## MATHEMATICS

### Category-I (Q. 1 to 30)

**(Carry 1 mark each. Only one option is correct. Negative mark: – ¼)**

1. If the complex number $Z$ and its conjugate $\bar{Z}$ satisfy the relation, $(Z-\bar{Z})^2+8a(Z+\bar{Z})=16a^2$ where $a$ is a positive real number, then in the Argand diagram principal value of amplitude representing $Z$ lies between

(A) $\frac{-\pi}{2}$ and $\frac{-\pi}{4}$

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

(C) $\frac{-\pi}{4}$ and $\frac{\pi}{4}$

(D) $\frac{\pi}{3}$ and $\frac{\pi}{2}$

2. Let $a=\cos\frac{2\pi}{7}+i\sin\frac{2\pi}{7}$.

If $\alpha=a+a^2+a^4$ and $\beta=a^3+a^5+a^6$, then $\alpha$, $\beta$ are the roots of the equation

(A) $x^2-x+2=0$

(B) $x^2+x+2=0$

(C) $x^2+x+1=0$

(D) $x^2-x-2=0$

3. If $ax+by+cz=1$

$bx+cy+az=0$

and $cx+ay+bz=0$, then the reciprocal of

$$\begin{vmatrix} a & b & c \\ b & c & a \\ c & a & b \end{vmatrix}$$ is

(A) $\begin{vmatrix} x & y & z \\ y & z & x \\ z & x & y \end{vmatrix}$

(B) $\begin{vmatrix} x & x & y \\ y & z & z \\ z & y & y \end{vmatrix}$

(C) $\begin{vmatrix} x^2-yz & y & z \\ y & z^2-xy & x \\ z & x & y^2-zx \end{vmatrix}$

(D) $\begin{vmatrix} x^2 & y^2 & z^2 \\ y^2 & z^2 & x^2 \\ z^2 & x^2 & y^2 \end{vmatrix}$

**4.** Let $f(x) = \sin x, x \neq n\pi\ (n = 0, \pm 1, \pm 2, ...)$

$= 0$, otherwise

and $g(x) = x^2 + 1, x \neq 0, 2$

$g(0) = 4$

$g(2) = 5$, then $\lim_{x \to 0} g\{f(x)\}$ is

(A) 0

(B) 1

(C) 2

(D) 4

**5.** The point on the conic $\frac{21}{r} = 5 - 2\cos\theta$, whose radius vector is the smallest is

(A) $\left(\frac{21}{5}, \frac{\pi}{2}\right)$

(B) (7, 0)

(C) $\left(\frac{5}{21}, \frac{\pi}{2}\right)$

(D) $(3, \pi)$

**6.** If the tangent at $(\alpha, \beta)$ to the parabola $y^2 = 4ax$ touches the parabola $x^2 = 4by$, then the locus of $(\alpha, \beta)$ is

(A) $x^2 + y^2 = ab$

(B) $xy + 2ab = 0$

(C) $x^2 + y^2 = a^2 + b^2$

(D) $xy = ab$

**7.** Let $f$ be a twice differentiable function such that $f''(x) = -f(x)$ and $f'(x) = g(x)$. If $h'(x) = (f(x))^2 + (g(x))^2$, $h(1) = 8$ and $h(0) = 2$, then the value of $h(2)$ is

(A) 6

(B) 8

(C) $\frac{1}{4}$

(D) 14

8. A box contains three blue balls and four red balls. Another identical box contains two blue balls and five red balls. One ball is picked at random from one of the two boxes and it is red. The probability that it came from the first box is

(A) $\frac{2}{7}$ (B) $\frac{4}{7}$

(C) $\frac{4}{9}$ (D) $\frac{2}{3}$

9. The rank of the matrix $A=\begin{bmatrix}1 & 2 & 3\\ 3 & 4 & 5\\ 4 & 6 & 8\end{bmatrix}$ is

(A) 0 (B) 1

(C) 2 (D) 3

10. Let $X = a^2\cos^2\theta - b^2\sin^2\theta$.

If $\phi(\theta)=\log\frac{a+b\tan\theta}{a-b\tan\theta}\cdot\sqrt{\frac{a\cos\theta-b\sin\theta}{a\cos\theta+b\sin\theta}}$, then $\phi'(\theta)$ is

(A) 0 (B) 1

(C) $\frac{\left(a^2-b^2\right)X}{\left(a^2+b^2\right)}$ (D) $\frac{ab}{X}$

11. The value of $\lim_{x\to 0}\frac{x\log\cos x}{e^{-\sin x}-1+\log(1+x)}$ is

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

(C) $\frac{2}{3}$ (D) $-\frac{1}{2}$

12. All the eigenvalues of the matrix $\begin{bmatrix}1 & 2 & 0\\ 2 & 1 & 0\\ 0 & 0 & -1\end{bmatrix}$ lie on the disc

(A) $|\lambda+1|\le 1$ (B) $|\lambda-1|\le 2$

(C) $|\lambda+1|\le 0$ (D) $|\lambda-1|\le 1$

13. If matrix $A$ is $m \times n$ and matrix $B$ is $n \times p$, then the number of multiplication operations and addition operations needed to calculate the matrix $AB$, respectively are

(A) $mn^2p$, $mpn$

(B) $mpn$, $mpn$

(C) $mn^2p$, $(m+p)n$

(D) $mnp$, $mp\,(n-1)$

14. Let $h$ be the height and $r$ be the radius of the circular base of a closed cylinder of given volume. If the surface of the closed cylinder is least, then

(A) $h = r$

(B) $2h = r$

(C) $h = 2r$

(D) $h = 3r$

15. The general solution of the differential equation $y\,(2xy + e^x)\,dx - e^x\,dy = 0$ is

(A) $e^{-x} = 2y\left(c - x^2\right)$

(B) $e^x = y\left(c - x^2\right)$

(C) $x^2e^x = y\left(c - x^2\right)$

(D) $e^x = xy + c$

16. If $\tan(\theta + i\phi) = \tan\beta + i\sec\beta$ where $0 < \beta < \pi$, then

(A) $e^{\phi} = \cot\frac{\beta}{2}$

(B) $e^{2\phi} = \cot\frac{\beta}{2}$

(C) $e^{2\phi} = 2\cot\frac{\beta}{2}$

(D) $e^{-4\phi} = \tan\frac{\beta}{2}$

17. If the volume of a tetrahedron is 2 and three of its vertices have position vectors (1, 1, 0), (1, 0, 1), (2, – 1, 1), then the locus of the fourth vertex is

(A) $x + y + z = 14$

(B) $x - y + z = 2$

(C) $x + y + z = 12$

(D) $x + y - z = 2$

18. If $\theta = t^n e^{-\left(\frac{r^2}{4tk}\right)}$ and $\frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2\frac{\partial\theta}{\partial r}\right) = \frac{1}{k}\frac{\partial\theta}{\partial t}$ ($k$ is a constant), then the value of $n$ is

(A) $\frac{1}{2}$

(B) $\frac{3}{2}$

(C) $-\frac{2}{3}$

(D) $-\frac{3}{2}$

19. The particular integral of $\left(D^2-1\right)y=xe^{2x}$ is given by

(A) $\frac{xe^{2x}}{3}(3x-4)$

(B) $\frac{e^{2x}}{2}(3x-4)$

(C) $\frac{e^{2x}}{9}(3x-4)$

(D) $\frac{e^{2x}}{9}(3x-1)$

20. If $f\left(\frac{1}{x}\right)+x^2f(x)=0,\forall x>0$, then the value of $\int_{\sin x}^{\operatorname{cosec} x} f(z)dz$ for $x\in\left(0,\frac{\pi}{2}\right)$ is

(A) 0

(B) $-1$

(C) 1

(D) $\frac{3}{2}$

21. Two tangents are drawn to $y^2 = 4ax$ meet at an angle 45°. The locus of their point of intersection is

(A) $x^2-4ax+y^2=0$

(B) $(x+a)^2=y^2-4ax$

(C) $\sqrt{2}\left(x^2+y^2\right)=a^2$

(D) $(x+a)^2+(y-a)^2=2$

22. The value of $\int\frac{\left(x^2-1\right)dx}{\left(x^4+3x^2+1\right)\tan^{-1}\left(\frac{x^2+1}{x}\right)}$ is

(A) $\frac{3}{4}\log\left|\tan^{-1}\left(x+\frac{1}{x}\right)\right|+c$

(B) $\frac{3}{4}\log\left|\tan^{-1}\left(x-\frac{1}{x}\right)\right|+c$

(C) $\frac{1}{2}\left(\tan^{-1}\left(x+\frac{1}{x}\right)\right)^2+c$

(D) $\log\left|\tan^{-1}\left(x+\frac{1}{x}\right)\right|+c$

**23.** If $\Delta = \begin{vmatrix} h & a & 0 \\ \frac{1}{h} & \frac{1}{b} & \frac{1}{f} \\ 0 & c & f \end{vmatrix}$ and $\Delta' = \begin{vmatrix} \frac{1}{bc} - \frac{1}{f^2} & -\frac{1}{ch} & \frac{1}{fh} \\ af & -fh & ch \\ \frac{1}{fh} & -\frac{1}{af} & \frac{1}{ab} - \frac{1}{h^2} \end{vmatrix}$, then the value of $\frac{\Delta'}{\Delta^2}$ in its simplest form is

(A) $\frac{h^2 - ab}{f^2 - bc}$

(B) $\frac{af}{ch}$

(C) $\frac{-1}{cafh}$

(D) $\frac{-ca}{fh}$

**24.** The region of the Z-plane for which $|Z-1| + |Z+1| \le 3$ is

(A) $\frac{x^2}{9/4} + \frac{y^2}{5/4} \le 1$

(B) $x^2 + y^2 \le 9$

(C) $\frac{x^2}{9} - \frac{y^2}{9} \le 1$

(D) $\frac{x^2}{9} + \frac{y^2}{4} \le 1$

**25.** The areal velocity of a particle which moves along the path $\vec{r} = a\cos\omega t\,\hat{i} + b\sin\omega t\,\hat{j}$, where $a$, $b$, $\omega$ are constant and $t$ is the time variable will be

(A) $a\hat{i} + b\hat{j} + \omega\hat{k}$

(B) $-a\hat{i} + b\hat{j} + \omega\hat{k}$

(C) $\frac{1}{2}ab\omega\hat{k}$

(D) $ab\omega\hat{k}$

**26.** The unit vector parallel to the xy-plane and perpendicular to the vector $4\hat{i} - 3\hat{j} + \hat{k}$ is

(A) $\pm\frac{1}{5}(3\hat{i} + 4\hat{j})$

(B) $\pm\frac{1}{5}(4\hat{i} + 3\hat{j})$

(C) $\pm\frac{1}{\sqrt{26}}(3\hat{i} + 4\hat{j})$

(D) $\pm\frac{1}{\sqrt{26}}(4\hat{i} + 3\hat{j})$

27. Let $f(x)$ be a function such that $f(x) > 0$ for all $x$ and $f'(x)$ is continuous at every real $x$. If $f'(t) \geq \sqrt{f(t)}$ for all $t$, then for all $x \geq 1$

(A) $\sqrt{f(x)} \geq \sqrt{f(1)} + \frac{x}{2}$

(B) $\sqrt{f(x)} \geq \sqrt{f(1)} + x$

(C) $\sqrt{f(x)} \geq \sqrt{f(1)} + \frac{1}{2}(x-1)$

(D) $\sqrt{f(x)} \geq \sqrt{f(1)} + (x-1)$

28. If $u = \sin^{-1}\frac{x+y}{\sqrt{x}+\sqrt{y}}$, then $\left(x\frac{\partial}{\partial x} + y\frac{\partial}{\partial y}\right)^2 u =$

(A) $-\frac{\sin 4u}{4\cos^3 u}$

(B) $-\frac{\sin u \cos 2u}{4\cos^3 u}$

(C) $\frac{\sin 2u \cos u}{4\cos^3 u}$

(D) $-\frac{\sin 2u \cos u}{4\cos^3 u}$

29. A student takes his examination in four subjects $\alpha$, $\beta$, $\gamma$ and $\delta$. He estimates his chance of passing in $\alpha$ as $\frac{4}{5}$, in $\beta$ as $\frac{3}{4}$, in $\gamma$ as $\frac{5}{6}$ and in $\delta$ as $\frac{2}{3}$. To qualify he must pass in $\alpha$ and at least two other subjects. The probability that he qualifies is

(A) $\frac{59}{90}$

(B) $\frac{37}{90}$

(C) $\frac{29}{90}$

(D) $\frac{61}{90}$

30. Water is running into a conical reservoir, 10 cm deep and 5 cm in radius at the rate of 1·5 cc per minute. The rate at which the wetted surface of the reservoir increasing when water is 8 cm deep is

(A) $\frac{\sqrt{5}\pi}{2}\text{cm}^2/\text{min}$

(B) $\frac{3\sqrt{5}}{8}\text{cm}^2/\text{min}$

(C) $2\sqrt{5}\pi\,\text{cm}^2/\text{min}$

(D) $\frac{4\sqrt{5}\pi}{3}\text{cm}^2/\text{min}$

## MATHEMATICS

### Category-II (Q. 31 to 40)

**(Carry 2 marks each. One or more options is/are correct. No negative marks.)**

**31.** $\int \frac{dx}{\left(1+x^4\right)\left(\sqrt{1+x^4}-x^2\right)^{\frac{1}{2}}} =$

(A) $\sec^{-1}\frac{x}{\sqrt{1+x^4}}+c$

(B) $\sin^{-1}\sqrt{\frac{x^2}{1+x^4}}+c$

(C) $-\sec^{-1}\frac{x}{\left(1+x^4\right)^{\frac{1}{4}}}+c$

(D) $\sin^{-1}\frac{x}{\left(1+x^4\right)^{\frac{1}{4}}}+c$

**32.** If the equation $13x^2+10xy+by^2-62\sqrt{2}x-46\sqrt{2}y+170=0$ represents a point ellipse, then the value of $b$ and the point are respectively

(A) $13,\left(\sqrt{2},\sqrt{2}\right)$

(B) $13,\left(2\sqrt{2},\sqrt{2}\right)$

(C) $13,\left(\sqrt{2},2\sqrt{2}\right)$

(D) $13,\left(\frac{\sqrt{2}}{3},2\sqrt{2}\right)$

**33.** The probability that a year, selected at random, in between 2001 and 2010 both inclusive will contain 53 Mondays is

(A) $\frac{4}{49}$

(B) $\frac{2}{35}$

(C) $\frac{6}{35}$

(D) $\frac{2}{49}$

**34.** The area bounded by $y=(\ln x)^2$ and $y=(\ln x)^3$, $x>0$ is

(A) $(3e-8)$ sq. unit

(B) $\left(\frac{2}{3}e-6\right)$ sq. unit

(C) $(6-2e)$ sq. unit

(D) $\left(2e+\frac{3\pi}{32}\right)$ sq. unit

**35.** A force of 15 units acts in the direction of the vector $\hat{i}-2\hat{j}+2\hat{k}$ and passes through a point $2\hat{i}-2\hat{j}+2\hat{k}$. The moment of force about the point $\hat{i}+\hat{j}+\hat{k}$ is

(A) $-40\hat{i}-5\hat{j}+5\hat{k}$

(B) $-40\hat{i}+5\hat{j}-25\hat{k}$

(C) $15\hat{i}-30\hat{j}+30\hat{k}$

(D) $-20\hat{i}-5\hat{j}+5\hat{k}$

**36.** If $\phi(t)=\lim\limits_{x\to\infty}\dfrac{f(t)+\cos^{2x}\pi t\{2g(t)-f(t)\}}{1+\cos^{2x}\pi t}$, then

(A) $\phi(t)=g(t)$, when $t$ is not an integer.

(B) $\phi(t)=g(t)$, when $t$ is an integer.

(C) $\phi(t)=f(t)$, when $t$ is not an integer.

(D) $\phi(t)=f(t)$, when $t$ is an integer.

**37.** The following system of equations

$x+y+z=1$

$x+2y-z=b$

$5x+7y+az=b^2$ admits of

(A) a unique solution for $a=1$, for all values of $b$.

(B) no solution for $a\neq 1, b\neq -1, 3$.

(C) an infinite number of solutions for $a=1, b=-1$ or $a=1, b=3$.

(D) no solution for $a=1, b\neq -1, 3$.

**38.** The product of all values of $\left(\sqrt{3}+i\right)^{\frac{3}{5}}$ is

(A) 0

(B) $8i$

(C) $\dfrac{3\sqrt{3}}{8}$

(D) $\dfrac{3\sqrt{3}}{8}i$

**39.** An integrating factor of the differential equation $(y^2+2x^2y)\,dx+(2x^3-xy)\,dy=0$ is

(A) $x^{\frac{-5}{2}}y^{\frac{1}{2}}$

(B) $x^{\frac{5}{2}}y^{\frac{-1}{2}}$

(C) $x^{\frac{5}{2}}y^{\frac{1}{2}}$

(D) $x^{\frac{-5}{2}}y^{\frac{-1}{2}}$

**40.** The equation of the family of curves which cut the members of the family of hyperbolas $y^2+2xy-x^2=c$ at an angle of 45° becomes

(A) $x^2+y^2=c^2$

(B) $x^2-y^2=c^2$

(C) $2(x^2+y^2)=c^2$

(D) $x^{\frac{2}{3}}+y^{\frac{2}{3}}=c^{\frac{2}{3}}$

## PHYSICS

### Category-I (Q. 41 to 65)

**(Carry 1 mark each. Only one option is correct. Negative mark: – ¼)**

**41.** Time period $T$ of a simple pendulum may depend on mass of the bob $m$, length of the string $l$ and acceleration due to gravity $g$, i.e, $T \propto m^a l^b g^c$

The values of $a$, $b$ and $c$ are

(A) $a = 0, b = \frac{1}{2}, c = -\frac{1}{2}$

(B) $a = 0, b = -\frac{1}{2}, c = \frac{1}{2}$

(C) $a = \frac{1}{2}, b = 0, c = -\frac{1}{2}$

(D) $a = -\frac{1}{2}, b = 0, c = \frac{1}{2}$

**42.** If $\vec{a} + \vec{b} = \vec{c}$ and $|\vec{a}| + |\vec{b}| = |\vec{c}|$, then the angle between $\vec{a}$ and $\vec{b}$ is

(A) zero

(B) 90°

(C) 120°

(D) 180°

**43.** Two equal plates (of equal areas and thickness) with thermal conductivities $K_1$ and $K_2$ are joined together to form a single plate of double thickness. The equivalent thermal conductivity of the composite plate is

(A) $\frac{K_1}{K_1 + K_2}$

(B) $\frac{K_2}{K_1 + K_2}$

(C) $\frac{K_1 K_2}{K_1 + K_2}$

(D) $\frac{2K_1 K_2}{K_1 + K_2}$

**44.** The radius of the earth is $R$ and $g$ is the acceleration due to gravity on its surface. The angular speed of the earth for which the bodies lying on the equator will appear weightless is

(A) $\sqrt{\frac{g}{R}}$

(B) $\sqrt{\frac{2g}{R}}$

(C) $\sqrt{gR}$

(D) $\sqrt{2gR}$

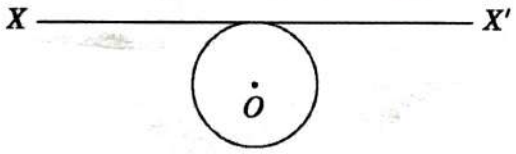
**45.** The angular momentum of the earth revolving around the sun is proportional to $R^n$ where, $R$ is the distance between the earth and the sun. The value of $n$ is

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

**46.** A boy of mass $m$ is sliding down a vertical pole by pressing it with a horizontal force $F$. If $\mu$ is the co-efficient of friction between his palms and the pole, then acceleration with which he slides down will be

(A) $g$
(B) $\frac{\mu F}{m}$
(C) $g+\frac{\mu F}{m}$
(D) $g-\frac{\mu F}{m}$

**47.** A thin wire of length $L$ and uniform linear mass density $\rho$ is bent into a circular loop with centre at $O$ as shown in figure below.




The moment of inertia of the loop about the axis $XX'$ is

(A) $\frac{\rho L^3}{8\pi^2}$
(B) $\frac{\rho L^3}{16\pi^2}$
(C) $\frac{5\rho L^3}{16\pi^2}$
(D) $\frac{3\rho L^3}{8\pi^2}$

**48.** A wire breaks when subjected to a stress $S$. If $\rho$ is the density of the material of the wire and $g$ is the acceleration due to gravity, then minimum length of the wire so that it breaks by its own weight is

(A) $\rho g S$
(B) $\frac{S}{\rho g}$
(C) $\frac{\rho g}{S}$
(D) $\frac{g S}{\rho}$

**49.** A liquid flows through two capillary tubes *A* and *B* connected in series. The length and radius of *B* are twice those of *A*. The ratio of the pressure difference across *A* to that across *B* is

(A) 8

(B) 4

(C) 2

(D) 1

**50.** One mole of an ideal gas ($\gamma = 1{\cdot}4$) is adiabatically compressed so that its temperature rises from 27°C to 35°C. The change in internal energy of the gas is ($R = 8{\cdot}3$ J/mole/K)

(A) –166J

(B) +166J

(C) –168J

(D) +168J

**51.** A tiny sphere of mass $m$ and density '$x$' is dropped in a tall jar of glycerine of density '$y$'. When the sphere acquires terminal velocity, the magnitude of the viscous force acting on it is

(A) $\frac{mgx}{y}$

(B) $\frac{mgy}{x}$

(C) $mg\left(1-\frac{y}{x}\right)$

(D) $mg\left(1+\frac{x}{y}\right)$

**52.** The reading in a barometer is $h$ when a lift is not moving. If the lift moves downwards with an acceleration $f$, then the reading of the barometer will be

(A) $h$

(B) $\frac{hg}{g-f}$

(C) $\frac{h(g-f)}{g}$

(D) $\frac{h(g+f)}{g}$

53. In rotational motion, the direction of angular momentum is

(A) along the direction of radius vector.

(B) parallel to the direction of linear momentum.

(C) in a plane perpendicular to the plane of rotation.

(D) in a plane parallel to the plane of rotation.

54. A simple pendulum of length $l$ has a maximum angular displacement $\theta$. The maximum kinetic energy of the bob will be

(A) $mgl\,(1 - \cos\theta)$

(B) $mgl\,(1 + \cos\theta)$

(C) $mgl\,(1 - \sin\theta)$

(D) $mgl\,(1 + \sin\theta)$

55. A ray of light falls on a transparent glass slab of refractive index 1·54. The angle of incidence when the refracted and the reflected rays are mutually perpendicular will be

(A) $\tan^{-1}\frac{1}{1{\cdot}54}$

(B) $\sin^{-1}1{\cdot}54$

(C) $\tan^{-1}1{\cdot}54$

(D) $\cos^{-1}\frac{1}{1{\cdot}54}$

56. A converging lens is used to form an image on a screen. When the lower half of the lens is covered by the opaque screen, then

(A) half of the image will disappear, without change in intensity.

(B) half of the image will disappear, with a decrease in intensity.

(C) complete image will be formed, without change in intensity.

(D) complete image will be formed, with a decrease in intensity.

**57.** A plano-convex lens of refractive index 1·5 and radius of curvature 30 cm is silvered at the curved surface. Now this lens has been used to form the image of an object. At what distance from this lens, an object be placed in order to have a real image of the size of the object?

(A) 20 cm

(B) 30 cm

(C) 60 cm

(D) 80 cm

**58.** In a given process on an ideal gas, $dW = 0$ and $dQ < 0$. Then, for the gas

(A) the temperature will decrease.

(B) the volume will increase.

(C) the pressure will remain constant.

(D) the temperature will increase.

**59.** A physical quantity $X$ is given by $X = \frac{a^3 b^2}{\sqrt{c}d}$.

If the percentage errors in the measurements of $a$, $b$, $c$ and $d$ are 1%, 2%, 4% and 3% respectively, then maximum percentage error in $X$ will be

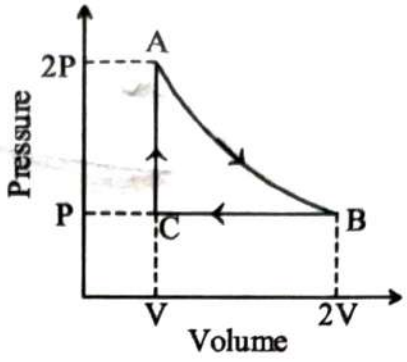
(A) 2%

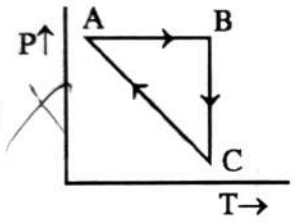
(B) 10%

(C) 12%

(D) 15%

**60.** The figure given below shows the P-V diagram for a fixed mass of an ideal gas undergoing cyclic process ABCA. Here AB represents isothermal process. The corresponding P-T diagram will be




(A)
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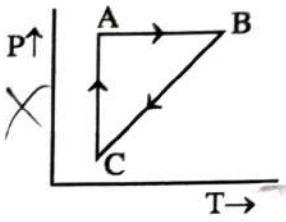


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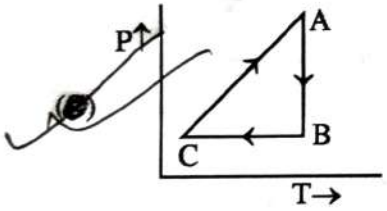
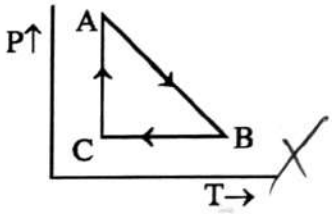
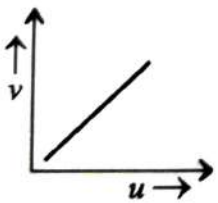
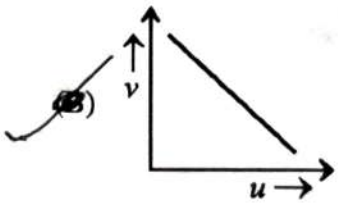
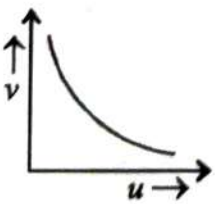


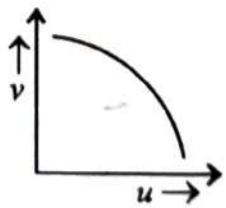

(D)



**61.** The distances '$v$' of the real images formed by a convex lens are measured for various object distances '$u$' and best represented by the following graph:

(A)



(B)



(C)



(D)


62. Light of two different frequencies, whose photons respectively have energies 2eV and 5eV, are used to successively illuminate a metal whose work function is 1eV. The ratio of the maximum speeds of the emitted electrons will be

(A) 1 : 5
(B) 1 : 4
(C) 1 : 3
(D) 1 : 2

63. Two spheres of same material and radii 1m and 4m are at temperatures 4000K and 2000K, respectively. The amount of energy radiated per second from them are in the ratio of

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

64. The work done ($w$) in shifting a particle of mass $m$ from infinity to the centre of the earth is

(A) $w = 0$
(B) $w < 0$
(C) $w > 0$
(D) $w \leq 0$

65. A sphere of relative density $\sigma$ and diameter $D$ has concentric cavity of diameter $d$. It will just float on water in a tank if the ratio $D/d$ is

(A) $\frac{\sigma}{\sigma-1}$
(B) $\frac{\sigma+1}{\sigma}$
(C) $\left(\frac{\sigma}{\sigma-1}\right)^{\frac{1}{3}}$
(D) $\left(\frac{\sigma+1}{\sigma}\right)^{\frac{1}{3}}$

## PHYSICS

### Category-II (Q. 66 to 70)

**(Carry 2 marks each. One or more options is/are correct. No negative mark.)**

**66.** A lens is placed in air. The focal length of the lens depends on

(A) the object and image distances.

(B) the refractive index of the material of the lens.

(C) the radii of curvature of its faces.

(D) the wavelength of light used.

**67.** A projectile thrown at an angle of 30° with the horizontal has a range $R_1$ and attains a maximum height $h_1$. Another projectile thrown with the same speed at an angle of 30° with the vertical has a range $R_2$ and attains a maximum height $h_2$. Then

(A) $R_2 = 2R_1$

(B) $R_2 = R_1$

(C) $h_2 = 2h_1$

(D) $h_2 = 3h_1$

**68.** When ultraviolet light is incident on a photo cell, its stopping potential is $V_0$ and the maximum kinetic energy of the photoelectrons is $K_{max}$. If X-rays are incident on the same cell, then

(A) $V_0$ will increase.

(B) $K_{max}$ will increase.

(C) $V_0$ will decrease.

(D) $K_{max}$ will decrease.

$P = \frac{F}{A}$

**69.** The dimension of pressure is same as those of

(A) stress

(B) strain

(C) Young's modulus $Y = \frac{F}{A\Delta}$

(D) surface tension

**70.** The height to which a liquid rises or falls in a capillary tube is inversely proportional to

(A) the radius of the capillary tube.

(B) the surface tension of the liquid.

(C) the density of the liquid.

(D) the angle of contact.

## CHEMISTRY

### Category-I (Q 71 to 85)

**(Carry 1 mark each. Only one option is correct. Negative mark: – ¼)**

**71.** Which of the following sets of quantum numbers cannot be associated with an electron in atom?

(A) $n = 5, l = 3, m = 0, s = +\frac{1}{2}$

(B) $n = 3, l = 2, m = -3, s = -\frac{1}{2}$

(C) $n = 3, l = 2, m = -2, s = -\frac{1}{2}$

(D) $n = 4, l = 0, m = 0, s = -\frac{1}{2}$

**72.** The boiling point of $NH_3$ is higher than that of $PH_3$ because

(A) $NH_3$ has ionic bonds while $PH_3$ has covalent bond.

(B) $NH_3$ has higher molecular weight than $PH_3$.

(C) $NH_3$ undergoes umbrella inversion.

(D) $NH_3$ forms stronger hydrogen bonds than $PH_3$.

**73.** If the density of $H_2O$ is 1g $ml^{-1}$ then the strength in molarity is
[Atomic weight of O is 16 and H is 1]

(A) 56

(B) 55·55

(C) 54·5

(D) 55·00

**74.** The pH of a mixture of strong acids of the following combination is:
500ml of 0·04 (M) HCl + 200ml of 0·05 (M) $H_2SO_4$ + 300ml of 0·2 (M) $HNO_3$

(A) 2

(B) 1·5

(C) 1·0

(D) 1·25

**75.** The reductant in the following reaction is:

$2KMnO_4\ (aq) + 10FeSO_4\ (aq) + 8H_2SO_4\ (aq)$
$\rightarrow MnSO_4\ (aq) + K_2SO_4\ (aq) + 5Fe_2(SO_4)_3\ (aq) + 8H_2O\ (l)$

(A) $KMnO_4$

(B) $FeSO_4$

(C) $H_2SO_4$

(D) $KMnO_4$ and $H_2SO_4$ both

**76.** The potential of the following electrochemical cell is close to

$Cr \mid Cr^{3+}(0.1M) \| Fe^{2+}(0.01M) \mid Fe$

[Given $E^0_{\frac{Cr^{3+}}{Cr}} = -0.74V$; $E^0_{\frac{Fe^{2+}}{Fe}} = -0.44V$]

(A) 0.26V

(B) 0.36V

(C) 0.16V

(D) 0.30V

**77.** Equilibrium constant (K) for the reaction $2NO(g) + Cl_2(g) \rightleftharpoons 2NOCl(g)$ is correctly given by the expression

(A) $\frac{[NOCl]^2}{[NO]^2[Cl_2]}$

(B) $\frac{[2NOCl]}{[2NO]\,[Cl_2]}$

(C) $\frac{[NO]^2[Cl_2]}{[NOCl]}$

(D) $\frac{[NO]^2[Cl_2]}{[NOCl]^2}$

**78.** The value of $K_c$ for the reaction $2A \rightleftharpoons B + C$ is $2{\cdot}0 \times 10^{-3}$. At a given time the composition of reaction mixtures is $[A] = [B] = [C] = 3 \times 10^{-4}$(M). The direction in which the reaction will proceed—

(A) Forward

(B) Backward

(C) Will not proceed in any direction

(D) Cannot be evaluated from the given data

**79.** For electroplating on a copper plate by gold, the electrolytic material, anode and cathode will be respectively

(A) Potassium argentocyanide, gold plate, copper plate.

(B) Potassium aurochloride, gold plate, copper plate.

(C) Potassium aurocyanide, copper plate, gold plate.

(D) Potassium argentochloride, gold plate, copper plate.

**80.** The slimy precipitate formed within the boil bath is soft and loose which is known as—

(A) Coagulant

(B) Scale

(C) Flocculant

(D) Sludge

**81.** A green coloured layer is deposited on copper or copper containing alloy when exposed to air. Chemical composition of the green coloured material is

(A) $CuCO_3 \cdot Cu(OH)_2$

(B) $Cu(ClO_4)_2 \cdot Cu(OH)_2$

(C) $CuSO_4 \cdot Cu(OH)_2$

(D) $CuCl_2 \cdot Cu(OH)_2$

**82.** Among the following, strongest acid is

(A) $C_6H_6$

(B) $C_2H_6$

(C) $HC \equiv CH$

(D) $CH_3OH$

**83.** For the reaction, $CH_3CH = CH_2 + HOCl \longrightarrow x$, the product $x$ is

(A) $CH_3-\underset{\displaystyle OH}{\underset{|}{CH}}-\underset{\displaystyle Cl}{\underset{|}{CH_2}}$

(B) $CH_3-\underset{\displaystyle Cl}{\underset{|}{CH}}-\underset{\displaystyle OH}{\underset{|}{CH_2}}$

(C) $CH_3-CH_2-CH_2OCl$

(D) $CH_3-CH_2-\underset{\displaystyle OCl}{\underset{|}{CH}}-CH_3$

**84.** Anhydrous $AlCl_3$ is used in Friedel - Craft reaction because it is

(A) soluble in water.

(B) electron rich.

(C) electron defficient.

(D) insoluble.

**85.** Which of the following carbocations will be most stable?

(A) $CH_3-\overset{+}{C}H_2$

(B) $Ph_3\overset{+}{C}$

(C) $(CH_3)_2\overset{+}{C}H$

(D) $CH_2=CH-\overset{+}{C}H_2$

## CHEMISTRY

### Category-II (Q 86 to 90)

**(Carry 2 marks each. One or more options is/are correct. No negative mark.)**

**86.** Which among the following mixtures are used for preparation of buffer solution in aqueous media?

(A) NaOH and $NH_4OH$ solutions

(B) HCl and NaCl solutions

(C) $NH_4OH$ and $NH_4Cl$ solutions

(D) $CH_3OOH$ and $CH_3COONa$ solutions

**87.** Which of the following compounds give positive iodoform test?

(A) $CH_3CH_2OH$

(B) $CH_3CH_2COCH_3$

(C) $CH_3CH_2OCH_3$

(D) $CH_3CH_2COOCH_3$

**88.** Of the following, the metals that cannot be obtained by electrolysis of the aqueous solution of their salt is

(A) Ag

(B) Mg

(C) Cu

(D) Al

**89.** Which of the following statements is correct about use of basic slag (by-product of steel industry)?

(A) As cost effective agricultural fertilizer

(B) As raw material in synthesis of bakelite

(C) In waste water treatment

(D) As raw material in synthesis of bulk drugs

**90.** Which of the following statement(s) is/are correct?

(A) The pH of $1{\cdot}0 \times 10^{-8}$M solution of HCl is 8.

(B) The conjugate base of $H_2PO_4^-$ is $HPO_4^{2-}$.

(C) Autoprotolysis constant of water increases with temperature.

(D) A substance which can accept a pair of electrons is a base.

## Fundamentals of Electrical & Electronics Engineering

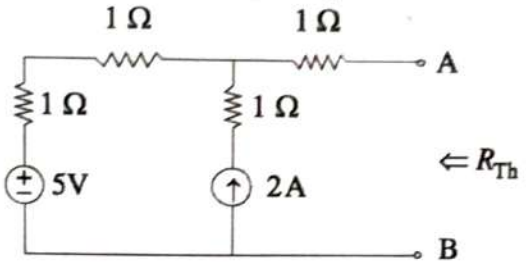
### Category-1 (Q. 91 to 100)

**(Carry 1 mark each. Only one option is correct. Negative mark: – ¼)**

**91.** A parallel plate capacitor has a capacitance of 10 μF. What will be the new value of capacitance, if the overlap area of the plates are doubled and separation between the plates are also doubled?

(A) 10 μF
(B) 20 μF
(C) 5 μF
(D) 40 μF

**92.** Find the Thevenin's equivalent resistance ($R_{Th}$) of the following circuit with respect to terminals A-B.




(A) 1 Ω
(B) 2 Ω
(C) 3 Ω
(D) 4 Ω

**93.** The stator magnetic field of a 3 phase 4 pole induction motor rotates at 1500 rpm. Find the supply frequency.

(A) 5 Hz
(B) 10 Hz
(C) 25 Hz
(D) 50 Hz

**94.** If $v(t) = 100\sqrt{2}\ \sin(314t + 30°)$V be the supply voltage and $i(t) = 10\sqrt{2}\ \sin(314t - 30°)$A be the load current, then find the active power.

(A) 100 watt
(B) 200 watt
(C) 500 watt
(D) 1000 watt

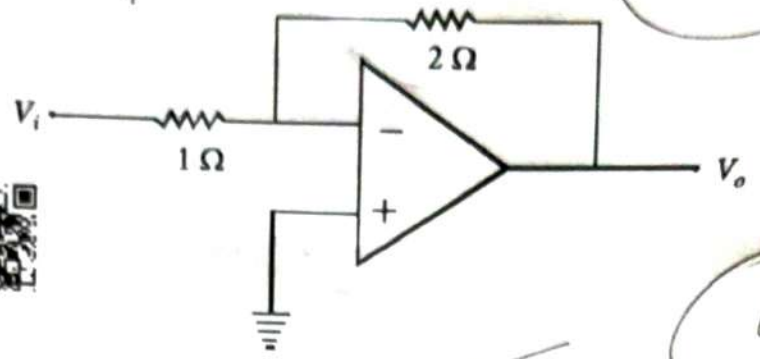
**95.** A 3 phase, 50 Hz, 4 pole induction motor runs at a speed of 1440 rpm. Find the motor slip ($s$).

(A) $s = 1\%$
(B) $s = 2\%$
(C) $s = 4\%$
(D) $s = 10\%$

**96.** Which of the following condition needs to be fulfilled for a transformer to operate at maximum efficiency?

(A) Hysteresis loss = Eddy current loss
(B) Hysteresis loss = Copper loss
(C) Eddy current loss = Copper loss
(D) Hysteresis loss + Eddy current loss = Copper loss

**97.** Determine the gain $\frac{V_o}{V_i}$ of the following amplifier.

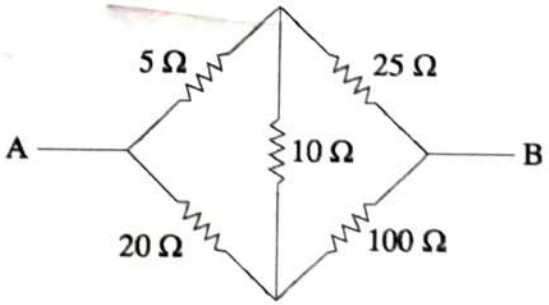



(A) 2
(B) – 2
(C) 10
(D) – 20

**98.** In a common base (CB) amplifier, the ratio of collector current to emitter current is 0.9. Find the base current, if the emitter current is 1.8 mA.

(A) 1.17 mA
(B) 0.18 mA
(C) 13 μA
(D) 1.3 mA

**99.** Determine the equivalent resistance of the following circuit across the terminals A-B.




(A) 24.0 Ω
(B) 34.5 Ω
(C) 10.5 Ω
(D) 36.0 Ω

**100.** What will be the power factor of a series R-L-C circuit, under the condition of electrical resonance?

(A) Lagging p.f.
(B) Leading p.f.
(C) Zero p.f.
(D) Unity p.f.