



## JEE Main – 2024

### 31<sup>st</sup> JANUARY 2024 (Morning 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.

1. Let  $g(x)$  be a linear function and  $f(x) = \begin{cases} g(x) & , x \leq 0 \\ \left(\frac{1+x}{2+x}\right)^{\frac{1}{x}} & , x > 0 \end{cases}$ , is continuous at  $x = 0$ . If  $f'(1) = f'(-1)$ ,

then the value  $g(3)$  is:

- (1)  $\frac{1}{3} \log_e \left( \frac{4}{9e^{1/3}} \right)$  (2)  $\log_e \left( \frac{4}{9} \right) - 1$  (3)  $\log_e \left( \frac{4}{9e^{1/3}} \right)$  (4)  $\frac{1}{3} \log_e \left( \frac{4}{9} \right) + 1$

2. Two marbles are drawn in succession from a box containing 10 red, 30 white, 20 blue and 15 orange marbles, with replacement being made after each drawing. Then the probability, that first drawn marble is red and second drawn marble is white, is:

- (1)  $\frac{4}{25}$  (2)  $\frac{2}{25}$  (3)  $\frac{4}{75}$  (4)  $\frac{2}{3}$

3. Let  $\alpha, \beta, \gamma, \delta \in \mathbb{Z}$  and let  $A(\alpha, \beta)$ ,  $B(1, 0)$ ,  $C(\gamma, \delta)$  and  $D(1, 2)$  be the vertices of a parallelogram  $ABCD$ . If  $AB = \sqrt{10}$  and the points A and C lie on the line  $3y = 2x + 1$ , then  $2(\alpha + \beta + \gamma + \delta)$  is equal to:

- (1) 10 (2) 5 (3) 12 (4) 8

4. Let  $S$  be the set of positive integral values of  $a$  for which  $\frac{ax^2 + 2(a+1)x + 9a + 4}{x^2 - 8x + 32} < 0, \forall x \in \mathbb{R}$ . Then, the number of elements in  $S$  is:

- (1) 3 (2) 0 (3) 1 (4)  $\infty$

5. For  $0 < c < b < a$ , let  $(a+b-2c)x^2 + (b+c-2a)x + (c+a-2b) = 0$  and  $\alpha \neq 1$  be one of its root, Then, among the two statements:

(I) If  $\alpha \in (-1, 0)$ , then  $b$  cannot be the geometric mean of  $a$  and  $c$

(II) If  $\alpha \in (0, 1)$ , then  $b$  may be the geometric mean of  $a$  and  $c$

- (1) Only (II) is true (2) Both (I) and (II) are true  
(3) Only (I) is true (4) Neither (I) nor (II) is true

6. For  $\alpha, \beta, \gamma \neq 0$ , is  $\sin^{-1} \alpha + \sin^{-1} \beta + \sin^{-1} \gamma = \pi$  and  $(\alpha + \beta + \gamma)(\alpha - \gamma + \beta) = 3\alpha\beta$ , then  $\gamma$  equals:

- (1)  $\sqrt{3}$  (2)  $\frac{\sqrt{3}}{2}$  (3)  $\frac{1}{\sqrt{2}}$  (4)  $\frac{\sqrt{3}-1}{2\sqrt{2}}$

7. Let  $y = y(x)$  be the solution of the differential equation  $\frac{dy}{dx} = \frac{(\tan x) + y}{\sin x(\sec x - \sin x \tan x)}, x \in \left(0, \frac{\pi}{2}\right)$

satisfying the condition  $y\left(\frac{\pi}{4}\right) = 2$ . Then,  $y\left(\frac{\pi}{3}\right)$  is:

- (1)  $\frac{\sqrt{3}}{2}(2 + \log_e 3)$  (2)  $\sqrt{3}(2 + \log_e \sqrt{3})$  (3)  $\sqrt{3}(1 + 2 \log_e 3)$  (4)  $\sqrt{3}(2 + \log_e 3)$

8. The area of the region  $\left\{ (x, y) : y^2 \leq 4x, x < 4, \frac{xy(x-1)(x-2)}{(x-3)(x-4)} > 0, x \neq 3 \right\}$  is:

- (1)  $\frac{8}{3}$  (2)  $\frac{64}{3}$  (3)  $\frac{32}{3}$  (4)  $\frac{16}{3}$

9. Let  $a$  be the sum of all coefficients in the expansion of  $(1 - 2x + 2x^2)^{2023}(3 - 4x^2 + 2x^3)^{2024}$  and  $b = \lim_{x \rightarrow 0} \left( \frac{\int_0^x \frac{\log(1+t)}{t^{2024}+1} dt}{x^2} \right)$ . If the equations  $cx^2 + dx + e = 0$  and  $2bx^2 + ax + 4 = 0$  have a common root, where  $c, d, e \in R$ , then  $d : c : e$  equals :
- (1) 4 : 1 : 4      (2) 1 : 1 : 4      (3) 1 : 2 : 4      (4) 2 : 1 : 4
10. Three rotten apples are accidentally mixed with fifteen good apples. Assuming the random variable  $x$  to be the number of rotten apples in a draw of two apples, the variance of  $x$  is:
- (1)  $\frac{40}{153}$       (2)  $\frac{37}{153}$       (3)  $\frac{47}{153}$       (4)  $\frac{57}{153}$
11. If one of the diameters of the circle  $x^2 + y^2 - 10x + 4y + 13 = 0$  is a chord of another circle  $C$ , whose centre is the point of intersection of the lines  $2x + 3y = 12$  and  $3x - 2y = 5$ , then the radius of the circle  $C$  is:
- (1) 6      (2)  $3\sqrt{2}$       (3)  $\sqrt{20}$       (4) 4
12. Let  $\vec{a} = 3\hat{i} + \hat{j} - 2\hat{k}$ ,  $\vec{b} = 4\hat{i} + \hat{j} + 7\hat{k}$  and  $\vec{c} = \hat{i} - 3\hat{j} + 4\hat{k}$  be three vectors. If a vectors  $\vec{p}$  satisfies  $\vec{p} \times \vec{b} = \vec{c} \times \vec{b}$  and  $\vec{p} \cdot \vec{a} = 0$ , then  $\vec{p} \cdot (\hat{i} - \hat{j} - \hat{k})$  is equal to :
- (1) 28      (2) 24      (3) 32      (4) 36
13. The sum of the series  $\frac{1}{1 - 3 \cdot 1^2 + 1^4} + \frac{2}{1 - 3 \cdot 2^2 + 2^4} + \frac{3}{1 - 3 \cdot 3^2 + 3^4} + \dots$  up to 10 terms is :
- (1)  $\frac{55}{109}$       (2)  $-\frac{45}{109}$       (3)  $-\frac{55}{109}$       (4)  $\frac{45}{109}$
14. The solution curve of the differential equation  $y \frac{dx}{dy} = x(\log_e x - \log_e y + 1)$ ,  $x > 0, y > 0$  passing through the point  $(e, 1)$  is:
- (1)  $2 \left| \log_e \frac{x}{y} \right| = y + 1$       (2)  $\left| \log_e \frac{y}{x} \right| = x$   
 (3)  $\left| \log_e \frac{x}{y} \right| = y$       (4)  $\left| \log_e \frac{y}{x} \right| = y^2$
15.  $\lim_{x \rightarrow 0} \frac{e^{2|\sin x|} - 2|\sin x| - 1}{x^2}$
- (1) is equal to -1      (2) is equal to 1      (3) does not exist      (4) is equal to 2
16. If the system of linear equations  
 $x - 2y + z = -4$   
 $2x + \alpha y + 3z = 5$   
 $3x - y + \beta z = 3$   
 has infinitely many solutions, then  $12\alpha + 13\beta$  is equal to:
- (1) 60      (2) 54      (3) 64      (4) 58
17. If  $f(x) = \frac{4x+3}{6x-4}$ ,  $x \neq \frac{2}{3}$  and  $(f \circ f)(x) = g(x)$ , where  $g : R - \left\{ \frac{2}{3} \right\} \rightarrow R - \left\{ \frac{2}{3} \right\}$ ,  $(g \circ g \circ g)(4)$  is equal to:
- (1)  $-\frac{19}{20}$       (2) 4      (3) -4      (4)  $\frac{19}{20}$

18. if  $f(x) = \begin{vmatrix} x^3 & 2x^2+1 & 1+3x \\ 3x^2+2 & 2x & x^3+6 \\ x^3-x & 4 & x^2-2 \end{vmatrix}$  for all  $x \in R$ , then  $2f(0) + f'(0)$  is equal to:
- (1) 48                      (2) 18                      (3) 42                      (4) 24
19. The distance of the point  $Q(0, 2, -2)$  from the line passing through the point  $P(5, -4, 3)$  and perpendicular to the lines  $\vec{r} = (-3\hat{i} + 2\hat{k}) + \lambda(2\hat{i} + 3\hat{j} + 5\hat{k})$ ,  $\lambda \in R$  and  $\vec{r} = (\hat{i} - 2\hat{j} + \hat{k}) + \mu(-\hat{i} + 3\hat{j} + 2\hat{k})$ ,  $\mu \in R$  is:
- (1)  $\sqrt{54}$                       (2)  $\sqrt{86}$                       (3)  $\sqrt{74}$                       (4)  $\sqrt{20}$
20. If the foci of a hyperbola are same as that of the ellipse  $\frac{x^2}{9} + \frac{y^2}{25} = 1$  and eccentricity of the hyperbola is  $\frac{15}{8}$  times the eccentricity of the ellipse, then the smaller focal distance of the point  $\left(\sqrt{2}, \frac{14}{3}\sqrt{\frac{2}{5}}\right)$  on the hyperbola, is equal to:
- (1)  $14\sqrt{\frac{2}{5}} - \frac{4}{3}$                       (2)  $14\sqrt{\frac{2}{5}} - \frac{16}{3}$                       (3)  $7\sqrt{\frac{2}{5}} - \frac{8}{3}$                       (4)  $7\sqrt{\frac{2}{5}} + \frac{8}{3}$

## 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.

21. If the integral  $525 \int_0^{\frac{\pi}{2}} \sin 2x \cos^{\frac{11}{2}} x \left( 1 + \cos^{\frac{5}{2}} x \right)^{\frac{1}{2}} dx$  is equal to  $(n\sqrt{2} - 64)$ , then  $n$  is equal to \_\_\_\_\_.
22. Let  $\vec{a}$  and  $\vec{b}$  be two vectors such that  $|\vec{a}| = 1$ ,  $|\vec{b}| = 4$ , and  $\vec{a} \cdot \vec{b} = 2$ . If  $\vec{c} = (2\vec{a} \times \vec{b}) - 3\vec{b}$  and the angle between  $\vec{b}$  and  $\vec{c}$  is  $\alpha$ , then  $192 \sin^2 \alpha$  is equal to \_\_\_\_\_.
23. Let  $S = (-1, \infty)$  and  $f : S \rightarrow R$  be defined as  $f(x) = \int_{-1}^x (e^t - 1)^{11} (2t - 1)^5 (t - 3)^{12} (2t - 10)^{61} dt$ .  
Let  $p$  = Sum of squares of the values of  $x$ , where  $f(x)$  attains local maxima on  $S$ , and  $q$  = Sum of the values of  $x$ , where  $f(x)$  attains local minima on  $S$ . Then, the value of  $p^2 + 2q$  is \_\_\_\_\_.
24. The total number of words (with or without meaning) that can be formed out of the letters of the word 'DISTRIBUTION' taken four at a time, is equal to \_\_\_\_\_.
25. Let the foci and length of the latus rectum of an ellipse  $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1, a > b$  be  $(\pm 5, 0)$  and  $\sqrt{50}$ , respectively. Then, the square of the eccentricity of the hyperbola  $\frac{x^2}{b^2} - \frac{y^2}{a^2 b^2} = 1$  equals: \_\_\_\_\_.
26. Let  $f : R \rightarrow R$  be a function defined by  $f(x) = \frac{4^x}{4^x + 2}$  and  $M = \int_{f(a)}^{f(1-a)} x \sin^4(x(1-x)) dx$ ,  
 $N = \int_{f(a)}^{f(1-a)} \sin^4(x(1-x)) dx$ ;  $a \neq \frac{1}{2}$ . If  $\alpha M = \beta N$ ,  $\alpha, \beta \in N$ , then the least value of  $\alpha^2 + \beta^2$  is equal to \_\_\_\_\_.
27. In the expansion of  $(1+x)(1-x^2) \left( 1 + \frac{3}{x} + \frac{3}{x^2} + \frac{1}{x^3} \right)^5$ ,  $x \neq 0$ , the sum of the coefficients of  $x^3$  and  $x^{-13}$  is equal to \_\_\_\_\_.
28. Let  $A = \{1, 2, 3, 4\}$  and  $R = \{(1, 2), (2, 3), (1, 4)\}$  be a relation on  $A$ . Let  $S$  be the equivalence relation on  $A$  such that  $R \subset S$  and the number of elements in  $S$  is  $n$ . Then, the minimum value of  $n$  is: \_\_\_\_\_.
29. Let  $Q$  and  $R$  be the feet of perpendiculars from the point  $P(a, a, a)$  on the lines  $x = y, z = 1$  and  $x = -y, z = -1$  respectively. If  $\angle QPR$  is a right angle, then  $12a^2$  is equal to: \_\_\_\_\_.
30. If  $\alpha$  denotes the number of solutions of  $|1 - i|^x = 2^x$  and  $\beta = \left( \frac{|z|}{\arg(z)} \right)$ , where  $z = \frac{\pi}{4}(1 + i)^4$   
 $\left[ \frac{1 - \sqrt{\pi}i}{\sqrt{\pi} + i} + \frac{\sqrt{\pi} - i}{1 + \sqrt{\pi}i} \right]$ ,  $i = \sqrt{-1}$ , then the distance of the point  $(\alpha, \beta)$  from the line  $4x - 3y = 7$  is \_\_\_\_\_.

**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.

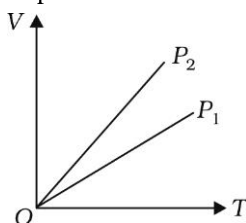
31. In a plane EM wave, the electric field oscillates sinusoidally at a frequency of  $5 \times 10^{10}$  Hz and an amplitude of  $50 \text{ Vm}^{-1}$ . The total average energy density of the electromagnetic field of the wave is:  
[Use  $\epsilon_0 = 8.58 \times 10^{-12} \text{ C}^2 / \text{Nm}^2$ ]

- (1)  $4.425 \times 10^{-8} \text{ Jm}^{-3}$  (2)  $2.212 \times 10^{-8} \text{ Jm}^{-3}$   
(3)  $1.106 \times 10^{-8} \text{ Jm}^{-3}$  (4)  $2.212 \times 10^{-10} \text{ Jm}^{-3}$

32. The parameter that remains the same for molecules of all gases at a given temperature is:

- (1) kinetic energy (2) momentum (3) mass (4) speed

33. The given figure represents two isobaric processes for the same mass of an ideal gas, then:



- (1)  $P_1 = P_2$  (2)  $P_2 > P_1$  (3)  $P_2 \geq P_1$  (4)  $P_1 > P_2$

34. The refractive index of a prism with apex angle  $A$  is  $\cot A / 2$ . The angle of minimum deviation is:

- (1)  $\delta_m = 180^\circ - 2A$  (2)  $\delta_m = 180^\circ - A$  (3)  $\delta_m = 180^\circ - 3A$  (4)  $\delta_m = 180^\circ - 4A$

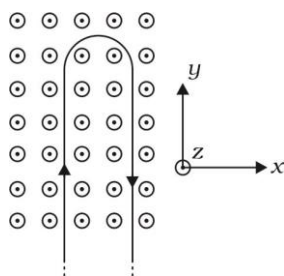
35. The fundamental frequency of a closed organ pipe is equal to the first overtone frequency of an open organ pipe. If length of the open pipe is 60 cm, the length of the closed pipe will be:

- (1) 45 cm (2) 15 cm (3) 60 cm (4) 30 cm

36. A coil is placed perpendicular to a magnetic field of 5000 T. When the field is changed to 3000 T in 2s, an induced emf of 22 V is produced in the coil. If the diameter of the coil is 0.02 m, then the number of turns in the coil is:

- (1) 7 (2) 35 (3) 70 (4) 140

37. A rigid wire consists of a semicircular position of radius  $R$  and two straight sections. The wire is partially immersed in a perpendicular magnetic field  $B = B_0 \hat{k}$  as shown in figure. The magnetic force on the wire if it has current  $i$  is:



- (1)  $2iBR\hat{j}$  (2)  $-iBR\hat{j}$  (3)  $iBR\hat{j}$  (4)  $-2iBR\hat{j}$

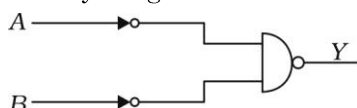
38. When a metal surface is illuminated by light of wavelength  $\lambda$ , the stopping potential is  $8V$ . When the same surface is illuminated by light of wavelength  $3\lambda$ , stopping potential is  $2V$ . The threshold wavelength for this surface is:

(1)  $9\lambda$  (2)  $3\lambda$  (3)  $5\lambda$  (4)  $4.5\lambda$

39. Four identical particles of mass  $m$  are kept at the four corners of a square. If the gravitational force exerted on one of the masses by the other masses is  $\left(\frac{2\sqrt{2}+1}{32}\right)\frac{Gm^2}{L^2}$ , the length of the sides of the square is:

(1)  $2L$  (2)  $4L$  (3)  $3L$  (4)  $\frac{L}{2}$

40. Identify the logic operation performed by the given circuit.

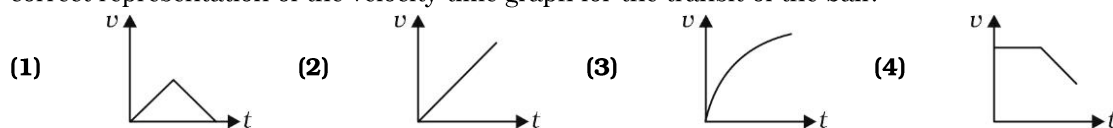


(1) AND (2) NAND (3) OR (4) NOR

41. If the percentage errors in measuring the length and the diameter of a wire are  $0.1\%$  each. The percentage error in measuring its resistance will be:

(1)  $0.2\%$  (2)  $0.1\%$  (3)  $0.144\%$  (4)  $0.3\%$

42. A small steel ball is dropped into a long cylinder containing glycerine. Which one of the following is the correct representation of the velocity time graph for the transit of the ball?



43. A coin is placed on a disc. The coefficient of friction between the coin and the disc is  $\mu$ . If the distance of the coin from the center of the disc is  $r$ , the maximum angular velocity which can be given to the disc, so that the coin does not slip away, is:

(1)  $\sqrt{\frac{r}{\mu g}}$  (2)  $\frac{\mu}{\sqrt{rg}}$  (3)  $\frac{\mu g}{r}$  (4)  $\sqrt{\frac{\mu g}{r}}$

44. A force is represented by  $F = ax^2 + bt^{\frac{1}{2}}$  where  $x$  = distance and  $t$  = time. The dimensions of  $b^2/a$  are:

(1)  $[MLT^{-2}]$  (2)  $[ML^3T^{-3}]$  (3)  $[ML^{-1}T^{-1}]$  (4)  $[ML^2T^{-3}]$

45. Two conductors have the same resistance at  $0^\circ\text{C}$  but their temperature coefficients of resistance are  $\alpha_1$  and  $\alpha_2$ . The respective temperature coefficients for their series and parallel combinations are:

(1)  $\alpha_1 + \alpha_2, \frac{\alpha_1\alpha_2}{\alpha_1 + \alpha_2}$  (2)  $\frac{\alpha_1 + \alpha_2}{2}, \frac{\alpha_1 + \alpha_2}{2}$   
 (3)  $\frac{\alpha_1 + \alpha_2}{2}, \alpha_1 + \alpha_2$  (4)  $\alpha_1 + \alpha_2, \frac{\alpha_1 + \alpha_2}{2}$

46. Two charges  $q$  and  $3q$  are separated by a distance ' $r$ ' in air. At a distance  $x$  from charge  $q$ , the resultant electric field is zero. The value of  $x$  is:

(1)  $\frac{r}{3(1+\sqrt{3})}$  (2)  $\frac{r}{(1+\sqrt{3})}$  (3)  $\frac{(1+\sqrt{3})}{r}$  (4)  $r(1+\sqrt{3})$

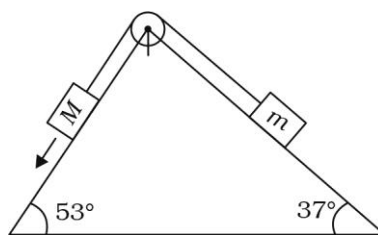
47. The relation between time ' $t$ ' and distance ' $x$ ' is  $t = \alpha x^2 + \beta x$ , where  $\alpha$  and  $\beta$  are constants. The relation between acceleration ( $a$ ) and velocity ( $v$ ) is:

(1)  $a = -5\alpha v^5$  (2)  $a = -4\alpha v^4$  (3)  $a = -3\alpha v^2$  (4)  $a = -2\alpha v^3$

48. If the wavelength of the first member of Lyman series of hydrogen is  $\lambda$ . The wavelength of the second member will be:

(1)  $\frac{5}{27}\lambda$  (2)  $\frac{32}{27}\lambda$  (3)  $\frac{27}{32}\lambda$  (4)  $\frac{27}{5}\lambda$

49. In the given arrangement of a doubly inclined plane two blocks of masses  $M$  and  $m$  are placed. The blocks are connected by a light string passing over an ideal pulley as shown. The coefficient of friction between the surface of the plane and the blocks is 0.25. The value of  $m$ , for which  $M = 10$  kg will move down with an acceleration of  $2\text{ m/s}^2$ , is: (take  $g = 10 \text{ m/s}^2$  and  $\tan 37^\circ = 3/4$ )



(1) 9 kg (2) 2.25 kg (3) 6.5 kg (4) 4.5 kg

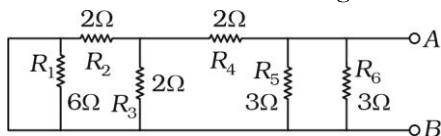
50. An artillery piece of mass  $M_1$  fires a shell of mass  $M_2$  horizontally. Instantaneously after the firing, the ratio of kinetic energy of the artillery and that of the shell is:

(1)  $M_2 / (M_1 + M_2)$  (2)  $M_1 / (M_1 + M_2)$  (3)  $\frac{M_2}{M_1}$  (4)  $\frac{M_1}{M_2}$

**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. Equivalent resistance of the following network is \_\_\_\_\_  $\Omega$ .



52. Two waves of intensity ratio 1:9 cross each other at a point. The resultant intensities at that point, when  
(a) Waves are incoherent is  $I_1$  (b) Waves are coherent is  $I_2$  and differ in phase by  $60^\circ$ . If  $\frac{I_1}{I_2} = \frac{10}{x}$  then  $x =$  \_\_\_\_\_.
53. The depth below the surface of sea to which a rubber ball be taken so as to decrease its volume by 0.02% is \_\_\_\_\_ m.  
(Take density of sea water =  $10^3 \text{ kgm}^{-3}$ . Bulk modulus of rubber =  $9 \times 10^8 \text{ Nm}^{-2}$ , and  $g = 10 \text{ ms}^{-2}$ )
54. A particle performs simple harmonic motion with amplitude A. Its speed is increased to three times at an instant when its displacement is  $\frac{2A}{3}$ . The new amplitude of motion is  $\frac{nA}{3}$ . The value of n is \_\_\_\_\_.
55. A small square loop of wire of side l is placed inside a large square loop of wire of side L ( $L = l^2$ ). The loops are coplanar and their centers coincide. The value of the mutual inductance of the system is  $\sqrt{x} \times 10^{-7} \text{ H}$ , where  $x =$  \_\_\_\_\_.
56. A body starts falling freely from height H hits an inclined plane in its path at height h. As a result of this perfectly elastic impact, the direction of the velocity of the body becomes horizontal. The value of  $\frac{H}{h}$  for which the body will take the maximum time to reach the ground is \_\_\_\_\_.
57. The mass defect in a particular reaction is 0.4g. The amount of energy liberated is  $n \times 10^7 \text{ kWh}$ , where  $n =$  \_\_\_\_\_. (speed of light =  $3 \times 10^8 \text{ m/s}$ )
58. A parallel plate capacitor with plate separation 5 mm is charged up by a battery. It is found that on introducing a dielectric sheet of thickness 2 mm, while keeping the battery connections intact, the capacitor draws 25% more charge from the battery than before. The dielectric constant of the sheet is \_\_\_\_\_.
59. A solid circular disc of mass 50 kg rolls along a horizontal floor so that its center of mass has a speed of 0.4 m/s. The absolute value of work done on the disc to stop it is:
60. An electron moves through a uniform magnetic field  $\vec{B} = B_0 \hat{i} + 2B_0 \hat{j} T$ . At a particular instant of time, the velocity of electron is  $\vec{u} = 3\hat{i} + 5\hat{j} \text{ m/s}$ . If the magnetic force acting on electron is  $\vec{F} = 5e\hat{k} \text{ N}$ , where e is the charge of electron, then the value of  $B_0$  is \_\_\_\_\_ T.

**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. The correct statements from following are:

- A. The strength of anionic ligands can be explained by crystal field theory.
- B. Valence bond theory does not give a quantitative interpretation of kinetic stability of coordination compounds.
- C. The hybridization involved in formation of  $[\text{Ni}(\text{CN})_4]^{2-}$  complex is  $\text{dsp}^2$ .
- D. The number of possible isomer(s) of  $\text{cis-}[\text{PtCl}_2(\text{en})_2]^{2+}$  is one

Choose the correct answer from the options given below:

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

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

**Assertion A:** Alcohols react both as nucleophiles and electrophiles.

**Reason R:** Alcohols reacts with active metals such as sodium, potassium and aluminium to yield corresponding alkoxides and liberate hydrogen.

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

- (1) A is false but R is true.
- (2) Both A and R are true but R is NOT the correct explanation of A.
- (3) Both A and R are true and R is the correct explanation of A.
- (4) A is true but R is false.

63. Given below are two statements:

**Statement I:** IUPAC name of  $\text{HO}-\text{CH}_2-(\text{CH}_2)_3-\text{CH}_2-\text{COCH}_3$  is 7-hydroxyheptan-2-one.

**Statement II:** 2-oxoheptan-7-ol is the correct IUPAC name for above compound.

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

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

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

**Assertion A:**  $\text{pK}_a$  value of phenol is 10.0 while that of ethanol is 15.9.

**Reason R:** Ethanol is stronger acid than phenol.

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

- (1) A is false but R is true.
- (2) A is true but R is false.
- (3) Both A and R are true but R is NOT the correct explanation of A.
- (4) Both A and R are true and R is the correct explanation of A.

65. Match List I with List II

LIST I		LIST II	
A.	Glucose/ $\text{NaHCO}_3$ / $\Delta$	I.	Gluconic acid
B.	Glucose/ $\text{HNO}_3$	II.	No reaction
C.	Glucose/ $\text{HI}$ / $\Delta$	III.	n-hexane
D.	Glucose/Bromine water	IV.	Saccharic acid

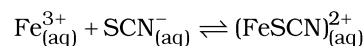
Choose the correct answer from the options given below:

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

66. Identify the mixture that shows positive deviations from Raoult's Law :

- (1)  $(\text{CH}_3)_2\text{CO} + \text{CS}_2$  (2)  $\text{CHCl}_3 + \text{C}_6\text{H}_6$   
(3)  $\text{CHCl}_3 + (\text{CH}_3)_2\text{CO}$  (4)  $(\text{CH}_3)_2\text{CO} + \text{C}_6\text{H}_5\text{NH}_2$

67. For the given reaction, choose the correct expression of  $K_C$  from the following :-



- (1)  $K_C = \frac{[\text{FeSCN}^{2+}]^2}{[\text{Fe}^{3+}][\text{SCN}^-]}$  (2)  $K_C = \frac{[\text{FeSCN}^{2+}]}{[\text{Fe}^{3+}][\text{SCN}^-]}$   
(3)  $K_C = \frac{[\text{FeSCN}^{2+}]}{[\text{Fe}^{3+}]^2[\text{SCN}^-]^2}$  (4)  $K_C = \frac{[\text{Fe}^{3+}][\text{SCN}^-]}{[\text{FeSCN}^{2+}]}$

68. The correct sequence of electron gain enthalpy of the elements listed below is

- A. Ar  
B. Br  
C. F  
D. S

Choose the most appropriate from the options given below:

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

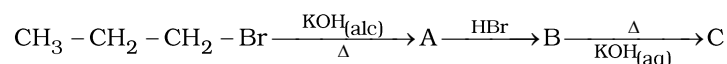
69. The linear combination of atomic orbitals to form molecular orbitals takes place only when the combining atomic orbitals

- A. have the same energy  
B. have the minimum overlap  
C. have same symmetry about the molecular axis  
D. have different symmetry about the molecular axis

Choose the most appropriate from the options given below:

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

70. The product (C) in the below mentioned reaction is:



- (1) Propan-1-ol (2) Propyne (3) Propene (4) Propan-2-ol

71. Identify the factor from the following that does not affect electrolytic conductance of a solution.

- (1) The nature of solvent used (2) Concentration of the electrolyte  
(3) The nature of the electrolyte added (4) The nature of the electrode used

72. Match List I with List II

LIST I (Technique)		LIST II (Application)	
A.	Distillation	I.	Separation of glycerol from spent-lye
B.	Fractional distillation	II.	Aniline – Water mixture
C.	Steam distillation	III.	Separation of crude oil fractions
D.	Distillation under reduced pressure	IV.	Chloroform - Aniline

Choose the correct answer from the options given below:

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

73. Identify correct statements from below:

- A. The chromate ion is square planar.  
 B. Dichromates are generally prepared from chromates.  
 C. The green manganate ion is diamagnetic.  
 D. Dark green coloured  $K_2MnO_4$  disproportionates in a neutral or acidic medium to give permanganate.  
 E. With increasing oxidation number of transition metal, ionic character of the oxides decreases.

Choose the correct answer from the options given below:

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

74. The compound that is white in color is:

- (1) ammonium arsinomolybdate                      (2) ammonium sulphide  
 (3) lead iodide                      (4) lead sulphate

75. Give below are two statements:

**Statement -I:** Noble gases have very high boiling points.**Statement -II:** Noble gases are monoatomic gases. They are held together by strong dispersion forces.

Because of this they are liquefied at very low temperature. Hence, they have very high boiling points.

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

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

76. Consider the oxides of group 14 elements

 $SiO_2, GeO_2, SnO_2, PbO_2, CO$  and  $GeO$ . The amphoteric oxides are :

- (1)  $GeO, GeO_2$       (2)  $SnO_2, PbO_2$       (3)  $SnO_2, CO$       (4)  $SiO_2, GeO_2$

77. A species having carbon with sextet of electrons and can act as electrophile is called:

- (1) carbocation                      (2) pentavalent carbon  
 (3) carbanion                      (4) carbon free radical

78. 'Adsorption' principle is used for which of the following purification method?

- (1) Distillation                      (2) Sublimation  
 (3) Chromatography                      (4) Extraction

**79.** The metals that are employed in the battery industries are:

- A.** Fe
- B.** Mn
- C.** Ni
- D.** Cr
- E.** Cd

Choose the correct answer from the options given below:

- |                             |                               |
|-----------------------------|-------------------------------|
| <b>(1)</b> A, B, C, D and E | <b>(2)</b> A, B, C and D only |
| <b>(3)</b> B, D and E only  | <b>(4)</b> B, C and E only    |

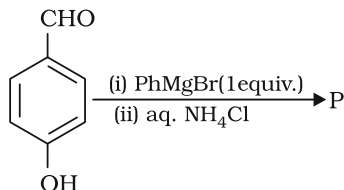
**80.** Integrated rate law equation for a first order gas phase reaction is given by (where  $P_i$  is initial pressure and  $P_t$  is total pressure at time  $t$ )

- |   |   |
|---|---|
| <b>(1)</b> $k = \frac{2.303}{t} \times \frac{P_i}{(2P_i - P_t)}$      | <b>(2)</b> $k = \frac{2.303}{t} \times \log \frac{(2P_i - P_t)}{P_i}$ |
| <b>(3)</b> $k = \frac{2.303}{t} \times \log \frac{P_i}{(2P_i - P_t)}$ | <b>(4)</b> $k = \frac{2.303}{t} \times \frac{2P_i}{(2P_i - P_t)}$     |

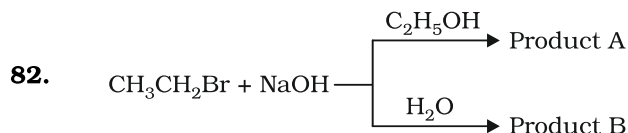
**SECTION-2**

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. The product of the following reaction is P.



The number of hydroxyl groups present in the product P is \_\_\_\_\_.



The total number of hydrogen atoms in product A and product B is \_\_\_\_\_.

83. Molar mass of the salt from NaBr, NaNO<sub>3</sub>, KI and CaF<sub>2</sub> which does not evolve coloured vapours on heating with concentrated H<sub>2</sub>SO<sub>4</sub> is \_\_\_\_\_ g mol<sup>-1</sup>.

(Molar mass in g mol<sup>-1</sup>: Na : 23, N : 14, K : 39, O : 16, Br : 80, I : 127, F : 19, Ca : 40)

84. Number of moles of methane required to produce 22g CO<sub>2(g)</sub> after combustion is  $x \times 10^{-2}$  moles. The value of x is \_\_\_\_\_.

85. The 'Spin only' Magnetic moment for [Ni(NH<sub>3</sub>)<sub>6</sub>]<sup>2+</sup> is \_\_\_\_\_  $\times 10^{-1}$  BM.  
(given = Atomic number of Ni : 28)

86. Number of alkanes obtained on electrolysis of a mixture of CH<sub>3</sub>COONa and C<sub>2</sub>H<sub>5</sub>COONa is \_\_\_\_\_.

87. One Faraday of electricity liberates  $x \times 10^{-1}$  gram atom of copper from copper sulphate. x is \_\_\_\_\_.

88. The ionization energy of sodium in kJ mol<sup>-1</sup>, if electromagnetic radiation of wavelength 242 nm is just sufficient to ionize sodium atom is \_\_\_\_\_.

89. The number of species from the following in which the central atom uses sp<sup>3</sup> hybrid orbitals in its bonding is \_\_\_\_\_.

NH<sub>3</sub>, SO<sub>2</sub>, SiO<sub>2</sub>, BeCl<sub>2</sub>, CO<sub>2</sub>, H<sub>2</sub>O, CH<sub>4</sub>, BF<sub>3</sub>

90. Consider the following reaction at 298 K.  $\frac{3}{2}\text{O}_{2(g)} \rightleftharpoons \text{O}_{3(g)}$ ,  $K_P = 2.47 \times 10^{-29}$ .

$\Delta_r G^\circ$  for the reaction is \_\_\_\_\_ kJ. (Given R = 8.314 JK<sup>-1</sup>mol<sup>-1</sup>)