

JEE Main 2021 Paper 1 (B.E./B.Tech) 27 July 2021 Shift 2 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) 2021 - Session 3**, conducted by the National Testing Agency (NTA) in Computer Based Test (CBT) mode on 27 July 2021, Shift 2. The total duration is **3 hours**.
- (ii) The paper has **90 questions**, of which **75 are to be attempted**, and a maximum of **300 marks**: Mathematics, Physics and Chemistry carry 30 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 **10 numerical value questions**; attempt **any 5** of them.
- (iv) **All Section A questions are compulsory**. Attempt only the specified number of Section B questions. 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**: MCQs carry **+4** for a correct answer and **-1** for an incorrect answer. Numerical questions carry **+4** for a correct answer and **0** for an incorrect answer. Unanswered questions carry **0**.
- (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. The point P (a, b) undergoes the following three transformations successively :

(a) reflection about the line $y = x$.

(b) translation through 2 units along the positive direction of x-axis.

(c) rotation through angle $\frac{\pi}{4}$ about the origin in the anti-clockwise direction.

If the co-ordinates of the final position of the point P are

$$\left(-\frac{1}{\sqrt{2}}, \frac{7}{\sqrt{2}}\right)$$

, then the value of $2a + b$ is equal to :

- (A) 13 (B) 9
(C) 5 (D) 7

2. A possible value of 'x', for which the ninth term in the expansion of

$$\left\{3^{\log_3 \sqrt{25^{x-1} + 7}} + 3^{\left(-\frac{1}{8}\right)\log_3(5^{x-1} + 1)}\right\}^{10}$$

in the increasing powers of

$$3^{\left(-\frac{1}{8}\right)\log_3(5^{x-1} + 1)}$$

is equal to 180, is :

- (A) 0 (B) -1
(C) 2 (D) 1

3. Let $f : \mathbb{R} \rightarrow \mathbb{R}$ be defined as

$$f(x+y) + f(x-y) = 2f(x)f(y), f\left(\frac{1}{2}\right) = -1$$

. Then, the value of

$$\sum_{k=1}^{20} \frac{1}{\sin(k)\sin(k+f(k))}$$

is equal to :

- (A) $\operatorname{cosec}^2(21) \cos(20)$ (B) $\sec^2(1) \sec(21)$
 $\cos(2)$ $\cos(20)$
(C) $\operatorname{cosec}^2(1) \operatorname{cosec}(21)$ (D) $\sec^2(21) \sin(20)$
 $\sin(20)$ $\sin(2)$

4. Let C be the set of all complex numbers. Let

$$S_1 = \{z \in \mathbb{C} : |z - 2| \leq 1\} \text{ and}$$

$$S_2 = \{z \in \mathbb{C} : z(1+i) + \bar{z}(1-i) \geq 4\}.$$

Then, the maximum value of

$$\left|z - \frac{5}{2}\right|^2$$

for $z \in S_1 \cap S_2$ is equal to :

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

5. If

$$\tan\left(\frac{\pi}{9}\right), x, \tan\left(\frac{7\pi}{18}\right)$$

are in arithmetic progression and

$$\tan\left(\frac{\pi}{9}\right), y, \tan\left(\frac{5\pi}{18}\right)$$

are also in arithmetic progression, then $|x - 2y|$ is equal to :

- (A) 4 (B) 3
(C) 0 (D) 1

6. Let the mean and variance of the frequency distribution

$$\begin{array}{cccc} x: & x_1 = 2 & x_2 = 6 & x_3 = 8 & x_4 = 9 \\ f: & 4 & 4 & \alpha & \beta \end{array}$$

be 6 and 6.8 respectively. If x_3 is changed from 8 to 7, then the mean for the new data will be :

- (A) 4
(B) 5
(C) $\frac{17}{3}$
(D) $\frac{16}{3}$

7. The area of the region bounded by $y - x = 2$ and $x^2 = y$ is equal to :

- (A) $\frac{16}{3}$
 (B) $\frac{2}{3}$
 (C) $\frac{9}{2}$
 (D) $\frac{4}{3}$

8. Let $y = y(x)$ be the solution of the differential equation $(x - x^3)dy = (y + yx^2 - 3x^4)dx$, $x > 2$. If $y(3) = 3$, then $y(4)$ is equal to :

- (A) 4 (B) 12
 (C) 8 (D) 16

9. The value of

$$\lim_{x \rightarrow 0} \left(\frac{x}{\sqrt[8]{1 - \sin x} - \sqrt[8]{1 + \sin x}} \right)$$

is equal to :

- (A) 0 (B) 4
 (C) -4 (D) -1

10. Two sides of a parallelogram are along the lines $4x + 5y = 0$ and $7x + 2y = 0$. If the equation of one of the diagonals of the parallelogram is $11x + 7y = 9$, then other diagonal passes through the point :

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

11. Let

$$\alpha = \max_{x \in R} \{8^{2 \sin 3x} \cdot 4^{4 \cos 3x}\}$$

and

$$\beta = \min_{x \in R} \{8^{2 \sin 3x} \cdot 4^{4 \cos 3x}\}$$

. If $8x^2 + bx + c = 0$ is a quadratic equation whose roots are $\alpha^{1/5}$ and $\beta^{1/5}$, then the value of $c - b$ is equal to :

- (A) 42 (B) 47
 (C) 43 (D) 50

12. Let $f : [0, \infty) \rightarrow [0, 3]$ be a function defined by

$$f(x) = \begin{cases} \max\{\sin t : 0 \leq t \leq x\}, & 0 \leq x \leq \pi \\ 2 + \cos x, & x > \pi \end{cases}$$

Then which of the following is true?

- (A) f is continuous everywhere but not differentiable exactly at one point in $(0, \infty)$
 (B) f is differentiable everywhere in $(0, \infty)$
 (C) f is not continuous exactly at two points in $(0, \infty)$
 (D) f is continuous everywhere but not differentiable exactly at two points in $(0, \infty)$

13. Let N be the set of natural numbers and a relation R on N be defined by

$$R = \{(x, y) \in N \times N : x^3 - 3x^2y - xy^2 + 3y^3 = 0\}$$

. Then the relation R is :

- (A) symmetric but neither reflexive nor transitive
 (B) reflexive but neither symmetric nor transitive
 (C) reflexive and symmetric, but not transitive
 (D) an equivalence relation

14. Consider a circle C which touches the y -axis at $(0, 6)$ and cuts off an intercept $6\sqrt{5}$ on the x -axis. Then the radius of the circle C is equal to :

- (A) $\sqrt{53}$
 (B) 9
 (C) 8
 (D) $\sqrt{82}$

15. Let $f : (a, b) \rightarrow \mathbb{R}$ be twice differentiable function such that

$$f(x) = \int_a^x g(t) dt$$

for a differentiable function $g(x)$. If $f(x) = 0$ has exactly five distinct roots in (a, b) , then $g(x)g'(x) = 0$ has at least :

- (A) twelve roots in (a, b) (B) five roots in (a, b)
(C) seven roots in (a, b) (D) three roots in (a, b)

16. For real numbers α and $\beta \neq 0$, if the point of intersection of the straight lines

$$\frac{x - \alpha}{1} = \frac{y - 1}{2} = \frac{z - 1}{3}$$

and

$$\frac{x - 4}{\beta} = \frac{y - 6}{3} = \frac{z - 7}{3}$$

, lies on the plane $x + 2y - z = 8$, then $\alpha - \beta$ is equal to :

- (A) 5 (B) 9
(C) 3 (D) 7

17. A student appeared in an examination consisting of 8 true-false type questions. The student guesses the answers with equal probability. the smallest value of n , so that the probability of guessing at least 'n' correct answers is less than $\frac{1}{2}$, is :

- (A) 5 (B) 6
(C) 3 (D) 4

18. Which of the following is the negation of the statement "for all $M > 0$, there exists $x \in S$ such that $x \geq M$ " ?

- (A) there exists $M > 0$, such that $x < M$ for all $x \in S$ (B) there exists $M > 0$, there exists $x \in S$ such that $x \geq M$
(C) there exists $M > 0$, there exists $x \in S$ such that $x < M$ (D) there exists $M > 0$, such that $x \geq M$ for all $x \in S$

19. Let $\vec{a}$, $\vec{b}$ and $\vec{c}$ be three vectors such that $\vec{a} = \vec{b} \times (\vec{b} \times \vec{c})$. If magnitudes of the vectors $\vec{a}$, $\vec{b}$ and $\vec{c}$ are $\sqrt{2}$, 1 and 2 respectively and the angle between $\vec{b}$ and $\vec{c}$ is

$$\theta \left(0 < \theta < \frac{\pi}{2} \right)$$

, then the value of $1 + \tan \theta$ is equal to :

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

20. Let A and B be two 3×3 real matrices such that $(A^2 - B^2)$ is invertible matrix. If $A^5 = B^5$ and $A^3 B^2 = A^2 B^3$, then the value of the determinant of the matrix $A^3 + B^3$ is equal to :

- (A) 2 (B) 4
(C) 1 (D) 0

21. If the real part of the complex number

$$z = \frac{3 + 2i \cos \theta}{1 - 3i \cos \theta}, \theta \in \left(0, \frac{\pi}{2}\right)$$

is zero, then the value of $\sin^2 3\theta + \cos^2 \theta$ is equal to _____.

22. If

$$\int_0^\pi (\sin^3 x) e^{-\sin^2 x} dx = \alpha - \frac{\beta}{e} \int_0^1 \sqrt{t} e^t dt$$

, then $\alpha + \beta$ is equal to _____.

23. The number of real roots of the equation $e^{4x} - e^{3x} - 4e^{2x} - e^x + 1 = 0$ is equal to _____.

24. Let $y = y(x)$ be the solution of the differential equation $dy = e^{\alpha x + y} dx$; $\alpha \in \mathbb{N}$. If $y(\log_e 2) = \log_e 2$ and $y(0) = \log_e \left(\frac{1}{2}\right)$

, then the value of α is equal to _____.

25. Let n be a non-negative integer. Then the number of divisors of the form " $4n + 1$ " of the number $(10)^{10} \cdot (11)^{11} \cdot (13)^{13}$ is equal to _____.

26. Let $A = \{n \in \mathbb{N} \mid n^2 \leq n + 10,000\}$, $B = \{3k + 1 \mid k \in \mathbb{N}\}$ and $C = \{2k \mid k \in \mathbb{N}\}$, then the sum of all the elements of the set $A \cap (B - C)$ is equal to _____.

27. If

$$A = \begin{bmatrix} 1 & 1 & 1 \\ 0 & 1 & 1 \\ 0 & 0 & 1 \end{bmatrix}$$

and $M = A + A^2 + A^3 + \dots + A^{20}$, then the sum of all the elements of the matrix M is equal to _____.

28. Let

$$\vec{a} = \hat{i} - \alpha \hat{j} + \beta \hat{k}$$

,

$$\vec{b} = 3\hat{i} + \beta \hat{j} - \alpha \hat{k}$$

and

$$\vec{c} = -\alpha \hat{i} - 2\hat{j} + \hat{k}$$

, where α and β are integers. If

$$\vec{a} \cdot \vec{b} = -1$$

and

$$\vec{b} \cdot \vec{c} = 10$$

, then $(\vec{a} \times \vec{b}) \cdot \vec{c}$ is equal to _____.

29. The distance of the point $P(3, 4, 4)$ from the point of intersection of the line joining the points $Q(3, -4, -5)$ and $R(2, -3, 1)$ and the plane $2x + y + z = 7$, is equal to _____.

30. Let E be an ellipse whose axes are parallel to the co-ordinates axes, having its center at $(3, -4)$, one focus at $(4, -4)$ and one vertex at $(5, -4)$. If $mx - y = 4$, $m > 0$ is a tangent to the ellipse E , then the value of $5m^2$ is equal to _____.

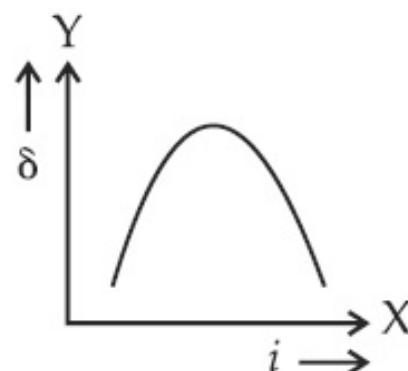
31. An electron and proton are separated by a large distance. The electron starts approaching the proton with energy 3 eV. The proton captures the electron and forms a hydrogen atom in second excited state. The resulting photon is incident on a photosensitive metal of threshold wavelength 4000

$\text{\AA}$. What is the maximum kinetic energy of the emitted photoelectron?

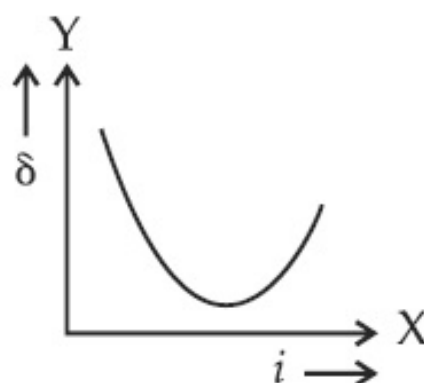
- (A) 7.61 eV (B) 1.41 eV
(C) 3.3 eV (D) No photoelectron would be emitted

32. The expected graphical representation of the variation of angle of deviation ' δ ' with angle of incidence ' i ' in a prism is :

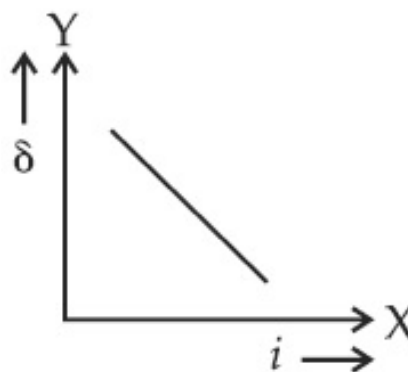
32. (continued)



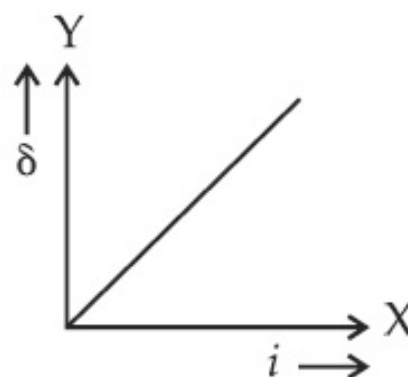
(A)



(B)



(C)



(D)

33. A raindrop with radius $R = 0.2 \text{ mm}$ falls from a cloud at a height $h = 2000 \text{ m}$ above the ground. Assume that the drop is spherical throughout its fall and the force of buoyance may be neglected, then the terminal speed attained by the raindrop is :

[Density of water $f_w = 1000 \text{ kg m}^{-3}$ and Density of air $f_a = 1.2 \text{ kg m}^{-3}$, $g = 10 \text{ m/s}^2$, Coefficient of viscosity of air $= 1.8 \times 10^{-5} \text{ Nsm}^{-2}$]

- (A) 250.6 ms^{-1} (B) 43.56 ms^{-1}
(C) 4.94 ms^{-1} (D) 14.4 ms^{-1}

34. One mole of an ideal gas is taken through an adiabatic process where the temperature rises from 27°C to 37°C . If the ideal gas is composed of polyatomic molecule that has 4 vibrational modes, which of the following is true? [$R = 8.314 \text{ J mol}^{-1} \text{ K}^{-1}$]

- (A) work done by the gas is close to 332 J (B) work done on the gas is close to 582 J
(C) work done by the gas is close to 582 J (D) work done on the gas is close to 332 J

35. An object of mass 0.5 kg is executing simple harmonic motion. Its amplitude is 5 cm and time period (T) is 0.2 s . What will be the potential energy of the object at an instant

$$t = \frac{T}{4} \text{ s}$$

starting from mean position. Assume that the initial phase of the oscillation is zero.

- (A) 0.62 J (B) $6.2 \times 10^{-3} \text{ J}$
(C) $1.2 \times 10^3 \text{ J}$ (D) $6.2 \times 10^3 \text{ J}$

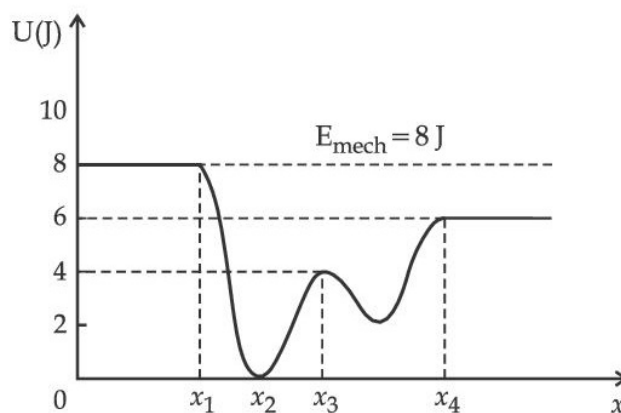
36. Match List I with List II.

	List - I		List - II
(a)	Capacitance, C	(i)	$M^1 L^1 T^{-3} A^{-1}$
(b)	Permittivity of free space, ϵ_0	(ii)	$M^{-1} L^{-3} T^4 A^2$
(c)	Permeability of free space, μ_0	(iii)	$M^{-1} L^{-2} T^4 A^2$
(d)	Electric field, E	(iv)	$M^1 L^1 T^{-2} A^{-2}$

Choose the correct answer from the options given below

- (A) (a) $\rightarrow$ (iii), (b) $\rightarrow$ (ii), (c) $\rightarrow$ (iv), (d) $\rightarrow$ (i) (B) (a) $\rightarrow$ (iii), (b) $\rightarrow$ (iv), (c) $\rightarrow$ (ii), (d) $\rightarrow$ (i)
(C) (a) $\rightarrow$ (iv), (b) $\rightarrow$ (ii), (c) $\rightarrow$ (iii), (d) $\rightarrow$ (i) (D) (a) $\rightarrow$ (iv), (b) $\rightarrow$ (iii), (c) $\rightarrow$ (ii), (d) $\rightarrow$ (i)

37. Given below is the plot of a potential energy function $U(x)$ for a system, in which a particle is in one dimensional motion, while a conservative force $F(x)$ acts on it. Suppose that $E_{\text{mech}} = 8 \text{ J}$, the incorrect statement for this system is :



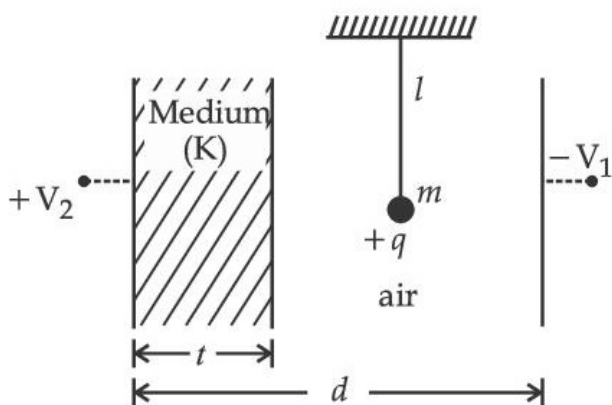
[where K.E. = kinetic energy]

- (A) at $x > x_4$ K.E. is constant throughout the region. (B) at $x < x_1$, K.E. is smallest and the particle is moving at the slowest speed.
(C) at $x = x_2$, K.E. is greatest and the particle is moving at the fastest speed. (D) at $x = x_3$, K.E. = 4 J .

38. A 100Ω resistance, a $0.1\ \mu\text{F}$ capacitor and an inductor are connected in series across a 250 V supply at variable frequency. Calculate the value of inductance of inductor at which resonance will occur. Given that the resonant frequency is 60 Hz .

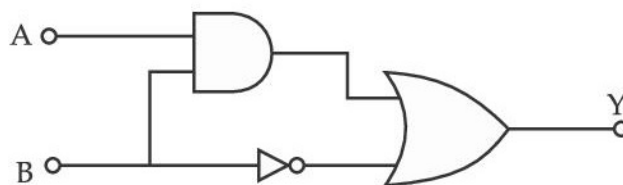
- (A) 0.70 H (B) 70.3 mH
(C) $7.03 \times 10^{-5}\text{ H}$ (D) 70.3 H

39. A simple pendulum of mass ' m ', length ' l ' and charge '+ q ' suspended in the electric field produced by two conducting parallel plates as shown. The value of deflection of pendulum in equilibrium position will be



- (A) $\tan^{-1} \left[\frac{q}{mg} \times \frac{C_1(V_2 - V_1)}{(C_1 + C_2)(d - t)} \right]$
(B) $\tan^{-1} \left[\frac{q}{mg} \times \frac{C_2(V_2 - V_1)}{(C_1 + C_2)(d - t)} \right]$
(C) $\tan^{-1} \left[\frac{q}{mg} \times \frac{C_2(V_1 + V_2)}{(C_1 + C_2)(d - t)} \right]$
(D) $\tan^{-1} \left[\frac{q}{mg} \times \frac{C_1(V_1 + V_2)}{(C_1 + C_2)(d - t)} \right]$

40. Find the truth table for the function Y of A and B represented in the following figure.



(A)

A	B	Y
0	0	0
0	1	1
1	0	0
1	1	0

(B)

A	B	Y
0	0	1
0	1	0
1	0	1
1	1	1

(C)

A	B	Y
0	0	0
0	1	0
1	0	0
1	1	1

(D)

A	B	Y
0	0	0
0	1	1
1	0	1
1	1	1

41. Figure A and B shown to long straight wires of circular cross-section (a and b with $a < b$), carrying current I which is uniformly distributed across the cross-section. The magnitude of magnetic field B varies with radius r and can be represented as :

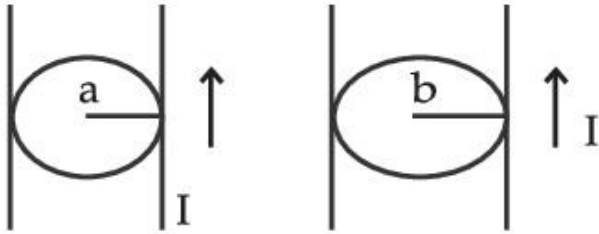
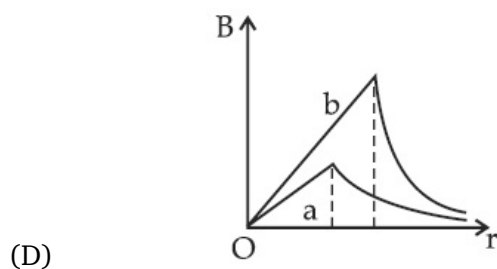
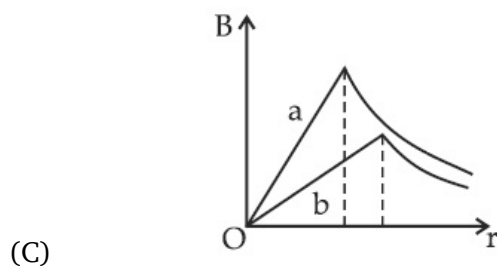
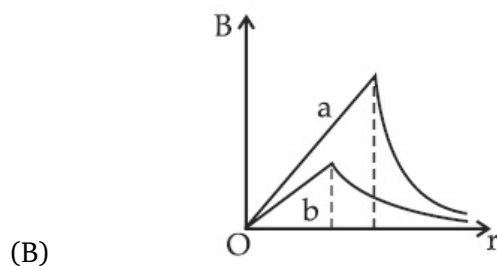
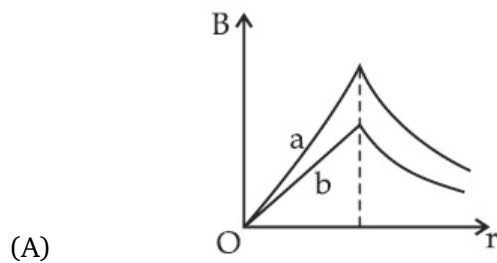


Fig. A

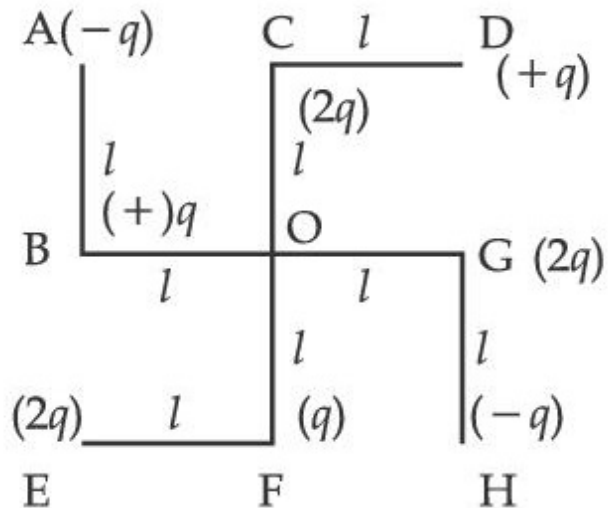
Fig. B



42. Two identical particles of mass 1 kg each go round a circle of radius R , under the action of their mutual gravitational attraction. The angular speed of each particle is :

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

43. What will be the magnitude of electric field at point O as shown in the figure? Each side of the figure is l and perpendicular to each other?



- (A) $\frac{1}{4\pi\epsilon_0} \frac{q}{l^2}$
 (B) $\frac{1}{4\pi\epsilon_0} \frac{q}{(2l^2)} (2\sqrt{2} - 1)$
 (C) $\frac{q}{4\pi\epsilon_0 (2l)^2}$
 (D) $\frac{1}{4\pi\epsilon_0} \frac{2q}{2l^2} (\sqrt{2})$

44. A physical quantity 'y' is represented by the formula

$$y = m^2 r^{-4} g^x l^{-\frac{3}{2}}$$

If the percentage errors found in y, m, r, l and g are 18, 1, 0.5, 4 and p respectively, then find the value of x and p.

- (A) 5 and ± 2 (B) 4 and ± 3
(C) $\frac{16}{3}$ and $\pm \frac{3}{2}$ (D) 8 and ± 2

45. An automobile of mass 'm' accelerates starting from origin and initially at rest, while the engine supplies constant power P. The position is given as a function of time by :

- (A) $\left(\frac{9P}{8m}\right)^{\frac{1}{2}} t^{\frac{3}{2}}$
(B) $\left(\frac{8P}{9m}\right)^{\frac{1}{2}} t^{\frac{2}{3}}$
(C) $\left(\frac{9m}{8P}\right)^{\frac{1}{2}} t^{\frac{3}{2}}$
(D) $\left(\frac{8P}{9m}\right)^{\frac{1}{2}} t^{\frac{3}{2}}$

46. The planet Mars has two moons, if one of them has a period 7 hours, 30 minutes and an orbital radius of 9.0×10^3 km. Find the mass of Mars.

$$\left\{ \text{Given } \frac{4\pi^2}{G} = 6 \times 10^{11} \text{ N}^{-1} \text{ m}^{-2} \text{ kg}^2 \right\}$$

- (A) 5.96×10^{19} kg (B) 3.25×10^{21} kg
(C) 7.02×10^{25} kg (D) 6.00×10^{23} kg

47. A particle of mass M originally at rest is subjected to a force whose direction is constant but magnitude varies with time according to the relation

$$F = F_0 \left[1 - \left(\frac{t-T}{T} \right)^2 \right]$$

Where F_0 and T are constants. The force acts only for the time interval 2T. The velocity v of the particle after time 2T is :

- (A) $2F_0 T/M$ (B) $F_0 T/2M$
(C) $4F_0 T/3M$ (D) $F_0 T/3M$

48. The resistance of a conductor at 15°C is 16Ω and at 100°C is 20Ω . What will be the temperature coefficient of resistance of the conductor?

- (A) 0.010°C^{-1} (B) 0.033°C^{-1}
(C) 0.003°C^{-1} (D) 0.042°C^{-1}

49. Two Carnot engines A and B operate in series such that engine A absorbs heat at T_1 and rejects heat to a sink at temperature T. Engine B absorbs half of the heat rejected by Engine A and rejects heat to the sink at T_3 . When workdone in both the cases is equal, to value of T is :

- (A) $\frac{2}{3}T_1 + \frac{3}{2}T_3$
(B) $\frac{1}{3}T_1 + \frac{2}{3}T_3$
(C) $\frac{3}{2}T_1 + \frac{1}{3}T_3$
(D) $\frac{2}{3}T_1 + \frac{1}{3}T_3$

50. Consider the following statements :

- A. Atoms of each element emit characteristics spectrum.
B. According to Bohr's Postulate, an electron in a hydrogen atom, revolves in a certain stationary orbit.
C. The density of nuclear matter depends on the size of the nucleus.
D. A free neutron is stable but a free proton decay is possible.
E. Radioactivity is an indication of the instability of nuclei.

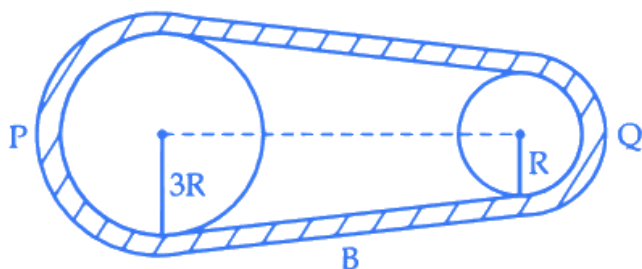
Choose the correct answer from the options given below :

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

51. In the given figure, two wheels P and Q are connected by a belt B. The radius of P is three times as that of Q. In case of same rotational kinetic energy, the ratio of rotational inertias

$$\left(\frac{I_1}{I_2}\right)$$

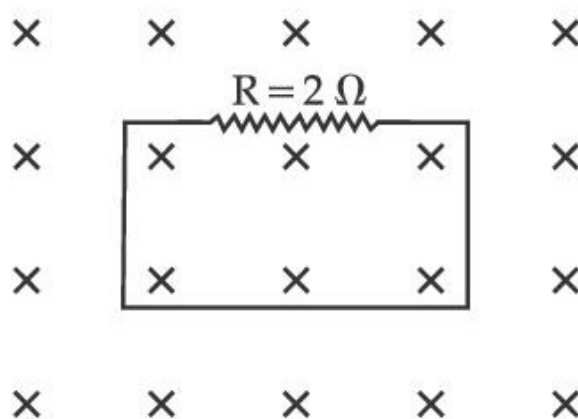
will be $x : 1$. The value of x will be _____.



52. The difference in the number of waves when yellow light propagates through air and vacuum columns of the same thickness is one. The thickness of the air column is _____ mm. [Refractive index of air = 1.0003, wavelength of yellow light in vacuum = $6000 \overset{\circ}{\text{A}}$]

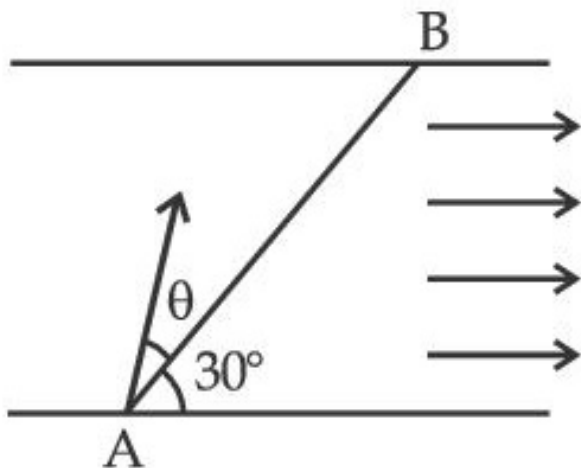
53. In the given figure the magnetic flux through the loop increases according to the relation $\phi_B(t) = 10t^2 + 20t$, where ϕ_B is in milliwebers and t is in seconds.

The magnitude of current through $R = 2\Omega$ resistor at $t = 5$ s is _____ mA.



54. A particle executes simple harmonic motion represented by displacement function as $x(t) = A \sin(\omega t + \phi)$. If the position and velocity of the particle at $t = 0$ s are 2 cm and 2ω cm s⁻¹ respectively, then its amplitude is $x\sqrt{2}$ cm where the value of x is _____.

55. A swimmer wants to cross a river from point A to point B. Line AB makes an angle of 30° with the flow of river. Magnitude of velocity of the swimmer is same as that of the river. The angle θ with the line AB should be _____ $^\circ$, so that the swimmer reaches point B.



56. For the circuit shown, the value of current at time $t = 3.2$ s will be _____ A.

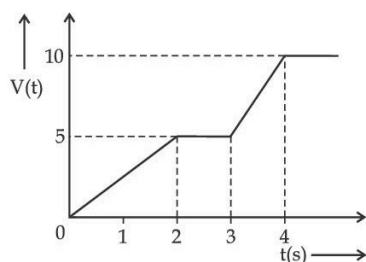


Figure 1

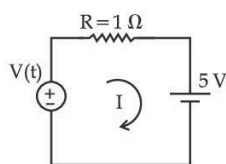
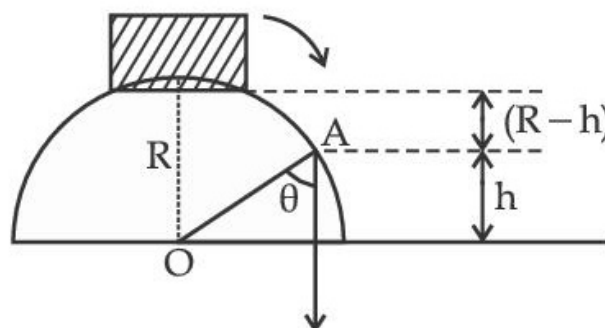


Figure 2

[Voltage distribution $V(t)$ is shown by Fig. (1) and the circuit is shown in Fig. (2)]

57. A small block slides down from the top of hemisphere of radius $R = 3$ m as shown in the figure. The height 'h' at which the block will lose contact with the surface of the sphere is _____ m.

(Assume there is no friction between the block and the hemisphere)



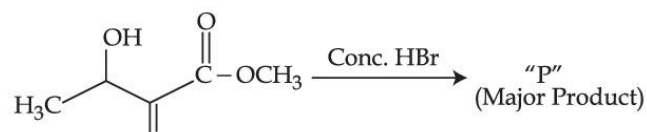
58. The K_α X-ray of molybdenum has wavelength 0.071 nm. If the energy of a molybdenum atoms with a K electron knocked out is 27.5 keV, the energy of this atom when an L electron is knocked out will be _____ keV. (Round off to the nearest integer)

$$[h = 4.14 \times 10^{-15} \text{ eVs}, c = 3 \times 10^8 \text{ ms}^{-1}]$$

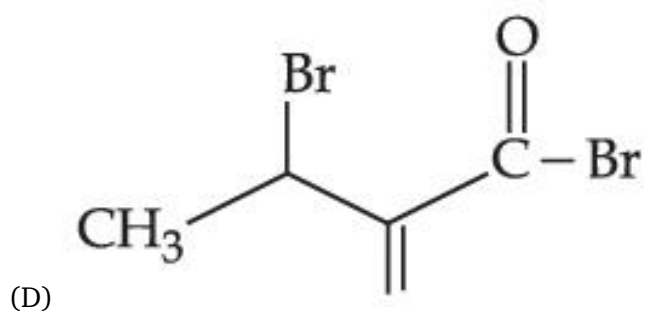
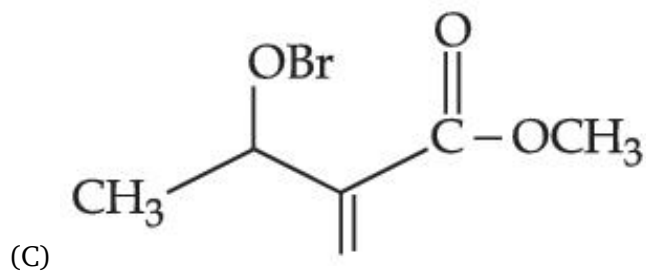
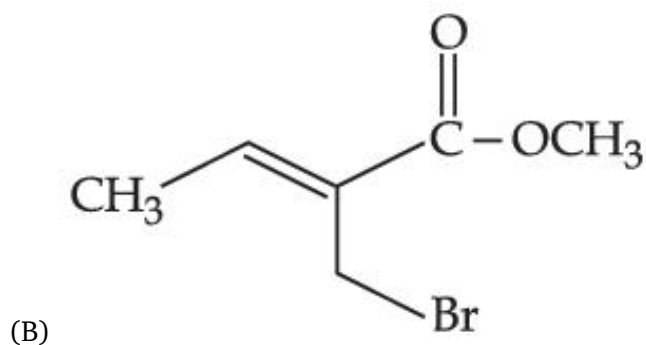
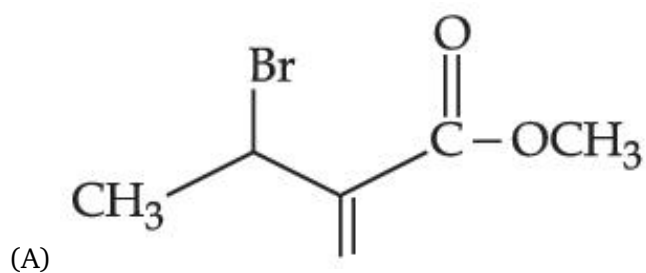
59. The water is filled upto height of 12 m in a tank having vertical sidewalls. A hole is made in one of the walls at a depth 'h' below the water level. The value of 'h' for which the emerging stream of water strikes the ground at the maximum range is _____ m.

60. The maximum amplitude for an amplitude modulated wave is found to be 12V while the minimum amplitude is found to be 3V. The modulation index is $0.6x$ where x is _____.

61.



Consider the above reaction, the major product "P" formed is :



62. Given below are two statement : one is labelled as Assertion A and the other is labelled as Reason R.

Assertion A : $\text{SO}_2(\text{g})$ is absorbed to a large extent than $\text{H}_2(\text{g})$ on activated charcoal.

Reason R : $\text{SO}_2(\text{g})$ has a higher critical temperature than $\text{H}_2(\text{g})$.

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

- | | |
|---|---|
| (A) Both A and R are correct but R is not the correct explanation of A. | (B) Both A and R are correct and R is the correct explanation of A. |
| (C) A is not correct but R is correct. | (D) A is correct but R is not correct. |

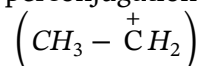
63. The correct order of first ionisation enthalpy is :

- | | |
|---|---|
| (A) $\text{Mg} < \text{S} < \text{Al} < \text{P}$ | (B) $\text{Mg} < \text{Al} < \text{S} < \text{P}$ |
| (C) $\text{Al} < \text{Mg} < \text{S} < \text{P}$ | (D) $\text{Mg} < \text{Al} < \text{P} < \text{S}$ |

64. Given below are two statements :

Statement I : Hyperconjugation is a permanent effect.

Statement II : Hyperconjugation in ethyl cation



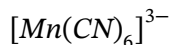
involves the overlapping of $\text{C}_{sp^2} - \text{H}_{1s}$ bond with empty 2p orbital of other carbon.

Choose the correct option :

- | | |
|--|---|
| (A) Both statement I and statement II are false | (B) Statement I is incorrect but statement II is true |
| (C) Statement I is correct but statement II is false | (D) Both statement I and statement II are true. |

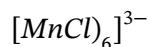
65. Given below are two statements :

Statement I :



, $[Fe(CN)_6]^{3-}$ and $[Co(C_2O_4)_3]^{3-}$ are d^2sp^3 hybridised.

Statement II :



and $[FeF_6]^{3-}$ are paramagnetic and have 4 and 5 unpaired electrons, respectively.

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

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

66. To an aqueous solution containing ions such as Al^{3+} , Zn^{2+} , Ca^{2+} , Fe^{3+} , Ni^{2+} , Ba^{2+} and Cu^{2+} was added conc. HCl, followed by H_2S .

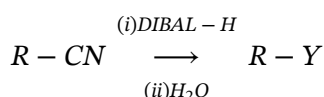
The total number of cations precipitated during this reaction is/are :

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

67. Compound A gives D-Galactose and D-Glucose on hydrolysis. The compound A is :

- | | |
|-------------|-------------|
| (A) Amylose | (B) Sucrose |
| (C) Maltose | (D) Lactose |

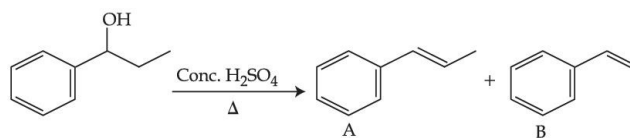
68.



Consider the above reaction and identify "Y"

- | | |
|-----------------|---------------|
| (A) $-CH_2NH_2$ | (B) $-CONH_2$ |
| (C) $-CHO$ | (D) $-COOH$ |

69.



Consider the above reaction, and choose the correct statement :

- | | |
|---|---|
| (A) The reaction is not possible in acidic medium | (B) Both compounds A and B are formed equally |
| (C) Compound A will be the major product | (D) Compound B will be the major product |

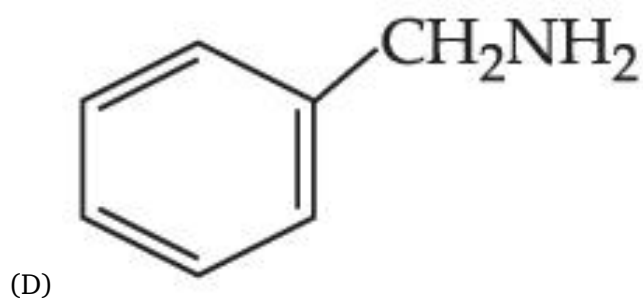
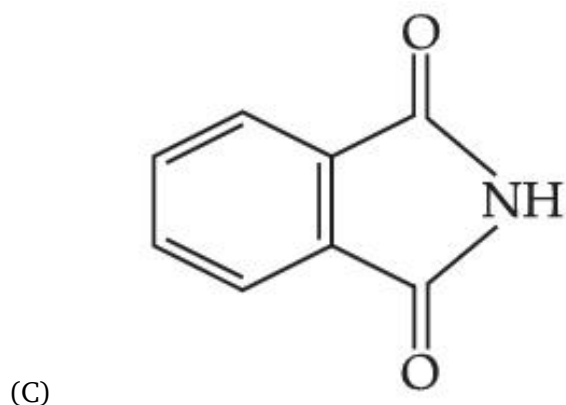
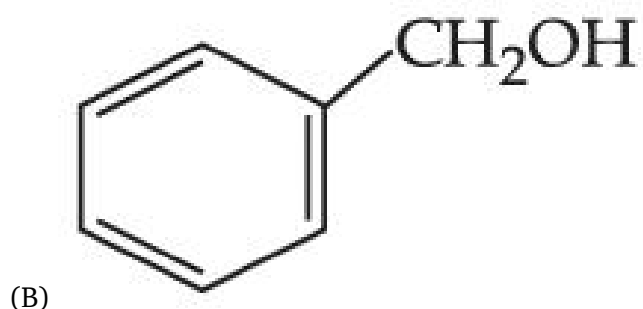
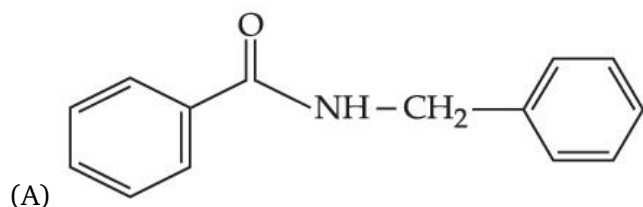
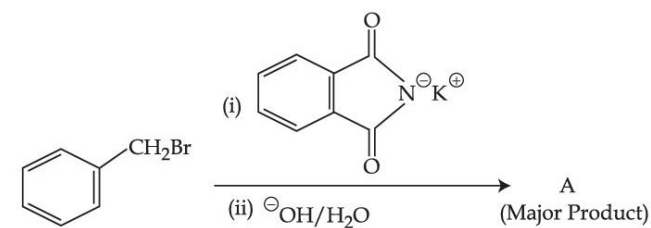
70. Match List - I with List - II :

	List - I (compound)		List - II (effect/affected species)
(a)	Carbon monoxide	(i)	Carcinogenic
(b)	Sulphur dioxide	(ii)	Metabolized by pyrus plants
(c)	Polychlorinated biphenyls	(iii)	haemoglobin
(d)	Oxides of Nitrogen	(iv)	Stiffness of flower buds

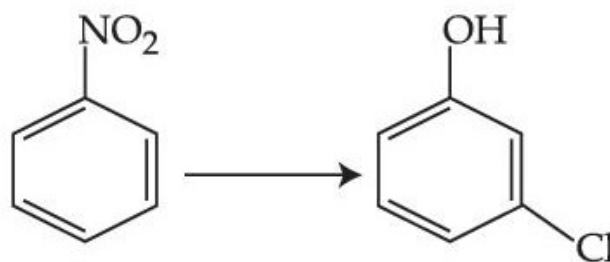
Choose the correct answer from the options given below :

- | | |
|--|--|
| (A) (a) - (iii), (b) - (iv), (c) - (i), (d) - (ii) | (B) (a) - (iv), (b) - (i), (c) - (iii), (d) - (ii) |
| (C) (a) - (i), (b) - (ii), (c) - (iii), (d) - (iv) | (D) (a) - (iii), (b) - (iv), (c) - (ii), (d) - (i) |

71. What is A in the following reaction?



72. The correct sequence of correct reagents for the following transformation is :



- | | |
|---|---|
| (A) (i) Fe, HCl | (B) (i) Fe, HCl |
| (ii) Cl ₂ , HCl | (ii) NaNO ₂ , HCl, 0° C |
| (iii) NaNO ₂ , HCl, 0° C | (iii) H ₂ O/H ⁺ |
| (iv) H ₂ O/H ⁺ | (iv) Cl ₂ , FeCl ₃ |
| (C) (i) Cl ₂ , FeCl ₃ | (D) (i) Cl ₂ , FeCl ₃ |
| (ii) Fe, HCl | (ii) NaNO ₂ , HCl, 0° C |
| (iii) NaNO ₂ , HCl, 0° C | (iii) Fe, HCl |
| (iv) H ₂ O/H ⁺ | (iv) H ₂ O/H ⁺ |

73. Which one of the following set of elements can be detected using sodium fusion extract?

- | | |
|---|---|
| (A) Sulfur, Nitrogen, Phosphorous, Halogens | (B) Phosphorous, Oxygen, Nitrogen, Halogens |
| (C) Nitrogen, Phosphorous, Carbon, Sulfur | (D) Halogens, Nitrogen, Oxygen, Sulfur |

74. The number of neutrons and electrons, respectively, present in the radioactive isotope of hydrogen is :

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

75. Match List - I with List - II :

	List - I		List - II
(a)	Li	(i)	photoelectric cell
(b)	Na	(ii)	absorbent of CO_2
(c)	K	(ii i)	coolant in fast breeder nuclear reactor
(d)	Cs	(i v)	treatment of cancer
		(v)	bearings for motor engines

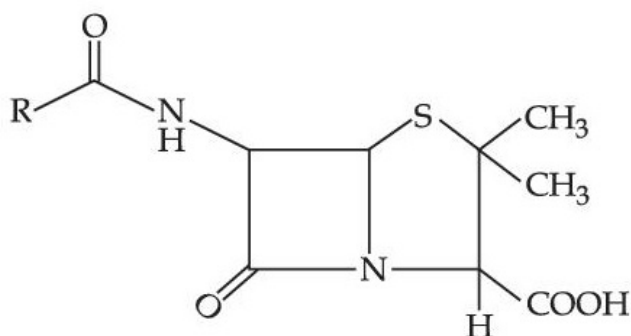
Choose the correct answer from the options given below :

- (A) (a) - (v), (b) - (i), (c) - (ii), (d) - (iv) (B) (a) - (v), (b) - (ii), (c) - (iv), (d) - (i)
 (C) (a) - (iv), (b) - (iii), (c) - (i), (d) - (ii) (D) (a) - (v), (b) - (iii), (c) - (ii), (d) - (i)

76. Given below are two statements :

Statement I : Penicillin is a bacteriostatic type antibiotic.

Statement II : The general structure of Penicillin is :



Choose the correct option :

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

77. If the Thompson model of the atom was correct, then the result of Rutherford's gold foil experiment would have been :

- (A) All of the α -particles pass through the gold foil without decrease in speed. (B) α -particles are deflected over a wide range of angles.
 (C) All α -particles get bounced back by 180° (D) α -particles pass through the gold foil deflected by small angles and with reduced speed.

78. Number of Cl = O bonds in chlorous acid, chloric acid and perchloric acid respectively are :

- (A) 3, 1 and 1 (B) 4, 1 and 0
 (C) 1, 1 and 3 (D) 1, 2 and 3

79. Select the correct statements

- (A) Crystalline solids have long range order.
 (B) Crystalline solids are isotropic
 (C) Amorphous solid are sometimes called pseudo solids.
 (D) Amorphous solids soften over a range of temperatures.
 (E) Amorphous solids have a definite heat of fusion.

Choose the most appropriate answer from the options given below.

- (A) (A), (B), (E) only (B) (B), (D) only
 (C) (C), (D) only (D) (A), (C), (D) only

80. The addition of silica during the extraction of copper from its sulphide ore :-

- (A) converts copper sulphide into copper silicate (B) converts iron oxide into iron silicate
 (C) reduces copper sulphide into metallic copper (D) reduces the melting point of the reaction mixture

Chemistry - Section B · Numerical Value Questions

81. The equilibrium constant for the reaction $A(s) \rightleftharpoons M(s) + \frac{1}{2}O_2(g)$ is $K_p = 4$. At equilibrium, the partial pressure of O_2 is _____ atm. (Round off to the nearest integer)

82. When 400 mL of 0.2 M H_2SO_4 solution is mixed with 600 mL of 0.1 M NaOH solution, the increase in temperature of the final solution is _____ $\times 10^{-2}$ K. (Round off to the nearest integer).

[Use : $H^+(aq) + OH^-(aq) \rightarrow H_2O$: Δ

$\gamma H = -57.1 \text{ kJ mol}^{-1}$]

Specific heat of $H_2O = 4.18 \text{ J K}^{-1} \text{ g}^{-1}$

density of $H_2O = 1.0 \text{ g cm}^{-3}$

Assume no change in volume of solution on mixing.

83. $2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$

The above reaction is carried out in a vessel starting with partial pressure $P_{SO_2} = 250 \text{ m bar}$, $P_{O_2} = 750 \text{ m bar}$ and $P_{SO_3} = 0 \text{ bar}$. When the reaction is complete, the total pressure in the reaction vessel is _____ m bar. (Round off of the nearest integer).

84. 10.0 mL of 0.05 M $KMnO_4$ solution was consumed in a titration with 10.0 mL of given oxalic acid dihydrate solution. The strength of given oxalic acid solution is _____ $\times 10^{-2} \text{ g/L}$. (Round off to the nearest integer)

85. The total number of electrons in all bonding molecular orbitals of O_2^{2-} is _____. (Round off to the nearest integer)

86. 3 moles of metal complex with formula $Co(en)_2Cl_3$ gives 3 moles of silver chloride on treatment with excess of silver nitrate. The secondary valency of Co in the complex is _____. (Round off to the nearest integer)

87. In a solvent 50% of an acid HA dimerizes and the rest dissociates. The van't Hoff factor of the acid is _____ $\times 10^{-2}$. (Round off to the nearest integer)

88. The dihedral angle in staggered form of Newman projection of 1, 1, 1-Trichloro ethane is _____ degree. (Round off to the nearest integer)

89. For the first order reaction $A \rightarrow 2B$, 1 mole of reactant A gives 0.2 moles of B after 100 minutes. The half life of the reaction is _____ min. (Round off to the nearest integer). [Use : $\ln 2 = 0.69$, $\ln 10 = 2.3$]

Properties of logarithms : $\ln x^y = y \ln x$;

$$\ln\left(\frac{x}{y}\right) = \ln x - \ln y$$

(Round off to the nearest integer)

90. For the cell

$Cu(s) | Cu^{2+}(aq) (0.1 \text{ M}) || Ag^+(aq) (0.01 \text{ M}) | Ag(s)$

the cell potential $E_1 = 0.3095 \text{ V}$

For the cell

$Cu(s) | Cu^{2+}(aq) (0.01 \text{ M}) || Ag^+(aq) (0.001 \text{ M}) | Ag(s)$

the cell potential = _____ $\times 10^{-2} \text{ V}$. (Round off the nearest integer).

[Use :

$$\frac{2.303RT}{F}$$

= 0.059]

- End of Question Paper -