FIITJEE

Solutions to JEE(Main)-2020

Test Date: 6th September 2020 (Second Shift)

PHYSICS, CHEMISTRY & MATHEMATICS

Paper - 1

Time Allotted: 3 Hours | **Maximum Marks: 300**

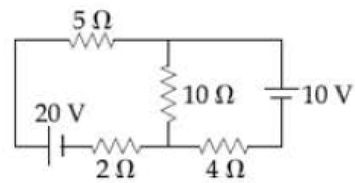
- Please read the instructions carefully. You are allotted 5 minutes specifically for this purpose.

Important Instructions:

1. The test is of **3 hours** duration.
2. This **Test Paper** consists of **75** questions. The maximum marks are **300**.
3. There are ***three*** parts in the question paper A, B, C consisting of **Physics, Chemistry** and **Mathematics** having 25 questions in each part of equal weightage out of which 20 questions are MCQs and 5 questions are numerical value based. Each question is allotted **4 (four)** marks for correct response.
4. **(Q. No. 01 – 20, 26 – 45, 51 – 70)** contains 60 multiple choice questions which have **only one correct answer**. Each question carries **+4 marks** for correct answer and **–1 mark** for wrong answer.
5. **(Q. No. 21 – 25, 46 – 50, 71 – 75)** contains 15 Numerical based questions with answer as numerical value. Each question carries **+4 marks** for correct answer. There is no negative marking.
6. Candidates will be awarded marks as stated above in **instruction No.3** 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 box.
7. There is only one correct response for each question. Marked up more than one response in any question will be treated as wrong response and marked up for wrong response will be deducted accordingly as per **instruction 6** above.

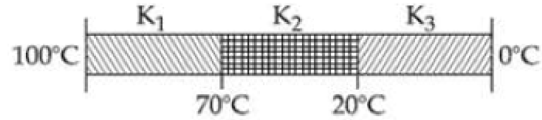
PART –A (PHYSICS)

1. In the figure shown, the current in the 10 V battery is close to:
(A) 0.71 A from positive to negative terminal
(B) 0.42 A from positive to negative terminal
(C) 0.21 A from positive to negative terminal.
(D) 0.36 A from negative to positive terminal.



2. A charged particle going around in a circle can be considered to be a current loop. A particle of mass m carrying charge q is moving in a plane with speed v under the influence of magnetic field $\vec{B}$. The magnetic moment of this moving particle:
(A) $\frac{mv^2\vec{B}}{2B^2}$ (B) $-\frac{mv^2\vec{B}}{2\pi B^2}$ (C) $-\frac{mv^2\vec{B}}{B^2}$ (D) $-\frac{mv^2\vec{B}}{2B^2}$

3. Three rods of identical cross-section and lengths are made of three different materials of thermal conductivity K_1, K_2 and K_3, respectively. They are joined together at their ends to make a long rod (see figure). One end of the long rod is maintained at 100°C and the other at 0°C (see figure). If the joints of the rod are at 70°C and 20°C in steady state and there
is no loss of energy from the surface of the rod, the correct relationship between K_1, K_2 and K_2 is:



(A) $K_1 : K_3 = 2 : 3$, $K_2 : K_3 = 2 : 5$ (B) $K_1 < K_2 < K_3$
(C) $K_1 : K_2 = 5 : 2$, $K_1 : K_3 = 3 : 5$ (D) $K_1 > K_2 > K_3$

4. Two identical electric point dipoles have dipole moments $\vec{p}_1 = p\hat{i}$ and $\vec{p}_2 = -p\hat{i}$ and are held on the x axis at distance 'a' from each other. When released, they move along the x-axis with the direction of their dipole moments remaining unchanged. If the mass of each dipole is 'm', their speed when they are infinitely far apart is:
(A) $\frac{p}{a}\sqrt{\frac{1}{\pi\epsilon_0 ma}}$ (B) $\frac{p}{a}\sqrt{\frac{1}{2\pi\epsilon_0 ma}}$ (C) $\frac{p}{a}\sqrt{\frac{2}{\pi\epsilon_0 ma}}$ (D) $\frac{p}{a}\sqrt{\frac{3}{2\pi\epsilon_0 ma}}$

5. For a plane electromagnetic wave, the magnetic field at a point x and time t is
$\vec{B}(x, t) = \left[1.2\times10^{-7}\sin(0.5\times10^3x + 1.5\times10^{11}t)\hat{k}\right]T$
The instantaneous electric field $\vec{E}$ corresponding to $\vec{B}$ is: (speed of light c = 3 × 10^8 ms^{-1})
(A) $\vec{E}(x, t) = \left[-36\sin(0.5\times10^3x + 1.5\times10^{11}t)\hat{j}\right]\frac{V}{m}$
(B) $\vec{E}(x, t) = \left[36\sin(1\times10^3x + 0.5\times10^{11}t)\hat{j}\right]\frac{V}{m}$
(C) $\vec{E}(x, t) = \left[36\sin(0.5\times10^3x + 1.5\times10^{11}t)\hat{k}\right]\frac{V}{m}$
(D) $\vec{E}(x, t) = \left[36\sin(1\times10^3x + 1.5\times10^{11}t)\hat{i}\right]\frac{V}{m}$

6. Two planets have masses M and 16 M and their radii are a and 2a, respectively. The separation between the centres of the planets is 10a. A body of mass m is fired from the surface of the larger planet towards the smaller planet along the line joining their centres. For the body to be able to reach at the surface of smaller planet, the minimum firings speed needed is:

(A) $2\sqrt{\frac{GM}{a}}$ (B) $4\sqrt{\frac{GM}{a}}$

(C) $\sqrt{\frac{GM^2}{ma}}$ (D) $\frac{3}{2}\sqrt{\frac{5GM}{a}}$

7. A particle moving in the xy plane experiences a velocity dependent force $\vec{F} = k\left(v_y\hat{i} + v_x\hat{j}\right)$, where v_x and v_y are the x and y components of its velocity $\vec{v}$. If $\vec{a}$ is the acceleration of the particle, then which of the following statements is true for the particle?

(A) quantity $\vec{v} \times \vec{a}$ is constant in time

(B) $\vec{F}$ arises due to a magnetic field.

(C) kinetic energy of particle is constant in time.

(D) quantity $\vec{v} \cdot \vec{a}$ is constant in time.

8. Particle A of mass m_1 moving with velocity $\left(\sqrt{3}\,\hat{i} + \hat{j}\right)ms^{-1}$ collides with another particle B of mass m_2 which is at rest initially. Let $\vec{V}_1$ and $\vec{V}_2$ be the velocities of particles A and B after collision respectively. If $m_1 = 2m_2$ and aftr collision $\vec{V}_1 = \left(\hat{i} + \sqrt{3}\hat{i}\right)ms^{-1}$, the angle between $\vec{V}_1$ and $\vec{V}_2$ is:

(A) 15° (B) 60□°

(C) –45° (D) 105°

9. When a car is at rest, its driver sees rain drops falling on it vertically. When driving the car with speed v, he sees that rain drops are coming at an angle 60° from the horizontal. On further increasing the speed of the car to $(1 + \beta)v$, this angle changes to 45°. The value of β is close to:

(A) 0.50 (B) 0.41

(C) 0.37 (D) 0.73

10. Given the masses of various atomic particles m_p = 1.0072 u, m_n = 1.0087 u, m_e = 0.000548 u, $m_{\bar{v}} = 0$, m_d = 2.0141 u, where p ≡ proton, n ≡ neutron, e ≡ electron, $\bar{v}$ ≡ antineutrino and d ≡ deuteron. Which of the following process is allowed by momentum and energy conservation?

(A) n + n $\rightarrow$ deuterium atom (electron bound to the nucleus)

(B) $p \rightarrow n + e^+ + \bar{v}$

(C) $n + p \rightarrow d + \gamma$

(D) $e^+ + e^- \rightarrow \gamma$

11. A circuit to verify Ohm's law uses ammeter and voltmeter in series or parallel connected correctly to the resistor. In the circuit:

(A) ammeter is always used in parallel and voltmeter is series.

(B) both ammeter and voltmeter must be connected in parallel.

(C) ammeter is always connected in series and voltmeter in parallel.

(D) both, ammeter and voltmeter must be connected in series.

12. Consider the force F on a charge 'q' due to a uniformly charged spherical shell of radius R carrying charge Q distributed uniformly over it. Which one of the following statements is true for F, if 'q' is placed at distance r from the centre of the shell?

(A) $F = \frac{1}{4\pi \in_0} \frac{Qq}{R^2}$ for $r < R$
(B) $\frac{1}{4\pi \in_0} \frac{qQ}{R^2} > F > 0$ for $r < R$
(C) $F = \frac{1}{4\pi \in_0} \frac{Qq}{r^2}$ for $r > R$
(D) $F = \frac{1}{4\pi \in_0} \frac{Qq}{r^2}$ for all r

13. A student measuring the diameter of a pencil of circular cross-section with the help of a vernier scale records the following four readings 5.50 mm, 5.55 mm, 5.45 mm ; 5.65 mm. The average of these four readings is 5.5375 mm and the standard deviation of the data is 0.07395 mm. The average diameter of the pencil should therefore be recorded as:

(A) (5.5375 ± 0.0739) mm
(B) (5.5375 ± 0.0740) mm
(C) (5.538 ± 0.074) mm
(D) (5.54 ± 0.07) mm

14. A double convex lens has power P and same radii of curvature R of both the surfaces. The radius of curvature of a surface of a plano-convex lens made of the same material with power 1.5 P is

(A) 2R
(B) $\frac{R}{2}$
(C) $\frac{3R}{2}$
(D) $\frac{R}{3}$

15. A square loop of side 2a and carrying current I is kept in xz plane with its centre at origin. A long wire carrying the same current I is placed parallel to z-axis and passing through point (0, b, 0), (b >> a). The magnitude of torque on the loop about z-axis will be

(A) $\frac{2\mu_0 I^2 a^2}{\pi b}$
(B) $\frac{2\mu_0 I^2 a^2 b}{\pi(a^2 + b^2)}$
(C) $\frac{\mu_0 I^2 a^2 b}{2\pi(a^2 + b^2)}$
(D) $\frac{\mu_0 I^2 a^2}{2\pi b}$

16. A fluid is flowing through a horizontal pipe of varying cross-section, with speed v ms^{-1} a ta point where the pressure is P Pascal. At another point where pressure is $\frac{P}{2}$ Pascal its speed is V ms^{-1}. If the density of the fluid is ρ kg m^{-3} and the flow is streamline, then V is equal to:

(A) $\sqrt{\frac{P}{p} + v}$
(B) $\sqrt{\frac{2P}{p} + v^2}$
(C) $\sqrt{\frac{P}{2p} + v^2}$
(D) $\sqrt{\frac{P}{p} + v^2}$

17. When a particle of mass m is attached to a vertical spring of spring constant k and released, its motion is described by $y(t) = y_0 \sin^2 \omega t$, where 'y' is measured from the lower end of unstretched spring. Then ω is:

(A) $\frac{1}{2}\sqrt{\frac{g}{y_0}}$
(B) $\sqrt{\frac{g}{y_0}}$
(C) $\sqrt{\frac{g}{2y_0}}$
(D) $\sqrt{\frac{2g}{y_0}}$

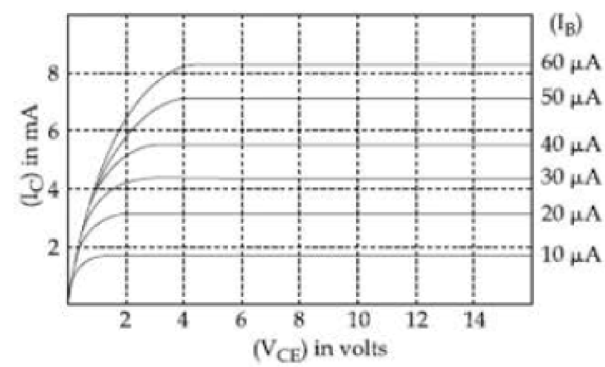
18. In a dilute gas at pressure P and temperature T, the mean time between successive collisions of a molecule varies with T as:

(A) T
(B) $\frac{1}{\sqrt{T}}$
(C) $\frac{1}{T}$
(D) $\sqrt{T}$

19. Assuming the nitrogen molecule is moving with r.m.s. velocity at 400 K, the de-Broglie wavelength of nitrogen molecule is close to:
(Given: nitrogen molecule weight: 4.64×10^{-26} kg, Boltzman constant: 1.38×10^{-23} J/K, Planck constant: 6.63×10^{-34} Js)
(A) 0.24 Å (B) 0.20 Å (C) 0.34 Å (D) 0.44 Å

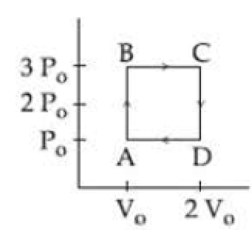
20. The liner mass density of a thin rod AB of length L varies from A to B as $\lambda(x) = \lambda_0\left(1+\frac{x}{L}\right)$, where x is the distance from A. If M is the mass of the rod hen its moment of inertia about an axis passing through A and perpendicular to the rod is:
(A) $\frac{5}{12}ML^2$ (B) $\frac{7}{18}ML^2$ (C) $\frac{2}{5}ML^2$ (D) $\frac{3}{7}ML^2$

21. The out put characteristics of a transistor is shown in the figure. When V_{CE} is 10 V and I_C = 4.0 mA, then value of β_{ac} is ____________.



22. The centre of mass of a solid hemisphere of radius 8 cm is x cm from the centre of the flat surface. Then value of x is ____________.

23. An engine operates by taking a monatomic ideal gas through the cycle shown in the figure. The percentage efficiency of the engine is close to ____________.



24. A Young's double-slit experiment is performed using monochromatic light of wavelength λ. The intensity of light at a point on the screen, where the path difference is λ, is K units. The intensity of the light at a point where the path difference is $\frac{\lambda}{6}$ is given by $\frac{nK}{12}$, where 'n' is an integer. The value of 'n' is ____________.

25. In a series LR circuit, power of 400 W is dissipated from a source of 250 V, 50 Hz. The power factor of the circuit is 0.8. In order to bring the power factor to unity, a capacitor of value C is added in series to the L and R. Taking the value of C as $\left(\frac{n}{3\pi}\right)\mu F$, then value of 'n' is ____________.

PART –B (CHEMISTRY)

26. For a reaction,
$4M(s) + nO_2(g) \rightarrow 2M_2O_n(s)$,
the free energy change is plotted as a function of temperature. The temperature below which the oxide is stable could be inferred from the plot as the point at which
(A) the slope changes from negative to positive.
(B) the free energy change shows a change from negative to positive value.
(C) the slope changes from positive to negative.
(D) the slope changes from positive to zero.

27. The average molar mass of chlorine is 35.5 g mol^{-1}. The ratio of ^{35}Cl to ^{37}Cl in naturally occurring chlorine is close to:
(A) 4 : 1 (B) 3 : 1
(C) 2 : 1 (D) 1 : 1

28. Which one of the following statements is not true?
(A) Lactose contains □-glycosidic linkage between C_1 of galactose and C_4 of glucose.

(B) Lactose is a reducing sugar and it gives Fehling's test.
(C) Lactose ($C_{11}H_{22}O_{11}$) is a disaccharide and it contains 8 hydorxyl groups.
(D) molecule of D(+)-glucose and one molecule of D(+)-galactose.

29. The value of K_C is 64 at 800 K for the reaction
$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$
The value of K_C for the following reaction is:
$NH_3(g) \rightleftharpoons \frac{1}{2}N_2(g) + \frac{3}{2}H_2(g)$
(A) $\frac{1}{64}$ (B) 8
(C) $\frac{1}{4}$ (D) $\frac{1}{8}$

30. Dihydrogen of high purity (>99.95%) is obtained through:
(A) the reaction of Zn with dilute HCl.
(B) the electrolysis of acidified water using Pt electrodes
(C) the electrolysis of brine solution.
(D) the electrolysis of warm $Ba(OH)_2$ solution using Ni electrodes.

31. The reaction of NO with N_2O_4 at 250 K gives:
(A) N_2O (B) NO_2
(C) N_2O_3 (D) N_2O_5

32. The correct match between Item-I (starting material) and Item-II (reagent) for the preparation of benzaldehyde is:

	Item-I		Item-II
(I)	Benzene	(P)	HCl and $SnCl_2$, H_3O^+
(II)	Benzonitrile	(Q)	H_2, Pd-$BaSO_4$, S and quinoline
(III)	Benzoyl Chloride	(R)	CO, HCl and $AlCl_3$

(A) (I) – (Q), (II) – (R) and (III) – (P)
(B) (I) – (P), (II) – (Q) and (III) – (R)
(C) (I) – (R), (II) – (P) and (III) – (Q)
(D) (I) – (R), (II) – (Q) and (III) – (P)

33. A crystal is made up of metal ions 'M_1' and 'M_2' and oxide ions. Oxide ions form a ccp lattice structure. The cation 'M_1' occupies 50% of octahedral voids and the cation 'M_2' occupies 12.5% of tetrahedral voids of oxide lattice. The oxidation numbers of 'M_1' and 'M_2' are respectively:
(A) +2, +4
(B) +1, +3
(C) +3, +1
(D) +4, +2

34. The element that can be refined by distillation is:
(A) nickel
(B) zinc
(C) tin
(D) gallium

35. For a d^4 metal ion in an octahedral field, the correct electronic configuration is:
(A) $t_{2g}^3 e_g^1$ when $\Delta_o < P$
(B) $t_{2g}^3 e_g^1$ when $\Delta_o > P$
(C) $t_{2g}^4 e_g^0$ when $\Delta_o < P$
(D) $t_g^2 e_{2g}^2$ when $\Delta_o < P$

36. Match the following:

	Test / Method		Reagent
(i)	Lucas Test	(a)	$C_6H_5SO_2Cl$ / aq. KOH
(ii)	Dumas method	(b)	HNO_3 / $AgNO_3$
(iii)	Kjeldahl's method	(c)	CuO / CO_2
(iv)	Hinsberg Test	(d)	Conc. HCl and $ZnCl_2$
		(e)	H_2SO_4

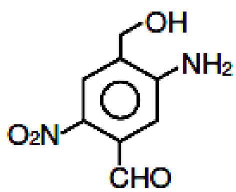
(A) (i)-(d), (ii)-(c), (iii)-(b), (iv)-(e)
(B) (i)-(b), (ii)-(d), (iii)-(e), (iv)-(a)
(C) (i)-(d), (ii)-(c), (iii)-(e), (iv)-(a)
(D) (i)-(b), (ii)-(a), (iii)-(c), (iv)-(d)

37. Match the following compounds (Column-I) with their uses (Column-II):

S. No.	Column-I	S. No.	Column-II
(i)	$Ca(OH)_2$	(A)	casts of statues
(ii)	NaCl	(B)	white wash
(iii)	$CaSO_4 \cdot \frac{1}{2}H_2O$	(C)	antacid
(iv)	$CaCO_3$	(D)	Washing soda preparation

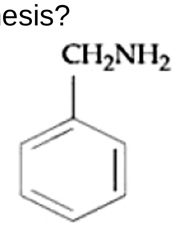
(A) (i)-(D), (ii)-(A), (iii)-(C), (iv)-(B)
(B) (i)-(B), (ii)-(D), (iii)-(A), (iv)-(A)
(C) (i)-(B), (ii)-(C), (iii)-(D), (iv)-(A)
(D) (i)-(C), (ii)-(D), (iii)-(B), (iv)-(A)

38. The IUPAC name of the following compound is

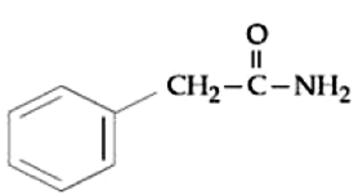


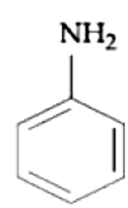
(A) 2-nitrogen-4-hydroxymethyl-5-amine benzaldehyde.
(B) 3-amino-4-hydroxymethyl 1-5-nitrobvenzaldehyde
(C) 5-amino-4hydroxymethyl-2-nitrobenzaldehyde
(D) 4-amino-2formyl-5hydroxymethyl nitrobenzene

39. Which of the following compounds can e prepared in good yield by Gabriel phthalimide synthesis?

(A)


(B) CH_3–CH_2–$NHCH_3$

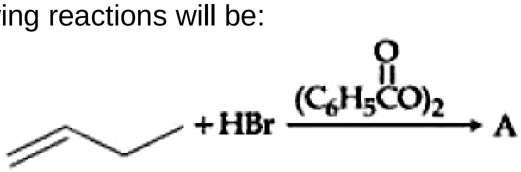
(C)


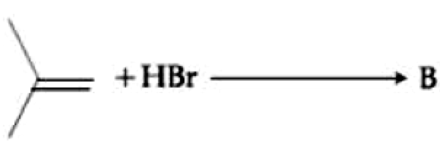
(D)


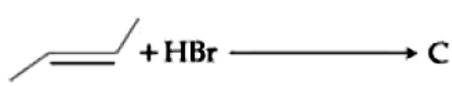
40. A set of solutions is prepared using 180 g of water as a solvent and 10 g of different non-volatile solutes A, B and C. The relative lowering of vapour pressure in the presence of these solutes are in the order [Given, molar mass of A = 100 g mol^{-1} ; B = 200 g mol^{-1} ; C = 10,000 g mol^{-1}]
(A) B > C > A
(B) C > B > A
(C) A > B > C
(D) A > C > B

41. For the given cell;
$Cu(s) \mid Cu^{2+} (C_1M) \parallel Cu^{2+} (C_2M) \mid Cu(s)$
Change in Gibbs energy (ΔG) is negative, if
(A) $C_1 = C_2$
(B) $\frac{C_2 = C_1}{\sqrt{2}}$
(C) $C_1 = 2C_2$
(D) $C_2 = \sqrt{2}C_1$

42. Reaction of an inorganic sulphite X with dilute H_2SO_4 generates compound Y. Reaction of Y with NaOH gives X. Further, the reaction of X. Further, the reaction of X with Y and water affords compound Z. Y and Z respectively, are:
(A) SO_2 and Na_2SO_3
(B) SO_3 and $NaHSO_3$
(C) SO_2 and $NaHSO_3$
(D) S and Na_2SO_3

43. The increasing order of the boiling points of the major products A, B and C of the following reactions will be:
(a)


(b)


(c)


(A) B < C < A
(B) C < A < B
(C) A < B < C
(D) A < C < B

44. Mischmetal is an alloy consisting mainly of:
(A) lanthanoid metals
(B) actinoid and transition metals
(C) lanthanoid and actinoid metals
(D) actionoid metals

45. The correct match between Item-I and Item-II is:

	Item-I		Item-II
(a)	Natural rubber	(I)	1, 3-butadiene + styrene
(b)	Neoprene	(II)	1, 3-butadiene + acrylonitrile
(c)	Buna-N	(III)	Chloroprene
(d)	Buna-S	(IV)	Isoprene

(A) (a) – (III), (b) – (IV), (c) – (I), (d) – (II)
(B) (a) – (III), (b) – (IV), (c) – (II), (d) – (I)
(C) (a) – (IV), (b) – (III), (c) – (II), (d) – (I)
(D) (a) – (IV), (b) – (III), (c) – (I), (d) – (II)

46. If the solubility product of AB_2 is 3.20×10^{-11} M^3, then the solubility of AB_2 in pure water is _________ $\times 10^{-4}$ mol L^{-1}. [Assuming that neither kind of ion reacts with water]

47. For Freudlich adsorption isotherm, a plot of log (x/m) (y-axis) and log p (x-axis) gives a straight line. The intercept and slope for the line is 0.4771 and 2, respectively. The mass of gas adsorbed per gram of adsorbent if the initial pressure is 0.04 atm, is __________ $\times 10^{-4}$ g. (log 3 = 0.4771)

48. A solution of phenol in chloroform when treated with aqueous NaOH gives compound P as a major product. The mass percentage of carbon in P is ___________. (to the nearest integer) (Atomic mass: C = 12 ; H = 1 ; O = 16)

49. The atomic number of Unnilunium is ___________.

50. The rate of a reaction decreased by 3.555 times when the temperature was changed from 40°C to 30°C. The activation energy (in kJ mol^{-1}) of the reaction is ___________.

PART–C (MATHEMATICS)

51. The integral $\int_1^2 e^x \cdot x^2(2+\log_e x)dx$ equals:
(A) e(4e + 1) (B) $4e^2 - 1$
(C) e(4e – 1) (D) e(2e – 1)

52. The area (in sq. units) of the region enclosed by the curves $y = x^2 - 1$ and $y = 1 - x^2$ is equal to
(A) $\frac{4}{3}$ (B) $\frac{8}{3}$
(C) $\frac{7}{2}$ (D) $\frac{16}{3}$

53. The angle of elevation of the summit of a mountain from a point on the ground is 45°. After climbing up one km towards the summit at an inclination of 30° from the ground, the angle of elevation of the summit is found to be 60°. Then the height (in km) of the summit from the ground is:
(A) $\frac{\sqrt{3}-1}{\sqrt{3}+1}$ (B) $\frac{\sqrt{3}+1}{\sqrt{3}-1}$
(C) $\frac{1}{\sqrt{3}-1}$ (D) $\frac{1}{\sqrt{3}+1}$

54. The set of all real values of λ for which the function $f(x)=(1-\cos^2 x)\cdot(\lambda+\sin x)$, $x \in \left(-\frac{\pi}{2}, \frac{\pi}{2}\right)$, has exactly one maxima and exactly one minima, is
(A) $\left(-\frac{1}{2}, \frac{1}{2}\right)-\{0\}$ (B) $\left(-\frac{3}{2}, \frac{3}{2}\right)$
(C) $\left(-\frac{1}{2}, \frac{1}{2}\right)$ (D) $\left(-\frac{3}{2}, \frac{3}{2}\right)-\{0\}$

55. If α and β are the roots of the equation 2x(2x + 1) = 1, then β is equal to:
(A) $2\alpha(\alpha + 1)$ (B) $-2\alpha(\alpha + 1)$
(C) $2\alpha(\alpha - 1)$ (D) $2\alpha^2$

56. For all twice differentiable functions
$f : R \to R$, with $f(0) = f(1) = f'(0) = 0$,
(A) $f''(x) \neq 0$, at every point $x\in(0,1)$ (B) $f''(x) = 0$, for some $x\in(0,1)$
(C) $f''(0) = 0$ (D) $f''(x) = 0$, at every point $x\in(0, 1)$

57. If $y = \left(\frac{2}{\pi}x - 1\right)$ cosec x is the solution of the differential equation,
$\frac{dy}{dx} + p(x)y = \frac{2}{\pi}\text{cosec } x, 0 < x < \frac{\pi}{2}$, then the function p(x) is equal to:
(A) cot x
(B) cosec x
(C) sec x
(D) tan x

58. Let L denote the line in the xy-plane with x and y intercepts as 3 and 1 respectively. Then the image of the point (–1, –4) in this line is:
(A) $\left(\frac{11}{5}, \frac{28}{5}\right)$
(B) $\left(\frac{29}{5}, \frac{8}{5}\right)$
(C) $\left(\frac{8}{5}, \frac{29}{5}\right)$
(D) $\left(\frac{29}{5}, \frac{11}{5}\right)$

59. If the tangent to the curve, $y = f(x) = x\log_e x$, (x > 0) at a point (c, f(c)) is parallel to the line – segment joining the points (1, 0) and (e, e) then c is equal to:
(A) $\frac{e-1}{e}$
(B) $\frac{1}{e-1}$
(C) $e^{\left(\frac{1}{e-1}\right)}$
(D) $e^{\left(\frac{1}{1-e}\right)}$

60. Let f : R $\rightarrow$ R be a function defined by f(x) = max {x, x^2}. Let S denote the set of all points in R, where f is not differentiable. Then:
(A) {0, 1}
(B) {0}
(C) ϕ(an empty set)
(D) {1}

61. Let $\theta = \frac{\pi}{5}$ and $A = \begin{bmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{bmatrix}$. If B = A + A^4, then det (B):
(A) is one.
(B) lies in (2, 3).
(C) is zero.
(D) lies in (1, 2).

62. A plane P meets the coordinate axes at A, B and C respectively. The centroid of ΔABC is given to be (1, 1, 2). Then the equation of the line through this centroid and perpendicular to the plane P is:
(A) $\frac{x-1}{2} = \frac{y-1}{1} = \frac{z-2}{1}$
(B) $\frac{x-1}{1} = \frac{y-1}{1} = \frac{z-2}{2}$
(C) $\frac{x-1}{2} = \frac{y-1}{2} = \frac{z-2}{1}$
(D) $\frac{x-1}{2} = \frac{y-1}{2} = \frac{z-2}{2}$

63. The common difference of the A.P. $b_1, b_2, \ldots, b_m$ is 2 more than the common difference of A.P. $a_1, a_2, \ldots, a_n$. If $a_{40} = -159$, $a_{100} = -399$ and $b_{100} = a_{70}$, then b_1 is equal to:
(A) 81
(B) –127
(C) –81
(D) 127

64. If the normal at an end of a latus rectum of an ellipse passes through an extremity of the minor axis, then the eccentricity e of the ellipse satisfies:
(A) $e^4 + 2e^2 - 1 = 0$ (B) $e^2 + e - 1 = 0$
(C) $e^2 + 2e - 1 = 0$ (D) $e^4 + e^2 - 1 = 0$

65. For a suitably chosen real constant a, let a function, f : R – {–a} → R be defined by $f(x) = \frac{a-x}{a+x}$. Further suppose that for any real number $x \neq -a$ and $f(x) \neq -a$, (fof)(x) = x. Then $f\left(-\frac{1}{2}\right)$ is equal to:
(A) $\frac{1}{3}$ (B) $-\frac{1}{3}$
(C) –3 (D) 3

66. If the constant term in the binomial expansion of $\left(\sqrt{x} - \frac{k}{x^2}\right)^{10}$ is 405, then | k | equals:
(A) 9 (B) 1
(C) 3 (D) 2

67. The centre of the circle passing through the point (0, 1) and touching the parabola $y = x^2$ at the point (2, 4) is:
(A) $\left(\frac{-53}{10}, \frac{16}{5}\right)$ (B) $\left(\frac{6}{5}, \frac{53}{10}\right)$
(C) $\left(\frac{3}{10}, \frac{16}{5}\right)$ (D) $\left(\frac{-16}{5}, \frac{53}{10}\right)$

68. Let z = x + iy be a non-zero complex number such that $z^2 = i|z|^2$, where $i = \sqrt{-1}$, then z lies on the:
(A) line, y = –x (B) imaginary axis
(C) line, y = x (D) real axis

69. Consider the statement: "For an integer n, if $n^3 - 1$ is even, then n is odd." The contrapositive statement of this statement is:
(A) For an integer n, if n is even, then $n^3 - 1$ is odd.
(B) For an integer n, if $n^3 - 1$ is not even then n is not odd.
(C) For an integer n, if n is even, then $n^3 - 1$ is even.
(D) For an integer n, if n is odd, then $n^3 - 1$ is even.

70. The probabilities of three events A, B and C are given by P(A) = 0.6, P(B) = 0.4 and P(C) = 0.5. If $P(A\cup B) = 0.8$, $P(A\cap C) = 0.3$, $P(A\cap B\cap C) = 0.2$, $P(B\cap C) = \beta$ and $P(A\cup B\cup C) = \alpha$, where $0.85 \le \alpha \le 0.95$, then β lies in the interval:
(A) [0.35, 0.36] (B) [0.25, 0.35]
(C) [0.20, 0.25] (D) [0.36, 0.40]

71. Suppose that a function f : R $\to$ R satisfies f(x + y) = f(x)f(y) for all x, y$\in$R and f(1) = 3. If $\sum_{i=1}^{n} f(i) = 363,$ then n is equal to ___________.

72. The sum of distinct values of λ for which the system of equations
$(\lambda - 1)x + (3\lambda + 1)y + 2\lambda z = 0$
$(\lambda - 1)x + (4\lambda - 2)y + (\lambda + 3)z = 0$
$2x + (3\lambda + 1)y + 3(\lambda - 1)z = 0,$
has non-zero solutions, is ___________.

73. If $\vec{x}$ and $\vec{y}$ be two non-zero vectors such that $|\vec{x} + \vec{y}| = |\vec{x}|$ and $2\vec{x} + \lambda\vec{y}$ is perpendicular to $\vec{y}$, then the value of λ is

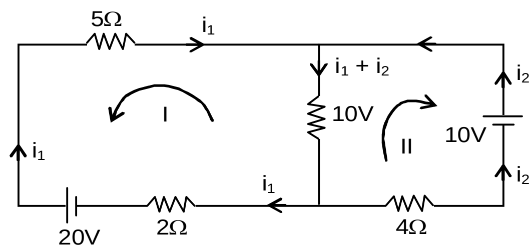
74. Consider the data on x taking the values 0, 2, 4, 8, …, 2^n with frequencies ${}^nC_0$, ${}^nC_1$, ${}^nC_2$, …, ${}^nC_n$ respectively. If the mean of this data is $\frac{728}{2^n}$, then n is equal to ___________.

75. The number of words (with or without meaning) that can be formed from all the letters of the word "LETTER" in which vowels never come together is ___________.

FIITJEE
Solutions to JEE (Main)-2020
PART –A (PHYSICS)

1. **C**

Sol. **Loop-I :**



$-20 + 2i_1 + 10(i_1 + i_2) + 5i_1 = 0$

$17i_1 + 10i_2 = 20$ …(1)

Loop-II :

$-10 + 4i_2 + 10(i_1 + i_2) = 0$

$10i_1 + 14i_2 = 10$ …(2)

Equation (1) × 10 – Equation (2) × 17

$170i_1 + 100i_2 = 200$

$-170i_1 + 238i_2 = 170$

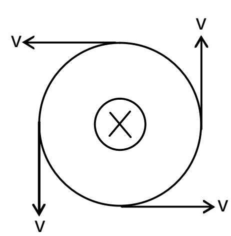
$-138i_2 = 30$

$$i_2 = -\frac{30}{138} = -0.217 \text{ A}$$

"–ve" sign indicates that current flows from "+ve" to "–ve" terminal in 10 V battery.

2. **D**

Sol. $\therefore \quad \frac{M}{L} = \frac{q}{2m}$



$\therefore \quad M = \frac{q}{2m}(mvr)$

$M = \frac{qv}{2}\left(\frac{mv}{qB}\right)$

$M = \frac{mv^2}{2B}$

As seen from figure Magnetic moment is opposite to field

So $\vec{M} = -\frac{mv^2\,\vec{B}}{2B^2}$

3. **A**

Sol. In steady state rate of flow of heat in all three rods are same.

$$\frac{dQ}{dt} = \frac{k_1A\,(100-70)}{\ell} = \frac{k_2A\,(70-20)}{\ell} = \frac{k_3A\,(20-0)}{\ell}$$

$30k_1 = 50k_2 = 20k_3$

$\therefore \; k_1 : k_3 = 2 : 3 \;\;\&\;\; k_2 : k_3 = 2 : 5$

4. **B**

Sol. By conservation of energy

$(K.E. + P.E.)_{initial} = (K.E. + P.E.)_{final}$

$$0+\left(\frac{1}{4\pi\epsilon_0}\frac{2P}{a^3}\right)\times P = 2\times\frac{1}{2}mv^2+0$$

$$v=\sqrt{\frac{P^2}{2\pi\epsilon_o\ ma^3}}=\frac{P}{a}\sqrt{\frac{1}{2\pi\epsilon_o ma}}$$

5. **A**

Sol. Given wave is moving in "–ve" x-direction and the given magnetic field is along "+ve" z-direction. Since $C=\frac{E_0}{B_0}$

$E_0 = CB_0 = 1.2 \times 10^{-7} \times 3 \times 10^8 = 36$ N/C

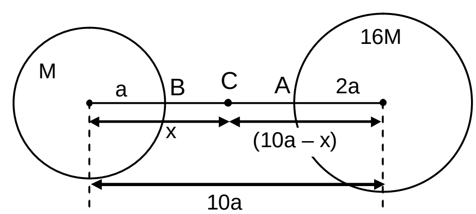
Also $\because \vec{S}=\frac{1}{2\mu_o}\left(\vec{E}\times\vec{B}\right)$ So electric field is along "-ve" y-direction

$$\therefore\ \vec{E}(x,t)=\left[-36\sin(0.5\times10^3x+1.5\times10^{11}t)\hat{j}\right]\frac{V}{m}$$

6. **D**

Sol. When a body fired from A, it should just cross the point 'C' where the gravitational field is zero.

$$\frac{GM}{x^2}=\frac{G(16M)}{(10a-x)^2}\ \Rightarrow\ \frac{1}{x}=\frac{4}{(10a-x)}$$



$\Rightarrow\quad 10a - x = 4x \ \Rightarrow\ x = 2a$

Now, potential at A, $V_A=-\frac{GM}{8a}-\frac{16\ GM}{2a}=-\frac{65\ GM}{8a}$

Potential at C, $V_C = -\frac{GM}{2a}-\frac{16\ GM}{8a}=-\frac{5\ GM}{2a}$

$$W=(V_C-V_A)m=\frac{1}{2}mv^2$$

$$v^2 = 2\,(V_C - V_A) = 2\left[\left(-\frac{5\ GM}{2a}\right)-\left(-\frac{65\ GM}{8a}\right)\right]$$

$$v^2=\frac{45\ GM}{4a}$$

$$v=\frac{3}{2}\sqrt{\frac{5\ GM}{a}}$$

7. **A**

Sol. $\frac{mdv_x}{dt}=kv_y\quad\ldots(1)$ and $\frac{mdv_y}{dt}=kv_x\quad\ldots(2)$

$$\frac{(2)}{(1)}\quad\frac{dv_y}{dv_x}=\frac{v_x}{v_y}$$

$V_y dv_y = v_x dv_x$

$$v_y^2=v_x^2+C$$

$v_y^2 - v_x^2 = C$ = Constant

Now, $\vec{v} \times \vec{a} = (v_x \hat{i} + v_y \hat{j}) \times \frac{k}{m}(v_y \hat{i} + v_x \hat{j})$

$= \frac{k}{m}\left[v_x^2\,\hat{k} - v_y^2\,\hat{k}\right] = \frac{k}{m}(v_x^2 - v_y^2)\,\hat{k}$ = Constant.

8. **D**

Sol. Using conservation of momentum

$m_1\overrightarrow{u_1} + m_2\overrightarrow{u_2} = m_1\overrightarrow{v_1} + m_2\overrightarrow{v_2}$

$2m_2(\sqrt{3}\hat{i} + \hat{j}) + 0 = 2m_2\left(\hat{i} + \sqrt{3}\,\hat{j}\right) + m_2\vec{v}_2$

$\overrightarrow{V_2} = 2(\sqrt{3} - 1)(\hat{i} - \hat{j})$

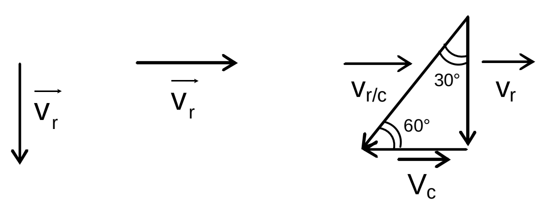
Angle between $\overrightarrow{v_1} \cdot \overrightarrow{v_2}$

$\text{Cos}\,\theta = \frac{\overrightarrow{v_1} \cdot \overrightarrow{v_2}}{[v_1][v_2]} = \frac{2(\sqrt{3}-1)(1-\sqrt{3})}{2 \times 2\sqrt{2}(\sqrt{3}-1)} = \frac{1-\sqrt{3}}{2\sqrt{2}}$

$\Rightarrow \quad \theta = 105°$

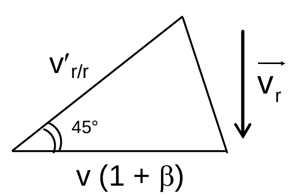
9. **D**

Sol.



Tan 60 = $\frac{v_r}{v_c} = \frac{v_r}{v}$

$v_r = v\sqrt{3}$ …(1)



Tan 45° = $\frac{v_r}{v(1+\beta)}$

$V_r = v(1 + \beta)$ …(2)

By (1) to (2)

$v\sqrt{3} = v(1+\beta)$

$\beta = \sqrt{3} - 1 = 0.73$

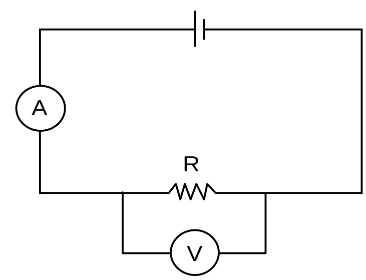
10. **C**

Sol. Total mass of reactant should be greater than that of product.

This condition is only fulfilled in case-3

11. **C**

Sol. In Ohm's law experiment, ammeter is used in series because in series same current will flow through it. But voltmeter is used in parallel to resistor to measure the potential difference across it.



12. **C**

Sol. (i) Inside the shell r < R

$E = 0 \Rightarrow F = 0$

(ii) On the surface r = R

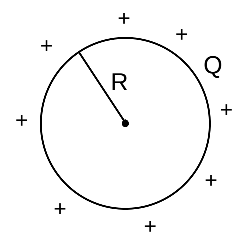
$$E = \frac{1}{4\pi\epsilon_0}\frac{Q}{R^2}$$

$$\Rightarrow \quad F = \frac{1}{4\pi\epsilon_0}\frac{Qq}{R^2}$$

(iii) Outside the shall r > R

$$E = \frac{1}{4\pi\epsilon_0}\frac{Q}{r^2}$$

$$\Rightarrow \quad F = \frac{1}{4\pi\epsilon_0}\frac{Qq}{r^2}$$



13. **D**

Sol. Since significant figures show the degree of correctness of any measurement, so in any mathematical calculation we cannot increase the number of significant digits. Because the four reading has 3 significant digits so the answer should also have 3 significant digits only.

14. **D**

Sol. $P = (\mu - 1)\left(\frac{1}{R} - \frac{1}{-R}\right)$

$P = \frac{2(\mu - 1)}{R}$ …(1)

$1.5\,P = \frac{(\mu - 1)}{R'}$; $\frac{1}{1.5} = \frac{2R'}{R}$

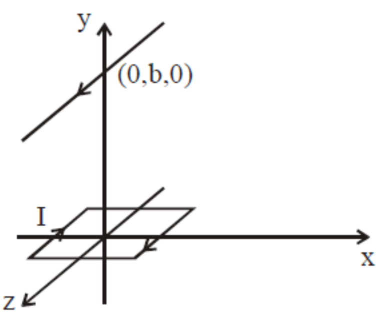
$R' = \frac{R}{3}$

15. **B**

Sol. F = I B (2a)

$$F = I\left(\frac{\mu_0 I}{2\pi\sqrt{a^2+b^2}}\right)2a$$

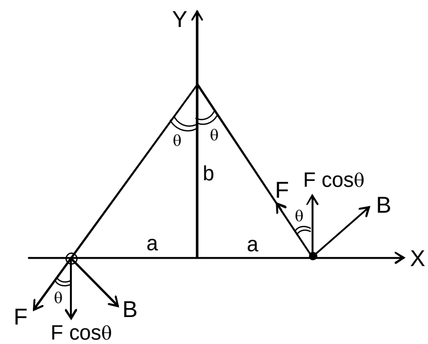
$$F = \frac{\mu_0 I^2 a}{\pi\sqrt{a^2+b^2}}$$



Torque $\tau = 2F(\cos\theta) \times a$

$$\tau = \frac{2\times\mu_0 I^2 a^2}{\pi\sqrt{a^2+b^2}} \times \frac{b}{\sqrt{a^2+b^2}}$$

$$\tau = \frac{2\mu_0 I^2 a^2 b}{\pi(a^2+b^2)}$$



16. **D**

Sol. Using Bernoulli's equation

$$P_1 + \frac{1}{2}\rho v_1^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g h_2$$

For horizontal tube $h_1 = h_2$

$$P + \frac{1}{2}\rho v^2 = \frac{P}{2} + \frac{1}{2}\rho V^2$$

$$\frac{1}{2}\rho V^2 = \frac{P}{2} + \frac{1}{2}\rho v^2$$

$$V = \sqrt{\frac{P}{\rho} + v^2}$$

17. **C**

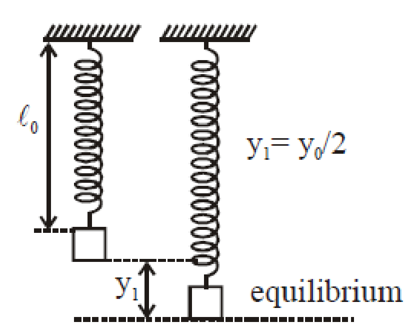
Sol. $y = y_o \sin^2\omega t$

$$y = \frac{y_0}{2}(1 - \cos 2\omega t)$$

At t = 0, y = 0 extreme

At $\omega t = \frac{\pi}{2}$, $y = y_0$ extreme

At $\omega t = \frac{\pi}{4}$, $y = \frac{y_0}{2}$ mean



$\therefore\ y_1 = \frac{y_0}{2}$, at equilibrium $mg = ky_1 = \frac{ky_0}{2}$

$$\frac{k}{m} = \frac{2g}{y_0}$$

$$2\omega = \sqrt{\frac{k}{m}} = \sqrt{\frac{2g}{y_0}}$$

$$\omega = \frac{1}{2}\sqrt{\frac{2g}{y_0}} = \sqrt{\frac{g}{2y_0}}$$

18. **B**

Sol. Mean relaxation time $T = \frac{\lambda}{V_{avg}} = \frac{\lambda}{\sqrt{\frac{8RT}{\pi m}}}$

$\therefore \quad T \propto \frac{1}{\sqrt{T}}$

19. **A**

Sol. de-Broglie wavelength

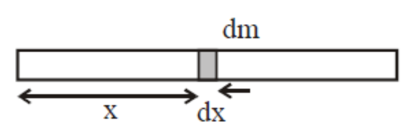
$$\lambda = \frac{h}{mv} = \frac{h}{m\sqrt{\frac{3kT}{m}}} = \frac{h}{\sqrt{3mkT}}$$

$$\lambda = \frac{6.63\times10^{-34}}{\sqrt{3\times4.64\times10^{-26}\times1.38\times10^{-23}\times400}}$$

$\lambda = \frac{6.63}{2.77}\times10^{-11}$ = 2.39 × 10^{-11} m ≈ 0.24 Å

20. **B**

Sol.



$$dm = \lambda dx = \lambda_0\left(1+\frac{x}{L}\right)dx$$

$$M = \lambda_0\int_o^L\left(1+\frac{x}{L}\right)dx = \lambda_o L + \lambda_o\frac{L}{2} = \frac{3\lambda_0 L}{2} \qquad \ldots(1)$$

$$dI = dmx^2 = \lambda_o\left(1+\frac{x}{L}\right)dx\times x^2$$

$$I = \lambda_o\left\{\int_o^L x^2dx + \frac{1}{L}\int_o^L x^3dx\right\} = \lambda_o\left\{\frac{L^3}{3}+\frac{L^3}{4}\right\}$$

$$I = \frac{7\lambda_o L^3}{12} = \frac{7}{12}\left(\frac{2M}{3L}\right)L^3 = \frac{7}{18}ML^2$$

21. **150**

Sol. As shown in figure.

ΔI_C = (4.5 – 3) mA = 1.5 × 10^{-3} A

ΔI_B = (30 – 20) μA = 10 × 10^{-6} A

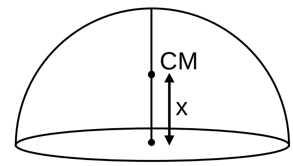
$\beta_{ac} = \frac{\Delta I_C}{\Delta I_B} = \frac{1.5\times10^{-3}}{10^{-5}}$ = 150

22. **3.00**

Sol. Centre of mass of solid sphere at

$x = \frac{3R}{8}$

$x = \frac{3 \times 8}{8}$ = 3 cm



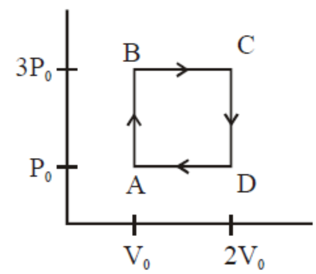
23. **19.00**

Sol. $W_{Total} = (3P_o - P_o) \times (2V_o - V_o)$

$W_{Total} = 2P_oV_o$ …(1)

$Q_{in} = Q_{AB} + Q_{BC}$

$Q_{AB} = nC_V(T_B - T_A) = \frac{3}{2}nR(T_B - T_A)$



$Q_{AB} = \frac{3}{2}(3P_oV_o - P_oV_o) = 3P_oV_o$ …(2)

$Q_{BC} = nC_P(T_C - T_B) = \frac{5}{2}nR(T_C - T_B)$

$Q_{BC} = \frac{5}{2}\left[3P_o \times 2V_o - 3P_o \times V_o\right] = \frac{15}{2}P_oV_o$ …(3)

By (2) and (3) $Q_{in} = 3P_oV_o + \frac{15}{2}P_oV_o = \frac{21}{2}P_oV_o$

$\eta = \frac{W_{Total}}{Q_{in}} \times 100 = \frac{2P_oV_o}{\frac{21}{2}P_oV_o} \times 100 = \frac{400}{21} \approx 19\%.$

24. **9.00**

Sol. We know $I = 4I_o\cos^2\left(\frac{\phi}{2}\right)$ but $\phi = \frac{2\pi}{\lambda}x$

$I = 4I_o\cos^2\left(\frac{\pi x}{\lambda}\right)$

(i) when $x = \lambda$, $I = k$

i.e. $k = 4I_o\cos^2\pi$

$k = 4I_o$

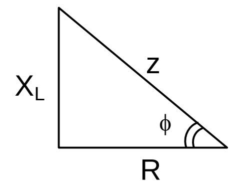
(ii) when $x = \frac{\lambda}{6}$

$I' = k\cos^2\left(\frac{\pi}{6}\right) = k\left(\frac{3}{4}\right)$

$I' = \frac{9k}{12}$

25. **400.00**

Sol. $P = \frac{V_{rms}^2}{z}\cos\phi$



$400 = \frac{(250)^2 \times 0.8}{z}$

$\Rightarrow$ z = 125 Ω

$\frac{R}{z} = \cos\phi \Rightarrow R = 125 \times 0.8 = 100\ \Omega$

$\frac{X_L}{z} = \sin\phi \Rightarrow X_L = 125 \times 0.6 = 75\ \Omega$

$\omega L = 75$; $L = \frac{75}{100\pi} = \frac{3}{4\pi}$

For power factor unity, resonance should be there i.e. $X_L = X_C$

$2\pi f = \frac{1}{\sqrt{LC}}$

$(100\ \pi)^2 = \frac{4\pi}{3C}$

$C = \frac{4\pi}{3 \times 10^4 \times \pi^2} = \frac{4}{3\pi} \times 10^{-4}$; $C = \frac{400}{3\pi}\mu F$

PART –B (CHEMISTRY)

26. B

Sol. For oxide to be stable its ΔG value should be negative.

27. B

Sol. ^{35}Cl ^{37}Cl

Molar ratio x 1 – x

M_{avg} $35 \times x + 37(1 - x) = 35.5$

$35x + 37 - 37x = 35.5$

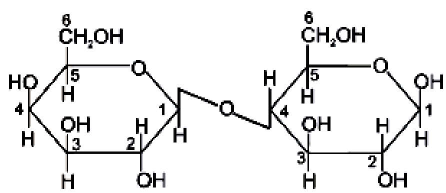
$2x = 1.5$

$X = \frac{3}{4}$

So, ratio of $^{35}Cl : ^{37}Cl = 3 : 1$

28. A

Sol.



The linkage is between C-1 of Galactose and C-4 of Glucose

$$\underset{(C_{12}H_{22}O_{11})}{\text{Lactose(Milk sugar)}} \xrightarrow{H_3O^+} \beta-\text{galactose} + \beta-\text{glucose}$$

It is hydrolysed by dilute acids or by the enzyme lactase, to an equimolecular mixture of D(+)-glucose and D(+)-galactose. Lactose is a reducing sugar.

29. D

Sol. $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

$$K_C = \frac{[NH_3]^2}{[N_2][H_2]^3} = 64$$

For the reaction

$$NH_3(g) \rightleftharpoons \frac{1}{2}N_2(g) + \frac{3}{2}H_2(g)$$

$$K'_C = \frac{[N_2]^{1/2}[H_2]^{3/2}}{[NH_3]} = \frac{1}{\sqrt{K_C}} = \frac{1}{\sqrt{64}} = \frac{1}{8}$$

30. D

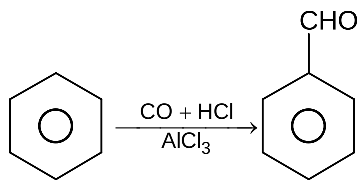
Sol. Dihydrogen of high degree of purity (>99.95%) is obtained by the electrolysis of warm aqueous barium hydroxide solution between nickel electrodes.

31. C

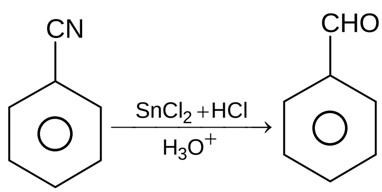
Sol. $2NO + N_2O_4 \longrightarrow 2N_2O_3$

32. C

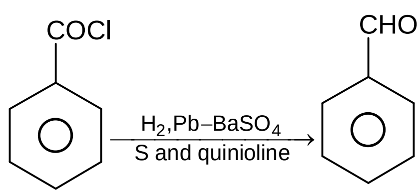
Sol.



Gatterman-Koach Reaction



Stephan Reduction



Rosenmund Reduction

33. A

Sol. In the ccp lattice of oxide ions effective number of O^{-2} ions = $8 \times \frac{1}{8} + 6 \times \frac{1}{2} = 4$

In the ccp lattice,
No. of octahedral voids = 4
No. of tetrahedral voids = 8
Given M_1 atoms occupies 50% of octahedral voids and M2 atoms occupies 12.5 of tetrahedral voids

No. of M_1 metal atoms = $4 \times \frac{50}{100} = 2$

No. of M_2 metal atoms = $8 \times \frac{12.5}{100} = 1$

$\therefore$ Formula of the compound = $(M_1)_2(M_2)O_4$

$\therefore$ Oxidation states of metals M_1 & M_2 respectively are +2 and +4.

34. B

Sol. Zn, Cd & Hg are purified by fractional distillation process.

35. A

Sol. For d^4 configuration if $\Delta_o < P$ the electronic configuration is $t_{2g}^3 e_g^1$

36. C

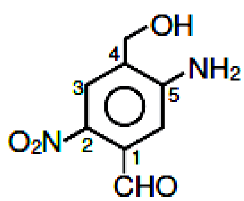
Sol. (I) Lucas reagent $\rightarrow$ Only ZnCl2/Conc.HCl
(II) Dumas method $\rightarrow$ CuO/Δ
(III) Kjeldahl's method $\rightarrow$ Conc. H_2SO_4/Δ
(IV) Heinsberg reagent $\rightarrow C_6H_5\ SO_2Cl$/aq.NaOH

37. B

Sol. (i) $Ca(OH)_2$ is used in white wash.
(ii) Plaster of paris is used in making of molds for plaster statues.
(iii) NaCl is used in preparation of washing soda.
(iv) A suspension of $Mg(OH)_2$ in water is used in medicine as an antacid under name of milk of magnesia.

38. C

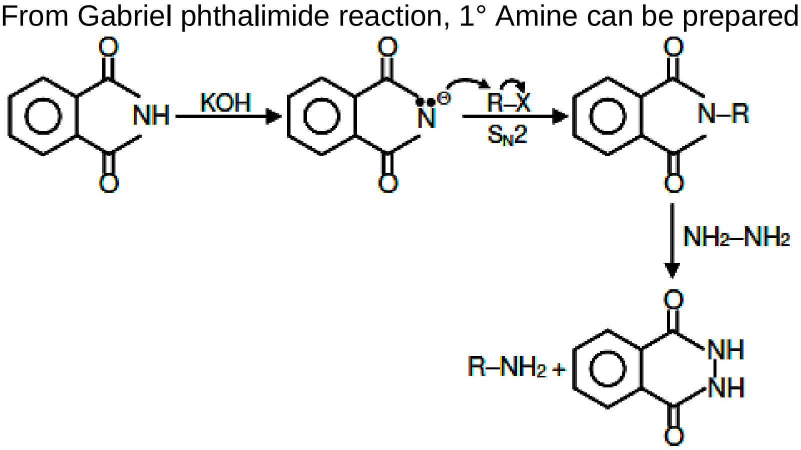
Sol.



5-Amino-4-(hydroxymethyl)-2-nitro benzene carbaldehyde.

39. A

Sol. From Gabriel phthalimide reaction, 1° Amine can be prepared.



40. C

Sol. Relative lowering in vapour pressure depends on no. of mole of solute greater the no. of mole of solute greater in RLVP and smaller will be vapour pressure. So order of vapour pressure is B > C > A.

41. D

Sol. For concentration cell $E^0_{cell} = 0$

Anode: $Cu(s) \longrightarrow Cu^{2+}(aq)_A$

Cathode: $Cu^{2+}(aq)_C \longrightarrow Cu(s)$

Overall: $Cu^{2+}(aq)_C \longrightarrow Cu^{2+}(aq)_A$

As $\Delta G = -nF\,E_{cell}$

If ΔG = -ve than E_{cell} is positive

$$E_{cell} = E^0_{cell} - \frac{0.059}{2}\log\frac{C_1}{C_2}$$

$$E_{cell} = \frac{-0.059}{2}\log\frac{C_1}{C_2}$$

$$E_{cell} > 0 \Rightarrow C_2 > C_1$$

42. C

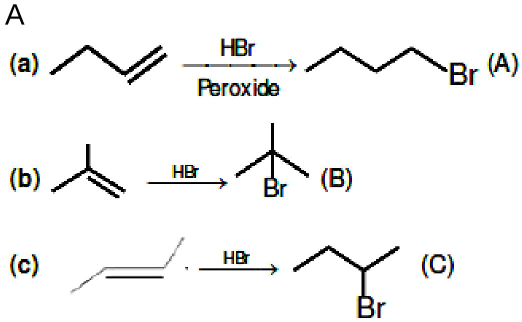
Sol. $\underset{X}{Na_2SO_3} + H_2SO_4 \longrightarrow \underset{Y}{SO_2} + Na_2SO_4 + H_2O$

$SO_2 + 2NaOH \longrightarrow \underset{X}{Na_2SO_4} + H_2O$

$Na_2SO_3 + SO_2 + H_2O \longrightarrow 2NaHSO_3$

43. A

Sol.



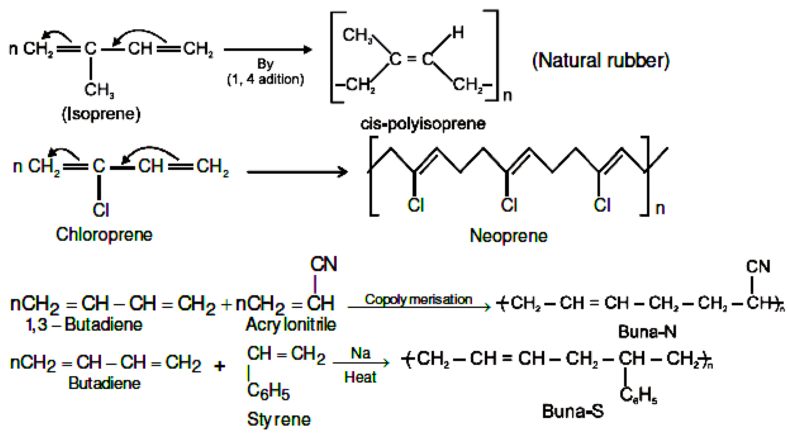
The boiling points of isomeric halo alkanes decrease with increase in branching.

44. A

Sol. Misch metal consists of Lanthanide metal (≈95%) and iron (≈5%) and traces of S, C, Ca and Al.

45. C

Sol.



46. 02.00

Sol. $AB_2 \rightleftharpoons \underset{s}{A^{2+}} + \underset{2s}{2B^-}$

$K_{sp} = 4s^3 = 3.20 \times 10^{-11}$

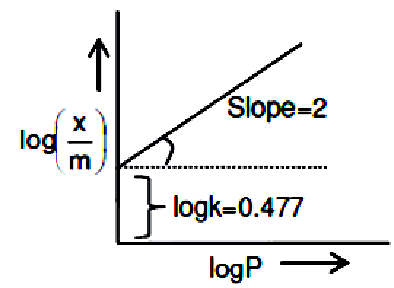
So, solubility = 2×10^{-4} mol L^{-1}

47. 48.00

Sol.

$$\left(\frac{x}{m}\right) = k(P)^{\frac{1}{n}}$$

$$\log\left(\frac{x}{m}\right) = \log k + \frac{1}{n}\log P$$



Slope $= \frac{1}{n} = 2$ So $n = \frac{1}{2}$.

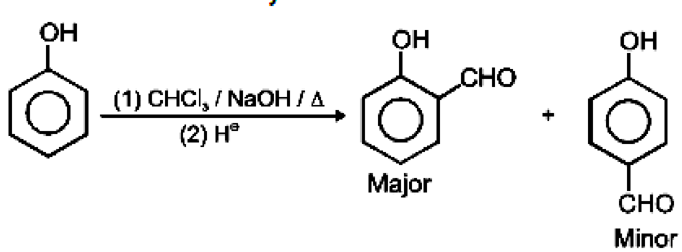
Intercept $\Rightarrow \log k = 0.477$ So $k = \text{Antilog}(0.477) = 3$

$$\text{So } \left(\frac{x}{m}\right) = k(P)^{\frac{1}{n}}$$

$= 3[0.04]^2 = 48 \times 10^{-4}$

48. 69.00

Sol. **Reimer-Tiemann formylation reaction :**



Molecular formula of product is $C_7H_6O_2$

Percentage weight of carbon $= \left(\frac{84}{122} \times 100\right) = 68.85\,\%$

49. 101.00

Sol. According to IUPAC convention for naming of elements with atomic number more than 100, different digits are written in order and at the end ium is added. For digits following naming is used.

0-nil

1-un

2-bi

3-tri

and so on…

50. 100.00

Sol.

$$\log\left(\frac{k_2}{k_1}\right) = \frac{Ea}{2.303R}\left[\frac{1}{T_1} - \frac{1}{T_2}\right]$$

$$\log(3.555) = \frac{Ea}{2.303R}\left[\frac{1}{303} - \frac{1}{313}\right]$$

$$1.268 \times 8.314 \times 303 \times 313 = 10\ Ea$$

So, $Ea = 100\ kJ$

PART–C (MATHEMATICS)

51. C

Sol. Let $y = (ex)^x$

$\ell n y = [1 + \ell n x]$

$\frac{1}{y}\frac{dy}{dx} = (2 + \ell n\ x)$

$\Rightarrow dy = (ex)^x (2 + \ell n x) dx$

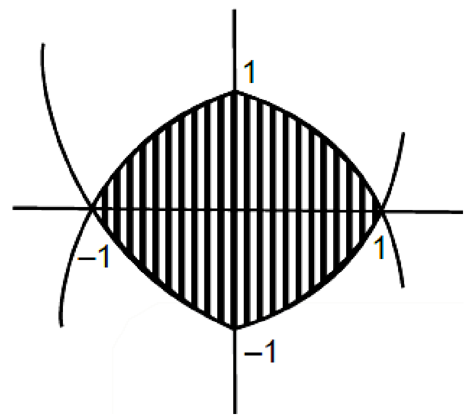
$\int_1^2 e^x . x^2 (2 + \log_e x) dx = (y)_1^2 = \left((ex)^x\right)_1^2 = 4e^2 - e$

52. B

Sol. Given curves are $y = x^2 - 1$ and $y = 1 - x^2$ so intersection point are $(\pm 1, 0)$ bounded area

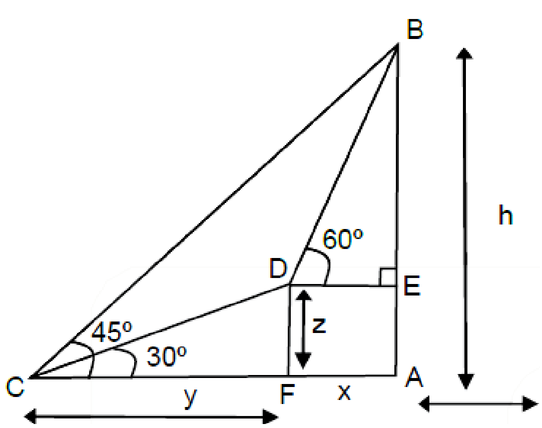
$= 4\int_0^1 (1 - x^2) dx = 4\left[x - \frac{x^3}{3}\right]_0^1$

$= 4\left(1 - \frac{1}{3}\right) = \frac{8}{3}$ sq. units



53. C

Sol.



In ΔCDF

$\sin 30^o = \frac{z}{1}$ [CD = 1 km (given)]

$z = \frac{1}{2}$ ....(1)

$\cos 30^o = \frac{y}{1} \Rightarrow = \frac{\sqrt{3}}{2}$

now in ΔABC

$\tan 45^o = \frac{h}{x+y}$

$\Rightarrow h = x + y$

$\Rightarrow x = h - \frac{\sqrt{3}}{2}$ ....(2)

Now

In ΔBDE,

$\tan 60^o = \frac{h-z}{x}$

$\sqrt{3}x = h - \frac{1}{2} \Rightarrow \sqrt{3}\left(h - \frac{\sqrt{3}}{2}\right) = h - \frac{1}{2} \Rightarrow \left(\sqrt{3}-1\right)h = 1$

$h = \frac{1}{\sqrt{3}-1}km$

54. D

Sol. $f(x) = \sin^2 x(\lambda + \sin x)$

$f'(x) = \sin x \cos x(2\lambda + 3\sin x)$

$\sin x = 0$ (one point)

$\sin x = -\frac{2\lambda}{3} \in (-1,1) \in \{0\}$ ....(i)

$\lambda \in \left(\frac{3}{2}, \frac{3}{2}\right) - \{0\}$

55. D

Sol. Given equation is $2x(2x+1) = 1 \Rightarrow 4x^2 + 2x - 1 = 0$ ....(1)

roots of equation (1) are α and β

$\therefore \alpha + \beta = -\frac{1}{2} \Rightarrow \beta = -\frac{1}{2} - \alpha$ ....(2)

and

$4\alpha^2 + 2\alpha - 1 = 0 \Rightarrow \alpha^2 = \frac{1}{4} - \frac{\alpha}{2}$ ....(3)

Now

$\Rightarrow \frac{\alpha}{2} = \frac{1}{4} - \alpha^2$

$$\alpha = \frac{1}{2} - \frac{\alpha^2}{2}$$
$$\Rightarrow -\frac{1}{2} - \alpha = 2\alpha^2$$

56. A

Sol. Applying Rolle's theorem in [0, 1] for function f(x)

$f'(c) = 0, c \in (0,1)$

again applying Rolle's theorem in [0, c] for function f'(x) is

$f''(c_1) = 0, c_1 \in (0, c)$

Option A is correct.

57. A

Sol. $y = \left(\frac{2}{\pi}x - 1\right)\operatorname{cosec} x$

$\Rightarrow \frac{dy}{dx} = \frac{2}{\pi}\operatorname{cosec} x - \left(\frac{2x}{\pi} - 1\right)\operatorname{cosec} x \cot x$

$\Rightarrow \frac{dy}{dx} + \left(\frac{2x}{\pi} - 1\right)\operatorname{cosec} x \cot x = \frac{2}{\pi}\operatorname{cosec} x$

$\Rightarrow \frac{dy}{dx} + y\cot x = \frac{2}{\pi}\operatorname{cosec} x\ k$

$\Rightarrow P(x) = \cot x$

58. A

Sol. Equation of line is

$\frac{x}{3} + \frac{y}{1} = 1$

$\Rightarrow x + 3y - 3 = 0$

If image is (x_1, y_1) then $\frac{x_1 + 1}{1} = \frac{y_1 + 4}{3} = -2\frac{-1 - 12 - 3}{10}$

$x_1 + 1 = \frac{y_1 + 4}{3} = \frac{16}{5}$

$\Rightarrow x_1 = \frac{11}{5}, y_1 + 1 = \frac{28}{5}$

59. C

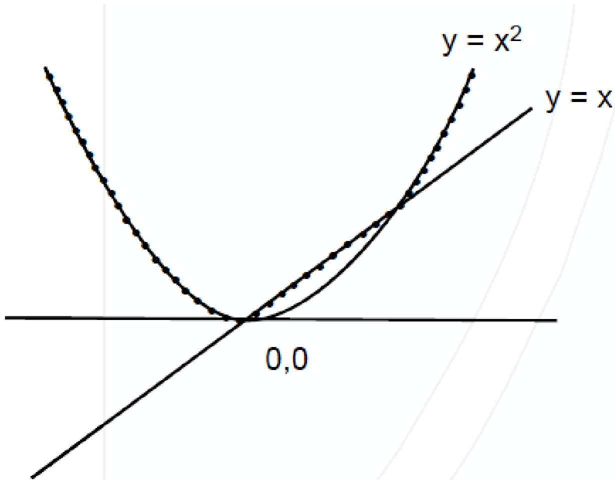
Sol. $f'(c) = 1 + \ell n c = \frac{e}{e - 1}$

$\ell n c = \frac{1}{e - 1}$

$c = e^{\frac{1}{e-1}}$

60. A

Sol.



61. D

Sol. $A^2 = \begin{bmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{bmatrix}\begin{bmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{bmatrix}$

$A^2 = \begin{bmatrix} \cos 2\theta & \sin 2\theta \\ -\sin 2\theta & \cos 2\theta \end{bmatrix}$

$\Rightarrow A^4 = \begin{bmatrix} \cos 4\theta & \sin 4\theta \\ -\sin 4\theta & \cos 4\theta \end{bmatrix}$

$B = \begin{bmatrix} \cos 4\theta & \sin 4\theta \\ -\sin 4\theta & \cos 4\theta \end{bmatrix} + \begin{bmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{bmatrix}$

$= \begin{bmatrix} \cos 4\theta + \cos\theta & \sin 4\theta + \sin\theta \\ -(\sin 4\theta + \sin\theta) & \cos 4\theta + \cos\theta \end{bmatrix}$

$B = (\cos 4\theta + \cos\theta)^2 + (\sin 4\theta + \sin\theta)^2$

$= 2 + 2(\cos 4\theta.\cos\theta + \sin 4\theta.\sin\theta)$

$= 2 + 2\cos(4\theta - \theta)$

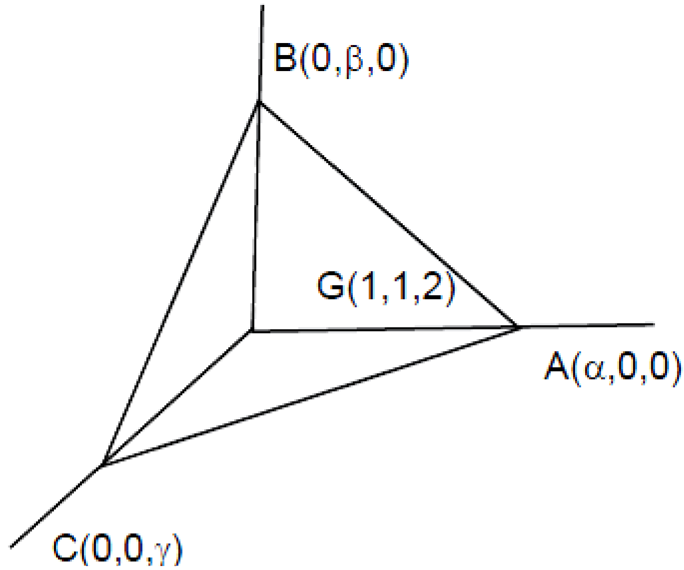
$= 2 + 2.\cos 3\theta$

$|B| = 2 + 2\cos\frac{3\pi}{5}$

$= 2 - \left(\frac{\sqrt{5}-1}{2}\right) = \frac{5-\sqrt{5}}{2} \in (1, 2)$

62. D

Sol. Let $A(\alpha,0,0), B(0,\beta,0), C(0,0,\gamma)$ then $G\left(\frac{\alpha}{3},\frac{\beta}{3},\frac{\gamma}{3}\right) = (1,1,2)$



$\alpha = 3, \beta = 3, \gamma = 6$

$\therefore$ Equation of plane is $\frac{x}{\alpha} + \frac{y}{\beta} + \frac{z}{\gamma} = 1$

$\Rightarrow \frac{x}{3} + \frac{y}{3} + \frac{z}{6} = 1$

$\Rightarrow 2x + 2y + z = 6$

$\therefore$ Required line $\frac{x-1}{2} = \frac{y-1}{2} = \frac{z-2}{1}$

63. C

Sol. Let $a_1 a_1 + d, a_1 + 2d$.......... first A.P.

$a_{40} = a_1 + 39d = -159$ ....(1)

$a_{100} = a_1 + 99d = -399$ ....(2)

From equation (1) and (2)

$d = -4, a_1 = -3$

Now

$b_{100} = a_{70}$

$\Rightarrow b_1 + 99d = a_1 + 69d$

$b_1 + 99x - 2 = -3 + 69 \times -4$ (According to question D = d + 2)

$\Rightarrow b_1 = -81$

64. D

Sol. Equation of normal at $\left(ae, \frac{b^2}{a}\right)$

$\frac{a^2 x}{ae} - \frac{b^2 y}{b^2 / a} = a^2 - b^2$

It passes through (0, –b)

$ab = a^2e^2$

$a^2b^2 = a^4e^4 \qquad \left(b^2 = a^2\left(1-e^2\right)\right)$

$1-e^2 = e^4$

65. D

Sol. $fof\left(x\right) = \dfrac{a-f\left(x\right)}{a+f\left(x\right)} = x$

$\Rightarrow \dfrac{a-ax}{1+x} = f\left(x\right)$

$\Rightarrow \dfrac{a\left(1-x\right)}{1+x} = \dfrac{a-x}{a+x}$

$\Rightarrow a = 1$

So $f\left(x\right) = \dfrac{1-x}{1+x}$

$f\left(-\dfrac{1}{2}\right) = 3$

66. C

Sol. $T_{r+1} = {}^{10}C_r.\left(\dfrac{-K}{x^2}\right)^r\left(\sqrt{x}\right)^{10-r}$

$= {}^{10}C_r.\left(-K\right)^r.x^{5-\frac{5r}{2}}$ for constant term $\Rightarrow 5-\dfrac{5r}{2} = 0 \Rightarrow r = 2$

$\Rightarrow T_3 = {}^{10}C_2.K^2 = 405$

$\Rightarrow \dfrac{10\left(9\right)}{2}K^2 = 405$

$\Rightarrow K^2 = 9 \Rightarrow \left|K\right| = 3$

67. D

Sol. $y = x^2, \left(2, 4\right)$

tangent at (2, 4) is $\dfrac{1}{2}\left(y+4\right) = 2x$

$y+4 = 4x \Rightarrow 4x-y-4 = 0$

Equation of circle $\left(x-2\right)^2+\left(y-4\right)^2+\lambda\left(4x-y-4\right) = 0$

It passes through (0, 1)

$\therefore 4+9+\lambda\left(0-1-4\right) = 0$

$13 = 5\lambda \Rightarrow \lambda = \dfrac{13}{5}$

$\therefore$ circle is $x^2 - 4x + 4 + y^2 - 8y + 16 + \frac{13}{5}(4x - y - 4) = 0$

$\Rightarrow x^2 + y^2 + \left(\frac{52}{5} - 4\right)x - \left(8 + \frac{13}{5}\right)y + 20 - \frac{52}{5} = 0$

$\Rightarrow x^2 + y^2 + \frac{32}{5}x - \frac{53}{5}y + \frac{48}{5} = 0$

$\because$ centre is $\left(-\frac{16}{5}, \frac{53}{10}\right)$

68. C

Sol. $(x + iy)^1 = i\left(x^2 + y^2\right)$

$\Rightarrow x^2 - y^2 + 2ixy = i\left(x^2 + y^2\right)$

compare real and imaginary parts

$\Rightarrow x = y$

69. A

Sol. $P: n^3 - 1$ is even, q : n is odd

contrapositive of $p \to q = \sim q \to \sim p$

$\Rightarrow$ "If n is not odd then $n^3 - 1$ is not even"

$\Rightarrow$ For an integer n, if n is even, then $n^3 - 1$ is odd.

70. B

Sol.

$P(A \cup B \cup C) = P(A) + P(B) + P(C) - P(A \cap B) - P(B \cap C) - P(C \cap A) + P(A \cap B \cap C)$

$\Rightarrow \alpha = 1.4 - P(A \cap B) - \beta \Rightarrow \alpha + \beta = 1.4 - P(A \cap B)$ ....(1)

again

$P(A \cup B) = P(A) + P(B) - P(A \cap B) \Rightarrow P(A \cap B) = .2$ ....(2)

by (1) and (2) $\alpha = 1.2 - \beta$

now $0.85 \le \alpha \le 0.95$

$\Rightarrow 0.85 \le 1.2 - \beta \le 0.95 \Rightarrow \beta \in [0.25, 0.35]$

71. 5

Sol. $f(x) = a^x$

$\Rightarrow f(x) = a^x$

$\Rightarrow f(1) = a = 3$

So $f(x) = 3^x$

$$\sum_{i=1}^{n} f(i) = 363$$

$$\Rightarrow 3 + 3^2 + ...3^n = 363$$

$$\frac{3(3^n - 1)}{2} = 363$$

$$3^n = 243 \Rightarrow n = 5$$

72. 3

Sol. $\begin{vmatrix} \lambda-1 & 3\lambda+1 & 2\lambda \\ \lambda-1 & 4\lambda-2 & \lambda+3 \\ 2 & 3\lambda+1 & 3(\lambda-1) \end{vmatrix} = 0$

$R_2 \to R_2 - R_1$

$R_3 \to R_3 - R_1$

$$\begin{vmatrix} \lambda-1 & 3\lambda+1 & 2\lambda \\ 0 & \lambda-3 & -\lambda+3 \\ 3-\lambda & 0 & \lambda-3 \end{vmatrix} = 0$$

$C_1 \to C_1 + C_3$

$$\begin{vmatrix} 3\lambda-1 & 3\lambda+1 & 2\lambda \\ 3-\lambda & \lambda-3 & 3-\lambda \\ 0 & 0 & \lambda-3 \end{vmatrix} = 0$$

$$\Rightarrow (\lambda-3)^2[6\lambda] = 0 \Rightarrow \lambda = 0,3$$

Sum of values of $\lambda = 3$

73. 1

Sol. $|\vec{x} + \vec{y}|^2 = |\vec{x}|^2$

$I \Rightarrow |\vec{y}|^2 + 2\vec{x}.\vec{y} = 0$ ……………(1)

and $(2\vec{x} + \lambda\vec{y})\vec{y} = 0\,s$

$\Rightarrow \lambda|\vec{y}|^2 + 2\vec{x}.\vec{y} = 0$ …………(2)

by (1) and (2) $\lambda = 1$

74. 6

Sol.

x_i (observation)	0	2	2^2		2^n
f_i (frequency)	${}^nC_0$	${}^nC_1$	${}^nC_2$		${}^nC_n$

$$\bar{x} = \frac{\sum f_i x_i}{\sum f_i}$$

$$\frac{0\times {}^nC_0 + 2\times {}^nC_1 + 2^2 \times {}^nC_2.....2^n \times {}^nC_n}{{}^nC_0 + {}^nC_1 + {}^nC_1......{}^nC_n} = \frac{3^n - 1}{2^n} = \frac{728}{2^n}$$

$\Rightarrow \quad 3^n = 3^6$

$\Rightarrow \quad n = 6$

75. 120

Sol. Consonants are L, T, T, R

Vowels are E, E

Total number of words (with or without meaning) from letters of word ‘LETTER’

$= \frac{6!}{2!2!} = 180$

Total number of words (with or without meaning) from letters of word ‘LETTER’ if vowels are together $= \frac{5!}{2!} = 60$

$\therefore$ Required $= 180 - 60 = 120$