# Global Education of Science

**Subject** : Mathematics, Chemistry, Physics
**Standard** : 12
**Total Mark** : 300

# MCQ and Numerical

**Paper Set** : 1
**Date** : 31-07-2024
**Time** : 0H:20M

## Mathematics - Section A (MCQ)

(1) Let f(x) be a polynomial of degree 3 such that $f(k) = -\frac{2}{k}$ for $k = 2, 3, 4, 5$. Then the value of $52 - 10f(10)$ is equal to : [JEE MAIN 2021]

(A) 26 (B) 36

(C) 52 (D) 87

(2) The values of $x$ in the following determinant equation, $\begin{vmatrix} a+x & a-x & a-x \\ a-x & a+x & a-x \\ a-x & a-x & a+x \end{vmatrix} = 0$ are

(A) $x = 0, x = 4a$ (B) $x = 0, x = a$

(C) $x = 0, x = 2a$ (D) $x = 0, x = 3a$

(3) Let $f(x) = 2x^n + \lambda, \lambda \in R, n \in N$, and $f(4) = 133$, $f(5) = 255$. Then the sum of all the positive integer divisors of $(f(3) - f(2))$ is [JEE MAIN 2023]

(A) 61 (B) 60

(C) 58 (D) 59

(4) $\begin{vmatrix} x+1 & x+2 & x+4 \\ x+3 & x+5 & x+8 \\ x+7 & x+10 & x+14 \end{vmatrix} =$

(A) 2 (B) $-2$

(C) $x^2 - 2$ (D) None of these

(5) If $A = \begin{bmatrix} 2 & 2 \\ a & b \end{bmatrix}$ and $A^2 = O$, then $(a, b) =$

(A) $(-2, -2)$ (B) $(2, -2)$

(C) $(-2, 2)$ (D) $(2, 2)$

(6) If $f(x) = \begin{cases} (1+2x)^{1/x}, & \text{for} x \neq 0 \\ e^2, & \text{for} x = 0 \end{cases}$, then

(A) $\lim_{x \to 0+} f(x) = e$

(B) $\lim_{x \to 0-} f(x) = e^2$

(C) $f(x)$ is discontinuous at $x = 0$

(D) None of these

(7) Let $S = \left\{ \begin{pmatrix} -1 & a \\ 0 & b \end{pmatrix} ; a, b \in \{1, 2, 3, \ldots 100\} \right\}$ and let $T_n = \{A \in S : A^{n(n+1)} = I\}$. Then the number of elements in $\bigcap_{n=1}^{100} T_n$ is [JEE MAIN 2022]

(A) 50 (B) 85

(C) 100 (D) 137

(8) Let the sets $A$ and $B$ denote the domain and range respectively of the function $f(x) = \frac{1}{\sqrt{[x]-x}}$ where $[x]$ denotes the smallest integer greater than or equal to $x$. Then among the statements
$(S1) : A \cap B = (1, \infty) - N$ and
$(S2) : A \cup B = (1, \infty)$ [JEE MAIN 2023]

(A) only $(S1)$ is true

(B) both $(S1)$ and $(S2)$ are true

(C) neither $(S1)$ nor $(S2)$ is true

(D) only $(S2)$ is true

(9) The inverse of the matrix $\begin{bmatrix} 3 & -2 \\ 1 & 4 \end{bmatrix}$ is

(A) $\begin{bmatrix} \frac{4}{14} & \frac{2}{14} \\ \frac{-1}{14} & \frac{3}{14} \end{bmatrix}$ (B) $\begin{bmatrix} \frac{3}{14} & \frac{-2}{14} \\ \frac{1}{14} & \frac{4}{14} \end{bmatrix}$

(C) $\begin{bmatrix} \frac{4}{14} & \frac{-2}{14} \\ \frac{1}{14} & \frac{3}{14} \end{bmatrix}$ (D) $\begin{bmatrix} \frac{3}{14} & \frac{2}{14} \\ \frac{1}{14} & \frac{4}{14} \end{bmatrix}$

(10) Let $A$ be a square matrix such that $AA^T = I$. Then $\frac{1}{2}A\left[\left(A + A^T\right)^2 + \left(A - A^T\right)^2\right]$ is equal to [JEE MAIN 2024]

(A) $A^2 + I$ (B) $A^3 + I$

(C) $A^2 + A^T$ (D) $A^3 + A^T$

(11) The number of values of $\theta \in (0, \pi)$ for which the system of linear equations
$x + 3y + 7z = 0$
$-x + 4y + 7z = 0$
$(\sin 3\theta)x + (\cos 2\theta)y + 2z = 0$ has a non-trivial solution, is [JEE MAIN 2019]

(A) 3 (B) 2

(C) 4 (D) 1

(12) The real valued function $f(x) = \frac{\text{cosec}^{-1} x}{\sqrt{x-[x]}}$, where $[x]$ denotes the greatest integer less than or equal to $x$, is defined for all $x$ belonging to [JEE MAIN 2021]

(A) all reals except integers

(B) all non-integers except the interval $[-1, 1]$

(C) all integers except $0, -1, 1$

(D) all reals except the Interval $[-1, 1]$

(13) The principal value of $\sin^{-1}\left[\sin\left(\frac{2\pi}{3}\right)\right]$ is [IIT 1986]

(A) $-\frac{2\pi}{3}$ (B) $\frac{2\pi}{3}$

(C) $\frac{4\pi}{3}$ (D) None of these

(14) Let $A = \begin{bmatrix} x & 1 \\ 1 & 0 \end{bmatrix}, x \in R$ and $A^4 = [a_{ij}]$. If $a_{11} = 109$, then $a_{22}$ is equal to [JEE MAIN 2020]

(A) 10 (B) $-8$

(C) $-10$ (D) 8

(15) Let $f(x) = \begin{vmatrix} x^3 & \sin x & \cos x \\ 6 & -1 & 0 \\ p & p^2 & p^3 \end{vmatrix}$, where $p$ is a constant. Then $\frac{d^3}{dx^3}\{f(x)\}$ at $x = 0$ is [IIT 1997]

(A) $p$ (B) $p + p^2$

(C) $p + p^3$ (D) Independent of $p$

(16) If the system of linear equations $2x + y - z = 7$; $x - 3y + 2z = 1$; $x + 4y + \delta z = k$, where $\delta, k \in R$ has infinitely many solutions, then $\delta + k$ is equal to [JEE MAIN 2022]

(A) $-3$ (B) $3$

(C) $6$ (D) $9$

(17) $\begin{vmatrix} 1+\sin^2\theta & \sin^2\theta & \sin^2\theta \\ \cos^2\theta & 1+\cos^2\theta & \cos^2\theta \\ 4\sin 4\theta & 4\sin 4\theta & 1+4\sin 4\theta \end{vmatrix} = 0$ then $\sin 4\theta$ equal to

(A) $1/2$ (B) $1$

(C) $-1/2$ (D) $-1$

(18) If $2X - \begin{bmatrix} 1 & 2 \\ 7 & 4 \end{bmatrix} = \begin{bmatrix} 3 & 2 \\ 0 & -2 \end{bmatrix}$, then $X$ is equal to

(A) $\begin{bmatrix} 2 & 2 \\ 7 & 4 \end{bmatrix}$ (B) $\begin{bmatrix} 1 & 2 \\ 7/2 & 2 \end{bmatrix}$

(C) $\begin{bmatrix} 2 & 2 \\ 7/2 & 1 \end{bmatrix}$ (D) None of these

(19) Find the value of $\cot\left(\tan^{-1} a + \cot^{-1} a\right)$

(A) $\frac{\pi}{3}$ (B) $\frac{\pi}{4}$

(C) $0$ (D) $\frac{\pi}{2}$

(20) If $D_r = \begin{vmatrix} 2^{r-1} & 2.3^{r-1} & 4.5^{r-1} \\ x & y & z \\ 2^n - 1 & 3^n - 1 & 5^n - 1 \end{vmatrix}$, then the value of $\sum_{r=1}^{n} D_r =$

(A) $1$ (B) $-1$

(C) $0$ (D) None of these

## Mathematics - Section B (NUMERIC) (Attempt any 5)

(21) $\begin{vmatrix} 0 & p-q & p-r \\ q-p & 0 & q-r \\ r-p & r-q & 0 \end{vmatrix} =$

(22) Let $A = \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix}$ and $B = \begin{bmatrix} 9^2 & -10^2 & 11^2 \\ 12^2 & 13^2 & -14^2 \\ -15^2 & 16^2 & 17^2 \end{bmatrix}$, then the value of $A'BA$ is. [JEE MAIN 2022]

(23) Let $A = \{2, 3, 4\}$ and $B = \{8, 9, 12\}$. Then the number of elements in the relation $R = \{((a_1, b_1), (a_2, b_2)) \in (A \times B, A \times B) : a_1$ divides $b_2$ and $a_2$ divides $b_1\}$ is: [JEE MAIN 2023]

(24) Let $A = \{1, 2, 3, \ldots 20\}$. Let $R_1$ and $R_2$ two relation on A such that $R_1 = \{(a, b) : b$ is divisible by a$\}$ $R_2 = \{(a, b) : a$ is an integral multiple of b$\}$. Then, number of elements in $R_1 - R_2$ is equal to_____. [JEE MAIN 2024]

(25) $2\begin{vmatrix} 1 & 1 & 1 \\ a & b & c \\ a^2 - bc & b^2 - ac & c^2 - ab \end{vmatrix} =$

(26) Let a function $f : R \to R$ be defined as
$f(x) = \sin x - e^x$ if $x \le 0$
$a + [-x]$ if $0 < x < 1$
$2x - b$ if $\ge 1$
where [x] is the greatest integer less than or equal to x. If f is continuous on R, then $(a + b)$ is equal to: [JEE MAIN 2021]

(27) Let $S$ be the set of all integer solutions, $(x, y, z)$, of the system of equations
$x - 2y + 5z = 0$
$-2x + 4y + z = 0$
$-7x + 14y + 9z = 0$
such that $15 \le x^2 + y^2 + z^2 \le 150$. Then, the number of elements in the set $S$ is equal to [JEE MAIN 2020]

(28) If $a, b, c$ be positive real numbers and the value of $\theta = \tan^{-1}\sqrt{\frac{a(a+b+c)}{bc}} + \tan^{-1}\sqrt{\frac{b(a+b+c)}{ca}} + \tan^{-1}\sqrt{\frac{c(a+b+c)}{ab}}$, then $\tan\theta$ is equal to [IIT 1981]

(29) Let $I$ be an identity matrix of order $2 \times 2$ and $P = \begin{bmatrix} 2 & -1 \\ 5 & -3 \end{bmatrix}$. Then the value of $n \in N$ for which $P^n = 5I - 8P$ is equal to ..... . [JEE MAIN 2021]

(30) Let $f : (0, +\infty) \to R$ and $F(x) = \int_0^x f(t)\,dt$. If $F(x^2) = x^2(1 + x)$, then $f(4)$ equals [IIT 2001]

## Chemistry - Section A (MCQ)

(31) NaCl reacts with conc. $H_2SO_4$ and $K_2Cr_2O_7$ to give reddish fumes $(B)$, which react with NaOH to give yellow solution $(C)$. $(B)$ and $(C)$ respectively are ; [JEE MAIN 2024]

(A) $CrO_2Cl_2, Na_2CrO_4$ (B) $Na_2CrO_4, CrO_2Cl_2$

(C) $CrO_2Cl_2, KHSO_4$ (D) $CrO_2Cl_2, Na_2Cr_2O_7$

(32) Which of the following lanthanoid ions is diamagnetic ? (At. nos. $Ce = 58, Sm = 62, Eu = 63, Yb = 70$) [NEET 2013]

(A) $Eu^{2+}$ (B) $Yb^{2+}$

(C) $Ce^{2+}$ (D) $Sm^{2+}$

(33) Liquids $A$ and $B$ form an ideal solution [AIEEE 2003]

(A) The enthalpy of mixing is zero

(B) The entropy of mixing is zero

(C) The free energy of mixing is zero

(D) The free energy as well as the entropy of mixing are each zero

(34) The half life for the decomposition of gaseous compound $A$ is $240\,s$ when the gaseous pressure was $500\,Torr$ initially. When the pressure was $250\,Torr$, the half life was found to be $4.0\,min$. The order of the reaction is..... (Nearest integer) [JEE MAIN 2022]

(A) $4$ (B) $3$

(C) $2$ (D) $1$

(35) The number of Faradays $(F)$ required to produce $20\,g$ of calcium from molten $CaCl_2$(Atomic mass of $Ca = 40\,g\,mol^{-1}$) is [NEET 2020]

(A) $4$ (B) $1$

(C) $2$ (D) $3$

(36) The emf of a galvanic cell, with electrode potentials of silver $= +0.80\,V$ and that of copper $= +0.34\,V$, is ..... V [AIIMS 1999]

(A) $-1.1$ (B) $+1.1$

(C) $+0.46$ (D) $+0.76$

(37) $1$ molal aqueous solution of an electrolyte $A_2B_3$ is $60\%$ ionised. The boiling point of the solution at $1\,atm$ is ..... $K$. (Rounded-off to the nearest integer)
[Given $K_b$ for $(H_2O) = 0.52\,K\,kg\,mol^{-1}$] [JEE MAIN 2021]

(A) $370$ (B) $380$

(C) $375$ (D) $385$

(38) The correct order of $E^o_{M^{2+}/M}$ values with negative sign for the four successive elements $Cr, Mn, Fe$ and $Co$ is [AIEEE 2010]

(A) $Mn > Cr > Fe > Co$ (B) $Cr < Fe > Mn > Co$

(C) $Fe > Mn > Cr > Co$ (D) $Cr > Mn > Fe > Co$

(39) Faraday's laws of electrolysis are related to [IIT 1983]

(A) The atomic number of positive ion

(B) The equivalent weight of electrolyte

(C) The atomic number of negative ion

(D) The velocity of positive ion

(40) The correct electronic configuration and spin only magnetic moment (BM) of $Gd^{3+}(Z=64)$, respectively, are [JEE MAIN 2020]

(A) $[Xe]5f^7$ and $8.9$ (B) $[Xe]4f^7$ and $7.9$

(C) $[Xe]5f^7$ and $7.9$ (D) $[Xe]4f^7$ and $8.9$

(41) When $7.1\,gm\,Na_2SO_4$ (molecular mass $142$) dissolves in $100\,ml\,H_2O$, the molarity of the solution is ..... $M$ [AIPMT 1991]

(A) $2.0$ (B) $1.0$

(C) $0.5$ (D) $0.05$

(42) If the conductivity of mercury at $0°$ C is $1.07 \times 10^6$ S m$^{-1}$ and the resistance of a cell containing mercury is $0.243\,\Omega$, then the cell constant of the cell is x $\times 10^4$ m$^{-1}$. The value of x is ..... .(Nearest integer) [JEE MAIN 2021]

(A) $260$ (B) $39$

(C) $26$ (D) $13$

(43) Elevation in boiling point for $1.5$ molal solution of glucose in water is $4\,K$. The depression in freezing point for $4.5$ molal solution of glucose in water is $4\,K$ The ratio of molal elevation constant to molal depression constant $(K_b/K_f)$ is .... [JEE MAIN 2022]

(A) $4$ (B) $1$

(C) $2$ (D) $3$

(44) A reduction in atomic size with increase in atomic number is a characteristic of elements of [AIEEE 2003]

(A) High atomic masses (B) $d-$ block

(C) $f-$ block (D) Radioactive series

(45) What will be the $emf$ for the given cell $Pt|H_2(P_1)|H^+{}_{(aq)}||H_2(P_2)|Pt$ [AIEEE 2002]

(A) $\frac{RT}{f}\log\frac{P_1}{P_2}$ (B) $\frac{RT}{2f}\log\frac{P_1}{P_2}$

(C) $\frac{RT}{f}\log\frac{P_2}{P_1}$ (D) None of these

(46) A solution of two miscible liquids showing negative deviation from Raoult's law will have : [JEE MAIN 2024]

(A) increased vapour pressure, increased boiling point

(B) increased vapour pressure, decreased boiling point

(C) decreased vapour pressure, decreased boiling point

(D) decreased vapour pressure, increased boiling point

(47) A $0.0020\,m$ aqueous solution of an ionic compound $[Co(NH_3)_5(NO_2)]Cl$ freezes at $-0.00732\,^oC$. Number of moles of ions which $1\,mol$ of ionic compound produces on being dissolved in water will be $(K_f = -1.86\,^oC/m)$ [AIPMT 2009]

(A) $3$ (B) $4$

(C) $1$ (D) $2$

(48) Given below are two statements: one is labelled as Assertion $(A)$ and the other is labelled as Reason $(R)$.
Assertion $(A)$ : In aqueous solutions $Cr^{2+}$ is reducing while $Mn^{3+}$ is oxidising in nature.
Reason $(R)$ : Extra stability to half filled electronic configuration is observed than incompletely filled electronic configuration.
In the light of the above statement, choose the most appropriate answer from the options given below: [JEE MAIN 2024]

(A) Both $(A)$ and $(R)$ are true and $(R)$ is the correct explanation of $(A)$

(B) Both $(A)$ and $(R)$ are true but $(R)$ is not the correct explanation of $(A)$

(C) $(A)$ is false but $(R)$ is true

(D) $(A)$ is true but $(R)$ is false

(49) The efficiency of a fuel cell is given by [AIPMT 2007]

(A) $\Delta G/\Delta S$ (B) $\Delta G/\Delta H$

(C) $\Delta S/\Delta G$ (D) $\Delta H/\Delta G$

(50) In chromyl chloride, the number of d-electrons present on chromium is same as in (Given at no. of $Ti:22, V:23, Cr:24, Mn:25, Fe:26$) [JEE MAIN 2023]

(A) $Ti\,(III)$ (B) $Fe\,(III)$

(C) $V\,(IV)$ (D) $Mn\,(VII)$

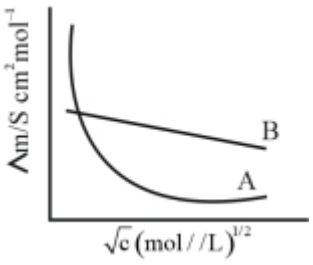
## Chemistry - Section B (NUMERIC) (Attempt any 5)

(51) The correct option for the value of vapour pressure of a solution at $45°$C with benzene to octane in molar ratio $3:2$ is ..... mm of Hg
[At $45°$C vapour pressure of benzene is $280$ mm Hg and that of octane is $420$ mm Hg. Assume Ideal gas] [NEET 2021]

(52) When $10$ mL of an aqueous solution of $KMnO_4$ was titrated in acidic medium, equal volume of $0.1$ M of an aqueous solution of ferrous sulphate was required for complete discharge of colour. The strength of $KMnO_4$ in grams per litre is ..... $\times 10^{-2}$. (Nearest integer)
Atomic mass of K $= 39$, Mn $= 55$, O $= 16$] [JEE MAIN 2021]

(53) A $KCl$ solution of conductivity $0.14\,Sm^{-1}$ shows a resistance of $4.19\,\Omega$ in a conductivity cell. If the same cell is filled with an $HCl$ solution, the resistance drops to $1.03\,\Omega$. The conductivity of the $HCl$ solution is ..... $\times 10^{-2}\,Sm^{-1}$. (Round off to the Nearest Integer). [JEE MAIN 2021]

(54) Following figure shows dependence of molar conductance of two electrolytes on concentration. $\Lambda\overset{0}{m}$ is the limiting molar conductivity.The number of Incorrect statement(s) from the following is .....
$(A)$ $\Lambda\overset{0}{m}$ for electrolyte $A$ is obtained by extrapolation
$(B)$ For electrolyte B, vx $\Lambda m$ vs $\sqrt{c}$ graph is a straight line with intercept equal to $\Lambda\overset{0}{m}$
$(C)$ At infinite dilution, the value of degree of dissociation approach zero for electrolyte $B$.
$(D)$ $\Lambda\overset{0}{m}$ for any electrolyte $A$ or $B$ can be calculated using $\lambda°$ for individual ions. [JEE MAIN 2023]




(55) The number of $4f$ electrons in the ground state electronic configuration of $Gd^{2+}$ is ..... .
[Atomic number of Gd $= 64$ ] [JEE MAIN 2021]

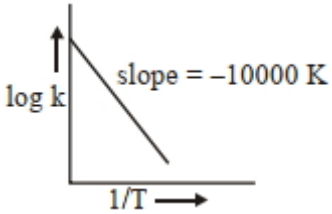
(56) r = k[A] for a reaction, 50% of A is decomposed in120 minutes. The time taken for 90% decomposition of A is..... minutes. [JEE MAIN 2024]

(57) The potential for the given half cell at 298 K is $(-)$ $(-)\ldots\ldots\ldots\times 10^{-2}$ V.
$2H^{+}_{(aq)} + 2e^{-} \rightarrow H_2(g)$
$[H^+] = 1M, P_{H_2} = 2$ atm
(Given: $2.303RT/F = 0.06$ V, $\log 2 = 0.3$ ) [JEE MAIN 2024]

(58) The electrode potential of the following half cell at $298\ K$
$X\left|X^{2+}(0.001M)\right\|Y^{2+}(0.01M)\left|Y\right.$
is ..... $\times 10^{-2}V$ (Nearest integer).
Given: $E^0_{x^{2+}|x} = -2.36\ V$
$E^0_{Y^{3+}|Y} = +0.36\ V$
$\frac{2.303\ RT}{F} = 0.06\ V$ [JEE MAIN 2023]

(59) The vapour pressures of two volatile liquids $A$ and $B$ at $25°C$ are $50\ Torr$ and $100\ Torr$, respectively. If the liquid mixture contains 0.3 mole fraction of $A$, then the mole fraction of liquid $B$ in the vapour phase is $\frac{x}{17}$. The value of $x$ is ... [JEE MAIN 2022]

(60) For the reaction, $aA + bB \rightarrow cC + dD$, the plot of log $k$ vs $\frac{1}{T}$ is given below
The temperature at which the rate constant of the reaction is $10^{-4}s^{-1}$ is ..... $K$.
(Rounded-off to the nearest integer)
[Given: The rate constant of the reaction is $10^{-5}s^{-1}$ at $500K$.] [JEE MAIN 2021]




## Physics - Section A (MCQ)

(61) A galvanometer, whose resistance is $50\ ohm$, has 25 divisions in it. When a current of $4 \times 10^{-4}\ A$ passes through it, its needle (pointer) deflects by one division. To use this galvanometer as a voltmeter of range $2.5\ V$, it should be connected to a resistance of.....$ohm$ [JEE MAIN 2019]

(A) 250 (B) 200

(C) 6200 (D) 6250

(62) $A$. The drift velocity of electrons decreases with the increase in the temperature of conductor.
$B$. The drift velocity is inversely proportional to the area of cross-section of given conductor.
$C$. The drift velocity does not depend on the applied potential difference to the conductor.
$D$. The drift velocity of electron is inversely proportional to the length of the conductor.
$E$. The drift velocity increases with the increase in the temperature of conductor.
Choose the correct answer from the options given below:
[JEE MAIN 2022]

(A) $A$ and $B$ only

(B) $A$ and $D$ only

(C) $B$ and $E$ only

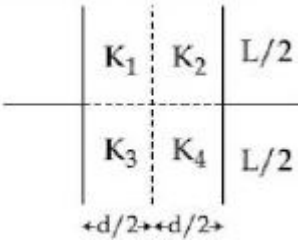
(D) $B$ and $C$ only

(63) The number density of free electrons in copper is nearly $8 \times 10^{28}\ m^{-3}$.$A$ copper wire has its area of cross section $= 2 \times 10^{-6}\ m^2$ and is carrying a current of $3.2\ A$. The drift speed of the electrons is ..... $\times 10^{-6}\ ms^{-1}$. [JEE MAIN 2023]

(A) 125 (B) 124

(C) 123 (D) 122

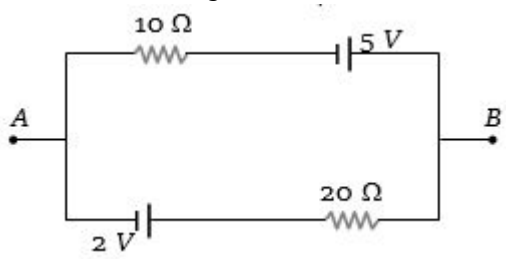
(64) A parallel palate capacitor with square plates is filled with four dielectrics of dielectric constants $K_1, K_2, K_3, K_4$ arranged as shown in the figure. The effective dielectric constant $K$ will be [JEE MAIN 2019]




(A) $K = \frac{(K_1+K_3)(K_2+K_4)}{K_1+K_2+K_3+K_4}$ (B) $K = \frac{(K_1+K_2)(K_3+K_4)}{2(K_1+K_2+K_3+K_4)}$

(C) $K = \frac{(K_1+K_2)(K_3+K_4)}{K_1+K_2+K_3+K_4}$ (D) $K = \frac{(K_1+K_4)(K_2+K_3)}{2(K_1+K_2+K_3+K_4)}$

(65) The current in the given circuit is ..... $A$ [AIIMS 2000]




(A) 0.1 (B) 0.2

(C) 0.3 (D) 0.4

(66) If two charges $q_1$ and $q_2$ are separated with distance '$d$' and placed in a medium of dielectric constant $K$. What will be the equivalent distance between charges in air for the same electrostatic force? [JEE MAIN 2023]

(A) $d\sqrt{k}$ (B) $k\sqrt{d}$

(C) $1.5d\sqrt{k}$ (D) $2d\sqrt{k}$

(67) Two long current carrying conductors are placed parallel to each other at a distance of $8\ cm$ between them. The magnitude of magnetic field produced at mid-point between the two conductors due to current flowing in them is $300\ \mu T$. The equal current flowing in the two conductors is ..... [JEE MAIN 2022]

(A) $30\ A$ in the same direction

(B) $30\ A$ in the opposite direction

(C) $60\ A$ in the opposite direction

(D) $300\ A$ in the opposite direction

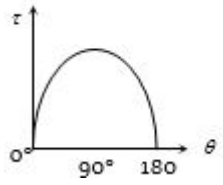
(68) In a spherical condenser radius of the outer sphere is $R$. The different in the radii of outer and inner sphere in $x$. Its capacity is proportional to

(A) $\frac{xR}{(R-x)}$ (B) $\frac{x(R-x)}{r}$

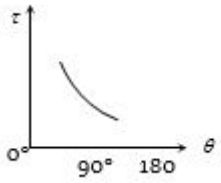
(C) $\frac{R(R-x)}{x}$ (D) $\frac{R}{x}$

(69) The $(\tau - \theta)$ graph for a coil is

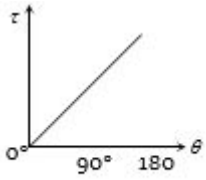
(A)



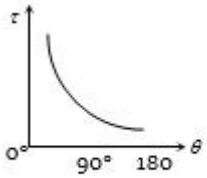

(B)




(C)




(D)




(70) A coaxial cable consists of an inner wire of radius '$a$' surrounded by an outer shell of inner and outer radii '$b$' and '$c$' respectively. The inner wire carries an electric current is, which is distributed uniformly across cross-sectional area. The outer shell carries an equal current in opposite direction and distributed uniformly. What will be the ratio of the magnetic field at a distance $x$ from the axis when $(i)\ x < a$ and $(ii)\ a < x < b$ ? [JEE MAIN 2021]

(A) $\frac{x^2}{a^2}$ (B) $\frac{a^2}{x^2}$

(C) $\frac{x^2}{b^2-a^2}$ (D) $\frac{b^2-a^2}{x^2}$

(71) A coil of one turn is made of a wire of certain length and then from the same length a coil of two turns is made. If the same current is passed in both the cases, then the ratio of the magnetic inductions at their centres will be [AIPMT 1998]

(A) $4:1$ (B) $1:4$

(C) $2:1$ (D) $2:1$

(72) A particle of mass $m$ and charge $q$ moves with a constant velocity $v$ along the positive $x$ direction. It enters a region containing a uniform magnetic field $B$ directed along the negative $z$ direction, extending from $x = a$ to $x = b$. The minimum value of $v$ required so that the particle can just enter the region $x > b$ is [IIT 2002]

(A) $qb\,B/m$ (B) $q(b-a)B/m$

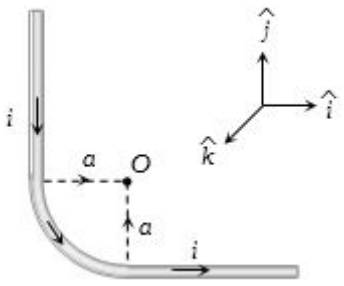
(C) $qa\,B/m$ (D) $q(b+a)B/2m$

(73) There is a uniform electrostatic field in a region. The potential at various points on a small sphere centred at $P$, in the region, is found to vary between in the limits $589.0\,V$ to $589.8\,V$. What is the potential at a point on the sphere whose radius vector makes an angle of $60^o$ with the direction of the field ?.....$V$ [JEE MAIN 2017]

(A) $589.5$ (B) $589.2$

(C) $589.4$ (D) $589.6$

(74) The unit vectors $\hat{i},\ \hat{j}$ and $\hat{k}$ are as shown below. What will be the magnetic field at $O$ in the following figure




(A) $\frac{\mu_0}{4\pi}\frac{i}{a}\left(2-\frac{\pi}{2}\right)\hat{j}$ (B) $\frac{\mu_0}{4\pi}\frac{i}{a}\left(2+\frac{\pi}{2}\right)\hat{j}$

(C) $\frac{\mu_0}{4\pi}\frac{i}{a}\left(2+\frac{\pi}{2}\right)\hat{i}$ (D) $\frac{\mu_0}{4\pi}\frac{i}{a}\left(2+\frac{\pi}{2}\right)\hat{k}$

(75) A wire $50\,cm$ long and $1\ mm^2$ in cross -section carries a current of $4\ A$ when connected to a $2\ V$ battery. The resistivity of the wire is [AIPMT 1994]

(A) $1\times10^{-6}\ \Omega-m$ (B) $4\times10^{-6}\ \Omega-m$

(C) $5\times10^{-7}\ \Omega-m$ (D) $2\times10^{-7}\ \Omega-m$

(76) In a building there are $15$ bulbs of $45$ W, $15$ bulbs of $100$ W, $15$ small fans of $10$ W and $2$ heaters of $1$ kW. The voltage of electric main is $220$ V. The minimum fuse capacity (rated value) of the building will be: ..... $A$ [JEE MAIN 2020]

(A) $10$ (B) $25$

(C) $15$ (D) $20$

(77) $n$ identical cells each of $e.m.f.\ E$ and internal resistance $r$ are connected in series. An external resistance $R$ is connected in series to this combination. The current through $R$ is

(A) $\frac{nE}{R+nr}$ (B) $\frac{nE}{nR+r}$

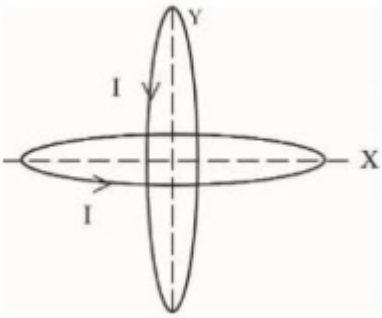
(C) $\frac{E}{R+nr}$ (D) $\frac{nE}{R+r}$

(78) $3\ A$ of current is flowing in a linear conductor having a length of $40\,cm$. The conductor is placed in a magnetic field of strength $500\ gauss$ and makes an angle of $30^\circ$ with the direction of the field. It experiences a force of magnitude

(A) $3\times10^4\ newton$ (B) $3\times10^2\ newton$

(C) $3\times10^{-2}\ newton$ (D) $3\times10^{-4}\ newton$

(79) Two identical circular wires of radius $20\,cm$ and carrying current $\sqrt{2}\,A$ are placed in perpendicular planes as shown in figure. The net magnetic field at the centre of the circular wire is ..... $\times10^{-8}\,T$. (Take $\pi = 3.14$ ) [JEE MAIN 2023]




(A) $689$ (B) $546$

(C) $487$ (D) $628$

(80) A long solenoid of $50\,cm$ length having $100$ turns carries a current of $2.5\ A$. The magnetic field at the centre of the solenoid is ..... $\times10^{-5}\ T$
$\left(\mu_0 = 4\pi\times10^{-7}\,T\,m\,A^{-1}\right)$ [NEET 2020]

(A) $3.14$ (B) $62.8$

(C) $31.4$ (D) $6.28$

## Physics - Section B (NUMERIC) (Attempt any 5)

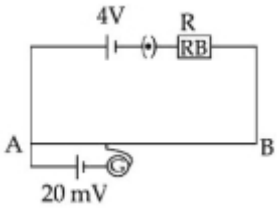
(81) In a circuit for finding the resistance of a galvanometer by half deflection method, a $6\,V$ battery and a high resistance of $11\,k\Omega$ are used. The figure of merit of the galvanometer $60\,\mu A/$ division. In the absence of shunt resistance, the galvanometer produces a deflection of $\theta = 9$ divisions when current flows in the circuit. The value of the shunt resistance that can cause the deflection of $\theta/2$, is closest to ..... $\Omega$ [JEE MAIN 2018]

(82) Two identical charged particles each having a mass $10\,g$ and charge $2.0\times10^{-7}\,C$ area placed on a horizontal table with a

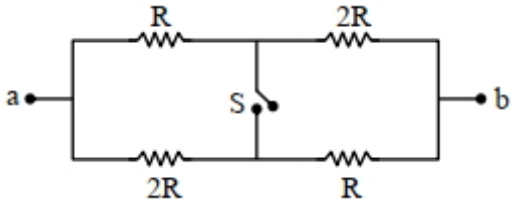
separation of $L$ between then such that they stay in limited equilibrium. If the coefficient of friction between each particle and the table is $0.25$, find the value of $L$.[Use $g = 10\, ms^{-2}$ ].....$cm$ [JEE MAIN 2022]

(83) Suppose a uniformly charged wall provides a uniform electric field of $2 \times 10^4$ N/C normally. A charged particle of mass $2$ g being suspended through a silk thread of length $20$ cm and remain stayed at a distance of $10$ cm from the wall. Then the charge on the particle will be $\frac{1}{\sqrt{x}}\ \mu$C where x = _____. use $g = 10$ m/s$^2$ ] [JEE MAIN 2024]

(84) As shown in the figure, a potentiometer wire of resistance $20\,\Omega$ and length $300\, cm$ is connected with resistance box (R.B.) and a standard cell of emf $4\, V$. For a resistance '$R$' of resistance box introduced into the circuit, the null point for a cell of $20\, mV$ is found to be $60\, cm$. The value of '$R$' is .....$\Omega$ [JEE MAIN 2022]




(85) The ratio of the equivalent resistance of the network (shown in figure) between the points $a$ and $b$ when switch is open and switch is closed is $x : 8$. The value of $x$ is ..... . [JEE MAIN 2021]

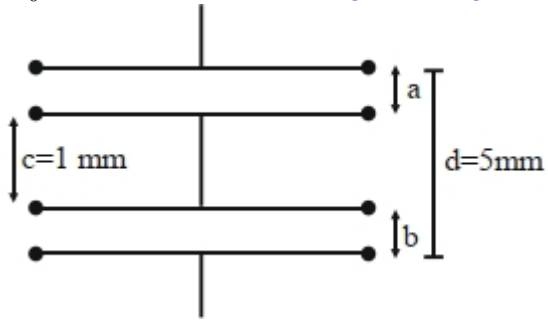



(86) A hollow cylindrical conductor has length of $3.14\, m$, while its inner and outer diameters are $4\, mm$ and $8\, mm$ respectively. The resistance of the conductor is $n \times 10^{-3}\,\Omega$.If the resistivity of the material is $2.4 \times 10^{-8}\,\Omega\, m$. The value of $n$ is ..... [JEE MAIN 2023]

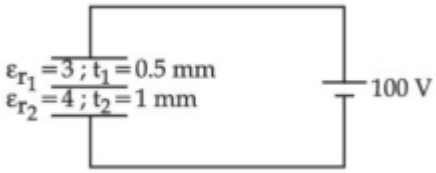
(87) A resistor develops $300\, J$ of thermal energy in $15\, s$, when a current of $2\, A$ is passed through it. If the current increases to $3\, A$, the energy developed in $10\ s$ is.....$J$. [JEE MAIN 2022]

(88) A voltmeter has resistance of $2000\, ohms$ and it can measure upto $2\, V$. If we want to increase its range to $10\, V$, then the required resistance in series will be ..... $\Omega$

(89) As shown in the figure, two parallel plate capacitors having equal plate area of $200\, cm^2$ are joined in such a way that $a \neq b$. The equivalent capacitance of the combination is $x\varepsilon_0 F$. The value of $x$ is ..... [JEE MAIN 2023]




(90) A composite parallel plate capacitor is made up of two different dielectric materials with different thickness $(t_1$ and $t_2)$ as shown in figure. The two different dielectric material are separated by a conducting foil $F$. The voltage of the conducting foil is .....$V$ [JEE MAIN 2022]



# Global Education of Science

**Subject** : Mathematics, Chemistry, Physics
**Standard** : 12
**Total Mark** : 300

# MCQ and Numerical

**(Answer Key)**

**Paper Set** : 1
**Date** : 31-07-2024
**Time** : 0H:20M

## Mathematics - Section A (MCQ)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 - A | 2 - D | 3 - B | 4 - B | 5 - A | 6 - B | 7 - C | 8 - A | 9 - A | 10 - D |
| 11 - B | 12 - B | 13 - D | 14 - A | 15 - D | 16 - B | 17 - C | 18 - C | 19 - C | 20 - C |

## Mathematics - Section B (NUMERIC)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 21 - 0 | 22 - 539 | 23 - 36 | 24 - 46 | 25 - 0 | 26 - 3 | 27 - 8 | 28 - 0 | 29 - 6 | 30 - 4 |

## Chemistry - Section A (MCQ)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 31 - A | 32 - B | 33 - A | 34 - D | 35 - B | 36 - C | 37 - C | 38 - A | 39 - B | 40 - B |
| 41 - C | 42 - C | 43 - D | 44 - C | 45 - B | 46 - D | 47 - D | 48 - A | 49 - B | 50 - D |

## Chemistry - Section B (NUMERIC)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 51 - 336 | 52 - 316 | 53 - 57 | 54 - 2 | 55 - 7 | 56 - 399 | 57 - 1 | 58 - 275 | 59 - 14 | 60 - 526 |



## Physics - Section A (MCQ)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 61 - B | 62 - B | 63 - A | 64 - A | 65 - A | 66 - A | 67 - B | 68 - C | 69 - A | 70 - A |
| 71 - B | 72 - B | 73 - C | 74 - D | 75 - A | 76 - D | 77 - A | 78 - C | 79 - D | 80 - B |

## Physics - Section B (NUMERIC)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 81 - 110 | 82 - 12 | 83 - 3 | 84 - 780 | 85 - 9 | 86 - 2 | 87 - 450 | 88 - 8000 | 89 - 5 | 90 - 60 |

## Mathematics - Section A (MCQ)

(1) Let f(x) be a polynomial of degree 3 such that $f(k) = -\frac{2}{k}$ for $k = 2, 3, 4, 5$. Then the value of $52 - 10f(10)$ is equal to : [JEE MAIN 2021]

**(A)** 26 (B) 36

(C) 52 (D) 87

**Solution:(Correct Answer:A)**

$k f(k) + 2 = \lambda(x-2)(x-3)(x-4)(x-5) \ldots (1)$
put $x = 0$
we get $\lambda = \frac{1}{60}$
Now put $\lambda$ in equation $(1)$
$\Rightarrow k f(k) + 2 = \frac{1}{60}(x-2)(x-3)(x-4)(x-5)$
Put $x = 10$
$\Rightarrow 10 f(10) + 2 = \frac{1}{60}(8)(7)(6)(5)$
$\Rightarrow 52 - 10 f(10) = 52 - 26 = 26$

(2) The values of $x$ in the following determinant equation, $\begin{vmatrix} a+x & a-x & a-x \\ a-x & a+x & a-x \\ a-x & a-x & a+x \end{vmatrix} = 0$ are

(A) $x = 0, x = 4a$ (B) $x = 0, x = a$

(C) $x = 0, x = 2a$ **(D)** $x = 0, x = 3a$

**Solution:(Correct Answer:D)**

(d) Trick: Putting $x = 0$ and $x = 3a$, the value of determinant becomes zero.

(3) Let $f(x) = 2x^n + \lambda, \lambda \in R, n \in N$, and $f(4) = 133$, $f(5) = 255$. Then the sum of all the positive integer divisors of $(f(3) - f(2))$ is [JEE MAIN 2023]

(A) 61 **(B)** 60

(C) 58 (D) 59

**Solution:(Correct Answer:B)**

$f(x) = 2x^n + \lambda$
$f(4) = 133$
$f(5) = 255$
$133 = 2 \times 4^n + \lambda \ldots\ldots (1)$
$255 = 2 \times 5^n + \lambda \ldots\ldots (2)$
$(2) - (1)$
$122 = 2(5^n - 4^n)$
$\Rightarrow 5^n - 4^n = 61$
$\therefore n = 3 \, and \, \lambda = 5$
Now, $f(3) - f(2) = 2(3^3 - 2^3) = 38$
Number of Divisors is $1, 2, 19, 38$; and their sum is $60$.

(4) $\begin{vmatrix} x+1 & x+2 & x+4 \\ x+3 & x+5 & x+8 \\ x+7 & x+10 & x+14 \end{vmatrix} =$

(A) 2 **(B)** $-2$

(C) $x^2 - 2$ (D) None of these

**Solution:(Correct Answer:B)**

(b) $\Delta = \begin{vmatrix} -1 & -2 & x+4 \\ -2 & -3 & x+8 \\ -3 & -4 & x+14 \end{vmatrix}$, by $\begin{matrix} C_1 \to C_1 - C_2 \\ C_2 \to C_2 - C_3 \end{matrix}$

$= \begin{vmatrix} -1 & -1 & x \\ -2 & -1 & x \\ -3 & -1 & x+2 \end{vmatrix}$, , by $\begin{matrix} C_2 \to C_2 - C_1 \\ C_3 \to C_3 + 4C_1 \end{matrix}$

$= -(-x - 2 + x) + 1 \, . \, (-2x - 4 + 3x) + x(2 - 3)$
$= 2 + x - 4 - x = -2.$

Trick : Put $x = 1$. Then $\begin{vmatrix} 2 & 3 & 5 \\ 4 & 6 & 9 \\ 8 & 11 & 15 \end{vmatrix} = -2$

Note : Since there is a option "None of these", therefore we should check for one more different value of $x$ . Put $x = -1$.

$\begin{vmatrix} 0 & 1 & 3 \\ 2 & 4 & 7 \\ 6 & 9 & 13 \end{vmatrix} = -1(26 - 42) + 3(18 - 24) = -2$

Therefore answer is $(b)$.

(5) If $A = \begin{bmatrix} 2 & 2 \\ a & b \end{bmatrix}$ and $A^2 = O$, then $(a, b) =$

**(A)** $(-2, -2)$ (B) $(2, -2)$

(C) $(-2, 2)$ (D) $(2, 2)$

**Solution:(Correct Answer:A)**

(a) $A^2 = \begin{bmatrix} 2 & 2 \\ a & b \end{bmatrix} \begin{bmatrix} 2 & 2 \\ a & b \end{bmatrix} = \begin{bmatrix} 4+2a & 4+2b \\ 2a+ab & 2a+b^2 \end{bmatrix} =$
$0 = \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix}$
$\Rightarrow 4 + 2a = 0, 4 + 2b = 0, 2a + ab = 0,$
$2a + b^2 = 0$ must be consistent.
$\Rightarrow a = -2, b = -2.$

(6) If $f(x) = \begin{cases} (1+2x)^{1/x}, \text{ for} x \neq 0 \\ e^2, \text{ for} x = 0 \end{cases}$, then

(A) $\lim\limits_{x \to 0+} f(x) = e$

**(B)** $\lim\limits_{x \to 0-} f(x) = e^2$

(C) $f(x)$ is discontinuous at $x = 0$

(D) None of these

**Solution:(Correct Answer:B)**

(b) $\lim\limits_{x \to 0-} f(x) = \lim\limits_{x \to 0} \left[(1+2x)^{1/2x}\right]^2 = e^2.$

(7) Let $S = \left\{ \begin{pmatrix} -1 & a \\ 0 & b \end{pmatrix} ; a, b \in \{1, 2, 3, \ldots 100\} \right\}$ and let $T_n = \{A \in S : A^{n(n+1)} = I\}$. Then the number of elements in $\bigcap\limits_{n=1}^{100} T_n$ is [JEE MAIN 2022]

(A) 50 (B) 85

**(C)** 100 (D) 137

**Solution:(Correct Answer:C)**

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

$A^2 = \begin{bmatrix} -1 & a \\ 0 & b \end{bmatrix}\begin{bmatrix} -1 & a \\ 0 & b \end{bmatrix}$

$= \begin{bmatrix} 1 & -a+ab \\ 0 & b^2 \end{bmatrix}$

$\therefore T_n = \{A \in S; A^{n(n+1)} = I\}$

$\therefore b$ must be equal to $1$

$\therefore$ In this case $A^2$ will become identity matrix and a can take any value from $1$ to $100$

$\therefore$ Total number of common element will be $100$.

(8) Let the sets $A$ and $B$ denote the domain and range respectively of the function $f(x) = \frac{1}{\sqrt{\lceil x \rceil - x}}$ where $\lceil x \rceil$ denotes the smallest integer greater than or equal to $x$. Then among the statements

$(S1) : A \cap B = (1, \infty) - N$ and

$(S2) : A \cup B = (1, \infty)$ [JEE MAIN 2023]

**(A)** only $(S1)$ is true

(B) both $(S1)$ and $(S2)$ are true

(C) neither $(S1)$ nor $(S2)$ is true

(D) only $(S2)$ is true

**Solution:(Correct Answer:A)**

$f(x) = \frac{1}{\sqrt{\lceil x \rceil - x}}$

If $x \in I \lceil x \rceil = [x]$ (greatest integer function)

If $x \notin I \lceil x \rceil = [x] + 1$

$\Rightarrow f(x) = \begin{cases} \frac{1}{\sqrt{[x]-x}}, x \in I \frac{1}{\sqrt{[x]+1-x}}, x \notin I \end{cases}$

$\Rightarrow f(x) = \begin{cases} \frac{1}{\sqrt{-\{x\}}}, x \in I, \text{ (does not exist)} \\ \frac{1}{\sqrt{1-\{x\}}}, x \notin I \end{cases}$

$\Rightarrow$ domain of $f(x) = R - I$

Now, $f(x) = \frac{1}{\sqrt{1-\{x\}}}, x \notin I$

$\Rightarrow 0 < \{x\} < 1$

$\Rightarrow 0 < \sqrt{1-\{x\}} < 1$

$\Rightarrow \frac{1}{\sqrt{1-\{x\}}} > 1$

$\Rightarrow$ Range $(1, \infty)$

$\Rightarrow A = R - I$

$B = (1, \infty)$

So, $A \cap B = (1, \infty) - N$

$A \cup B \neq (1, \infty)$

$\Rightarrow S1$ is only correct

(9) The inverse of the matrix $\begin{bmatrix} 3 & -2 \\ 1 & 4 \end{bmatrix}$ is

**(A)** $\begin{bmatrix} \frac{4}{14} & \frac{2}{14} \\ \frac{-1}{14} & \frac{3}{14} \end{bmatrix}$ (B) $\begin{bmatrix} \frac{3}{14} & \frac{-2}{14} \\ \frac{1}{14} & \frac{4}{14} \end{bmatrix}$

(C) $\begin{bmatrix} \frac{4}{14} & \frac{-2}{14} \\ \frac{1}{14} & \frac{3}{14} \end{bmatrix}$ (D) $\begin{bmatrix} \frac{3}{14} & \frac{2}{14} \\ \frac{1}{14} & \frac{4}{14} \end{bmatrix}$

**Solution:(Correct Answer:A)**

(a) Let $A = \begin{bmatrix} 3 & -2 \\ 1 & 4 \end{bmatrix} \Rightarrow |A| = 14$

$\therefore adj\ A = \begin{bmatrix} 4 & 2 \\ -1 & 3 \end{bmatrix} \Rightarrow A^{-1} = \begin{bmatrix} \frac{4}{14} & \frac{2}{14} \\ \frac{-1}{14} & \frac{3}{14} \end{bmatrix}$.

(10) Let $A$ be a square matrix such that $AA^T = I$. Then $\frac{1}{2}A\left[\left(A + A^T\right)^2 + \left(A - A^T\right)^2\right]$ is equal to [JEE MAIN 2024]

(A) $A^2 + I$ (B) $A^3 + I$

(C) $A^2 + A^T$ **(D)** $A^3 + A^T$

**Solution:(Correct Answer:D)**

$AA^T = I = A^TA$

On solving given expression, we get

$\frac{1}{2}A\left[A^2 + \left(A^T\right)^2 + 2AA^T + A^2 + \left(A^T\right)^2 - 2AA^T\right]$

$= A\left[A^2 + \left(A^T\right)^2\right] = A^3 + A^T$

(11) The number of values of $\theta \in (0, \pi)$ for which the system of linear equations

$x + 3y + 7z = 0$

$-x + 4y + 7z = 0$

$(sin\, 3\theta)x + (cos\, 2\theta)y + 2z = 0$ has a non-trivial solution, is [JEE MAIN 2019]

(A) $3$ **(B)** $2$

(C) $4$ (D) $1$

**Solution:(Correct Answer:B)**

$\begin{vmatrix} \sin 3\theta & -1 & 1 \\ \cos 2\theta & 4 & 3 \\ 2 & 7 & 7 \end{vmatrix} = 0$

$7 \sin 3\theta + 14 \cos 2\theta - 14 = 0$

$\sin 3\theta + 2 \cos 2\theta - 2 = 0, \sin\theta = \frac{1}{2}$

(12) The real valued function $f(x) = \frac{\text{cosec}^{-1} x}{\sqrt{x-[x]}}$, where $[x]$ denotes the greatest integer less than or equal to $x$, is defined for all $x$ belonging to [JEE MAIN 2021]

(A) all reals except integers

**(B)** all non-integers except the interval $[-1, 1]$

(C) all integers except $0, -1, 1$

(D) all reals except the Interval $[-1, 1]$

**Solution:(Correct Answer:B)**

$f(x) = \frac{\text{cosec}^{-1} x}{\sqrt{\{x\}}}$

Domain $\in (-\infty, -1] \cup [1, \infty)$

$\{x\} \neq 0$ so $x \neq$ integers

(13) The principal value of $\sin^{-1}\left[\sin\left(\frac{2\pi}{3}\right)\right]$ is [IIT 1986]

(A) $-\frac{2\pi}{3}$ (B) $\frac{2\pi}{3}$

(C) $\frac{4\pi}{3}$ **(D)** None of these

**Solution:(Correct Answer:D)**

(d) The principal value of $\sin^{-1}\left[\sin\left(\pi - \frac{2\pi}{3}\right)\right]$

$= \sin^{-1} \sin\left(\frac{\pi}{3}\right) = \frac{\pi}{3}$.

(14) Let $A = \begin{bmatrix} x & 1 \\ 1 & 0 \end{bmatrix}, x \in R$ and $A^4 = [a_{ij}]$. If $a_{11} = 109$, then $a_{22}$ is equal to [JEE MAIN 2020]

**(A)** $10$ (B) $-8$

(C) $-10$ (D) $8$

**Solution:(Correct Answer:A)**

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

$A^2 = \begin{bmatrix} x & 1 \\ 1 & 0 \end{bmatrix}\begin{bmatrix} x & 1 \\ 1 & 0 \end{bmatrix} = \begin{bmatrix} x^2+1 & x \\ x & 1 \end{bmatrix}$

$A^4 = \begin{bmatrix} x^2+1 & x \\ x & 1 \end{bmatrix}\begin{bmatrix} x^2+1 & x \\ x & 1 \end{bmatrix}$

$= \begin{bmatrix} \left(x^2+1\right)^2 + x^2 & x\left(x^2+1\right) + x \\ x\left(x^2+1\right) + x & x^2+1 \end{bmatrix}$

$a_{11} = \left(x^2+1\right)^2 + x^2 = 109$

$\Rightarrow x = \pm 3$

$a_{22} = x^2 + 1 = 10$

(15) Let $f(x)=\begin{vmatrix} x^3 & \sin x & \cos x \\ 6 & -1 & 0 \\ p & p^2 & p^3 \end{vmatrix}$, where $p$ is a constant.
Then $\frac{d^3}{dx^3}\{f(x)\}$ at $x=0$ is [IIT 1997]

(A) $p$ (B) $p+p^2$

(C) $p+p^3$ **(D)** Independent of $p$

**Solution:(Correct Answer:D)**

(d) $f'''(x)=\begin{vmatrix} \frac{d^3}{dx^3}x^3 & \frac{d^3}{dx^3}\sin x & \frac{d^3}{dx^3}\cos x \\ 6 & -1 & 0 \\ p & p^2 & p^3 \end{vmatrix}=$
$\begin{vmatrix} 6 & -\cos x & \sin x \\ 6 & -1 & 0 \\ p & p^2 & p^3 \end{vmatrix}$
$\therefore f'''(0)=\begin{vmatrix} 6 & -1 & 0 \\ 6 & -1 & 0 \\ p & p^2 & p^3 \end{vmatrix}=0,$
which is independent of $p$.

(16) If the system of linear equations $2x+y-z=7$;
$x-3y+2z=1$; $x+4y+\delta z=k$, where $\delta, k\in R$ has infinitely many solutions, then $\delta+k$ is equal to [JEE MAIN 2022]

(A) $-3$ **(B)** $3$

(C) $6$ (D) $9$

**Solution:(Correct Answer:B)**

$\begin{vmatrix} 2 & 1 & -1 \\ 1 & -3 & 2 \\ 1 & 4 & \delta \end{vmatrix}=0$
$\Rightarrow \delta=-3$
And $\begin{vmatrix} 7 & 1 & -1 \\ 1 & -3 & 2 \\ K & 4 & -3 \end{vmatrix}=0\Rightarrow K=6$
$\Rightarrow \delta+K=3$
Alternate
$2x+y-z=7\ldots(1)$
$x-3y+2z=1\ldots(2)$
$x+4y+\delta z=k\ldots(3)$
Equation $(2)+(3)$
We get $2x+y+(2+\delta)z=1+K\ldots(4)$
For infinitely solution
Form equation $(1)$ and $(4)$
$2+\delta=-1\Rightarrow\delta=-3$
$1+k=7\Rightarrow k=6$
$\delta+k=3$

(17) $\begin{vmatrix} 1+\sin^2\theta & \sin^2\theta & \sin^2\theta \\ \cos^2\theta & 1+\cos^2\theta & \cos^2\theta \\ 4\sin 4\theta & 4\sin 4\theta & 1+4\sin 4\theta \end{vmatrix}=0$ then $\sin 4\theta$ equal to

(A) $1/2$ (B) $1$

**(C)** $-1/2$ (D) $-1$

**Solution:(Correct Answer:C)**

(c) $\begin{vmatrix} 1+\sin^2\theta & \sin^2\theta & \sin^2\theta \\ \cos^2\theta & 1+\cos^2\theta & \cos^2\theta \\ 4\sin 4\theta & 4\sin 4\theta & 1+4\sin 4\theta \end{vmatrix}=0$
Using $C_1\to C_1-C_2, C_2\to C_2-C_3$
$==>\begin{vmatrix} 1 & 0 & \sin^2\theta \\ -1 & 1 & \cos^2\theta \\ 0 & -1 & 1+4\sin 4\theta \end{vmatrix}=0$
$==>2(1+2\sin 4\theta)=0\Rightarrow\sin 4\theta=\frac{-1}{2}.$

(18) If $2X-\begin{bmatrix} 1 & 2 \\ 7 & 4 \end{bmatrix}=\begin{bmatrix} 3 & 2 \\ 0 & -2 \end{bmatrix}$, then $X$ is equal to

(A) $\begin{bmatrix} 2 & 2 \\ 7 & 4 \end{bmatrix}$ (B) $\begin{bmatrix} 1 & 2 \\ 7/2 & 2 \end{bmatrix}$

**(C)** $\begin{bmatrix} 2 & 2 \\ 7/2 & 1 \end{bmatrix}$ (D) None of these

**Solution:(Correct Answer:C)**

(c) $2X-\begin{bmatrix} 1 & 2 \\ 7 & 4 \end{bmatrix}=\begin{bmatrix} 3 & 2 \\ 0 & -2 \end{bmatrix}$
$==>2X=\begin{bmatrix} 3 & 2 \\ 0 & -2 \end{bmatrix}+\begin{bmatrix} 1 & 2 \\ 7 & 4 \end{bmatrix}$
$==>2X=\begin{bmatrix} 4 & 4 \\ 7 & 2 \end{bmatrix}$
$==>X=\begin{bmatrix} 2 & 2 \\ 7/2 & 1 \end{bmatrix}.$

(19) Find the value of $\cot\left(\tan^{-1}a+\cot^{-1}a\right)$

(A) $\frac{\pi}{3}$ (B) $\frac{\pi}{4}$

**(C)** $0$ (D) $\frac{\pi}{2}$

**Solution:(Correct Answer:C)**

$\cot\left(\tan^{-1}a+\cot^{-1}a\right)$
$=\cot\left(\frac{\pi}{2}\right)$
$=0$

(20) If $D_r=\begin{vmatrix} 2^{r-1} & 2.3^{r-1} & 4.5^{r-1} \\ x & y & z \\ 2^n-1 & 3^n-1 & 5^n-1 \end{vmatrix}$, then the value of $\sum_{r=1}^{n}D_r=$

(A) $1$ (B) $-1$

**(C)** $0$ (D) None of these

**Solution:(Correct Answer:C)**

(c) $D_r=\begin{vmatrix} 2^{r-1} & 2.3^{r-1} & 4.5^{r-1} \\ x & y & z \\ 2^n-1 & 3^n-1 & 5^n-1 \end{vmatrix}$
$\Rightarrow\sum_{r=1}^{n}D_r=\begin{vmatrix} \sum_{r=1}^{n}2^{r-1} & \sum_{r=1}^{n}2.3^{r-1} & \sum_{r=1}^{n}4.5^{r-1} \\ x & y & z \\ 2^n-1 & 3^n-1 & 5^n-1 \end{vmatrix}$
$\Rightarrow\sum_{r=1}^{n}D_r=\begin{vmatrix} 2^n-1 & 3^n-1 & 5^n-1 \\ x & y & z \\ 2^n-1 & 3^n-1 & 5^n-1 \end{vmatrix}$
Since we know that $\sum_{r=1}^{n}2^{r-1}=\frac{2^n-1}{2-1}=2^n-1,$
$2\sum_{r=1}^{n}3^{r-1}=2\frac{3^n-1}{3-1}=3^n-1$
and $4\sum_{r=1}^{n}5^{r-1}=4\frac{5^n-1}{5-1}=5^n-1$
$\Rightarrow\sum_{r=1}^{n}D_r=0,(\because R_1\equiv R_3).$

## Mathematics - Section B (NUMERIC) (Attempt any 5)

(21) $\begin{vmatrix} 0 & p-q & p-r \\ q-p & 0 & q-r \\ r-p & r-q & 0 \end{vmatrix}=$

**Solution:**

(a) Since determinant of a skew-symmetric matrix of odd order is zero.

(22) Let $A=\begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix}$ and $B=\begin{bmatrix} 9^2 & -10^2 & 11^2 \\ 12^2 & 13^2 & -14^2 \\ -15^2 & 16^2 & 17^2 \end{bmatrix}$, then the value of $A'BA$ is. [JEE MAIN 2022]

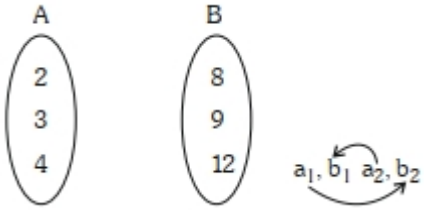
**Solution:**

$$A'BA = \begin{bmatrix} 1 & 1 & 1 \end{bmatrix} \begin{bmatrix} 9^2 & -10^2 & 11^2 \\ 12^2 & 13^2 & -14^2 \\ -15^2 & 16^2 & 17^2 \end{bmatrix} \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix}$$
$$= \begin{bmatrix} 9^2+12^2-15^2 & -10^2+13^2+16^2 & 11^2-14^2+17^2 \end{bmatrix} \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix}$$
$$= \left[9^2+12^2-15^2-10^2+13^2+16^2+11^2-14^2+17^2\right]$$
$$= [539]$$

(23) Let $A = \{2, 3, 4\}$ and $B = \{8, 9, 12\}$. Then the number of elements in the relation
$R = \{((a_1, b_1), (a_2, b_2)) \in (A \times B, A \times B) : a_1$ divides $b_2$ and $a_2$ divides $b_1\}$ is: [JEE MAIN 2023]

**Solution:**

$a_1$ divides $b_2$
Each element has 2 choices
$\Rightarrow 3 \times 2 = 6$
$a_2$ divides $b_1$
Each element has 2 choices
$\Rightarrow 3 \times 2 = 6$
Total $= 6 \times 6 = 36$




(24) Let $A = \{1, 2, 3, \ldots 20\}$. Let $R_1$ and $R_2$ two relation on A such that $R_1 = \{(a, b) : b$ is divisible by $a\}$ $R_2 = \{(a, b) : a$ is an integral multiple of $b\}$. Then, number of elements in $R_1 - R_2$ is equal to_____. [JEE MAIN 2024]

**Solution:**

$n(R_1) = 20 + 10 + 6 + 5 + 4 + 3 + 2 + 2 + 2$
$+2 + \underbrace{1 + \ldots + 1}_{10 \text{ times}}$
$n(R_1) = 66$
$R_1 \cap R_2 = \{(1, 1), (2, 2), \ldots (20, 20)\}$
$n(R_1 \cap R_2) = 20$
$n(R_1 - R_2) = n(R_1) - n(R_1 \cap R_2)$
$= n(R_1) - 20$
$= 66 - 20$
$R_1 - R_2 = 46$ Pair

(25) $2\begin{vmatrix} 1 & 1 & 1 \\ a & b & c \\ a^2-bc & b^2-ac & c^2-ab \end{vmatrix} =$

**Solution:**

(a) We have $2\begin{vmatrix} 1 & 1 & 1 \\ a & b & c \\ a^2-bc & b^2-ac & c^2-ab \end{vmatrix}$
$= 2\begin{vmatrix} 1 & 1 & 1 \\ a & b & c \\ a^2 & b^2 & c^2 \end{vmatrix} - 2\begin{vmatrix} 1 & 1 & 1 \\ a & b & c \\ bc & ac & ab \end{vmatrix}$
$= 2\begin{vmatrix} 1 & 1 & 1 \\ a & b & c \\ a^2 & b^2 & c^2 \end{vmatrix} - \frac{2}{abc}\begin{vmatrix} a & b & c \\ a^2 & b^2 & c^2 \\ abc & abc & abc \end{vmatrix}$
Applying $C_1(a), C_2(b), C_3(c)$
$= 2\begin{vmatrix} 1 & 1 & 1 \\ a & b & c \\ a^2 & b^2 & c^2 \end{vmatrix} - \frac{2}{abc}(abc)\begin{vmatrix} a & b & c \\ a^2 & b^2 & c^2 \\ 1 & 1 & 1 \end{vmatrix} = 0.$

(26) Let a function $f : R \to R$ be defined as
$f(x) = \sin x - e^x$ if $x \leq 0$
$a + [-x]$ if $0 < x < 1$
$2x - b$ if $\geq 1$
where [x] is the greatest integer less than or equal to x. If f is continuous on R, then (a + b) is equal to: [JEE MAIN 2021]

**Solution:**

Continuous at $x = 0$
$f(0^+) = f^- \Rightarrow a - 1 = 0 - e^0$
$\Rightarrow a = 0$
Continuous at x = 1
$f(1^+) = f(1^-)$
$\Rightarrow 2(1) - b = a + (-1)$
$\Rightarrow b = 2 - a + 1 \Rightarrow b = 3$
$\therefore a + b = 3$

(27) Let $S$ be the set of all integer solutions, $(x, y, z)$, of the system of equations
$x - 2y + 5z = 0$
$-2x + 4y + z = 0$
$-7x + 14y + 9z = 0$
such that $15 \leq x^2 + y^2 + z^2 \leq 150$. Then, the number of elements in the set $S$ is equal to [JEE MAIN 2020]

**Solution:**

$\Delta = \begin{vmatrix} 1 & -2 & 5 \\ -2 & 4 & 1 \\ -7 & 14 & 9 \end{vmatrix} = 0$
Let $x = k$
$\Rightarrow$ Put in $(1)$ and $(2)$
$k - 2y + 5z = 0$
$-2k + 4y + z = 0$
$z = 0, y = \frac{k}{2}$
$\therefore$ $x, y, z$ are integer
$\Rightarrow$ $k$ is even integer
Now $x = k, y = \frac{k}{2}, z = 0$ put in condition
$15 \leq k^2 + \left(\frac{k}{2}\right)^2 + 0 \leq 150$
$12 \leq k^2 \leq 120$
$\Rightarrow$ $k = \pm 4, \pm 6, \pm 8, \pm 10$
$\Rightarrow$ Number of element in $S = 8$

(28) If $a, b, c$ be positive real numbers and the value of $\theta = \tan^{-1}\sqrt{\frac{a(a+b+c)}{bc}} + \tan^{-1}\sqrt{\frac{b(a+b+c)}{ca}} + \tan^{-1}\sqrt{\frac{c(a+b+c)}{ab}}$, then $\tan\theta$ is equal to [IIT 1981]

**Solution:**

(a)
$\theta = \tan^{-1}\sqrt{\frac{a(a+b+c)}{bc}} + \tan^{-1}\sqrt{\frac{b(a+b+c)}{ca}} + \tan^{-1}\sqrt{\frac{c(a+b+c)}{ab}}$
Let $s^2 = \frac{a+b+c}{abc}$
Hence $\theta = \tan^{-1}\sqrt{a^2s^2} + \tan^{-1}\sqrt{b^2s^2} + \tan^{-1}\sqrt{c^2s^2}$
$= \tan^{-1}(as) + \tan^{-1}(bs) + \tan^{-1}(cs)$
$= \tan^{-1}\left[\frac{as+bs+cs-abcs^3}{1-abs^2-acs^2-bcs^2}\right]$
Hence $\tan\theta = \left[s\frac{(a+b+c)-abcs^2}{1-(ab+bc+ca)s^2}\right]$
$= \left[\frac{s[(a+b+c)-(a+b+c)]}{1-s^2(ab+bc+ca)}\right] = 0,$
[Since $s^2abc = (a+b+c)$]
Trick : Since it is an identity, so it will be true for any value of $a, b, c$.
Let $a = b = c = 1$, then $\theta = \tan^{-1}\sqrt{3} + \tan^{-1}\sqrt{3}$
$+\tan^{-1}\sqrt{3} = \pi \Rightarrow \tan\theta = 0.$

(29) Let $I$ be an identity matrix of order $2 \times 2$ and $P = \begin{bmatrix} 2 & -1 \\ 5 & -3 \end{bmatrix}$. Then the value of $n \in N$ for which $P^n = 5I - 8P$ is equal to ..... . [JEE MAIN 2021]

**Solution:**

$$P = \begin{bmatrix} 2 & -1 \\ 5 & -3 \end{bmatrix}$$

$$5I - 8P = \begin{bmatrix} 5 & 0 \\ 0 & 5 \end{bmatrix} - \begin{bmatrix} 16 & -8 \\ 40 & -24 \end{bmatrix} = \begin{bmatrix} -11 & 8 \\ -40 & 29 \end{bmatrix}$$

$$P^2 = \begin{bmatrix} -1 & 1 \\ -5 & 4 \end{bmatrix}$$

$$P^3 = \begin{bmatrix} 3 & -2 \\ 10 & -7 \end{bmatrix} \Rightarrow P^6 = \begin{bmatrix} -11 & 8 \\ -40 & 29 \end{bmatrix} = P^n$$

$\Rightarrow n = 6$

(30) Let $f : (0, +\infty) \to R$ and $F(x) = \int_0^x f(t)\,dt$. If $F(x^2) = x^2(1 + x)$, then $f(4)$ equals [IIT 2001]

**Solution:**

(c) $x^2(1 + x) = \int_0^{x^2} f(t)\,dt.$

Differentiating w.r.t. $x$, $2x(1 + x) + x^2 = f(x^2) \cdot 2x$

==> $f(x^2) = 1 + x + \frac{x}{2},\ x > 0$

Putting $x = 2$, $f(4) = 1 + 2 + \frac{2}{2} = 4.$

## Chemistry - Section A (MCQ)

(31) NaCl reacts with conc. $H_2SO_4$ and $K_2Cr_2O_7$ to give reddish fumes $(B)$, which react with NaOH to give yellow solution $(C)$. $(B)$ and $(C)$ respectively are ; [JEE MAIN 2024]

**(A)** $CrO_2Cl_2, Na_2CrO_4$ (B) $Na_2CrO_4, CrO_2Cl_2$

(C) $CrO_2Cl_2, KHSO_4$ (D) $CrO_2Cl_2, Na_2Cr_2O_7$

**Solution:(Correct Answer:A)**

$NaCl +$ conc. $H_2SO_4 + K_2Cr_2O_7$

$\to CrO_2Cl_2[(B)Reddishbrown] + KHSO_4 + NaHSO_4 + H_2O$

$CrO_2Cl_2 + NaOH \to Na_2CrO_4[(C)Yellowcolour] + NaCl + H_2O$

(32) Which of the following lanthanoid ions is diamagnetic ? (At. nos. $Ce = 58, Sm = 62, Eu = 63, Yb = 70$) [NEET 2013]

(A) $Eu^{2+}$ **(B)** $Yb^{2+}$

(C) $Ce^{2+}$ (D) $Sm^{2+}$

**Solution:(Correct Answer:B)**

Lanthanoid ion with no unpaired electron is diamagnetic in nature.

$Ce_{58} = [Xe]4f^2 5d^0 6s^2$

$Ce^{2+} = [Xe]4f^2$ (two unpaired electrons)

$Sm_{62} = [Xe]4f^6 5d^0 6s^2$

$Sm^{2+} = [Xe]4f^6$ (six unpaired electron )

$Eu_{63} = [Xe]4f^7 5d^0 6s^2$

$Eu^{2+} = [Xel]4f^7$ (seven unpaired electron)

$Yb_{70} = [Xe]4f^{14} 5d^0 6s^2$

$Yb^{2+} = [Xe]4f^{14}$ (No unpaired electron)

Because of the absence of unpaired electrons, $Yb^{2+}$ is diamagnetic.

(33) Liquids $A$ and $B$ form an ideal solution [AIEEE 2003]

**(A)** The enthalpy of mixing is zero

(B) The entropy of mixing is zero

(C) The free energy of mixing is zero

(D) The free energy as well as the entropy of mixing are each zero

**Solution:(Correct Answer:A)**

For an ideal solution, we know that:-

$a) V_{mix} = 0$

$b) H_{mix} = 0$

$c) \Delta G_{mix} = -ve$

Final Answer : Hence, option $A$ is correct.

(34) The half life for the decomposition of gaseous compound $A$ is $240\,s$ when the gaseous pressure was $500\,Torr$ initially. When the pressure was $250\,Torr$, the half life was found to be $4.0\,min$. The order of the reaction is..... (Nearest integer) [JEE MAIN 2022]

(A) 4 (B) 3

(C) 2 **(D)** 1

**Solution:(Correct Answer:D)**

$(t_{1/2})_{500\text{ torr}} = 240\,sec = 4\,min.$

$(t_{1/2})_{250\text{ torr}} = 4\,min$

$t_{1/2} \propto a^{1-n}$

As $t_{1/2}$ is independent of initial pressure. Hence, order is $1^{st}$ order.

(35) The number of Faradays $(F)$ required to produce $20\,g$ of calcium from molten $CaCl_2$(Atomic mass of $Ca = 40\,g\,mol^{-1}$) is [NEET 2020]

(A) 4 **(B)** 1

(C) 2 (D) 3

**Solution:(Correct Answer:B)**

$Ca^{+2} + 2e^- \to Ca_{(s)}$

$v.f. = 2$

As per faraday's $1^{st}$ law

Charge passed in faraday $=$ $g$.eq of product

$= \frac{20}{40} \times 2 = 1F$

(36) The emf of a galvanic cell, with electrode potentials of silver $= +0.80\,V$ and that of copper $= +0.34\,V$, is ..... V [AIIMS 1999]

(A) $-1.1$ (B) $+1.1$

**(C)** $+0.46$ (D) $+0.76$

**Solution:(Correct Answer:C)**

(c) $E^o = E^o_{Ag^{2+}/Ag} + E^o_{Cu/Cu^{2+}}$

$= -0.34 + 0.80 = +0.46\,V.$

(37) 1 molal aqueous solution of an electrolyte $A_2B_3$ is 60% ionised. The boiling point of the solution at $1\,atm$ is ..... $K$. (Rounded-off to the nearest integer)

[Given $K_b$ for $(H_2O) = 0.52\,K\,kg\,mol^{-1}$] [JEE MAIN 2021]

(A) 370 (B) 380

**(C)** 375 (D) 385

**Solution:(Correct Answer:C)**

$\Delta T_b = iK_b m$

$= (1 + 4\alpha) \times 0.52 \times 1$

$= 3.4 \times 0.52 \times 1 = 1.768$

$T_b = 1.768 + 313.15 = 374.918K$

$= 375K$

(38) The correct order of $E^o_{M^{2+}/M}$ values with negative sign for the four successive elements $Cr, Mn, Fe$ and $Co$ is [AIEEE 2010]

**(A)** $Mn > Cr > Fe > Co$ (B) $Cr < Fe > Mn > Co$

(C) $Fe > Mn > Cr > Co$ (D) $Cr > Mn > Fe > Co$

**Solution:(Correct Answer:A)**

The value of $E^\circ_{M^{2+}/M}$ for given metal ions are

$E^\circ_{Mn^{2+}/Mn} = -1.18V$

$E^\circ_{Cr^{2+}/Cr} = -0.9V$

$E^\circ_{Fe^{2+}/Fe} = -0.44V$ and

$E^\circ_{Co^{2+}/Co} = -0.28V$

The correct order of $E^\circ_{M^{2+}/M}$ values without considering negative sign would be

$Mn^{2+} > Cr^{2+} > Fe^{2+} > Co^{2+}$

(39) Faraday's laws of electrolysis are related to [IIT 1983]

(A) The atomic number of positive ion

**(B)** The equivalent weight of electrolyte

(C) The atomic number of negative ion

(D) The velocity of positive ion

**Solution:(Correct Answer:B)**

Faraday's first law of elecrolysis :
This law states that 'The amount of a substance deposited or dissolved at an electrode is directly proportional to the charge passing through the electrolytes.
Faraday's second law: This law states that the amounts of different substances deposited at electrodes by passage of the same quantity of electricity are proportional to their chemical equivalent($E$).

(40) The correct electronic configuration and spin only magnetic moment (BM) of $Gd^{3+}(Z=64)$, respectively, are [JEE MAIN 2020]

(A) $[Xe]5f^7$ and $8.9$ **(B)** $[Xe]4f^7$ and $7.9$

(C) $[Xe]5f^7$ and $7.9$ (D) $[Xe]4f^7$ and $8.9$

**Solution:(Correct Answer:B)**

Electronic configuration of $Gd^{3+}$ is
$64Gd^{3+}=[Xe]4f^7$
$Gd^{3+}$ having 7 unpaired electrons.
Magnetic moment $(\mu)=\sqrt{n(n+2)}\ B.M.$
$\mu=\sqrt{7(7+2)}B\cdot M$
$=7.9B.M$
$n\Rightarrow$ Number of unpaired electrons.


(41) When $7.1\,gm\ Na_2SO_4$ (molecular mass $142$) dissolves in $100\,ml\ H_2O$, the molarity of the solution is ..... $M$ [AIPMT 1991]

(A) $2.0$ (B) $1.0$

**(C)** $0.5$ (D) $0.05$

**Solution:(Correct Answer:C)**

(c) Molarity $=\frac{w\times1000}{ml\text{wt.}\times\text{Volume}ml.}=\frac{7.1\times1000}{142\times100}=0.5\,M.$

(42) If the conductivity of mercury at $0^\circ$ C is $1.07\times10^6$ S m$^{-1}$ and the resistance of a cell containing mercury is $0.243\,\Omega$, then the cell constant of the cell is x $\times\ 10^4$ m$^{-1}$. The value of x is ..... .(Nearest integer) [JEE MAIN 2021]

(A) $260$ (B) $39$

**(C)** $26$ (D) $13$

**Solution:(Correct Answer:C)**

$k=1.07\times10^6\ Sm^{-1},\quad R=0.243\,\Omega$
$G=\frac{1}{R}=\frac{1}{0.243}\,\Omega^{-1}$
$k=G\times G^*$
$G^*=\frac{k}{G}=\frac{1.07\times10^6}{\frac{1}{0.243}}\simeq26\times10^4\ m^{-1}$

(43) Elevation in boiling point for $1.5$ molal solution of glucose in water is $4\,K$. The depression in freezing point for $4.5$ molal solution of glucose in water is $4\,K$ The ratio of molal elevation constant to molal depression constant $(K_b/K_f)$ is .... [JEE MAIN 2022]

(A) $4$ (B) $1$

(C) $2$ **(D)** $3$

**Solution:(Correct Answer:D)**

$\Delta T_b=i\,K_b\,m$
$\Delta T_f=i\,K_i\,m$
$\frac{4}{4}=\frac{K_b1.5}{K_f4.5}$
$\frac{K_b}{K_f}=3$

(44) A reduction in atomic size with increase in atomic number is a characteristic of elements of [AIEEE 2003]

(A) High atomic masses (B) $d-$ block

**(C)** $f-$ block (D) Radioactive series

**Solution:(Correct Answer:C)**

(c)Lanthanide contraction takes place.

(45) What will be the $emf$ for the given cell $Pt|H_2(P_1)|H^+{}_{(aq)}||H_2(P_2)|Pt$ [AIEEE 2002]

(A) $\frac{RT}{f}\log\frac{P_1}{P_2}$ **(B)** $\frac{RT}{2f}\log\frac{P_1}{P_2}$

(C) $\frac{RT}{f}\log\frac{P_2}{P_1}$ (D) None of these

**Solution:(Correct Answer:B)**

(b)Anodic reaction : $H_2(P_1)\rightarrow2H^+$
Cathodic reaction : $2H^+\rightarrow H_2(P_2)$
$E_{cathode}=-\frac{RT}{2F}\ln\frac{P_2}{[H^+]^2}$ ;$E_{\text{anode}}=-\frac{RT}{2F}\ln\frac{[H^+]^2}{P_1}$
$E_{\text{inf}}=E_{anode}+E_{cathode}=-\frac{RT}{2F}\ln\frac{(H^+)^2}{P_1}-\frac{RT}{2F}\ln\frac{P_2}{(H^+)^2}$
$=-\frac{RT}{2F}\ln\frac{P_2}{P_1}=\frac{RT}{2F}\ln\frac{P_1}{P_2}.$

(46) A solution of two miscible liquids showing negative deviation from Raoult's law will have : [JEE MAIN 2024]

(A) increased vapour pressure, increased boiling point

(B) increased vapour pressure, decreased boiling point

(C) decreased vapour pressure, decreased boiling point

**(D)** decreased vapour pressure, increased boiling point

**Solution:(Correct Answer:D)**

Solution with negative deviation has
$P_T<P_{A^0}X_A+P_{B^0}X_B$
$P_A<P_{A^0}X_A$
$P_B<P_{B^0}X_B$
If vapour pressure decreases so boiling point increases.

(47) A $0.0020\,m$ aqueous solution of an ionic compound $[Co(NH_3)_5(NO_2)]Cl$ freezes at $-0.00732\,^oC$. Number of moles of ions which $1\,mol$ of ionic compound produces on being dissolved in water will be $(K_f=-1.86\,^o\,C/m)$ [AIPMT 2009]

(A) $3$ (B) $4$

(C) $1$ **(D)** $2$

**Solution:(Correct Answer:D)**

$\Delta T_f=ik_f\cdot m$
$i=\frac{\Delta T_f}{k_f\cdot m}$
$=\frac{0.00732}{1.86\times0.002}=\frac{0.00732}{0.00372}$
$i=2$
Compound will be $[\text{Co}(\text{NH}_3)_5]\,\text{NO}_5\text{NO}_2]\,\text{Cl}$
Total possible ions $=2$

(48) Given below are two statements: one is labelled as Assertion $(A)$ and the other is labelled as Reason $(R)$.
Assertion $(A)$ : In aqueous solutions $Cr^{2+}$ is reducing while $Mn^{3+}$ is oxidising in nature.
Reason $(R)$ : Extra stability to half filled electronic

configuration is observed than incompletely filled electronic configuration.
In the light of the above statement, choose the most appropriate answer from the options given below: [JEE MAIN 2024]

**(A)** Both $(A)$ and $(R)$ are true and $(R)$ is the correct explanation of $(A)$

(B) Both $(A)$ and $(R)$ are true but $(R)$ is not the correct explanation of $(A)$

(C) $(A)$ is false but $(R)$ is true

(D) $(A)$ is true but $(R)$ is false

**Solution:(Correct Answer:A)**

$Cr^{2+}$ is reducing as it configuration changes from $d^4$ to $d^3$ due to formation of $Cr^{3+}$, which has half filled $t_{2g}$ level, on other hand, the change $Mn^{3+}$ to $Mn^{2+}$ result half filled $d^3$ configuration which has extra stability.

(49) The efficiency of a fuel cell is given by [AIPMT 2007]

(A) $\Delta G/\Delta S$ **(B)** $\Delta G/\Delta H$

(C) $\Delta S/\Delta G$ (D) $\Delta H/\Delta G$

**Solution:(Correct Answer:B)**

Efficiency of a fuel cell $(\phi) = \frac{\Delta G}{\Delta H} \times 100$
Fuel cells are expected to have an efficiency of $100\%$

(50) In chromyl chloride, the number of d-electrons present on chromium is same as in (Given at no. of $Ti: 22, V: 23, Cr: 24, Mn: 25, Fe: 26$) [JEE MAIN 2023]

(A) $Ti\,(III)$ (B) $Fe\,(III)$

(C) $V\,(IV)$ **(D)** $Mn\,(VII)$

**Solution:(Correct Answer:D)**

In $CrO_2Cl_2$ oxidation state of $Cr$ is +6
$Cr(VI) = [Ar]^{18}3d^0$
$Mn(VII) = [Ar]^{18}3d^0$
$Fe(III) = [Ar]^{18}3d^5$
$Ti(III) = [Ar]^{18}3d^1$
$V(IV) = [Ar]^{18}3d^1$
Hence $Cr$ (VI) and $Mn$ (VII) have same $d^0$ configuration.

## Chemistry - Section B (NUMERIC) (Attempt any 5)

(51) The correct option for the value of vapour pressure of a solution at $45°C$ with benzene to octane in molar ratio $3:2$ is ..... mm of Hg
[At $45°C$ vapour pressure of benzene is $280$ mm Hg and that of octane is $420$ mm Hg. Assume Ideal gas] [NEET 2021]

**Solution:**

$P_s = P_A^O x_A + P_B^O x_B$
$= 280 \times \frac{3}{5} + 420 \times \frac{2}{5}$
$= 56 \times 3 + 84 \times 2$
$= 168 + 168$
$= 336$

(52) When $10$ mL of an aqueous solution of $KMnO_4$ was titrated in acidic medium, equal volume of $0.1$ M of an aqueous solution of ferrous sulphate was required for complete discharge of colour. The strength of $KMnO_4$ in grams per litre is ..... $\times 10^{-2}$. (Nearest integer)
Atomic mass of K $= 39$, Mn $= 55$, O $= 16$] [JEE MAIN 2021]

**Solution:**

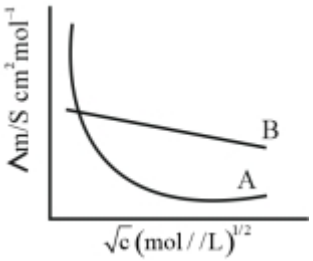
Let molarity of $KMnO_4 = x$
$KMnO_4 + FeSO_4 \rightarrow Fe_2(SO_4)_3 + Mn^{2+}$
$n = 5 \quad n = 1$
(Equivalents of $KMnO_4$ reacted ) = (Equivalents of $FeSO_4$ reacted )
$\Rightarrow (5 \times x \times 10\,ml) = 1 \times 0.1 \times 10\,ml$
$\Rightarrow x = 0.02\,M$
Molar mass of $KMnO_4 = 158\,gm/mol$
$\Rightarrow$ Strength $= (x \times 158) = 3.16\ g/\ell$

(53) A $KCl$ solution of conductivity $0.14\,Sm^{-1}$ shows a resistance of $4.19\,\Omega$ in a conductivity cell. If the same cell is filled with an $HCl$ solution, the resistance drops to $1.03\,\Omega$. The conductivity of the $HCl$ solution is ..... $\times 10^{-2}\,Sm^{-1}$. (Round off to the Nearest Integer). [JEE MAIN 2021]

**Solution:**

$\kappa = \frac{1}{R} \cdot G^*$
For same conductivity cell, $G^*$ is constant and hence $\kappa.R. =$ constant.
$\therefore 0.14 \times 4.19 = \kappa \times 1.03$
or,$\kappa$ of HCl solution $= \frac{0.14 \times 4.19}{1.03}$
$= 0.5695\,Sm^{-1}$
$= 56.95 \times 10^{-2} Sm^{-1} \approx 57 \times 10^{-2}\,Sm^{-1}$

(54) Following figure shows dependence of molar conductance of two electrolytes on concentration. $\Lambda\overset{0}{m}$ is the limiting molar conductivity.The number of Incorrect statement(s) from the following is .....
$(A)$ $\Lambda\overset{0}{m}$ for electrolyte $A$ is obtained by extrapolation
$(B)$ For electrolyte B, vx $\Lambda m$ vs $\sqrt{c}$ graph is a straight line with intercept equal to $\Lambda\overset{0}{m}$
$(C)$ At infinite dilution, the value of degree of dissociation approach zero for electrolyte $B$.
$(D)$ $\Lambda\overset{0}{m}$ for any electrolyte $A$ or $B$ can be calculated using $\lambda°$ for individual ions. [JEE MAIN 2023]




**Solution:**

Statement $(A)$ and Statement $(C)$ are incorrect

(55) The number of $4f$ electrons in the ground state electronic configuration of $Gd^{2+}$ is ..... .
[Atomic number of Gd $= 64$ ] [JEE MAIN 2021]

**Solution:**

The electronic configuration of
$_{64}Gd$ : $[Xe]4f^7 5\,d^1 6\,s^2$
So the electronic configuration of
$_{64}Gd^{2+}$ : $[Xe]4f^7 5\,d^1 6\,s^0$
$i.e.$ the number of $4f$ electrons in the ground state electronic configuration of $Gd^{2+}$ is $7$

(56) $r = k[A]$ for a reaction, $50\%$ of A is decomposed in$120$ minutes. The time taken for $90\%$ decomposition of A is..... minutes. [JEE MAIN 2024]

**Solution:**

$r = k[A]$

So, , rder of reaction $= 1$

$t_{1/2} = 120$ min

For 90% completion of reactio

$\Rightarrow k = \frac{2.303}{t} \log\left(\frac{a}{a-x}\right)$

$\Rightarrow \frac{0.693}{t_{1/2}} = \frac{2.303}{t} \log \frac{100}{10}$

$\therefore t = 399$ min.

(57) The potential for the given half cell at 298 K is $(-)$

$(-) \ldots\ldots\ldots\ldots \times 10^{-2}$ V.

$2H^{+}_{(aq)} + 2e^{-} \rightarrow H_2(g)$

$[H^+] = 1M, P_{H_2} = 2$ atm

(Given: $2.303RT/F = 0.06$ V, $\log 2 = 0.3$ ) [JEE MAIN 2024]

**Solution:**

$E = E^0_{H^+/H_2} - \frac{0.06}{2} \log \frac{P_{H_2}}{[H^+]^2}$

$E = 0.00 - \frac{0.06}{2} \log \frac{2}{[1]^2}$

$E = -0.03 \times 0.3 = -0.9 \times 10^{-2}$ V

(58) The electrode potential of the following half cell at $298\,K$

$X\left|X^{2+}(0.001M)\right\|Y^{2+}(0.01M)\left|Y\right.$

is ..... $\times 10^{-2} V$ (Nearest integer).

Given: $E^0_{x^{2+}|x} = -2.36\,V$

$E^0_{Y^{3+}|Y} = +0.36\,V$

$\frac{2.303\,RT}{F} = 0.06\,V$ [JEE MAIN 2023]

**Solution:**

$X + Y^{2+} \rightarrow Y + X^{2+}$

$E^0_{Cell} = 0.36 - (-2.36) = 2.72\,V$

$E_{Cell} = 2.72 - \frac{0.06}{2} \log \frac{0.001}{0.01}$

$= 2.72 + 0.03 = 2.75\,V$

$= 275 \times 10^{-2}\,V$

(59) The vapour pressures of two volatile liquids $A$ and $B$ at $25°C$ are $50\,Torr$ and $100\,Torr$, respectively. If the liquid mixture contains $0.3$ mole fraction of $A$, then the mole fraction of liquid $B$ in the vapour phase is $\frac{x}{17}$. The value of $x$ is ... [JEE MAIN 2022]

**Solution:**

$\frac{y_B}{1-y_B} = \frac{P^\circ_B}{P^\circ_A} \frac{X_B}{1-X_B}$

$\Rightarrow \frac{y_B}{1-y_B} = \frac{100}{50}\left[\frac{0.7}{0.3}\right] = \frac{14}{3}$

$\Rightarrow y_B = \frac{14}{17}$

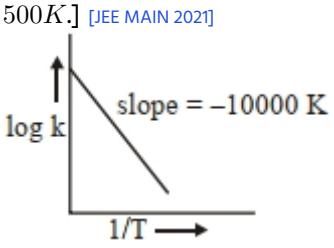
Ans. 14

(60) For the reaction, $aA + bB \rightarrow cC + dD$, the plot of log $k$ vs $\frac{1}{T}$ is given below

The temperature at which the rate constant of the reaction is $10^{-4}s^{-1}$ is ..... $K$.

(Rounded-off to the nearest integer)

[Given: The rate constant of the reaction is $10^{-5}s^{-1}$ at $500K$.] [JEE MAIN 2021]




**Solution:**

$\log K = \log A - \frac{Ea}{2.303RT}$

$|\text{Slope}| = \frac{Ea}{2.303R} = 10,000$

$\log\left(\frac{K_2}{K_1}\right) = \frac{Ea}{2.303R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$

$\log\left(\frac{10^{-4}}{10^{-5}}\right) = 10,000\left[\frac{1}{500} - \frac{1}{T_2}\right]$

$T_2 = 526.31 \simeq 526K$

Hence answer is $(526)$

## Physics - Section A (MCQ)

(61) A galvanometer, whose resistance is $50\,ohm$, has 25 divisions in it. When a current of $4 \times 10^{-4}\,A$ passes through it, its needle (pointer) deflects by one division. To use this galvanometer as a voltmeter of range $2.5\,V$, it should be connected to a resistance of.....$ohm$ [JEE MAIN 2019]

(A) 250 **(B)** 200

(C) 6200 (D) 6250

**Solution:(Correct Answer:B)**

$V_o = i_{g_0}(R_G + R)$

$i_{g_0} = 4 \times 10^{-4} \times 25 = 10^{-2}$ A

$V_0 = 2.5$ V

$R_0 + R = \frac{V_0}{i_0} = \frac{2.5}{10^{-2}} = 250$

$\Rightarrow \quad R = 200\,\Omega$

(62) $A$. The drift velocity of electrons decreases with the increase in the temperature of conductor.

$B$. The drift velocity is inversely proportional to the area of cross-section of given conductor.

$C$. The drift velocity does not depend on the applied potential difference to the conductor.

$D$. The drift velocity of electron is inversely proportional to the length of the conductor.

$E$. The drift velocity increases with the increase in the temperature of conductor.

Choose the correct answer from the options given below:

[JEE MAIN 2022]

(A) $A$ and $B$ only

**(B)** $A$ and $D$ only

(C) $B$ and $E$ only

(D) $B$ and $C$ only

**Solution:(Correct Answer:B)**

Drift velocity $= \left(\frac{e\tau}{m}\right)E$

$v_d = \left(\frac{e\tau}{m}\right)\left(\frac{\Delta V}{\ell}\right)$

$\Delta V =$ Potential difference applied across the wire

As temperature increases, relaxation time decreases, hence $V_d$ decreases.

As per formula, $V_d \propto \frac{1}{\ell}$

$v_d = \frac{I}{neA}$, as it is not mentioned that current is at steady state neither it is mentioned that $n$ is constant for given conductor. So it can't be said that $v_d$ is inversely proportional to $A$.

$I = neAv_d = \frac{V}{R} = \frac{V}{\rho\ell}A$

$v_d = \frac{V}{\rho\ell\, ne} \quad \left(E = \frac{V}{\ell}\right)$

$v_d = \frac{eE\tau}{m}$

$\tau$ decrease with temperature increase.

First and fourth statements are correct.

(63) The number density of free electrons in copper is nearly $8 \times 10^{28}\,m^{-3}$.$A$ copper wire has its area of cross section $= 2 \times 10^{-6}\,m^2$ and is carrying a current of $3.2\,A$. The drift speed of the electrons is ..... $\times 10^{-6}\,ms^{-1}$. [JEE MAIN 2023]

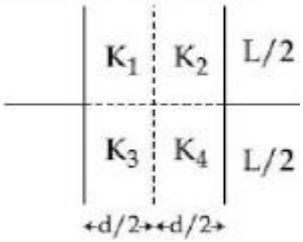
**(A)** 125 (B) 124

(C) 123 (D) 122

**Solution:(Correct Answer:A)**

$n = 8 \times 10^{28}\, m^{-3}$
Area $= 2 \times 10^{-6}\, m^2$
$I = 3.2\, A$
$I = neAv_d$
$V_d = \frac{I}{neA} = 125 \times 10^{-6}\, m/s$

(64) A parallel palate capacitor with square plates is filled with four dielectrics of dielectric constants $K_1, K_2, K_3, K_4$ arranged as shown in the figure. The effective dielectric constant $K$ will be [JEE MAIN 2019]



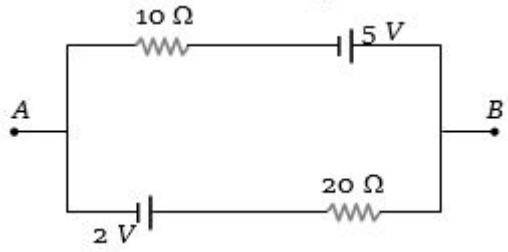

**(A)** $K = \frac{(K_1+K_3)(K_2+K_4)}{K_1+K_2+K_3+K_4}$ (B) $K = \frac{(K_1+K_2)(K_3+K_4)}{2(K_1+K_2+K_3+K_4)}$

(C) $K = \frac{(K_1+K_2)(K_3+K_4)}{K_1+K_2+K_3+K_4}$ (D) $K = \frac{(K_1+K_4)(K_2+K_3)}{2(K_1+K_2+K_3+K_4)}$

**Solution:(Correct Answer:A)**

$C_1 = \frac{\varepsilon_0 K_1 \frac{L^2}{2}}{\frac{d}{2}} + \frac{\varepsilon_0 K_3 \frac{L^2}{2}}{\left(\frac{d}{2}\right)} = \frac{\varepsilon_0 L^2}{d}(K_1 + K_3)$
$C_2 = \frac{\varepsilon_0 K_2 \frac{L^2}{2}}{\frac{d}{2}} + \frac{\varepsilon_0 K_4 \frac{L^2}{2}}{\frac{d}{2}} = \frac{\varepsilon_0 L^2}{d}(K_2 + K_4)$
$\therefore \quad \frac{1}{c} = \frac{1}{c_1} + \frac{1}{c_2}$
$\Rightarrow \quad \frac{d}{\varepsilon_0 KL^2} = \frac{d}{\varepsilon_0 L^2 (K_1+K_3)} + \frac{d}{\varepsilon_0 L^2 (K_2+K_4)}$

(65) The current in the given circuit is ..... $A$ [AIIMS 2000]

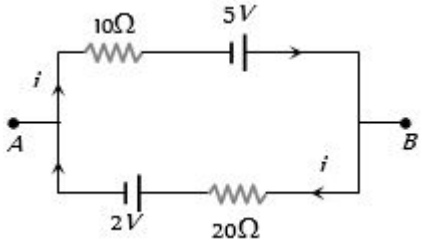



**(A)** $0.1$ (B) $0.2$

(C) $0.3$ (D) $0.4$

**Solution:(Correct Answer:A)**

Applying Kirchoff's voltage law in the loop
$-10i + 5 - 20i - 2 = 0 \Rightarrow i = 0.1\, A$




(66) If two charges $q_1$ and $q_2$ are separated with distance '$d$' and placed in a medium of dielectric constant $K$. What will be the equivalent distance between charges in air for the same electrostatic force? [JEE MAIN 2023]

**(A)** $d\sqrt{k}$ (B) $k\sqrt{d}$

(C) $1.5d\sqrt{k}$ (D) $2d\sqrt{k}$

**Solution:(Correct Answer:A)**

$F = \frac{1}{(4\pi\varepsilon_0)} \frac{q_1 q_2}{kd^2}$ ( in medium )
$F_{\text{Air}} = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{d'^2}$
$F = F_{Air}$
$\frac{q_1 q_2}{4\pi\varepsilon_0 kd^2} = \frac{q_1 q_2}{4\pi\varepsilon_0 d'^2}$
$d' = d\sqrt{k}$

(67) Two long current carrying conductors are placed parallel to each other at a distance of $8\, cm$ between them. The magnitude of magnetic field produced at mid-point between the two conductors due to current flowing in them is $300\, \mu T$. The equal current flowing in the two conductors is ..... [JEE MAIN 2022]

(A) $30\, A$ in the same direction

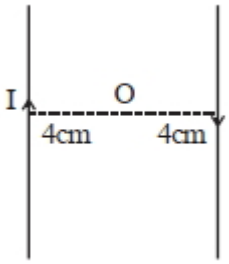
**(B)** $30\, A$ in the opposite direction

(C) $60\, A$ in the opposite direction

(D) $300\, A$ in the opposite direction

**Solution:(Correct Answer:B)**

$B$ at $O = 2\frac{\mu_0 I}{2\pi r}$
$\frac{2\times 4\pi\times 10^{-7} I}{2\pi 4\times 10^{-2}} = 3 \times 10^{-4} T$
$I = 30\, A$ in opp. direction




(68) In a spherical condenser radius of the outer sphere is $R$. The different in the radii of outer and inner sphere in $x$. Its capacity is proportional to

(A) $\frac{xR}{(R-x)}$ (B) $\frac{x(R-x)}{r}$

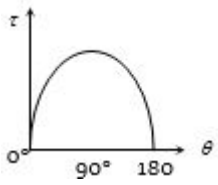
**(C)** $\frac{R(R-x)}{x}$ (D) $\frac{R}{x}$

**Solution:(Correct Answer:C)**

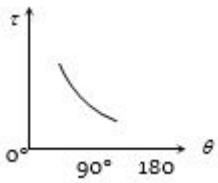
(c) $C \propto \frac{ab}{b-a}; a = R - x, b = R$
$C \propto \frac{R(R-x)}{x}$

(69) The $(\tau - \theta)$ graph for a coil is

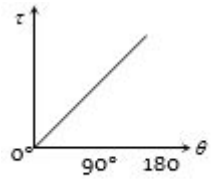
**(A)**



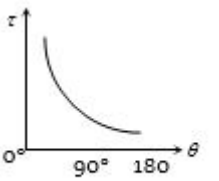

(B)




(C)




(D)




**Solution:(Correct Answer:A)**

(a) $\tau = NBiA \sin\theta$ so the graph between $\tau$ and $\theta$ is a sinusoidal graph.

(70) A coaxial cable consists of an inner wire of radius '$a$' surrounded by an outer shell of inner and outer radii '$b$' and '$c$' respectively. The inner wire carries an electric current is, which is distributed uniformly across cross-sectional area. The outer shell carries an equal current in opposite direction

and distributed uniformly. What will be the ratio of the magnetic field at a distance $x$ from the axis when $(i)\ x < a$ and $(ii)\ a < x < b$ ? [JEE MAIN 2021]

**(A)** $\frac{x^2}{a^2}$ (B) $\frac{a^2}{x^2}$

(C) $\frac{x^2}{b^2-a^2}$ (D) $\frac{b^2-a^2}{x^2}$

**Solution:(Correct Answer:A)**

when $x < a$

$B_1(2\pi x) = \mu_\circ \left(\frac{i_\circ}{\pi a^2}\right) \pi x^2$

$B(2\pi x) = \frac{\mu_\circ i_\circ x^2}{a^2}$

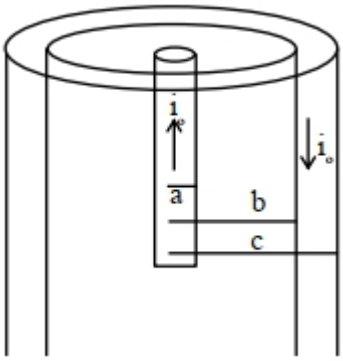
$B_1 = \frac{\mu_\circ i_\circ x}{2\pi a^2} ...(1)$

when $a < x < b$

$B_2(2\pi x) = \mu_0 i_0$

$B_2 = \frac{\mu_\circ i_\circ}{2\pi x} ...(2)$

$\frac{B_1}{B_2} = \frac{\mu_\circ i_\circ \frac{x}{2\pi a^2}}{\frac{\mu_\circ i_\circ}{2\pi x}} = \frac{x^2}{a^2}$




(71) A coil of one turn is made of a wire of certain length and then from the same length a coil of two turns is made. If the same current is passed in both the cases, then the ratio of the magnetic inductions at their centres will be [AIPMT 1998]

(A) $4:1$ **(B)** $1:4$

(C) $2:1$ (D) $2:1$

**Solution:(Correct Answer:B)**

Magnetic field at the centre of the coil, $B = \frac{\mu_0}{2\pi}\frac{NI}{a}$

Let $l$ be the length of the wire, then

$B_1 = \frac{\mu_0}{2\pi} \cdot \frac{1\times I}{l/2\pi} = \frac{\mu_0 I}{l}$

and $B_2 = \frac{\mu_0}{2\pi} \cdot \frac{2\times I}{l/4\pi} = \frac{4\mu_0 I}{l}$

Therefore, $\frac{B_1}{B_2} = \frac{1}{4}$

or, $B_1 : B_2 = 1:4$

(72) A particle of mass $m$ and charge $q$ moves with a constant velocity $v$ along the positive $x$ direction. It enters a region containing a uniform magnetic field $B$ directed along the negative $z$ direction, extending from $x = a$ to $x = b$. The minimum value of $v$ required so that the particle can just enter the region $x > b$ is [IIT 2002]

(A) $qb\,B/m$ **(B)** $q(b-a)B/m$

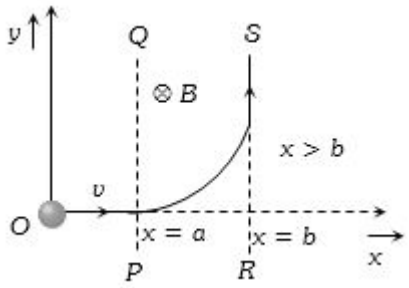
(C) $qa\,B/m$ (D) $q(b+a)B/2m$

**Solution:(Correct Answer:B)**

(b) In the figure, the $z$-axis points out of the paper, and the magnetic field is directed into the paper, existing in the region between $PQ$ and $RS$. The particle moves in a circular path of radius $r$ in the magnetic field. It can just enter the region $x > b$ for $r \geq (b-a)$

Now, $r = \frac{mv}{qB} \geq (b-a)$

or $v \geq \frac{q(b-a)B}{m} ==> \nu_{\text{min}} = \frac{q(b-a)B}{m}$




(73) There is a uniform electrostatic field in a region. The potential at various points on a small sphere centred at $P$, in the region, is found to vary between in the limits $589.0\,V$ to $589.8\,V$. What is the potential at a point on the sphere whose radius vector makes an angle of $60^o$ with the direction of the field ?.....$V$ [JEE MAIN 2017]

(A) $589.5$ (B) $589.2$

**(C)** $589.4$ (D) $589.6$

**Solution:(Correct Answer:C)**

Potential gradient is given by,

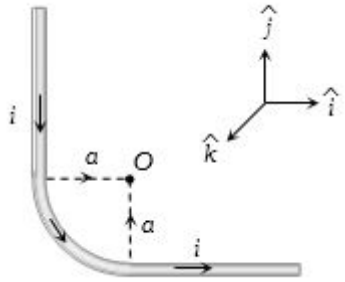
$\Delta V = E.d$

$0.8 = Ed(\text{max})$

$\Delta V = Ed\cos\theta = 0.8 \times \cos 60 = 0.4$

Hence, maximum potential at a point on the sphere $= 589.4\,V$

(74) The unit vectors $\hat{i},\ \hat{j}$ and $\hat{k}$ are as shown below. What will be the magnetic field at $O$ in the following figure




(A) $\frac{\mu_0}{4\pi}\frac{i}{a}\left(2-\frac{\pi}{2}\right)\hat{j}$ (B) $\frac{\mu_0}{4\pi}\frac{i}{a}\left(2+\frac{\pi}{2}\right)\hat{j}$

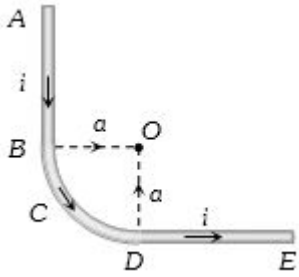
(C) $\frac{\mu_0}{4\pi}\frac{i}{a}\left(2+\frac{\pi}{2}\right)\hat{i}$ **(D)** $\frac{\mu_0}{4\pi}\frac{i}{a}\left(2+\frac{\pi}{2}\right)\hat{k}$

**Solution:(Correct Answer:D)**

(d) The field at $O$ due to $AB$ is $\frac{\mu_0}{4\pi}\cdot\frac{i}{a}\hat{k}$ and that due to $DE$ is also $\frac{\mu_0}{4\pi}\cdot\frac{i}{a}\hat{k}$.

However the field due to $BCD$ is $\frac{\mu_0}{4\pi}\cdot\frac{i}{a}\left(\frac{\pi}{2}\right)\hat{k}$.

Thus the total field at $O$ is $\frac{\mu_0}{4\pi}\cdot\frac{i}{a}\left(2+\frac{\pi}{2}\right)\hat{k}$




(75) A wire $50\,cm$ long and $1\ mm^2$ in cross -section carries a current of $4\ A$ when connected to a $2\ V$ battery. The resistivity of the wire is [AIPMT 1994]

**(A)** $1\times10^{-6}\ \Omega - m$ (B) $4\times10^{-6}\ \Omega - m$

(C) $5\times10^{-7}\ \Omega - m$ (D) $2\times10^{-7}\ \Omega - m$

**Solution:(Correct Answer:A)**

$R = \frac{V}{i} = \rho\frac{l}{A} \Rightarrow \frac{2}{4} = \rho\frac{50\times10^{-2}}{(1\times10^{-3})^2}$

$\Rightarrow \rho = 1 \times 10^{-6}\,\Omega m.$

(76) In a building there are $15$ bulbs of $45$ W, $15$ bulbs of $100$ W, $15$ small fans of $10$ W and $2$ heaters of $1$ kW. The voltage of electric main is $220$ V. The minimum fuse capacity (rated value) of the building will be: ..... $A$ [JEE MAIN 2020]

(A) $10$ (B) $25$

(C) $15$ **(D)** $20$

**Solution:(Correct Answer:D)**

$220\text{I} = \text{P} = 15\times45 + 15\times100 + 15\times10 + 2\times10^3$

$I = \frac{4325}{220} = 19.66$

$\text{I} \simeq 20\text{A}$

(77) $n$ identical cells each of $e.m.f.$ $E$ and internal resistance $r$ are connected in series. An external resistance $R$ is connected in series to this combination. The current through $R$ is

**(A)** $\frac{nE}{R+nr}$ (B) $\frac{nE}{nR+r}$

(C) $\frac{E}{R+nr}$ (D) $\frac{nE}{R+r}$

**Solution:(Correct Answer:A)**

Total $e.m.f. = nE$,

Total resistance $R + nr$

$\Rightarrow i = \frac{nE}{R+nr}$

(78) $3\,A$ of current is flowing in a linear conductor having a length of $40\,cm$. The conductor is placed in a magnetic field of strength $500\,gauss$ and makes an angle of $30°$ with the direction of the field. It experiences a force of magnitude

(A) $3\times10^4\,newton$ (B) $3\times10^2\,newton$

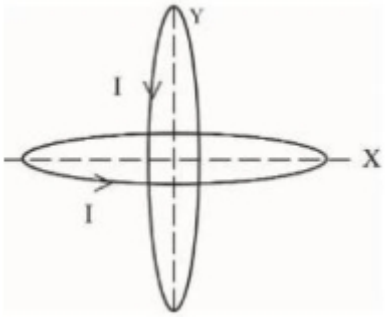
**(C)** $3\times10^{-2}\,newton$ (D) $3\times10^{-4}\,newton$

**Solution:(Correct Answer:C)**

(c) $F = Bil\sin\theta$

$= 500\times10^{-4}\times3\times(40\times10^{-2})\times\frac{1}{2} = 3\times10^{-2}\,N$

(79) Two identical circular wires of radius $20\,cm$ and carrying current $\sqrt{2}\,A$ are placed in perpendicular planes as shown in figure. The net magnetic field at the centre of the circular wire is ..... $\times10^{-8}\,T$. (Take $\pi = 3.14$ ) [JEE MAIN 2023]




(A) $689$ (B) $546$

(C) $487$ **(D)** $628$

**Solution:(Correct Answer:D)**

Magnetic field $B_C$ at center $= \frac{\mu_0 i}{2r}$

$= \frac{4\pi\times10^{-7}}{2\times0.2}\times\sqrt{2}\,T$

Net magnetic field is

$B_C\sqrt{2} = \frac{4\pi\times10^{-7}\times\sqrt{2}}{2\times0.2}\times\sqrt{2}T = 2\pi\times10^{-6}\,T$

$= 200\pi\times10^{-8}\,T$

$= 2\times314\times10^{-8}\,T$

$= 628\times10^{-8}\,T$

(80) A long solenoid of $50\,cm$ length having $100$ turns carries a current of $2.5\,A$. The magnetic field at the centre of the solenoid is ..... $\times10^{-5}\,T$

$(\mu_0 = 4\pi\times10^{-7}\,T\,m\,A^{-1})$ [NEET 2020]

(A) $3.14$ **(B)** $62.8$

(C) $31.4$ (D) $6.28$

**Solution:(Correct Answer:B)**

$B = \mu_0\frac{N}{\ell}I$

$= 4\pi\times10^{-7}\times\frac{100}{(0.5)}\times2.5$

$= 6.28\times10^{-4}T$

## Physics - Section B (NUMERIC) (Attempt any 5)

(81) In a circuit for finding the resistance of a galvanometer by half deflection method, a $6\,V$ battery and a high resistance of $11\,k\Omega$ are used. The figure of merit of the galvanometer $60\,\mu A/$ division. In the absence of shunt resistance, the galvanometer produces a deflection of $\theta = 9$ divisions when current flows in the circuit. The value of the shunt resistance that can cause the deflection of $\theta/2$, is closest to ..... $\Omega$ [JEE MAIN 2018]

**Solution:**

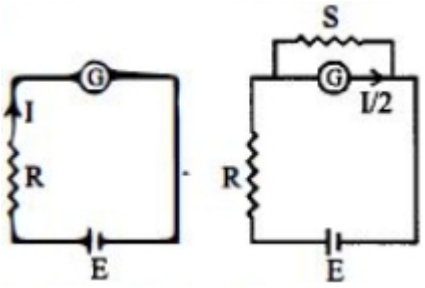
Figure of merit of a galvanometer is the current required to produce a deflection of one division in the galvancmeter i.e., figure of merit $= \frac{I}{\theta}$

$\text{I} = \frac{\varepsilon}{\text{R+G}}$ $\quad \text{G} = \frac{1}{9}\,\text{K}\,\Omega$

$\frac{1}{2} = \frac{\varepsilon}{R+\frac{GS}{G+S}}\times\frac{S}{S+G} \Rightarrow \frac{1}{2} = \frac{\varepsilon S}{R(S+G)+GS}$

$S = \frac{RG\times\frac{1}{2}}{\varepsilon - \frac{(R+G)I}{2}}$

$S = \frac{11\times10^3\times\frac{1}{2}\times10^2\times270\times10^{-6}}{6-\left(\frac{6}{2}\right)} = 110\,\Omega$




(82) Two identical charged particles each having a mass $10\,g$ and charge $2.0\times10^{-7}\,C$ area placed on a horizontal table with a separation of $L$ between then such that they stay in limited equilibrium. If the coefficient of friction between each particle and the table is $0.25$, find the value of $L$.[Use $g = 10\,ms^{-2}$ ].....$cm$ [JEE MAIN 2022]

**Solution:**

$\frac{kq^2}{L^2} = \mu mg \Rightarrow L = \sqrt{\frac{k}{\mu mg}q}$

(83) Suppose a uniformly charged wall provides a uniform electric field of $2\times10^4$ N/C normally. A charged particle of mass $2$ g being suspended through a silk thread of length $20$ cm and remain stayed at a distance of $10$ cm from the wall. Then the charge on the particle will be $\frac{1}{\sqrt{x}}\,\mu$C where x = _____. use $g = 10$ m/s$^2$ ] [JEE MAIN 2024]

**Solution:**

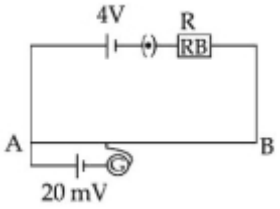
$\sin\theta = \frac{10}{20} = \frac{1}{2}$

$\theta = 30°$

$\tan\theta = \frac{qE}{mg}$

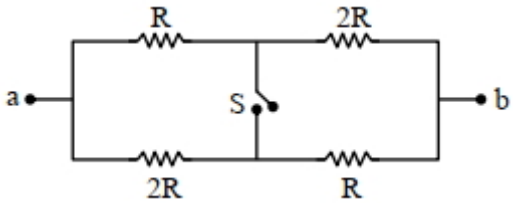
$\tan 30° = \frac{q \times 2 \times 10^4}{1 \times 10^{-3} \times 10}$
$\frac{1}{\sqrt{3}} = q \times 10^6$
$q = \frac{1}{\sqrt{3}} \times 10^{-6} C$
$x = 3$

(84) As shown in the figure, a potentiometer wire of resistance $20\,\Omega$ and length $300\,cm$ is connected with resistance box (R.B.) and a standard cell of emf $4\,V$. For a resistance '$R$' of resistance box introduced into the circuit, the null point for a cell of $20\,mV$ is found to be $60\,cm$. The value of '$R$' is .....$\Omega$ [JEE MAIN 2022]




**Solution:**
$E = \frac{AC}{AB}(V_A - V_B)$
$\therefore 20 \times 10^{-3} = \frac{60}{300} \times \frac{4 \times 20}{R+20}$
$\therefore R = 780\,\Lambda$

(85) The ratio of the equivalent resistance of the network (shown in figure) between the points $a$ and $b$ when switch is open and switch is closed is $x : 8$. The value of $x$ is ..... . [JEE MAIN 2021]




**Solution:**
$R_{eq\ \text{open}} = \frac{3R}{2}$
$R_{eq\ \text{closed}} = 2 \times \frac{R \times 2R}{3R} = \frac{4R}{3}$
$\frac{R_{\text{eq open}}}{R_{\text{eq closed}}} = \frac{3R}{2} \times \frac{3}{4R} = \frac{9}{8}$
$\therefore \quad X = 9$

(86) A hollow cylindrical conductor has length of $3.14\,m$, while its inner and outer diameters are $4\,mm$ and $8\,mm$ respectively. The resistance of the conductor is $n \times 10^{-3}\,\Omega$.If the resistivity of the material is $2.4 \times 10^{-8}\,\Omega\,m$. The value of $n$ is ..... [JEE MAIN 2023]

**Solution:**
$R = \rho\frac{\ell}{A}$, the cross-sectional area is $\pi\left(b^2 - a^2\right)$
$R = \rho\frac{\ell}{\pi(b^2-a^2)} = \frac{2.4 \times 10^{-8} \times 3.14}{3.14 \times (4^2 - 2^2) \times 10^{-6}}$
$= 2 \times 10^{-3}\,\Omega$
$\rightarrow n = 2$

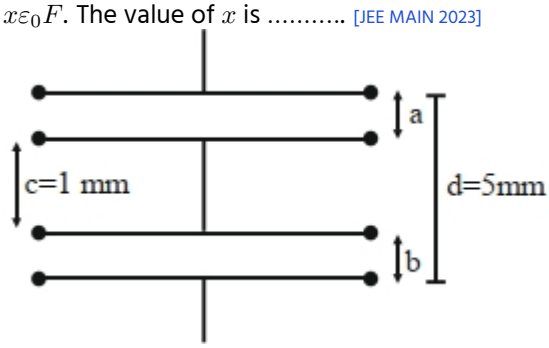
(87) A resistor develops $300\,J$ of thermal energy in $15\,s$, when a current of $2\,A$ is passed through it. If the current increases to $3\,A$, the energy developed in $10\ s$ is.....$J$. [JEE MAIN 2022]

**Solution:**
$H = i^2Rt$
$300 = 2^2 \times R \times 15$
$\Rightarrow R = \frac{300}{60} = 5\Omega$
Now, for $i = 3A, t = 10s, R = 5\Omega$
$H = 3^2 \times 5 \times 10 = 450\,J$

(88) A voltmeter has resistance of $2000\,ohms$ and it can measure upto $2\,V$. If we want to increase its range to $10\,V$, then the required resistance in series will be ..... $\Omega$

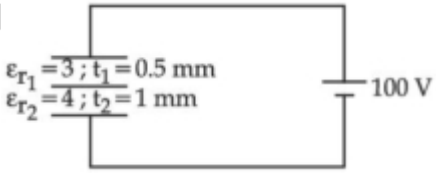
**Solution:**
(d) Here $n = \frac{10}{2} = 5$
$R = (n-1)G = (5-1)2000 = 8000\,\Omega$

(89) As shown in the figure, two parallel plate capacitors having equal plate area of $200\,cm^2$ are joined in such a way that $a \neq b$. The equivalent capacitance of the combination is $x\varepsilon_0 F$. The value of $x$ is ..... [JEE MAIN 2023]




**Solution:**
$c = \frac{\varepsilon_0 A}{(d-c)}$
$= \frac{\varepsilon_0 \times 200 \times 10^{-4}}{4 \times 10^{-3}}$
$\therefore x = 5$
The situation is equivalent to a conducting slab placed between the plates

(90) A composite parallel plate capacitor is made up of two different dielectric materials with different thickness ($t_1$ and $t_2$) as shown in figure. The two different dielectric material are separated by a conducting foil $F$. The voltage of the conducting foil is .....$V$ [JEE MAIN 2022]




**Solution:**
Capacitance of each capacitor
$C_1 = \frac{A3\epsilon_0}{\frac{1}{2}} = 6A\epsilon_0$
$C_2 = A4E_0 = 4A\,\epsilon_0$
Equivalent capacitance
$C_{\text{eq}} = \frac{C_1C_2}{C_1+C_2} \Rightarrow \frac{24}{10}A\,\epsilon_0$
$q_{\text{net}} = C_{\text{eq}}(\Delta V) \Rightarrow 240A\,\epsilon_0$
$\Delta V_2 = \frac{240A\epsilon_0}{4A\epsilon_0} = 60\,V$
($\Delta V_2 =$ Potential drop across $C_2$)
$V_{\text{foil}} = 60\,V$