MHT-CET 2024

General Instructions

- *This question booklet contains 150 Multiple Choice Questions (MCQs).*
  ***Section-A:** Physics & Chemistry - 50 Questions each and*
  ***Section-B:** Mathematics - 50 Questions.*
- *Choice and sequence for attempting questions will be as per the convenience of the candidate.*
- *Read each question carefully.*
- *Determine the one correct answer out of the four available options given for each question.*
- *Each question with correct response shall be awarded one (1) mark. There shall be no negative marking.*
- *No mark shall be granted for marking two or more answers of same question, scratching or overwriting.*
- *Duration of paper is 3 Hours.*

SECTION-A

PHYSICS

1. Force between two point charges q_1 and q_2 placed in vacuum at 'r' cm apart is F. Force between them when placed in a medium having dielectric K = 5 at 'r/5' cm apart will be:

(a) F/25 (b) 5F
(c) F/5 (d) 25F

2. A thin circular disc of mass M and radius R is rotating in a horizontal plane about an axis passing through its centre and perpendicular to its plane with angular velocity ω. If another disc of same dimensions but of mass $M/2$ is placed gently on the first disc co-axially, then the new angular velocity of the system is :

(a) $\frac{4}{5}\omega$ (b) $\frac{5}{4}\omega$
(c) $\frac{2}{3}\omega$ (d) $\frac{3}{2}\omega$

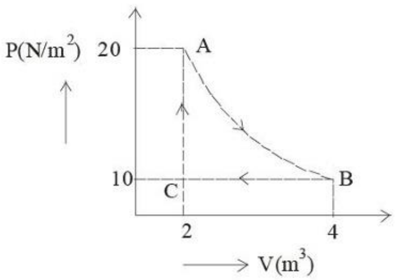
3. Correct Bernoulli's equation is (symbols have their usual meaning) :

(a) $P + mgh + \frac{1}{2}mv^2 = \text{constant}$
(b) $P + \rho gh + \frac{1}{2}\rho v^2 = \text{constant}$
(c) $P + \rho gh + \rho v^2 = \text{constant}$
(d) $P + \frac{1}{2}\rho gh + \frac{1}{2}\rho v^2 = \text{constant}$

4. Two projectiles are projected at 30° and 60° with the horizontal with the same speed. The ratio of the maximum height attained by the two projectiles respectively is:

(a) $2:\sqrt{3}$ (b) $\sqrt{3}:1$
(c) 1 : 3 (d) $1:\sqrt{3}$

5. A real gas within a closed chamber at 27°C undergoes the cyclic process as shown in figure. The gas obeys $PV^3 = RT$ equation for the path A to B . The net work done in the complete cycle is (assuming R = 8J/molK):

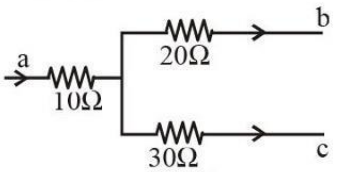


(a) 225 J (b) 205 J
(c) 20 J (d) – 20 J

6. Light emerges out of a convex lens when a source of light kept at its focus. The shape of wavefront of the light is:
(a) Both spherical and cylindrical
(b) Cylindrical
(c) Spherical
(d) Plane

7. A monkey of mass 50 kg climbs on a rope which can withstand the tension (T) of 350 N. If monkey initially climbs down with an acceleration of 4 m/s^2 and then climbs up with an acceleration of 5m/s^2. Choose the corret option (g = 10 m/s^2).
(a) T = 700 N while climbing upward
(b) T = 350 N while goint downward
(c) Rope will break while climbing upward
(d) Rope will break while going downward

8. Figure shows a part of an electric circuit. The potentials at points a, b and c are 30 V, 12 V and 2V respectively. The current through the 20Ω resistor will be.



(a) 0.4 A (b) 0.2A
(c) 0.6 A (d) 1.0 A

9. A current of 200 μA deflects the coil of a moving coil galvanometer through 60^0. The current to cause deflection through $\frac{\pi}{10}$ radian is :
(a) 30 μA (b) 120 μA
(c) 60 μA (d) 180 μA

10. The value of acceleration due to gravity at Earth's surface is 9.8 ms^{-2}. The altitude above its surface at which the acceleration due to gravity decreases to 4.9 ms^{-2}, is close to : (Radius of earth = 6.4×10^6 m)
(a) 2.6×10^6 m (b) 6.4×10^6 m
(c) 9.0×10^6 m (d) 1.6×10^6 m

11. Relative permittivity and permeability of a material ε_r and μ_r, respectively. Which of the following values of these quantities are allowed for a diamagnetic material?
(a) $\varepsilon_r = 0.5, \mu_r = 1.5$ (b) $\varepsilon_r = 1.5, \mu_r = 0.5$
(c) $\varepsilon_r = 0.5, \mu_r = 0.5$ (d) $\varepsilon_r = 1.5, \mu_r = 1.5$

12. The magnetic flux through a coil perpendicular to its plane is varying according to the relation $\phi = (5t^3 + 4t^2 + 2t - 5)$ Weber. If the resistant of the coil is 5 ohm, then the induced current through the coil at $t = 2$ sec will be:
(a) 15.6A (b) 16.6A (c) 17.6A (d) 18.6A

13. A solid metallic cube having total surface area 24 m^2 is uniformly heated. If its temperature is increased by 10°C, calculate the increase in volume of the cube.
(Given : $\alpha = 5.0 \times 10^{-4}$ °C^{-1})
(a) 2.4×10^6 cm^3 (b) 1.2×10^5 cm^3
(c) 6.0×10^4 cm^3 (d) 4.8×10^5 cm^3

14. Two coils are placed close to each other. The mutual inductance of the pair of coils depends upon
(a) the rates at which currents are changing in the two coils
(b) relative position and orientation of the two coils
(c) the materials of the wires of the coils
(d) the currents in the two coils

15. A proton, an electron and an alpha particle have the same energies. Their de-Broglie wavelengths will be compared as:
(a) $\lambda_e > \lambda_\alpha > \lambda_p$ (b) $\lambda_\alpha < \lambda_p < \lambda_e$
(c) $\lambda_p < \lambda_e < \lambda_\alpha$ (d) $\lambda_p > \lambda_e > \lambda_\alpha$

16. An ice cube has a bubble inside. When viewed from one side the apparent distance of the bubble is 12 cm. When viewed from the opposite side, the apparent distance of the bubble is observed as 4 cm. If the side of the ice cube is 24 cm, the refractive index of the ice cube is
(a) $\frac{4}{3}$ (b) $\frac{3}{2}$ (c) $\frac{2}{3}$ (d) $\frac{6}{5}$

17. The longest wavelength associated with Paschen series is : (Given R_H = 1.097×10^7 SI unit)
(a) 1.094×10^{-6}m (b) 2.973×10^{-6}m
(c) 3.646×10^{-6}m (d) 1.876×10^{-6}m

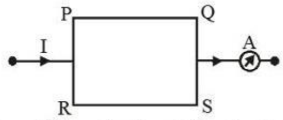
18. The ratio of the mass densities of nuclei of ^{40}Ca and ^{16}O is close to :
(a) 1 (b) 0.1 (c) 5 (d) 2

19. Point charge of 10 μC is placed at the origin. At what location on the X-axis should a point charge of 40μC be placed so that the net electric field is zero at x = 2 cm on the X-axis ?

(a) $x = 6$ cm (b) $x = 4$ cm
(c) $x = 8$ cm (c) $x = -4$ cm

20. A magnetic needle is kept in a non-uniform magnetic field. It experiences
(a) neither a force nor a torque
(b) a torque but not a force
(c) a force but not a torque
(d) a force and a torque

21. A current carrying rectangular loop PQRS is made of uniform wire. The length PR = QS = 5 cm and PQ = RS = 100 cm. If ammeter current reading changes from I to 2I, the ratio of magnetic forces per unit length on the wire PQ due to wire RS in the two cases respectively $f_{PQ}^{I} : f_{PQ}^{21}$ is:



(a) 1 : 2 (b) 1 : 4 (c) 1 : 5 (d) 1 : 3

22. At which temperature the r.m.s. velocity of a hydrogen molecule equal to that of an oxygen molecule at 47° C?
(a) 80 K (b) – 73 K
(c) 4 K (d) 20 K

23. A light emitting diode (LED) is fabricated using GaAs semiconducting material whose band gap is 1.42 eV. The wavelength of light emitted from the LED is:
(a) 650 nm (b) 1243 nm
(c) 875 nm (d) 1400 nm

24. A steel wire with mass per unit length 7.0×10^{-3} kg m^{-1} is under tension of 70N. The speed of transverse waves in the wire will be:
(a) 100 m/s (b) 50 m/s
(c) 10 m/s (d) 200 π m/s

25. 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 pressures of the gases in A and B respectively, then $\frac{P_A}{P_B}$ is:
(a) 8 (b) 16 (c) 32 (d) 4

26. A wire of length 1 m moving with velocity 8 m/s at right angles to a magnetic field of 2T. The magnitude of induced emf, between the ends of wire will be
(a) 20V (b) 8V (c) 12V (d) 16V

27. Two identical particles each of mass 'm' go round a circle of radius *a* under the action of their mutual gravitational attraction. The angular speed of each particle will be:
(a) $\sqrt{\frac{Gm}{2a^3}}$ (b) $\sqrt{\frac{Gm}{8a^3}}$
(c) $\sqrt{\frac{Gm}{4a^3}}$ (d) $\sqrt{\frac{Gm}{a^3}}$

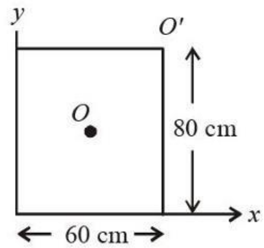
28. In an unbiased n-p junction electrons diffuse from n-region to p-region because :
(a) holes in p-region attract them
(b) electrons travel across the junction due to potential difference
(c) only electrons move from n to p region and not the vice-versa
(d) electron concentration in n-region is more compared to that in p-region

29. A particle is executing Simple Harmonic Motion (SHM). The ratio of potential energy and kinetic energy of the particle when its displacement is half of its amplitude will be:
(a) 1 : 1 (b) 2 : 1
(c) 1 : 4 (d) 1 : 3

30. Eight equal drops of water are falling through air with a steady speed of 10 cm/s. If the drops coalesce, the new velocity is:
(a) 10 cm/s (b) 40 cm/s
(c) 16 cm/s (d) 5 cm/s

31. In a coil, the current changes form –2 A to +2A in 0.2 s and induces an emf of 0.1 V. The selfinductance of the coil is :
(a) 5 mH (b) 1 mH
(c) 2.5 mH (d) 4 mH

32. For a uniform rectangular sheet shown in the figure, the ratio of moments of inertia about the axes perpendicular to the sheet and passing through *O* (the centre of mass) and *O'* (corner point) is :



(a) 2/3 (b) 1/4
(c) 1/8 (d) 1/2

33. If n is the number density and d is the diameter of the molecule, then the average distance covered by a molecule between two successive collisions (i.e. mean free path) is represented by:

(a) $\frac{1}{\sqrt{2n\pi d^2}}$ (b) $\sqrt{2}n\pi d^2$

(c) $\frac{1}{\sqrt{2}n\pi d^2}$ (d) $\frac{1}{\sqrt{2}n^2\pi^2 d^2}$

34. A mixture of one mole of monoatomic gas and one mole of a diatomic gas (rigid) are kept at room temperature (27°C). The ratio of specific heat of gases at constant volume respectively is:

(a) $\frac{7}{5}$ (b) $\frac{3}{2}$ (c) $\frac{3}{5}$ (d) $\frac{5}{3}$

35. In an a.c. circuit, voltage and current are given by :

V = 100 sin (100 t) V and

$I = 100 \sin(100t + \frac{\pi}{3})$ mA respectively.

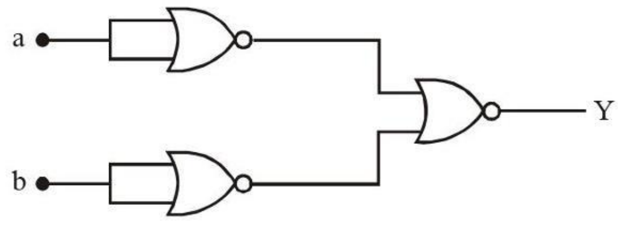
The average power dissipated in one cycle is:

(a) 10 W (b) 2.5 W (c) 25 W (d) 5 W

36. The difference between threshold wavelengths for two metal surfaces A and B having work function $\phi_A = 9$ eV and $\phi_B = 4.5$ eV in nm is:
(Given, hc = 1242 eV nm)

(a) 264 (b) 138 (c) 276 (d) 540

37. The logic performed by the circuit shown in figure is equivalent to:



(a) AND (b) NAND
(c) OR (d) NOR

38. A particle performs simple harmonic mition with amplitude A. Its speed is tripled at the instant that it is at a distance $\frac{2A}{3}$ from equilibrium position. The new amplitude of the motion is :

(a) $A\sqrt{3}$ (b) $\frac{7A}{3}$

(c) $\frac{A}{3}\sqrt{41}$ (d) 3A

39. The mass of proton, neutron and helium nucleus are respectively 1.0073 *u*, 1.0087 *u* and 4.0015 *u*. The binding energy of helium nucleus is:

(a) 14.2 MeV (b) 56.8 MeV
(c) 28.4 MeV (d) 7.1 MeV

40. A series LCR circuit is subjected to an AC signal of 200 V, 50 Hz. If the voltage across the inductor (L = 10 mH) is 31.4 V, then the current in this circuit is

(a) 68 A (b) 63 A (c) 10 A (d) 10 mA

41. When two soap bubbles of radii a and b (b > a) coalesce, the radius of curvature of common surface is

(a) $\frac{ab}{b-a}$ (b) $\frac{ab}{a+b}$ (c) $\frac{b-a}{ab}$ (d) $\frac{a+b}{ab}$

42. A liquid is allowed to flow into a tube of truncated cone shape. Identify the correct statement from the following:

(a) the speed is high at the wider end and high at the narrow end.
(b) the speed is low at the wider end and high at the narrow end.
(c) the speed is same at both ends in a stream line flow.
(d) the liquid flows with uniform velocity in the tube.

43. The velocity of sound in a gas in which two wavelengths 4.08m and 4.16m produce 40 beats in 12s, will be :

(a) $2.828\ ms^{-1}$ (b) $175.5\ ms^{-1}$
(c) $353.6\ ms^{-1}$ (d) $707.2\ ms^{-1}$

44. σ is the uniform surface charge density of a thin spherical shell of radius R. The electric field at any point on the surface of the spherical shell is:

(a) $\frac{\sigma}{\epsilon_0 R}$ (b) $\frac{\sigma}{2\epsilon_0}$ (c) $\frac{\sigma}{\epsilon_0}$ (d) $\frac{\sigma}{4\epsilon_0}$

45. An electric field is given by $\left(6\hat{i}+5\hat{j}+3\hat{k}\right)N/C$. The electric flux through a surface area $30\hat{i}$ m^2 lying in YZ-plane (in SI unit) is ;

(a) 180 (b) 90 (c) 150 (d) 60

46. A big drop is formed by coalescing 1000 small droplets of water. The surface energy will become:

(a) $\frac{1}{100}$th (b) $\frac{1}{10}$th
(c) 100 times (d) 10 times

47. If 'M' is the mass of water that rises in a capillary tube of radius 'r', then mass of water which will rise in a capillary tube of radius '2r' is :

(a) M (b) $\frac{M}{2}$ (c) 4 M (d) 2 M

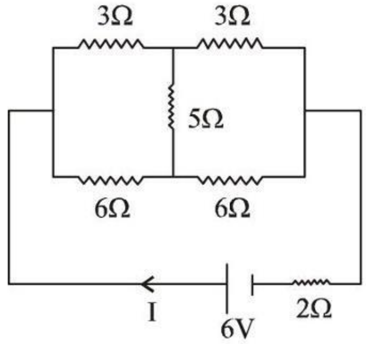
48. A closed organ pipe (closed at one end) is excited to support the third overtone. It is found that air in the pipe has

(a) three nodes and three antinodes
(b) three nodes and four antinodes
(c) four nodes and three antinodes
(d) four nodes and four antinodes

49. The electrostatic potential due to an electric dipole at a distance 'r' varies as:

(a) r (b) $\frac{1}{r^2}$ (c) $\frac{1}{r^3}$ (d) $\frac{1}{r}$

50. A battery of 6 V is connected to the circuit as shown below. The current I drawn from the battery is :



(a) 1A (b) 2A (c) $\frac{6}{11}$A (d) $\frac{4}{3}$A

CHEMISTRY

51. If the length of the body diagonal of a FCC unit cell is xÅ, the distance between two octahedral voids in the cell in Å is

(a) $\frac{x}{\sqrt{2}}$ (b) $\frac{x}{\sqrt{3}}$
(c) $\frac{x}{\sqrt{6}}$ (d) $\frac{x}{\sqrt{8}}$

52. Ortho-sulphobenzimide is used as

(a) Anti oxidant
(b) Artificial sweetener
(c) Food Preservative
(d) Food supplement

53. Volume of a gas at NTP is 1.12×10^{-7}cm^3. The number of molecules in it is :

(a) 3.01×10^{12} (b) 3.01×10^{24}
(c) 3.01×10^{23} (d) 3.01×10^{20}

54. The wavelength of the radiation emitted, when in a hydrogen atom electron falls from infinity to stationary state 1, would be (Rydberg constant $= 1.097 \times 10^7$ m^{-1})

(a) 406 nm (b) 192 nm
(c) 91 nm (d) 9.1×10^{-8} nm

55. In NO^-_3 ion, the number of bond pairs and lone pairs of electrons on nitrogen atom are

(a) 2, 2 (b) 3, 1
(c) 1, 3 (d) 4, 0

56. In which of the compounds does 'manganese' exhibit highest oxidation number ?

(a) MnO_2 (b) Mn_3O_4
(c) K_2MnO_4 (d) $MnSO_4$

57. Alkali metals are powerful reducing agents because

(a) they are metals
(b) they are monovalent
(c) their ionic radii are large
(d) their ionisation energies are low

58. A balloon filled with an air sample occupies 3 L volume at 35°C. On lowering the temperature to T, the volume decreases to 2.5 L. The temperature T is?
[Assume p-constant]

(a) 16°C (b) –16°C
(c) 24°C (d) –20°C

59. Which one of the following is used as an eye lotion?

(a) Milk of magnesia
(b) Silver sol
(c) Colloidal antimony
(d) Chromium salt sol

60. Identify *ortho* and *para* directing groups from the following :

$$\underset{\text{I}}{—CHO},\ \underset{\text{II}}{—NHCOCH_3},\ \underset{\text{III}}{—OCH_3},\ \underset{\text{IV}}{—SO_3H}$$

(a) III, IV (b) II, III
(c) II, IV (d) I, IV

61. Which one of the carbanions is the least stable?

(a) $\overset{\ominus}{C}H_2-NO_2$ (b) $\overset{\ominus}{C}H_2-CHO$
(c) $\overset{\ominus}{C}H_2-CH_3$ (d) $\overset{\ominus}{C}H_3$

62. In O_2^-, O_2 and O_2^{2-} molecular species, the total number of antibonding electrons respectively are

(a) 7, 6, 8 (b) 1, 0, 2
(c) 6, 6, 6 (d) 8, 6, 8

63. People living at high attitudes often reported with a problem of feeling weak and inability to think clearly. The reason for this is.

(a) at high altitudes the partial pressure of oxygen is less than at the ground level.
(b) at high altitudes the partial pressure of oxygen is more than at the ground level.
(c) at high altitudes the partial pressure of oxygen is equal to at the ground level.
(d) None of these.

64. Specific conductance of 0.1 M HNO_3 is 6.3×10^{-2} ohm^{-1} cm^{-1}. The molar conductance of the solution is

(a) 100 ohm^{-1} cm^2 (b) 515 ohm^{-1} cm^2
(c) 630 ohm^{-1} cm^2 (d) 6300 ohm^{-1} cm^2

65. The rate constant for a first order reaction whose half-life, is 480 seconds is :

(a) 2.88×10^{-3} sec^{-1} (b) 2.72×10^{-3} sec^{-1}
(c) 1.44×10^{-3} sec^{-1} (d) 1.44 sec^{-1}

66. If the activation energy for the forward reaction is 150 kJ mol^{-1} and that of the reverse reaction is 260 kJ mol^{-1}, what is the enthalpy change for the reaction ?

(a) 410 kJ mol^{-1} (b) –110 kJ mol^{-1}
(c) 110 kJ mol^{-1} (d) – 410 kJ mol^{-1}

67. For As_2S_3 sol, the most effective coagulating agent is

(a) $CaCO_3$ (b) NaCl
(c) $FeCl_3$ (d) Clay

68. Element not showing variable oxidation state is:

(a) Bromine (b) Iodine
(c) Chlorine (d) Fluorine

69. Which of the following arrangements does not represent the correct order of the property stated against it ?

(a) $V^{2+} < Cr^{2+} < Mn^{2+} < Fe^{2+}$: paramagnetic behaviour
(b) $Ni^{2+} < Co^{2+} < Fe^{2+} < Mn^{2+}$: ionic size
(c) $Co^{3+} < Fe^{3+} < Cr^{3+} < Sc^{3+}$: stability in aqueous solution
(d) Sc < Ti < Cr < Mn : number of oxidation states

70. The IUPAC name for the complex $[Co(ONO)(NH_3)_5]Cl_2$ is

(a) pentaamminenitrito-O-cobalt(II) chloride
(b) pentaamminenitrito-O-cobalt(III) chloride
(c) nitrito-N-pentaamminecobalt(III) chloride
(d) nitrito-N-pentaamminecobalt(II) chloride

71. Which of the following compounds will give racemic mixture on nucleophilic substitution by OH^- ion?

(i) $\begin{array}{l} CH_3-\underset{\displaystyle C_2H_5}{\underset{|}{C}H}-Br \end{array}$

(ii) $\begin{array}{l} CH_3-\overset{\displaystyle Br}{\overset{|}{\underset{\displaystyle C_2H_5}{\underset{|}{C}H}}}-CH_3 \end{array}$

(iii) $\begin{array}{l} CH_3-\underset{\displaystyle C_2H_5}{\underset{|}{C}H}-CH_2Br \end{array}$

(a) (i) (b) (i), (ii) and (iii)
(c) (ii) and (iii) (d) (i) and (iii)

72. Which one of the following is not correct for an ideal solution?

(a) It must obey Raoult's law
(b) $\Delta H = 0$
(c) $\Delta H = \Delta V \neq 0$
(d) All are correct

73. For a relation

$\Delta_r G = -nFE_{cell}$

$E_{cell} = E^\circ_{cell}$ in which of the following condition?

(a) Concentration of any one of the reacting species should be unity
(b) Concentration of all the product species should be unity.

(c) Concentration of all the reacting species should be unity.

(d) Concentration of all reacting and product species should be unity.

74. Which one of the lanthanoids given below is the most stable in divalent form?

(a) Ce (Atomic Number 58)

(b) Sm (Atomic Number 62)

(c) Eu (Atomic Number 63)

(d) Yb (Atomic Number 70)

75. The value of the 'spin only' magnetic moment for one of the following configurations is 2.84 BM. The correct one is

(a) d^5 (in strong ligand field)

(b) d^3 (in weak as well as in strong fields)

(c) d^4 (in weak ligand fields)

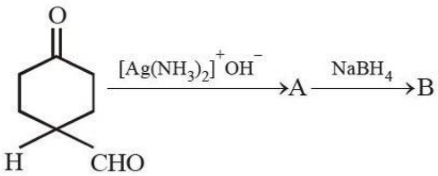
(d) d^4 (in strong ligand fields)

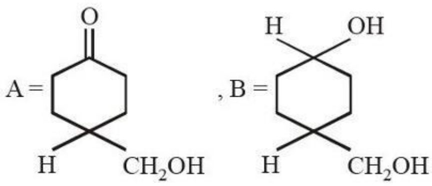
76. Chlorobenzene reacts with Mg in dry ether to give a compound (A) which further reacts with ethanol to yield

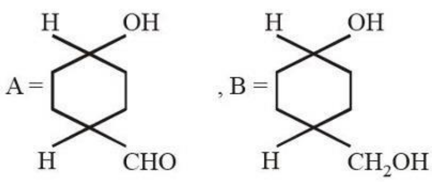
(a) Phenol (b) Benzene

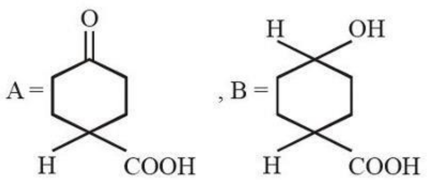
(c) Ethylbenzene (d) Phenyl ether

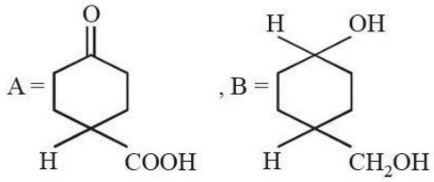
77. The products formed in the following reaction, **A** and **B** are



(a) 

(b) 

(c) 

(d) 

78. Which of the following represents the correct order of the acidity in the given compounds?

(a) $FCH_2COOH > CH_3COOH > BrCH_2COOH > ClCH_2COOH$

(b) $BrCH_2COOH > ClCH_2COOH > FCH_2COOH > CH_3COOH$

(c) $FCH_2COOH > ClCH_2COOH > BrCH_2COOH > CH_3COOH$

(d) $CH_3COOH > BrCH_2COOH > ClCH_2COOH > FCH_2COOH$

79. Ethyl alcohol can be prepared from Grignard reagent by the reaction of :

(a) HCHO (b) R_2CO

(c) RCN (d) RCOCl

80. Which of the following is most acidic?

(a) Benzyl alcohol (b) Cyclohexanol

(c) Phenol (d) *m*-chlorophenol

81. Nitration of the compound is carried out, this compound gives red–orange ppt. with 2,4–DNP, this compound undergoes Cannizzaro reaction but not aldol, then possible product due to nitration is

(a) 3–nitroacetophenone

(b) (2–nitro)–2–phenylethanal

(c) (2–nitro)–1–phenylpropan–2–one

(d) 3–nitrobezaldehyde

82. Which of the following reactions will not give a primary amine?

(a) $CH_3CONH_2 \xrightarrow{Br_2/KOH}$

(b) $CH_3CN \xrightarrow{LiAlH_4}$

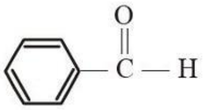
(c) $CH_3NC \xrightarrow{LiAlH_4}$

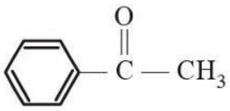
(d) $CH_3CONH_2 \xrightarrow{LiAlH_4}$

83. Which of the following compounds is most reactive towards nucleophilic addition reactions?

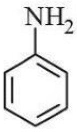
(a) $CH_3-\overset{\overset{\displaystyle O}{\|}}{C}-H$

(b) $CH_3-\overset{\overset{\displaystyle O}{||}}{C}-CH_3$

(c) 

(d) 

84. Molecules whose mirror image is non – superimposable over them are known as chiral. Which of the following molecules is chiral in nature?
(a) 2 - bromobutane
(b) 1 - bromobutane
(c) 2 - bromopropane
(d) 2 -bromopropan - 2 - ol

85. The most reactive amine towards dilute hydrochloric acid is ....
(a) CH_3-NH_2 (b) $(CH_3)_2NH$
(c) $(CH_3)_2N-CH_3$ (d) 

86. One of essential α-amino acids is
(a) lysine (b) serine
(c) glycine (d) proline

87. Which of the following statements is true about a peptide bond (RCONHR)?
(a) It is non planar.
(b) It is capable of forming a hydrogen bond.
(c) The *cis* configuration is favoured over the *trans* configuration.
(d) Single bond rotation is permitted between nitrogen and the carbonyl group.

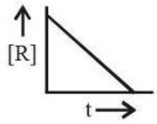
88. Which of the following is an example for chain-growth polymer?
(a) Bakelite (b) Teflon
(c) Nylon (d) Terylene

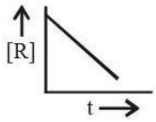
89. Which of the following polymer is formed due to the co-polymerisation of 1,3-butadiene and phenylethene?
(a) Buna-N (b) Neoprene
(c) Novalac (d) Buna-S

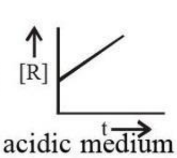
90. For 1 molal aqueous solution of the following compounds, which one will show the highest freezing point?
(a) $[Co(H_2O)_6]Cl_3$
(b) $[Co(H_2O)_5Cl]Cl_2.H_2O$
(c) $[Co(H_2O)_4Cl_2]Cl.2H_2O$
(d) $[Co(H_2O)_3Cl_3].3H_2O$

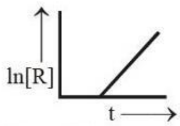
91. Which of the following expression correctly represents molar conductivity?
(a) $\wedge_m = \dfrac{K}{C}$ (b) $\wedge_m = \dfrac{KA}{l}$
(c) $\wedge_m = KV$ (d) All of these

92. The plot that represents the zero order reaction is :

(a) 

(b) 

(c) 

(d) 

93. In acidic medium which of the following does not change its colour?
(a) MnO_4^- (b) MnO_4^{2-}
(c) CrO_4^{2-} (d) FeO_4^{2-}

94. Which of the following is the life saving mixture for an asthma patient ?
(a) Mixture of helium and oxygen
(b) Mixture of neon and oxygen
(c) Mixture of xenon and nitrogen
(d) Mixture of argon and oxygen

95. The compounds $[PtCl_2(NH_3)_4]Br_2$ and $[PtBr_2(NH_3)_4]Cl_2$ constitutes a pair of
(a) coordination isomers
(b) linkage isomers
(c) ionization isomers
(d) optical isomers

96. Tincture of iodine is the common name for
(a) iodoform
(b) 2-iodopropane
(c) 2-3% iodine solution in alcohol-water
(d) iodobenzene

97. The monomers of buna-S rubber are
(a) Isoprene and butadiene
(b) Butadiene and phenol
(c) Styrene and butadiene
(d) Vinyl chloride and sulphur

98. The number of nearest neighbours in a bcc unit cell is

(a) 12 (b) 8 (c) 6 (d) 4

99. The cell potential for the following cell notation is approximately

$M(s)|M^{3+}(aq, 0.01M)||N^{2+}(aq, 0.1M)|N(s)$

$E^0_{M^{3+}/M} = 0.6$ V and $E^0_{N^{2+}/N} = 0.1$ V

(a) 0.51 V (b) 1.5V (c) 2.0V (d) 2.5V

100. In Williamson synthesis if tertiary alkyl halide is used than

(a) ether is obtained in good yield

(b) ether is obtained in poor yield

(c) alkene is the only reaction product

(d) a mixture of alkene as a major product and ether as a minor product forms.

SECTION-B

MATHEMATICS

101. If $A = \begin{bmatrix} 1 & 0 \\ 1/2 & 1 \end{bmatrix}$, then A^{50} is

(a) $\begin{bmatrix} 1 & 0 \\ 0 & 50 \end{bmatrix}$ (b) $\begin{bmatrix} 1 & 0 \\ 50 & 1 \end{bmatrix}$

(c) $\begin{bmatrix} 1 & 25 \\ 0 & 1 \end{bmatrix}$ (d) None of these

102. The range of function $f(x) = \sin^{-1}(x - \sqrt{x})$ is equal to

(a) $\left[\sin^{-1}\frac{1}{4}, \frac{\pi}{2}\right]$ (b) $\left[\sin^{-1}\frac{1}{2}, \frac{\pi}{2}\right]$

(c) $\left[-\sin^{-1}\frac{1}{4}, \frac{\pi}{2}\right]$ (d) $\left[-\sin^{-1}\frac{1}{2}, \frac{\pi}{2}\right]$

103. If $\vec{a} = \hat{i} + 2\hat{j} - 3\hat{k}$ and $\vec{b} = 2\hat{i} - 3\hat{j} - 5\hat{k}$, then

(a) $|\vec{a} - \vec{b}| > |\vec{a}| + |\vec{b}|$ (b) $|\vec{a} - \vec{b}| > |\vec{b}| - |\vec{a}|$

(c) $|\vec{a} + \vec{b}| < |\vec{a} - \vec{b}|$ (d) $||\vec{a}| - |\vec{b}|| > |\vec{a} - \vec{b}|$

104. If $\sqrt{\frac{y}{x}} + 4\sqrt{\frac{x}{y}} = 4$, then $\frac{dy}{dx}$

(a) xy (b) x/y

(c) -4 (d) 4

105. The function $f(x) = \tan^{-1}(\sin x + \cos x)$ is an increasing function in

(a) $\left(0, \frac{\pi}{2}\right)$ (b) $\left(-\frac{\pi}{2}, \frac{\pi}{2}\right)$

(c) $\left(\frac{\pi}{4}, \frac{\pi}{2}\right)$ (d) $\left(-\frac{\pi}{2}, \frac{\pi}{4}\right)$

106. If $f(x) = ||x| - 1|$, then points, where $f(x)$ is not differentiable, is/are

(a) 0, 1 (b) $\pm$ 1, 0

(c) 0 (d) 1 only

107. $\int_{\pi/11}^{9\pi/22} \frac{dx}{1+\sqrt{\tan x}} =$

(a) $\pi/4$ (b) $\pi/22$

(c) $\pi/11$ (d) $7\pi/44$

108. Let

$\vec{a} = \hat{i} + 2\hat{j} + \hat{k}, \vec{b} = \hat{i} - \hat{j} + \hat{k}$ and $\vec{c} = \hat{i} + \hat{j} - \hat{k}$.

A vector in the plane of $\vec{a}$ and $\vec{b}$ whose projection on $\vec{c}$ is $\frac{1}{\sqrt{3}}$, is

(a) $4\hat{i} - \hat{j} + 4\hat{k}$ (b) $3\hat{i} + \hat{j} - 3\hat{k}$

(c) $2\hat{i} + \hat{j} - 2\hat{k}$ (d) $4\hat{i} + \hat{j} - 4\hat{k}$

109. Let p : I am brave.

q : I will climb the Mount Everest.

The symbolic form of a statement,

'I am neither brave nor I will climb the mount Everest' is

(a) $p \wedge q$ (b) $\sim (p \wedge q)$

(c) $\sim p \wedge \sim q$ (d) $\sim p \wedge q$

110. If $x \neq 0$, then

$$\frac{\sin(\pi+x)\cos\left(\frac{\pi}{2}+x\right)\tan\left(\frac{3\pi}{2}-x\right)\cot(2\pi-x)}{\sin(2\pi-x)\cos(2\pi+x)\operatorname{cosec}(-x)\sin\left(\frac{3\pi}{2}+x\right)} =$$

(a) 0 (b) -1
(c) 1 (d) 2

111. $i^2 + i^3 + \ldots + i^{4000} =$

(a) 1 (b) 0
(c) i (d) $-i$

112. The number of all four digit numbers which begin with 4 and end with either zero or five is

(a) 200 (b) 64
(c) 256 (d) 32

113. The number of ways of distributing 500 dissimilar boxes equally among '50' persons is

(a) $500!/(10!)^{50} . 50!$
(b) $500!/(50!)^{10} .10!$
(c) $500!/(50!)^{10}$
(d) $500!/(10!)^{50}$

114. Given, the function $f(x) = \frac{a^x + a^{-x}}{2}$ $(a > 2)$, then $f(x + y) + f(x - y)$ is equal to

(a) $f(x) - f(y)$ (b) $f(y)$
(c) $2f(x)f(y)$ (d) $f(x)f(y)$

115. The point on the line $4x - y - 2 = 0$ which is equidistant from the point $(-5, 6)$ and $(3, 2)$ is

(a) (2, 6) (b) (4, 14)
(c) (1, 2) (d) (3, 10)

116. The equation of a circle with centre (5, 4) and touch the Y-axis is

(a) $x^2 + y^2 - 10x - 8y - 16 = 0$
(b) $x^2 + y^2 - 10x - 8y - 16 = 0$
(c) $x^2 + y^2 + 10x + 8y + 16 = 0$
(d) $x^2 + y^2 - 10x - 8y + 16 = 0$

117. $\lim\limits_{\theta \to -\frac{\pi}{4}} \frac{\cos\theta + \sin\theta}{\theta + \frac{\pi}{4}} =$

(a) 0 (b) 1
(c) $\sqrt{2}$ (d) $1/\sqrt{2}$

118. Marks of 5 students of a group are 8, 12, 13, 15 and 22, then find the variance.

(a) 22.1 (b) 23
(c) 20.2 (d) 21.2

119. If two numbers p and q are choosen randomly from the set {1, 2, 3, 4} with replacement, then the probability that $p^2 \geq 4q$ is equal to

(a) $\frac{1}{4}$ (b) $\frac{3}{16}$
(c) $\frac{1}{2}$ (d) $\frac{7}{16}$

120. Let $F(\alpha) = \begin{bmatrix} \cos\alpha & -\sin\alpha & 0 \\ \sin\alpha & \cos\alpha & 0 \\ 0 & 0 & 1 \end{bmatrix}$ where $\alpha \in R$.

Then $[F(\alpha)]^{-1}$ is equal to

(a) $F(-\alpha)$ (b) $F(\alpha^{-1})$
(c) $F(2\alpha)$ (d) None of these

121. Let $\vec{a}, \vec{b}$ and $\vec{c}$ be non-zero vectors such that $(\vec{a} \times \vec{b}) \times \vec{c} = \frac{1}{3}|\vec{b}||\vec{c}|\vec{a}$. If θ is the acute angle between the vectors $\vec{b}$ and $\vec{c}$, then $\sin\theta$ equals

(a) $\frac{2\sqrt{2}}{3}$ (b) $\frac{\sqrt{2}}{3}$
(c) $\frac{2}{3}$ (d) $\frac{1}{3}$

122. Let the foot of the perpendicular from the point (1, 2, 4) on the line $\frac{x+2}{4} = \frac{y-1}{2} = \frac{z+1}{3}$ be P. Then the distance of P from the plane $3x + 4y + 12z + 23 = 0$

(a) 5 (b) $\frac{50}{13}$
(c) 4 (d) $\frac{63}{13}$

123. If one of the lines given by $6x^2 - xy + 4cy^2 = 0$ is $3x + 4y = 0$, then c equals

(a) –3 (b) 1

(c) 3 (d) 1

124. If $x = a\,(\cos\theta + \theta\sin\theta)$, $y = a\,(\sin\theta - \theta\cos\theta)$,

then $\dfrac{d^2y}{dx^2} =$

(a) $\dfrac{\sec^3\theta}{a\theta}$ (b) $\dfrac{\sec^2\theta}{\theta}$

(c) $a\theta\cos^3\theta$ (d) $\dfrac{\sec^2\theta}{a}$

125. The absolute maximum value of the function $f(x) = 2x^3 - 3x^2 - 36x + 9$ defined on $[-3, 3]$ is

(a) 36 (b) 53

(c) 63 (d) 72

126. Define $f(x) = \begin{cases} x^2 + bx + c, & x < 1 \\ x, & x \geq 1 \end{cases}$. If $f(x)$ is differentiable at $x = 1$, then $(b - c)$ is equal to

(a) –2 (b) 0

(c) 1 (d) 2

127. The Boolean expression $(\sim(p \wedge q)) \vee q$ is equivalent to :

(a) $q \rightarrow (p \wedge q)$ (b) $p \rightarrow q$

(c) $p \rightarrow (p \rightarrow q)$ (d) $p \rightarrow (p \vee q)$

128. If $x = \dfrac{1-t^2}{1+t^2}$ and $y = \dfrac{2t}{1+t^2}$, then $\dfrac{dy}{dx}$ is equal to

(a) $-\dfrac{y}{x}$ (b) $\dfrac{y}{x}$

(c) $-\dfrac{x}{y}$ (d) $\dfrac{x}{y}$

129. The tangent at the point (x_1, y_1) on the curve $y = x^3 + 3x^2 + 5$ passes through the origin, then (x_1, y_1) does NOT lie on the curve:

(a) $x^2 + \dfrac{y^2}{81} = 2$ (b) $\dfrac{y^2}{9} - x^2 = 8$

(c) $y = 4x^2 + 5$ (d) $\dfrac{x}{3} - y^2 = 2$

130. The value of $\displaystyle\int \frac{x\sin^{-1}x}{\sqrt{1-x^2}}dx$ is equal to :

(a) $\sqrt{(1-x^2)}\sin^{-1}x + C$

(b) $x\sin^{-1}x + C$

(c) $x - \sqrt{(1-x^2)}\sin^{-1}x + C$

(d) $\sqrt{(\sin^{-1}x)} + C$

131. $\displaystyle\int \frac{x+1}{x\left(1+xe^x\right)}dx$ is equal to

(a) $\log\left|\dfrac{1+xe^x}{xe^x}\right| + C$

(b) $\log\left|\dfrac{xe^x}{1+xe^x}\right| + C$

(c) $\log|xe^x(1 + xe^x)| + C$

(d) $\log|1 + xe^x| + C$

132. The order and degree of the differential equation $\sqrt{\dfrac{dy}{dx}} - 4\dfrac{dy}{dx} - 7x = 0$ are respectively

(a) 1 and $\dfrac{1}{2}$ (b) 2 and 1

(c) –1 and 1 (d) 1 and 2

133. Let $\vec{a} = \hat{i} + \hat{j} + \hat{k}$, $\vec{b} = \hat{i} + 3\hat{j} + 5\hat{k}$ and $\vec{c} = 7\hat{i} + 9\hat{j} + 11\hat{k}$, then the area of parallelogram having diagonals $\vec{a} + \vec{b}$ and $\vec{b} + \vec{c}$ is

(a) $4\sqrt{6}$ sq units (b) $4\sqrt{6}$ sq units

(c) $\sqrt{6}$ sq units (d) $6\sqrt{6}$ sq units

134. If X is a random variable such that $P(X = -2) = P(X = -1) = P(X = 2) = P(X = 1) = \dfrac{1}{6}$ and $P(X = 0) = \dfrac{1}{3}$, then the mean of X is

(a) $\frac{5}{3}$ (b) 1

(c) 0 (d) $\frac{3}{5}$

135. $\int e^x \left(\frac{2+\sin 2x}{1+\cos 2x}\right) dx =$

(a) $e^x \sec x + C$ (b) $e^x \tan x + C$

(c) $e^x \cot x + C$ (d) $e^x \operatorname{cosec} x + C$

136. The solution of the differential equation

$y^2 dx + (x^2 - xy + y^2) dy = 0$ is

(a) $\tan^{-1}\left(\frac{x}{y}\right) + \ln y + C = 0$

(b) $2\tan^{-1}\left(\frac{x}{y}\right) + \ln x + C = 0$

(c) $\ln(v + \sqrt{x^2 + y^2}) + \ln y + C = 0$

(d) $\ln(x + \sqrt{x^2 + y^2}) + C = 0$

137. The lines whose vector equations are

$r = 2\hat{i} - 3\hat{j} + 7\hat{k} + \lambda(2\hat{i} + p\hat{j} + 5\hat{k})$

and $r = \hat{i} - 2\hat{j} + 3\hat{k} + \mu(3\hat{i} + p\hat{j} + p\hat{k})$

are perpendicular for all values of λ and μ if $p =$

(a) 1 (b) -1

(c) -6 (d) 6

138. $\sin\left(\tan^{-1}\frac{4}{5} + \tan^{-1}\frac{4}{3} + \tan^{-1}\frac{1}{9} - \tan^{-1}\frac{1}{7}\right)$ is equal to

(a) $\frac{1}{2}$ (b) $\frac{1}{\sqrt{2}}$

(c) $\frac{\sqrt{3}}{2}$ (d) 1

139. Let $f(x) = \frac{2 - \sqrt{x+4}}{\sin 2x}, x \neq 0$. In order that $f(x)$ is continuous at $x = 0, f(0)$ is to be defined as

(a) $\frac{-1}{8}$ (b) $\frac{1}{2}$

(c) 1 (d) $\frac{1}{8}$

140. $\int_0^{\frac{\pi}{4}} \frac{\cos^2 x}{\cos^2 x + 4\sin^2 x} dx =$

(a) $\frac{\pi}{4} + \frac{2}{3}\tan^{-1} 2$

(b) $-\frac{\pi}{3} - \frac{2}{3}\tan^{-1} 3$

(c) $-\frac{\pi}{12} + \frac{2}{3}\tan^{-1} 2$

(d) $\frac{\pi}{6} - \frac{2}{3}\tan^{-1} 4$

141. The area of the region described by $\{(x, y) / x^2 + y^2 \leq 1$ and $y^2 \leq 1 - x\}$ is

(a) $\frac{\pi}{2} - \frac{2}{3}$ (b) $\frac{\pi}{2} + \frac{2}{3}$

(c) $\frac{\pi}{2} + \frac{4}{3}$ (d) $\frac{\pi}{2} - \frac{4}{3}$

142. Two players A and B are alternately throwing a coin and a die together. A player who first throws head and 6 wins the game. If A starts the game, then the probability that B wins the game is

(a) $\frac{12}{23}$ (b) $\frac{11}{23}$

(c) $\frac{5}{119}$ (d) $\frac{12}{119}$

143. Let the following system of equations

$kx + y + z = 1$

$x + ky + z = k$

$x + y + kz = k^2$

has no solution. Find $|k|$.

(a) 0 (b) 1

(c) 2 (d) 3

144. If $f(x)$ is differentiable at $x = 1$ and

$\lim\limits_{h \to 0} \frac{1}{h} f(1+h) = 5$, then $f'(1)$ is equal to

(a) 6 (b) 5
(c) 4 (d) 3

145. The area of the region

$\{(x, y): 0 \le y \le x^2 + 1, 0 \le y \le x + 1, 0 \le x \le 2\}$ is

(a) $\frac{23}{6}$ (b) $2\sqrt{2} + 5$

(c) $\frac{9}{2}$ (d) None of these

146. The solution of the differential equation $\sqrt{1 - y^2}\, dx + x\, dy - \sin^{-1} y\, dy = 0$, is

(a) $x = \sin^{-1} y - 1 + ce^{-\sin^{-1} y}$

(b) $y = x\sqrt{1 - y^2} + \sin^{-1} y + c$

(c) $x = 1 + \sin^{-1} y + ce^{\sin^{-1} y}$

(d) $y = \sin^{-1} y - 1 + x\sqrt{1 - y^2} + c$

147. Let X be the discrete random variable representing the number (x) appeared on the face of a biased die when it is rolled. The probability distribution of X is

X = x	1	2	3	4	5	6
P(X = x)	0.1	0.15	0.3	0.25	k	k

Then variance of X is

(a) 1.64 (b) 1.93
(c) 2.16 (d) 2.28

148. If vector equation of the line

$\frac{x-2}{2} = \frac{2y-5}{-3} = z + 1$, is

$\vec{r} = \left(2\hat{i} + \frac{5}{2}\hat{j} - \hat{k}\right) + \lambda\left(2\hat{i} - \frac{3}{2}\hat{j} + p\hat{k}\right)$ then p is equal to

(a) 0 (b) 1
(c) 2 (d) 3

149. Which of the following is correct ?

(a) B' AB is symmetric if A is symmetric.
(b) B' AB is skew-symmetric if A is symmetric.
(c) B' AB is symmetric if A is skew-symmetric.
(d) B' AB is symmetric if A is skew-symmetric.

150. A spherical iron ball 10 cm in radius is coated with a layer of ice of uniform thickness that melts at a rate of 50 cm^3 /min. When the thickness of ice is 15 cm, then the rate at which the thickness of ice decreases, is

(a) $\frac{5}{6\pi}$ cm/min (b) $\frac{1}{54\pi}$ cm/min

(c) $\frac{1}{18\pi}$ cm/min (d) $\frac{1}{36\pi}$ cm/min

ANSWER KEYS & SOLUTIONS

(MHT-CET 2024)

Answer Keys

SECTION-A																			
PHYSICS																			
1	(b)	**6**	(d)	**11**	(b)	**16**	(b)	**21**	(b)	**26**	(d)	**31**	(a)	**36**	(b)	**41**	(a)	**46**	(b)
2	(c)	**7**	(c)	**12**	(a)	**17**	(d)	**22**	(d)	**27**	(c)	**32**	(b)	**37**	(a)	**42**	(b)	**47**	(d)
3	(b)	**8**	(a)	**13**	(b)	**18**	(a)	**23**	(c)	**28**	(d)	**33**	(c)	**38**	(b)	**43**	(d)	**48**	(d)
4	(c)	**9**	(c)	**14**	(b)	**19**	(a)	**24**	(a)	**29**	(d)	**34**	(c)	**39**	(c)	**44**	(c)	**49**	(b)
5	(b)	**10**	(a)	**15**	(b)	**20**	(d)	**25**	(b)	**30**	(b)	**35**	(b)	**40**	(c)	**45**	(a)	**50**	(a)
CHEMISTRY																			
51	(c)	**56**	(c)	**61**	(c)	**66**	(b)	**71**	(b)	**76**	(b)	**81**	(d)	**86**	(a)	**91**	(d)	**96**	(c)
52	(b)	**57**	(d)	**62**	(a)	**67**	(c)	**72**	(c)	**77**	(c)	**82**	(c)	**87**	(b)	**92**	(b)	**97**	(c)
53	(a)	**58**	(b)	**63**	(a)	**68**	(d)	**73**	(d)	**78**	(c)	**83**	(a)	**88**	(b)	**93**	(a)	**98**	(b)
54	(c)	**59**	(b)	**64**	(c)	**69**	(a)	**74**	(c)	**79**	(a)	**84**	(a)	**89**	(d)	**94**	(a)	**99**	(a)
55	(d)	**60**	(b)	**65**	(c)	**70**	(b)	**75**	(d)	**80**	(d)	**85**	(b)	**90**	(d)	**95**	(c)	**100**	(c)
SECTION-B																			
MATHEMATICS																			
101	(d)	**106**	(b)	**111**	(d)	**116**	(d)	**121**	(a)	**126**	(a)	**131**	(b)	**136**	(a)	**141**	(c)	**146**	(a)
102	(c)	**107**	(d)	**112**	(a)	**117**	(c)	**122**	(a)	**127**	(d)	**132**	(d)	**137**	(d)	**142**	(b)	**147**	(b)
103	(b)	**108**	(a)	**113**	(d)	**118**	(d)	**123**	(a)	**128**	(c)	**133**	(a)	**138**	(d)	**143**	(c)	**148**	(a)
104	(d)	**109**	(c)	**114**	(c)	**119**	(d)	**124**	(a)	**129**	(d)	**134**	(c)	**139**	(a)	**144**	(b)	**149**	(a)
105	(d)	**110**	(c)	**115**	(b)	**120**	(a)	**125**	(b)	**130**	(c)	**135**	(b)	**140**	(c)	**145**	(a)	**150**	(c)

SECTION-A

PHYSICS

1. **(b)** Electrostatic force acting between two point charges in vacuum

$$F = \frac{1}{4\pi \in_0} \frac{q_1 q_2}{r^2}$$

Electrostatic force acting between two point charges in a medium of dielectric constant K is

$$F' = \frac{1}{4\pi(K \in_0)} \frac{q_1 q_2}{(r')^2} = \frac{25}{4\pi(5 \in_0)} \frac{q_1 q_2}{(r)^2}$$

$\Rightarrow$ $F' = 5F$

2. **(c)** Using law of conservation of angular momentum, $I_1\omega = I_2\omega_2$

$$\frac{MR^2}{2}\omega = \frac{3}{2}\left(\frac{MR^2}{2}\right)\omega_2 \Rightarrow \omega_2 = \frac{2}{3}\omega$$

3. **(b)** From the Bernoulli's theorem

$$P + \rho gh + \frac{1}{2}\rho V^2 = \text{constant}$$

4. **(c)** Maximum height in projectile motion

$$H_{max} = \frac{u^2 \sin^2\theta}{2g}$$

For two projectiles $\theta_1 = 30°$ and $\theta_2 = 60°$

$$\therefore \quad \frac{H_1}{H_2} = \frac{\frac{u^2 \sin^2 30°}{2g}}{\frac{u^2 \sin^2 60°}{2g}} = \frac{1}{3}$$

5. **(b)** AC is an isochoric process

$\therefore$ $W_{AC} = 0$

BC is an isobaric process

$\therefore$ $W_{BC} = P\Delta V = 10(2-4) = -20$ J

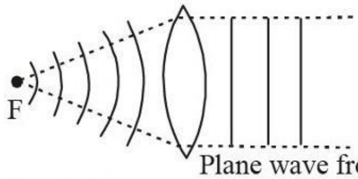
Work done during process AB

$$W_{AB} = \int PdV = \int_2^4 \frac{RT}{V^3} dV = \frac{-RT}{2}\left[\frac{1}{V^2}\right]_2^4$$

$$\frac{-RT}{2}\left[\frac{1}{11} - \frac{1}{4}\right] = 225 \text{ J}$$

$\therefore$ Total work done $= -20$ J $+ 225$ J $= 205$ J

6. **(d)**



Plane wave front

As, the light emerges parallel. So, plane wavefront is formed.

7. **(c)** Given that mass of monkey, $m = 50$ kg

Acceleration due to gravity, $g = 10$ m/s^2

Tension (T) = 350 N

Given monkey climbs downward, acceleration of monkey, $a = 4$ m/s^2

When monkey climbs upward, acceleration of monkey,

$a = 5$ m/s^2

(For upward)

$T - mg = ma \Rightarrow T = mg + ma = 50(10 + 5) =$ 750 N

Rope will break while climbing upward

(For downward)

$T = m(g - a) = 50(10 - 4) = 300$ N

Rope will not break while climbing downward

8. **(a)** Sum of current at junction point will be zero:

$$\frac{x-30}{10} + \frac{x-12}{20} + \frac{x-2}{30} = 0$$

$$\Rightarrow x\left(\frac{1}{10} + \frac{1}{20} + \frac{1}{30}\right) = \frac{30}{10} + \frac{12}{20} + \frac{2}{30}$$

$$\Rightarrow x\left(\frac{6+3+2}{60}\right) = \frac{180+36+4}{60}$$

$$\Rightarrow x = \frac{220}{11} = 20\text{V}$$

Hence, current through the 20Ω resistor will be $\frac{x-12}{20} = \frac{20-12}{20} = \frac{2}{5} = 0.4$A

9. **(c)** Electric current,

$i \propto \theta$ (angle of deflection)

$$\therefore \frac{i_2}{i_1} = \frac{\theta_2}{\theta_1} \Rightarrow \frac{i_2}{200\mu A} = \frac{\pi/10}{\pi/3} = \frac{3}{10}$$

$$\left[\because 60° = \frac{\pi}{3}\right]$$

$\therefore$ $i_2 = 60$ μA

10. **(a)** $g_{\text{eff}} = \dfrac{g}{\left(1+\dfrac{h}{R}\right)^2}$

$\Rightarrow \dfrac{g}{2} = \dfrac{g}{\left(1+\dfrac{h}{R}\right)^2} \Rightarrow \sqrt{2} = 1+\dfrac{h}{R}$

$\Rightarrow \dfrac{h}{R} = \sqrt{2}-1$

$\Rightarrow h = (\sqrt{2}-1)\times 6400\times 10^3 \text{ m} = 2.6\times 10^6 \text{ m}$

11. **(b)** For a diamagnetic material, the value of μ_r is slightly less than one. For any material, the value of $\in_r$ is always greater than 1.

12. **(a)** $\phi = 5t^3 + 4t + 2t - 5$

$|e| = 15t^2 + 8t + 2 \qquad \left[\because |e| = \dfrac{d\phi}{dt}\right]$

$R = 5\Omega$

So, $i = \dfrac{|e|}{R} = \dfrac{15t^2+8t+2}{5} = 3t^2 + 1.6t + 0.4$

$= 3.2^2 + 1.6\times 2 + 0.4 = 15.6\text{ A} \quad (\because t = 2 \text{ sec})$

13. **(b)** We have $\Delta V = V_0\gamma\Delta T$

$\Delta V = a^3.(3\alpha)\,\Delta T$

Now, $6a^2 = 24$ $\quad$ [$\because$ Total surface area of cube = $6a^2$]

$\Rightarrow a^2 = 4 \quad \Rightarrow a = 2$

So, $\Delta V = 2^3(3\times 5\times 10^{-4})\times 10 = 1200\times 10^{-4}\text{ m}^3$

$= 1200\times 10^2 \text{ cm}^3 = 1.2\times 10^5 \text{ cm}^3$

14. **(b)** Mutual inductance depends on the relative position and orientation of the two coils.

15. **(b)** de-Broglie wavelength is given by

$\lambda = \dfrac{h}{mv} = \dfrac{h}{\sqrt{2mk}} \qquad \therefore \quad \lambda\alpha = \dfrac{1}{\sqrt{m}}$

$\because \quad m_e < mp < m_\alpha$

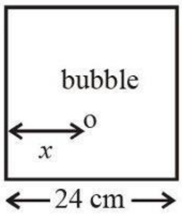
$\therefore \quad \lambda_a < \lambda_p < \lambda_e$

16. **(b)** Refractive index, $\mu = \dfrac{d_{\text{real}}}{d_{\text{apparent}}}$

When viewed from one side

$\mu = \dfrac{x}{12} \qquad \text{...(i)}$

When viewed from other side



$\mu = \dfrac{24-x}{4} \qquad \text{...(ii)}$

From (i) and (ii)

$\Rightarrow \dfrac{x}{12} = \dfrac{24-x}{4} \Rightarrow \dfrac{x}{12} = 6 - \dfrac{x}{4} \Rightarrow \dfrac{x}{12} + \dfrac{x}{4} = 6$

$\Rightarrow \dfrac{4x}{12} = 6 \Rightarrow x = 18$

$\therefore \mu = \dfrac{18}{12} = 1.5 \qquad \text{(using (i))}$

17. **(d)** Longest wavelength in Paschen's series occurs for $n_2 = 4$ to $n_1 = 3$

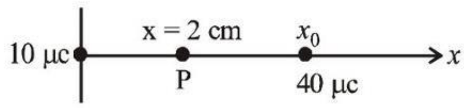
$\dfrac{1}{\lambda} = R\left[\dfrac{1}{n_1^2} - \dfrac{1}{n_2^2}\right]$

$\dfrac{1}{\lambda} = R\left[\dfrac{1}{(3)^2} - \dfrac{1}{(4)^2}\right] = R\left[\dfrac{16-9}{16\times 9}\right]$

$\Rightarrow \lambda = \dfrac{16\times 9}{7R} = \dfrac{16\times 9}{7\times 1.097\times 10^7} = 1.876\times 10^{-6}\text{m}$

18. **(a)** Nuclear density is independent of atomic number.

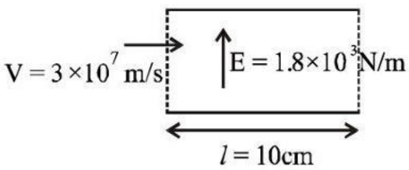
19. **(a)**



As,

$E_P = 0 \Rightarrow K\times\dfrac{10\times 10^{-6}}{2^2}\hat{i} - K\dfrac{(40\times 10^{-6})}{(x_0-2)^2}\hat{i} = 0$

$\Rightarrow \dfrac{10\times 10^{-6}}{40\times 10^{-6}} = \dfrac{2^2}{(x_0-2)^2}$



$\Rightarrow \dfrac{1}{2} = \dfrac{2}{x_0-2} \Rightarrow x_0 - 2 = 4 \Rightarrow x_0 = 6 \text{ cm}$

20. **(d)** A magnetic needle kept in non uniform magnetic field experience a force and torque due to unequal forces acting on poles.

21. **(b)** Magnetic force per unit length on wire PQ due to wire RS is given by

$$\frac{F}{\ell}=\frac{\mu_o}{4\pi}\frac{2I_1I_2}{r}$$

$\therefore \quad F_1 \propto I_1 I_2 \propto (I)^2$

When ammeter current reading is changed to 2I.

$F_2 \propto (2I)^2$

$\therefore \quad F_1 : F_2 = 1:4$

22. **(d)** $T_{O_2} = 47+273 = 320\,K$

$$v_{H_2} = v_{O_2}$$

$$\sqrt{\frac{3RT_{H_2}}{m_{H_2}}} = \sqrt{\frac{3RT_{O_2}}{m_{O_2}}}$$

$$\because v_{rms} = \sqrt{\frac{3RT}{m}} \Rightarrow \sqrt{\frac{T_{H_2}}{2}} = \sqrt{\frac{320}{32}}$$

$$\Rightarrow T_{H_2} = \frac{320}{16} = 20K$$

23. **(c)** Given,
B and gap of semiconducting material Eg = 1.42 eV

Using, $Eg = \frac{1240}{\lambda}$

$$\Rightarrow \quad \lambda = \frac{1240}{1.42} = 875 \text{ nm (Approx)}$$

24. **(a)** The speed of transverse wave in the wire is

$$v = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{70}{7\times10^{-3}}} = 100 \text{ m/s}$$

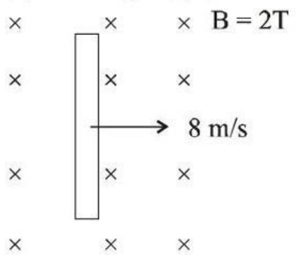
25. **(b)** $n_A = \frac{1}{2}$ mol, $n_B = \frac{1}{32}$ mol

By ideal gas equation,

$PV = nRT \Rightarrow P \propto n$

$$\therefore \frac{P_A}{P_B} = \frac{n_A}{n_B} = \frac{32}{2} = 16$$

26. **(d)** Given, length, $\ell = 1$m



Velocity, v = 8 m/s

Magnetic Field, B = 2T

Induced emf across

the ends = $Bv\ell$

$= 2\times8\times1 = 16\,V$

27. **(c)** Radius of circle, r = a

Centrifugal force, $F = m\omega^2 r$

$$\Rightarrow \frac{Gmm}{(2a)^2} = m\omega^2 a \qquad \left(\because F = \frac{G M_1M_2}{d}\right)$$

Here $M_1 = m$; $M_2 = m$ and $d = 2a$

$$\Rightarrow \text{angular speed, } \omega = \sqrt{\frac{Gm}{4a^3}}$$

28. **(d)** Electrons in an unbiased *p-n* junction, diffuse from *n*-region i.e. higher electron concentration to *p*-region i.e. low electron concentration region.

29. **(d)** Total energy in SHM $= \frac{1}{2}kA^2$

Here, k = force constant

A = amplitude of S.H.M.

Potential energy, $= \frac{1}{2}kx^2$

x = displacement from mean position

Kinetic energy $= \frac{1}{2}kA^2 - \frac{1}{2}kx^2$

$$\therefore \frac{P.E}{K.E} = \frac{x^2}{A^2-x^2} = \frac{\left(\frac{A}{2}\right)^2}{A^2-\left(\frac{A}{2}\right)^2} = \frac{A^2}{4\left(\frac{3A^2}{4}\right)} = \frac{1}{3}$$

30. **(b)** Let r be the radius of small drops of water.

R = radius of big drop formed

as volume remain same.

$$\therefore 8.\frac{4}{3}\pi r^3 - \frac{4}{3}\pi R^3 \Rightarrow R = 2r$$

Terminal velocity,

$$v_T = \frac{2}{9\eta}(\rho-\sigma)r^2 g$$

$$\therefore v_T \propto r^2 \qquad \therefore \frac{v_1}{v_2} = \left(\frac{r}{R}\right)^2$$

$$\Rightarrow \frac{10}{v_2} = \left(\frac{1}{2}\right)^2 \qquad (\because v_1 = 10 \text{ cm/s given})$$

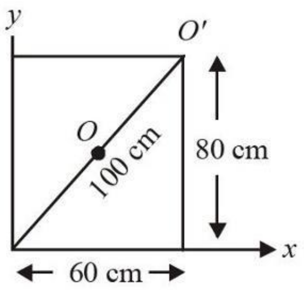
$$\Rightarrow v_2 = 40 \text{ cm/s}$$

31. **(a)** Induced Emf is given as,

$$E_L = -L\frac{di}{dt} \Rightarrow 0.1 = \frac{(L)[+2-(-2)]}{0.2} \Rightarrow L = 5mH$$

32. **(b)** Moment of inertia of rectangular sheet about an axis passing through O,

$$I_O = \frac{M}{12}(a^2+b^2) = \frac{M}{12}[(80)^2+(60)^2]$$



From the parallel axis theorem, moment of inertia about O',

$$I_{O'} = I_O + M(50)^2$$

$$\frac{I_O}{I_{O'}} = \frac{\frac{M}{12}(80^2+60^2)}{\frac{M}{12}(80^2+60^2)+M(50)^2} = \frac{1}{4}$$

33. **(c)** The average distance between two successive collisions of molecule is

$$\lambda = \frac{1}{\sqrt{2}\pi d^2 n}$$

34. **(c)** For monoatomic gas, $C_v = \frac{3}{2}R$

For diatomic gas, $C'_v = \frac{5}{2}R$

$$\therefore \text{Ratio} = \frac{C_v}{C'_v} = \frac{\frac{3}{2}R}{\frac{5}{2}R} = \frac{3}{5}$$

35. **(b)** The average power in one cycle is

$P_{avg} = V_{rms} I_{rms} \cos(\Delta\phi)$

$$= \frac{100}{\sqrt{2}} \times \frac{100\times10^{-3}}{\sqrt{2}} \times \cos\left(\frac{\pi}{3}\right)$$

$$\left[\because V_{rms} = \frac{V_0}{\sqrt{2}}, I_{rms} = \frac{I_0}{\sqrt{2}}\right]$$

$$= \frac{10^4}{2} \times \frac{1}{2} \times 10^{-3}$$

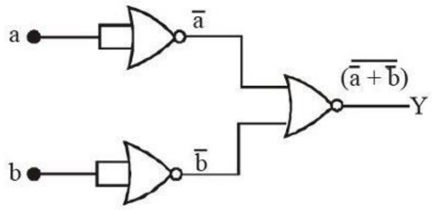
$$= \frac{10}{4} = 2.5\,W$$

36. **(b)** Energy $E = \frac{hc}{\lambda} \Rightarrow \lambda = \frac{hc}{E} = \frac{hc}{\phi} = \frac{1242}{\phi}$

$$\lambda_A = \left(\frac{1242}{9}\right) = 138\,nm$$

$$\lambda_B = \left(\frac{1242}{4.5}\right) = 276\,nm$$

37. **(a)**



$$Y = \overline{\bar{a}+\bar{b}} = \overline{(\overline{a.b})}a.b$$

The circuit will follow truth table

A	B	Output
0	0	0
0	1	0
1	0	0
1	1	1

Hence it is AND gate.

38. **(b)** We know that $V = \omega\sqrt{A^2 - x^2}$

Initially $V = \omega\sqrt{A^2 - \left(\frac{2A}{3}\right)^2}$

Finally $3V = \omega\sqrt{A'^2 - \left(\frac{2A}{3}\right)^2}$

Where A'= final amplitude (Given at $x = \frac{2A}{3}$, velocity to trebled)

On dividing we get

$$\frac{3}{1} = \frac{\sqrt{A'^2 - \left(\frac{2A}{3}\right)^2}}{\sqrt{A^2 - \left(\frac{2A}{3}\right)^2}} \Rightarrow 9\left[A^2 - \frac{4A^2}{9}\right] =$$

$$A'^2 - \frac{4A^2}{9}$$

$$\Rightarrow A' = \frac{7A}{3}$$

39. **(c)** Given, $m_P = 1.0073\text{u}; m_N = 1.0087\text{u}; m_{He} = 4.0015\text{u}$

$B.E$ of Helium $= (2m_P + 2m_N - m_{He})c^2$

$= (2 \times 1.0073 + 2 \times 1.0087 - 4.0015) \times 931.5$

$= 28.4\,\text{MeV}$

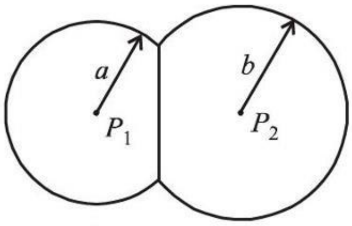
40. **(c)** Voltage across inductor, $V_L = IX_L = I\omega L$

$$\therefore I = \frac{V_L}{\omega L} = \frac{V_L}{2\pi f L} = \frac{31.4}{2\pi \times 50 \times 10 \times 10^{-3}} = 10\text{A}$$

41. **(a)** Let R be the radius of curvature of common surface

$$P_1 = P_0 + \frac{4T}{a} \text{ and } P_2 = P_0 + \frac{4T}{b}$$

$$\text{And } P_1 - P_2 = \frac{4T}{R}$$



$$\left(P_0 + \frac{4T}{a}\right) - \left(P_0 + \frac{4T}{b}\right) = \frac{4T}{R}$$

$$\Rightarrow \quad \frac{1}{a} - \frac{1}{b} = \frac{1}{R} \qquad \therefore \quad R = \frac{ab}{(b-a)}$$

42. **(b)**

43. **(d)** Beat frequency $= f_1 - f_2$

$$\frac{40}{12} = \frac{v}{4.08} - \frac{v}{4.16} \Rightarrow \frac{10}{3} = v\left(\frac{0.08}{4.08 \times 4.16}\right)$$

$\Rightarrow v = 707.2\,\text{m/s}$

44. **(c)** Using Gauss law

$$\int \vec{E} \cdot d\vec{A} = \frac{Q}{\varepsilon_0}$$

$$EdA = \frac{\sigma \times dA}{\varepsilon_0} \qquad [\because Q = \sigma dA]$$

$$\Rightarrow E = \frac{\sigma}{\varepsilon_0}$$

45. **(a)** $\vec{E} = \left(6\hat{i} + 5\hat{j} + 3\hat{k}\right)\text{N/C}$

$\vec{A} = 30\hat{i}\,\text{m}^2$

Electric flux, $\phi = \vec{E}.\vec{A}$

$= \left(6\hat{i} + 5\hat{j} + 3\hat{k}\right).\left(30\hat{i}\right) = 6 \times 30 = 180\,\text{V-m}$

46. **(b)** Since volume conserved, so $V_B = V_S$

$$\frac{4}{3}\pi R^3 = 1000\frac{4}{3}\pi r^3 \Rightarrow R = 10\,r$$

Here,

r = Radius of small drop

R = Radius of big drop

Initial energy $E_i = 1000\,(4\pi r^2 S)$

final energy $E_f = 4\pi R^2 S = 100\,(4\pi r^2 S)$

$$\therefore \frac{E_f}{E_i} = \frac{1}{10} \Rightarrow E_f = \frac{1}{10}E_i$$

47. **(d)** We have, $h = \dfrac{2T\cos\theta}{r\rho g}$

Mass of the water in the capillary

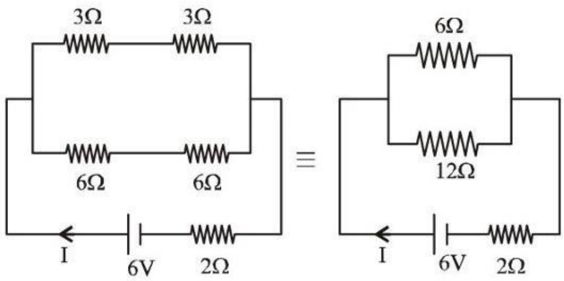
$$m = \rho V = \rho \times \pi r^2 h = \rho \times \pi r^2 \times \frac{2T\cos\theta}{r\rho g} \Rightarrow m \propto r$$

$$\therefore \frac{m_1}{m_2} = \frac{r}{2r} \quad \text{or } m_2 = 2m_1 = 2\,\text{M}.$$

48. **(d)** Third overtone has a frequency 7 n, which means $L = \dfrac{7\lambda}{4}$ = three full loops + one half loop, which would make four nodes and four antinodes.

49. **(b)** The electrostatic potential due to an electronic dipole at a distance r given as $V_P \propto \dfrac{1}{r^2}$

50. **(a)** Balanced wheat stone bridge in circuit so there is no current in 5Ω resistor so it can be removed from the circuit.



The equivalent resistance will be

$$R_{eq} = \frac{6 \times 12}{6 + 12} + 2 = 6\,\Omega$$

Now, apply K.V.L, we have

$$I = \frac{V}{R_{eq}} = \frac{6}{6} = 1\text{A}$$

CHEMISTRY

51. **(c)** Octahedral voids are present at body centre and edge centre.

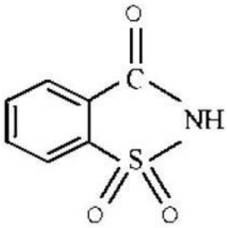
Distance between octahedral void $= \dfrac{a}{\sqrt{2}}$

Length of body diagonal $= \sqrt{3}a$

$x = \sqrt{3}a \qquad a = \dfrac{x}{\sqrt{3}}$

Distance $= \dfrac{a}{\sqrt{2}} = \dfrac{x}{\sqrt{3} \times \sqrt{2}} = \dfrac{x}{\sqrt{6}} A$

52. **(b)**



ortho- Sulphobenzimide = Artificial Sweetener (Saccharin)

53. **(a)** Given, $V = 1.12 \times 10^{-7}\ cm^3$

$22400\ cm^3$ at NTP $= 6.02 \times 10^{23}$ molecules

$\therefore \quad 1.12 \times 10^{-7}\ cm^3$ at NTP

$= \dfrac{6.02 \times 10^{23}}{22400} \times 1.12 \times 10^{-7}$

$= 3.01 \times 10^{12}$ molecules.

54. **(c)** $\dfrac{1}{\lambda} = R\left(\dfrac{1}{n_1^2} - \dfrac{1}{n_2^2}\right)$

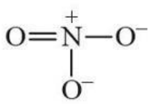
$\dfrac{1}{\lambda} = 1.097 \times 10^7 \left(\dfrac{1}{1} - \dfrac{1}{\infty}\right) = 1.097 \times 10^7\ m^{-1}$

$\lambda = 91.15 \times 10^{-9}\ m \approx 91 nm$

55. **(d)** In NO_3^- ion,

number of bond pairs (or shared pairs) = 4

number of lone pairs = 0



56. **(c)** O.N. of Mn in K_2MnO_4 is +6

57. **(d)** Alkali metals have only one valence electron in their outermost shell. Due to low ionisation enthalpy get oxidised to reduces other compounds.

58. **(b)** $V_1 = 3L; T_1 = 273 + 35 = 308K$

$V_2 = 2.5L; T_2 = ?$

According to Charle's law

$\dfrac{V_1}{T_1} = \dfrac{V_2}{T_2} \Rightarrow \dfrac{3}{308} = \dfrac{2.5}{T_2}$

$T_2 = \dfrac{2.5 \times 308}{3} = 256.6K$

$\Rightarrow 256.6 - 273 = -16.3°C \approx -16°C$

At $-16°C$, the volume decreases to 2.5 L.

59. **(b)** Silver sols can be used as an eye-lotion because it can heal eye infections.

Hence, option (b) is the correct answer.

60. **(b)** Electron donating groups such as $-OCH_3$, $-NHCOCH_3$ are *ortho* and *para* directing group.

61. **(c)** Due to e^- donating group –Me, it is least stable.

62. **(a)** Molecular orbital electronic configuration of these species are :

$O_2^-(17e^-) = \sigma 1s^2 \sigma^* 1s^2 \sigma 2s^2 \sigma^* 2s^2 \sigma 2p_z^2$

$\pi 2p_x^2 = \pi 2p_y^2 \pi^* 2p_\lambda^2 = \pi^* 2p_y^1$

$O_2(16e^-) = \sigma 1s^2 \sigma^* 1s^2 \sigma 2s^2 \sigma^* 2s^2 \sigma 2p_z^2$

$\pi 2p_x^2 = \pi 2p_y^2 \pi^* 2p_x^1 = \pi^* 2p_y^1$

$O_2^{2-}(18e^-) = \sigma 1s^2 \sigma^* 1s^2 \sigma 2s^2 \sigma^* 2s^2 \sigma 2p_z^2$

$\pi 2p_x^2 = \pi 2p_y^2\ \pi^* 2p_x^2 = \pi^* 2p_y^2$

Hence, number of antibonding electrons are 7, 6 and 8 respectively.

63. **(a)** At high altitudes, the partial pressure of oxygen is less than that at the ground level. This leads to low concentrations of oxygen in the blood and tissues of people living at high altitudes or climbers. Low blood oxygen causes climbers to become weak and unable to think clearly, symptoms of a condition known as anoxia.

64. **(c)** Molar conductance of solution is related to specific conductance as follows :

$$\wedge_m = \kappa \times \frac{1000}{C} \quad ....(a)$$

$$\wedge_m = (6.3 \times 10^{-2} \text{ohm}^{-1}\text{cm}^{-1}) \times \frac{1000}{(0.1\text{mol}/\text{cm}^3)}$$

$= 6.3 \times 10^{-2} \times 10^4 \text{ ohm}^{-1}\text{cm}^2 \text{ mol}^{-1} = 630 \text{ ohm}^{-1} \text{cm}^2 \text{ mol}^{-1}$

65. **(c)** For first order reaction, $k = \frac{0.693}{t_{1/2}}$

where k = rate constant

$t_{1/2}$ = half life period = 480 sec.

$\therefore k = \frac{0.693}{480} = 1.44 \times 10^{-3} \text{ sec}^{-1}$

66. **(b)** For a reversible reaction,

$\Delta H = E_a$ (forward) – E_a (backward)

$\Delta H = 150 - 260 = -110 \text{ kJ mol}^{-1}$

67. **(c)** For As_2S_3 sol, $FeCl_3$ is the most effective coagulating agent as it has highest charge among other given options. Thus, it has the highest coagulating power.

68. **(d)** Fluorine does not show variable oxidation state as it is the most electronegative element and shows only –1 state.

69. **(a)** $V = 3d^3\,4s^2$; $V^{2+} = 3d^3$ = 3 unpaired electrons

$Cr = 3d^5\,4s^1$; $Cr^{2+} = 3d^4$ = 4 unpaired electrons

$Mn = 3d^5 4s^2$; $Mn^{2+} = 3d^5$ = 5 unpaired electrons

$Fe = 3d^6\,4s^2$; $Fe^{2+} = 3d^6$ = 4 unpaired electrons

Hence the correct order of paramagnetic behaviour

$V^{2+} < Cr^{2+} = Fe^{2+} < Mn^{2+}$

70. **(b)** $[Co(ONO)(NH_3)_5]Cl_2$

pentaamminenitrito-O-cobalt (III) chloride

71. **(b)** All those compounds which follow S_N1 mechanism during nucleophilic substitution reaction will give racemic mixture.

Order of reactivity of alkyl halides for S_N1.

$$3° > 2° > 1°\, CH_3X$$

Thus, $CH_3 - \underset{\underset{C_2H_5}{|}}{CH} - Br$ contains a 2° carbon so gives a racemic product.

72. **(c)** For an ideal solution, $\Delta H = 0$, $\Delta V = 0$

Hence, option (c) is incorrect.

73. **(d)** When the concentration of all reacting and product species kept unity, then $E_{cell} = E°_{cell}$ and the given relation will become $\Delta_r G = -nFE°_{cell}$. *e.g.* redox reaction for Daniell cell : $Zn(s) + Cu^{2+}(aq) \rightarrow Zn^{2+}(aq) + Cu(s)$ solutions of $CuSO_4$ and $ZnSO_4$ are the reacting species.

The E_{cell} for this cell : $E_{cell} = E°_{cell}$

$$-\frac{RT}{nF}\ln\frac{[Zn^{2+}]}{[Cu^{2+}]} \Rightarrow E_{cell} = E_{cell}$$

if $[Zn^{2+}] = [Cu^{2+}] = 1$

74. **(c)** $Ce^{2+} \rightarrow 4f^1$; $Sm^{2+} \rightarrow 4f^6$

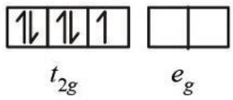
$Eu^{2+} \rightarrow 4f^7$; $Yb^{2+} \rightarrow 4f^{14}$

(fully filled configuration)

$$E°_{M^{3+}/M^{2+}} \Rightarrow \begin{matrix} Eu & Yb \\ -0.35 & -1.05 \end{matrix}$$

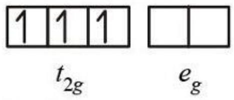
Hence, due to more reduction potential in Eu as compared to Yb, it can concluded that Eu^{2+} is more stable than Yb^{2+}.

75. **(d)** d^5 —— strong ligand field



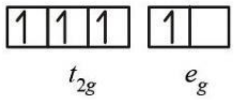
$\mu = \sqrt{n(n+2)} = \sqrt{3} = 1.73$ B.M.

d^3— in weak as well as in strong field



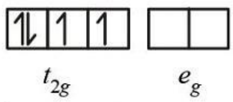
$\mu = \sqrt{3(5)} = \sqrt{15} = 3.87$ B.M.

d^4– in weak ligand field



$\mu = \sqrt{4(4+2)} = \sqrt{24} = 4.89$

d^4– in strong ligand field

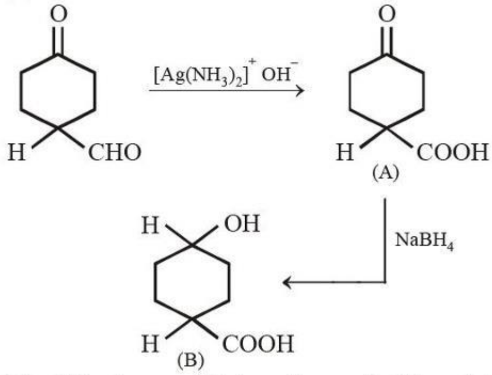


$\mu = \sqrt{2(4)} = \sqrt{8} = 2.82.$

76. **(b)** $C_6H_5Cl \xrightarrow{Mg} C_6H_5MgCl$

$\xrightarrow{CH_3CH_2OH} C_6H_6 + CH_3CH_2OMgCl$

77. **(c)**



78. **(c)** Electron withdrawing substituent (like halogen, —NO_2, C_6H_5 etc.) would disperse the negative charge and hence stabilise the carboxylate ion and thus increases acidity of the parent acid. On the other hand, electron-releasing substituents would intensify the negative charge, destabilise the carboxylate ion and thus decrease acidity of the parent acid.

Electronegativity decreases in order

$$F > Cl > Br$$

and hence –I effect also decreases in the same order, therefore the correct option is

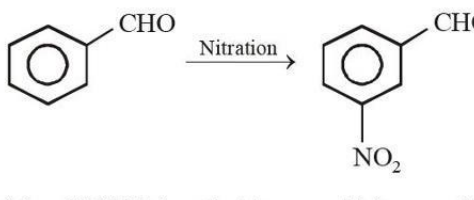
[$FCH_2COOH > ClCH_2COOH > BrCH_2COOH > CH_3COOH$]

79. **(a)** $HCHO \xrightarrow{CH_3MgBr} CH_3CH_2OMgBr$

$\xrightarrow{H_3O^+} CH_3CH_2OH$

80. **(d)** Presence of electron withdrawing group increases the acidic strength. So, *m*-chlorophenol is most acidic among all the given compounds.

81. **(d)**



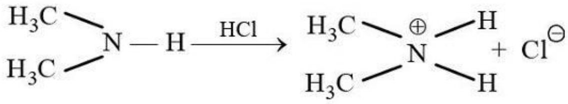
82. **(c)** CH_3NC (methyl isocyanide) on reduction with $LiAlH_4$ gives secondary amine

83. **(a)** The carbonyl group in ketones being influenced by two alkyl group is less reactive than in aldehydes where the carbonyl group is under the influence of one alkyl group only. As the number of alkyl group increases both the +I effect and the steric hinderance get increases preventing the attack of nucleophile.

Now among benzaldehyde and acetaldehyde former is less electrophilic than carbon atom of carbonyl group present in ethanal. The polarity of carbonyl group is reduced in benzaldehyde due to resonance hence it is less reactive than ethanal.

84. **(a)** Carbon in which four bonds are different is known as Chiral carbon.

85. **(b)** Reactivity of a base towards dilute HCl is directly proportional to the strength of the base. Thus, as $(CH_3)_2NH$ has the highest basic strength, so it will have highest reactivity.



86. **(a)** It is a basic amino acid.

87. **(b)** The NH of the amide can act as a hydrogen bond donor and the carbonyl group can act as a hydrogen bond acceptor. Statements (a), (c) and (d) are false. The peptide bond has double bond character due to the interaction of the nitrogen lone pair with the carbonyl group. This prevents bond rotation and makes the bond planar. The *trans* isomer is favoured over the *cis* isomer.

88. **(b)** Chain-growth polymerisation or chain polymerisation involve addition of monomer molecules onto the active site of a growing polymer chain one at a time. Addition of each monomer unit regenerates the active site. Polyethylene, polypropylene, polyvinyl chloride (PVC) and teflon are common types of plastics made by chain-growth polymerisation.

89. **(d)** Co-polymerisation of 1,3-butadine and phenylethene gives buna-S:

$n\,CH_2{=}CH{-}CH{=}CH_2 + n\,CH_2{=}CH{-}Ph$

$$[CH_2-CH=CH-CH_2-CH_2-\underset{\displaystyle Ph}{\underset{|}{CH}}]$$

buna-S

90. (d)

	Compounds	Number of particles (i)
(a)	$[Co(H_2O)_6]Cl_3$	4
(b)	$[Co(H_2O)_5Cl]Cl_2.H_2O$	3
(c)	$[Co(H_2O)_4Cl_2]Cl.2H_2O$	2
(d)	$[Co(H_2O)_3Cl_3].3H_2O$	1

91. (d) Conductance $G = \frac{KA}{l}$

Molar conductivity of a solution at a given concentration is the conductance of the volume V of solution containing one mole of electrolyte kept between two electrodes with area of cross section A and distance of unit length.

Molar conductivity $\wedge_m = \frac{KA}{l}$

Since, $l = 1$ and $A = V$ (volume containing one mole of electrolyte) then $\wedge_m = K.V$

If the concentration is C mol/litre then $\wedge_m = K/C$

92. (b) For zero order reaction,

rate, $r = k[R]^\circ \Rightarrow \text{rate} = \frac{-d[R]}{dt} = k \times 1$

$\Rightarrow \quad d[R] = k\,dt \quad \Rightarrow \quad [R] = -kt + R_0$

where R_0 is the concentration of reactant at time $t = 0$.

Thus, [R] decreases with time t.

93. (a) MnO_4^- is stable in acidic medium, MnO_4^{2-} disproportionates, CrO_4^{2-} converts into $Cr_2O_7^{2-}$ and FeO_4^{2-} decomposes.

94. (a) Mixture of (He + O_2) is used for asthma patient.

95. (c) $[PtCl_2(NH_3)_4]Br_2$ and $[PtBr_2(NH_3)_4]Cl_2$ are ionisation isomers.

96. (c) Tincture of iodine is usually 2-3% I_2. alongwith potassium iodide, dissolved in a mixture of ethanol and water.

97. (c)

98. (b) Coordination number of an atom in BCC unit cell is 8.

99. (a) $(M \rightarrow M^{3+} + 3e) \times 2$; $(N^{2+} + 2e \rightarrow N) \times 3$

Overall reaction : $2M(s) + 3N^{2+}(aq) \rightarrow 2M^{3+}(aq) + 3N(s)$

$$\therefore\ E_{cell} = E^\circ_{cell} - \frac{0.059}{6}\log\frac{[M^{3+}]^2}{[N^{2+}]^3}$$

$$= -0.6 + 0.1 - \frac{0.059}{6}\log\frac{(10^{-2})^2}{(10^{-1})^3}$$

$$= -0.5 - \frac{0.059}{6}\log 10^{-1} = 0.51\text{ V}$$

100. (c) If a tertiary alkyl halide is used, an alkene is the only reaction product and no ether is formed. For example, the reaction of CH_3ONa with $(CH_3)_3C{-}Br$ gives exclusively 2-methylpropene.

$$(CH_3)_3-C-Br + \overset{+}{Na}\ddot{\overset{-}{O}}-CH_3 \longrightarrow \underset{\text{2-Methylpropene}}{(CH_3)_2-C=CH_2} + NaBr + CH_3OH$$

It is because alkoxides are not only nucleophiles but strong bases as well. They react with alkyl halides leading to elimination reactions.

SECTION-B

MATHEMATICS

101. (d) We have

$$A^2 = \begin{bmatrix}1 & 0\\ 1/2 & 1\end{bmatrix}\begin{bmatrix}1 & 0\\ 1/2 & 1\end{bmatrix} = \begin{bmatrix}1 & 0\\ 2(1/2) & 1\end{bmatrix} = \begin{bmatrix}1 & 0\\ 1 & 1\end{bmatrix}$$

$$A^4 = \begin{bmatrix}1 & 0\\ 1 & 1\end{bmatrix}\begin{bmatrix}1 & 0\\ 1 & 1\end{bmatrix} = \begin{bmatrix}1 & 0\\ 2 & 1\end{bmatrix};$$

$$A^8 = \begin{bmatrix}1 & 0\\ 2 & 1\end{bmatrix}\begin{bmatrix}1 & 0\\ 2 & 1\end{bmatrix} = \begin{bmatrix}1 & 0\\ 4 & 1\end{bmatrix}$$

In general, by induction $A^n = \begin{bmatrix}1 & 0\\ n/2 & 1\end{bmatrix}$

$$\Rightarrow\ A^{50} = \begin{bmatrix}1 & 0\\ 25 & 1\end{bmatrix}$$

102. (c) We have $f(x) = \sin^{-1}(x-\sqrt{x})$

$$= \sin^{-1}\left(\left(\sqrt{x}-\frac{1}{2}\right)^2 - \frac{1}{4}\right)$$

$\therefore$ Range of $f(x)$ is $\left[\sin^{-1}\left(\frac{-1}{4}\right), \sin^{-1} 1\right]$

$$= \left[-\sin^{-1}\frac{1}{4}, \frac{\pi}{2}\right]$$

103. (b) $\vec{a} = \hat{i}+2\hat{j}-3\hat{k}, \vec{b} = 2\hat{i}-3\hat{j}-5\hat{k}$

$$\vec{a}-\vec{b} = -\hat{i}+5\hat{j}+2\hat{k} \Rightarrow |\vec{a}-\vec{b}| = \sqrt{1+25+4} = \sqrt{30}$$

$$|\vec{a}| = \sqrt{1+4+9} = \sqrt{14} \quad |\vec{b}| = \sqrt{4+9+25} = \sqrt{38}$$

$$\therefore \quad |\vec{a}-\vec{b}| > |\vec{b}| - |\vec{a}|$$

104. (d) Given $\sqrt{\frac{y}{x}} + 4\sqrt{\frac{x}{y}} = 4$

Now, squaring both sides, we get

$$\frac{y}{x} + \frac{16x}{y} + 8 = 16 \Rightarrow \frac{y}{x} + 16\frac{x}{y} = 8$$

$\Rightarrow y^2 + 16x^2 = 8xy$

Differentiating both sides w.r.t. x, we get

$$2y\frac{dy}{dx} + 32x = 8y + 8x\frac{dy}{dx}$$

$$\Rightarrow (4x-y)\frac{dy}{dx} = 4(4x-y) \Rightarrow \frac{dy}{dx} = 4$$

105. (d) Given $f(x) = \tan^{-1}(\sin x + \cos x)$

$$f'(x) = \frac{1}{1+(\sin x+\cos x)^2}.(\cos x - \sin x)$$

$$= \frac{\sqrt{2}.\left(\frac{1}{\sqrt{2}}\cos x - \frac{1}{\sqrt{2}}\sin x\right)}{1+(\sin x+\cos x)^2}$$

$$= \frac{\left(\cos\frac{\pi}{4}.\cos x - \sin\frac{\pi}{4}.\sin x\right)}{1+(\sin x+\cos x)^2}$$

$$\therefore \quad f'(x) = \frac{\sqrt{2}\cos\left(x+\frac{\pi}{4}\right)}{1+(\sin x+\cos x)^2}$$

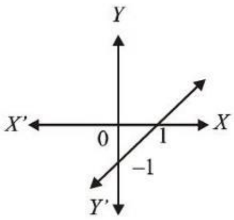
if $f'(x) > 0$ then $f(x)$ is increasing function.

Hence $f(x)$ is increasing, if $-\frac{\pi}{2} < x + \frac{\pi}{4} < \frac{\pi}{2}$

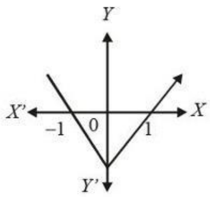
$$\Rightarrow -\frac{3\pi}{4} < x < \frac{\pi}{4}$$

Hence, $f(x)$ is increasing when $x \in \left(-\frac{\pi}{2}, \frac{\pi}{4}\right)$

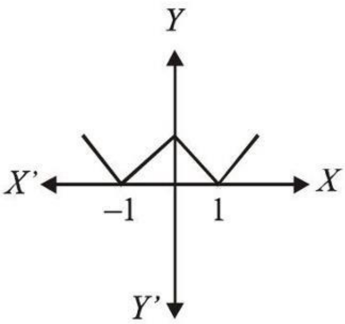
106. (b) Using graphical transformation



(i) $y = x - 1$



(ii) $y = |x| - 1$



(iii) $y = ||x| - 1|$

As, we know the function is not differentiable at sharp edges and in figure (iii), $y = ||x| - 1|$ we have 3 sharp edges at $x = -1, 0, 1$.

So, $f(x)$ is not differetiable at $\{0, \pm 1\}$

107. (d) $I = \int_{\frac{\pi}{11}}^{\frac{9\pi}{22}} \frac{dx}{1+\sqrt{\tan x}}$

$$I = \int_{\frac{\pi}{11}}^{\frac{9\pi}{22}} \frac{\sqrt{\cos x}}{\sqrt{\sin x}+\sqrt{\cos x}} dx \qquad \text{...(i)}$$

$$= \int_{\frac{\pi}{11}}^{\frac{9\pi}{22}} \frac{\sqrt{\cos\left(\frac{9\pi}{22}+\frac{\pi}{11}-x\right)}}{\sqrt{\sin\left(\frac{9\pi}{22}+\frac{\pi}{11}-x\right)}+\sqrt{\cos\left(\frac{9\pi}{22}+\frac{\pi}{11}-x\right)}} dx$$

$$I = \int_{\frac{\pi}{11}}^{\frac{9\pi}{22}} \frac{\sqrt{\cos x}}{\sqrt{\sin x}+\sqrt{\cos x}} dx \quad \text{...(ii)}$$

Adding (i) and (ii)

$$2I = \int_{\frac{\pi}{11}}^{\frac{9\pi}{22}} 1 dx = [x]_{\pi/11}^{9\pi/22}$$

$$2I = \frac{7\pi}{22} \Rightarrow I = \frac{7\pi}{44}$$

108. (a) A vector in the plane of $\vec{a}$ and $\vec{b}$ is

$$\vec{u} = \vec{a} + \lambda\vec{b} = (1+\lambda)\hat{i} + (2-\lambda)\hat{j} + (1+\lambda)\hat{k}.$$

Projection of $\vec{u}$ on $\vec{c} = \frac{1}{\sqrt{3}} \Rightarrow \frac{\vec{u}.\vec{c}}{|\vec{c}|} = \frac{1}{\sqrt{3}}$

$\Rightarrow \vec{u}.\vec{c} = 1 \Rightarrow |1+\lambda+2-\lambda-1-\lambda| = 1$

$\Rightarrow |2-\lambda| = 1 \Rightarrow \lambda = 1$ or 3

$\Rightarrow \vec{u} = 2\hat{i}+\hat{j}+2\hat{k}$ or $4\hat{i}-\hat{j}+4\hat{k}$.

109. (c) $\sim P \wedge \sim q$

110. (c) Given, 2 5

$$\frac{\sin(\pi+x)\cos\left(\frac{\pi}{2}+x\right)\tan\left(\frac{3\pi}{2}-x\right)\cot(2\pi-x)}{\sin(2\pi-x)\cos(2\pi+x)\operatorname{cosec}(-x)\sin\left(\frac{3x}{2}+x\right)},$$

where $(x \neq 0)$

$$\frac{(-\sin x)(-\sin x)(\cot x)(-\cot x)}{(-\sin x)(\cos x)(-\operatorname{cosec} x)(-\cos x)} = 1$$

111. (d) $\because i^n + i^{n+1} + i^{n+2} + i^{n+3} = 0, \forall n \in$ Integer

So, $i^2 + i^3 + i^4 + \ldots + i^{4000} = i - i + i^2 + i^3 + \ldots + i^{4000}$

$= -i + [i + i^2 + i^3 + \ldots + i^{4000}] = -i$

112. (a) 4 □ □ □

0 5

The required no. of all four digit number = $1 \times 10^2 \times 2 = 200$

113. (d) We know that number of ways in which $m \times n$ distinct things can be distributed among n persons.

$$= \frac{(mn)!}{(m!)^n}$$

$\therefore$ Number of ways of distributing 500

i.e. 50×10

dissimilar bones equally among 50 persons.

$$= \frac{500!}{(10!)^{50}}$$

114. (c) Given, $f(x) = \frac{a^x + a^{-x}}{2}$

Then, $f(x+y) + f(x-y)$

put $x + y \to x$

and $x - y \to x$

$$= \frac{a^{x+y} + a^{-(x+y)}}{2} + \frac{a^{x-y} + a^{-(x-y)}}{2}$$

$$= \frac{a^x(a^y + a^{-y}) + a^{-x}(a^y + a^{-y})}{2}$$

$$= \frac{(a^x + a^{-x})(a^y + a^{-y})}{2}$$

$$= 2.\frac{(a^x + a^{-x})}{2}.\frac{(a^y + a^{-y})}{2} = 2f(x)f(y)$$

115. (b) Let the point be $P(a, b)$ which lies on line

$4x - y - 2 = 0 \quad \ldots$(i)

and point P is equidistant from $A(-5, 6)$ and $B(3,2)$.

Then, $PA = PB$ or $PA^2 = PB^2$

$\Rightarrow (a+5)^2 + (b-6)^2 = (a-3)^2 + (b-2)^2$

$\Rightarrow a^2 + 10a + 25 + b^2 - 12b + 36$

$= a^2 - 6a + 9 + b^2 - 4b + 4 \Rightarrow 16a - 8b + 48 = 0$

$\Rightarrow 2a - b + 6 = 0 \quad \ldots$(ii)

On solving equations (i) and (ii), we get $a = 4, b = 14$

116. (d) Given centre (5, 4) of the circle touches Y-axis.

So, radius = 5 units

Equation of circle $(x-5)^2+(y-4)^2=5^2$

$\Rightarrow x^2+y^2-10x-8y+16=0$

117. (c) Put $\theta+\frac{\pi}{4}=h$ or $\theta=-\frac{\pi}{4}+h$

$$\text{Limit}=\lim_{h\to 0}\frac{\cos\left(\frac{\pi}{4}-h\right)-\sin\left(\frac{\pi}{4}-h\right)}{h}$$

$$=\lim_{h\to 0}\frac{\cos\left(\frac{\pi}{4}-h\right)-\cos\left(\frac{\pi}{4}+h\right)}{h}=$$

$$\lim_{h\to 0}\frac{2\sin\frac{\pi}{4}.\sin h}{h}=\sqrt{2}$$

118. (d) $\bar{x}=\frac{8+12+13+15+22}{5}=14$

Calculation of variance

x_i	$x_i-\bar{x}$	$(x_i-\bar{x})^2$
8	−6	36
12	−2	4
13	−1	1
15	1	1
22	8	64

$n=5,\ \sum(x_i-\bar{x})^2=106$

$\text{Var}(x)=\frac{1}{n}\sum(x_i-\bar{x})^2=\frac{106}{5}=21.2.$

119. (d) Total number of outcomes

S = {(1, 1), (1, 2), (1, 3), (1, 4), (2, 1), (2, 2), (2, 3), (2, 4), (3, 1), (3, 2), (3, 3), (3, 4), (4, 1), (4, 2), (4, 3), (4, 4)}

n(S) = 16

Number of favourable outcomes

E = {(2, 1), (3, 1), (3, 2), (4, 1), (4, 2), (4, 3), (4, 4)}

n(E) = 7

$$\text{Required probability}=\frac{n(E)}{n(S)}=\frac{7}{16}$$

120. (a) $F(\alpha).F(-\alpha)$

$$\begin{bmatrix}\cos\alpha & -\sin\alpha & 0\\ \sin\alpha & \cos\alpha & 0\\ 0 & 0 & 1\end{bmatrix}\begin{bmatrix}\cos(-\alpha) & -\sin(-\alpha) & 0\\ \sin(-\alpha) & \cos(-\alpha) & 0\\ 0 & 0 & 1\end{bmatrix}$$

$$=\begin{bmatrix}\cos^2\alpha+\sin^2\alpha+0 & \cos\alpha\sin\alpha-\cos\alpha\sin\alpha+0 & 0+0+0\\ \sin\alpha\cos\alpha-\sin\alpha\cos\alpha+0 & \sin^2\alpha+\cos^2\alpha+0 & 0+0+0\\ 0+0+0 & 0+0+0 & 0+0+1\end{bmatrix}$$

$$=\begin{bmatrix}1 & 0 & 0\\ 0 & 1 & 0\\ 0 & 0 & 1\end{bmatrix}=I \qquad [\because \cos^2\alpha+\sin^2\alpha=1]$$

$F(\alpha).F(-\alpha)=I \quad \therefore [F(\alpha)]^{-1}=F(-\alpha)$

121. (a) Given that $(\vec{a}\times\vec{b})\times\vec{c}=\frac{1}{3}|\vec{b}||\vec{c}|\vec{a}$

Clearly $\vec{a}$ and $\vec{b}$ are non collinear

$\Rightarrow (\vec{a}.\vec{c})\vec{b}-(\vec{b}.\vec{c})\vec{a}=\frac{1}{3}|\vec{b}||\vec{c}|\vec{a}$

Comparing both side.

$\therefore\ \vec{a}.\vec{c}=0$ and $-\vec{b}.\vec{c}=\frac{1}{3}|\vec{b}||\vec{c}|$

$\Rightarrow \cos\theta=\frac{-1}{3}$

$\therefore\ \sin\theta=\sqrt{1-\frac{1}{9}}=\frac{2\sqrt{2}}{3}$

[θ is acute angle between $\vec{b}$ and $\vec{c}$]

122. (a) Let the coordinate of foot of perpendicular be (x, y, z)

Take, $\frac{x+2}{4}=\frac{y-1}{2}=\frac{z+1}{3}=\lambda$

$(x, y, z)=(4\lambda-2,\ 2\lambda+1,\ 3\lambda-1)$

Equation of line from point A to point

$P=(4\lambda-3)\hat{i}+(2\lambda-1)\hat{j}+(3\lambda-5)\hat{k}$

Line passes through the vector $\vec{b}$. Then,

$b = 4\hat{i} + 2\hat{j} + 3\hat{k}$

So, $\overrightarrow{AP} \cdot \vec{b} = 0$

$4(4\lambda - 3) + 2(2\lambda - 1) + 3(3\lambda - 5) = 0$

$29\lambda = 12 + 2 + 15 = 29 \Rightarrow \lambda = 1$

Now, put the value of λ in the value of point P.

Then, $P = (2, 3, 2)$

Distance of point P from the plane $3x + 4y + 12z + 23 = 0$.

Required distance

$$d = \left|\frac{6 + 12 + 24 + 23}{\sqrt{9 + 16 + 144}}\right|,\ d = \left|\frac{65}{13}\right| = 5$$

123. (a) $3x + 4y = 0$ is one of the line of the pair equations of lines

$6x^2 - xy + 4cy^2 = 0$, Put $y = -\frac{3}{4}x$,

we get, $6x^2 + \frac{3}{4}x^2 + 4c\left(-\frac{3}{4}x\right)^2 = 0$

$\Rightarrow 6 + \frac{3}{4} + \frac{9c}{4} = 0 \Rightarrow c = -3$

124. (a) Here, $\frac{dx}{d\theta} = a(-\sin\theta + \theta\cos\theta + \sin\theta) = a\theta\cos\theta$

and $\frac{dy}{d\theta} = a(\cos\theta + \theta\sin\theta - \cos\theta) = a\theta\sin\theta$

$\therefore \frac{dy}{dx} = \frac{dy/d\theta}{dx/d\theta} = \frac{a\theta\sin\theta}{a\theta\cos\theta} = \tan\theta$

$\Rightarrow \frac{d^2y}{dx^2} = \frac{d}{dx}(\tan\theta) = \sec^2\theta\frac{d\theta}{dx} = \frac{\sec^3\theta}{a\theta}$

125. (b) Given $f(x) = 2x^3 - 3x^2 - 36x + 9$

Now $f'(x) = 6(x^2 - x - 6)$

at $f'(x) = 0$

$x^2 - x - 6 = 0 \Rightarrow x = -2, 3$

$f(-2) = 2(-2)^3 - 3(-2)^2 - 36(-2) + 9 = 53$ will be absolute maximum value

$f(-3) = -54 - 27 + 108 + 9 = 36$

$f(3) = 54 - 27 - 108 + 9 = -72$

126. (a) $f'(x) = \begin{cases} 2x + b, & x < 1 \\ 1, & x \geq 1 \end{cases}$

Since, $f(x)$ is differentiable at $x = 1$.

$\lim_{x\to1^-} f'(x) = \lim_{x\to1^+} f'(x)$

$\lim_{x\to1^-} (2x + b) = \lim_{x\to1^+} 1$

$2 + b = 1 \Rightarrow b = -1$

As form is differentiable at $x = 1$ So, it will be continuous at $x = 1$ also.

$\Rightarrow \lim_{x\to1^-} f'(x) = \lim_{x\to1^+} f'(x) = f(1)$

$\Rightarrow \lim_{x\to1^-} x^2 + bx + c = \lim_{x\to1^+} x = 1$

$\Rightarrow 1 + b + c = 1$

$\Rightarrow 1 - 1 + c = 1 \Rightarrow c = 1$

Hence, $b - c = -1 - 1 = -2$

127. (d) Given expression is $(\sim(p \wedge q)) \vee q$

$= (\sim p \vee \sim q) \vee q = \sim p \vee \sim q \vee q = \sim p \vee T$

make truth table

p	q	p∧q	~(p∧q)	~(p∧q)∨q	p∨q	p→(p∨q)
T	T	T	F	T	T	T
T	F	F	T	T	T	T
F	T	F	T	T	T	T
F	F	F	T	T	F	T

$p \to (p \vee q)$ is also a tautology.

128. (c) $\therefore x = \frac{1 - t^2}{1 + t^2}$ and $y = \frac{2t}{1 + t^2}$

Put $t = \tan\theta$ in both the equations, we get

$$x = \frac{1 - \tan^2\theta}{1 + \tan^2\theta} = \cos 2\theta \qquad ...(i)$$

and $y = \frac{2\tan\theta}{1+\tan^2\theta} = \sin 2\theta$ ...(ii)

Differentiating (i) and (ii), we get

$\frac{dx}{d\theta} = -2\sin 2\theta$ and $\frac{dx}{d\theta} = 2\cos 2\theta$

Therefore, $\frac{dy}{dx} = \frac{\frac{dy}{d\theta}}{\frac{dx}{d\theta}} = -\frac{\cos 2\theta}{\sin 2\theta} = -\frac{x}{y}$

129. (d) Given equation of curve is $y = x^3 + 3x^2 + 5$.

Slope of tangent, $\frac{dy}{dx} = 3x^2 + 6x$

Satisfy the point (x_1, y_1) in the slope. Then the equation of tangent represented as,

$y - y_1 = (3x_1^2 + 6x_1)(x - x_1)$

Put $(x, y) = (0, 0)$

$-y_1 = (3x_1^2 + 6x_1)(-x_1)$

$y_1 = (3x_1^3 + 6x_1^2)$ ...(i)

Here, (x_1, y_1) lies on the curve $y = x^3 + 3x^2 + 5$

$y_1 = x_1^3 + 3x_1^2 + 5$ ...(ii)

From equations (i) and (ii), $2y_1 = 3x_1^2 + 15$

Hence the equation of curve $y = \frac{3}{2}x^2 + \frac{15}{2}$ is symmetrical about y-axis and it will not because intersect the curve $\frac{x}{3} - y^2 = 2$ it is symmetrical about x-axis.

130. (c) Let $I = \int \frac{x\sin^{-1}x}{\sqrt{1-x^2}}dx$

Take, $\sin^{-1}x = t \Rightarrow x = \sin t$

$\frac{1}{\sqrt{1-x^2}}dx = dt$, $\therefore \cos t = \sqrt{1-x^2}$

$I = \int \sin t.t\, dt = t.(-\cos t) - \int(-\cos t)dt$

$= -t\cos t + \sin t + C = -(\sqrt{1-x^2})\sin^{-1}x + x + C$

131. (b) Let $I = \int \frac{x+1}{x(1+xe^x)}dx$

Put $xe^x = t \Rightarrow (x+1)dx = \frac{dt}{e^x}$

$\Rightarrow I = \int \frac{dt}{xe^x(1+xe^x)} = \int \frac{1}{t(1+t)}dt = \int \frac{t+1-t}{t(t+1)}dt$

$\therefore I = \int\left(\frac{1}{t} - \frac{1}{t+1}\right)dt$

$= \log t - \log(t+1) + C = \log\left|\frac{t}{t+1}\right| + C$

$= \log\left|\frac{xe^x}{xe^x+1}\right| + C$

132. (d) Given difference equation is,

$\sqrt{\frac{dy}{dx}} - 4\frac{dy}{dx} - 7x = 0$

$\sqrt{\frac{dy}{dx}} = 4\frac{dy}{dx} + 7x$

Squaring on both the side, we get

$\frac{dy}{dx} = 16\left(\frac{dy}{dx}\right)^2 + 49x^2 + 56x\frac{dy}{dx}$

Order = 1 and degree = 2

133. (a) Given $\vec{a} = \hat{i} + \hat{j} + \hat{k}$

$\vec{b} = \hat{i} + 3\hat{j} + 5\hat{k}$

$\vec{c} = 7\hat{i} + 9\hat{j} + 11\hat{k}$

Then, $\vec{a} + \vec{b} = 2\hat{i} + 4\hat{j} + 6\hat{k}$

and $\vec{b} + \vec{c} = 8\hat{i} + 12\hat{j} + 16\hat{k}$

Area of parallelogram $= \frac{1}{2}|(\vec{a}+\vec{b})\times(\vec{b}+\vec{c})|$

$= \frac{1}{2}|2(\hat{i}+2\hat{j}+3\hat{k})\times 4(2\hat{i}+3\hat{j}+4\hat{k})|$

$$=\frac{8}{2}|(\hat{i}+2\hat{j}+3\hat{k})\times(2\hat{i}+3\hat{j}+4\hat{k})|$$

$$=4\begin{vmatrix}\hat{i} & \hat{j} & \hat{k}\\ 1 & 2 & 3\\ 2 & 3 & 4\end{vmatrix}=4|-\hat{i}+2\hat{j}-\hat{k}|$$

$$=4\sqrt{1+4+1}=4\sqrt{6}\text{ sq. units.}$$

134. (c) $P(X=-2)=P(X=-1)$

$$=P(X=2)=P(X=1)=\frac{1}{6}$$

$$\&\ P(X=0)=\frac{1}{3}$$

Mean $=(-2).P(X=-2)+(-1)\,P(X=-1)+0.$

$P(X=0)+1.P(X=1)+2\text{P}p(X=2)$

$$=-2\times\frac{1}{6}-\frac{1}{6}+0+\frac{1}{6}+2\times\frac{1}{6}\ \Rightarrow \text{Mean}=0$$

135. (b) Let $I=\int e^x\left(\frac{2+\sin 2x}{1+\cos 2x}\right)dx$

$$=\int e^x\left(\frac{2+\sin 2x}{2\cos^2 x}\right)dx$$

$$=\int e^x\sec^2 x\,dx+\int e^x\tan x\,dx$$

$$=\left[e^x\int\sec^2 dx-\int e^x\tan x\,dx\right]+\int e^x\tan x\,dx+c$$

$=e^x\tan x+c$

136. (a) $\frac{dx}{dy}+\frac{x^2}{y^2}-\frac{x}{y}+1=0$

Put $x=vy$

$$\Rightarrow \frac{dx}{dy}=v+y\frac{dv}{dy}$$

$$\therefore v+y\frac{dv}{dy}+v^2-v+1=0$$

$$\Rightarrow -y\frac{dv}{dy}=(1+v^2)$$

$$\Rightarrow \frac{dv}{v^2+1}=-\frac{dy}{y}$$

Integrating, we get

$$\tan^{-1}v+C=-\ln y$$

$$\Rightarrow \tan^{-1}\left(\frac{x}{y}\right)+\ln y+C=0$$

where C is arbitrary constant

137. (d) $2\hat{i}-p\hat{j}+5\hat{k}$ and $3\hat{i}+p\hat{j}+p\hat{k}$ are perpendicular

$\Rightarrow\ 2\times3+p(-p)+5(p)=0$

$\Rightarrow\ p=-1$ or $p=6$

Hence for $p=6$, the lines are perpendicular.

138. (d)

$$\sin\left(\tan^{-1}\frac{4}{5}+\tan^{-1}\frac{4}{3}+\tan^{-1}\frac{1}{9}-\tan^{-1}\frac{1}{7}\right)$$

$$=\sin\left[\left(\tan^{-1}\frac{4}{5}+\tan^{-1}\frac{1}{9}\right)+\left(\tan^{-1}\frac{4}{3}-\tan^{-1}\frac{1}{7}\right)\right]$$

$$=\sin\left[\tan^{-1}\left(\frac{\frac{4}{5}+\frac{1}{9}}{1-\frac{4}{5}\frac{1}{9}}\right)+\tan^{-1}\left(\frac{\frac{4}{3}-\frac{1}{7}}{1+\frac{4}{3}\cdot\frac{1}{7}}\right)\right]$$

$$=\sin\left[\tan^{-1}\left(\frac{36+5}{45-4}\right)+\tan^{-1}\left(\frac{28-3}{21+4}\right)\right]$$

$$=\sin\left(\tan^{-1}\frac{41}{41}+\tan^{-1}\frac{25}{25}\right)$$

$$=\sin[\tan^{-1}(1)+\tan^{-1}(1)]$$

$$=\sin\left(\frac{\pi}{4}+\frac{\pi}{4}\right)=\sin\frac{\pi}{2}=1$$

139. (a) $f(0)=\lim_{x\to 0}f(x)$

$$=\lim_{x\to 0}\frac{2-\sqrt{x+4}}{\sin 2x}\quad\text{[0/0 form]}$$

$$=\lim_{x\to 0}\frac{-\frac{1}{2\sqrt{x+4}}}{2\cos 2x}\quad\text{[Using L' Hospital rule]}$$

$$=\lim_{x\to 0}\frac{-1}{4\sqrt{x+4}\,\cos 2x}=\frac{-1}{4\times\sqrt{4}\times1}=\frac{-1}{8}$$

140. (c) We have, $\int_0^{\pi/4} \frac{\cos^2 x}{\cos^2 x + 4\sin^2 x} dx$

$$= \int_0^{\pi/4} \frac{dx}{1 + 4\tan^2 x}$$

Let $\tan x = t$

$\Rightarrow \sec^2 x \, dx = dt$

$$\Rightarrow dx = \frac{dt}{\sec^2 x} = \frac{dt}{1+t^2} \quad \text{...(i)}$$

when $x = 0, t = 0$, and when $x = \frac{\pi}{4}, t = 1$

From Eq. (i), $\int_0^1 \frac{dt}{(1+t^2)(1+4t^2)}$

$$= \frac{1}{3}\int_0^1 \frac{4(1+t^2) - (1+4t^2)}{(1+4t^2)(1+t^2)} dx$$

$$= \frac{1}{3}\int_0^1 \left(\frac{4}{1+4t^2} - \frac{1}{1+t^2}\right) dt$$

$$= \frac{1}{3}\left[\frac{4}{4}\int_0^1 \frac{dt}{\left(\frac{1}{2}\right)^2 + t^2} - \int_0^1 \frac{1}{1+t^2} dt\right]$$

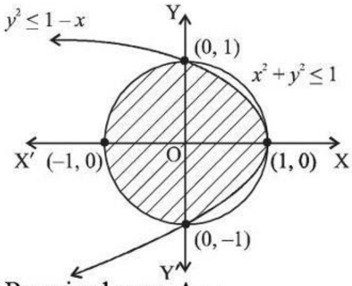
$$= \frac{1}{3}\left[\frac{1}{1/2}\left(\tan^{-1}\frac{t}{1/2}\right)_0^1 - (\tan^{-1} t)_0^1\right]$$

$$= \frac{1}{3}\left[2(\tan^{-1} 2t)_0^1 - \frac{\pi}{4}\right] =$$

$$\frac{1}{3}\left[2\tan^{-1}(2) - \frac{\pi}{4}\right]$$

$$= -\frac{\pi}{12} + \frac{2}{3}\tan^{-1} 2$$

141. (c) Region: $\{(x, y) \mid x^2 + y^2 \le 1 \text{ and } y^2 \le 1 - x\}$



Required area A =

$$2\left[\int_{-1}^0 \sqrt{1-x}\, dx + \int_0^1 \sqrt{1-x}\, dx\right]$$

=

$$2\left[\frac{x}{2}\sqrt{1-x^2} + \frac{1}{2}\sin^{-1} x\right]_{-1}^0 + 2\left[\frac{-2}{3}(1-x)^{\frac{3}{2}}\right]_0^1$$

$$= \frac{\pi}{2} + \frac{4}{3}$$

142. (b) Let P(getting head and 6) $= \frac{1}{12}$

Since, B can win the game in 2nd throw, 4th throw, 6th throw and so on.

Hence P(B) to win the game is

$$= P(\bar{A})P(B) + P(\bar{A})P(\bar{B})P(\bar{A})P(B) + ...\infty$$

$$= \frac{11}{12}\times\frac{1}{12} + \frac{11}{12}\times\frac{11}{12}\times\frac{11}{12}\times\frac{1}{12} + ...$$

$$= \frac{1}{12}\left[\frac{11}{12} + \left(\frac{11}{12}\right)^3 + \left(\frac{11}{12}\right)^5 + ...\right]$$

$$= \frac{1}{12}\times\frac{\frac{11}{12}}{1-\left(\frac{11}{12}\right)^2} = \frac{11}{23}$$

143. (c) $D = \begin{vmatrix} k & 1 & 1 \\ 1 & k & 1 \\ 1 & 1 & k \end{vmatrix} = 0 \Rightarrow (k-1)^2(k+2) = 0$

also $D_1 = \begin{vmatrix} 1 & 1 & 1 \\ k & k & 1 \\ k^2 & 1 & k \end{vmatrix} \ne 0 \Rightarrow k \ne 1 \Rightarrow k = -2$

144. (b) $f'(1) = \lim_{h\to 0} \frac{f(1+h)-f(1)}{h}$

$= \lim_{h\to 0} \frac{f(1+h)}{h} - \lim_{h\to 0} \frac{f(1)}{h}$

Given, $\lim_{h\to 0} \frac{f(1+h)}{h} = 5$

So, $\lim_{h\to 0} \frac{f(1)}{h}$, must be finite as $f'(1)$ exists and

$\lim_{h\to 0} \frac{f(1)}{h}$ can be finite only, if $f(1) = 0$ and

$\lim_{h\to 0} \frac{f(1)}{h} = 0$

So, $f'(1) = \lim_{h\to 0} \frac{f(1+h)}{h} = 5$

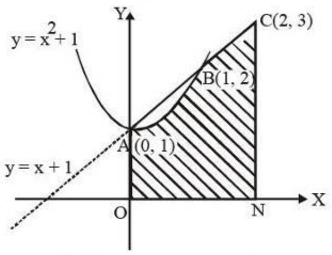
145. (a) The required region is the intersection of the following regions

$A_1 = \{(x, y) : 0 \le y \le x^2 + 1\}$. It represents the region below the parabola $y = x^2+1$

$A_2 = \{(x, y) : 0 \le y \le x + 1\}$. It represents the region below the straight line $y = x+1$, and

$A_3 = \{(x, y) : 0 \le x \le 2\}$. It represents the region lying between the ordinates $x = 0$ and $x = 2$.

The required area is the region shown as the shaded region in the following figure :



By solving $y = x + 1$ and $y = x^2+1$, we get the points of intersection A(0,1) and B (1,2). Hence the required region is bounded by $y = f(x)$, $y = 0$, $x = 0$, $x = 2$,

where $f(x) = \begin{cases} x^2 + 1, & 0 \le x \le 1 \\ x + 1, & 1 \le x \le 2 \end{cases}$

$\therefore$ Required area

$A = \int_0^2 f(x)dx = \int_0^1 (x^2+1)dx + \int_1^2 (x+1)dx$

$= \frac{23}{6}$

146. (a) $\sqrt{1-y^2}\, dx + x\, dy - \sin^{-1} y\, dy = 0$

$\sqrt{1-y^2}\, dx + x\, dy = \sin^{-1} y\, dy$

$\frac{dx}{dy} + \frac{x}{\sqrt{1-y^2}} = \frac{\sin^{-1} y}{\sqrt{1-y^2}}$

Here, $P(y) = \frac{1}{\sqrt{1-y^2}}$, $Q(y) = \frac{\sin^{-1} y}{\sqrt{1-y^2}}$

Integrating factor, IF $= e^{\int \frac{dy}{\sqrt{1-y^2}} dx} = e^{\sin^{-1} y}$

Solution of given differential equation,

$\Rightarrow \quad xe^{\sin^{-1} y} = \int e^{\sin^{-1} y} \frac{\sin^{-1} y}{\sqrt{1-y^2}} dy$

$\Rightarrow \quad xe^{\sin^{-1} y} = e^{\sin^{-1} y} (\sin^{-1} y - 1) + c$

$\Rightarrow \quad x = \sin^{-1} y - 1 + ce^{-\sin^{-1} y}$

147. (b) We know that,

$\sum_{r=0}^{m} P(X) = 1$

$\Rightarrow 0.1 + 0.15 + 0.3 + 0.25 + k + k = 1$

$\Rightarrow 0.80 + 2k = 1$

$\Rightarrow 2k = 0.2 \Rightarrow k = 0.1$

Now, mean, $\bar{X} = \Sigma XP(X)$

$= 1 \times 0.1 + 2 \times 0.15 + 3 \times 0.3 + 4 \times 0.25 + 5k + 6k = 3.4$ $\quad [k = 0.1]$

and $\Sigma X^2P(X) = 1 \times 0.1 + 4 \times 0.15 + 9 \times 0.3 + 16 \times 0.25 + 25k + 36k = 13.5$

$\therefore$ Variance $\sigma^2 = \Sigma X^2 P(X) - (\Sigma XP(X))^2$

$= 13.5 - (3.4)^2 = 13.5 - 11.56$

$= 1.94$ or 1.93

148. (a) The given line is

$$\frac{x-2}{2} = \frac{2y-5}{-3} = z+1,$$

$$\Rightarrow \quad \frac{x-2}{2} = \frac{y-\frac{5}{2}}{-\frac{3}{2}} = \frac{z+1}{0}$$

This shows that the given line passes through the point $\left(2, \frac{5}{2}, -1\right)$ and has direction ratios $\left(2, \frac{-3}{2}, 0\right)$. Thus, given line passes through the point having position vector $\vec{a} = 2\hat{i} + \frac{5}{2}\hat{j} - \hat{k}$ and is parallel to the vector

$\vec{b} = \left(2\hat{i} - \frac{3}{2}\hat{j} - 0\hat{k}\right)$. So, its vector equation is

$\vec{r} = \left(2\hat{i} + \frac{5}{2}\hat{j} - \hat{k}\right) + \lambda\left(2\hat{i} - \frac{3}{2}\hat{j} - 0\hat{k}\right)$.

Hence, $p = 0$

149. (a) Let A be a symmetric matrix.

Then $A' = A$

Now, $(B'AB)' = B'A'(B')'$ $\quad [\because (AB)' = B'A']$

$= B'A'B$ $\quad [\because (B)' = B]$

$= B'AB$ $\quad [\because A' = A]$

$\Rightarrow$ $B'AB$ is a symmetric matrix.

Now, Let A be a skew-symmetric matrix.

Then $A' = -A$

$\therefore \quad (B'AB)' = B'A'(B')'$ $\quad [\because (AB)' = B'A']$

$= B'A'B$ $\quad [\because (B')' = B]$

$= B'(-A)B$ $\quad [\because A' = -A]$

$= -B'AB$

$\therefore \quad B'AB$ is a skew-symmetric matrix

150. (c) Given that $\frac{dV}{dt} = 50 \text{ cm}^3/\text{min}$

$$\Rightarrow \quad \frac{d}{dt}\left(\frac{4}{3}\pi r^3\right) = 50$$

$$\Rightarrow \quad 3r^2\frac{dr}{dt} = \frac{150}{4\pi} \Rightarrow \frac{dr}{dt} = \frac{50}{4\pi r^2}$$

$$\Rightarrow \quad \left(\frac{dr}{dt}\right)_{r=15} = \frac{50}{4\pi \times 225} = \frac{1}{18\pi} \text{ cm/min}$$