1. Which of the following gives a reversible operation?

2. A 60HP electric motor lifts an elevator having a maximum total load capacity of 2000 Kg. If the operational force on the elevator is 4000N, the speed of the elevator at full load is close to:

\[ \text{1HP = 746 W, } g = 10 \text{ m/s}^2 \]

3. A LCR circuit behaves like a damped harmonic oscillator. Comparing it with a physical spring-mass damped oscillator having damping constant \( b' \), the correct equivalence would be:

\[ L \rightarrow \frac{b}{2}, C \rightarrow b, R \rightarrow \frac{1}{2} \]

4. As shown in the figure, a bob of mass \( m \) is tied by a massless string whose other end is wound on a fly wheel of radius \( r \) and mass \( M \). When released from rest, the bob starts falling vertically. When it has covered a distance of \( h \), the angular speed of the wheel will be:

\[ h = \frac{2}{3} \]

5. Three point particles of masses 10 Kg, 1.5 Kg and 2.5 Kg are placed at three corners of a equilateral triangle of side 4.0 cm, 3.0 cm and 5.0 cm as shown. The centre of mass of the system is at a point:

\[ C = \frac{1}{2} \]

6. A parallel plate capacitor has plates of area \( A \) separated by distance \( d \) between them. It is filled with a dielectric which has a dielectric constant that varies as \( k = k_0 (1 + \varepsilon) \), where \( \varepsilon \) is the dielectric constant measured from one of the plates. \( \varepsilon_0 \) ( vac ) \( \approx 1 \), the total capacitance of the system is given by the expression:

\[ C = \frac{\varepsilon_0 k_0 d}{1 + \varepsilon} \]

7. The time period of revolution of an electron with ground-state orbital in a hydrogen atom is \( 1.6 \times 10^{-10} \) s. The frequency of the electron in its first excited state \( C(\text{en}, 1) \) is:

\[ f = \frac{1}{T} \]

8. The current \( I \) flowing through a \( 1 \Omega \) resistor in the following circuit is:

\[ I = \frac{V}{R} \]

9. A satellite of mass \( m \) is launched vertically upwards with an initial speed \( v_0 \) from the surface of the earth. After it reaches height \( R \) (radius of the earth), it ejects a rocket of mass \( m_0 \) so that subsequently the satellite moves in a circular orbit. The kinetic energy of the rocket is:

\[ \text{KE} = \frac{1}{2} m_0 v_0^2 \]

10. A long solenoid of radius \( R \) carries a time-dependent current \( I(t) = I_0 (1 - t) \). A ring of radius \( r \) is placed coaxially near its middle. During the time interval \( 0 \leq t \leq 1 \), the induced emf \( (V_r) \) and the induced \( B(r) \) in the ring changes as:

\[ E = \frac{d}{dt} \int_B \Phi = 0 \]

11. The modulus of gyration of a uniform rod of length \( L \) about an axis passing through a point \( P \) away from the centre of the rod, an perpendicular to it is:

\[ K = \sqrt{\frac{I}{M}} \]

12. Two moles of an ideal gas with \( C_p = \frac{5}{2} \) are mixed with 3 moles of another ideal gas with \( C_v = \frac{3}{2} \). The value of \( C_p / C_v \) for the mixture is:

\[ \frac{C_p}{C_v} = \frac{5}{3} \]

13. A little of dry air at STP expands adiabatically to a volume of \( 3 \). By \( \gamma = 1.40 \), the work done by air is:

\[ W = \frac{3}{\gamma} \]

14. Take air to be an ideal gas.
15. A polarized-analyzer set is adjusted such that the intensity of light coming out of the analyzer is just 10% of the original intensity. Assuming that the polarizer-analyzer set does not absorb any light, the angle by which the analyzer needs to be rotated further to reduce the output intensity to be zero, is:

a. 45°  

b. 71.6°  

c. 90°  

d. 18.4°

16. Speed of transverse wave of a straight wire (mass 6.0 g, length 60 cm and area of cross-section 1.0 mm²) is 90 m/s. If the Young's modulus of wire over its natural length is 1 x 10¹¹ N/m², the extension of wire over its natural length is:

17. Two infinite planes each with uniform surface charge density +σ are kept in such a way that the angle between them is 30°. The electric field in the region shown is given by:

18. If we need a magnification of 3.75 from a compound microscope of tube length 15 cm, the focal length of the eye-piece should be, and an objective of focal length 5 cm, close to:

a. 12 m  

b. 33 m  

c. 22 m  

d. 2 m

19. Visible light of wavelength 6000 x 10⁻⁵ m falls normally on a single slit and produces a diffraction pattern. It is found that the second diffraction min. is at 60 from the central max. If the first minimum is produced at B', then B' is close to:

a. 25°  

b. 45°  

c. 30°  

d. 20°

20. Consider a coil of wire carrying current I, forming a magnetic dipole. The magnetic flux through an infinite plane that contains the circular coil and excluding the circular coil area is given by Φ. The magnetic flux through the area is given by φ. Which of the following is correct?

a. Φ = -φ  

b. Φ = φ  

c. φ = 0  

d. φ = Φ

21. A particle of mass 1 kg slides down a frictionless track (ABC) starting from rest at point A (height 2 m). After reaching C, the particle continues to move freely in air as a projectile. When it reaches its highest point P (height 1 m), the kinetic energy of the particle in J is:

22. A Carnot engine operates between two reservoirs, one at 900 K and 300 K. The engine performs 1200 J of work per cycle. The heat energy (in J) delivered by the engine to the low-temperature reservoir, in a cycle, is:

23. A loop ABCDEF of straight edge has six corner points A (0, 0), B (5, 0), C (5, 5), D (0, 5), E (0, 0), and F (0, 0). The magnetic field in this region is B = (3i + 4k) T. The quantity of flux through the loop ABCDEF (in Wb) is:

24. A beam of electromagnetic radiations of intensity 6.4 x 10⁻⁵ W/cm² is composed of wavelength 310 mm. It falls normally on a metal (work function 4 eV). If one in 10³ photons ejects an electron, total number of electrons ejected in 1 s is 10⁶ J (hc = 1240 eV nm, eV = 1.6 x 10⁻¹⁹ J), then x is ————

25. A non-isotropic solid metal cube has coefficients of linear expansion as: 5 x 10⁻⁵ °C along the x-axis and 5 x 10⁻⁵ °C along the y and the z-axis. If coefficient of volume expansion of the solid is C x 10⁻⁴ °C, then the value of C is ————.
1. The relative strength of interionic/intermolecular forces in decreasing order is:
   a) ion-dipole > ion-ion > dipole-dipole > ion-dipole
   b) dipole-dipole > ion-dipole > ion-ion > ion-ion
   c) ion-ion > ion-dipole > dipole-dipole
   d) ion-dipole > ion-ion > dipole-dipole

2. Oxidation number of potassium in K₂O, K₂O₂ and K₂O₂, respectively is:
   a) +1, +2, +3
   b) +2, +3, +4
   c) +1, +3, +5
   d) +3, +5, +7

3. At 35°C, the vapour pressure of CS₂ is 512 mHg and that of acetone is 844 mHg. A solution of CS₂ in acetone has a total vapour pressure of 600 mmHg. The false statement among is:
   a) CS₂ and acetone are less attracted to each other than to themselves
   b) heat must be absorbed in order to produce the solution at 35°C
   c) Raoult's law is not obeyed by this system
   d) a mixture of 100 mL CS₂ and 180 mL acetone has a volume of <280 mL

4. The atomic radius of Ag is closest to:
   a) Ni
   b) Cu
   c) Au
   d) Hg

5. The dipole moments of CH₄, CH₃Cl, and CH₂Cl₂ are in the order:
   a) CH₄ > CH₃Cl > CH₂Cl₂
   b) CH₂Cl₂ > CH₃Cl > CH₄
   c) CH₃Cl > CH₂Cl₂ > CH₄
   d) CH₄ > CH₂Cl₂ > CH₃Cl

6. In comparison to the zeolite process for the removal of permanent hardness, the synthetic zeolite method is:
   a) less efficient as it exchanges only cations
   b) more efficient as it can exchange both cations and anions
   c) as efficient as it can exchange both cations and anions
   d) less efficient as it exchanges only anions

7. Among the following statements that which was not proposed by Dalton was:
   a) Matter consists of invisible atoms
   b) When gases combine or reproduce in a chemical reaction, they do so in simple ratios
   c) Chemical reactions involve reorganization of atoms. These are neither created nor destroyed.
   d) The reacting cannot be generated

8. The increasing order of pKa for the following compounds will be:
   a) NH₂CH₂NH₃⁺
   b) CH₃NH₂
   c) H₃N⁺
   d) NH₃

9. What is the product of the following reaction?
   a) Hex-3-ynal (i) NaOH, H₂O
   b) Hex-3-ynal (ii) PbO₂ (iii) Mg/ether
   c) Hex-3-ynal (iv) CO₂/NaOH

10. The number of orbitals associated with quantum numbers n = 5, m_s = 1/2 is:

11. The unit cell form of commercial iron is:
   a) Bcc
   b) Fcc
   c) Hexagonal

12. The theory that can completely/properly explain the nature of bonding in [Ni(CO)₄]₂⁻ is:
   a) Werner's theory
   b) Crystal field theory
   c) Molecular orbital theory
   d) Valence bond theory

13. The IUPAC name of the complex [Pt(NH₃)₂Cl(NH₂CH₃)]Cl is:

14. 1-methyl ethylene oxide when treated with an excess of HBr produces:

15. Consider the following reaction:

   The product X is used:
   a) in protein estimation as an alternative to ninhydrin
   b) as food grade coalescnet
   c) in laboratory test for phenols
   d) in acid base titration as an indicator

16. Match the following:
   a) Riboflavin
   b) Thyroxine
   c) Biotin
   d) Tetracycline

   1) Selenium
   2) Beriberi
   3) Pantothenic acid
   4) Iodine

17. The reaction of H₃N⁺ + Na⁺ : SO₃⁻ → N₂Cl⁻ + X⁻ is:

   a) as food grade coalescent
   b) in acid base titration as an indicator
   c) in laboratory test for phenols
   d) in protein estimation as an alternative to ninhydrin
17. Given that the standard potentials \( E^\circ \) of \( Cu^2+ / Cu \) and \( Cu^+ / Cu \) are 0.34 V and 0.522 V, respectively, the \( E^\circ \) of \( Cu^{1+} / Cu \) is:

18. A solution of m-chlorophenol, m-chlorobenzaldehyde, and m-chlorobenzoic acid is methyl
acetate was extracted initially with a saturated solution of \( NaHCO_3 \) to give fraction A. The
leftover organic phase was extracted with dilute \( NaOH \) solution to give fraction B. The
final organic layer was labelled as fraction C. Fractions A, B and C contain resp:

19. The electron gain enthalpy (in kJ/mol) of fluorine, chlorine, bromine, iodine, resp.
are:

20. Consider the following reactions: a) \( CH_3CHO + CH_2OH \rightarrow \) b) \( CH_3CH_2OH \rightarrow \) c) \( CH_3CH_2OH \rightarrow \) d) \( CH_3CH_2OH \rightarrow \) Which of these reaction(s) will not yield products? OH

21. Two solutions A and B, each of 10 L, was made by dissolving 49 g of \( NaOH \) and 9.8 g of
\( H_2SO_4 \) in water, resp. The pH of the resultant solution obtained from mixing 40 L of
solution A and 10 L of solution B is:

22. During the nuclear explosion, one of the products of \( ^{90}Sr \) was absorbed in the bones
of a newly born baby in place of \( Ca \). How much time, in years, is required to reduce it by 90% if
it is not lost metabolically?

23. Chlorine reacts with hot and concentrated \( NaOH \) and produces compound (X) and
(Y). Compound (X) gives white precipitate with silver nitrate solution. The avg
bond order between C1 and O1 atom in (Y) is

24. The number of \( \sigma \)-bonds in \( CH_2OH \) is

25. For the reaction \( A (s) \rightarrow B (g) \)
\[ \Delta U = -2.1 \text{ Kcal}, \Delta S = 2.0 \text{ cal K}^{-1} \text{ atm}^{-1}, K = 3 \times 10^3 \text{ at } 300 \text{ K} \]
Hence \( \Delta G \) in Kcal is:

Mathematics

1. If \( f(a + b + n - x) = f(x) \), for all \( n \), where \( a \) and \( b \) are fixed positive real numbers,
then \( \int_a^{a+b} x f(n + x) \, dx \) is equal to:

2. Let \( \alpha \) and \( \beta \) be two equal roots of the equation \( (n+1)x^2 + \sqrt{2}x + \tan x = 1 - K \),
where \( K \neq 1 \) and \( x \) are real numbers. If \( \tan \frac{\alpha + \beta}{2} = 50 \), then the value of \( \lambda \) is:

3. Total number of 6 digit numbers, in which only and all the five digits 1, 3, 5, 7 and
9 appear is:

4. If \( y = mx + 4 \) is a tangent to both the parabolas \( y^2 = 4x \) and \( x^2 = 2by \), then \( b \)
is equal to:

5. Let \( \alpha \) be a root of the equation \( x^2 + x + 1 = 0 \) and the matrix \( A = \frac{1}{\sqrt{3}} \begin{bmatrix} 1 & \alpha & \alpha^2 \\ \alpha & \alpha^2 & \alpha \\ \alpha^2 & \alpha & 1 \end{bmatrix} \), then the matrix \( A^{31} \) is equal to:

6. If \( y = g(x) \) is the solution of the differential equation, \( \frac{dy}{dx} - 1 = e^x \) such that \( y(0) = 0 \), then \( y(1) \) is equal to:

7. If \( y(x) = \frac{1}{2} \left( \tan \frac{x}{2} + \cot \frac{x}{2} \right), x \in \left[ \frac{3\pi}{4}, \frac{5\pi}{4} \right] \), then \( \frac{dy}{dx} \) at \( x = \frac{3\pi}{4} \) is:

8. Let the function \( f : [-7, 0] \rightarrow R \) be continuous on \([-7, 0]\) and differentiable on \((-7, 0)\). If \( f(-7) = 3 \) and \( f'(x) \leq 2 \), for all \( x \in (-7, 0) \), and for all such \( f' \), \( f(-1) + f(0) \) lies in the interval:
10. If the distance between the foci of an ellipse is 6 and the distance between its directrices is 12, then the length of its latus rectum is:

11. The greatest positive integer k, for which \(49^k + 1\) is a factor of the sum:

\[49^{12} + 49^{14} + \ldots + 49^2 + 49 + 1\].

a) 65  
b) 32  
c) 60  
d) 1563

12. Let \(P\) be a plane passing through the pts. \((2, 1, 0), (4, 1, 1)\) and \((3, 0, 1)\) and \(K\) be any point \((2, 1, 1)\). Then the image of \(K\) in the plane \(P\) is:

13. If the system of linear equations:

\[2x + 2ay + az = 0\]
\[2x + 3by + bz = 0\]
\[2x + 4cy + cz = 0\]

where \(a, b, c \in \mathbb{R}\) are non-zero and distinct, have non-zero solution then:

- \(a \neq b \neq c\) are in A.P. 
- \(b \neq a \neq c\) are in A.P. 
- \(a, b, c\) are in G.P.
- \(a + b + c = 0\)

14. The area of the region enclosed by the circle \(x^2 + y^2 = 2\) which is not common to the region bounded by the parabola \(y^2 = x\) and the straight line \(y = x\), is:

15. The logical statement \((p \Rightarrow q) \land (q \Rightarrow r)\) is equivalent to:

a) \(p \Rightarrow q\)  
b) \(p \land q\)  
c) \(p \land r\)  
d) \(q \Rightarrow r\)

16. An unbiased coin is tossed 5 times. Suppose that a variable \(X\) is assigned the value \(k\) when \(k\) consecutive heads are obtained for \(k = 3, 4, 5\), otherwise \(X\) takes the value \(-1\). The expected value of \(X\), is:

17. Let \(x^2 + y^2 = a^2 (a > 0)\) and \(dy/(dx) = -\frac{3}{2}\), then \(a^2\) is:

18. If \(\text{Re}\left(\frac{2 - i}{2z + 1}\right) = 1\), where \(z = x + iy\), then the point \((x, y)\) lies on:

- a. straight line whose slope is \(-\frac{2}{3}\)
- b. circle whose centre is \((\frac{\sqrt{2}}{2}, -\frac{3}{2})\)

19. If \(g(x) = x^2 + x - 1\) and \((g \circ f)(x) = 4x^2 - 10x + 5\), then \(f(\frac{5}{3})\) is equal to:

20. Five numbers are in A.P. whose sum is 25 and product is 2520. If one of these five numbers is \(-\frac{1}{2}\), then the greatest number amongst them is:

\(a) \frac{2}{3}\)  
\(b) 10\)  
\(c) 27\)  
\(d) 7\)

21. Let \(A(1, 0), B(6, 1)\) and \(C(\frac{3}{2}, 6)\) be the vertices of a triangle \(ABC\). If \(P\) is a point inside the \(\triangle ABC\) such that \(\Delta APC\), \(\Delta PBC\) and \(\Delta PBA\) have equal areas, then the length of the line segment \(PR\), where \(Q\) is the point \((-\frac{7}{3}, -\frac{1}{3})\), is:

22. If the variance of the first \(n\) natural numbers is 10 and the variance of the first \(m\) even natural numbers is 16, then \(m + n\) is equal to:

\(a) 23\)  
\(b) 25\)  
\(c) 27\)  
\(d) 29\)
24. If the sum of the coefficients of all even powers of $x$ in the product $(1 + x + x^2 + \ldots + x^n)(1 - x + x^2 - x^3 + \ldots + x^n)$ is $61$, then $n$ is equal to.

25. Let $S$ be the set of all points where the function $f(x) = |2x - 1|$, $x \in \mathbb{R}$, is not differentiable. Then $\sum_{x \in S} f(x)$ is equal to.