



## JEE Main – 2024

29<sup>th</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.

- If  $\alpha, -\frac{\pi}{2} < \alpha < \frac{\pi}{2}$  is the solution of  $4\cos\theta + 5\sin\theta = 1$ , then the value of  $\tan\alpha$  is:

(1)  $\frac{10 - \sqrt{10}}{12}$       (2)  $\frac{\sqrt{10} - 10}{6}$       (3)  $\frac{10 - \sqrt{10}}{6}$       (4)  $\frac{\sqrt{10} - 10}{12}$
- Consider the function  $f: \left[\frac{1}{2}, 1\right] \rightarrow \mathbb{R}$  defined by  $f(x) = 4\sqrt{2}x^3 - 3\sqrt{2}x - 1$ .

Consider the statements:

(I) The curve  $y = f(x)$  intersects the  $x$ -axis exactly at one point

(II) The curve  $y = f(x)$  intersects the  $x$ -axis at  $x = \cos\frac{\pi}{12}$

Then:

(1) Both (I) and (II) are incorrect      (2) Only (II) is correct

(3) Only (I) is correct      (4) Both (I) and (II) are correct
- A function  $y = f(x)$  satisfies  $f(x)\sin 2x + \sin x - (1 + \cos^2 x)f'(x) = 0$  with condition  $f(0) = 0$ . Then,  $f\left(\frac{\pi}{2}\right)$  is equal to:

(1) 1      (2) 0      (3) -1      (4) 2
- Let  $R$  be a relation on  $Z \times Z$  defined by  $(a, b) R (c, d)$  if and only if  $ad - bc$  is divisible by 5. Then  $R$  is:

(1) Reflexive and symmetric but not transitive

(2) Reflexive but neither symmetric nor transitive

(3) Reflexive and transitive but not symmetric

(4) Reflexive, symmetric and transitive
- $\lim_{x \rightarrow \frac{\pi}{2}} \frac{1}{\left(x - \frac{\pi}{2}\right)^2} \int_{x^3}^{\left(\frac{\pi}{2}\right)^3} \cos\left(t^{\frac{1}{3}}\right) dt$  is equal to:

(1)  $\frac{3\pi^2}{4}$       (2)  $\frac{3\pi}{4}$       (3)  $\frac{3\pi}{8}$       (4)  $\frac{3\pi^2}{8}$
- Let  $A = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \alpha & \beta \\ 0 & \beta & \alpha \end{bmatrix}$  and  $|2A|^3 = 2^{21}$  where  $\alpha, \beta \in Z$ , then a value of  $\alpha$  is:

(1) 3      (2) 17      (3) 5      (4) 9

7. Let  $PQR$  be a triangle with  $R(-1,4,2)$ . Suppose  $M(2,1,2)$  is the mid point of  $PQ$ . The distance of the centroid of  $\Delta PQR$  from the point of intersection of the lines  $\frac{x-2}{0} = \frac{y}{2} = \frac{z+3}{-1}$  and  $\frac{x-1}{1} = \frac{y+3}{-3} = \frac{z+1}{1}$  is:
- (1)  $\sqrt{69}$  (2) 69 (3) 9 (4)  $\sqrt{99}$
8. Let  $A$  be a square matrix such that  $AA^T = I$ . Then  $\frac{1}{2}A\left[(A+A^T)^2 + (A-A^T)^2\right]$  is equal to:
- (1)  $A^3 + I$  (2)  $A^3 + A^T$  (3)  $A^2 + I$  (4)  $A^2 + A^T$
9. A fair die is thrown until; 2 appears. Then the probability, that 2 appears in even number of throws, is:
- (1)  $\frac{5}{11}$  (2)  $\frac{5}{6}$  (3)  $\frac{1}{6}$  (4)  $\frac{6}{11}$
10. Let  $\left(5, \frac{a}{4}\right)$  be the circumcenter of a triangle with vertices  $A(a, -2), B(a, 6)$  and  $C\left(\frac{a}{4}, -2\right)$ . Let  $\alpha$  denote the circumradius,  $\beta$  denote the area and  $\gamma$  denote the perimeter of the triangle. Then  $\alpha + \beta + \gamma$  is:
- (1) 53 (2) 60 (3) 30 (4) 62
11. In a  $\Delta ABC$ , suppose  $y = x$  is the equation of the bisector of the angle  $B$  and the equation of the side  $AC$  is  $2x - y = 2$ . If  $2AB = BC$  and the points  $A$  and  $B$  are respectively  $(4, 6)$  and  $(\alpha, \beta)$ , then  $\alpha + 2\beta$  is equal to:
- (1) 45 (2) 39 (3) 42 (4) 48
12. Let  $\vec{a}, \vec{b}$  and  $\vec{c}$  be three non-zero vectors such that  $\vec{b}$  and  $\vec{c}$  are non-collinear. If  $\vec{a} + 5\vec{b}$  is collinear with  $\vec{c}$ ,  $\vec{b} + 6\vec{c}$  is collinear with  $\vec{a}$  and  $\vec{a} + \alpha\vec{b} + \beta\vec{c} = \vec{0}$ , then  $\alpha + \beta$  is equal to:
- (1) -30 (2) -25 (3) 35 (4) 30
13. If the value of the integral  $\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} \left( \frac{x^2 \cos x}{1 + \pi^x} + \frac{1 + \sin^2 x}{1 + e^{\sin x^{2023}}} \right) dx = \frac{\pi}{4}(\pi + a) - 2$ , then the value of  $a$  is:
- (1) 3 (2)  $\frac{3}{2}$  (3)  $-\frac{3}{2}$  (4) 2
14. If  $z = \frac{1}{2} - 2i$  is such that  $|z + 1| = \alpha z + \beta(1 + i), i = \sqrt{-1}$  and  $\alpha, \beta \in R$ , then  $\alpha + \beta$  is equal to:
- (1) -1 (2) 3 (3) 2 (4) -4
15. For  $x \in \left(-\frac{\pi}{2}, \frac{\pi}{2}\right)$ , if  $y(x) = \int \frac{\operatorname{cosec} x + \sin x}{\operatorname{cosec} x \sec x + \tan x \sin^2 x} dx$ , and  $\lim_{x \rightarrow \left(\frac{\pi}{2}\right)^-} y(x) = 0$  then  $y\left(\frac{\pi}{4}\right)$  is equal to:
- (1)  $\frac{1}{\sqrt{2}} \tan^{-1}\left(-\frac{1}{2}\right)$  (2)  $-\frac{1}{\sqrt{2}} \tan^{-1}\left(\frac{1}{\sqrt{2}}\right)$  (3)  $\frac{1}{2} \tan^{-1}\left(\frac{1}{\sqrt{2}}\right)$  (4)  $\tan^{-1}\left(\frac{1}{\sqrt{2}}\right)$
16. If  $f(x) = \begin{cases} 2 + 2x, & -1 \leq x < 0 \\ 1 - \frac{x}{3}, & 0 \leq x \leq 3 \end{cases}; g(x) = \begin{cases} -x, & -3 \leq x \leq 0 \\ x, & 0 < x \leq 1 \end{cases}$ , then range of  $(f \circ g)(x)$  is:
- (1)  $[0, 1]$  (2)  $[0, 3]$  (3)  $[0, 1)$  (4)  $[0, 1]$

- 17.** Suppose  $f(x) = \frac{(2^x + 2^{-x}) \tan x \sqrt{\tan^{-1}(x^2 - x + 1)}}{(7x^2 + 3x + 1)^3}$ . Then the value of  $f'(0)$  is equal to:
- (1) 0                      (2)  $\sqrt{\pi}$                       (3)  $\pi$                       (4)  $\frac{\pi}{2}$
- 18.** Let  $O$  be the origin and the position vectors of  $A$  and  $B$  be  $2\hat{i} + 2\hat{j} + \hat{k}$  and  $2\hat{i} + 4\hat{j} + 4\hat{k}$  respectively. If the internal bisector of  $\angle AOB$  meets the line  $AB$  at  $C$ , then the length of  $OC$  is:
- (1)  $\frac{3}{2}\sqrt{31}$                       (2)  $\frac{3}{2}\sqrt{34}$                       (3)  $\frac{2}{3}\sqrt{31}$                       (4)  $\frac{2}{3}\sqrt{34}$
- 19.** In an A.P., the sixth term  $a_6 = 2$ . If the product  $a_1 a_4 a_5$  is the greatest, then the common difference of the A.P. is equal to:
- (1)  $\frac{5}{8}$                       (2)  $\frac{2}{3}$                       (3)  $\frac{3}{2}$                       (4)  $\frac{8}{5}$
- 20.** If in a G.P. of 64 terms, the sum of all the terms is 7 times the sum of the odd terms of the G.P., then the common ratio of the G.P. is equal to:
- (1) 7                      (2) 4                      (3) 6                      (4) 5

## SECTION-2

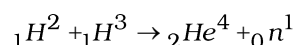
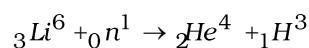
Section 2 contains 10 Numerical Value Type Questions Out of which ONLY 5 (any) questions have to be attempted. The answer to each question should be rounded off to the nearest integer.

21. Let  $\alpha, \beta$  be the roots of the equation  $x^2 - x + 2 = 0$  with  $\text{Im}(\alpha) > \text{Im}(\beta)$ . Then  $\alpha^6 + \alpha^4 + \beta^4 - 5\alpha^2$  is equal to \_\_\_\_\_.
22. If the points of intersection of two distinct conics  $x^2 + y^2 = 4b$  and  $\frac{x^2}{16} + \frac{y^2}{b^2} = 1$  lie on the curve  $y^2 = 3x^2$ , then  $3\sqrt{3}$  times the area of the rectangle formed by intersection points is \_\_\_\_\_.
23. Equations of two diameters of a circle are  $2x - 3y = 5$  and  $3x - 4y = 7$ . The line joining the points  $\left(-\frac{22}{7}, -4\right)$  and  $\left(-\frac{1}{7}, 3\right)$  intersects the circle at only one point  $P(\alpha, \beta)$ . Then  $17\beta - \alpha$  is equal to \_\_\_\_\_.
24. If the solution curve  $y = y(x)$  of the differential equation  $(1 + y^2)(1 + \log_e x)dx + x dy = 0, x > 0$  passes through the point  $(1, 1)$  and  $y(e) = \frac{\alpha - \tan\left(\frac{3}{2}\right)}{\beta + \tan\left(\frac{3}{2}\right)}$ , then  $\alpha + 2\beta$  is \_\_\_\_\_.
25. If the mean and variance of the data 65, 68, 58, 44, 48, 45, 60,  $\alpha, \beta$ , 60 where  $\alpha > \beta$ , are 56 and 66.2 respectively, then  $\alpha^2 + \beta^2$  is equal to \_\_\_\_\_.
26. A line with direction ratios 2, 1, 2 meets the lines  $x = y + 2 = z$  and  $x + 2 = 2y = 2z$  respectively at the points  $P$  and  $Q$ . If the length of the perpendicular from the point  $(1, 2, 12)$  to the line  $PQ$  is  $l$ , then  $l^2$  is \_\_\_\_\_.
27. If  $\frac{{}^{11}C_1}{2} + \frac{{}^{11}C_2}{3} + \dots + \frac{{}^{11}C_9}{10} = \frac{n}{m}$  with  $\text{gcd}(n, m) = 1$ , then  $n + m$  is equal to \_\_\_\_\_.
28. Let  $f(x) = 2^x - x^2, x \in \mathbb{R}$ . If  $m$  and  $n$  are respectively the number of points at which the curves  $y = f(x)$  and  $y = f'(x)$  intersect the  $x$ -axis, then the value of  $m + n$  is \_\_\_\_\_.
29. All the letters of the word "GTWENTY" are written in all possible ways with or without meaning and these words are written as in a dictionary. The serial number of the word "GTWENTY" is \_\_\_\_\_.
30. The area (in sq. units) of the part of the circle  $x^2 + y^2 = 169$  which is below the line  $5x - y = 13$  is  $\frac{\pi\alpha}{2\beta} - \frac{65}{2} + \frac{\alpha}{\beta} \sin^{-1}\left(\frac{12}{13}\right)$ , where  $\alpha, \beta$  are coprime numbers. Then  $\alpha + \beta$  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. The explosive in a Hydrogen bomb is a mixture of  ${}_1H^2$ ,  ${}_1H^3$  and  ${}_3Li^6$  in some condensed form. The chain reaction is given by:



During the explosion the energy released is approximately:

[Given:  $M({}_3Li) = 6.01690$  amu,  $M({}_1H^2) = 2.01471$  amu,  $M({}_2He^4) = 4.00388$  amu and  $1 \text{ amu} = 931.5 \text{ MeV}$ ]

- (1) 22.22 MeV      (2) 12.64 MeV      (3) 16.48 MeV      (4) 28.12 MeV

32. The de-Broglie wavelength of an electron is the same as that of a photon. If velocity of electron is 25% of the velocity of light, then the ratio of K.E. of electron and K.E. of photon will be:

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

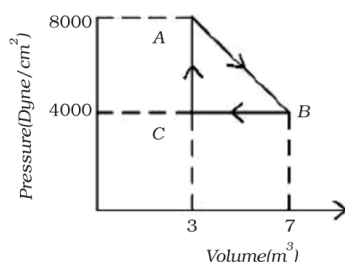
33. Match List I with List II:

|    | LIST I   |      | LIST II                    |
|----|--|------|----------------------------|
| A. | $\oint \vec{B} \cdot d\vec{l} = \mu_0 i_C + \mu_0 \epsilon_0 \frac{d\phi_E}{dt}$ | I.   | Gauss' law for electricity |
| B. | $\oint \vec{E} \cdot d\vec{l} = \frac{d\phi_B}{dt}$                              | II.  | Gauss' law for magnetism   |
| C. | $\oint \vec{E} \cdot d\vec{A} = \frac{Q}{\epsilon_0}$                            | III. | Faraday law                |
| D. | $\oint \vec{B} \cdot d\vec{A} = 0$   | IV.  | Ampere – Maxwell law       |

Choose the correct answer from the options given below:

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

34. A thermodynamic system is taken from an original state A to an intermediate state B by a linear process as shown in the figure. It's volume is then reduced to the original value from B to C by an isobaric process. The total work done by the gas from A to B and B to C would be:



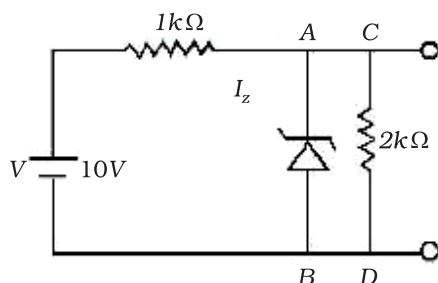
- (1) 2200 J      (2) 600 J      (3) 1200 J      (4) 33800 J

- 35.** A biconvex lens of refractive index 1.5 has a focal length of 20 cm in air. Its focal length when immersed in a liquid of refractive index 1.6 will be:  
**(1)** +16 cm      **(2)** -16 cm      **(3)** -160 cm      **(4)** +160 cm
- 36.** The potential energy function (in  $J$ ) of a particle in a region of space is given as  $U = (2x^2 + 3y^3 + 2z)$ . Here  $x$ ,  $y$  and  $z$  are in meter. The magnitude of x-component of force (in  $N$ ) acting on the particle at point  $P(1,2,3)$  is:  
**(1)** 6      **(2)** 4      **(3)** 8      **(4)** 2
- 37.** A convex mirror of radius of curvature 30 cm forms an image that is half the size of the object. The object distance is:  
**(1)** 15 cm      **(2)** -45 cm      **(3)** 45 cm      **(4)** -15 cm
- 38.** If the radius of curvature of the path of two particles of same mass are in the ratio 3:4, then in order to have constant centripetal force, their velocities will be in the ratio of:  
**(1)**  $2 : \sqrt{3}$       **(2)**  $\sqrt{3} : 2$       **(3)**  $\sqrt{3} : 1$       **(4)**  $1 : \sqrt{3}$
- 39.** A body starts moving from rest with constant acceleration covers displacement  $S_1$  in first  $(p-1)$  seconds and  $S_2$  in first  $p$  seconds. The displacement  $S_1 + S_2$  will be made in time:  
**(1)**  $(2p^2 - 2p + 1)s$       **(2)**  $(2p + 1)s$   
**(3)**  $\sqrt{(2p^2 - 2p + 1)}s$       **(4)**  $(2p - 1)s$
- 40.** A galvanometer having coil resistance  $10\Omega$  shows a full scale deflection for a current of  $3mA$ . For it to measure a current of  $8A$ , the value of the shunt should be:  
**(1)**  $3.75 \times 10^{-3}\Omega$       **(2)**  $2.75 \times 10^{-3}\Omega$       **(3)**  $4.85 \times 10^{-3}\Omega$       **(4)**  $3 \times 10^{-3}\Omega$
- 41.** The resistance  $R = \frac{V}{I}$  where  $V = (200 \pm 5)V$  and  $I = (20 \pm 0.2)A$ , the percentage error in the measurement of  $R$  is:  
**(1)** 3%      **(2)** 5.5%      **(3)** 3.5%      **(4)** 7%
- 42.** Two vessels  $A$  and  $B$  are of the same size and are at same temperature.  $A$  contains 1g of hydrogen and  $B$  contains 1g of oxygen.  $P_A$  and  $P_B$  are the pressure of the gases in  $A$  and  $B$  respectively, then  $\frac{P_A}{P_B}$  is:  
**(1)** 8      **(2)** 16      **(3)** 32      **(4)** 4
- 43.** A block of mass 100 kg slides over a distance of 10 m on a horizontal surface. If the co-efficient of friction between the surfaces is 0.4, then the work done against friction (in  $J$ ) is:  
**(1)** 3900      **(2)** 4200      **(3)** 4500      **(4)** 4000
- 44.** The electric current through a wire varies with time as  $I = I_0 + \beta t$ , where  $I_0 = 20A$  and  $\beta = 3 A/s$ . The amount of electric charge crossed through a section of the wire in 20 s is:  
**(1)** 80 C      **(2)** 800 C      **(3)** 1000 C      **(4)** 1600 C
- 45.** At what distance above and below the surface of the earth a body will have same weight. (take radius of earth as  $R$ )  
**(1)**  $\frac{\sqrt{3}R - R}{2}$       **(2)**  $\sqrt{5}R - R$       **(3)**  $\frac{\sqrt{5}R - R}{2}$       **(4)**  $\frac{R}{2}$

46. Two charges of  $5Q$  and  $-2Q$  are situated at the points  $(3a, 0)$  and  $(-5a, 0)$  respectively. The electric flux through a sphere of radius ' $4a$ ' having center at origin is:

(1)  $\frac{5Q}{\epsilon_0}$       (2)  $\frac{7Q}{\epsilon_0}$       (3)  $\frac{2Q}{\epsilon_0}$       (4)  $\frac{3Q}{\epsilon_0}$

47. In the given circuit, the breakdown voltage of the Zener diode is  $3.0\text{ V}$ . What is the value of  $I_z$ ?



- (1)  $10\text{ mA}$       (2)  $7\text{ mA}$       (3)  $3.3\text{ mA}$       (4)  $5.5\text{ mA}$

48. Given below are two statements:

**Statement I :** If a capillary tube is immersed first in cold water and then in hot water, the height of capillary rise will be smaller in hot water.

**Statement II :** If a capillary tube is immersed first in cold water and then in hot water, the height of capillary rise will be smaller in cold water.

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

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

49. The deflection in moving coil galvanometer falls from 25 divisions to 5 division when a shunt of  $24\Omega$  is applied. The resistance of galvanometer coil will be:

- (1)  $12\Omega$       (2)  $100\Omega$       (3)  $96\Omega$       (4)  $48\Omega$

50. A capacitor of capacitance  $100\mu\text{F}$  is charged to a potential of  $12\text{ V}$  and connected to a  $6.4\text{ mH}$  inductor to produce oscillations. The maximum current in the circuit would be:

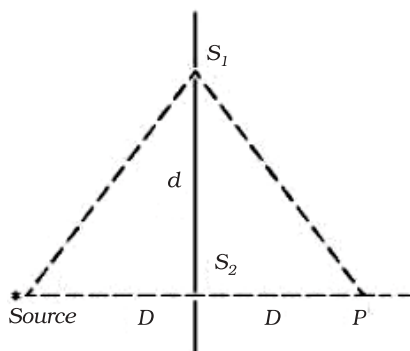
- (1)  $1.5\text{ A}$       (2)  $1.2\text{ A}$       (3)  $2.0\text{ A}$       (4)  $3.2\text{ A}$



**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. When the displacement of a simple harmonic oscillator is one third of its amplitude, the ratio of total energy to the kinetic energy is  $\frac{x}{8}$ , where  $x =$  \_\_\_\_\_.
52. A square loop of side 10 cm and resistance  $0.7 \Omega$  is placed vertically in east-west plane. A uniform magnetic field of  $0.20 T$  is set up across the plane in north east direction. The magnetic field is decreased to zero in 1 s at a steady rate. Then, magnitude of induced emf is  $\sqrt{x} \times 10^{-3} V$ . The value of  $x$  is \_\_\_\_\_.
53. An electron is moving under the influence of the electric field of a uniformly charged infinite plane sheet  $S$  having surface charge density  $+\sigma$ . The electron at  $t = 0$  is at a distance of 1 m from  $S$  and has a speed of 1 m/s. The maximum value of  $\sigma$  if the electron strikes  $S$  at  $t = 1$  s is  $\alpha \left[ \frac{m \epsilon_0}{e} \right] \frac{C}{m^2}$ , the value of  $\alpha$  is \_\_\_\_\_.
54. A ball rolls off the top of a stairway with horizontal velocity  $u$ . The steps are 0.1 m high and 0.1 m wide. The minimum velocity  $u$  with which that ball just hits the step 5 of the stairway will be  $\sqrt{x} \text{ ms}^{-1}$  where  $x =$  \_\_\_\_\_ [use  $g = 10 \text{ m/s}^2$ ].
55. A cylinder is rolling down on an inclined plane of inclination  $60^\circ$ . Its acceleration during rolling down will be  $\frac{x}{\sqrt{3}} \text{ m/s}^2$ , where  $x =$  \_\_\_\_\_ (use  $g = 10 \text{ m/s}^2$ ).
56. When a hydrogen atoms going from  $n = 2$  to  $n = 1$  emits a photon, its recoil speed is  $\frac{x}{5} \text{ m/s}$ . Where  $x =$  \_\_\_\_\_. (Use, mass of hydrogen atom  $= 1.6 \times 10^{-27} \text{ kg}$ )
57. The magnetic potential due to a magnetic dipole at a point on its axis situated at a distance of 20 cm from its center is  $1.5 \times 10^{-5} Tm$ . The magnetic moment of the dipole is \_\_\_\_\_  $A m^2$ .  
(Given :  $\frac{\mu_0}{4\pi} = 10^{-7} T m A^{-1}$ ).
58. In a double slit experiment shown in figure, when light of wavelength  $400 \text{ nm}$  is used, dark fringe is observed at  $P$ . If  $D = 0.2 \text{ m}$ , the minimum distance between the slits  $S_1$  and  $S_2$  is \_\_\_\_\_ mm.



59. In a test experiment on a model aeroplane in wind tunnel, the flow speeds on the upper and lower surfaces of the wings are  $70 \text{ ms}^{-1}$  and  $65 \text{ ms}^{-1}$  respectively. If the wing area is  $2 \text{ m}^2$ , the lift of the wing is \_\_\_\_\_ N. (Given density of air =  $1.2 \text{ kg m}^{-3}$ )
60. A  $16 \Omega$  wire is bend to form a square loop. A  $9\text{V}$  battery with internal resistance  $1 \Omega$  is connected across one of its sides. If a  $4\mu\text{F}$  capacitor is connected across one of its diagonals, the energy stored by the capacitor will be  $\frac{x}{2} \mu\text{J}$ , where  $x =$  \_\_\_\_\_.

**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 set of four quantum numbers for the valence electron of rubidium atom ( $Z = 37$ ) is:

- (1)  $5, 1, 1, +\frac{1}{2}$       (2)  $5, 0, 1, +\frac{1}{2}$       (3)  $5, 1, 0, +\frac{1}{2}$       (4)  $5, 0, 0, +\frac{1}{2}$

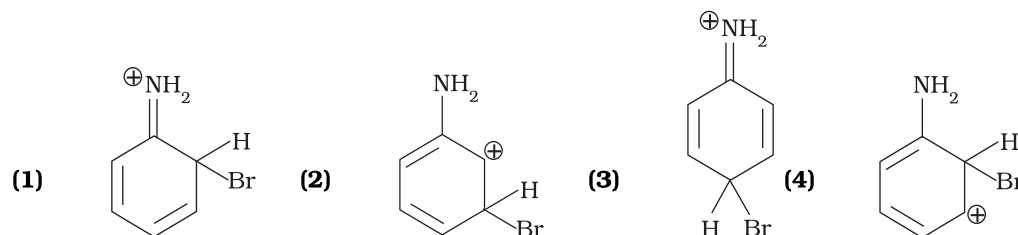
62. In which one of the following metal carbonyls, CO forms a bridge between metal atoms?

- (1)  $[\text{Os}_3(\text{CO})_{12}]$       (2)  $[\text{Ru}_3(\text{CO})_{12}]$       (3)  $[\text{Mn}_2(\text{CO})_{10}]$       (4)  $[\text{Co}_2(\text{CO})_8]$

63. Which of the following is **not** correct?

- (1)  $\Delta G$  is positive for a non-spontaneous reaction  
 (2)  $\Delta G$  is negative for a spontaneous reaction  
 (3)  $\Delta G$  is positive for a spontaneous reaction  
 (4)  $\Delta G$  is zero for a reversible reaction

64. The arenium ion which is not involved in the bromination of Aniline is \_\_\_\_\_.



65. Chlorine undergoes disproportionation in alkaline medium as shown below:



The values of a, b, c and d in a balanced redox reaction are respectively:

- (1) 2, 2, 1 and 3      (2) 1, 2, 1 and 1      (3) 2, 4, 1 and 3      (4) 3, 4, 4 and 2

66. In alkaline medium,  $\text{MnO}_4^{-}$  oxidises  $\text{I}^{-}$  to:

- (1)  $\text{IO}_3^{-}$       (2)  $\text{IO}^{-}$       (3)  $\text{IO}_4^{-}$       (4)  $\text{I}_2$

67. Appearance of blood red colour, on treatment of the sodium fusion extract of an organic compound with  $\text{FeSO}_4$  in presence of concentrated  $\text{H}_2\text{SO}_4$  indicates the presence of element/s

- (1) N and S      (2) Br      (3) N      (4) S

68. Match List I with List II.

|    | LIST I<br>(Substance) |      | LIST II<br>(Element Present) |
|----|-----------------------|------|------------------------------|
| A. | Ziegler catalyst      | I.   | Rhodium                      |
| B. | Blood pigment         | II.  | Cobalt                       |
| C. | Wilkinson catalyst    | III. | Iron                         |

|           |                         |            |          |
|-----------|-------------------------|------------|----------|
| <b>D.</b> | Vitamin B <sub>12</sub> | <b>IV.</b> | Titanium |
|-----------|-------------------------|------------|----------|

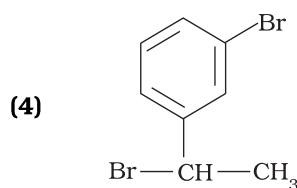
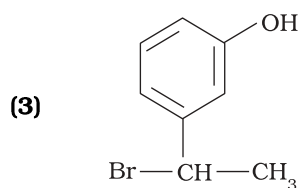
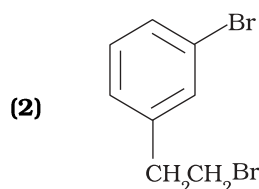
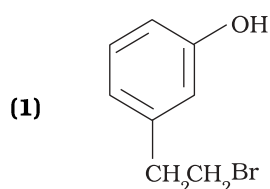
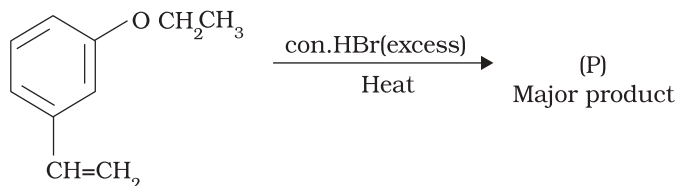
Choose the correct answer from the option given below:

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

69. In chromyl chloride test for confirmation of Cl<sup>–</sup> ion, a yellow solution is obtained. Acidification of the solution and addition of amyl alcohol and 10% H<sub>2</sub>O<sub>2</sub> turns organic layer blue indicating formation of chromium pentoxide. The oxidation state of chromium in that is:

- (1) +10                      (2) +6                      (3) +3                      (4) +5

70. The major product(P) in the following reaction is:



71. The interaction between  $\pi$  bond and lone pair of electrons present on a adjacent atom is responsible for:

- (1) Electromeric effect                      (2) Inductive effect  
 (3) Resonance effect                      (4) Hyperconjugation

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

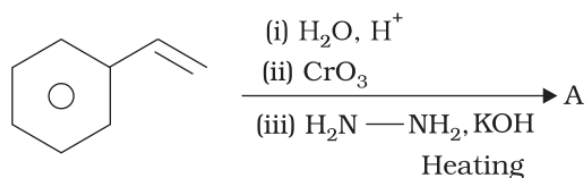
**Assertion A :** The first ionization enthalpy decreases across a period.

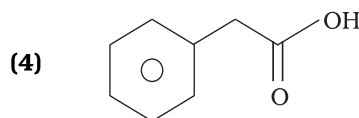
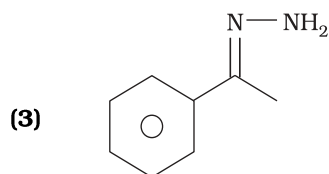
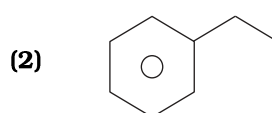
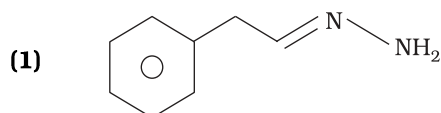
**Reason R :** The increasing nuclear charge outweighs the shielding across the period.

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

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

73. The final product A formed in the following multistep reaction sequence is:





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

**Assertion A** : Aryl halides cannot be prepared by replacement of hydroxyl group of phenol by halogen atom.

**Reason R** : Phenols react with halogen acids violently.

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

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

75. Given below are two statements:

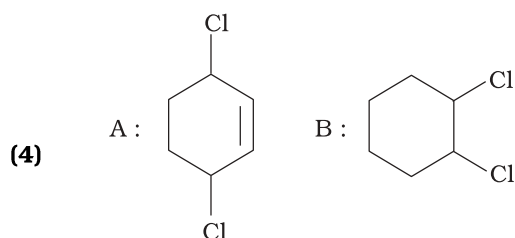
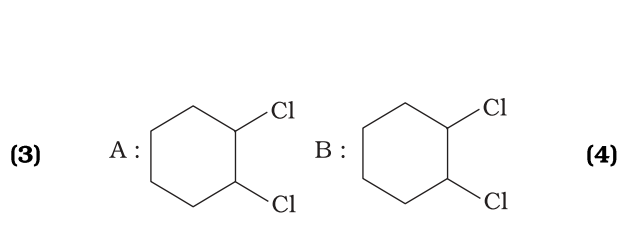
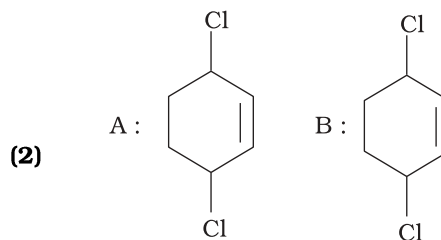
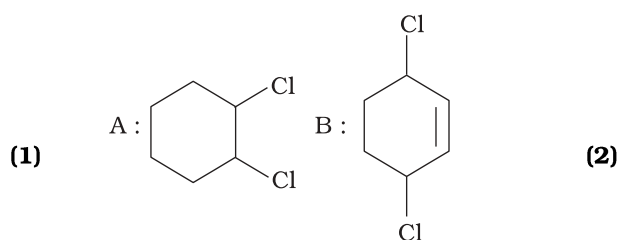
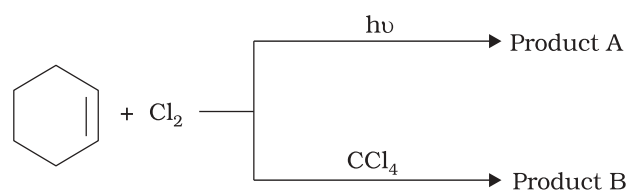
**Statement I** : The electronegativity of group 14 elements from Si to Pb, gradually decreases.

**Statement II** : Group 14 contains non-metallic, metallic, as well as metalloid elements.

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

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

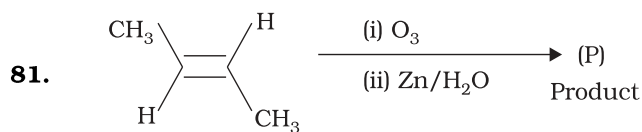
76. Identify product A and product B:



77. The difference in energy between the actual structure and the lowest energy resonance structure for the given compound is:
- |     |                         |     |                     |
|-----|-------------------------|-----|---------------------|
| (1) | ionization energy       | (2) | resonance energy    |
| (3) | hyperconjugation energy | (4) | electromeric energy |
78. Type of amino acids obtained by hydrolysis of proteins is:
- |     |          |     |          |     |          |     |         |
|-----|----------|-----|----------|-----|----------|-----|---------|
| (1) | $\delta$ | (2) | $\gamma$ | (3) | $\alpha$ | (4) | $\beta$ |
|-----|----------|-----|----------|-----|----------|-----|---------|
79. Identify the incorrect pair from the following:
- |     |  |     |   |
|-----|--|-----|---|
| (1) | Cryolite – $\text{Na}_3\text{AlF}_6$                             | (2) | Fluorspar – $\text{BF}_3$   |
| (3) | Fluoroapatite – $3\text{Ca}_3(\text{PO}_4)_2 \cdot \text{CaF}_2$ | (4) | Carnallite – $\text{KCl} \cdot \text{MgCl}_2 \cdot 6\text{H}_2\text{O}$ |
80.  $\text{KMnO}_4$  decomposes on heating at 513K to form  $\text{O}_2$  along with:
- |     |   |     |  |
|-----|---|-----|--|
| (1) | $\text{K}_2\text{MnO}_4$ & $\text{MnO}_2$ | (2) | $\text{Mn}$ & $\text{KO}_2$            |
| (3) | $\text{MnO}_2$ & $\text{K}_2\text{O}_2$   | (4) | $\text{K}_2\text{MnO}_4$ & $\text{Mn}$ |

**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.

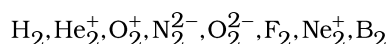


Consider the given reaction. The total number of oxygen atom/s present per molecule of the product (P) is \_\_\_\_\_.

82. The mass of zinc produced by the electrolysis of zinc sulphate solution with a steady current of 0.015 A for 15 minutes is \_\_\_\_\_  $\times 10^{-4}$  g. (Atomic mass of zinc = 65.4 amu)

83. For a reaction taking place in three steps at same temperature, overall rate constant  $K = \frac{K_1 K_2}{K_3}$ . If  $E_{a1}$ ,  $E_{a2}$  and  $E_{a3}$  are 40, 50 and 60 kJ/mol respectively, the overall  $E_a$  is \_\_\_\_\_ kJ/mol.

84. The number of species from the following which are paramagnetic and with bond order equal to one is \_\_\_\_\_.



85. A solution of  $H_2SO_4$  is 31.4%  $H_2SO_4$  by mass and has a density of 1.25 g/mL.

The molarity of the  $H_2SO_4$  solution is \_\_\_\_\_ M (nearest integer)

[Given molar mass of  $H_2SO_4$  = 98 g  $mol^{-1}$ ]

86. From the compounds given below, number of compounds which give positive Fehling's test is \_\_\_\_\_.

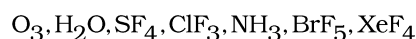
Benzaldehyde, Acetaldehyde, Acetone, Acetophenone, Methanal, 4-nitrobenzaldehyde, cyclohexane carbaldehyde.

87. The osmotic pressure of a dilute solution is  $7 \times 10^5$  Pa at 273 K. Osmotic pressure of the same solution at 283 K is \_\_\_\_\_  $\times 10^4$   $Nm^{-2}$ .

88. For the reaction  $N_2O_4(g) \rightleftharpoons 2NO_2(g)$ ,  $K_p = 0.492$  atm at 300 K.  $K_c$  for the reaction at same temperature is \_\_\_\_\_  $\times 10^{-2}$ .

(Given :  $r = 0.082$  L atm  $mol^{-1}$   $K^{-1}$ )

89. Number of compounds with one lone pair of electrons on central atom amongst following is \_\_\_\_\_.



90. Number of compounds among the following which contain sulphur as heteroatom is \_\_\_\_\_.

Furan, Thiophene, Pyridine, Pyrrole, Cysteine, Tyrosine.