose foci are  $(2, 5)$  and  $(2, -3)$  and eccentricity is  $\frac{4}{5}$ , is

- (A)  $\frac{50}{3}$  (B)  $\frac{18}{5}$   
(C)  $\frac{6}{5}$  (D)  $\frac{10}{3}$

5. Consider the equation  $x^2 + 4x - n = 0$ , where  $n \in [20, 100]$  is a natural number. Then the number of all distinct values of  $n$ , for which the given equation has integral roots, is equal to

- (A) 6 (B) 5  
(C) 8 (D) 7

6. Consider the sets

$$A = \{(x, y) \in \mathbb{R} \times \mathbb{R} : x^2 + y^2 = 25\}, B = \{(x, y) \in \mathbb{R} \times \mathbb{R} : x^2 + 9y^2 = 144\}$$

,  $C = \{(x, y) \in \mathbb{Z} \times \mathbb{Z} : x^2 + y^2 \leq 4\}$  and  $D = A \cap B$ . The total number of one-one functions from the set  $D$  to the set  $C$  is:

- (A) 15120 (B) 18290  
(C) 17160 (D) 19320

7.  $1 + 3 + 5^2 + 7 + 9^2 + \dots$  upto 40 terms is equal to

- (A) 40870 (B) 41880  
(C) 43890 (D) 33980

8. If  $10 \sin^4 \theta + 15 \cos^4 \theta = 6$ , then the value of  $\frac{27 \operatorname{cosec}^6 \theta + 8 \sec^6 \theta}{16 \sec^8 \theta}$  is

- (A)  $\frac{2}{5}$  (B)  $\frac{3}{5}$   
(C)  $\frac{1}{5}$  (D)  $\frac{3}{4}$

9. The value of  $\int_{-1}^1 \frac{(1 + \sqrt{|x|-x})e^x + (\sqrt{|x|-x})e^{-x}}{e^x + e^{-x}} dx$  is equal to

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

10. Let  $f : [0, \infty) \rightarrow \mathbb{R}$  be a differentiable function such that

$$f(x) = 1 - 2x + \int_0^x e^{x-t} f(t) dt \text{ for all } x \in [0, \infty).$$

Then the area of the region bounded by  $y = f(x)$  and the coordinate axes is

- (A)  $\sqrt{5}$  (B) 2  
(C)  $\sqrt{2}$  (D)  $\frac{1}{2}$

11. The probability, of forming a 12 persons committee from 4 engineers, 2 doctors and 10 professors containing at least 3 engineers and at least 1 doctor, is

- (A)  $\frac{129}{182}$  (B)  $\frac{17}{26}$   
(C)  $\frac{19}{26}$  (D)  $\frac{103}{182}$

12. A box contains 10 pens of which 3 are defective. A sample of 2 pens is drawn at random and let  $X$  denote the number of defective pens. Then the variance of  $X$  is

- (A)  $\frac{11}{15}$  (B)  $\frac{2}{15}$   
(C)  $\frac{3}{5}$  (D)  $\frac{28}{75}$

13. Consider two vectors  $\vec{u} = 3\hat{i} - \hat{j}$  and  $\vec{v} = 2\hat{i} + \hat{j} - \lambda\hat{k}$ ,  $\lambda > 0$ . The angle between them is given by  $\cos^{-1}\left(\frac{\sqrt{5}}{2\sqrt{7}}\right)$ . Let  $\vec{v} = \vec{v}_1 + \vec{v}_2$ , where  $\vec{v}_1$  is parallel to  $\vec{u}$  and  $\vec{v}_2$  is perpendicular to  $\vec{u}$ . Then the value  $|\vec{v}_1|^2 + |\vec{v}_2|^2$  is equal to

- (A)  $\frac{23}{2}$  (B)  $\frac{25}{2}$   
(C) 10 (D) 14

14. For an integer  $n \geq 2$ , if the arithmetic mean of all coefficients in the binomial expansion of  $(x + y)^{2n-3}$  is 16, then the distance of the point  $P(2n-1, n^2-4n)$  from the line  $x + y = 8$  is

- (A)  $\sqrt{2}$  (B)  $2\sqrt{2}$   
(C)  $5\sqrt{2}$  (D)  $3\sqrt{2}$

15. Let  $A$  and  $B$  be two distinct points on the line  $L: \frac{x-6}{3} = \frac{y-7}{2} = \frac{z-7}{-2}$ . Both  $A$  and  $B$  are at a distance  $2\sqrt{17}$  from the foot of perpendicular drawn from the point  $(1, 2, 3)$  on the line  $L$ . If  $O$  is the origin, then  $\vec{OA} \cdot \vec{OB}$  is equal to

- (A) 49 (B) 21  
(C) 47 (D) 62

16. Let  $f, g: (1, \infty) \rightarrow \mathbb{R}$  be defined as  $f(x) = \frac{2x+3}{5x+2}$  and  $g(x) = \frac{2-3x}{1-x}$ . If the range of the function  $\text{fog}: [2, 4] \rightarrow \mathbb{R}$  is  $[\alpha, \beta]$ , then  $\frac{1}{\beta-\alpha}$  is equal to

- (A) 56 (B) 2  
(C) 29 (D) 68

17. If  $\lim_{x \rightarrow 1^+} \frac{(x-1)(6+\lambda \cos(x-1))+\mu \sin(1-x)}{(x-1)^3} = -1$ , where  $\lambda, \mu \in \mathbb{R}$ , then  $\lambda + \mu$  is equal to

- (A) 20 (B) 19  
(C) 18 (D) 17

18. Let the three sides of a triangle are on the lines  $4x - 7y + 10 = 0$ ,  $x + y = 5$  and  $7x + 4y = 15$ . Then the distance of its orthocentre from the orthocentre of the triangle formed by the lines  $x = 0$ ,  $y = 0$  and  $x + y = 1$  is

- (A)  $\sqrt{20}$  (B) 20  
(C)  $\sqrt{5}$  (D) 5

19. In the expansion of  $\left(\sqrt[3]{2} + \frac{1}{\sqrt[3]{3}}\right)^n$ ,  $n \in \mathbb{N}$ , if the ratio of 15<sup>th</sup> term from the beginning to the 15<sup>th</sup> term from the end is  $\frac{1}{6}$ , then the value of  ${}^nC_3$  is

- (A) 4960 (B) 2300  
(C) 1040 (D) 4060

20. Considering the principal values of the inverse trigonometric functions,  $\sin^{-1}\left(\frac{\sqrt{3}}{2}x + \frac{1}{2}\sqrt{1-x^2}\right)$ ,  $-\frac{1}{2} < x < \frac{1}{\sqrt{2}}$ , is equal to

- (A)  $\frac{-5\pi}{6} - \sin^{-1}x$  (B)  $\frac{5\pi}{6} - \sin^{-1}x$   
(C)  $\frac{\pi}{6} + \sin^{-1}x$  (D)  $\frac{\pi}{4} + \sin^{-1}x$

21. Let  $C$  be the circle  $x^2 + (y - 1)^2 = 2$ ,  $E_1$  and  $E_2$  be two ellipses whose centres lie at the origin and major axes lie on  $x$ -axis and  $y$ -axis respectively. Let the straight line  $x + y = 3$  touch the curves  $C$ ,  $E_1$  and  $E_2$  at  $P(x_1, y_1)$ ,  $Q(x_2, y_2)$  and  $R(x_3, y_3)$  respectively. Given that  $P$  is the mid point of the line segment  $QR$  and  $PQ = \frac{2\sqrt{2}}{3}$ , the value of  $9(x_1y_1 + x_2y_2 + x_3y_3)$  is equal to \_\_\_\_\_.

22. Let  $m$  and  $n$  be the number of points at which the function  $f(x) = \max\{x, x^3, x^5, \dots, x^{21}\}$ ,  $x \in \mathbb{R}$ , is not differentiable and not continuous, respectively. Then  $m + n$  is equal to \_\_\_\_\_.

23. Let  $A = \begin{bmatrix} \cos \theta & 0 & -\sin \theta \\ 0 & 1 & 0 \\ \sin \theta & 0 & \cos \theta \end{bmatrix}$ . If for some  $\theta \in (0, \pi)$ ,  $A^2 = A^T$ , then the sum of the diagonal elements of the matrix  $(A + I)^3 + (A - I)^3 - 6A$  is equal to \_\_\_\_\_.

24. If the area of the region  $\{(x, y) : |x - 5| \leq y \leq 4\sqrt{x}\}$  is  $A$ , then  $3A$  is equal to \_\_\_\_\_.

25. Let  $A = \{z \in \mathbb{C} : |z - 2 - i| = 3\}$ ,  $B = \{z \in \mathbb{C} : \operatorname{Re}(z - iz) = 2\}$  and  $S = A \cap B$ . Then  $\sum_{z \in S} |z|^2$  is equal to \_\_\_\_\_.

26. Consider the sound wave travelling in ideal gases of He, CH<sub>4</sub>, and CO<sub>2</sub>. All the gases have the same ratio  $\frac{P}{\rho}$ , where  $P$  is the pressure and  $\rho$  is the density. The ratio of the speed of sound through the gases  $V_{\text{He}} : V_{\text{CH}_4} : V_{\text{CO}_2}$  is given by

- (A)  $\sqrt{\frac{7}{5}} : \sqrt{\frac{5}{3}} : \sqrt{\frac{4}{3}}$  (B)  $\sqrt{\frac{5}{3}} : \sqrt{\frac{4}{3}} : \sqrt{\frac{4}{3}}$   
(C)  $\sqrt{\frac{5}{3}} : \sqrt{\frac{4}{3}} : \sqrt{\frac{7}{5}}$  (D)  $\sqrt{\frac{4}{3}} : \sqrt{\frac{5}{3}} : \sqrt{\frac{7}{5}}$

27. In an electromagnetic system, the quantity representing the ratio of electric flux and magnetic flux has dimension of  $M^P L^Q T^R A^S$ , where value of 'Q' and 'R' are

- (A) (3, -5) (B) (-2, 1)  
(C) (-2, 2) (D) (1, -1)

28. Two simple pendulums having lengths  $l_1$  and  $l_2$  with negligible string mass undergo angular displacements  $\theta_1$  and  $\theta_2$ , from their mean positions, respectively. If the angular accelerations of both pendulums are same, then which expression is correct?

- (A)  $\theta_1 l_2 = \theta_2 l_1$  (B)  $\theta_1 l_1 = \theta_2 l_2$   
(C)  $\theta_1 l_2^2 = \theta_2 l_1^2$  (D)  $\theta_1 l_1^2 = \theta_2 l_2^2$

29. In a Young's double slit experiment, the slits are separated by 0.2 mm. If the slits separation is increased to 0.4 mm, the percentage change of the fringe width is:

- (A) 25% (B) 50%  
(C) 0% (D) 100%

30. Current passing through a wire as function of time is given as  $I(t) = 0.02t + 0.01$  A. The charge that will flow through the wire from  $t = 1$  s to  $t = 2$  s is

- (A) 0.02 C (B) 0.07 C  
(C) 0.06 C (D) 0.04 C

31. An alternating current is represented by the equation,  $i = 100\sqrt{2} \sin(100\pi t)$  ampere. The RMS value of current and the frequency of the given alternating current are

- (A)  $\frac{100}{\sqrt{2}}$  A, 100 Hz (B)  $50\sqrt{2}$  A, 50 Hz  
(C)  $100\sqrt{2}$  A, 100 Hz (D) 100 A, 50 Hz

32. Two liquids A and B have  $\theta_A$  and  $\theta_B$  as contact angles in a capillary tube. If  $K = \cos \theta_A / \cos \theta_B$ , then identify the correct statement:

- (A) K is negative, then liquid A and liquid B have convex meniscus. (B) K is negative, then liquid A and liquid B have concave meniscus.  
(C) K is zero, then liquid A has convex meniscus and liquid B has concave meniscus. (D) K is negative, then liquid A has concave meniscus and liquid B has convex meniscus.

33. Which of the following are correct expression for torque acting on a body?

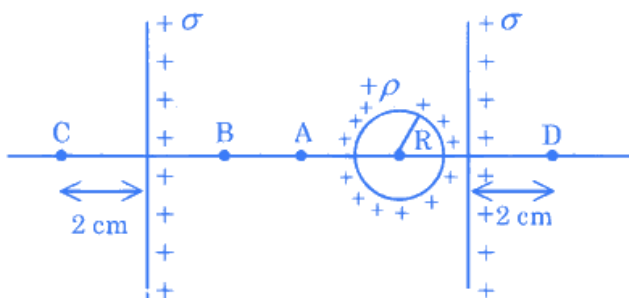
- A.  $\vec{\tau} = \vec{r} \times \vec{L}$   
B.  $\vec{\tau} = \frac{d}{dt}(\vec{r} \times \vec{p})$   
C.  $\vec{\tau} = \vec{r} \times \frac{d\vec{p}}{dt}$   
D.  $\vec{\tau} = I\vec{\alpha}$   
E.  $\vec{\tau} = \vec{r} \times \vec{F}$

( $\vec{r}$  = position vector;  $\vec{p}$  = linear momentum;  $\vec{L}$  = angular momentum;  $\vec{\alpha}$  = angular acceleration;  $I$  = moment of inertia;  $\vec{F}$  = force;  $t$  = time)

Choose the correct answer from the options given below:

- (A) A, B, D and E Only (B) C and D Only  
(C) B, C, D and E Only (D) B, D and E Only

34. Two infinite identical charged sheets and a charged spherical body of charge density ' $\rho$ ' are arranged as shown in figure. Then the correct relation between the electrical fields at A, B, C and D points is:



- (A)  $|\vec{E}_A| = |\vec{E}_B|; \vec{E}_C > \vec{E}_D$   
 (B)  $\vec{E}_A = \vec{E}_B; \vec{E}_C = \vec{E}_D$   
 (C)  $\vec{E}_C \neq \vec{E}_D; \vec{E}_A > \vec{E}_B$   
 (D)  $\vec{E}_A > \vec{E}_B; \vec{E}_C = \vec{E}_D$

35. Considering the Bohr model of hydrogen like atoms, the ratio of the radius of 5<sup>th</sup> orbit of the electron in  $\text{Li}^{2+}$  and  $\text{He}^+$  is

- (A)  $\frac{3}{2}$  (B)  $\frac{2}{3}$   
 (C)  $\frac{4}{9}$  (D)  $\frac{9}{4}$

36. When an object is placed 40 cm away from a spherical mirror an image of magnification  $\frac{1}{2}$  is produced. To obtain an image with magnification of  $\frac{1}{3}$ , the object is to be moved :

- (A) 20 cm away from the mirror. (B) 20 cm towards the mirror.  
 (C) 80 cm away from the mirror. (D) 40 cm away from the mirror.

37. In an experiment with a closed organ pipe, it is filled with water by  $(\frac{1}{5})$  th of its volume. The frequency of the fundamental note will change by

- (A) 20% (B) 25%  
 (C) -20% (D) -25%

38. A body of mass  $m$  is suspended by two strings making angles  $\theta_1$  and  $\theta_2$  with the horizontal ceiling with tensions  $T_1$  and  $T_2$  simultaneously.  $T_1$  and  $T_2$  are related by  $T_1 = \sqrt{3}T_2$ , the angles  $\theta_1$  and  $\theta_2$  are

- (A)  $\theta_1 = 30^\circ, \theta_2 = 60^\circ$  with  $T_2 = \frac{3mg}{4}$  (B)  $\theta_1 = 45^\circ, \theta_2 = 45^\circ$  with  $T_2 = \frac{3mg}{4}$   
 (C)  $\theta_1 = 30^\circ, \theta_2 = 60^\circ$  with  $T_2 = \frac{4mg}{5}$  (D)  $\theta_1 = 60^\circ, \theta_2 = 30^\circ$  with  $T_2 = \frac{mg}{2}$

39. A small mirror of mass  $m$  is suspended by a massless thread of length  $l$ . Then the small angle through which the thread will be deflected when a short pulse of laser of energy  $E$  falls normal on the mirror

( $c$  = speed of light in vacuum and  $g$  = acceleration due to gravity)

- (A)  $\theta = \frac{E}{mc\sqrt{gl}}$  (B)  $\theta = \frac{E}{2mc\sqrt{gl}}$   
 (C)  $\theta = \frac{3E}{4mc\sqrt{gl}}$  (D)  $\theta = \frac{2E}{mc\sqrt{gl}}$

40. Given below are two statements : one is labelled as **Assertion A** and the other is labelled as **Reason R**

**Assertion A** : The kinetic energy needed to project a body of mass  $m$  from earth surface to infinity is  $\frac{1}{2}mgR$ , where  $R$  is the radius of earth.

**Reason R** : The maximum potential energy of a body is zero when it is projected to infinity from earth surface.

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

- (A) **A** is false but **R** is true (B) Both **A** and **R** are true and **R** is the correct explanation of **A**  
 (C) **A** is true but **R** is false (D) Both **A** and **R** are true but **R** is NOT the correct explanation of **A**

41. The Boolean expression  $Y = A\bar{B}C + \bar{A}\bar{C}$  can be realised with which of the following gate configurations.

- A. One 3-input AND gate, 3 NOT gates and one 2-input OR gate, One 2-input AND gate,  
B. One 3-input AND gate, 1 NOT gate, One 2-input NOR gate and one 2-input OR gate  
C. 3-input OR gate, 3 NOT gates and one 2-input AND gate

Choose the correct answer from the options given below:

- (A) B, C Only (B) A, B, C Only  
(C) A, B Only (D) A, C Only

42. The mean free path and the average speed of oxygen molecules at 300 K and 1 atm are  $3 \times 10^{-7}$  m and 600 m/s, respectively. Find the frequency of its collisions.

- (A)  $5 \times 10^8/\text{s}$   
(B)  $9 \times 10^5/\text{s}$   
(C)  $2 \times 10^{10}/\text{s}$   
(D)  $2 \times 10^9/\text{s}$

43. If  $\vec{L}$  and  $\vec{P}$  represent the angular momentum and linear momentum respectively of a particle of mass '  $m$  ' having position vector as  $\vec{r} = a(\hat{i} \cos \omega t + \hat{j} \sin \omega t)$ . The direction of force is

- (A) Opposite to the direction of  $\vec{L}$  (B) Opposite to the direction of  $\vec{L} \times \vec{P}$   
(C) Opposite to the direction of  $\vec{r}$  (D) Opposite to the direction of  $\vec{P}$

44. Given below are two statements: one is labelled as **Assertion A** and the other is labelled as **Reason R**

**Assertion A** : In photoelectric effect, on increasing the intensity of incident light the stopping potential increases.

**Reason R** : Increase in intensity of light increases the rate of photoelectrons emitted, provided the frequency of incident light is greater than threshold frequency.

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

- (A) Both **A** and **R** are true and **R** is the correct explanation of **A**  
(B) **A** is false but **R** is true  
(C) Both **A** and **R** are true but **R** is NOT the correct explanation of **A**  
(D) **A** is true but **R** is false

45. Two small spherical balls of mass 10 g each with charges  $-2\mu\text{C}$  and  $2\mu\text{C}$ , are attached to two ends of very light rigid rod of length 20 cm. The arrangement is now placed near an infinite non-conducting charge sheet with uniform charge density of  $100\mu\text{C}/\text{m}^2$  such that length of rod makes an angle of  $30^\circ$  with electric field generated by charge sheet. Net torque acting on the rod is: (Take  $\epsilon_0 : 8.85 \times 10^{-12} \text{C}^2/\text{Nm}^2$ )

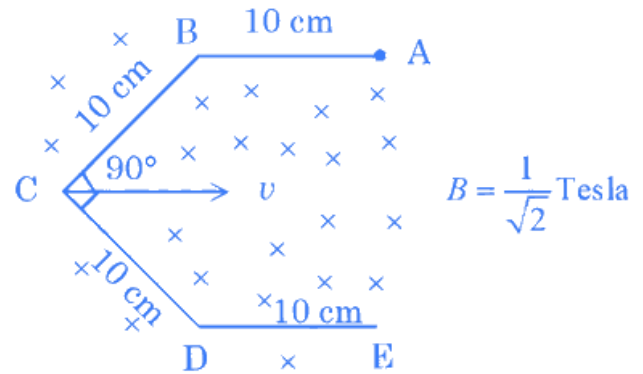
- (A) 1.12 Nm (B) 2.24 Nm  
(C) 11.2 Nm (D) 112 Nm

46. A circular ring and a solid sphere having same radius roll down on an inclined plane from rest without slipping. The ratio of their velocities when reached at the bottom of the plane is  $\sqrt{\frac{x}{5}}$  where  $x =$  \_\_\_\_\_.

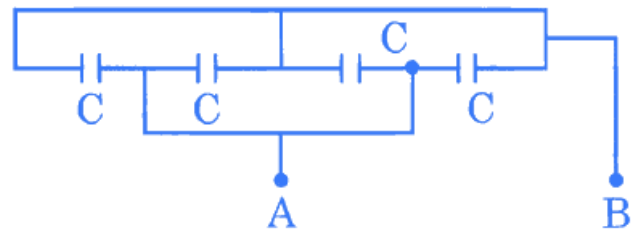
47. Distance between object and its image (magnified by  $-\frac{1}{3}$ ) is 30 cm. The focal length of the mirror used is  $(\frac{x}{4})$  cm, where magnitude of value of  $x$  is \_\_\_\_\_.

48. Two slabs with square cross section of different materials (1, 2) with equal sides ( $l$ ) and thickness  $d_1$  and  $d_2$  such that  $d_2 = 2d_1$  and  $l > d_2$ . Considering lower edges of these slabs are fixed to the floor, we apply equal shearing force on the narrow faces. The angle of deformation is  $\theta_2 = 2\theta_1$ . If the shear moduli of material 1 is  $4 \times 10^9 \text{ N/m}^2$ , then shear moduli of material 2 is  $x \times 10^9 \text{ N/m}^2$ , where value of  $x$  is \_\_\_\_\_.

49. Conductor wire ABCDE with each arm 10 cm in length is placed in magnetic field of  $\frac{1}{\sqrt{2}}$  Tesla, perpendicular to its plane. When conductor is pulled towards right with constant velocity of 10 cm/s, induced emf between points A and E is \_\_\_\_\_ mV.



50. Four capacitors each of capacitance  $16\mu\text{F}$  are connected as shown in the figure. The capacitance between points A and B is : \_\_\_\_\_ ( $\mu\text{F}$ ).



51. For  $A_2 + B_2 \rightleftharpoons 2AB$

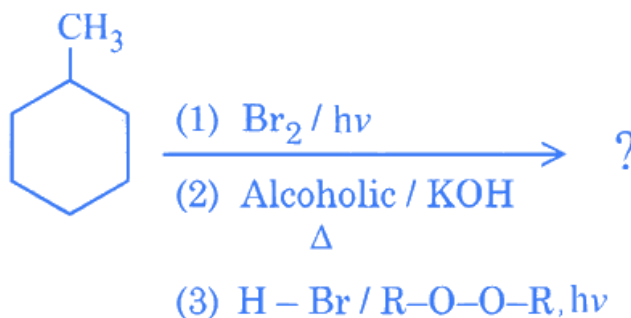
$E_a$  for forward and backward reaction are 180 and  $200 \text{ kJ mol}^{-1}$  respectively

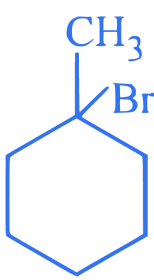
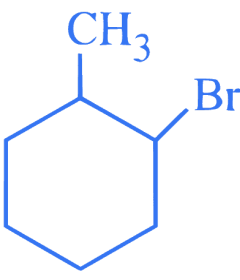
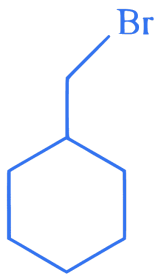
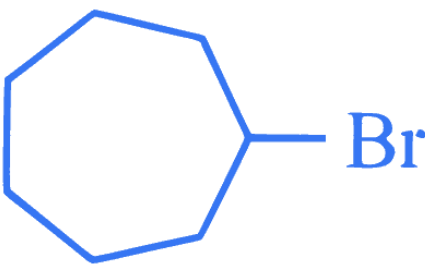
If catalyst lowers  $E_a$  for both reaction by  $100 \text{ kJ mol}^{-1}$ .

Which of the following statement is correct?

- |                                                                    |                                                                                                    |
|--------------------------------------------------------------------|----------------------------------------------------------------------------------------------------|
| (A) Catalyst does not alter the Gibbs energy change of a reaction. | (B) The enthalpy change for the reaction is $+20 \text{ kJ mol}^{-1}$ .                            |
| (C) Catalyst can cause non-spontaneous reactions to occur.         | (D) The enthalpy change for the catalysed reaction is different from that of uncatalysed reaction. |

52. Predict the major product of the following reaction sequence:-



- (A) 
- (B) 
- (C) 
- (D) 

53. Which one of the following about an electron occupying the 1 s orbital in a hydrogen atom is incorrect?

(Bohr's radius is represented by  $a_0$ )

- |                                                                               |                                                                                                 |
|-------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------|
| (A) The probability density of finding the electron is maximum at the nucleus | (B) The total energy of the electron is maximum when it is at a distance $a_0$ from the nucleus |
| (C) The electron can be found at a distance $2a_0$ from the nucleus           | (D) The 1 s orbital is spherically symmetrical                                                  |

54. Rate law for a reaction between  $A$  and  $B$  is given by

$$r = k[A]^n[B]^m$$

If concentration of  $A$  is doubled and concentration of  $B$  is halved from their initial value, the ratio of new rate of reaction to the initial rate of reaction  $\left(\frac{r_2}{r_1}\right)$  is

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

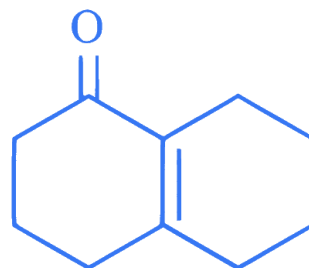
55. Pair of transition metal ions having the same number of unpaired electrons is

- |                        |                        |
|------------------------|------------------------|
| (A) $Ti^{3+}, Mn^{2+}$ | (B) $Ti^{2+}, Co^{2+}$ |
| (C) $Fe^{3+}, Cr^{2+}$ | (D) $V^{2+}, Co^{2+}$  |

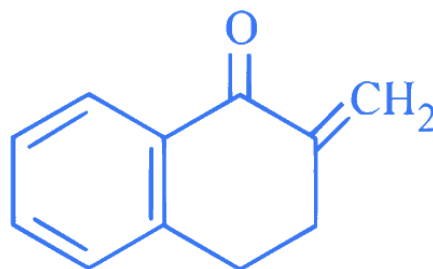
56. On charging the lead storage battery, the oxidation state of lead changes from  $x_1$  to  $y_1$  at the anode and from  $x_2$  to  $y_2$  at the cathode. The values of  $x_1, y_1, x_2, y_2$  are respectively :

- |                   |                   |
|-------------------|-------------------|
| (A) 0, +2, +4, +2 | (B) +2, 0, 0, +4  |
| (C) +4, +2, 0, +2 | (D) +2, 0, +2, +4 |

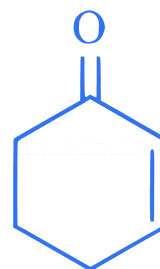
57. Aldol condensation is a popular and classical method to prepare  $\alpha, \beta$ -unsaturated carbonyl compounds. This reaction can be both intermolecular and intramolecular. Predict which one of the following is not a product of intramolecular aldol condensation?



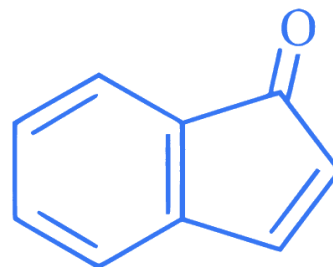
(A)



(B)

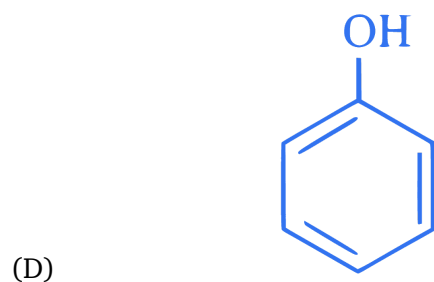
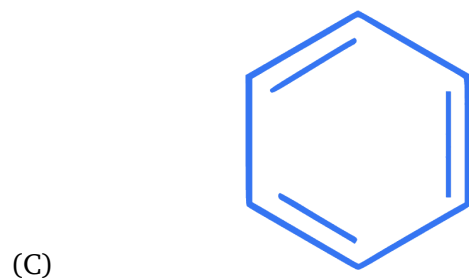
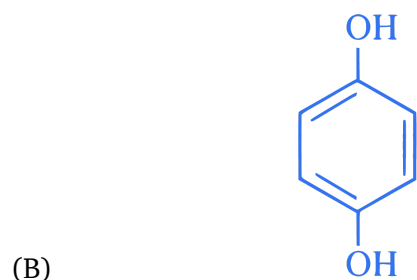
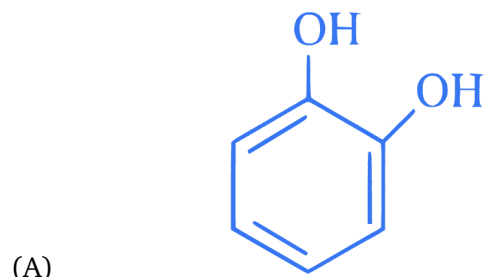


(C)



(D)

58. Benzene is treated with oleum to produce compound (X) which when further heated with molten sodium hydroxide followed by acidification produces compound (Y). The compound Y is treated with zinc metal to produce compound (Z). Identify the structure of compound (Z) from the following option.



59. One mole of an ideal gas expands isothermally and reversibly from  $10\text{dm}^3$  to  $20\text{dm}^3$  at  $300\text{ K}$ .  $\Delta U$ ,  $q$  and work done in the process respectively are

Given:  $R = 8.3\text{ J K}^{-1}\text{ mol}^{-1}$

$\ln 10 = 2.3$

$\log 2 = 0.30$

$\log 3 = 0.48$

- (A)  $0, 21.84\text{ kJ}, -1.726\text{ J}$   
 (B)  $0, 21.84\text{ kJ}, 21.84\text{ kJ}$   
 (C)  $0, 1.718\text{ kJ}, -1.718\text{ kJ}$   
 (D)  $0, -17.18\text{ kJ}, 1.718\text{ J}$

60. Given below are two statements.

Statement I: The dipole moment of  $\overset{4}{\text{CH}_3}-\overset{3}{\text{CH}}=\overset{2}{\text{CH}}-\overset{1}{\text{CH}}=\text{O}$  is greater than  $\overset{4}{\text{CH}_3}-\overset{3}{\text{CH}_2}-\overset{2}{\text{CH}_2}-\overset{1}{\text{CH}}=\text{O}$

Statement II:  $\text{C}_1-\text{C}_2$  bond length of  $\overset{4}{\text{CH}_3}-\overset{3}{\text{CH}}=\overset{2}{\text{CH}}-\overset{1}{\text{CH}}=\text{O}$  is greater than  $\text{C}_1-\text{C}_2$  bond length of  $\overset{4}{\text{CH}_3}-\overset{3}{\text{CH}_2}-\overset{2}{\text{CH}_2}-\overset{1}{\text{CH}}=\text{O}$

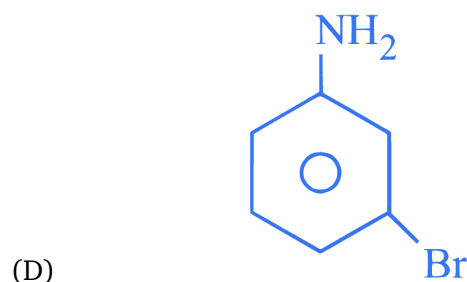
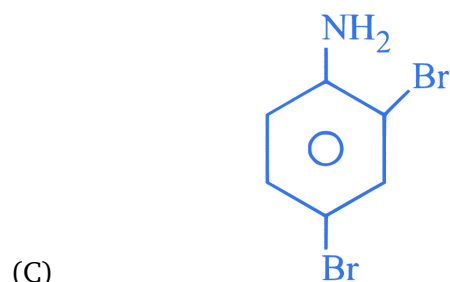
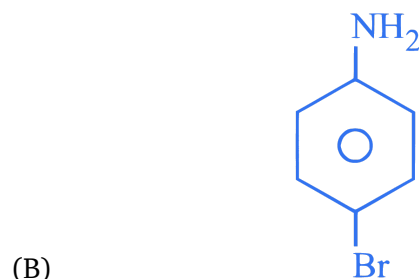
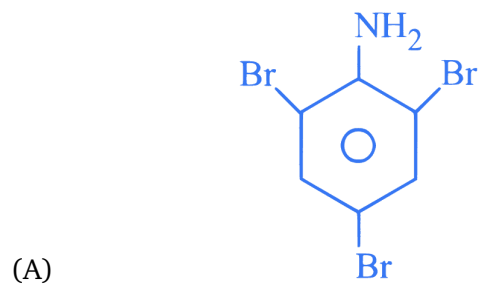
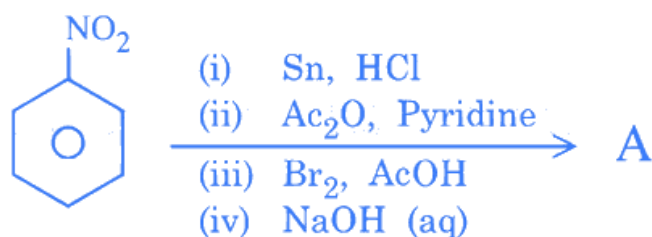
In the light of the above statements, choose the correct answer from the options given below:

- (A) Both Statement I and Statement II are true  
 (B) Statement I is true but Statement II is false  
 (C) Statement I is false but Statement II is true  
 (D) Both Statement I and Statement II are false

61. Which one of the following complexes will have  $\Delta_o = 0$  and  $\mu = 5.96\text{ B.M.}$ ?

- (A)  $[\text{FeF}_6]^{4-}$   
 (B)  $[\text{Mn}(\text{SCN})_6]^{4-}$   
 (C)  $[\text{Co}(\text{NH}_3)_6]^{3+}$   
 (D)  $[\text{Fe}(\text{CN})_6]^{4-}$

62. The major product (A) formed in the following reaction sequence is



63. Given below are two statements:

Statement I: Nitrogen forms oxides with +1 to +5 oxidation states due to the formation of  $p\pi - p\pi$  bond with oxygen.

Statement II: Nitrogen does not form halides with +5 oxidation state due to the absence of d-orbital in it.

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

- |                                                    |                                                   |
|----------------------------------------------------|---------------------------------------------------|
| (A) Both Statement I and Statement II are true     | (B) Statement I is true but Statement II is false |
| (C) Statement I is false but Statement II are true | (D) Both Statement I and Statement II are False   |

64. Number of stereoisomers possible for the complexes,  $[\text{CrCl}_3(\text{py})_3]$  and  $[\text{CrCl}_2(\text{ox})_2]^{3-}$  are respectively (*py* = pyridine, *ox* = oxalate )

- |           |           |
|-----------|-----------|
| (A) 3 & 3 | (B) 2 & 3 |
| (C) 1 & 2 | (D) 2 & 2 |

65. An organic compound (X) with molecular formula  $\text{C}_3\text{H}_6\text{O}$  is not readily oxidised. On reduction it gives  $\text{C}_3\text{H}_8\text{O}$  (Y) which reacts with HBr to give a bromide (Z) which is converted to Grignard reagent. This Grignard reagent on reaction with (X) followed by hydrolysis give 2,3-dimethylbutan-2-ol. Compounds (X), (Y) and (Z) respectively are:

- (A)  $\text{CH}_3\text{CH}_2\text{CHO}$ ,  $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$ ,  $\text{CH}_3\text{CH}_2\text{CH}_2\text{Br}$
- (B)  $\text{CH}_3\text{COCH}_3$ ,  $\text{CH}_3\text{CH}(\text{OH})\text{CH}_3$ ,  $\text{CH}_3\text{CH}(\text{Br})\text{CH}_3$
- (C)  $\text{CH}_3\text{COCH}_3$ ,  $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$ ,  $\text{CH}_3\text{CH}(\text{Br})\text{CH}_3$
- (D)  $\text{CH}_3\text{CH}_2\text{CHO}$ ,  $\text{CH}_3\text{CH}=\text{CH}_2$ ,  $\text{CH}_3\text{CH}(\text{Br})\text{CH}_3$

66. Let us consider a reversible reaction at temperature, T. In this reaction, both  $\Delta H$  and  $\Delta S$  were observed to have positive values. If the equilibrium temperature is  $T_e$ , then the reaction becomes spontaneous at:

- |               |                 |
|---------------|-----------------|
| (A) $T_e > T$ | (B) $T > T_e$   |
| (C) $T = T_e$ | (D) $T_e = 5 T$ |

67. Which of the following molecule(s) show/s paramagnetic behavior?

- A.  $O_2$
- B.  $N_2$
- C.  $F_2$
- D.  $S_2$
- E.  $Cl_2$

Choose the correct answer from the options given below:

- (A) A & C only
- (B) A & E Only
- (C) A & D Only
- (D) B Only

68. Identify the pair of reactants that upon reaction, with elimination of HCl will give rise to the dipeptide Gly-Ala.

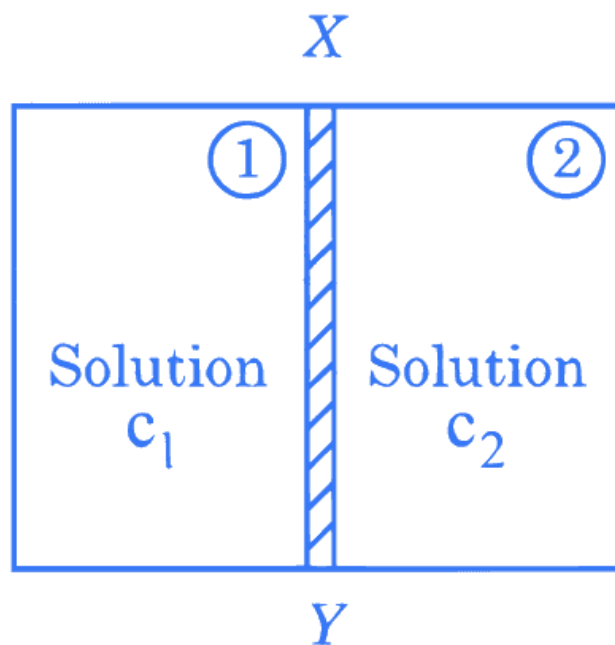
- (A)  $NH_2-CH_2-COOH$  and  $NH_2-\overset{\overset{CH_3}{|}}{CH}-COOH$
- (B)  $NH_2-CH_2-COCl$  and  $\overset{\oplus}{NH_3}-\overset{\overset{CH_3}{|}}{CH}-COCl$
- (C)  $NH_2-CH_2-COCl$  and  $NH_2-\overset{\overset{CH_3}{|}}{CH}-COOH$
- (D)  $NH_2-CH_2-COOH$  and  $NH_2-\overset{\overset{CH_3}{|}}{CH}-COCl$

69. Given below are the pairs of group 13 elements showing their relation in terms of atomic radius. ( $B < Al$ ), ( $Al < Ga$ ), ( $Ga < In$ ) and ( $In < Tl$ ) Identify the elements present in the incorrect pair and in that pair find out the element (X) that has higher ionic radius ( $M^{3+}$ ) than the other one. The atomic number of the element (X) is

- (A) 49
- (B) 81
- (C) 31
- (D) 13

70. XY is the membrane/partition between two chambers 1 and 2 containing sugar solutions of concentration  $c_1$  and  $c_2$  ( $c_1 > c_2$ )  $\text{molL}^{-1}$ . For the reverse osmosis to take place identify the correct condition.

(Here  $p_1$  and  $p_2$  are pressures applied on chamber 1 and 2 ).



- A. Membrane/Partition : Cellophane,  $p_1 > \pi$
  - B. Membrane/Partition : Porous,  $p_2 > \pi$
  - C. Membrane/Partition : Parchment paper,  $p_1 > \pi$
  - D. Membrane/Partition : Cellophane,  $p_2 > \pi$
- Choose the correct answer from the option given below:

- (A) A and C Only
- (B) A and D Only
- (C) B and D Only
- (D) C Only

## Chemistry - Section B · Numerical Value Questions

71. The pH of a 0.01 M weak acid HX ( $K_a = 4 \times 10^{-10}$ ) is found to be 5. Now the acid solution is diluted with excess of water so that the pH of the solution changes to 6. The new concentration of the diluted weak acid is given as  $x \times 10^{-4}$  M. The value of  $x$  is \_\_\_\_\_ (nearest integer)

72. In Dumas' method for estimation of nitrogen 1 g of an organic compound gave 150 mL of nitrogen collected at 300 K temperature and 900 mm Hg pressure. The percentage composition of nitrogen in the compound is \_\_\_\_\_ % (nearest integer)  
(Aqueous tension at 300 K = 15 mm Hg)

73. Fortification of food with iron is done using  $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$ . The mass in grams of the  $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$  required to achieve 12 ppm of iron in 150 kg of wheat is \_\_\_\_\_ (Nearest integer)  
[Given: Molar mass of Fe, S and O respectively are 56, 32 and 16  $\text{g mol}^{-1}$ ]

74.  $\text{KMnO}_4$  acts as an oxidising agent in acidic medium. 'X' is the difference between the oxidation states of Mn in reactant and product. 'Y' is the number of 'd' electrons present in the brown red precipitate formed at the end of the acetate ion test with neutral ferric chloride. The value of  $X + Y$  is \_\_\_\_\_.

75. The total number of hydrogen bonds of a DNA-double Helix strand whose one strand has the following sequence of bases is \_\_\_\_\_.

5' – G – G – C – A – A – A – T – C – G – G  
– C – T – A – 3'

- End of Question Paper -