

FIITJEE

Solutions to JEE (Main)-2019

JEE–Main–2019 –Apr–12–First–Shift
PHYSICS, CHEMISTRY & MATHEMATICS

Time Allotted: 3 Hours

Maximum Marks: 360

- Do not open this Test Booklet until you are asked to do so.
- Please read the instructions carefully. You are allotted 5 minutes specifically for this purpose.

Important Instructions:

1. Immediately fill in the particulars on this page of the Test Booklet with *Blue / Black Ball Point Pen*. Use of pencil is strictly prohibited.
2. The Answer Sheet is kept inside this Test Booklet. When you are directed to open the Test Booklet, take out the Answer Sheet and fill in the particulars carefully.
3. The test is of **3 hours** duration.
4. The Test Booklet consists of **90** questions. The maximum marks are **360**.
5. There are **three** parts in the question paper A, B, C consisting of **Physics, Chemistry and Mathematics** having 30 questions in each part of equal weightage. Each question is allotted **4 (four)** marks for correct response.
6. *Candidates will be awarded marks as stated above in instruction No.5 for correct response of each question. One mark will be deducted for indicating incorrect response of each question. No deduction from the total score will be made if no response is indicated for an item in the answer sheet.*
7. There is only one correct response for each question. Filling up more than one response in any question will be treated as wrong response and marks for wrong response will be deducted accordingly as per instruction 6 above.
8. Use **Blue / Black Ball Point Pen only** for writing particulars / marking responses on **Side-1** and **Side-2** of the Answer Sheet. **Use of pencil is strictly prohibited.**
9. No candidate is allowed to carry any textual material, printed or written, bits of papers, pager, mobile phone, any electronic device, etc. except the Admit Card inside the examination hall / room.
10. On completion of the test, the candidate must hand over the Answer Sheet to the Invigilator on duty in the Room / Hall. **However, the candidates are allowed to take away this Test Booklet with them.**
11. **Do not fold or make any stray marks on the Answer Sheet.**

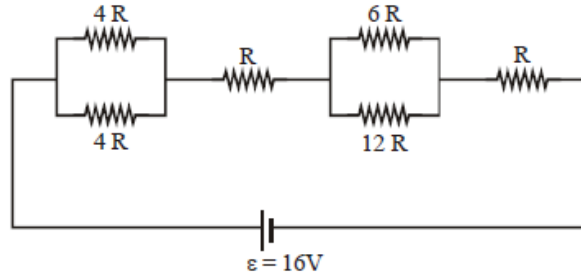
Name of the Candidate (in Capital Letters) : _____

Roll Number : _____

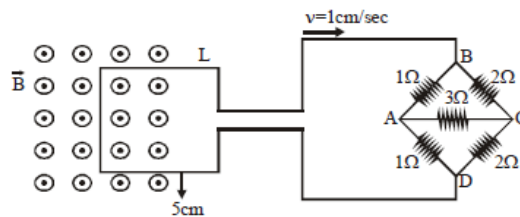
Candidate's Signature: _____

PART –A (PHYSICS)

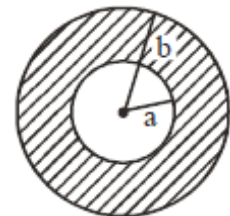
- The value of numerical aperture of the objective lens of a microscope is 1.25. If light of wavelength 5000 \AA is used, the minimum separation between two points, to be seen as distinct, will be :
 (A) 0.48 \mu m (B) 0.38 \mu m
 (C) 0.24 \mu m (D) 0.12 \mu m
- The resistive network shown below is connected to a D.C. source of 16 V. The power consumed by the network is 4 Watt. The value of R is:



- (A) 8 \Omega (B) 6 \Omega
 (C) 16 \Omega (D) 1 \Omega
- The figure shows a square loop L of side 5 cm which is connected to a network of resistances. The whole set up is moving towards right with a constant speed of 1 cm s^{-1} . At some instant, a part of L is in a uniform magnetic field of 1 T, perpendicular to the plane of the loop. If the resistance of L is 1.7 \Omega , the current in the loop at that instant will be close to :

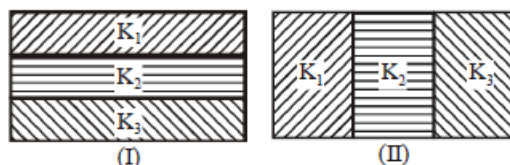


- (A) 115 \mu A (B) 170 \mu A
 (C) 60 \mu A (D) 150 \mu A
- A circular disc of radius b has a hole of radius a at its centre (see figure). If the mass per unit area of the disc varies as $\left(\frac{\sigma_0}{r}\right)$, then the radius of gyration of the disc about its axis passing through the centre is :



- (A) $\frac{a+b}{3}$ (B) $\sqrt{\frac{a^2 + b^2 + ab}{3}}$
 (C) $\frac{a+b}{2}$ (D) $\sqrt{\frac{a^2 + b^2 + ab}{2}}$

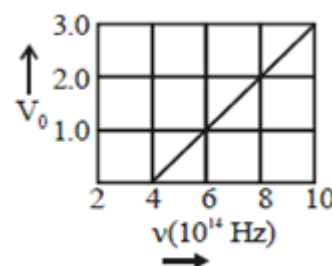
5. A man (mass = 50 kg) and his son (mass = 20 kg) are standing on a frictionless surface facing each other. The man pushes his son so that he starts moving at a speed of 0.70 ms^{-1} with respect to the man. The speed of the man with respect to the surface is :
 (A) 0.47 ms^{-1} (B) 0.28 ms^{-1}
 (C) 0.14 ms^{-1} (D) 0.20 ms^{-1}
6. Two identical parallel plate capacitors, of capacitance C each, have plates of area A , separated by a distance d . The space between the plates of the two capacitors, is filled with three dielectrics, of equal thickness and dielectric constants K_1 , K_2 and K_3 . The first capacitor is filled as shown in fig. I, and the second one is filled as shown in fig. II. If these two modified capacitors are charged by the same potential V , the ratio of the energy stored in the two, would be (E_1 refers to capacitor (I) and E_2 to capacitor (II)) :



- (A) $\frac{E_1}{E_2} = \frac{K_1 K_2 K_3}{(K_1 + K_2 + K_3)(K_2 K_3 + K_3 K_1 + K_1 K_2)}$ (B) $\frac{E_1}{E_2} = \frac{9K_1 K_2 K_3}{(K_1 + K_2 + K_3)(K_2 K_3 + K_3 K_1 + K_1 K_2)}$
 (C) $\frac{E_1}{E_2} = \frac{(K_1 + K_2 + K_3)(K_2 K_3 + K_3 K_1 + K_1 K_2)}{9K_1 K_2 K_3}$ (D) $\frac{E_1}{E_2} = \frac{(K_1 + K_2 + K_3)(K_2 K_3 + K_3 K_1 + K_1 K_2)}{K_1 K_2 K_3}$

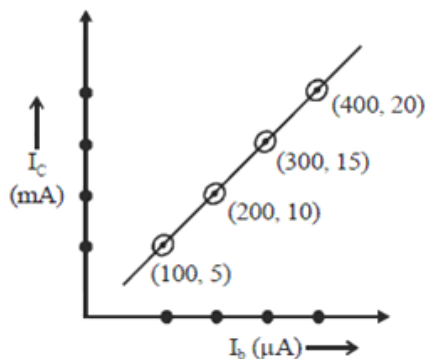
7. Two moles of helium gas is mixed with three moles of hydrogen molecules (taken to be rigid). What is the molar specific heat of mixture at constant volume? ($R = 8.3 \text{ J/mol K}$)
 (A) 17.4 J/mol K (B) 15.7 J/mol K
 (C) 19.7 J/mol K (D) 21.6 J/mol K

8. The stopping potential V_0 (in volt) as a function of frequency (ν) for a sodium emitter, is shown in the figure. The work function of sodium, from the data plotted in the figure, will be :
 (Given : Planck's constant (h) = $6.63 \times 10^{-34} \text{ Js}$, electron charge $e = 1.6 \times 10^{-19} \text{ C}$)
 (A) 1.82 eV (B) 1.66 eV
 (C) 2.12 eV (D) 1.95 eV

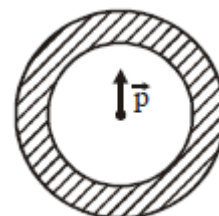


9. At 40°C , a brass wire of 1 mm is hung from the ceiling. A small mass, M is hung from the free end of the wire. When the wire is cooled down from 40°C to 20°C it regains its original length of 0.2 m . The value of M is close to :
 (Coefficient of linear expansion and Young's modulus of brass are $10^{-5}/^\circ\text{C}$ and 10^{11} N/m^2 , respectively; $g = 10 \text{ ms}^{-2}$)
 (A) 0.5 kg (B) 9 kg
 (C) 0.9 kg (D) 1.5 kg
10. A magnetic compass needle oscillates 30 times per minute at a place where the dip is 45° , and 40 times per minute where the dip is 30° . If B_1 and B_2 are respectively the total magnetic field due to the earth at the two places, then the ratio B_1/B_2 is best given by :
 (A) 3.6 (B) 1.8
 (C) 2.2 (D) 0.7

11. An excited He^+ ion emits two photons in succession, with wavelengths 108.5 nm and 30.4 nm, in making a transition to ground state. The quantum number n , corresponding to its initial excited state is (for photon of wavelength λ , energy $E = \frac{1240 \text{ eV}}{\lambda(\text{in nm})}$:)
- (A) $n = 4$ (B) $n = 6$
 (C) $n = 5$ (D) $n = 7$
12. When M_1 gram of ice at -10°C (specific heat = $0.5 \text{ cal g}^{-1}\text{C}^{-1}$) is added to M_2 gram of water at 50°C , finally no ice is left and the water is at 0°C . The value of latent heat of ice, in cal g^{-1} is:
- (A) $\frac{50M_2}{M_1} - 5$ (B) $\frac{5M_2}{M_1} - 5$
 (C) $\frac{50M_2}{M_1}$ (D) $\frac{5M_1}{M_2} - 50$
13. A shell is fired from a fixed artillery gun with an initial speed u such that it hits the target on the ground at a distance R from it. If t_1 and t_2 are the values of the time taken by it to hit the target in two possible ways, the product $t_1 t_2$ is:
- (A) $2R / g$ (B) $R / 4g$
 (C) R / g (D) $R/2g$
14. The transfer characteristic curve of a transistor, having input and output resistance 100Ω and $100 \text{ k}\Omega$ respectively, is shown in the figure. The Voltage and Power gain, are respectively :



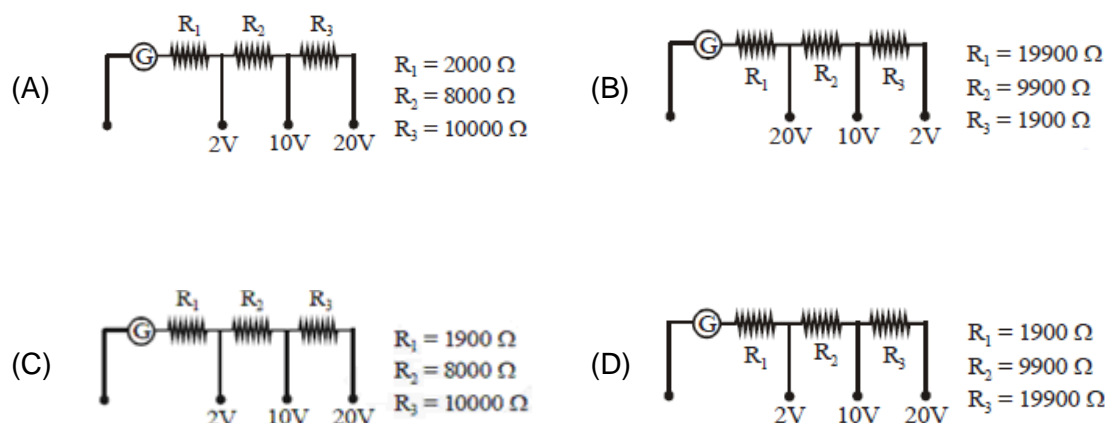
- (A) $5 \times 10^4, 2.5 \times 10^6$ (B) $5 \times 10^4, 5 \times 10^6$
 (C) $5 \times 10^4, 5 \times 10^5$ (D) $2.5 \times 10^4, 2.5 \times 10^6$
15. Shown in the figure is a shell made of a conductor. It has inner radius a and outer radius b , and carries charge Q . At its centre is a dipole \vec{P} as shown. In this case :
- (A) Surface charge density on the inner surface of the shell is zero everywhere.
 (B) Electric field outside the shell is the same as that of a point charge at the centre of the shell.
 (C) Surface charge density on the inner surface is uniform and equal to $\frac{(Q/2)}{4\pi a^2}$
 (D) Surface charge density on the outer surface depends on $|\vec{P}|$



16. Which of the following combinations has the dimension of electrical resistance (ϵ_0 is the permittivity of vacuum and μ_0 is the permeability of vacuum)?

- (A) $\sqrt{\frac{\epsilon_0}{\mu_0}}$ (B) $\frac{\mu_0}{\epsilon_0}$
 (C) $\frac{\epsilon_0}{\mu_0}$ (D) $\sqrt{\frac{\mu_0}{\epsilon_0}}$

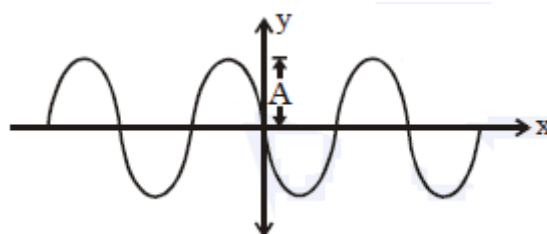
17. A galvanometer of resistance 100Ω has 50 divisions on its scale and has sensitivity of $20 \mu\text{A} / \text{division}$. It is to be converted to a voltmeter with three ranges, of $0-2 \text{ V}$, $0-10 \text{ V}$ and $0-20 \text{ V}$. The appropriate circuit to do so is :



18. In a double slit experiment, when a thin film of thickness t having refractive index μ is introduced in front of one of the slits, the maximum at the centre of the fringe pattern shifts by one fringe width. The value of t is (λ is the wavelength of the light used) :

- (A) $\frac{\lambda}{2(\mu - 1)}$ (B) $\frac{\lambda}{(\mu - 1)}$
 (C) $\frac{\lambda}{(2\mu - 1)}$ (D) $\frac{2\lambda}{(\mu - 1)}$

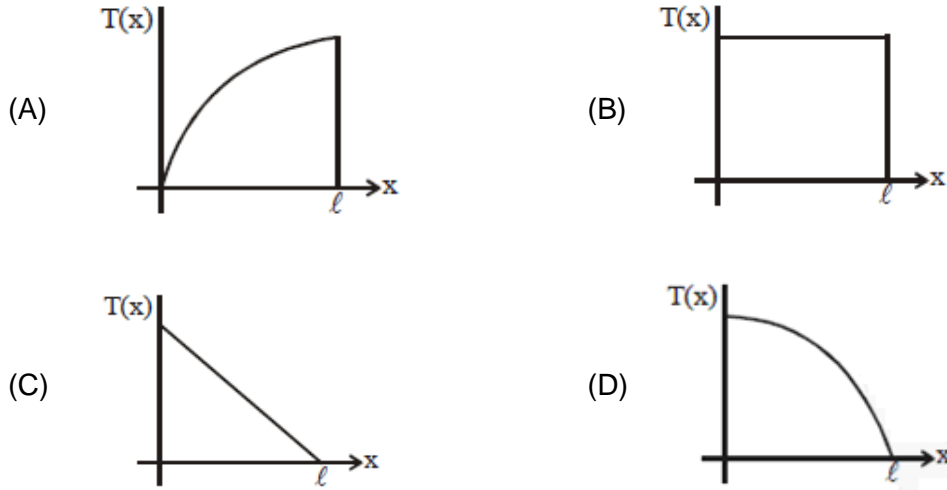
19. A progressive wave travelling along the positive x -direction is represented by $y(x, t) = A \sin(kx - \omega t + \phi)$. Its snapshot at $t = 0$ is given in the figure:



For this wave, the phase ϕ is :

- (A) π (B) $\frac{\pi}{2}$
 (C) $-\frac{\pi}{2}$ (D) 0

20. A uniform rod of length ℓ is being rotated in a horizontal plane with a constant angular speed about an axis passing through one of its ends. If the tension generated in the rod due to rotation is $T(x)$ at a distance x from the axis, then which of the following graphs depicts it most closely?



21. A point dipole $\vec{p} = -p_0 \hat{x}$ is kept at the origin. The potential and electric field due to this dipole on the y -axis at a distance d are, respectively : (Take $V = 0$ at infinity)

(A) $\frac{|\vec{p}|}{4\pi\epsilon_0 d^2}, \frac{-\vec{p}}{4\pi\epsilon_0 d^3}$ (B) $0, \frac{\vec{p}}{4\pi\epsilon_0 d^3}$

(C) $\frac{|\vec{p}|}{4\pi\epsilon_0 d^2}, \frac{\vec{p}}{4\pi\epsilon_0 d^3}$ (D) $0, \frac{-\vec{p}}{4\pi\epsilon_0 d^3}$

22. An electromagnetic wave is represented by the electric field $\vec{E} = E_0 n \sin[\omega t + (6y - 8z)]$. Taking unit vectors in x, y and z directions to be $\hat{i}, \hat{j}, \hat{k}$, the direction of propagation \hat{s} , is :

(A) $\hat{s} = \left(\frac{-3\hat{j} + 4\hat{k}}{5} \right)$ (B) $\hat{s} = \left(\frac{4\hat{j} - 3\hat{k}}{5} \right)$

(C) $\hat{s} = \left(\frac{-4\hat{k} + 3\hat{j}}{5} \right)$ (D) $\hat{s} = \left(\frac{-3\hat{i} - 4\hat{j}}{5} \right)$

23. A submarine (A) travelling at 18 km/hr is being chased along the line of its velocity by another submarine (B) travelling at 27 km/hr. B sends a sonar signal of 500 Hz to detect A and receives a reflected sound of frequency ν . The value of ν is close to : (Speed of sound in water = 1500 ms^{-1})

(A) 499 Hz (B) 502 Hz
(C) 504 Hz (D) 507 Hz

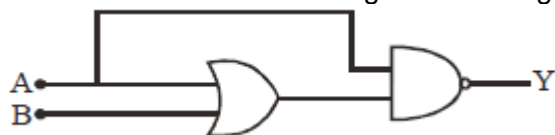
24. The trajectory of a projectile near the surface of the earth is given as $y = 2x - 9x^2$. If it were launched at an angle θ_0 with speed v_0 then ($g = 10 \text{ ms}^{-2}$) :

(A) $\theta_0 = \cos^{-1}\left(\frac{1}{\sqrt{5}}\right)$ and $v_0 = \frac{5}{3} \text{ ms}^{-1}$ (B) $\theta_0 = \cos^{-1}\left(\frac{2}{\sqrt{5}}\right)$ and $v_0 = \frac{3}{5} \text{ ms}^{-1}$

(C) $\theta_0 = \sin^{-1}\left(\frac{2}{\sqrt{5}}\right)$ and $v_0 = \frac{3}{5} \text{ ms}^{-1}$ (D) $\theta_0 = \sin^{-1}\left(\frac{1}{\sqrt{5}}\right)$ and $v_0 = \frac{5}{3} \text{ ms}^{-1}$

25. A thin ring of 10 cm radius carries a uniformly distributed charge. The ring rotates at a constant angular speed of $40\pi \text{ rad s}^{-1}$ about its axis, perpendicular to its plane. If the magnetic field at its centre is $3.8 \times 10^{-9} \text{ T}$, then the charge carried by the ring is close to ($\mu_0 = 4\pi \times 10^{-7} \text{ N/A}^2$).
- (A) $2 \times 10^{-6} \text{ C}$ (B) $7 \times 10^{-6} \text{ C}$
 (C) $4 \times 10^{-5} \text{ C}$ (D) $3 \times 10^{-5} \text{ C}$

26. The truth table for the circuit given in the fig is :



(A)

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

(B)

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

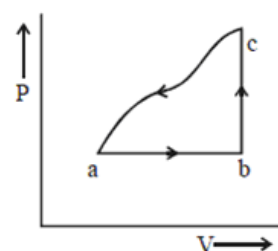
(C)

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

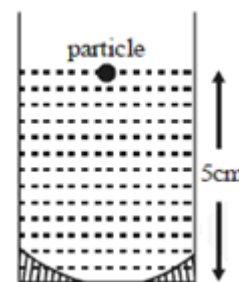
(D)

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

27. A sample of an ideal gas is taken through the cyclic process abca as shown in the figure. The change in the internal energy of the gas along the path ca is -180 J . The gas absorbs 250 J of heat along the path ab and 60 J along the path bc. The work done by the gas along the path abc is :
- (A) 120 J (B) 100 J
 (C) 140 J (D) 130 J



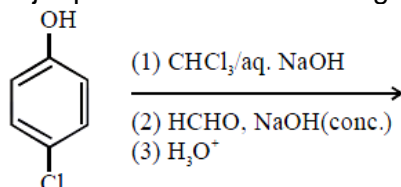
28. A concave mirror has radius of curvature of 40 cm. It is at the bottom of a glass that has water filled up to 5 cm (see figure). If a small particle is floating on the surface of water, its image as seen, from directly above the glass, is at a distance d from the surface of water. The value of d is close to : (Refractive index of water = 1.33)
- (A) 13.4 cm (B) 8.8 cm
 (C) 6.7 cm (D) 11.7 cm

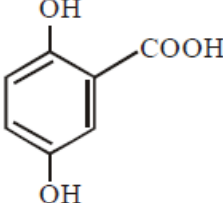
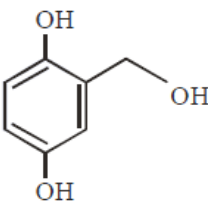
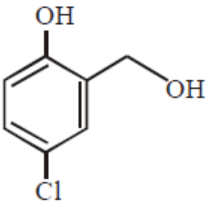
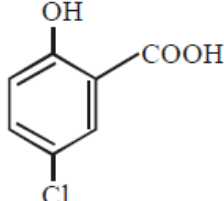


PART –B (CHEMISTRY)

31. The mole fraction of a solvent in aqueous solution of a solute is 0.8. The molality (in mol kg⁻¹) of the aqueous solution is
 (A) 13.88×10^{-2} (B) 13.88×10^{-1}
 (C) 13.88 (D) 13.88×10^{-3}

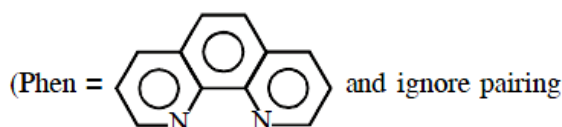
32. The major products of the following reaction are:



- (A)  and Methanol
- (B)  and Formic acid
- (C)  and Formic acid
- (D)  and Methanol

33. The correct statement among the following is
 (A) $(\text{SiH}_3)_3\text{N}$ is planar and less basic than $(\text{CH}_3)_3\text{N}$.
 (B) $(\text{SiH}_3)_3\text{N}$ is planar and more basic than $(\text{CH}_3)_3\text{N}$.
 (C) $(\text{SiH}_3)_3\text{N}$ is pyramidal and less basic than $(\text{CH}_3)_3\text{N}$.
 (D) $(\text{SiH}_3)_3\text{N}$ is pyramidal and more basic than $(\text{CH}_3)_3\text{N}$.

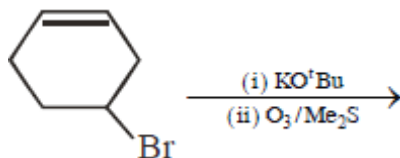
34. The complex ion that will lose its crystal field stabilization energy upon oxidation of its metal to +3 state is



energy)

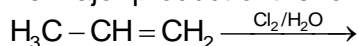
- (A) $[\text{Ni}(\text{phen})_3]^{2+}$ (B) $[\text{Zn}(\text{phen})_3]^{2+}$
 (C) $[\text{Co}(\text{phen})_3]^{2+}$ (D) $[\text{Fe}(\text{phen})_3]^{2+}$
35. The correct set of species responsible for the photochemical smog is :
 (A) NO , NO_2 , O_3 and hydrocarbons (B) CO_2 , NO_2 , SO_2 and hydrocarbons
 (C) N_2 , NO_2 and hydrocarbons (D) N_2 , O_2 , O_3 and hydrocarbons

36. The major product(s) obtained in the following reaction is/ are:



- (A) (B)
- (C) and (D)

37. The major product of the following addition reaction is:



- (A) (B)
- (C) (D)

38. The correct sequence of thermal stability of the following carbonates is :

- (A) $\text{BaCO}_3 < \text{SrCO}_3 < \text{CaCO}_3 < \text{MgCO}_3$ (B) $\text{BaCO}_3 < \text{CaCO}_3 < \text{SrCO}_3 < \text{MgCO}_3$
 (C) $\text{MgCO}_3 < \text{CaCO}_3 < \text{SrCO}_3 < \text{BaCO}_3$ (D) $\text{MgCO}_3 < \text{SrCO}_3 < \text{CaCO}_3 < \text{BaCO}_3$

39. The group number, number of valence electrons and valency of an element with atomic number 15, respectively, are:

- (A) 15, 5 and 3 (B) 15, 6 and 2
 (C) 16, 5 and 2 (D) 16, 6 and 3

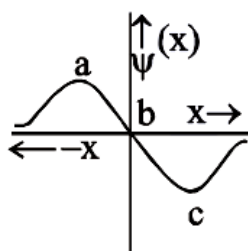
40. Peptization is a :

- (A) process of converting soluble particles to form colloidal solution
 (B) process of converting precipitate into colloidal solution
 (C) process of converting a colloidal solution into precipitate
 (D) process of bringing colloidal molecule into solution

41. The metal that gives hydrogen gas upon treatment with both acid as well as base is:

- (A) iron (B) magnesium
 (C) zinc (D) mercury

42. The electrons are more likely to be found:



- (A) in the region a and b (B) in the region a and c
 (C) only in the region a (D) only in the region c

43. An example of a disproportionation reaction is :
 (A) $2\text{KMnO}_4 \longrightarrow \text{K}_2\text{MnO}_4 + \text{MnO}_2 + \text{O}_2$
 (B) $2\text{NaBr} + \text{Cl}_2 \longrightarrow 2\text{NaCl} + \text{Br}_2$
 (C) $2\text{CuBr} \longrightarrow \text{CuBr}_2 + \text{Cu}$
 (D) $2\text{MnO}_4^- + 10\text{I}^- + 16\text{H}^+ \longrightarrow 2\text{Mn}^{2+} + 5\text{I}_2 + 8\text{H}_2\text{O}$
44. 5 moles of AB_2 weigh 125×10^{-3} kg and 10 moles of A_2B_2 weigh 300×10^{-3} kg. The molar mass of A (M_A) and molar mass of B (M_B) in kg mol^{-1} are :
 (A) $M_A = 50 \times 10^{-3}$ and $M_B = 25 \times 10^{-3}$ (B) $M_A = 10 \times 10^{-3}$ and $M_B = 5 \times 10^{-3}$
 (C) $M_A = 5 \times 10^{-3}$ and $M_B = 10 \times 10^{-3}$ (D) $M_A = 25 \times 10^{-3}$ and $M_B = 50 \times 10^{-3}$
45. The basic structural unit of feldspar, zeolites, mica and asbestos is :
 (A) $\begin{array}{c} \text{R} \\ | \\ \text{-(Si-O)}_n \\ | \\ \text{R} \end{array}$ (R=Me) (B) $(\text{SiO}_3)^{2-}$
 (C) SiO_2 (D) $(\text{SiO}_4)^{4-}$
46. Enthalpy of sublimation of iodine is 24 cal g^{-1} at 200°C . If specific heat of $\text{I}_2(\text{s})$ and $\text{I}_2(\text{vap})$ are 0.055 and $0.031 \text{ cal g}^{-1}\text{K}^{-1}$ respectively, then enthalpy of sublimation of iodine at 250°C in cal g^{-1} is :
 (A) 2.85 (B) 11.4
 (C) 5.7 (D) 22.8
47. Which of the following is a thermosetting polymer?
 (A) PVC (B) Bakelite
 (C) Buna-N (D) Nylon 6
48. An element has a face-centred cubic (fcc) structure with a cell edge of a . The distance between the centres of two nearest tetrahedral voids in the lattice is:
 (A) $\frac{a}{2}$ (B) $\sqrt{2}a$
 (C) $\frac{3}{2}a$ (D) a
49. An organic compound 'A' is oxidized with Na_2O_2 followed by boiling with HNO_3 . The resultant solution is then treated with ammonium molybdate to yield a yellow precipitate. Based on above observation, the element present in the given compound is :
 (A) Phosphorus (B) Sulphur
 (C) Nitrogen (D) Fluorine
50. The idea of froth floatation method came from a person X and this method is related to the process Y of ores. X and Y, respectively, are:
 (A) washer woman and concentration (B) fisher woman and concentration
 (C) fisher man and reduction (D) washer man and reduction
51. In the following reaction; $x\text{A} \longrightarrow y\text{B}$

$$\log_{10} \left[-\frac{d[\text{A}]}{dt} \right] = \log_{10} \left[\frac{d[\text{B}]}{dt} \right] + 0.3010$$
 'A' and 'B' respectively can be :
 (A) C_2H_2 and C_6H_6 (B) n-Butane and Iso-butane
 (C) N_2O_4 and NO_2 (D) C_2H_4 and C_4H_8

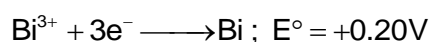
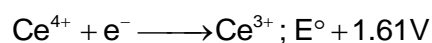
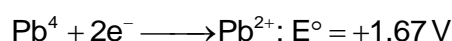
52. Glucose and Galactose are having identical configuration in all the positions except position.
 (A) C-4 (B) C-3
 (C) C-5 (D) C-2
53. Which of the following statements is not true about RNA?
 (A) It has always double stranded α -helix structure
 (B) It is present in the nucleus of the cell
 (C) It controls the synthesis of protein
 (D) It usually does not replicate
54. What is the molar solubility of Al(OH)_3 in 0.2 M NaOH solution? Given that, solubility product of $\text{Al(OH)}_3 = 2.4 \times 10^{-24}$:
 (A) 3×10^{-19} (B) 12×10^{-21}
 (C) 12×10^{-23} (D) 3×10^{-22}

55. The increasing order of the pK_b of the following compound is :



- (A) (c) < (a) < (d) < (b)
 (B) (b) < (d) < (a) < (c)
 (C) (a) < (c) < (d) < (b)
 (D) (b) < (d) < (c) < (a)

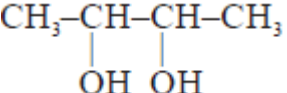
56. Given :



Oxidizing power of the species will increase in the order

- (A) $\text{Ce}^{4+} < \text{Pb}^{4+} < \text{Bi}^{3+} < \text{Co}^{3+}$ (B) $\text{Co}^{3+} < \text{Pb}^{4+} < \text{Ce}^{4+} < \text{Bi}^{3+}$
 (C) $\text{Bi}^{3+} < \text{Ce}^{4+} < \text{Pb}^{4+} < \text{Co}^{3+}$ (D) $\text{Co}^{3+} < \text{Ce}^{4+} < \text{Bi}^{3+} < \text{Pb}^{4+}$

57. But-2-ene on reaction with alkaline KMnO_4 at elevated temperature followed by acidification will give :

- (A) One molecule of CH_3CHO and one molecule of CH_3COOH
 (B) 2 molecules of CH_3CHO
 (C) 2 molecules of CH_3COOH
 (D) 

PART-C (MATHEMATICS)

61. Let P be the point of intersection of the common tangents to the parabola $y^2 = 12x$ and the hyperbola $8x^2 - y^2 = 8$. If S and S' denote the foci of the hyperbola where S lies on the positive x-axis then P divides SS' in a ratio:
 (A) 2:1 (B) 13:11
 (C) 5:4 (D) 14:13
62. If three of the six vertices of a regular hexagon are chosen at random, then the probability that the triangle formed with these chosen vertices is equilateral is :
 (A) $\frac{3}{10}$ (B) $\frac{1}{5}$
 (C) $\frac{1}{10}$ (D) $\frac{3}{20}$
63. Let $f : \mathbb{R} \rightarrow \mathbb{R}$ be a continuously differentiable function such that $f(2) = 6$ and $f'(2) = \frac{1}{48}$. If $\int_6^{f(x)} 4t^3 dt = (x-2)g(x)$, then $\lim_{x \rightarrow 2} g(x)$ is equal to :
 (A) 24 (B) 18
 (C) 12 (D) 36
64. The integral $\int \frac{2x^3 - 1}{x^4 + x} dx$ is equal to :
 (Here C is a constant of integration)
 (A) $\frac{1}{2} \log_e \left| \frac{x^3 + 1}{x^2} \right| + C$ (B) $\frac{1}{2} \log_e \frac{|x^3 + 1|^2}{|x^3|} + C$
 (C) $\log_e \left| \frac{x^3 + 1}{x} \right| + C$ (D) $\log_e \frac{|x^3 + 1|}{x^2} + C$
65. The coefficient of x^{18} in the product $(1+x)(1-x)^{10}(1+x+x^2)^9$ is :
 (A) 84 (B) 126
 (C) -126 (D) -84
66. The number of ways of choosing 10 objects out of 31 objects of which 10 are identical and the remaining 21 are distinct, is :
 (A) 2^{20} (B) $2^{20} + 1$
 (C) 2^{21} (D) $2^{20} - 1$
67. Let a random variable X have a binomial distribution with mean 8 and variance 4. If $P(X \leq 2) = \frac{k}{2^{16}}$, then k is equal to :
 (A) 17 (B) 137
 (C) 1 (D) 121
68. The equation $|z - i| = |z - 1|, i = \sqrt{-1}$, represents :
 (A) a circle of radius $\frac{1}{2}$ (B) the line through the origin with slope 1
 (C) a circle of radius 1 (D) the line through the origin with slope -1

69. If m is the minimum value of k for which the function $f(x) = x\sqrt{kx - x^2}$ is increasing in the interval $[0, 3]$ and M is the maximum value of f in $[0, 3]$ when $k = m$, then the ordered pair (m, M) is equal to :
- (A) $(5, 3\sqrt{6})$ (B) $(4, 3\sqrt{2})$
 (C) $(3, 3\sqrt{3})$ (D) $(4, 3\sqrt{3})$
70. If the data x_1, x_2, \dots, x_{10} is such that the mean of first four of these is 11, the mean of the remaining six is 16 and the sum of squares of all of these is 2,000; then the standard deviation of this data is :
- (A) $2\sqrt{2}$ (B) 2
 (C) 4 (D) $\sqrt{2}$
71. If the area (in sq. units) of the region $\{(x, y) : y^2 \leq 4x, x + y \leq 1, x \geq 0, y \geq 0\}$ is $a\sqrt{2} + b$, then $a - b$ is equal to :
- (A) $\frac{10}{3}$ (B) 6
 (C) $\frac{8}{3}$ (D) $-\frac{2}{3}$
72. Consider the differential equation, $y^2 dx + \left(x - \frac{1}{y}\right) dy = 0$. If value of y is 1 when $x = 1$, then the value of x for which $y = 2$, is :
- (A) $\frac{3}{2} - \sqrt{e}$ (B) $\frac{1}{2} + \frac{1}{\sqrt{e}}$
 (C) $\frac{3}{2} - \frac{1}{\sqrt{e}}$ (D) $\frac{5}{2} + \frac{1}{\sqrt{e}}$
73. If α and β are the roots of the equation $375x^2 - 25x - 2 = 0$, then $\lim_{n \rightarrow \infty} \sum_{r=1}^n \alpha^r + \lim_{n \rightarrow \infty} \sum_{r=1}^n \beta^r$ is equal to :
- (A) $\frac{1}{12}$ (B) $\frac{29}{358}$
 (C) $\frac{7}{116}$ (D) $\frac{21}{346}$
74. A 2 m ladder leans against a vertical wall. If the top of the ladder begins to slide down the wall at the rate 25 cm/ sec., then the rate (in cm/sec.) at which the bottom of the ladder slides away from the wall on the horizontal ground when the top of the ladder is 1 m above the ground is :
- (A) 25 (B) $\frac{25}{3}$
 (C) $25\sqrt{3}$ (D) $\frac{25}{\sqrt{3}}$
75. The number of solutions of the equation $1 + \sin^4 x = \cos^2 3x$, $x \in \left[-\frac{5\pi}{2}, \frac{5\pi}{2}\right]$ is :
- (A) 3 (B) 4
 (C) 5 (D) 7

76. If $e^y + xy = e$, the ordered pair $\left(\frac{dy}{dx}, \frac{d^2y}{dx^2}\right)$ at $x = 0$ is equal to :
- (A) $\left(\frac{1}{e}, -\frac{1}{e^2}\right)$ (B) $\left(\frac{1}{e}, \frac{1}{e^2}\right)$
 (C) $\left(-\frac{1}{e}, \frac{1}{e^2}\right)$ (D) $\left(-\frac{1}{e}, -\frac{1}{e^2}\right)$
77. The value of $\sin^{-1}\left(\frac{12}{13}\right) - \sin^{-1}\left(\frac{3}{5}\right)$ is equal to :
- (A) $\pi - \cos^{-1}\left(\frac{33}{65}\right)$ (B) $\pi - \sin^{-1}\left(\frac{63}{65}\right)$
 (C) $\frac{\pi}{2} - \cos^{-1}\left(\frac{9}{65}\right)$ (D) $\frac{\pi}{2} - \sin^{-1}\left(\frac{56}{65}\right)$
78. If the normal to the ellipse $3x^2 + 4y^2 = 12$ at a point P on it is parallel to the line, $2x + y = 4$ and the tangent to the ellipse at P passes through Q(4, 4) then PQ is equal to :
- (A) $\frac{\sqrt{157}}{2}$ (B) $\frac{5\sqrt{5}}{2}$
 (C) $\frac{\sqrt{221}}{2}$ (D) $\frac{\sqrt{61}}{2}$
79. Let $\vec{a} = 3\hat{i} + 2\hat{j} + 2\hat{k}$ and $\vec{b} = \hat{i} + 2\hat{j} - 2\hat{k}$ be two vectors. If a vector perpendicular to both the vectors $\vec{a} + \vec{b}$ and $\vec{a} - \vec{b}$ has the magnitude 12 then one such vector is:
- (A) $4(2\hat{i} - 2\hat{j} - \hat{k})$ (B) $4(2\hat{i} - 2\hat{j} + \hat{k})$
 (C) $4(2\hat{i} + 2\hat{j} + \hat{k})$ (D) $4(2\hat{i} + 2\hat{j} - \hat{k})$
80. The equation $y = \sin x \sin(x + 2) - \sin^2(x+1)$ represents a straight line lying in :
- (A) first, third and fourth quadrants (B) first, second and fourth quadrants
 (C) third and fourth quadrants only (D) second and third quadrants only
81. For $x \in \left(0, \frac{3}{2}\right)$, let $f(x) = \sqrt{x}$, $g(x) = \tan x$ and $h(x) = \frac{1-x^2}{1+x^2}$. If $\phi(x) = ((hof)og)(x)$, then $\phi\left(\frac{\pi}{3}\right)$ is equal to :
- (A) $\tan \frac{11\pi}{12}$ (B) $\tan \frac{\pi}{12}$
 (C) $\tan \frac{5\pi}{12}$ (D) $\tan \frac{7\pi}{12}$
82. If the angle of intersection at a point where the two circles with radii 5 cm and 12 cm intersect is 90° , then the length (in cm) of their common chord is :
- (A) $\frac{13}{2}$ (B) $\frac{120}{13}$
 (C) $\frac{13}{5}$ (D) $\frac{60}{13}$

83. If $\int_0^{\frac{\pi}{2}} \frac{\cot x}{\cot x + \operatorname{cosec} x} dx = m(\pi + n)$, then $m \cdot n$ is equal to
 (A) 1 (B) $\frac{1}{2}$
 (C) $-\frac{1}{2}$ (D) -1
84. Let S_n denote the sum of the first n terms of an A.P.. If $S_4 = 16$ and $S_6 = -48$, then S_{10} is equal to :
 (A) -410 (B) -260
 (C) -320 (D) -380
85. If $B = \begin{bmatrix} 5 & 2\alpha & 1 \\ 0 & 2 & 1 \\ \alpha & 3 & -1 \end{bmatrix}$ is the inverse of a 3×3 matrix A , then the sum of all values of α for which $\det(A) + 1 = 0$, is :
 (A) 0 (B) -1
 (C) 1 (D) 2
86. If the line $\frac{x-2}{3} = \frac{y+1}{2} = \frac{z-1}{1}$ intersects the plane $2x + 3y - z + 13 = 0$ at a point P and the plane $3x + y + 4z = 16$ at a point Q , then PQ is equal to :
 (A) $2\sqrt{14}$ (B) 14
 (C) $2\sqrt{7}$ (D) $\sqrt{14}$
87. If the volume of parallelepiped formed by the vectors $\hat{i} + \lambda\hat{j} + k$, $\hat{j} + \lambda k$ and $\lambda\hat{i} + k$ is minimum, then λ is equal to :
 (A) $\sqrt{3}$ (B) $\frac{1}{\sqrt{3}}$
 (C) $-\frac{1}{\sqrt{3}}$ (D) $-\sqrt{3}$
88. If A is a symmetric matrix and B is a skew-symmetric matrix such that $A + B = \begin{bmatrix} 2 & 3 \\ 5 & -1 \end{bmatrix}$, then AB is equal to :
 (A) $\begin{bmatrix} 4 & -2 \\ 1 & -4 \end{bmatrix}$ (B) $\begin{bmatrix} 4 & -2 \\ -1 & -4 \end{bmatrix}$
 (C) $\begin{bmatrix} -4 & 2 \\ 1 & 4 \end{bmatrix}$ (D) $\begin{bmatrix} -4 & -2 \\ -1 & 4 \end{bmatrix}$
89. If the truth value of the statement $p \rightarrow (\sim q \vee r)$ is false (F), then the truth values of the statement p , q , r are respectively :
 (A) T, T, F (B) F, T, T
 (C) T, F, T (D) T, F, F
90. For $x \in \mathbb{R}$, let $[x]$ denote the greatest integer $\leq x$, then the sum of the series
 $\left[-\frac{1}{3}\right] + \left[-\frac{1}{3} - \frac{1}{100}\right] + \left[-\frac{1}{3} - \frac{2}{100}\right] + \dots + \left[-\frac{1}{3} - \frac{99}{100}\right]$
 (A) -135 (B) -153
 (C) -133 (D) -131

JEE (Mains) – 2019

ANSWERS

PART A – PHYSICS

1.	C	2.	A	3.	B	4.	B
5.	D	6.	B	7.	A	8.	B
9.	B	10.	D	11.	C	12.	A
13.	A	14.	A	15.	B	16.	D
17.	C	18.	B	19.	A	20.	D
21.	D	22.	A	23.	B	24.	A
25.	D	26.	D	27.	D	28.	B
29.	C	30.	A				

PART B – CHEMISTRY

31.	C	32.	C	33.	A	34.	D
35.	A	36.	C	37.	B	38.	C
39.	A	40.	B	41.	C	42.	B
43.	C	44.	C	45.	D	46.	D
47.	B	48.	A	49.	A	50.	A
51.	D	52.	A	53.	A	54.	D
55.	C	56.	C	57.	C	58.	C
59.	B	60.	B				

PART C – MATHEMATICS

61.	C	62.	C	63.	B	64.	C
65.	A	66.	A	67.	B	68.	B
69.	D	70.	B	71.	B	72.	C
73.	A	74.	D	75.	C	76.	C
77.	D	78.	B	79.	A	80.	C
81.	A	82.	B	83.	D	84.	C
85.	C	86.	A	87.	Bonus	88.	B
89.	A	90.	C				

HINTS AND SOLUTIONS

PART A – PHYSICS

1. Numerical aperture of the microscope is given as

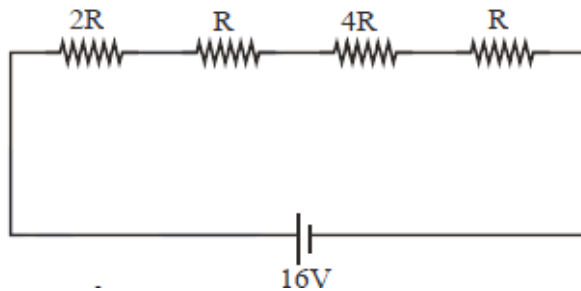
$$NA = \frac{0.61\lambda}{d}$$

Where d = minimum separation between two points to be seen as distinct

$$d = \frac{0.61\lambda}{NA} = \frac{(0.61) \times (5000 \times 10^{-10})}{1.25} = 2.4 \times 10^{-7} \text{ m}$$

$$= 0.24 \mu\text{m}$$

- 2.



$$P = \frac{16^2}{8R} = 4$$

$$\therefore R = 8\Omega$$

3. Since it is a balanced wheatstone bridge, its equivalent resistance = $\frac{4}{3}\Omega$

$$\varepsilon = Blv = 5 \times 10^{-4} \text{ V}$$

So total resistance

$$R = \frac{4}{3} + 1.7 \approx 3\Omega$$

$$\therefore i = \frac{\varepsilon}{R} \approx 166 \mu\text{A} \approx 170 \mu\text{A}$$

- 4.

$$dI = (dm)r^2$$

$$= (\sigma dA)r^2$$

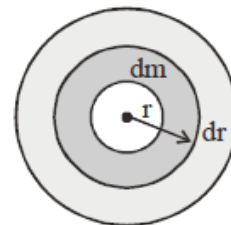
$$= \left(\frac{\sigma_0}{r} 2\pi dr\right)r^2 = (\sigma_0 2\pi r^2 dr)$$

$$I = \int dI = \int_a^b \sigma_0 2\pi r^2 dr$$

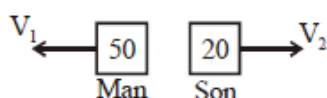
$$= \sigma_0 2\pi \left(\frac{b^3 - a^3}{3}\right)$$

$$m = \int dm = \int \sigma dA$$

$$= \sigma_0 2\pi \int_a^b dr$$



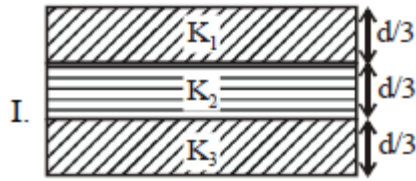
- 5.



$$\Rightarrow 0 = 50V_1 - 20V_2 \text{ and } V_1 + V_2 = 0.7$$

$$\Rightarrow V_1 = 0.2$$

6.



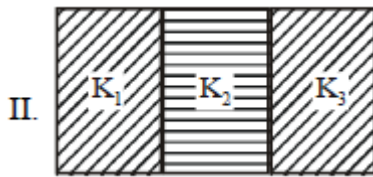
$$C_1 = \frac{3\epsilon_0 AK_1}{d}$$

$$C_2 = \frac{3\epsilon_0 AK_2}{d}$$

$$C_3 = \frac{3\epsilon_0 AK_3}{d}$$

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

$$\Rightarrow C_{eq} = \frac{3\epsilon_0 AK_1 K_2 K_3}{d(K_1 K_2 + K_2 K_3 + K_3 K_1)} \quad \dots(i)$$



$$C_1 = \frac{\epsilon_0 K_1 A}{3d}$$

$$C_2 = \frac{\epsilon_0 K_2 A}{3d}$$

$$C_3 = \frac{\epsilon_0 K_3 A}{3d}$$

$$C'_{eq} = C_1 + C_2 + C_3$$

$$= \frac{\epsilon_0 A}{3d} (K_1 + K_2 + K_3) \quad \dots(ii)$$

Now,

$$\frac{E_1}{E_2} = \frac{\frac{1}{2} C_{eq} \cdot V^2}{\frac{1}{2} C'_{eq} V^2} = \frac{9K_1 K_2 K_3}{(K_1 + K_2 + K_3)(K_1 K_2 + K_2 K_3 + K_3 K_1)}$$

7. $f_{mix} = \frac{n_1 f_1 + n_2 f_2}{n_1 + n_2} = \frac{2 \times 3 + 3 \times 5}{5} = \frac{21}{5}$

$$C_v = \frac{fR}{5} = \frac{21}{5} \times \frac{R}{2} = 17.4 \text{ J/mol K}$$

8. $h\nu = \phi + eV_0$

$$V_0 = \frac{h\nu}{e} - \frac{\phi}{e}$$

V_0 is zero for $\nu = 4 \times 10^{14}$ Hz

$$0 = \frac{h\nu}{e} - \frac{\phi}{e}$$

$$\Rightarrow \phi = h\nu$$

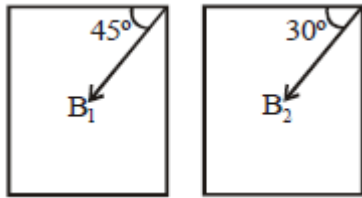
$$= \frac{6.63 \times 10^{-34} \times 4 \times 10^{14}}{1.6 \times 10^{-19}} = 1.66 \text{ eV}$$

9. $Mg = \left(\frac{Ay}{\ell} \right) \Delta \ell$

$$Mg = (Ay)\alpha \Delta T = 2\pi$$

It is closest to 9.

10.



$$f_1 = \frac{1}{2\pi} \sqrt{\frac{\mu B_1 \cos 45^\circ}{l}} \quad f_2 = \frac{1}{2\pi} \sqrt{\frac{\mu B_2 \cos 30^\circ}{l}}$$

$$\frac{f_1}{f_2} = \frac{B_1 \cos 45^\circ}{B_2 \cos 30^\circ} \quad \therefore \frac{B_1}{B_2} \times 0.7$$

11.

$$\frac{1}{\lambda} = R \left(\frac{1}{m^2} - \frac{1}{n^2} \right) z^2$$

$$\frac{1}{1085} = R \left(\frac{1}{m^2} - \frac{1}{n^2} \right) z^2$$

$$\therefore m = 2$$

$$\therefore n = 5$$

12.

Heat lost = Heat gain

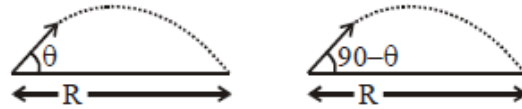
$$\Rightarrow M_2 \times 1 \times 50 = M_1 \times 0.5 \times 10 + M_1 \cdot L_f$$

$$\Rightarrow L_f = \frac{50M_2 - 5M_1}{M_1}$$

$$= \frac{50M_2}{M_1} - 5$$

13.

Range will be same for time t_1 and t_2 , so angles of projection will be ' θ ' & ' $90^\circ - \theta$ '



$$t_1 = \frac{2u \sin \theta}{g} \quad t_2 = \frac{2u \sin(90^\circ - \theta)}{g} \quad \text{and} \quad R = \frac{u^2 \sin 2\theta}{g}$$

$$t_1 t_2 = \frac{4u^2 \sin \theta \cos \theta}{g^2} = \frac{2}{g} \left[\frac{2u^2 \sin \theta \cos \theta}{g} \right]$$

$$= \frac{2R}{g}$$

14.

$$V_{\text{gain}} = \left(\frac{\Delta I_C}{\Delta I_B} \right) \frac{R_{\text{out}}}{R_{\text{in}}} = \left(\frac{5 \times 10^{-3}}{100 \times 10^{-6}} \right) \times 10^3$$

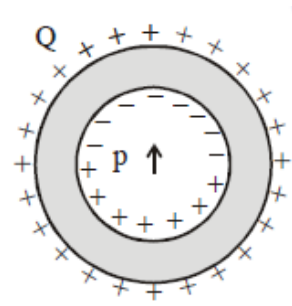
$$= \frac{1}{20} \times 10^8 = 5 \times 10^4$$

$$P_{\text{gain}} = \left(\frac{\Delta I_C}{\Delta I_b} \right) (V_{\text{gain}})$$

$$= \left(\frac{5 \times 10^{-3}}{100 \times 10^{-6}} \right) (5 \times 10^4)$$

$$= 2.5 \times 10^6$$

15. Total charge of dipole = 0, so charge induced on outside surface = 0.
 But due to non uniform electric field of dipole, the charge induced on inner surface is non zero and non uniform.
 So, for any observer outside the shell, the resultant electric field is due to Q uniformly distributed on outer surface only and it is equal to.



$$E = \frac{KQ}{r^2}$$

16. $[\epsilon_0] = M^{-1} L^{-3} T^4 A^2$
 $[\mu_0] = M L T^{-2} A^{-2}$
 $[R] = M L^2 T^{-3} A^{-2}$

$$[R] = \left[\sqrt{\frac{\mu_0}{\epsilon_0}} \right]$$

17. $20 \times 50 \times 10^{-6} = 10^{-3}$ Amp.

$$V_1 = \frac{2}{10^{-3}} = 100 + R_1$$

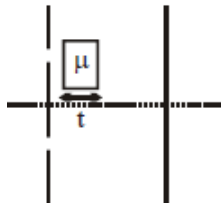
$$1900 = R_1$$

$$V_2 = \frac{10}{10^{-3}} = (2000 + R_2)$$

$$R_2 = 8000$$

$$V_3 = \frac{20}{10^{-3}} = 10 \times 10^3 + R_3 = 10 \times 10^3 R_3$$

- 18.

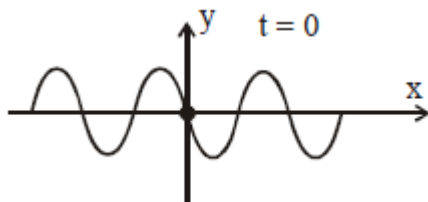


$$\Delta x = (\mu - 1)t = 1\lambda$$

for one maximum shift

$$t = \frac{\lambda}{\mu - 1}$$

- 19.

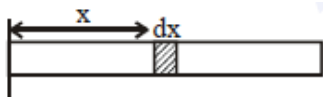


$$y = A \sin (kx - wt + \phi)$$

at $x = 0, t = 0$ and slope is negative

$$\Rightarrow \phi = \pi$$

20.



$$T = \int_{x=x}^{x=l} dm \omega^2 x = \int_{x=x}^{x=l} \frac{m}{l} dx \omega^2 x$$

$$= \frac{m\omega^2}{2l} (\ell^2 - x^2)$$

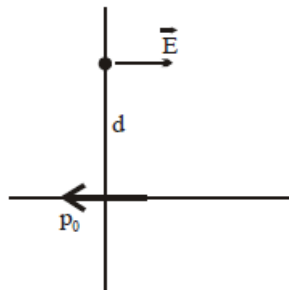
$$T = \frac{m\omega^2}{2l} (\ell^2 - x^2)$$

21.

$$V = 0$$

$$E = -\frac{K\vec{P}}{r^3}$$

$$= -\frac{\vec{p}}{4\pi\epsilon_0 d^3}$$



22. $\vec{E} = E_0 \hat{n} \sin(\omega t + (6y - 8z)) = E_0 \hat{n} \sin(\omega t + \vec{k} \cdot \vec{r})$

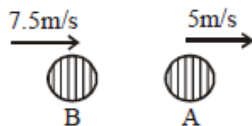
where $\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$ and $\vec{k} \cdot \vec{r} = 6y - 8z$

$$\Rightarrow \vec{k} = 6\hat{j} - 8\hat{k}$$

direction of propagation $\hat{s} = -\hat{k}$

$$= \left(\frac{-3\hat{j} + 4\hat{k}}{5} \right)$$

23.



$f_0 = 500$ Hz frequency received by B again =
 $\leftarrow 1500$

(B) \leftarrow (A) & \Rightarrow
 7.5 m/s \rightarrow \rightarrow 5 m/sec

$$f_2 = \left(\frac{1500 + 7.5}{1500 + 5} \right) \times \left(\frac{1500 - 5}{1500 - 7.5} \right) f_0 = 502 \text{ Hz}$$

24. Equation of trajectory is given as

$$y = 2x - 9x^2 \quad \dots(A)$$

Comparing with equation:

$$y = x \tan \theta - \frac{g}{2u^2 \cos^2 \theta} \cdot x^2 \quad \dots(B)$$

We get, $\tan \theta = 2$

$$\therefore \cos \theta = \frac{1}{\sqrt{5}}$$

$$\text{Also, } \frac{g}{2u^2 \cos^2 \theta} = 9$$

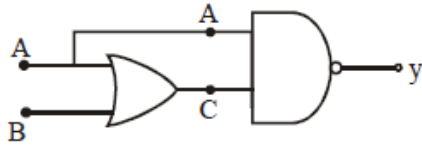
$$\Rightarrow \frac{10}{2 \times 9 \times \left(\frac{1}{\sqrt{5}} \right)^2} = u^2 \quad ; \quad u^2 = \frac{25}{9}$$

$$\Rightarrow u = \frac{5}{3} \text{ m/s}$$

25. $B = \frac{\mu_0 i}{2R} = \frac{\mu_0 q \omega}{2R \cdot 2\pi}$

$$\Rightarrow q = 3 \times 10^{-5} \text{ C}$$

26.



$$C = A + B$$

$$\text{and } y = \overline{A \cdot C}$$

A	B	$C = (A + B)$	A.C.	$y = \overline{A \cdot C}$
0	0	0	0	1
0	1	1	0	1
1	0	1	1	0
1	1	1	1	0

27.

	ΔE	ΔW	ΔQ
ab			250
bc		0	60
ca	-180		

	ΔE	ΔW	ΔQ
ab	120	130	250
bc	60	0	60
ca	-180		

28.

Light incident from particle P will be reflected at mirror.

$$u = -5 \text{ cm}, f = m - \frac{R}{2} = -20 \text{ cm}$$

$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f} \quad ; \quad v_1 = +\frac{20}{3} \text{ cm}$$

This image will act as object for light getting refracted at water surface.

$$\text{So, object distance } d = 5 + \frac{20}{3} = \frac{35}{3} \text{ cm}$$

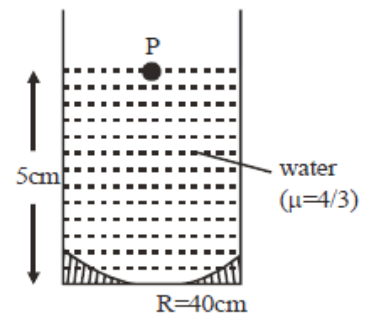
Below water surface.

After refraction, final image is at

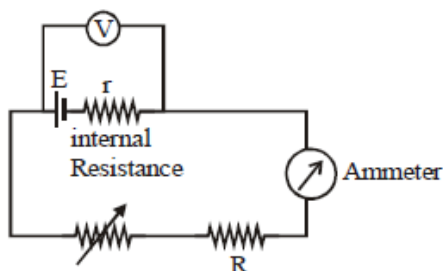
$$d' = d \left(\frac{\mu_2}{\mu_1} \right) = \left(\frac{35}{3} \right) \left(\frac{1}{4/3} \right)$$

$$= \frac{35}{4} = 8.75 \text{ cm}$$

$$\approx 8.8 \text{ cm}$$



29.



$$V = E - Ir$$

$$\text{When } V = V_0 = 0 \Rightarrow 0 = E - Ir$$

$$\therefore E = r$$

$$\text{When } I = 0, V = E = 1.5 \text{ V}$$

$$\therefore r = 1.5 \Omega$$

30. Angular momentum conservation

$$MV_0L = MV_1(L - \ell)$$

$$V_1 = V_0 \left(\frac{L}{L - \ell} \right)$$

$$W_g + W_p = \Delta KE$$

$$-mg\ell + W_p = \frac{1}{2}m(V_1^2 - V_0^2)$$

$$W_p = mg\ell + \frac{1}{2}mV_0^2 \left(\left(\frac{L}{L - \ell} \right)^2 - 1 \right)$$

$$= mg\ell + \frac{1}{2}mV_0^2 \left(\left(1 - \frac{\ell}{L} \right)^{-2} - 1 \right)$$

Now, $\ell \ll L$

By, Binomial approximation

$$= mg\ell + \frac{1}{2}mV_0^2 \left(\left(1 + \frac{\ell}{L} \right)^{-2} - 1 \right)$$

$$= mg\ell + \frac{1}{2}mV_0^2 \left(\frac{2\ell}{L} \right)$$

$$W_p = mg\ell + mV_0^2 \frac{\ell}{L}$$

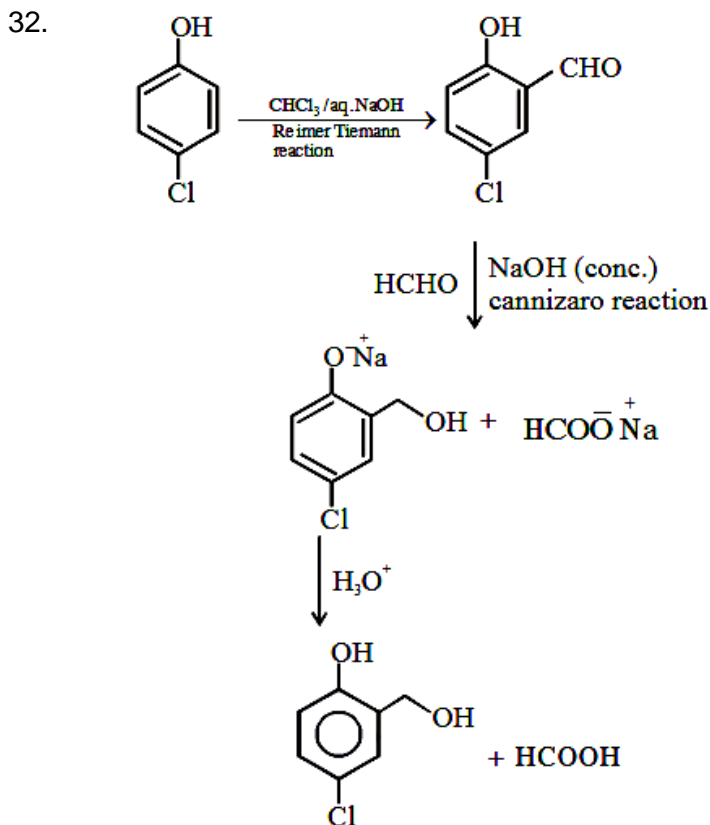
$$\text{Here, } V_0 = \text{maximum velocity} = \omega \times A = \left(\sqrt{\frac{g}{L}} \right) (\theta_0 L)$$

$$\text{So, } W_p = mg\ell + m \left(\theta_0 \sqrt{gL} \right)^2 \frac{\ell}{L}$$

$$= mg\ell (1 + \theta_0^2)$$

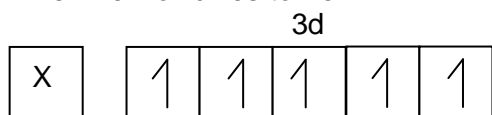
PART B – CHEMISTRY

31. $X_{\text{solvent}} = 0.8 = 8/10$
 $N_{\text{Total}} = 10, n_{\text{solvent}} = 8, n_{\text{solute}} = 2$
 Wt of solvent = 8×18
 Molality = $\frac{2 \times 1000}{8 \times 18}$

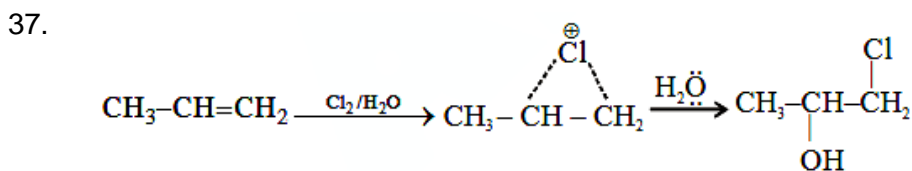
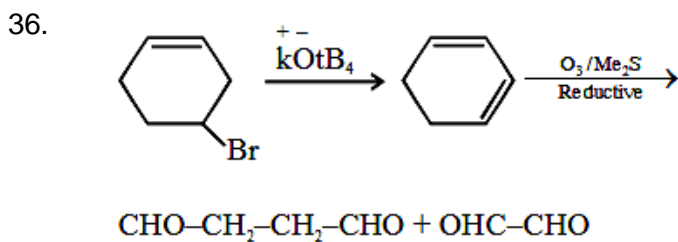


33. $p\pi-d\pi$ bonding in $\text{N}(\text{SiH}_3)_3$.

34. When Fe^{2+} oxidizes to Fe^{3+}



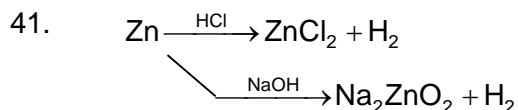
35. Smog photochemical is $\text{NO}, \text{NO}_2, \text{O}_3$.



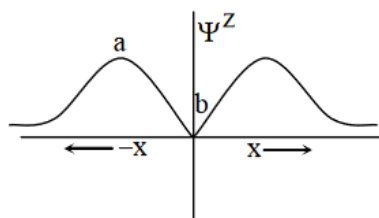
38. Smaller the size of cation, more polarisability high thermal decomposition of carbonates.

39. $15 \rightarrow 1s^2, 2s^2, 2p^6, 3s^2, 3p^3$ } Period- III, Group-V

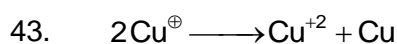
40. Peptization is process to form collidal solution by adding peptizing agent.



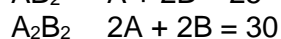
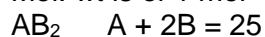
42.



At a & c, probability of finding electron is maximum



44. Mol. wt is of 1 mol



45. Basic unit is silicate $(\text{SiO}_4)^{4-}$

46.
$$\Delta C_p = \frac{\Delta H_2 - \Delta H_1}{T_2 - T_1}$$

47. Thermosetting are cross-linked polymer.

48. Two nearest tetrahedral voids are along one body-diagonal.

49. Canary yellow ppt comes in test of PO_4^{3-} ion.

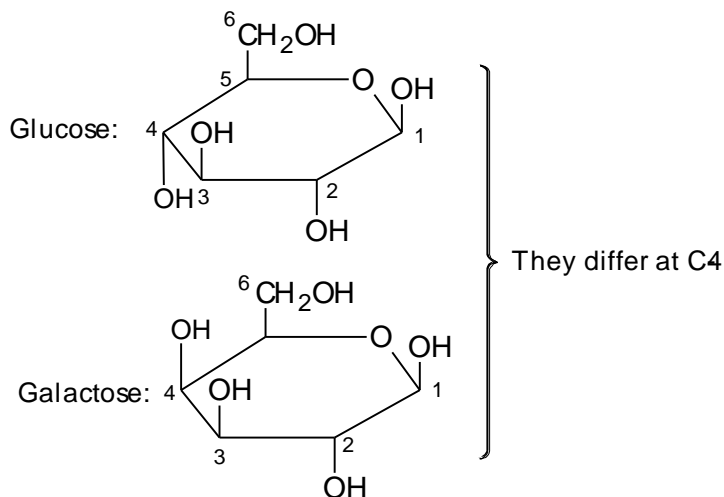
50. Concentration(on dressing), i.e. washing of ore.

51.
$$-\frac{1}{x} \left(\frac{dA}{dt} \right) = \frac{1}{y} \left(\frac{dB}{dt} \right)$$

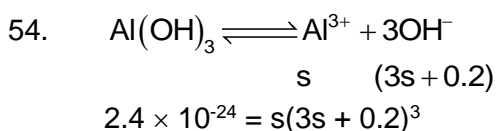
$$\log_{10} \left[-\frac{d(A)}{dt} \right] = \left[\log_{10} \left(\frac{dB}{dt} \right) \right] + \log \frac{x}{y} \quad] \log \frac{x}{y} = \log 0.3$$

$$\left(\frac{x}{y} = 2 \right)$$

52.

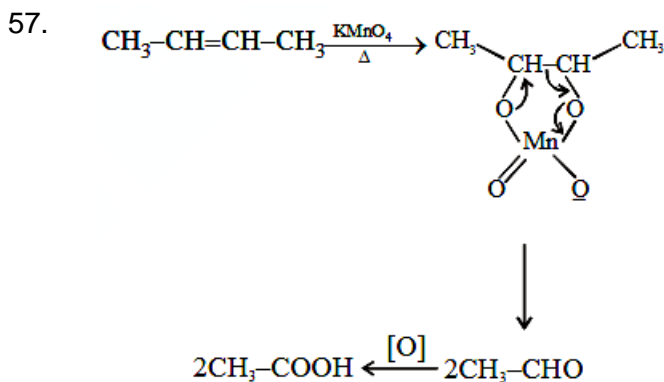


53. Not always double stranded α -helix.

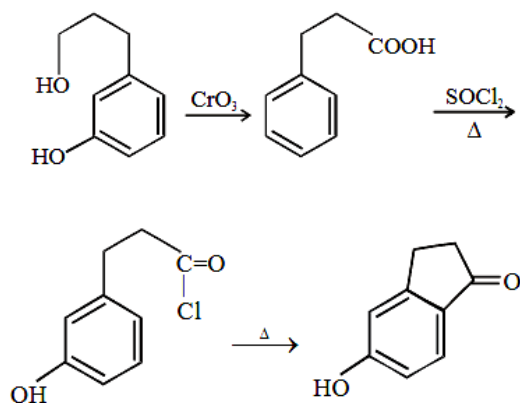


55. $\text{CH}_3\text{O}-$, CH_3- , H is electron donating, But $-\text{NO}_2$ is electron withdrawing group.

56. Lower the standard reduction potential, more the ability to get reduced higher the oxidizing power.



58.



59. Ligand field exerts mass repulsion along x, y axis as compared to Z-axis so $d_{x^2-y^2}$ and d_{xx} will have increase in energy y

60. $W = -P_{\text{ext}}(V_2 - V_1)$

PART C – MATHEMATICS

61. Tangents $y^2 = 12x \Rightarrow y = 2x + \frac{3}{m}$

$$\frac{x^2}{1} - \frac{y^2}{8} = 1 \Rightarrow y = mx \pm \sqrt{m^2 - 8}$$

Common tangent gives

$$\therefore \frac{3}{m} = \pm \sqrt{m^2 - 8}$$

$$m^4 - 8m^2 - 9 = 0$$

$$m = \pm 3$$

$$\therefore y = 3x + 1 \quad P\left(-\frac{1}{3}, 0\right)$$

$$y = -3x - 1$$

P divides SS' in 5 : 4.

$$\frac{x^2}{1} - \frac{y^2}{8} = 1$$

$$e = 3$$

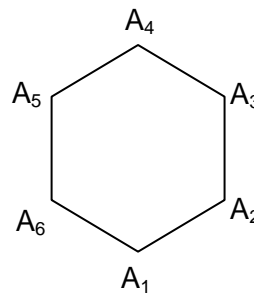
$$ae = 3$$

$$S = (3, 0)$$

$$S' = (-3, 0)$$

62. Only two equilateral triangle are possible $A_1A_3A_5$ and $A_2A_4A_6$

$$\frac{2}{{}^6C_3} = \frac{2}{20} = \frac{1}{10}$$



63.
$$\lim_{x \rightarrow 2} \frac{\int_0^x 4t^3 dt}{x - 2}$$

$$= \lim_{x \rightarrow 2} \frac{4 \cdot f^3(x) \cdot f'(x)}{1}$$

$$= 4f^3(2)f'(2) = 18$$

64.
$$\int \frac{2x^3 - 1}{x^4 + x} dx$$

$$\int \frac{2x - \frac{1}{x^2}}{x^2 + \frac{1}{x}} dx$$

$$x^2 + \frac{1}{x} = t$$

$$\left(2x - \frac{1}{x^2}\right) dx = dt$$

$$\int \frac{dt}{t} = \ln(t) + C$$

$$= \ln\left(x^2 + \frac{1}{x}\right) + C$$

65. $(1+x)(1-x)^{10}(1+x+x^2)^9$

$$(1-x^2)(1-x^3)^9$$

$${}^9C_6 = 84$$

66. Since ${}^{21}C_0 + \dots + {}^{21}C_{10} + {}^{21}C_{11} + \dots + {}^{21}C_{21} = 2^{21}$
 \Rightarrow but we have to select 10 objects and ${}^{21}C_0 + \dots + {}^{21}C_{10} = {}^{21}C_{11} + \dots + {}^{21}C_{21}$
 $({}^{21}C_0 + \dots + {}^{21}C_{10}) = 2^{20}$

67. $np = 8$
 $npq = 4$

$$q = \frac{1}{2} \Rightarrow p = \frac{1}{2}$$

$$n = 16$$

$$p(x=r) = {}^{16}C_r \left(\frac{1}{2}\right)^{16}$$

$$p(x \leq 2) = \frac{{}^{16}C_0 + {}^{16}C_1 + {}^{16}C_2}{2^{16}}$$

$$= \frac{137}{2^{16}}$$

68. $|z - i| = |z - 1|$
gives $y = x$

69. $f(x) = x\sqrt{kx - x^2}$
 $f'(x) = \frac{3kx - 4x^2}{2\sqrt{kx - x^2}}$

For increasing $f(x) \geq 0$

$$kx - x^2 \geq 0$$

$$x^2 - kx \leq 0$$

$$x(x - k) \leq 0 \text{ so } x \in [0, 3]$$

$$\text{+ve } \boxed{x \geq 3}$$

$$3kx - 4x^2 \geq 0$$

$$4x^2 - 3kx \leq 0$$

$$4x \left(x - \frac{3k}{4}\right) \leq 0$$

$$3 - \frac{3k}{4} \leq 0$$

$$k \geq 4$$

minimum value of k is $m = 4$

$$f(x) = x\sqrt{kx - x^2}$$

$$= 3\sqrt{4 \times 3 - 3^2} = 3\sqrt{3}, M = 3\sqrt{3}$$

70. $x_1 + \dots + x_4 = 44$

$$x_5 + \dots + x_{10} = 96$$

$$\bar{x} = 14, \sum x_i = 140$$

$$\text{Variance} = \frac{\sum x_i^2}{n} - \bar{x}^2 = 4$$

$$\text{Standard deviation} = 2$$

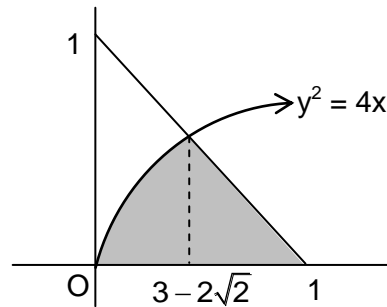
71. $\{(x, y) : y^2 \leq 4x, x + y \leq 1, x \geq 0, y \geq 0\}$

$$A = \int_0^{3-2\sqrt{2}} 2\sqrt{x} dx + \frac{1}{2}(1 - (3 - 2\sqrt{2}))(1 - (3 - 2\sqrt{2}))$$

$$= \frac{2[x^{3/2}]_0^{3-2\sqrt{2}}}{3/2} + \frac{1}{2}(2\sqrt{2} - 2)(2\sqrt{2} - 2)$$

$$= \frac{8\sqrt{2}}{3} + \left(-\frac{10}{3}\right)$$

$a = \frac{8}{3}, b = -\frac{10}{3}$
 $a - b = 6$



72. $y^2 dx + x dy = \frac{dy}{y}$

$$\frac{dx}{dy} + \frac{x}{y^2} = \frac{1}{y^3}$$

$$IF = e^{\int \frac{1}{y^2} dy} = e^{-\frac{1}{y}}$$

$$e^{\frac{1}{y}} \cdot x = \int e^{\frac{1}{y}} \cdot \frac{1}{y^3} dy + C$$

$$xe^{\frac{1}{y}} = e^{\frac{1}{y}} + \frac{e^{-\frac{1}{y}}}{y} + C$$

$$C = -\frac{1}{e}$$

$$x = \frac{3}{2} - \frac{1}{\sqrt{e}} \text{ when } y = 2$$

73. $375x^2 - 25x - 2 = 0$

$$\alpha + \beta = \frac{25}{375}, \alpha\beta = \frac{-2}{375}$$

$$\Rightarrow (\alpha + \alpha^2 + \dots \text{upto infinite terms}) + (\beta + \beta^2 + \dots \text{upto infinite terms})$$

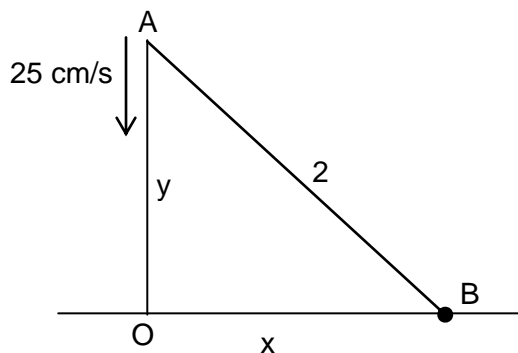
$$= \frac{\alpha}{1-\alpha} + \frac{\beta}{1-\beta} = \frac{1}{12}$$

74. $x^2 + y^2 = 4 \left(\frac{dy}{dt} = -25 \right)$

$$x \frac{dx}{dt} + y \frac{dy}{dt} = 0$$

$$\sqrt{3} \frac{dx}{dt} - 1(25) = 0$$

$$\frac{dx}{dt} = \frac{25}{\sqrt{3}} \text{ cm/sec}$$



75. $1 + \sin^4 x = \cos^2 3x$
 $\sin x = 0$ and $\cos 3x = 1$
 $0, 2\pi, -2\pi, -\pi, \pi$

76. $e^y = xy = e$ differentiate w.r.t. x

$$e^y \frac{dy}{dx} + x \frac{dy}{dx} + y = 0$$

$$e^y \frac{dy}{dx} + x \frac{dy}{dx} + y = 0$$

$$\frac{dy}{dx}(x + e^y) = -y, \left. \frac{dy}{dx} \right|_{(0,1)} = -\frac{1}{e} \text{ again differentiate w.r.t. } x$$

$$e^y \cdot \frac{d^2y}{dx^2} + \frac{dy}{dx} \cdot e^y \cdot \frac{dy}{dx} + x \cdot \frac{d^2y}{dx^2} + \frac{dy}{dx} + \frac{dy}{dx} = 0$$

$$(x + e^y) \frac{d^2y}{dx^2} + \left(\frac{dy}{dx}\right)^2 \cdot e^y + 2 \frac{dy}{dx} = 0$$

$$e \frac{d^2y}{dx^2} + \frac{1}{e} e + 2\left(-\frac{1}{e}\right) = 0$$

$$\therefore \frac{d^2y}{dx^2} = \frac{1}{e^2}$$

77. $\sin^{-1}\left(\frac{12}{13}\right) - \sin^{-1}\left(\frac{3}{5}\right)$

$$\sin^{-1}(x\sqrt{1-y^2} - y\sqrt{1-x^2})$$

$$= \sin^{-1}\left(\frac{33}{65}\right) = \cos^{-1}\left(\frac{56}{65}\right) = \frac{\pi}{2} - \sin^{-1}\left(\frac{56}{65}\right)$$

78. $3x^2 + 4y^2 = 12$

$$\frac{x^2}{4} + \frac{y^2}{3} = 1$$

$$x = 2\cos\theta, y = \sqrt{3}\sin\theta$$

$$\text{Equation of normal is } \frac{a^2x}{x_1} - \frac{b^2y}{y_1} = a^2 - b^2$$

$$2x \sin\theta - \sqrt{3} \cos\theta y = \sin\theta \cos\theta$$

$$\text{Slope } \frac{2}{\sqrt{3}} \tan\theta = -2 \quad \therefore \tan\theta = -\sqrt{3}$$

Equation of tangent is it passes through (4, 4)

$$3x \cos\theta + 2\sqrt{3} \sin\theta y = 6$$

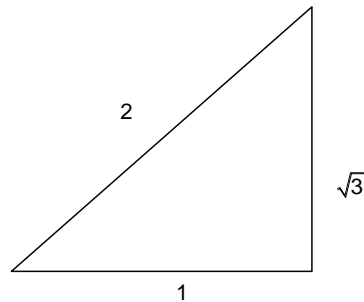
$$12 \cos\theta + 8\sqrt{3} \sin\theta = 6$$

$$\cos\theta = -\frac{1}{2}, \sin\theta = \frac{\sqrt{3}}{2} \quad \therefore \theta = 120^\circ$$

Hence point P is $(2\cos 120^\circ, \sqrt{3}\sin 120^\circ)$

$$P\left(-1, \frac{2}{2}\right), Q(4, 4)$$

$$PQ = \frac{5\sqrt{5}}{2}$$



79. $(\vec{a} + \vec{b}) \times (\vec{a} - \vec{b})$

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

$$= 2(8\hat{i} - 8\hat{j} + 4\hat{k})$$

Required vector = $\pm 12 \frac{(2\hat{i} - 2\hat{j} - \hat{k})}{3}$

$$= \pm 4(2\hat{i} - 2\hat{j} - \hat{k})$$

80. $2y = 2\sin x \sin(x + 2) - 2\sin^2(x + 1)$

$$2y = \cos 2 - \cos(2x + 2) - (1 - \cos(2x + 2))$$

$$= \cos 2 - 1$$

$$2y = -2\sin^2 \frac{1}{2}$$

$$y = -\sin^2 \frac{1}{2} \leq 0$$

81. $f(x) = \sqrt{x}, g(x) = \tan x, h(x) = \frac{1-x^2}{1+x^2}$

$$f \circ g(x) = \sqrt{\tan x}$$

$$h \circ f \circ g(x) = h(\sqrt{\tan x}) = \frac{1 - \tan x}{1 + \tan x}$$

$$= -\tan\left(\frac{\pi}{4} - x\right)$$

$$\phi(x) = \tan\left(\frac{\pi}{4} - x\right)$$

$$\phi\left(\frac{\pi}{3}\right) = \tan\left(\frac{\pi}{4} - \frac{\pi}{3}\right) = \tan\left(-\frac{\pi}{12}\right) = -\tan \frac{\pi}{12}$$

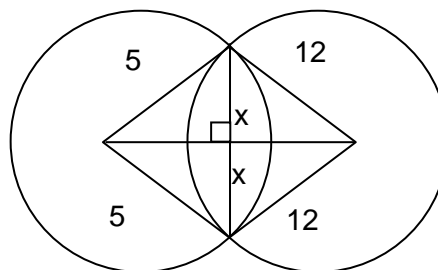
$$= \tan\left(\pi - \frac{\pi}{12}\right) = \tan \frac{11\pi}{12}$$

82. Let length of common chord = $2x$

$$\sqrt{25 - x^2} + \sqrt{144 - x^2} = 13$$

After solving $x = \frac{12 \times 5}{13}$

$$2x = \frac{120}{13}$$



83. $\int_0^{\pi/2} \frac{\cot x \, dx}{\cot x + \operatorname{cosec} x}$

$$\int_0^{\pi/2} \frac{\cos x}{\cos x + 1} = \int \frac{2\cos^2 \frac{x}{2} - 1}{2\cos^2 \frac{x}{2}}$$

$$\int_0^{\pi/2} \left(1 - \frac{1}{2} \sec^2 \frac{x}{2}\right) dx$$

$$\left[x - \tan \frac{x}{2} \right]_0^{\pi/2}$$

$$\frac{1}{2} [\pi - 2] \quad m = \frac{1}{2}, n = -2$$

$$mn = -1$$

84. $2\{2a + 3d\} = 16$

$$3(2a + 5d) = -48$$

$$2a + 3d = 8$$

$$2a + 5d = -16$$

$$d = -12$$

$$S_{10} = 5\{44 - 9 \times 12\}$$

$$= -320$$

85. $|B| = 5(-5) - 2\alpha(-\alpha) - 2\alpha$

$$= 2\alpha^2 - 2\alpha - 25$$

$$1 + |A| = 0$$

$$\alpha^2 - \alpha - 12 = 0$$

$$\text{Sum} = 1$$

86. $\frac{x-2}{3} = \frac{y+1}{2} = \frac{z-1}{-1} = \lambda$

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

Intersection with plane $2x + 3y - z + 13 = 0$

$$2(3\lambda + 2) + 3(2\lambda - 1) - (-\lambda + 1) + 13 = 0$$

$$13\lambda + 13 = 0$$

$$\lambda = -1$$

$$\therefore P(-1, -3, 2)$$

Intersection with plane

$$3x + y + 4z = 16$$

$$3(3\lambda + 2) + (2\lambda - 1) + 4(-\lambda + 1) = 16$$

$$\lambda = 1$$

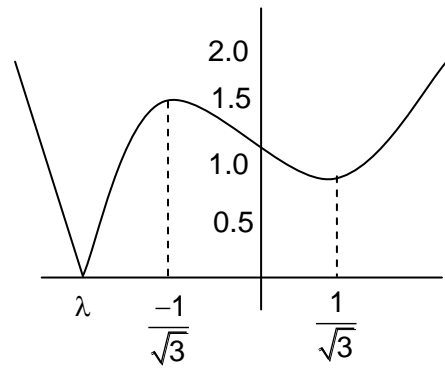
$$Q(5, 1, 0)$$

$$PQ = \sqrt{6^2 + 4^2 + 2^2} = \sqrt{56} = 2\sqrt{14}$$

87. Volume of parallelepiped = $\begin{vmatrix} 1 & \lambda & 1 \\ 0 & 1 & \lambda \\ \lambda & 0 & 1 \end{vmatrix}$

$$f(\lambda) = |\lambda^3 - \lambda + 1|$$

Its graphs as follows



where $\lambda \approx -1.32$

For minimum value of volume of paralelopiped and corresponding value of λ ; the minimum value is zero, \therefore cubic always has at least one real root.

Hence answer to the question must be root of cubic $\lambda^3 - \lambda + 1 = 0$. None of the options satisfies the cubic.

Hence Question must be Bonus.

88. $A = A', B = -B'$

$$A + B = \begin{bmatrix} 2 & 3 \\ 5 & -1 \end{bmatrix} \dots\dots\dots(1)$$

$$A' - B' = \begin{bmatrix} 2 & 5 \\ 3 & -1 \end{bmatrix}$$

$$A - B = \begin{bmatrix} 2 & 5 \\ 3 & -1 \end{bmatrix} \dots\dots\dots(2)$$

After adding equation (1) and (2)

$$A = \begin{bmatrix} 2 & 4 \\ 4 & -1 \end{bmatrix}, B = \begin{bmatrix} 0 & -1 \\ 1 & 0 \end{bmatrix}$$

$$AB = \begin{bmatrix} 4 & -2 \\ -1 & -4 \end{bmatrix}$$

89. $P \rightarrow (\sim q \vee r)$

$$\sim p \vee (\sim q \vee r)$$

$$\left. \begin{array}{l} \sim p \rightarrow F \\ \sim q \rightarrow F \\ \sim r \rightarrow F \end{array} \right\} \Rightarrow \left. \begin{array}{l} p \rightarrow T \\ q \rightarrow T \\ r \rightarrow F \end{array} \right\}$$

90.
$$\underbrace{\left[-\frac{1}{3} \right] + \left[-\frac{1}{3} - \frac{1}{100} \right] + \dots + \left[\frac{1}{3} - \frac{66}{100} \right]}_{(-1)67} + \underbrace{\left[-\frac{1}{3} - \frac{67}{100} \right] + \dots + \left[-\frac{1}{3} - \frac{99}{100} \right]}_{-2(33)} = -133$$