JEE MAIN 2026

Sample Paper – 10

Time Allowed: 3 hours **Maximum Marks:** 300

General Instructions:

1. The test consists of total **75 questions.**

2. Each subject **(PCM)** has **25 questions.**

3. Each subject divided into two sections. **Section A** consists of 20 multiple-choice questions & **Section B** consists of 5 numerical value-type questions.

4. Marking Scheme:

- **Section A (MCQs):** +4 marks for each correct answer, –1 mark for each incorrect answer, 0 marks for unattempted.
- **Section B (Numerical):** +4 marks for each correct answer, 0 marks for incorrect or unattempted.

5. Any textual, printed, or written material, mobile phones, calculator etc. is not allowed for the students appearing for the test.

6. All calculations/written work should be done in the rough sheet is provided with the Question Paper.

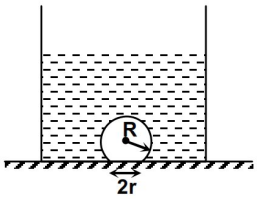
Physics

PART – A

SECTION – A
(One Options Correct Type)

*This section contains **20 multiple choice questions**. Each question has **four choices** (A), (B), (C) and (D), out of which **ONLY ONE** option is correct.*

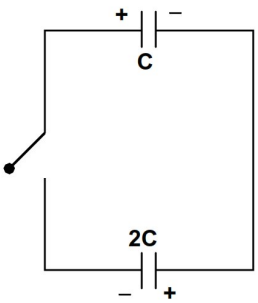
1. On heating water, bubbles being formed at the bottom of the vessel detach and rise. Take the bubbles to be spherical of radius R and making a circular contact of radius r with the bottom of the vessel. If r << R, and the surface tension of water is T, value of r just before bubbles detach is (density of water is ρ_W)



(A) $R^2\sqrt{\frac{2\rho_w g}{3T}}$ (B) $R^2\sqrt{\frac{\rho_w g}{6T}}$

(C) $R^2\sqrt{\frac{\rho_w g}{T}}$ (D) $R^2\sqrt{\frac{3\rho_w g}{2T}}$

2. A parallel plate capacitor of capacitance C is connected to a battery and is charge to a potential difference V. Another capacitor of capacitance 2C is similarly charged to a potential difference 2V. The charging battery is then disconnected and the capacitors are connected in parallel to each other in such a way that the positive terminal of one is connected to the negative terminal of the other. Then the energy lost in the final circuit of only capacitor C and 2C is



(A) $\frac{3}{2}CV^2$ (B) $3CV^2$

(C) $\frac{9}{2}CV^2$ (D) zero

3. A photoelectric surface is illuminated successively by monochromatic light of wavelength λ and $\frac{\lambda}{2}$. If the maximum kinetic energy of the emitted photoelectron in the second case is 3 times that in the first case, then the threshold wavelength for the surface is

(A) 2λ (B) 3λ

(C) 4λ (D) 6λ

4. The resultant intensity after interference of two coherent waves represented by the equations.

$y_1 = A_1 \sin(\omega t)$

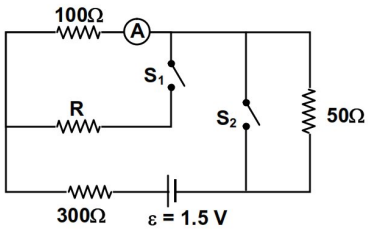
and $y_2 = A_2 \sin\left(\omega t - \frac{\pi}{2}\right)$

will be proportional to

(A) $A_1^2 + A_2^2$ (B) $(A_1 + A_2)^2$

(C) A_1A_2 (D) $(A_1 - A_2)^2$

5. In the circuit shown in the figure, the reading of the ammeter is the same with both switches open as with both closed. Then find the resistance R. The ammeter is ideal.



(A) 600 Ω
(B) 400 Ω
(C) 200 Ω
(D) 100 Ω

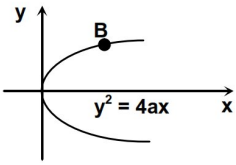
6. Two identical charges, 4 μC each are in vacuum. What is the charge to be transferred from one charge to another keeping the separation same as before, so that their columbic force of interaction decreases to half ?

(A) $\sqrt{2}$ μC
(B) $2\sqrt{6}$ μC
(C) $2\sqrt{2}$ μC
(D) 2 μC

7. If unpolarized light is incident on a block of crystal at 60° so that the reflected light is completely polarized. Then refractive index of the block is

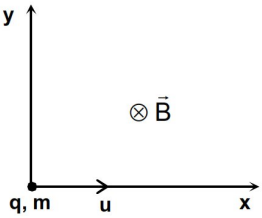
(A) 1
(B) $\sqrt{3}$
(C) $\sqrt{2}$
(D) 1.5

8. A thin wire is bent into the shape of a parabola ($y^2 = 4ax$) in the vertical plane as shown in the figure. A small bead B can freely slide along the wire. The coefficient of static friction between the bead and the wire is μ_S. The minimum y-coordinate of the wire $y_0 (y_0 > 0)$, where the bead does not slip on the wire is



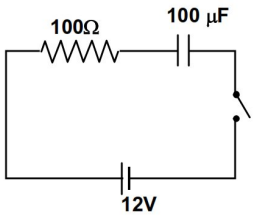
(A) $2a\mu_S$
(B) $\frac{2a}{\mu_S}$
(C) $a\mu_S$
(D) $\frac{a}{\mu_S}$

9. In the diagram shown, a non-uniform magnetic field $\vec{B} = B_0 x(-\hat{k})$ has been applied in the direction shown, where B_0 is a positive constant and x is coordinate. A particle of mass m and positive charge q is projected with an initial velocity $(u\hat{i})$ form origin. The displacement of the charge particle along x-direction when its velocity becomes parallel to y-direction is (neglect gravity)



(A) $\sqrt{\frac{mu}{qB_0}}$
(B) $\sqrt{\frac{2mu}{qB_0}}$
(C) $\sqrt{\frac{mu}{2qB_0}}$
(D) $\sqrt{\frac{4mu}{qB_0}}$

10. The value of displacement current at t = 1 time constant after closing of the switch is



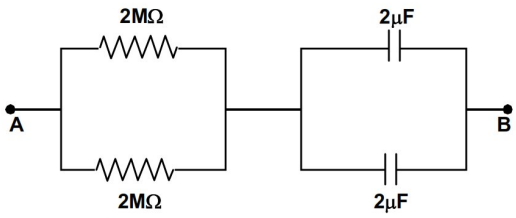
(A) $\frac{120}{e}$ mA
(B) $\frac{120}{e^2}$ mA
(C) 120 mA
(D) $\frac{60}{e}$ mA

11. The amplitude of a damped oscillation decreases to 0.9 times its original magnitude in 5 sec. In another 10 s it will decreases to α times its original magnitude. Then α is

(A) 0.346 (B) 0.693

(C) 0.363 (D) 0.729

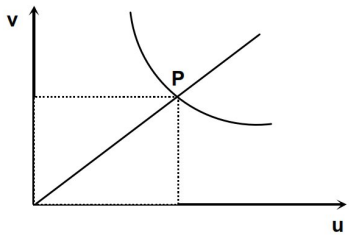
12. At time t = 0 a battery of 10V is connected across points A and B in the given circuit. If the capacitor have no charge initially, the time t (in seconds) when the voltage across the capacitor becomes 4V is



(A) $3\ell n\left(\frac{5}{2}\right)$ (B) $4\ell n\left(\frac{5}{3}\right)$

(C) $5\ell n\left(\frac{4}{3}\right)$ (D) $10\ell n(4)$

13. In an optics experiment, with the position of the object fixed, a student varies the position of convex lens and for each position, the screen is adjusted to get a clear image of the object. A graph between the object distance u and the image distance v, from the lens, is plotted using the same scale for the two axes. A straight line passing through the origin and making an angle of 45° with the x-axis meets the experimental curve at P. The coordinates of P will be



(A) (f, f) (B) (4f, 4f)

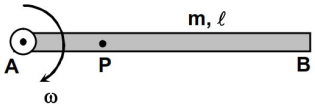
(C) (2f, 2f) (D) $\left(\frac{f}{2},\frac{f}{2}\right)$

14. A particle of mass m is attached to a light spring and vibrates with its natural angular frequency ω_0. An external force $F = F_0\cos(\omega t)$ is applied to the oscillator. The maximum displacement of the oscillator is proportional to

(A) $\frac{m}{(\omega_0^2+\omega^2)}$ (B) $\frac{1}{m(\omega_0^2-\omega^2)}$

(C) $\frac{1}{m(\omega_0^2+\omega^2)}$ (D) $\frac{m}{(\omega_0^2-\omega^2)}$

15. A uniform thin rod AB of length ℓ and mass m is undergoing fixed axis rotation about end A such that end A remains stationary as shown in the figure. The kinetic energy of section AP of rod is equal to kinetic energy of section BP of rod at an instant. Then the ratio of length AP and length AB, that is $\frac{AP}{AB}$ is equal to



(A) $\frac{1}{2}$ (B) $\frac{1}{2^{1/3}}$

(C) $\frac{1}{\sqrt{2}}$ (D) $\frac{1}{2\sqrt{2}}$

16. 400 gm of ice at 253 K is mixed with 0.05 kg of steam at 100°C. Latent heat of vaporization of steam is 540 cal/gm. Latent heat of fusion of ice is 80 cal/gm. Specific heat capacity of ice is 0.5 cal/g°C. The resultant temperature of the mixture is

(A) 273 K
(B) 300 K
(C) 330 K
(D) 373 K

17. Two rods of different materials having coefficient of thermal expansion α_1, α_2 and Young's modulus Y_1, Y_2 respectively are fixed separately between two rigid massive walls. The rods are heated such that they undergo the same increase in temperatures. There is no bending of the rods. If $\alpha_1 : \alpha_2 = 2:3$, then thermal stress developed in the two rods are equal provided $Y_1 : Y_2$ is equal to

(A) 2 : 3
(B) 1 : 1
(C) 3 : 2
(D) 4 : 9

18. A nucleus of mass no. 220, initially at rest emits an α-particle. If the Q value of the reaction is 5.5 MeV, the energy of the emitted α-particle will be

(A) 4.8 MeV
(B) 5.4 MeV
(C) 6.0 MeV
(D) 6.8 MeV

19. A thin convex lens of focal length 1 m is cut into three parts A, B and C along the parallel to principal axis of the lens as shown in the figure (a). The thickness of the middle layer C is 1 cm. The middle layer is now removed and the two parts A and B are put together to from a composite lens. Then the part C is also placed in front of the composite lens symmetrically as shown in the figure (b). Paraxial beam of light is incident along the axis of the part C. Then the distance between the two final images formed is

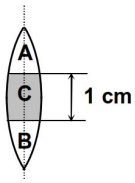


Figure (a)

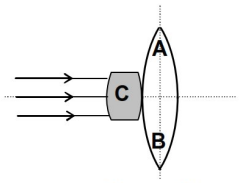


Figure (b)

(A) 0.2 cm
(B) 0.4 cm
(C) 0.5 cm
(D) 0.6 cm

20. The magnetic susceptibility of paramagnetic substance at –73°C is 0.0060. The its value at – 173°C will be

(A) 0.0030
(B) 0.0120
(C) 0.0180
(D) 0.0045

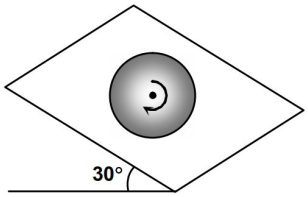
SECTION – B

(Numerical Answer Type)

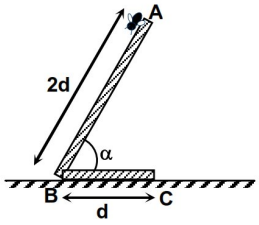
*This section contains **05** Numerical based questions. The answer to each question is rounded off to the nearest integer value.*

21. A simple second pendulum is constructed out of a very thin string of thermal coefficient of linear expansions $\alpha = 20 \times 10^{-4}$ /°C and a heavy particle attached to one end. The free end of the string is suspended from the ceiling of an elevator at rest. The pendulum keeps correct time at 0°C. When the temperature rises to 50°C the elevator operator of mass 70 kg being a student of physics accelerates the elevator vertically to have the pendulum correct time. The apparent weight of the operator when the pendulum keeps correct time at 50° is .....Newton. (Take g = 10 m/s^2)

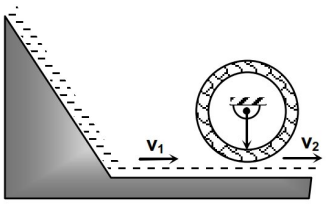
22. A record player of radius r = 10 cm turns at 10 rad/s is mounted on a 30° inclined plane as shown in the figure. A particle of mass m can be placed anywhere on the rotating record. If the minimum value of coefficient of static friction is μ_S that must exist for no slipping to occur, then find the value of μ_S^2. (Take g = 10 m/s^2)



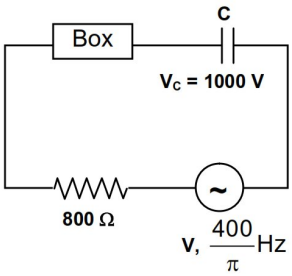
23. A uniform rigid ribbon of mass 3m and length 3d is bent at B as shown and placed on a horizontal table in vertical plane. An insect of mass m is sitting at point A. If the angle $\alpha = \alpha_0$ at which the ribbon is just about to topple. Then find $8\cos\alpha_0$.



24. Water flowing along an open channel drives an undershot waterwheel of radius 0.5 m as shown in the figure. The water approaches the wheel with a speed of v_1 = 5 m/s and leaves with a speed of v_2 = 2.5 m/s, the amount of water passing by is 100 kg/sec. At what rate does the water deliver angular momentum to the wheel (in J)



25. A circuit shown in the figure contains a box having either a capacitor or an inductor. The power factor of the circuit is 0.8. Current lags behind the source voltage. Then find the inductance/capacitance of the box in S.I. unit. The circuit draws 1 ampere current.



Chemistry

PART – B

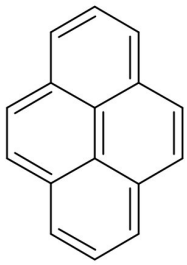
SECTION – A
(One Options Correct Type)

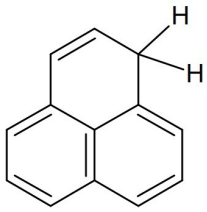
*This section contains **20 multiple choice questions**. Each question has **four choices** (A), (B), (C) and (D), out of which **ONLY ONE** option is correct.*

26. $K_2Cr_2O_7$ on reaction with conc. H_2SO_4 under cold and warm condition produces x and y are product respectively. x and y are:
(A) $Cr_2(SO_4)_3$ and CrO_3
(B) $Cr_2(SO_4)_3$, $Cr_2(SO_4)_3$
(C) CrO_3 and $Cr_2(SO_4)_3$
(D) Cr_2O_3, CrO_3

27. Which of the following is not a byproduct when excess F_2 reacts with H_2O:
(A) O_2 (B) HF
(C) HOF (D) O_3

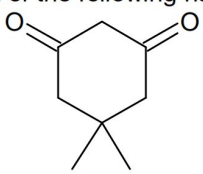
28. The reaction of $NiBr_2$ with 2 equivalent of PPh_3 is CS_2 at $-78^\circ C$ gives a red coloured diamagnetic complex $\left[NiBr_2(PPh_3)_2\right]$. This transforms to a green coloured paramagnetic complex with same molecular formula at 25°C. The geometry and number of unpaired electrons in the coloured complex respectively are:
(A) Square planar and 2 (B) Tetrahedral and 2
(C) Square planar and 4 (D) Tetrahedral and 1

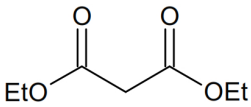
29.

(I)

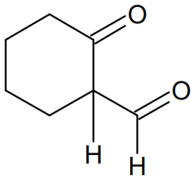


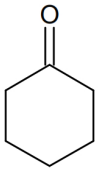
(II)

Choose the correct statement regarding (I) and (II)
(A) Peripheral π bonds are out of configuration in both (I) and (II)
(B) Non-peripheral π bonds are out of configuration in both (I) and (II)
(C) Peripheral π bonds are out of configuration in (I) and not in (II)
(D) Peripheral π bonds are out of configuration in (II) and not in (I)

30. Which of the following has the largest enol content out of the following:
(A)


(B) 

(C) 

(D) 

31. An adiabatic cylinder fitted with an adiabatic piston at the right end of cylinder, is divided into two equal halves with a monoatomic gas on left side and diatomic gas on right side, using an impermeable movable adiabatic wall. If the piston is pushed slowly to compress the diatomic gas to $\frac{3}{4}$th of its original volume. The ratio of new volume of monoatomic gas to its initial volume would be

(A) $\left(\frac{4}{3}\right)^{\frac{25}{21}}$ (B) $\left(\frac{7}{5}\right)^{\frac{3}{4}}$

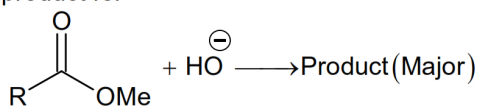
(C) $\left(\frac{3}{4}\right)^{\frac{21}{25}}$ (D) $\frac{3}{4}$

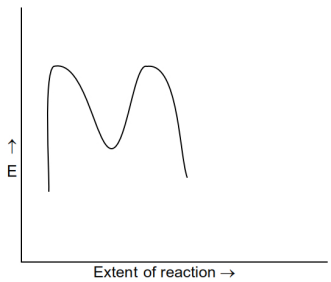
32. $I_2 + I^- \rightleftharpoons I_3^-$. The reaction is set up in aqueous medium we start with 1 mole of I_2 and 0.5 mol of I^- in 1 L flask. After equilibrium is reached, excess of $AgNO_3$ gave 0.25 mol of yellow precipitate. Using this information, calculate the equilibrium constant for $\frac{1}{2}I_2 + \frac{1}{2}I^- \rightleftharpoons \frac{1}{2}I_3^-$

(A) 1.33 (B) 1.15

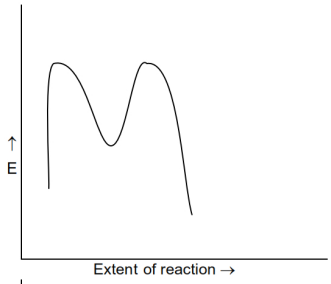
(C) 1.77 (D) 1.45

33. Choose the correct graph which represents the energy transformation involved in the formation of product for

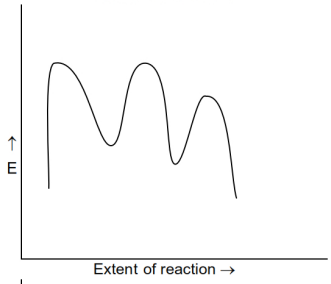


(A) 

(B)



(C)



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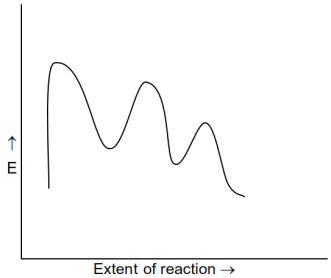


34. The binding energy of an electron in the ground state of hydrogen-like ions in whose spectrum, the third line of the Balmer series is equal to 108.5 nm, is

(A) 13.6 eV
(B) 54.4 eV
(C) 122.4 eV
(D) 14.4 eV

35. For the first order gaseous reaction $A(g) \xrightarrow{K_1} 2B(g)$, the initial pressure in a container of fixed volume, V litre, is 1 atm. Pressure of the system is 1.4 atm at t = 10 minute and the pressure is 1.5 atm after a very long time. The only correct information about the reactions is [ln2 = 0.7, ln10 = 2.3]

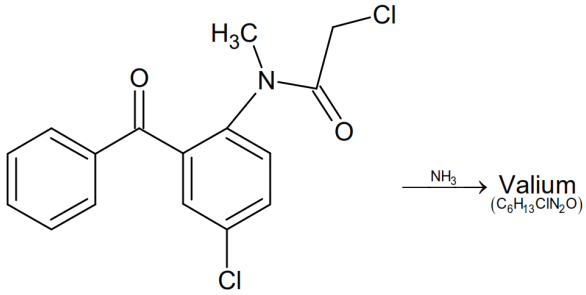
(A) $2K_1 = K_2 = 0.08\ min^{-1}$

(B) $K_1 = K_2 = 0.08\ min^{-1}$

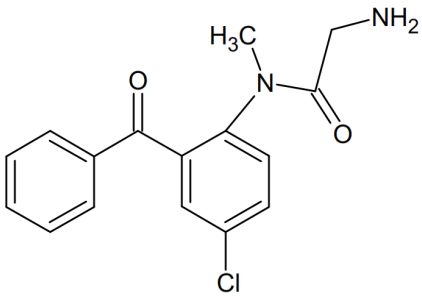
(C) $K_1 = 2K_2 = 0.08\ min^{-1}$

(D) $K_1 = K_2 = 0.16\ min^{-1}$

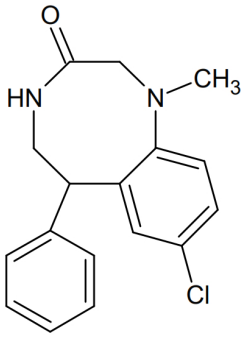
36. The last step in the synthesis of Valium is treatment of the following aromatic compound with NH_3. Choose the correct structure of Valium



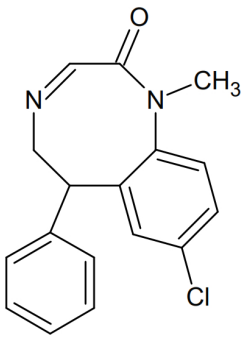
(A)



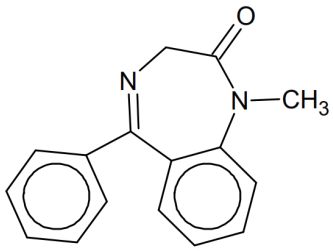
(B)



(C)

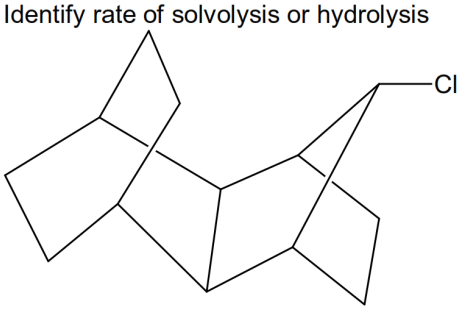


(D)

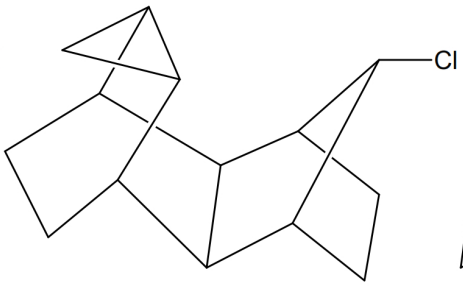


37. Which of the following amino acid contains an amide group?
(A) Glutamine (B) Alanine
(C) Proline (D) Serine

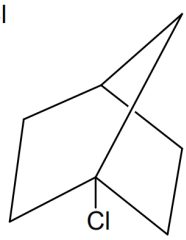
38. Identify rate of solvolysis or hydrolysis



(i)



(ii)



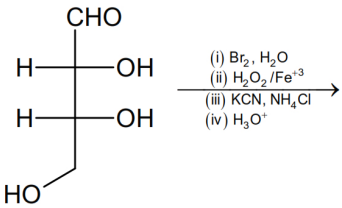
(iii)

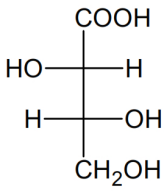
(A) i > ii > iii (B) ii > iii > i
(C) ii > i > iii (D) iii > i > ii

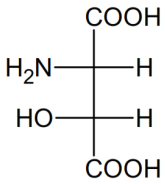
39. Which of the following is a primary standard?
(A) NaOH (B) HCl
(C) $H_2C_2O_4$ (D) $KMnO_4$

40. When glycerin is added to a litre of water, then which of the following is observed?
(A) Water evaporates more easily.
(B) The temperature of water increases.
(C) The freezing point of water is lowered.
(D) The viscosity of water is lowered.

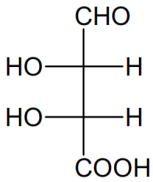
41. Identify the final product of the reaction



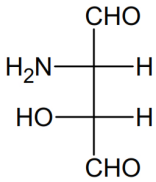
(A)


(B)


(C)



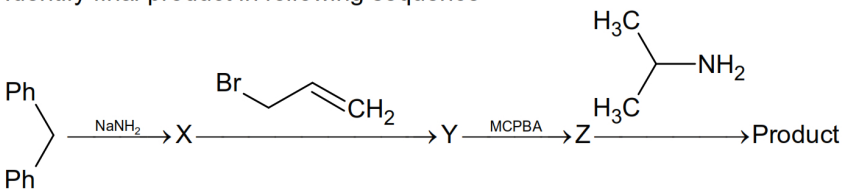
(D)



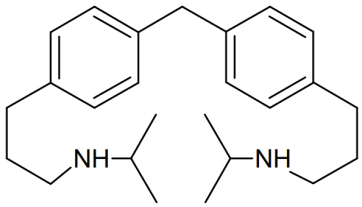
42. The EMF of cell: $H_2(g)$ | Buffer || Normal calomel electrode, is 0.70 V at 25°C, when barometric pressure is 760 mm. What is the pH of the buffer solution? $E^{\circ}_{Calomel} = 0.28$ V.$[2.303RT/F = 0.06]$

(A) 3.5
(B) 7.0
(C) tending to zero
(D) tending to 14.0

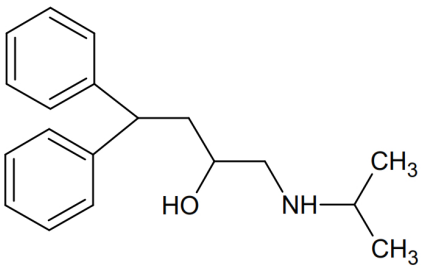
43. Identify final product in following sequence



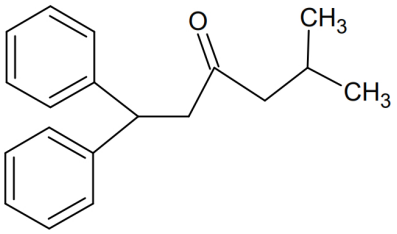
(A)



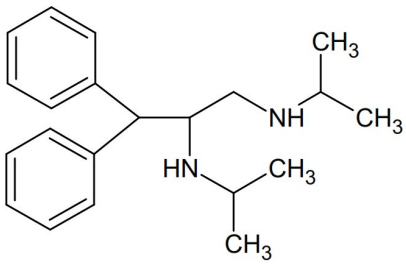
(B)



(C)



(D)



44. Choose the correct option regarding correct statements out of the following:

I. $(IE_1 + IE_2 + IE_3)$ for indium is more than that of Al.

II. IE_1 of Sc is higher than cobalt.

III. IE_1 of Ga is lower than that of Se.

IV. IE of N is greater than that of O.

(A) I, II and IV
(B) III and IV
(C) I and IV
(D) II and III

45. The decreasing order of ionic nature of the following compound is:

(A) LiI > NaBr > KCl > CsF
(B) LiI > KCl > NaBr > CsF
(C) CsF > NaBr > KCl > LiI
(D) CsF > KCl > NaBr > LiI

SECTION – B

(Numerical Answer Type)

*This section contains **05** Numerical based questions. The answer to each question is rounded off to the nearest integer value.*

46. The oxidation state of molybdenum in its oxocomplex $\left[Mo_2O_4(C_2H_4)_2(H_2O)_2\right]^{-2}$ is

47. A mixture of Xe and F_2 was heated. A sample of white solid thus formed reacted with hydrogen to give 56 ml of Xe at 0^oC and 1 atm and HF formed required 60 ml of 0.25 M NaOH for complete neutralization. If the molecular formula of the solid formed is XeF_x, then the value of x is:

48. The hybridization of central atom in $\left[H_6SnO_6\right]^{2-}$ is $s^xp^yd^z$. Then the value of $\frac{x+y}{z}$ is?

49. The total sum of correct statement number(s) out of the following is/are:

(1) AgCl, $PbCl_2$ and Hg_2Cl_2 are insoluble in cold H_2O while other chlorides are soluble.
(3) In presence of NH_4OH and NH_4Cl Fe^{3+} precipitate as red-brown compound whereas Cr^{3+} as green coloured compound.
(7) Basic sulphides are soluble in yellow ammonium sulphides and are grouped in IIA.
(5) $CuSO_4$ on reaction with $K_4[Fe(CN)_6]$ gives a chocolate brown precipitate.

50. 20 mL of 0.2 M H_3A (Tribasic acid) is titrated with 0.2 M NaOH. The ratio of $\frac{[A^{-3}]}{[H_3A]}$ at second equivalence point is $10^{|x|}$. The value of x is?

Given: $K_{a_1} = 10^{-3}$

$K_{a_2} = 10^{-8}$

$K_{a_3} = 10^{-12}$

Mathematics

PART – C

SECTION – A
(One Options Correct Type)

*This section contains **20 multiple choice questions**. Each question has **four choices** (A), (B), (C) and (D), out of which **ONLY ONE** option is correct.*

51. If both roots of the quadratic $ax^2 + bx + c = 0$ lie in (0, 2) then $25ac + 20bc + 16c^2$ is always
(A) positive
(B) negative
(C) equal to zero
(D) cannot say with given information

52. Let L_1, L_2 be two distinct lines such that L_1 and L_2 are not perpendicular. Let P be a plane such that L_1 and L_2 are not perpendicular to P. Let L_3 and L_4 be projections of L_1 and L_2 on plane P respectively. If θ be angle between L_3 and L_4 then θ **CANNOT** be equal to
(A) 0
(B) $\frac{\pi}{3}$
(C) $\frac{\pi}{2}$
(D) none of these

53. Let 'A' be a non-singular idempotent matrix of order 2025×2025, then consider these statements
(i) Trace of matrix A has to be 2025
(ii) A has to be a scalar matrix
(iii) Trace of adjoint matrix of A^2 has to be equal to 2025
Which of the given statements are true ?
(A) (i) and (ii)
(B) (ii) and (iii)
(C) (i), (ii) and (iii)
(D) none of these

54. Let A, B, C be 3 points on the parabola $y^2 = 4x$. Let D, E, F be midpoints of AB, BC and AC respectively. If G is the centroid of triangle DEF and normals to the parabola at points A, B and C are concurrent at Point H(5, 1) then slope of the line GH is
(A) $\frac{1}{2}$
(B) $\frac{1}{3}$
(C) 1
(D) $\frac{3}{4}$

55. Minimum value of the expression $(a - b)^2 + \left(4\sqrt{1+a^2} + 2\sqrt{2b - b^2}\right)^2$ is
(A) 16
(B) 4
(C) $8\sqrt{2}$
(D) none of these

56. The curve satisfying the differential equation $2xy(y^2\cos(x^2y) - 1) + x^2y'(y^2\cos(x^2y) + 1) = 0$ and passing through (0, 1) is
(A) $\sin^2(x^2y) = x$
(B) $\sin(x^2y) = xy^2$
(C) $\sin(x^2y) = x^2y$
(D) $\sin(x^2y) = \frac{x^2}{y}$

57. Let $x_1, x_2, \ldots, x_{100}$ be an A.P with $x_1 = 1$ and $x_{100} = 199$. If $y_i = i(x_i + 1)$; $i = 1, 2, \ldots, 100$ then mean of $y_1, y_2, \ldots, y_{100}$ is
(A) 6867
(B) 6767
(C) 6967
(D) none of these

58. Let P(A) be defined as power set of set A = {1, 2, 3, ….. , 2025}. Let R be a relation defined on P(A) as (B, C) $\in$ R if B is superset of C, then R is

(A) reflexive and transitive relation
(B) reflexive and symmetric relation
(C) symmetric and transitive relation
(D) equivalence relation

59. Let set A denotes the solutions of the equation $\cos^{-1}(4x^3 - 3x) = \tan^{-1}\left(\frac{2x}{1-x^2}\right)$ then

(A) n(A) = 0

(B) n(A) = 1 and only one element in A is less than $-\frac{1}{2}$

(C) n(A) = 1 and only one element in A is greater than $\frac{1}{2}$

(D) n(A) = 2 and absolute value of two elements in A is greater than $\frac{1}{2}$

60. If $\begin{vmatrix} \sin x+1 & \sin 2x & \sin 3x \\ \sin 2x & \sin 3x+a & \sin 4x \\ \sin 3x & \sin 4x & \sin 5x+a^2 \end{vmatrix}$ = 2025 (f(x) + 45) where f(x) is some function of 'x' and 'a' is a complex number then sum of all possible values of 'a' is

(A) 0
(B) 45
(C) 135
(D) 2025

61. Let f : R $\to$ R be defined as $f(x) = \lim_{p\to\infty} \frac{\sin\left((2x-1)\frac{\pi}{2}\right) - x^{4p}e^{x^2-1} + x^{4p}}{1+x^{4p+2}-x^{4p}}$. f(x) is continuous for all x in

(A) R
(B) R – {1}
(C) R – {–1}
(D) R – {–1, 1}

62. A ladder of 3m length leans against a wall. Initially the ladder forms a vertical angle of 30° with the wall. If the top of the ladder begins to slide down the wall at constant rate of 20 cm/s, the bottom of the ladder slides away from the wall at rate of 20 cm/s at time 't' seconds. The average velocity of a person halfway up the ladder for the first 't' seconds is

(A) $\frac{\sqrt{3}+\sqrt{2}}{5}\left[\left(1-\frac{1}{\sqrt{2}}\right)\hat{i}+\left(1-\frac{3}{\sqrt{2}}\right)\hat{j}\right]$
(B) $\frac{\sqrt{3}+\sqrt{2}}{10}\left[\left(1-\frac{1}{\sqrt{2}}\right)\hat{i}+\left(1-\sqrt{\frac{3}{2}}\right)\hat{j}\right]$
(C) $\frac{\sqrt{3}+\sqrt{2}}{5}\left[(\sqrt{2}-1)\hat{i}+(\sqrt{2}-3)\hat{j}\right]$
(D) $\frac{\sqrt{3}+\sqrt{2}}{10}\left[(\sqrt{2}-1)\hat{i}+(\sqrt{2}-3)\hat{j}\right]$

63. The probability that in a random arrangement of the word **MATHEMATICS,** the two M's are not together given that the two A's are not together is

(A) $\frac{73}{90}$
(B) $\frac{36}{45}$
(C) $\frac{5}{6}$
(D) $\frac{37}{45}$

64. Value of $\int_0^1 \frac{\sin x}{x}dx$ lies in the interval

(A) $\left(\frac{1695}{1800}, \frac{1699}{1800}\right)$
(B) $\left(\frac{1699}{1800}, \frac{1703}{1800}\right)$
(C) $\left(\frac{1703}{1800}, \frac{1707}{1800}\right)$
(D) $\left(\frac{1707}{1800}, \frac{1711}{1800}\right)$

65. Let ABCDEF be a hexagon which has unequal side lengths. Let G and H be centroids of ΔACE and ΔBDF respectively. If $\overrightarrow{AB}-\overrightarrow{BC}+\overrightarrow{CD}-\overrightarrow{DE}+\overrightarrow{EF}-\overrightarrow{FA}=\lambda\overrightarrow{HG}$, then λ equals

(A) 4 (B) –4
(C) 6 (D) –6

66. Let $f(x) = x^2 + x$ be written as $f(x) = g(x) + h(x)$ where g(x) is an odd function and h(x) is an even function. Then $g(xy) + h\left(\frac{x}{y}\right)$ equals

(A) $xy+\frac{x^2}{y^2}$ (B) $xy-\frac{x^2}{y^2}$
(C) $\frac{x^2}{y^2}-xy$ (D) none of these

67. Given that $\alpha\bar{z}+\beta z+\gamma=0$ is equation of a line where γ is purely imaginary number. If $\alpha^2-\beta^2=2$, where $Re(\alpha)$ and $Im(\alpha)$ are whole numbers, then slope of the line is

(A) 0 (B) $\frac{3}{5}$
(C) $-\frac{3}{5}$ (D) none of these

68. The sum $\sum_{n=1}^{\infty}\frac{9n^2}{(3n)!}$ is equal to

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

69. Let (α, β) be circumcentre of the triangle formed by vertices (1,5), (–3, 4) and (10, –31) then value of $8\alpha - 2\beta$ equals

(A) 55 (B) –2
(C) 108 (D) none of these

70. Sum of length of all the common tangents of the circles
$x^2 + y^2 - 2x - 8y + 15 = 0$
$x^2 + y^2 - 6x - 12y + 43 = 0$
is

(A) $\sqrt{2}$ (B) $2\sqrt{2}$
(C) $4\sqrt{2}$ (D) $5\sqrt{2}$

SECTION – B

(Numerical Answer Type)

*This section contains **05** Numerical based questions. The answer to each question is rounded off to the nearest integer value.*

71. Let A = {1, 2, 3, ….. , 10}, B = {4, 8, 12, 16, 20} and C = {D : $D \subseteq A$, $D \cap B \neq \phi$} then number of elements in set C which have atleast 3 but atmost 6 cardinal number is

72. The number of integral values of α for which the equation $\frac{16}{\tan x}+\frac{4}{4-\tan x}=\alpha$ does not have any solution is

73. Let $I(x) = \int \frac{x+1}{x(x^2e^{2x}-1)}dx = \frac{1}{4}\ln\left(\frac{(xe^x)^\alpha - 2(xe^x)^\beta + \gamma}{x^4e^{4x}}\right) + c$, then $\alpha + \beta + \gamma$ equals

74. Area bounded by the set of points $S = \{(x, y) : ||x| - 1| + ||y| - 1| \le 1\}$ is

75. If ${}^{30}C_0\,{}^{30}C_{20} - {}^{30}C_1\,{}^{30}C_{19} + {}^{30}C_2\,{}^{30}C_{18} - \ldots\ldots + {}^{30}C_{20}\,{}^{30}C_0$ equals ${}^{n}C_r$ then maximum possible value of n + r equals

SOLUTIONS

Physics

PART – A

SECTION – A

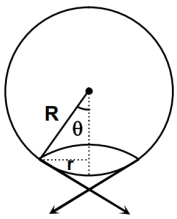
1. A

Sol. To detach

$$\rho_w\left(\frac{4}{3}\pi R^3 g\right) = T2\pi r\sin\theta$$

So, $\rho_w\left(\frac{4}{3}\pi R^3 g\right) = T2\pi r\frac{r}{R}$

So, $r = R^2\sqrt{\frac{2\rho_w g}{3T}}$



2. B

Sol. When switch is closed

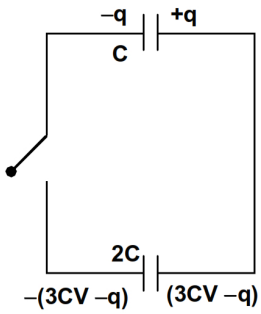
$$\frac{q}{C} = \frac{3CV - q}{2C}$$

So, q = CV

Initial energy, $U_i = \frac{C^2V^2}{2C} + \frac{(4CV)^2}{2(2C)}$

Final energy, $U_f = \frac{C^2V^2}{2C} + \frac{(2CV)^2}{2(2C)}$

So, energy lost = $U_i - U_f = 3CV^2$



3. A

Sol. $k_1 = \frac{hC}{\lambda} - \phi$

$$3k_1 = \frac{2hC}{\lambda} - \phi$$

So, $\frac{1}{3} = \frac{\frac{hC}{\lambda} - \phi}{\frac{2hC}{\lambda} - \phi}$

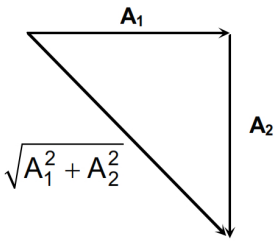
So, $\phi = \frac{hC}{2\lambda}$

4. A

Sol. From Phasor diagram

Because intensity I is proportional to square of amplitude

So, $I \propto (A_1^2 + A_2^2)$



5. A

Sol. When both S_1 and S_2 are open,

Current in the ammeter $i = \frac{1.5}{300 + 100 + 50} = \frac{1}{300}$ A

When both S_1 and S_2 are closed,

$$i = \frac{1.5}{300 + \left(\frac{100R}{100 + R}\right)} \left(\frac{R}{R + 100}\right) = \frac{1.5R}{400R + 30000}$$

So, according to the question,

$$\frac{1}{300} = \frac{1.5R}{400R + 30000}$$

$\Rightarrow R = 600\ \Omega$

6. C

Sol. $\frac{K(4)^2}{r^2(2)} = \frac{K(4 - q)(4 + q)}{r^2}$

So, $8 = 16 - q^2$

$\Rightarrow q = 2\sqrt{2}\ \mu C$

7. B

Sol. From Brewster's law

$\mu = \tan 60° = \sqrt{3}$

8. B

Sol. $\frac{dy}{dx} = \frac{2a}{y} = \tan\theta$ (slope of the wire)

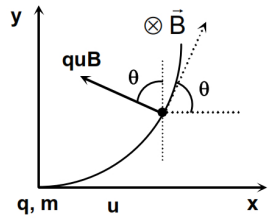
For no slipping $\tan\theta \le \mu_S$

So, $\frac{2a}{y_0} \le \mu_S$

So, $y_0 \ge \frac{2a}{\mu_S}$

9. B

Sol. Impulse momentum theorem along y-direction



$$\int quB\cos\theta dt = mu$$

$$\Rightarrow \quad q\int B_0 xu\cos\theta dt = mu$$

$$\Rightarrow \quad qB_0\int_0^{x_m} xdx = mu$$

$$\Rightarrow \quad qB_0\frac{x_m^2}{2} = mu$$

$$\Rightarrow x_m = \sqrt{\frac{2mu}{qB_0}}$$

10. A

Sol. $i_d = \frac{dQ}{dt} = \frac{12}{100}e^{-\frac{t}{\tau}}$

So, i_d after a time constant = $\frac{12000}{100e} = \frac{120}{e}$mA

11. D

Sol. $0.9A_0 = A_0e^{-c(5)}$

and $\alpha A_0 = A_0e^{-c(15)}$

So, $\alpha = (0.9)^3 = 0.729$

12. B

Sol. In the given circuit R_{eq} = 1MΩ

and $C_{eq} = 4\,\mu F$

So, $V = (10)\left(1 - e^{-\frac{t}{R_{eq}C_{eq}}}\right)$

So, $4 = 10\left(1 - e^{-\frac{t}{4}}\right)$

So, $e^{-\frac{t}{4}} = \frac{3}{5}$

So, t = $4\ell n\left(\frac{5}{3}\right)$

13. C

Sol. For a convex lens forming a real image

$$\frac{1}{v} - \frac{1}{-u} = \frac{1}{f}$$

So, if u = v, then

u = v = 2f

14. B

Sol. In forced oscillation

If $F = F_0\cos(\omega t)$

Then $x = A\sin(\omega t - \phi)$, where $A = \dfrac{F_0}{m(\omega_0^2 - \omega^2)}$

15. B

Sol. Suppose length AP = x

So, $\dfrac{1}{3}\left(\dfrac{m}{\ell}x\right)x^2 = \dfrac{m\ell^2}{3} - \dfrac{mx^3}{3\ell}$

So, $x = \dfrac{\ell}{2^{1/3}}$

16. A

Sol. Heat required to melt the whole of ice is

$Q_1 = mS\Delta T + mL$

$= 400 \times 0.5 \times 20 + 400 \times 80 = 36000$ cal

The maximum heat released by steam when the whole steam is converted into water at 0°C

$Q_2 = mS\Delta T + mL$

$= 50 \times 1 \times 100 + 540 \times 50 = 32000$ cal

Because $Q_2 < Q_1$, so the whole ice will not melt. Hence the final temperature of the mixture is 0°C.

17. C

Sol. Thermal stress is given by $Y \propto \Delta\theta$

So, for stress to be same

$Y_1\alpha_1 = Y_2\alpha_2$

So, $\dfrac{Y_1}{Y_2} = \dfrac{\alpha_2}{\alpha_1} = \dfrac{3}{2}$

18. B

Sol. $Q = \dfrac{p^2}{2\times 4} + \dfrac{p^2}{2\times(220-4)}$

$5.5 = p^2\left(\dfrac{1}{8} + \dfrac{1}{432}\right) = p^2\left(\dfrac{440}{8\times 432}\right)$

So, $\dfrac{p^2}{2\times 4} = \dfrac{(5.5)(8\times 432)}{2\times 4\times 440} = 5.4$ MeV

19. C

Sol. From lens C, image is formed at 1 m along the direction of incident ray. So for the position of final image from the final system is

$\dfrac{1}{v} - \dfrac{1}{1} = \dfrac{1}{1}$

$\Rightarrow v = \dfrac{1}{2}$ m

So, magnification $m = \dfrac{1}{2}$

So, separation between both the images = $\dfrac{1}{2}\times\dfrac{1}{2}\times 2 = 0.5$ cm

20. B

Sol. $X = \frac{C}{T}$

Or $\frac{X_1}{X_2} = \frac{273-173}{273-73} = \frac{100}{200}$

So, $X_2 = 2 \times 0.0060 = 0.0120$

SECTION – B

21. 770

Sol. For second pendulum

$$2 = 2\pi\sqrt{\frac{\ell}{g}} = 2\pi\sqrt{\frac{\ell(1+\alpha\Delta T)}{g+a}}$$

So, $1+\alpha\Delta T = \frac{g+a}{g} = 1+\frac{a}{g}$

So, $a = g\alpha\Delta T = (10)(20\times10^{-4})(50) = 1\,m/s^2$

So, $N = m(g+a) = 770\ N$

22. 3

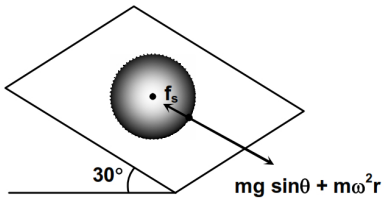
Sol. At the limiting situation

$f_S = mg\sin\theta + m\omega^2 r$

$mg\sin\theta + m\omega^2 r \le \mu_S mg\cos\theta$

So, $\mu_S \ge \tan\theta + \frac{\omega^2 r}{g\cos\theta}$

So, $\mu_S \ge \frac{1}{\sqrt{3}} + \frac{(10)^2\left(\frac{1}{10}\right)}{10\left(\frac{\sqrt{3}}{2}\right)} = \sqrt{3}$



23. 7

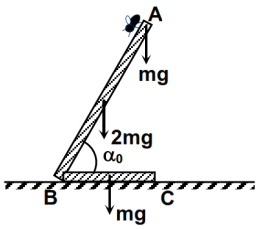
Sol. At the verge of toppling, normal applied by table will pass through point C. So, torque about point C,

$mg(2d\cos\alpha_0 - d) = 2mg(d - d\cos\alpha_0) + mg\frac{d}{2}$

$2\cos\alpha_0 - 1 = 2 - 2\cos\alpha_0 + \frac{1}{2}$

$4\cos\alpha_0 = \frac{7}{2}$

So, $\cos\alpha_0 = \frac{7}{8}$



24. 125

Sol. $\frac{dL}{dt} = \frac{dm}{dt}R(v_1 - v_2)$

$= (100)(0.5)(5-2.5) = 125\ J$

25. 2

Sol. $X_C = \frac{V_C}{I} = 1000\ \Omega$

Current lags behind voltage, so box has an inductor

Power factor = 0.8 = $\frac{R}{Z} = \frac{800}{\sqrt{(800)^2 + (X_L - 1000)^2}}$

So, $X_L = 1600\ \Omega$

So, $L = \frac{1600}{2 \times \pi \times \frac{400}{\pi}} = 2$ Henry

Chemistry

PART – B

SECTION – A

26. C

Sol. $K_2Cr_2O_7 + \text{cold. } 4H_2SO_4 \longrightarrow 2CrO_3 + 2KHSO_4 + 2H_2O$

$2K_2Cr_2O_7 + \text{warm } 8H_2SO_4 \xrightarrow{\Delta} 2K_2SO_4 + 2Cr_2(SO_4)_3 + 8H_2O + 3O_2$

27. C

Sol. $2F_2 + 2H_2O \longrightarrow 4HF(aq) + O_2(g)$

$3F_2 + 3H_2O \longrightarrow 6HF(aq) + O_3(g)$

28. B

Sol. $Ni^{+2} \rightarrow in\left[Ni(Br_2)(PPh_3)_2\right] \longrightarrow \left[NiBr_2(PPh_3)_2\right]$

Square planar	Tetrahedral
Red colour	Green coloured
Diamagnetic	Paramagnetic

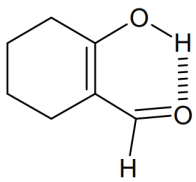
Tetrahedral splitting of Ni^{+2} in $NiBr_2(PPh_3)_2$ will have configuration $e^4t_2^4$, thus unpaired electrons.

29. D

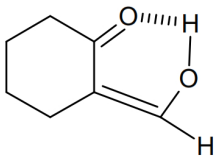
Sol. In (I) annulene systems, only peripheral bonds are counted but in (II) fused ring system only connected benzoic bonds are counted.

30. C

Sol.



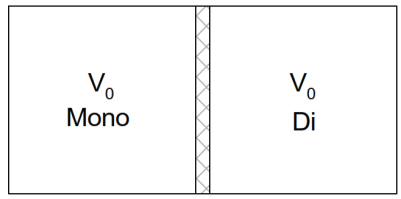
or



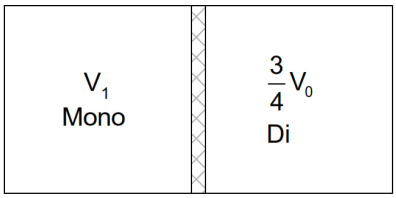
1, 2 diketones in enol form strong H-bonding with stable ring.

31. C

Sol.



Initial



Monoatomic : $P_1.V_0^{5/3} = P_2.V_1^{5/3}$

Diatomic : $P_1.V_0^{7/5} = P_2.\left(\frac{3}{4}V_0\right)^{7/5}$

$$\therefore \frac{V_1}{V_0} = \left(\frac{3}{4}\right)^{\frac{21}{25}}$$

32. B

Sol.

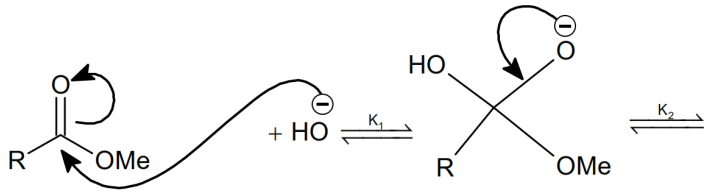
	I_2	+	I^-	$\rightleftharpoons$	I_3^-
	1		0.5		–
Volume = 1L	1 – 0.25		0.5 – 0.25		0.25

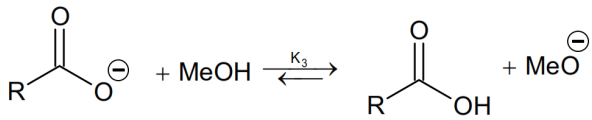
$$K_c = \frac{0.25}{0.75 \times 0.25} = \frac{4}{3}$$

$\therefore K_c$ for $\frac{1}{2}I_2 + \frac{1}{2}I^- \rightleftharpoons \frac{1}{2}I_3^-$ is $\sqrt{\frac{4}{3}} = 1.15$

33. C

Sol.





3 step mechanism where $K_1 \simeq K_2$ but K_3 is largely formed.

34. B

Sol. $\frac{1}{\lambda} = R_H.Z^2\left[\frac{1}{2^2} - \frac{1}{5^2}\right]$

$$\frac{1}{108.5 \times 10^{-9}} = R_H.Z^2\left[\frac{25-4}{25 \times 4}\right]$$

$$Z^2 = \frac{1}{R_H}.\frac{1}{1085 \times 10^{-10}} \times \frac{25 \times 4}{21}$$

$$= \frac{916 \times 25 \times 4}{1085 \times 21}$$

$$\text{B. E.} = 13.6 \times \frac{Z^2}{n^2}$$

$$\text{B.E.} = \frac{+13.6 \times 916 \times 25 \times 4}{1085 \times 21}$$

B.E. = 54.4 eV

35. B

Sol.

	$A(g) \xrightarrow{K_1}$	$2B(g)$		$A(g) \xrightarrow{K2}$	$C(g)$
$t = 0$	1 atm	0	$t = 0$	1 atm	0
t = 10 min	$(1 - x - y)$	2x	t = 10 min	$(1 - x - y)$	y
$t = \infty$	$(1 - a - b)$	2a	$t = \infty$	$(1 - a - b)$	b
	≈ 0			≈ 0	

From question, a + b = 1 and 2a + b = 1.5

$\therefore a = b = 0.5$

Now, $\frac{P_B}{P_C} = \frac{2K_1}{K_2} = \frac{2a}{b} = \frac{2x}{y} \Rightarrow \frac{K_1}{K_2} = 1 = \frac{x}{y}$

Now, $P_{10\ min} = (1 - x - y) + 2x + y = 1.4$

$\Rightarrow x = y = 0.4 \therefore P_A = 1 - x - y = 0.2$ atm at t =10 min

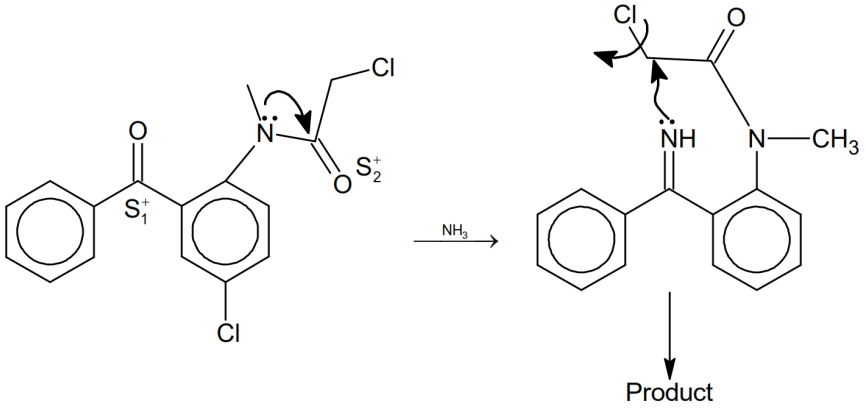
Now, $K_1 + K_2 = \frac{1}{t}.\ln\frac{P_A^o}{P_A} = \frac{1}{10}.\ln\frac{1}{0.2} = 0.16\ min^{-1}$

$\therefore K_1 = K_2 = 0.08\ min^{-1}$

36. C

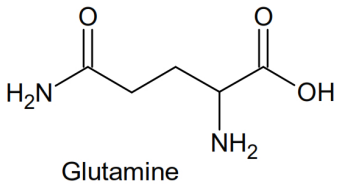
Sol. Rate: Addition of nucleophilic on polar π – bond > Nucleophilic substitution $S_1^+ > S_2^+$

$\therefore NH_3$ (nucleophile) attacks 1st at S_1^+



37. A

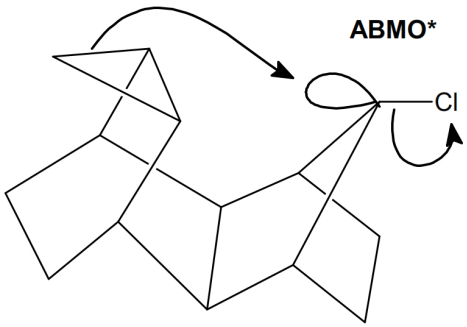
Sol.



Glutamine

38. C

Sol.



3 membered ring act as an internal nucleophile.

39. C

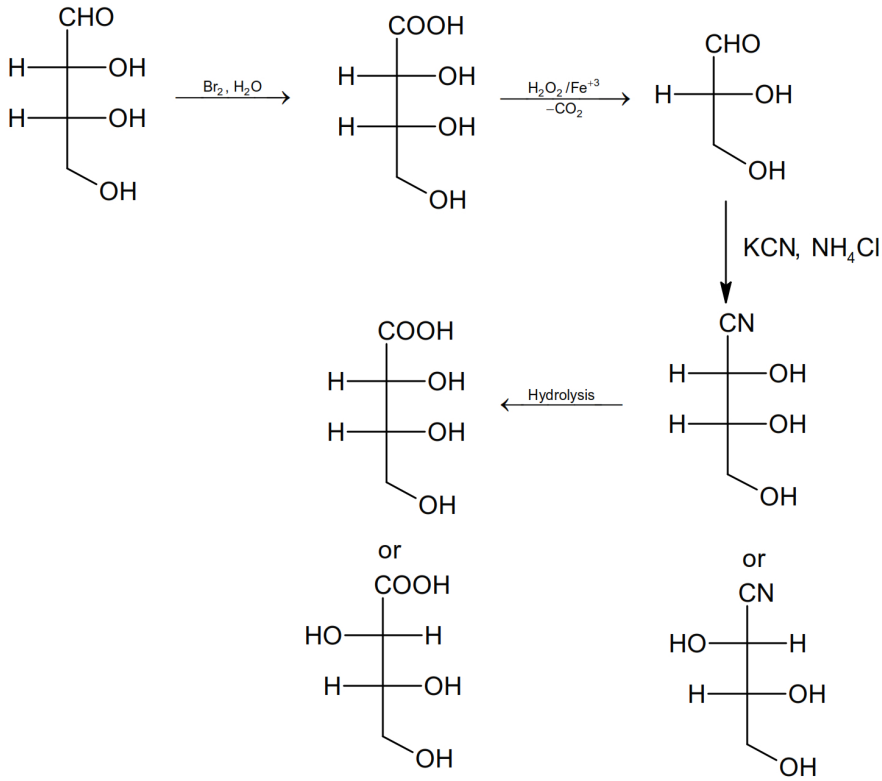
Sol. $H_2C_2O_4$ is obtained in pure form and is not much effected by surrounding conditions and is therefore suitable as a primary standard.

40. C

Sol. Glycerin and H_2O are highly miscible and most water molecules turned to glycerin via H-bond, therefore, vapour pressure of solution decreases. Hence, depression in freezing point is observed.

41. C

Sol.



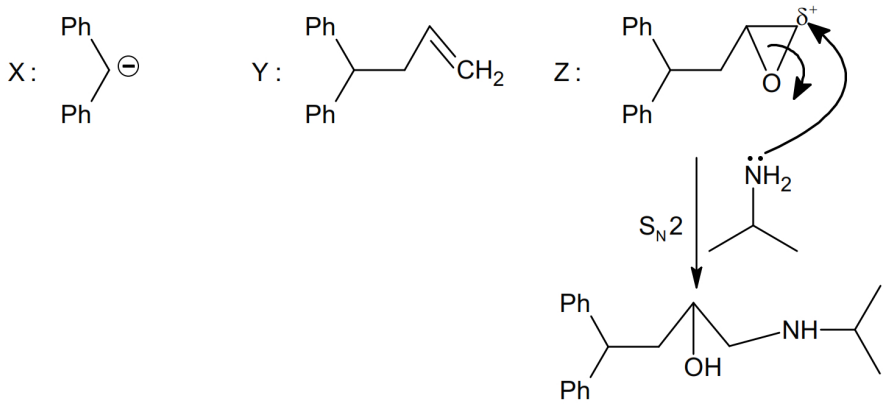
42. B

Sol. $E_{cell} = E^{o}_{cell} - \frac{0.06}{n}.\log\frac{[H^+]^2}{P_{H_2}}$

Or, $0.70 = (0.28 - 0) - \frac{0.06}{2}.\log\frac{[H^+]^2}{1} \Rightarrow pH = 7.0$

43. B

Sol.



44. B

Sol. Factual

45. D

Sol. Covalent character $\propto \frac{\text{Charge of cation}}{\text{Size of cation}}$

Covalent character $\propto$ size of anion.

SECTION – B

46. 3

Sol. $2x - 8 + 0 + 0 = -2$

$2x = 6$

$x = +3$

47. 6

Sol.

$$XeF_x + \frac{x}{2}H_2 \longrightarrow Xe + xHF$$

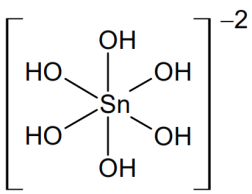
a mole a x mole

$a = \frac{56}{22400}$

and $ax \times 1 = \frac{60 \times 0.25}{1000} \times 1 \Rightarrow x = 6$

48. 2

Sol.



$\rightarrow$ sp^3d^2

$x = 1$

$y = 3$

$z = 2$

49. 9

Sol. Statement number 1, 3 and 5 are correct.

Statement 3: $Fe^{+3} \longrightarrow \underset{\text{Red-brown}}{Fe(OH)_3}$; $Cr^{+3} \longrightarrow \underset{\text{Green}}{Cr(OH)_3}$

Statement 5: $2CuSO_4 + K_4[Fe(CN)_6] \longrightarrow \underset{\text{Chocolate brown}}{Cu_2[Fe(CN)_6]} + K_2SO_4$

50. 7

Sol. At 2nd equivalence point; only $[HA]^{-2}$ is left.

$$[H^+] = \sqrt{K_{a_2} \times K_{a_3}} = 10^{-10}$$

Now; $K_{a_1} \times K_{a_2} \times K_{a_3} = [H^+]^3 \dfrac{[A_3^-]}{[H_3A]}$

$$\frac{[A^{-3}]}{[H_3A]} = \frac{10^{-3} \times 10^{-8} \times 10^{-12}}{[10^{-10}]^3} = 10^7$$

SECTION – A

51. D

Sol. $f(0).f\left(\frac{5}{4}\right)$ can be positive, negative or equal to zero.

52. D

Sol. $\theta \in \left[0, \frac{\pi}{2}\right]$

53. C

Sol. A = I

54. B

Sol. Centroid, $G \equiv (2, 0)$

Slope of GH = $\frac{1}{3}$

55. A

Sol. Minimum distance between $x = 4\sqrt{1+y^2}$ and $x = -2\sqrt{2y-y^2}$ x is 4.

56. D

Sol. $y^2\cos(x^2y)\,(2xy + x^2y') + x^2y' - 2xy = 0$

$\Rightarrow \quad \cos(x^2y)\,d(x^2y) = d\left(\frac{x^2}{y}\right)$

$\Rightarrow \quad \sin(x^2y) = \frac{x^2}{y} + c$ where c = 0

57. B

Sol. $\bar{y} = \frac{\sum_{i=1}^{100} y_i}{100} = \frac{2 \cdot 100 \cdot 101 \cdot 201}{100 \cdot 6} = 6767$

58. A

Sol. $(B, B) \in R \;\; \forall B \in P(A) \Rightarrow$ R is reflexive

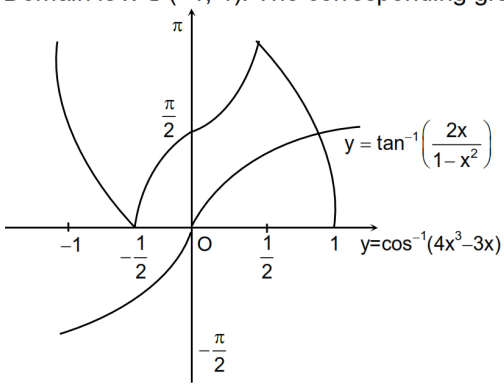
R is not symmetric

$(B, C), (C, D) \in R \Rightarrow (B, D) \in R \;\; \forall B, C, D \in P(A)$

So, R is transitive.

59. C

Sol. Domain is $x \in (-1, 1)$. The corresponding graph in this interval is given



60. A

Sol. $a^3 = 45^3 \Rightarrow a = 45, 45\omega, 45\omega^2$

61. D

Sol. $$f(x) = \begin{cases} -\left(\dfrac{e^{x^2-1}-1}{x^2-1}\right) & |x| > 1 \\ \sin\left((2x-1)\dfrac{\pi}{2}\right) & |x| < 1 \\ 1 & |x| = 1 \end{cases}$$

62. D

Sol. $$\text{Displacement} = \frac{3}{2\sqrt{2}}\left[\left(1-\frac{1}{\sqrt{2}}\right)\hat{i} + \left(1-\sqrt{\frac{3}{2}}\right)\hat{j}\right]$$

$$\text{time, } t = \frac{\frac{3}{\sqrt{2}}\left(\sqrt{\frac{3}{2}}-1\right)}{0.2}$$

$$\text{Use, velocity} = \frac{\text{displacement}}{\text{time}}$$

63. D

Sol. $$P = \frac{\frac{11!}{2!2!2!} - \frac{10!}{2!2!}\times 2 + \frac{9!}{2!}}{\frac{9!}{2!2!}\,{}^{10}C_2} = \frac{37}{45}$$

64. B

Sol. $$\int_0^1 1-\frac{x^2}{6}dx < \int_0^1 \frac{\sin x}{x}dx < \int_0^1 1-\frac{x^2}{6}+\frac{x^4}{120}dx$$

$$\Rightarrow \frac{17}{18} < \int_0^1 \frac{\sin x}{x}dx < \frac{1703}{1800}$$

65. D

Sol. $\overrightarrow{AB} - \overrightarrow{BC} + \overrightarrow{CD} - \overrightarrow{DE} + \overrightarrow{EF} - \overrightarrow{FA} = -6(\overrightarrow{GH})$

66. A

Sol. $$g(xy) + h\left(\frac{x}{y}\right) = \frac{\left[(xy)^2+xy\right]-\left[(xy)^2-xy\right]}{2} + \frac{\left(\frac{x}{y}\right)^2+\frac{x}{y}+\left(\frac{x}{y}\right)^2-\frac{x}{y}}{2} = xy + \left(\frac{x}{y}\right)^2$$

67. A

Sol. Let $\alpha = x + iy$; $x, y \in I^+$

$\Rightarrow x^2 - y^2 = 4 \Rightarrow x = 2, y = 0$

$\Rightarrow$ slope = 0

68. D

Sol. $$\sum_{n=1}^{\infty}\frac{1}{(3n-2)!}+\frac{1}{(3n-1)!} = e - \frac{\left(e+\frac{2\cos\left(\frac{\sqrt{3}}{2}\right)}{\sqrt{e}}\right)}{3} = \frac{2}{3}\left(e-\frac{1}{\sqrt{e}}\cos\left(\frac{\sqrt{3}}{2}\right)\right)$$

69. A

Sol. $\alpha = \frac{7}{2}, \beta = -\frac{27}{2}$

70. C

Sol. The circles have 3 common tangents of lengths $2\sqrt{2}$, $2\sqrt{2}$ and 0 respectively.

SECTION – B

71. 9036

Sol. ${}^5C_1({}^{10}C_2 + {}^{10}C_3 + \ldots.. + {}^{10}C_5) + {}^5C_2({}^{10}C_1 + \ldots.. + {}^{10}C_4) + {}^5C_3({}^{10}C_0 + \ldots.. + {}^{10}C_3) + {}^5C_4({}^{10}C_0 + {}^{10}C_1 + {}^{10}C_2) + {}^5C_5({}^{10}C_0 + {}^{10}C_1) = 9036$

72. 7

Sol. Let tanx = t $\Rightarrow \alpha t^2 + 4t(-3 - \alpha) + 64 = 0$

$D < 0 \Rightarrow \alpha \in (1, 9)$.

73. 7

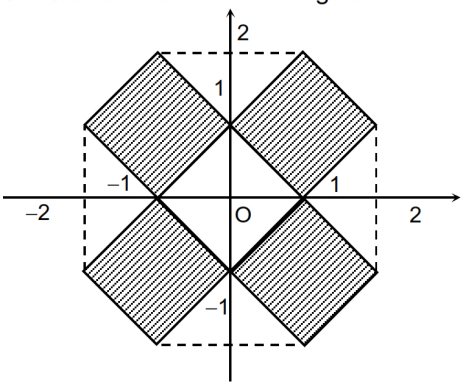
Sol. $I(x) = \frac{1}{2}\ln(xe^x + 1) - \ln(xe^x) + \frac{1}{2}\ln(xe^x - 1) + c$

$= \frac{1}{4}\ln\left(\frac{x^4e^{4x} - 2x^2e^{2x} + 1}{x^4e^{4x}}\right) + c$

$= \alpha = 4, \beta = 2, \gamma = 1$

74. 8

Sol. Set S bounds the shaded region



75. 50

Sol. Coeff. of x^{20} in $(1 - x^2)^{30} = {}^{30}C_{10}$ or ${}^{30}C_{20}$