1. Two blocks $A$ and $B$ of masses $3m$ and $m$ respectively are connected by a massless and inextensible string. The whole system is suspended by a massless spring as shown in figure. The magnitudes of acceleration of $A$ and $B$ immediately after the string is cut, are respectively
(a) $g$, $\frac{\bar{g}}{3}$  
(b) $\frac{\bar{g}}{3}$, $g$  
(c) $g$, $g$  
(d) $\frac{\bar{g}}{3}$, $\frac{\bar{g}}{3}$

2. The acceleration due to gravity at a height 1 km above the earth is the same as at a depth $d$ below the surface of earth. Then
(a) $d = \frac{1}{2}$ km  
(b) $d = 1$ km  
(c) $d = \frac{3}{2}$ km  
(d) $d = 2$ km

3. A particle executes linear simple harmonic motion with an amplitude of 3 cm. When the particle is at 2 cm from the mean position, the magnitude of its velocity is equal to that of its acceleration. Then, its time period in seconds is
(a) $\frac{\sqrt{5}}{\pi}$  
(b) $\frac{\sqrt{5}}{2\pi}$  
(c) $\frac{4\pi}{\sqrt{5}}$  
(d) $\frac{2\pi}{\sqrt{3}}$

4. The resistance of a wire is $R$ ohm. If it is melted and stretched to $n$ times its original length, its new resistance will be
(a) $nR$  
(b) $\frac{R}{n}$  
(c) $n^2R$  
(d) $\frac{R}{n^2}$

5. A capacitor is charged by a battery. The battery is removed and another identical uncharged capacitor is connected in parallel. The total electrostatic energy of resulting system
(a) increases by a factor of 4  
(b) decreases by a factor of 2  
(c) remains the same  
(d) increases by a factor of 2

6. Two rods $A$ and $B$ of different materials are welded together as shown in figure. Their thermal conductivities are $K_1$ and $K_2$. The thermal conductivity of the composite rod will be
(a) $\frac{K_1 + K_2}{2}$  
(b) $\frac{3(K_1 + K_2)}{2}$  
(c) $K_1 + K_2$  
(d) $2(K_1 + K_2)$
7. The two nearest harmonics of a tube closed at one end and open at other end are 220 Hz and 260 Hz. What is the fundamental frequency of the system?
(a) 10 Hz  (b) 20 Hz  (c) 30 Hz  (d) 40 Hz

8. The bulk modulus of a spherical object is $B$. If it is subjected to uniform pressure $p$, the fractional decrease in radius is
(a) $\frac{p}{B}$  (b) $\frac{3p}{B}$  (c) $\frac{3p}{2B}$  (d) $\frac{p}{3B}$

9. A physical quantity of the dimensions of length that can be formed out of $c$, $G$ and $\frac{e^2}{4\pi\varepsilon_0}$ is [c is velocity of light, $G$ is universal constant of gravitation and $e$ is charge]
(a) $\frac{1}{c^2} \left[ \frac{G}{4\pi\varepsilon_0} \right]^{3/2}$  (b) $c^2 \left[ \frac{G}{4\pi\varepsilon_0} \right]^{3/2}$
(c) $\frac{1}{c^2} \left[ \frac{e^2}{4\pi\varepsilon_0} \right]^{3/2}$  (d) $\frac{1}{c} \left[ \frac{e^2}{4\pi\varepsilon_0} \right]^{3/2}$

10. Figure shows a circuit that contains three identical resistors with resistance $R = 9.0 \ \Omega$ each, two identical inductors with inductance $L = 2.0 \ \text{mH}$ each, and an ideal battery with emf $\varepsilon = 18 \ \text{V}$. The current $i$ through the battery just after the switch closed is

(a) $2 \ \text{mA}$  (b) $0.2 \ \text{A}$  (c) $2 \ \text{A}$  (d) $0 \ \text{A}$

11. One end of the string of length $l$ is connected to a particle of mass $m$ and the other end is connected to a small peg on a smooth horizontal table. If the particle moves in circle with speed $v$, the net force on the particle (directed towards center) will be ($T$ represents the tension in the string)
(a) $T$  (b) $T + \frac{mv^2}{l}$  (c) $T - \frac{mv^2}{l}$  (d) Zero

12. The photoelectric threshold wavelength of silver is $3250 \times 10^{-10} \ \text{m}$. The velocity of the electron ejected from a silver surface by ultraviolet light of wavelength $2536 \times 10^{-10} \ \text{m}$ is (Given, $h = 4.14 \times 10^{-15} \text{eVs}$ and $c = 3 \times 10^8 \text{ms}^{-1}$)
(a) $6 \times 10^6 \text{ms}^{-1}$  (b) $0.6 \times 10^6 \text{ms}^{-1}$  (c) $61 \times 10^3 \text{ms}^{-1}$  (d) $0.3 \times 10^6 \text{ms}^{-1}$

13. Radioactive material $A$ has decay constant $\lambda$ and material $B$ has decay constant $\lambda$. Initially, they have same number of nuclei. After what time, the ratio of number of nuclei of material $B$ to that $A$ will be $\frac{1}{e}$
(a) $\frac{1}{\lambda}$  (b) $\frac{1}{7\lambda}$  (c) $\frac{1}{8\lambda}$  (d) $\frac{1}{9\lambda}$

14. A rope is wound around a hollow cylinder of mass 3 kg and radius 40 cm. What is the angular acceleration of the cylinder, if the rope is pulled with a force of 30 N?
(a) $25 \text{ m/s}^2$  (b) $0.25 \text{ rad/s}^2$  (c) $25 \text{ rad/s}^2$  (d) $5 \text{ m/s}^2$

15. Two cars moving in opposite directions approach each other with speed of 22 m/s and 16.5 m/s respectively. The driver of the first car blows a horn having a frequency 400 Hz. The frequency heard by the driver of the second car is [velocity of sound 340 m/s]
(a) $350 \ \text{Hz}$  (b) $361 \ \text{Hz}$  (c) $411 \ \text{Hz}$  (d) $448 \ \text{Hz}$

16. A 250-turn rectangular coil of length 2.1 cm and width 1.25 cm carries a current of 85 $\mu$A and subjected to a magnetic field of strength 0.85 T. Work done for rotating the coil by $180^\circ$ against the torque is
(a) 9.1 $\mu$J  (b) 4.55 $\mu$J  (c) 2.3 $\mu$J  (d) 1.5 $\mu$J

17. A long solenoid of diameter 0.1 m has $2 \times 10^4$ turns per metre. At the centre of the solenoid, a coil of 100 turns and radius 0.01 m is placed with its axis coinciding with the solenoid axis. The current in the solenoid reduces at a constant rate to 0 A
from 4 A in 0.05 s. If the resistance of the coil is $10\pi^2 \, \Omega$, the total charge flowing through the coil during this time is

(a) $32\pi \, \mu C$  
(b) $16\mu C$  
(c) $32 \, \mu C$  
(d) $16\pi \, \mu C$

18. Suppose the charge of a proton and an electron differ slightly. One of them is $-e$ and the other is $(e + \Delta e)$. If the net of electrostatic force and gravitational force between two hydrogen atoms placed at a distance $d$ (much greater than atomic size) apart is zero, then $\Delta e$ is of the order [Given mass of hydrogen, $m_h = 1.67 \times 10^{-27} \, \text{kg}$]

(a) $10^{20}$ C  
(b) $10^{23}$ C  
(c) $10^{37}$ C  
(d) $10^{47}$ C

19. Two astronauts are floating in gravitational free space after having lost contact with their spacecraft. The two will

(a) keep floating at the same distance between them  
(b) move towards each other  
(c) move away from each other  
(d) will become stationary

20. The ratio of wavelengths of the last line of Balmer series and the last line of Lyman series is

(a) 2  
(b) 1  
(c) 4  
(d) 0.5

21. The de-Broglie wavelength of a neutron in thermal equilibrium with heavy water at a temperature $T$ (Kelvin) and mass $m$, is

(a) $\frac{h}{\sqrt{2mkT}}$  
(b) $\frac{h}{\sqrt{3mkT}}$  
(c) $\frac{h}{\sqrt{2mkT}}$  
(d) $\frac{h}{\sqrt{mkT}}$

22. A thin prism having refracting angle 10° is made of glass of refractive index 1.42. This prism is combined with another thin prism of glass of refractive index 1.7. This combination produces dispersion without deviation. The refracting angle of second prism should be

(a) 4°  
(b) 6°  
(c) 8°  
(d) 10°

23. Thermodynamic processes are indicated in the following diagram

Match the following:

<table>
<thead>
<tr>
<th>Column-I</th>
<th>Column-II</th>
</tr>
</thead>
<tbody>
<tr>
<td>P. Process I</td>
<td>a. Adiabatic</td>
</tr>
<tr>
<td>Q. Process II</td>
<td>b. Isobaric</td>
</tr>
<tr>
<td>R. Process III</td>
<td>c. Isochoric</td>
</tr>
<tr>
<td>S. Process IV</td>
<td>d. Isothermal</td>
</tr>
</tbody>
</table>

(a) P→a, Q→c, R→d, S→b  
(b) P→c, Q→a, R→d, S→b  
(c) P→c, Q→d, R→b, S→a  
(d) P→d, Q→b, R→a, S→c

24. A U tube with both ends open to the atmosphere, is partially filled with water. Oil, which is immiscible with water, is poured into one side until it stands at a distance of 10 mm above the water level on the other side. Meanwhile the water rises by 65 mm from its original level (see diagram). The density of the oil is

(a) 650 kg m$^{-3}$  
(b) 425 kg m$^{-3}$  
(c) 800 kg m$^{-3}$  
(d) 928 kg m$^{-3}$

25. A spring of force constant $k$ is cut into lengths of ratio 1 : 2 : 3. They are connected in series and the new force constant is $k'$. If they are connected in parallel and force constant is $k''$, then $k':k''$ is

(a) 1 : 6  
(b) 1 : 9  
(c) 1 : 11  
(d) 1 : 14
26. Which of the following statements are correct?
   1. Centre of mass of a body always coincides with the centre of gravity of the body.
   2. Centre of mass of a body is the point at which the total gravitational torque on the body is zero.
   3. A couple on a body produce both translational and rotational motion in a body.
   4. Mechanical advantage greater than one means that small effort can be used to lift a large load.

(a) (2) and (4)  (b) (1) and (2)
(c) (2) and (3)  (d) (3) and (4)

27. A beam of light from a source $L$ is incident normally on a plane mirror fixed at a certain distance $x$ from the source. The beam is reflected back as a spot on a scale placed just above the source $L$. When the mirror is rotated through a small angle $\theta$, the spot of the light is found to move through a distance $y$ on the scale. The angle $\theta$ is given by

(a) $\frac{y}{x}$  (b) $\frac{y}{x}$  (c) $\frac{x}{2y}$  (d) $\frac{x}{y}$

28. A gas mixture consists of 2 moles of $O_2$ and 4 moles of Ar at temperature $T$. Neglecting all vibrational modes, the total internal energy of the system is

(a) $4RT$  (b) $15RT$  (c) $9RT$  (d) $11RT$

29. Consider a drop of rain water having mass 1 g falling from a height of 1 km. It hits the ground with a speed of 50 m/s. Take $g$ constant with a value of 10 m/s$^2$. The work done by the (i) gravitational force and the (ii) resistive force of air is

(a) (i) $-10$ J, (ii) $-8.25$ J  (b) (i) $1.25$ J, (ii) $-8.25$ J
(c) (i) $100$ J, (ii) $8.75$ J  (d) (i) $10$ J, (ii) $-875$ J

30. A Carnot engine having an efficiency of $\frac{1}{10}$ as heat engine, is used as a refrigerator. If the work done on the system is 10 J, the amount of energy absorbed from the reservoir at lower temperature is

(a) 1 J  (b) 90 J  (c) 99 J  (d) 100 J

31. An arrangement of three parallel straight wires placed perpendicular to plane of paper carrying same current $I$ along the same direction is shown in figure. Magnitude of force per unit length on the middle wire $B$ is given by

(a) $\frac{\mu_0 I^2}{2\pi d}$  (b) $\frac{2\mu_0 I^2}{\pi d}$  (c) $\frac{\sqrt{2}\mu_0 I^2}{\pi d}$  (d) $\mu_0 I^2$  

32. The $x$ and $y$ coordinates of the particle at any time are $x = 5t - 2t^2$ and $y = 10t$ respectively, where $x$ and $y$ are in metres and $t$ in seconds. The acceleration of the particle at $t = 2$ s is

(a) 0  (b) 5 m/s$^2$  (c) $-4$ m/s$^2$  (d) $-8$ m/s$^2$

33. The ratio of resolving powers of an optical microscope for two wavelengths $\lambda_1 = 4000$ Å and $\lambda_2 = 6000$ Å is

(a) 8 : 27  (b) 9 : 4  (c) 3 : 2  (d) 16 : 81

34. Preeti reached the metro station and found that the escalator was not working. She walked up the stationary escalator in time $t_1$. On other days, if she remains stationary on the moving escalator, then the escalator takes her up in time $t_2$. The time taken by her to walk up on the moving escalator will be

(a) $\frac{t_1 + t_2}{2}$  (b) $\frac{2t_2}{t_2 - t_1}$  (c) $\frac{t_2}{t_2 + t_1}$  (d) $t_1 - t_2$

35. A spherical black body with a radius of 12 cm radiates 450 watt power at 500 K. If the radius were halved and the temperature doubled, the power radiated in watt would be

(a) 225  (b) 450  (c) 1000  (d) 1800

36. A potentiometer is an accurate and versatile device to make electrical measurement of EMF because the method involves

(a) cells  (b) potential gradients
(c) a condition of no current flow through the galvanometer  (d) a combination of cells, galvanometer and resistances
37. The given electrical network is equivalent to

(a) AND gate  (b) OR gate  
(c) NOR gate  (d) NOT gate

38. In a common emitter transistor amplifier, the audio signal voltage across the collector is 3 V. The resistance of collector is 3 kΩ. If current gain is 100 and the base resistance is 2 kΩ, the voltage and power gain of the amplifier is

(a) 200 and 1000  
(b) 15 and 200  
(c) 150 and 15000  
(d) 20 and 2000

39. Two discs of same moment of inertia rotating about their regular axis passing through centre and perpendicular to the plane of disc with angular velocities \( \omega_1 \) and \( \omega_2 \). They are brought into contact face to face coinciding the axis of rotation. The expression for loss of energy during this process is

(a) \( \frac{1}{2} (\omega_1 + \omega_2)^2 \)  
(b) \( \frac{1}{4} (\omega_1 - \omega_2)^2 \)  
(c) \( \frac{1}{8} (\omega_1 - \omega_2)^2 \)  
(d) \( \cot \theta \cot \theta \cot \theta \)  

40. Young’s double slit experiment is first performed in air and then in a medium other than air. It is found that 8th bright fringe in the medium lies where 5th dark fringe lies in air. The refractive index of the medium is nearly

(a) 1.25  
(b) 1.59  
(c) 1.69  
(d) 1.78

41. Which one of the following represents forward bias diode?

(a) 0V \[ \rightarrow \] R \[ \rightarrow \] -2V  
(b) -4V \[ \rightarrow \] R \[ \rightarrow \] -3V  
(c) -2V \[ \rightarrow \] R \[ \rightarrow \] +2V  
(d) 3V \[ \rightarrow \] R \[ \rightarrow \] 5V

42. Two polaroids \( P_1 \) and \( P_2 \) are placed with their axis perpendicular to each other. Unpolarised light \( I_0 \) is incident on \( P_1 \). A third polaroid \( P_2 \) is kept in between \( P_1 \) and \( P_2 \) such that its axis makes an angle 45° with that of \( P_1 \). The intensity of transmitted light through \( P_2 \) is

(a) \( \frac{I_0}{2} \)  
(b) \( \frac{I_0}{4} \)  
(c) \( \frac{I_0}{8} \)  
(d) \( \frac{I_0}{16} \)

43. In an electromagnetic wave in free space the root mean square value of the electric field is \( E_{rms} = 6 \) V/m. The peak value of the magnetic field is

(a) \( 1.41 \times 10^{-8} \) T  
(b) \( 2.83 \times 10^{-8} \) T  
(c) \( 0.70 \times 10^{-8} \) T  
(d) \( 4.23 \times 10^{-8} \) T

44. If \( \theta_1 \) and \( \theta_2 \) be the apparent angles of dip observed in two vertical planes at right angles to each other, then the true angle of dip \( \theta \) is given by

(a) \( \cot^2 \theta = \cot^2 \theta_1 + \cot^2 \theta_2 \)  
(b) \( \tan^2 \theta = \tan^2 \theta_1 + \tan^2 \theta_2 \)  
(c) \( \cot^2 \theta = \cot^2 \theta_1 - \cot^2 \theta_2 \)  
(d) \( \tan^2 \theta = \tan^2 \theta_1 - \tan^2 \theta_2 \)

45. The diagrams below show regions of equipotentials.

A positive charge is moved from A to B in each diagram.

(a) Maximum work is required to move \( q \) in figure (iii)  
(b) In all the four cases, the work done is the same  
(c) Minimum work is required to move \( q \) in figure (i)  
(d) Maximum work is required to move \( q \) in figure (ii)
1. The reason for greater range of oxidation states in actinoids is attributed to:
   (a) the radioactive nature of actinoids
   (b) actinoid contraction
   (c) $5f$, $6d$ and $7s$ levels having comparable energies
   (d) $4f$ and $5d$ levels being close in energies

2. An example of a sigma bonded organometallic compound is:
   (a) ruthenocene
   (b) Grignard’s reagent
   (c) ferrocene
   (d) cobaltocene

3. Which one is the wrong statement?
   (a) de-Broglie’s wavelength is given by $\lambda = \frac{\hbar}{mv}$, where $m$ = mass of the particle, $v$ = group velocity of the particle
   (b) The uncertainty principle is $\Delta E \Delta t \geq \hbar / 4\pi$
   (c) Half-filled and fully filled orbitals have greater stability due to greater exchange energy, greater symmetry and more balanced arrangement
   (d) The energy of $2s$-orbital is less than the energy of $2p$-orbital in case of hydrogen like atoms

4. Mixture of chloroxylenol and terpineol acts as:
   (a) analgesic
   (b) antiseptic
   (c) antipyretic
   (d) antibiotic

5. The element $Z = 114$ has been discovered recently. It will belong to which of the following family/group and electronic configuration?
   (a) Halogen family, [Rn] $5f^{14}6d^{10}7s^27p^5$
   (b) Carbon family, [Rn] $5f^{14}6d^{10}7s^27p^2$
   (c) Oxygen family, [Rn] $5f^{14}6d^{10}7s^27p^4$
   (d) Nitrogen family, [Rn] $5f^{14}6d^{10}7s^27p^6$

6. A 20 litre container at 400 K contains $\text{CO}_2(g)$ at pressure 0.4 atm and an excess of SrO (neglect the volume of solid SrO). The volume of the container is now decreased by moving the movable piston fitted in the container. The maximum volume of the container, when pressure of $\text{CO}_2$ attains its maximum value, will be

   [Given that: $\text{SrCO}_3(s) \rightleftharpoons \text{SrO}(s) + \text{CO}_2(g)$]
   (a) 5 L (b) 10 L (c) 4 L (d) 2 L

7. Predict the correct intermediate and product in the following reaction.
   $\text{H}_2\text{C} = \text{C} \rightleftharpoons \text{CH}(\text{H}_2\text{O})\text{H}_2\text{SO}_4 \rightarrow \text{Intermediate} \rightarrow \text{Product}$
   (A) $A = \text{H}_2\text{C} = \text{C} \rightleftharpoons \text{CH}_3; B = \text{H}_2\text{C} = \text{C} \rightleftharpoons \text{CH}_3$
   (B) $A = \text{H}_2\text{C} = \text{C} \rightleftharpoons \text{CH}_3; B = \text{H}_2\text{C} = \text{C} \rightleftharpoons \text{CH}_3$
   (c) $A = \text{H}_2\text{C} = \text{C} \rightleftharpoons \text{CH}_3; B = \text{H}_2\text{C} = \text{C} \rightleftharpoons \text{CH}_3$
   (d) $A = \text{H}_2\text{C} = \text{C} \rightleftharpoons \text{CH}_3; B = \text{H}_2\text{C} = \text{C} \rightleftharpoons \text{CH}_3$

8. Which of the following is a sink for CO?
   (a) Haemoglobin
   (b) Microorganisms present in the soil
   (c) Oceans
   (d) Plants

9. Which of the following reactions is appropriate for converting acetaldehyde to methanamine?
   (a) Carbylamine reaction
   (b) Hofmann hypobromamide reaction
   (c) Stephens reaction
   (d) Gabriels phthalimide synthesis

10. The species, having bond angles of 120° is:
    (a) PH$_3$
    (b) CIF$_3$
    (c) NCl$_3$
    (d) BCl$_3$

11. The correct order of the stoichiometrics of AgCl formed when AgNO$_3$ in excess is treated with the complexes: $\text{CoCl}_3 \cdot 6\text{NH}_3$, $\text{CoCl}_3 \cdot 5\text{NH}_3$, $\text{CoCl}_3 \cdot 4\text{NH}_3$ respectively is
    (a) 1 AgCl, 3 AgCl, 2 AgCl
    (b) 3 AgCl, 1 AgCl, 2 AgCl
    (c) 3 AgCl, 2 AgCl, 1 AgCl
    (d) 2 AgCl, 3 AgCl, 1 AgCl
12. For a given reaction, $\Delta H = 35.5 \text{ kJ mol}^{-1}$ and $\Delta S = 83.6 \text{ JK mol}^{-1}$. The reaction is spontaneous at: (Assume that $\Delta H$ and $\Delta S$ do not vary with temperature)

(a) $T < 425 \text{ K}$  
(b) $T > 425 \text{ K}$

(c) all temperatures  
(d) $T > 298 \text{ K}$

13. Match the interhalogen compounds of Column I with the geometry in Column II and assign the correct code.

<table>
<thead>
<tr>
<th>Column I</th>
<th>Column II</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. $XX^-$</td>
<td>(i) T- shape</td>
</tr>
<tr>
<td>B. $XX'_3$</td>
<td>(ii) Pentagonal bipyramidal</td>
</tr>
<tr>
<td>C. $XX'_5$</td>
<td>(iii) Linear</td>
</tr>
<tr>
<td>D. $XX'_7$</td>
<td>(iv) Square-pyramidal</td>
</tr>
<tr>
<td></td>
<td>(v) Tetrahedral</td>
</tr>
</tbody>
</table>

Code

A B C D
(a) (iii) (iv) (i) (ii)
(b) (vi) (i) (iv) (ii)
(c) (v) (vi) (i) (ii)
(d) (iv) (iii) (ii) (i)

14. Identify A and predict the type of reaction,

\[ \text{Cyclic} \quad \text{(I)} \quad \text{OCH}_3 \quad \text{Br} \quad \text{NaH}_2 \]

(a) and substitution reaction
(b) and elimination addition reaction
(c) and cine substitution reaction
(d) and cine substitution reaction

15. Which one of the following statements is not correct?

(a) Catalyst does not initiate any reaction
(b) The value of equilibrium constant is changed in the presence of a catalyst in the reaction equilibrium
(c) Enzymes catalyse mainly biochemical reaction
(d) Coenzymes increase the catalytic activity of enzyme

16. Name the gas that can readily decolourise acidified KMnO$_4$ solution.

(a) CO$_2$  
(b) SO$_2$  
(c) NO$_2$  
(d) P$_2$O$_5$

17. The correct increasing order of basic strength for the following compounds is

(a) $\text{NH}_2$  
(b) $\text{NH}_2$  
(c) $\text{NH}_2$  
(d) $\text{CH}_3$

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<table>
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<tbody>
<tr>
<td>(i)</td>
<td>(ii)</td>
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<td>(iii)</td>
<td>(iv)</td>
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<td>(v)</td>
<td>(vi)</td>
</tr>
</tbody>
</table>

Code

A B C D
(a) (ii) (i) (ii) (i)
(b) (ii) (i) (ii) (i)
(c) (ii) (i) (ii) (i)
(d) (ii) (i) (ii) (i)

18. If molality of the dilute solution is doubled, the value of molal depression constant ($K_f$) will be

(a) doubled  
(b) halved  
(c) tripled  
(d) unchanged

19. Of the following which is the product formed when cyclohexanone undergoes aldol condensation followed by heating?

(a)  
(b)  
(c)  
(d)  

20. The equilibrium constants of the following are

- $\text{N}_2 + 3\text{H}_2 \rightleftharpoons 2\text{NH}_3$: $K_1$
- $\text{N}_2 + \text{O}_2 \rightleftharpoons 2\text{NO}$: $K_2$
- $\text{H}_2 + \frac{1}{2}\text{O}_2 \rightarrow \text{H}_2\text{O}$: $K_3$
The equilibrium constant \( (K) \) of the reaction

\[
2\text{NH}_4 + \frac{5}{2}\text{O}_2 \xrightarrow{K} 2\text{NO} + 3\text{H}_2\text{O}
\]

will be

(a) \( K_1 K_2^2 / K_3 \)

(b) \( K_2 K_3^2 / K_1 \)

(c) \( K_2 K_3 / K_1 \)

(d) \( K_2^2 K_3 / K_1 \)

21. The correct statement regarding electrophile is

(a) Electrophile is a negatively charge species and can form a bond by accepting a pair of electrons from a nucleophile

(b) Electrophile is a negatively charged species and can form a bond by accepting a pair of electrons from another electrophile

(c) Electrophiles are generally neutral species and can form a bond by accepting a pair of electrons from a nucleophile

(d) Electrophile can be either neutral or positively charged species and can form a bond by accepting a pair of electrons from a nucleophile

22. A gas is allowed to expand in a well insulated container against a constant external pressure of 2.5 atm from an initial volume of 2.50 L to a final volume of 4.50 L. The change in internal energy \( \Delta U \) of the gas in joules will be

(a) 1136.25 J

(b) \( -500 J \)

(c) \( -505 J \)

(d) \( +505 J \)

23. Which of the following pairs of compounds is isoelectronic and isostructural?

(a) BeCl_2, XeF_2

(b) TeI_2, XeF_2

(c) IBr, XeF_2

(d) IF_3, XeF_2

24. Which is the incorrect statement?

(a) FeO_{0.98} has non-stoichiometric metal deficiency defect

(b) Density decreases in case of crystals with Schottky's defect

(c) NaCl(\text{s}) is insulator, silicon is semiconductor, silver is conductor, quartz is piezoelectric crystal

(d) Frenkel defect is favoured in those ionic compounds in which sizes of cation and anions are almost equal

25. The heating of phenyl-methyl ethers with HI produces.

(a) Ethyl chlorides

(b) Iodobenzene

(c) Phenol

(d) Benzene

26. Correct increasing order for the wavelengths of absorption in the visible region for the complexes of CO^2+ is

(a) [Co(en)_3]^{3+}, [Co(NH_3)_6]^{3+}, [Co(H_2O)_6]^{3+}

(b) [Co(H_2O)_6]^{3+}, [Co(en)_3]^{3+}, [Co(NH_3)_6]^{3+}

(c) [Co(H_2O)_6]^{3+}, [Co(NH_3)_6]^{3+}, [Co(en)_3]^{3+}

(d) [Co(NH_3)_6]^{3+}, [Co(en)_3]^{3+}, [Co(H_2O)_6]^{3+}

27. Pick out the correct statement with respect to [Mn(CN)_6]^{3-}.

(a) It is sp^3d^2 hybridised and octahedral

(b) It is sp^3d^2 hybridised and tetrahedral

(c) It is d^2sp^3 hybridised and octahedral

(d) It is dsp^2 hybridised and square planar

28. With respect to the conformers of ethane, which of the following statements is true?

(a) Bond angle remains same but bond length changes

(b) Bond angle changes but bond length remains same

(c) Both bond angle and bond length change

(d) Both bond angles and bond length remain same

29. Which of the following is dependent on temperature?

(a) Molality

(b) Molarity

(c) Mole fraction

(d) Weight percentage

30. Which of the following statements is not correct?

(a) Insulin maintains sugar level in the blood of a human body

(b) Ovalbumin is a simple food reserve in egg white

(c) Blood proteins thrombin and fibrinogen are involved in blood clotting

(d) Denaturation makes the proteins more active

31. The IUPAC name of the compound

\[
\text{H} \quad \text{C} \quad \text{O} \quad \text{O} \quad \text{is} \quad \text{...........}
\]

(a) 3-keto-2-methylhex-4-enal

(b) 5-formylhex-2-en-3-one

(c) 5-methyl-4-oxohex-2-en-5-al

(d) 3-keto-2-methylhex-5-enal
32. HgCl₂ and I₂ both when dissolved in water containing I⁻ ions the pair of species formed is
(a) HgI₂, I³⁻ (b) HgI₂, I⁻
(c) HgI₄²⁻, I₅⁻ (d) HgJ₂, J⁻

33. It is because inability of ns² electrons of the valence shell to participate in bonding that
(a) Sn²⁺ is reducing while Pb⁴⁺ is oxidising
(b) Sn²⁺ is oxidising while Pb⁴⁺ is reducing
(c) Sn²⁺ and Pb²⁺ are both oxidising and reducing
(d) Sn²⁺ is reducing while Pb⁴⁺ is oxidising

34. Mechanism of a hypothetical reaction

X₂ + Y₂ → 2XY is given below
(i) X₂ ↔ X + X (fast)
(ii) X + Y₂ → XY + Y (slow)
(iii) X + Y → XY (fast)

The overall order of the reaction will be
(a) 1 (b) 2 (c) 0 (d) 1.5

35. Concentration of the Ag⁺ ions in a saturated solution of Ag₂C₂O₄ is 2.2 × 10⁻⁴ mol⁻¹

(a) 2.42 × 10⁻⁸ (b) 2.66 × 10⁻¹²
(c) 4.5 × 10⁻¹¹ (d) 5.3 × 10⁻¹²

36. Extraction of gold and silver involves leaching with CN⁻ ion. Silver is later recovered by
(a) liqation
(b) distillation
(c) zone refining
(d) displacement with Zn

37. Which one is the correct order of acidity?
(a) CH₄ > CH₂ > CH₃ > CH₂ = CH₂ > CH₃ = CH₂
(b) CH₃ > CH > CH₃ = C > CH₂ = CH₂ > CH₃ = CH₂
(c) CH = CH > CH₂ > CH₃ = C > CH₂ > CH₃ = CH₂
(d) CH₃ = CH₂ > CH₃ > CH₂ > CH₃ = C > CH = CH

38. Ionic mobility of which of the following alkali metal ions is lowest when aqueous solution of their salts are put under an electric field?
(a) Na (b) K (c) Rb (d) Li

39. Consider the reactions,

Identify A, X, Y and Z
(a) A-methoxymethane, X-ethanoic acid, Y-acetate ion, Z-hydrazine
(b) A-methoxymethane, X-ethanol, Y-ethanoic acid, Z-semicarbazide
(c) A-ethanal, X-Acetaldelyde, Y-but-2-enal, Z-semicarbazone
(d) A-ethanol, X-acetaldehyde, Y-butanoic, Z-hydrazone

40. In which pair of ions both the species contain S-S bond?
(a) S₂O₇²⁻, S₂O₅²⁻
(b) S₂O₅²⁻, S₂O₃²⁻
(c) S₂O₇²⁻, S₂O₆²⁻
(d) S₂O₆²⁻, S₂O₇²⁻

41. Which one is the most acidic compound?
42. In the electrochemical cell

\[ \text{Zn} \mid \text{ZnSO}_4 \ (0.01 \text{ M})) \mid \text{CuSO}_4 \ (1.0 \text{ M}) \mid \text{Cu}, \]

the emf of this Daniel cell is \( E_1 \). When the concentration of \( \text{ZnSO}_4 \) is changed to 1.0 M and that of \( \text{CuSO}_4 \) changed to 0.01 M, the emf changes to \( E_2 \). From the followings, which one is the relationship between \( E_1 \) and \( E_2 \)?

\[ \frac{RT}{F} = 0.059 \]

(a) \( E_1 = E_2 \)
(b) \( E_1 > E_2 \)
(c) \( E_2 = 0 \neq E_1 \)

43. A first order reaction has a specific reaction rate of \( 10^{-2} \text{s}^{-1} \). How much time will it take for 20 g of the reactant to reduce to 5 g?

(a) 238.6 s  (b) 138.6 s  (c) 346.5 s  (d) 693.0 s

44. The most suitable method of separation of a 1:1 mixture of ortho and para-nitrophenols is

(a) sublimation  (b) chromatography  
(c) crystallisation  (d) steam distillation

45. Which one of the following pairs of species have the same bond order?

(a) CO, NO  (b) O_2, NO^+  
(c) CN, CO^-  (d) N_2, O_2^-  

Biology

1. Which one of the following statements is correct, with reference to enzymes?

(a) Apoenzyme = Holoenzyme + Coenzyme  
(b) Holoenzyme = Apoenzyme + Coenzyme  
(c) Coenzyme = Apoenzyme + Holoenzyme  
(d) Holoenzyme = Coenzyme + Cofactor

2. Which cells of 'Crypts of Lieberkuhn' secrete antibacterial lysozyme?

(a) Argentaffin cells  (b) Paneth cells  
(c) Zymogen cells  (d) Kupffer cells

3. Phosphoenol pyruvate (PEP) is the primary CO_2 acceptor in

(a) C_3-plants  (b) C_4-plants  
(c) C_2-plants  (d) C_3 and C_4-plants

4. Match the following sexually transmitted diseases (Column - I) with their causative agent (Column - II) and select the correct option.

<table>
<thead>
<tr>
<th>Column I</th>
<th>Column II</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A) Gonorrhea</td>
<td>(i) HIV</td>
</tr>
<tr>
<td>(B) Syphilis</td>
<td>(ii) Neisseria</td>
</tr>
<tr>
<td>(C) Genital Warts</td>
<td>(iii) Treponema</td>
</tr>
<tr>
<td>(D) AIDS</td>
<td>(iv) Human Papilloma Virus</td>
</tr>
</tbody>
</table>

Codes

(a) (i) (ii) (iii) (iv)  
(b) (ii) (iii) (iv) (i)  
(c) (iv) (iii) (i) (ii)  
(d) (iv) (iii) (ii) (i)

5. Which among the following are the smallest living cells, known without a definite cell wall, pathogenic to plants as well as animals and can survive without oxygen?

(a) Bacillus  (b) Pseudomonas  
(c) Mycoplasma  (d) Nostoc

6. Which one from those given below is the period of Mendel’s hybridisation experiments?

(a) 1856 - 1863  (b) 1840 - 1850  
(c) 1857 - 1869  (d) 1870 - 1877

7. Flowers, which have single ovule in the ovary and are packed into inflorescence are usually pollinated by

(a) water  (b) bee  
(c) wind  (d) bat

8. Asymptote in a logistic growth curve is obtained, when

(a) The value of \( r \) approaches zero  
(b) \( K = N \)  
(c) \( K > N \)  (d) \( K < N \)
9. Out of ‘X’ pairs of ribs in humans only ‘Y’ pairs are true ribs. Select the option that correctly represents values of X and Y and provides their explanation.

(a) \( X = 12, Y = 7 \)  True ribs are attached dorsally to vertebral column and ventrally to the sternum.

(b) \( X = 12, Y = 5 \)  True ribs are attached dorsally to vertebral column and sternum on the two ends.

(c) \( X = 24, Y = 7 \)  True ribs are dorsally attached to vertebral column, but are free on ventral side.

(d) \( X = 24, Y = 12 \)  True ribs are dorsally attached to vertebral column, but are free on ventral side.

10. MALT constitutes about ............... per cent of the lymphoid tissue in human body.

(a) 50%  
(b) 20%  
(c) 70%  
(d) 10%

11. Homozygous purelines in cattle can be obtained by

(a) mating of related individuals of same breed  
(b) mating of unrelated individuals of same breed  
(c) mating of individuals of different breed  
(d) mating of individuals of different species

12. Among the following characters, which one was not considered by Mendel in his experiments on pea?

(a) Stem – Tall or Dwarf  
(b) Trichomes – Glandular or Non-glandular  
(c) Seed – Green or Yellow  
(d) Pod – Inflated or Constricted

13. Which of the following cell organelles is responsible for extracting energy from carbohydrates to form ATP?

(a) Lysosome  
(b) Ribosome  
(c) Chioroplast  
(d) Mitochondrion

14. If there are 999 bases in an RNA that codes for a protein with 333 amino acids and the base at position 901 is deleted such that the length of the RNA becomes 998 bases, how many codons will be altered?

(a) 1  
(b) 11  
(c) 33  
(d) 333

15. Which of the following are found in extreme saline conditions?

(a) Archaebacteria  
(b) Eubacteria  
(c) Cyanobacteria  
(d) Mycobacteria

16. Receptor sites for neurotransmitters are present on

(a) membranes of synaptic vesicles  
(b) pre-synaptic membrane  
(c) tips of axons  
(d) post-synaptic membrane

17. Artificial selection to obtain cows yielding high milk output represents

(a) stabilising selection as it stabilises this character in the population  
(b) directional as it pushes the mean of the character in one direction  
(c) disruptive as it splits the population into two, one yielding higher output and the other lower output  
(d) stabilising followed by disruptive as stabilises the population of produce higher yielding cows

18. The hepatic portal vein drains blood to liver from

(a) heart  
(b) stomach  
(c) kidneys  
(d) intestine

19. The water potential of pure water is

(a) zero  
(b) less than zero  
(c) more than zero, but less than one  
(d) more than one

20. Which of the following represents order of ‘Horse’?

(a) Equidae  
(b) Perissodactyla  
(c) Caballus  
(d) Ferus

21. Alexander von Humbolt described for the first time

(a) ecological biodiversity  
(b) law of limiting factor  
(c) species area relationships  
(d) population growth equation

22. DNA fragments are

(a) positively charged  
(b) negatively charged  
(c) neutral  
(d) either positively or negatively charged depending on their size
23. A baby boy aged two years is admitted to play school and passes through a dental check-up. The dentist observed that the boy had twenty teeth. Which teeth were absent?
(a) Incisors (b) Canines (c) Premolars (d) Molars

24. Anaphase Promoting Complex (APC) is a protein degradation machinery necessary for proper mitosis of animal cells. If APC is defective in a human cell, which of the following is expected to occur?
(a) Chromosomes will not condense (b) Chromosomes will be fragmented (c) Chromosomes will not segregate (d) Recombination of chromosome arms will occur

25. An important characteristic that hemichordates share with chordates is
(a) absence of notochord (b) ventral tubular nerve cord (c) pharynx with gill slits (d) pharynx without gill slits

26. The genotypes of a husband and wife are $I^A I^A$ and $i^A i$. Among the blood types of their children, how many different genotypes and phenotypes are possible?
(a) 3 genotypes ; 3 phenotypes (b) 3 genotypes ; 4 phenotypes (c) 4 genotypes ; 3 phenotypes (d) 4 genotypes ; 4 phenotypes

27. Transplantation of tissues/organisms fails often due to non-acceptance by the patient's body. Which type of immune-response is responsible for such rejections?
(a) Autoimmune response (b) Cell-mediated immune response (c) Hormonal immune response (d) Physiological immune response

28. Adult human RBCs are enucleate. Which of the following statement(s) is/are most appropriate explanation for this feature?
(I) They do not need to reproduce. (II) They are somatic cells. (III) They do not metabolise. (IV) All their internal space is available for oxygen transport.

29. Lungs are made up of air-filled sacs, the alveoli. They do not collapse even after forceful expiration, because of
(a) Residual Volume (RV) (b) Inspiratory Reserve Volume (IRV) (c) Tidal Volume (TV) (d) Expiratory Reserve Volume (ERV)

30. Zygotic meiosis is characteristic of
(a) Marchantia (b) Fucus (c) Funaria (d) Chlamydomonas

31. Select the correct route for the passage of sperms in male frogs.
(a) Testes → Bidder’s canal → Kidney → Vasa efferentia → Ureter → Cloaca (b) Testes → Vasa efferentia → Kidney → Seminal vesicle → Ureter → Cloaca (c) Testes → Vasa efferentia → Bidder’s canal → Ureter → Cloaca (d) Testes → Vasa efferentia → Kidney → Bidder’s canal → Ureter → Cloaca

32. Which one of the following statements is not valid for aerosols?
(a) They are harmful to human health (b) They alter rainfall and monsoon patterns (c) They cause increased agricultural productivity (d) They have negative impact on agricultural land

33. Viroids differ from viruses in having
(a) DNA molecules with protein coat (b) DNA molecules without protein coat (c) RNA molecules with protein coat (d) RNA molecules without protein coat

34. During DNA replication, Okazaki fragments are used to elongate
(a) The leading strand towards replication fork (b) The lagging strand towards replication fork (c) The leading strand away from replication fork (d) The lagging strand away from the replication fork
35. Plants, which produce characteristic pneumatophores and show vivipary belong to
(a) mesophytes
(b) halophytes
(c) psammophytes
(d) hydrophytes

36. The process of separation and purification of expressed protein before marketing is called
(a) upstream processing
(b) downstream processing
(c) bioprocessing
(d) postproduction processing

37. Identify the wrong statement in context of heartwood.
(a) Organic compounds are deposited in it
(b) It is highly durable
(c) It conducts water and minerals efficiently
(d) It comprises dead elements with highly lignified walls

38. Spliceosomes are not found in cells of
(a) plants
(b) fungi
(c) animals
(d) bacteria

39. Which of the following statements is correct?
(a) The ascending limb of loop of Henle is impermeable to water
(b) The descending limb of loop of Henle is impermeable to water
(c) The ascending limb of loop of Henle is permeable to water
(d) The descending limb of loop of Henle is permeable to electrolytes

40. Which ecosystem has the maximum biomass?
(a) Forest ecosystem
(b) Grassland ecosystem
(c) Pond ecosystem
(d) Lake ecosystem

41. The final proof for DNA as the genetic material came from the experiments of
(a) Griffith
(b) Hershey and Chase
(c) Avery, Macleod and McCarty
(d) Hargobind Khorana

42. The function of copper ions in copper releasing IUD’s is
(a) they suppress sperm motility and fertilising capacity of sperms
(b) they inhibit gametogenesis
(c) they make uterus unsuitable for implantation
(d) they inhibit ovulation

43. An example of colonial alga is
(a) Chlorella
(b) Volvox
(c) Ulithrix
(d) Spirogyra

44. Root hairs develop from the region of
(a) maturation
(b) elongation
(c) root cap
(d) meristematic activity

45. Hypersecretion of growth hormone in adults does not cause further increase in height because
(a) growth hormone becomes inactive in adults
(b) epiphyseal plates close after adolescence
(c) bones lose their sensitivity to growth hormone in adults
(d) muscle fibres do not grow in size after birth

46. Which of the following in sewage treatment removes suspended solids?
(a) Tertiary treatment
(b) Secondary treatment
(c) Primary treatment
(d) Sludge treatment

47. Select the mismatch.
(a) Pinus - Dioecious
(b) Cycas - Dioecious
(c) Salvinia - Heterosporous
(d) Equisetum - Homosporous

48. What is the criterion for DNA fragments movement on agarose gel during gel electrophoresis?
(a) The larger the fragment size, the farther it moves
(b) The smaller the fragment size, the farther it moves
(c) Positively charged fragments move to farther end
(d) Negatively charged fragments do not move

49. In *Bougainvillea* thorns are the modifications of
(a) stipules
(b) adventitious root
(c) stem
(d) leaf
50. The association of histone H1 with a nucleosome indicates
(a) transcription is occurring
(b) DNA replication is occurring
(c) the DNA is condensed into chromatin fibre
(d) the DNA double helix is exposed

51. A temporary endocrine gland in the human body is
(a) pineal gland  (b) corpus cardiacum
(c) corpus luteum  (d) corpus allatum

52. Select the mismatch.

<p>| | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>(a)</td>
<td>Frankia</td>
</tr>
<tr>
<td>(b)</td>
<td>Rhodospirillum</td>
</tr>
<tr>
<td>(c)</td>
<td>Anabaena</td>
</tr>
<tr>
<td>(d)</td>
<td>Rhizobium</td>
</tr>
</tbody>
</table>

53. GnRH, a hypothalamic hormone, needed in reproduction, acts on
(a) anterior pituitary gland and stimulates secretion of LH and oxytocin
(b) anterior pituitary gland and stimulates secretion of LH and FSH
(c) posterior pituitary gland and stimulates secretion of oxytocin and FSH
(d) posterior pituitary gland and stimulates secretion of LH and relaxin

54. A gene, whose expression helps to identify transformed cells is known as
(a) selectable marker  (b) vector
(c) plasmid  (d) structural gene

55. Presence of plants arranged into well defined vertical layers depending on their height can best seen best in
(a) tropical savannah  (b) tropical rain forest
(c) grassland  (d) temperate forest

56. Functional megaspor in an angiosperm develops into
(a) ovule  (b) endosperm
(c) embryo sac  (d) embryo

57. DNA replication in bacteria occurs
(a) during S-phase
(b) within nucleolus
(c) prior to fission
(d) just before transcription

58. Which among these is the correct combination of aquatic mammals?
(a) Seals, Dolphins, Sharks
(b) Dolphins, Seals, Trygon
(c) Whales, Dolphins, Seals
(d) Trygon, Whales, Seals

59. Coconut fruit is a
(a) drupe  (b) berry  (c) nut  (d) capsule

60. Double fertilisation is exhibited by
(a) gymnosperms  (b) algae
(c) fungi  (d) angiosperms

61. Which of the following components provides sticky character to the bacterial cell?
(a) Cell wall
(b) Nuclear membrane
(c) Plasma membrane
(d) Glycocalyx

62. Life cycle of *Ectocarpus* and *Fucus* respectively are
(a) Haplontic, Diplontic
(b) Diplontic, Haplodiplontic
(c) Haplodiplontic, Diplontic
(d) Haplodiplontic, Haplontic

63. Which one of the following is related to *Ex-situ* conservation of threatened animals and plants?
(a) Wildlife Safari parks
(b) Biodiversity hotspots
(c) Amazon rainforest
(d) Himalayan region

64. Good vision depends on adequate intake of carotene rich food.
Select the best option from the following statements.

I. Vitamin-A derivatives are formed from carotene.
II. The photopigments are embedded in the membrane discs of the inner segment.
III. Retinal is a derivative of vitamin-A.
IV. Retinal is a light absorbing part of all the visual photopigments.

(a) (I) and (II)  (b) (I), (III) and (IV)
(c) (I) and (III)  (d) (II), (III) and (IV)
65. Thalassemia and sickle-cell anaemia are caused due to a problem in globin molecule synthesis. Select the correct statement.
   (a) Both are due to a qualitative defect in globin chain synthesis
   (b) Both are due to a quantitative defect in globin chain synthesis
   (c) Thalassemia is due to less synthesis of globin molecules
   (d) Sickle-cell anaemia is due to a quantitative problem of globin molecules

66. Which of the following are not polymeric?
   (a) Nucleic acid  (b) Proteins
   (c) Polysaccharides  (d) Lipids

67. A disease caused by an autosomal primary non-disjunction is
   (a) Down’s syndrome  (b) Klinefelter’s syndrome
   (c) Turner’s syndrome  (d) Sickle-cell anemia

68. With reference to factors affecting the rate of photosynthesis, which of the following statements is not correct?
   (a) Light saturation for CO₂-fixation occurs at 10% of full sunlight
   (b) Increasing atmospheric CO₂ concentration upto 0.05% can enhance CO₂-fixation rate
   (c) C₄ plants respond to higher temperature with enhanced photosynthesis, while C₃ plants have much lower temperature optimum
   (d) Tomato is a greenhouse crop, which can be grown in CO₂-enriched atmosphere for higher yield

69. Fruit and leaf drop at early stages can be prevented by the application of
   (a) cytokinins  (b) ethylene
   (c) auxins  (d) gibberellic acid

70. The region of biosphere reserve, which is legally protected and where no human activity is allowed is known as
    (a) core zone  (b) buffer zone
    (c) transition zone  (d) restoration zone

71. In case of poriferans, the spongocoel is lined with flagellated cells called
   (a) ostia  (b) oscula
   (c) choanocytes  (d) mesenchymal cells

72. A decrease in blood pressure/volume will not cause the release of
    (a) renin  (b) atrial natriuretic factor
    (c) aldosterone  (d) ADH

73. A dioecious flowering plant prevents both
    (a) autogamy and xenogamy
    (b) autogamy and geitonogamy
    (c) geitonogamy and xenogamy
    (d) cleistogamy and xenogamy

74. Which of the following facilitates opening of stomatal aperture?
    (a) Contraction of outer wall of guard cells
    (b) Decrease in turgidity of guard cells
    (c) Radial orientation of cellulose microfibrils in the cell wall of guard cells
    (d) Longitudinal orientation of cellulose microfibrils in the cell wall of guard cells

75. The DNA fragments separated on an agarose gel can be visualised after staining with
    (a) bromophenol blue  (b) acetocarmine
    (c) aniline blue  (d) ethidium bromide

76. Which statement is wrong for Krebs’ cycle?
    (a) There are three points in the cycle where NAD⁺ is reduced to NADH + H⁺
    (b) There is one point in the cycle where FAD⁺ is reduced to FADH₂
    (c) During conversion of succinyl Co-A to succinic acid, a molecule of GTP is synthesised
    (d) The cycle starts with condensation of acetyl group (acetyl Co-A) with pyruvic acid to yield citric acid

77. Mycorrhizae are the example of
    (a) fungistasis  (b) amensalism
    (c) antibiosis  (d) mutualism

78. The pivot joint between atlas and axis is a type of
    (a) fibrous joint  (b) cartilaginous joint
    (c) synovial joint  (d) saddle joint

79. Which of the following is correctly matched for the product produced by them?
    (a) Acetobacter aceti: Antibiotics
    (b) Methanobacterium: Lactic acid
    (c) Penicillium notatum: Acetic acid
    (d) Saccharomyces cerevisiae: Ethanol
80. Frog’s heart when taken out of the body continues to beat for sometime. Select the best option from the following statements.
   I. Frog is a poikilotherm.
   II. Frog does not have any coronary circulation.
   III. Heart is “myogenic” in nature.
   IV. Heart is autoexcitable.
   (a) Only II
   (b) Only IV
   (c) I and II
   (d) III and IV

81. Myelin sheath is produced by
   (a) Schwann cells and Oligodendrocytes
   (b) Astrocytes and Schwann cells
   (c) Oligodendrocytes and Osteoclasts
   (d) Osteoclasts and Astrocytes

82. Capacitation occurs in
   (a) rete testis
   (b) epididymis
   (c) vas deferens
   (d) female reproductive tract

83. The morphological nature of the edible part of coconut is
   (a) perisperm
   (b) cotyledon
   (c) endosperm
   (d) pericarp

84. Which of the following is made up of dead cells?
   (a) Xylem parenchyma
   (b) Collenchyma
   (c) Phellem
   (d) Phloem

85. In case of a couple, where the male is having a very low sperm count, which technique will be suitable for fertilisation?
   (a) Intrauterine Transfer
   (b) Gamete intracytoplasmic Fallopian Transfer
   (c) Artificial Insemination
   (d) Intracytoplasmic Sperm Injection

86. Which of the following RNAs should be most abundant in animals cell?
   (a) rRNA
   (b) tRNA
   (c) mRNA
   (d) miRNA

87. The vascular cambium normal gives rise to
   (a) phelloderm
   (b) primary phloem
   (c) secondary xylem
   (d) periderm

88. Which of the following options gives the correct sequences of events during mitosis?
   (a) Condensation → nuclear membrane disassembly → crossing over → segregation → telophase
   (b) Condensation → nuclear membrane disassembly → arrangement at equator → centromere division → segregation → telophase
   (c) Condensation → crossing over → nuclear membrane disassembly → segregation → telophase
   (d) Condensation → arrangement at equator → centromere division → segregation → telophase

89. Which of the following options best represents enzyme composition of pancreatic juice?
   (a) Amylase, peptidase, trypsinogen, rennin
   (b) Amylase, pepsin, trypsinogen, maltase
   (c) Peptidase, amylase, pepsin, rennin
   (d) Lipase, amylase, trypsinogen, procarboxypeptidase

90. Attractants and rewards are required for
   (a) anemophily
   (b) entomophily
   (c) hydrophily
   (d) cleistogamy
Physics

1. (b) Initially system, is in equilibrium with a total weight of 4mg over spring.

\[ (3m + m)kx = 4mg \]

∴ ... \[ kx = 4mg \]

When string is cut at the location as shown above.

Free body diagram for \( m \) is

If \( a \) = acceleration of block of mass \( 3m \), then

\[ F_{ul} = 4mg - 3mg \]

\[ 3m \cdot a_h = mg \]

or \[ a_h = \frac{g}{3} \]

So, accelerations for blocks \( A \) and \( B \) are

\[ a_A = \frac{g}{3} \] and \[ a_B = g \]

2. (d) Thinking Process \( g_h \) = Acceleration due to gravity at height \( h \) above earth’s surface

\[ g_h = g \left(1 - \frac{d}{R}\right) \]

\( g_d \) = Acceleration at depth \( d \) below earth’s surface

\[ g_d = g \left(1 - \frac{d}{R}\right) \]

\[ \frac{kx}{4mg} \]

\[ (3m + m) \]

\[ 4mg \]

3. (c) Thinking Process Magnitude of velocity of particle when it is at displacement \( x \) from mean position

\[ \omega = \sqrt{\frac{\omega^2}{A^2 - x^2}} \]

Also, magnitude of acceleration of particle in SHM

\[ \omega = \omega \]

Given, when \( h = 1 \) km, \( g_d = g_h \)

or \[ g \left(1 - \frac{d}{R}\right) = g \left(1 - \frac{2h}{R}\right) \]

\[ \Rightarrow d = 2h \]

or \[ d = 2 \text{ km} \]

3. (c) Thinking Process Magnitude of velocity of particle when it is at displacement \( x \) from mean position

\[ \omega = \sqrt{\frac{\omega^2}{A^2 - x^2}} \]

Also, magnitude of acceleration of particle in SHM

\[ \omega = \omega \]

Given, when \( x = 2 \) cm

\[ |v| = |a| \]

\[ \Rightarrow \omega \sqrt{A^2 - x^2} = \omega x \]

\[ \Rightarrow \omega = \sqrt{\frac{\omega^2}{A^2}} \]

\[ \Rightarrow \text{Angular velocity} \omega = \frac{\sqrt{5}}{2} \]

\[ : \text{Time period of motion} \]

\[ T = \frac{2\pi}{\omega} = \frac{4\pi}{\sqrt{5}} \text{ s} \]

4. (c) Thinking Process Volume of material remains same in stretching.

As volume remains same,

\[ A_{b_1} = A_{b_2} \]

Now, given \( l_1 = n l_2 \)

\[ \therefore \text{New area} A_2 = A_{b_2} = \frac{A}{n} \]

Resist ance of wire after stretching

\[ R_2 = \rho \cdot \frac{l_2}{A_2} \]

\[ = \rho \cdot \frac{n l_2}{n A_{b_2}} \]

\[ = \left( \rho \cdot \frac{l_1}{A_1} \right) \cdot n^2 = n^2 \cdot R \]

\[ \therefore R = \left( \rho \cdot \frac{l_1}{A_1} \right) \]
5. (d) Thinking Process

Energy stored in a system of capacitors

\[ U = \sum \frac{1}{2} CV^2 \]

Also, potential drop remains same in parallel across both capacitors.

Initially stored energy

\[ U_1 = \frac{1}{2} CV^2 \]

Finally, potential drop across each capacitor will be still \( V \).

So, finally stored energy

\[ U_2 = \frac{1}{2} CV^2 + \frac{1}{2} CV^2 = 2U_1 \]

6. (a) In parallel arrangement of \( n \) rods

Equivalent thermal conductivity is given by

\[ K_{eq} = K_1 + K_2 + \ldots + K_n \]

If rods are of same area, then

\[ K_{eq} = \frac{K_1 + K_2 + \ldots + K_n}{n} \]

7. (b) Thinking Process

Frequency of \( n \)th harmonic in an closed end tube

\[ f = \frac{2(n - 1) v}{4l} \quad n = 1, 2, 3, \ldots \]

Also, only odd harmonics exists in a closed end tube.

Now, given two nearest harmonics are of frequency 220 Hz and 260 Hz.

\[ \frac{(2n - 1) v}{4l} = 220 \text{ Hz} \]

Next harmonic occurs at

\[ \frac{(2n + 1) v}{4l} = 260 \text{ Hz} \]

On subtracting Eq. (i) from Eq. (ii), we get

\[ \frac{2v}{4l} = 40 \Rightarrow \frac{v}{4l} = 20 \text{ Hz} \]

\[ \therefore \text{Fundamental frequency of the system} = \frac{v}{4l} = 20 \text{ Hz} \]

8. (d) The object is spherical and the bulk modulus is represented by \( B \). It is the ratio of normal stress to the volumetric strain.

Hence

\[ B = \frac{F/A}{\Delta V/V} \]

\[ \Rightarrow \Delta V/V = \frac{p}{B} \Rightarrow \Delta V/V \]

Here \( p \) is applied pressure on the object and \( \Delta V/V \) is volume strain.

Fractional decreases in volume

\[ \Rightarrow \Delta V/V = 3\Delta R/R \quad \left[ \because V = \frac{4}{3} \pi R^3 \right] \]

Volume of the sphere decreases due to the decrease in its radius.

Hence

\[ \Delta V/V = 3\Delta R/R = \frac{p}{B} \Rightarrow \Delta R/R = \frac{p}{3B} \]

9. (a) As force

\[ F = \frac{\varepsilon^2}{4\pi\varepsilon_0} r^2 \]

Putting dimensions of \( r \) and \( F \), we get,

\[ \Rightarrow \left[ \frac{\varepsilon^2}{4\pi\varepsilon_0} \right] = \left[ \text{ML}^2\text{T}^{-2} \right] \quad \text{...(i)} \]

Also, force, \( F = \frac{Qm^2}{r^2} \)

\[ \Rightarrow \left[ Q \right] = \left[ \text{ML}^{-1}\text{T}^{-2} \right] \quad \text{[L]} \]

\[ \Rightarrow \left[ m^2 \right] \quad \text{...(ii)} \]

and

\[ \left[ \frac{1}{c^2} \right] = \left[ \text{L}^{-2}\text{T}^{-4} \right] \quad \text{...(iii)} \]

Now, checking optionwise,

\[ \frac{1}{c^2} \left( \frac{Q\varepsilon^2}{4\pi\varepsilon_0} \right)^{1/2} \]

\[ = \left[ \text{L}^{-2}\text{T}^{-4} \right] \left[ \text{L}^{-2}\text{T}^{-4} \right]^{1/2} = \left[ \text{L} \right] \]
10. (*) No option is matching.

**Thinking Process** Just after switch is closed, inductor acts like an open switch (open path) and capacitor acts like a closed switch (closed path) because in D.C. circuit inductive resistance becomes zero.

Just after switch is closed, given circuit is equivalent to the circuit shown below.

\[ \begin{array}{c}
\text{R} \\
\text{R} \\
\text{R} \\
\text{R} \\
\text{R} \\
\text{R} \\
\text{R} \\
\text{R} \\
\text{R} \\
\text{R} \\
\end{array} \]

So, equivalent resistor

\[ R = \frac{9}{2} \text{ ohms} \]

Battery emf, \( V = 18 \text{ volts} \)

\[ \text{Current in circuit} = \frac{V}{R} = \frac{18 \times 2}{9} = 4 \text{ A} \]

11. (a) Consider the string of length \( l \) connected to a particle as shown in the figure.

\[ \begin{array}{c}
\text{peg} \\
\text{particle} \\
\end{array} \]

\[ v \]

\[ l \]

Speed of the particle is \( v \). As the particle is in uniform circular motion, net force on the particle must be equal to centripetal force which is provided by the tension (\( T \)).

\[ \text{Net force} = \text{Centripetal force} \]

\[ \frac{mv^2}{l} = T \]

12. (a, b) **Thinking Process** Applying Einstein’s photoelectric equation, kinetic energy of emitted electron can be given by

\[ K = \frac{1}{2} mv^2 = hv - h\nu_0 \]

\[ = \frac{hc}{\lambda} - \frac{hc}{\lambda_0} \]

Given threshold wavelength, \( \lambda_0 = 3250 \times 10^{-10} \text{ m} \)

Wavelength of ultraviolet light, \( \lambda = 2536 \times 10^{-10} \text{ m} \)

Let, velocity of ejected electron be \( v \).

Now, applying Einstein’s photoelectric equation, we have

\[ E = K + \Phi_0 \]

\[ \Rightarrow \quad hv = \frac{1}{2} mv^2 + h\nu_0 \]

\[ \Rightarrow \quad \frac{1}{2} mv^2 = hv - h\nu_0 = \frac{hc}{\lambda} - \frac{hc}{\lambda_0} \]

\[ \Rightarrow \quad \text{Velocity of electron} v = \sqrt{\frac{2hc}{m} \left( \frac{1}{\lambda} - \frac{1}{\lambda_0} \right)} \]

\[ = \sqrt{\frac{2 \times 4.14 \times 10^{-15} \times 1.6 \times 10^{-19} \times 3 \times 10^8}{9.1 \times 10^{-31} \times \frac{3250 - 2536}{3250 \times 2536}}} \]

\[ = 0.6 \times 10^6 \text{ ms}^{-1} = 6 \times 10^5 \text{ ms}^{-1} \]

13. (b) Let initial number of nuclei in \( A \) and \( B \) is \( N_0 \).

Number of nuclei of \( A \) after time \( t \) is

\[ N_A = N_0 e^{-\lambda t} \]  \( \ldots (i) \)

Similarly, number of nuclei of \( A \) after time \( t \) is

\[ N_B = N_0 e^{-\lambda t} \]  \( \ldots (ii) \)

It is given that

\[ \frac{N_A}{N_B} = \frac{1}{e} \]

\[ \Rightarrow \quad e^{\lambda t} = e^{-\lambda t} \quad \Rightarrow \quad \lambda t = 1 \]

\[ \Rightarrow \quad \text{Time} (t) = \frac{1}{\lambda} \]

14. (c) **Thinking Process** Torque \( (\tau) \) acting on a body and angular acceleration \( (\alpha) \) produced in it are related as \( \tau = \alpha \).

Consider a hollow cylinder, around which a rope is wound as shown in the figure.
Torque acting on the cylinder due to the force \( F \) is
\[ \tau = Fr \]
Now, we have
\[ \tau \propto I \]
where, \( I = \) moment of inertia of the cylinder about the axis through the centre
\[ = mr^2 \]
\( \alpha = \) angular acceleration
\[ \Rightarrow \alpha \tau = I \]
\[ = F \left( \frac{mr^2}{m} \right) \]
\[ = \frac{Fm}{r^2} \]
\[ = \frac{100}{4} \times 25 \text{ rad/s}^2 \]
\[ = 250 \text{ rad/s}^2 \]

15. (d) Thinking Process: When both source and observer are moving towards each other, apparent frequency is given by
\[ f = f_0 + \frac{v_s - v_0}{v_s} \]
where, \( f_0 = \) original frequency of source\(, v_s = \) speed of source\(, v_0 = \) speed of observer\(, v = \) speed of sound
Frequency of the horn,
\[ f_0 = 400 \text{ Hz} \]
Speed of observer in the second car,
\[ v_0 = 16.5 \text{ m/s} \]
\[ \Rightarrow v_s = 22 \text{ m/s} \]
\[ \Rightarrow v_0 = 16.5 \text{ m/s} \]
Speed of source,
\[ v_s = \] speed of first car
\[ = 22 \text{ m/s} \]
Frequency heard by the driver in the second car
\[ f_0 = f_0 \left( \frac{v + v_0}{v - v_s} \right) \]
\[ = 400 \left( \frac{340 + 16.5}{340 - 22} \right) \]
\[ = 448 \text{ Hz} \]

16. (a) Work done for rotating the coil
\[ W = MB(\cos \theta_1 - \cos \theta_2) \]
where, \( M = \) magnetic moment\(, B = \) magnetic field

17. (c) Thinking Process: Current induced in the coil is given by
\[ i = \frac{1}{R} \left( \frac{\partial \phi}{\partial t} \right) \]
\[ \Rightarrow \Delta q = \frac{1}{R} \left( \frac{\Delta \phi}{\Delta t} \right) \]
Given, resistance of the solenoid,
\[ R = 10 \pi^2 \Omega \]
Radius of second coil \( r = 10^{-2} \)
\[ \Delta t = 0.05 \text{ s}, \Delta t = 4 - 0 = 4 \text{ A} \]
Charge flowing through the coil is given by
\[ \Delta q = \frac{1}{R} \left( \frac{\Delta \phi}{\Delta t} \right) \]
\[ = \frac{4 \pi \times 10^{-7} \times 2 \times 10^4 \times 100 \times \pi \times (10^{-2})^2 \times (\frac{4}{10 \pi} \times \frac{1}{0.05}) \times \frac{1}{10 \pi} \times 0.05 \]
\[ = 32 \times 10^{-6} \text{ C} = 32 \mu \text{C} \]

18. (c) Net charge on one H-atom
\[ q = - e + e + \Delta e = \Delta e \]
Net electrostatic repulsive force between two H-atoms
\[ F_i = \frac{Kq^2}{d^2} = \frac{K(\Delta e)^2}{d^2} \]
Similarly, net gravitational attractive force between two H-atoms
\[ F_G = \frac{Gm_i^2}{d^2} \]
It is given that
\[ F_i - F_G = 0 \]
\[ \Rightarrow \frac{K(\Delta e)^2}{d^2} - \frac{Gm_i^2}{d^2} = 0 \]
\[ \Rightarrow (\Delta e)^2 = \frac{Gm_i^2}{K} \]
19. (b) In the space, there is no external gravity. Due to masses of the astronauts, there will be small gravitational attractive force between them. Thus, these astronauts will move towards each other.

20. (c) Wavelength of spectral lines are given by

\[ \frac{1}{\lambda} = z^2 R \left( \frac{1}{n_1^2} - \frac{1}{n_2^2} \right) \]

For last line of Balmer series,

\[ n_1 = 2 \quad \text{and} \quad n_2 = \infty \]

\[ \Rightarrow \frac{1}{\lambda_B} = z^2 R \left( \frac{1}{2^2} - \frac{1}{\infty} \right) = \frac{R}{4} \]

\[ \therefore \lambda_B = 4 R \]

Similarly, for last line of Lyman series,

\[ n_1 = 1 \quad \text{and} \quad n_2 = \infty \]

\[ \Rightarrow \frac{1}{\lambda_L} = z^2 R \left( \frac{1}{1^2} - \frac{1}{\infty} \right) = \frac{R}{4} \]

\[ \therefore \lambda_L = 4 \]

21. (b) Thinking Process de-Broglie wavelength associated with a moving particle can be given as

\[ \lambda = \frac{h}{p} = \frac{h}{\sqrt{2mKE}} \]

At thermal equilibrium, temperature of neutron and heavy water will be same. This common temperature is given as, \( T \).

Also, we know that, kinetic energy of a particle

\[ KE = \frac{p^2}{2m} \]

where, \( p \) = momentum of the particle

\( m \) = mass of the particle

Kinetic energy of the neutron is

\[ KE = \frac{3}{2} kT \]

\[ \therefore \] de-Broglie wavelength of the neutron

\[ \lambda = \frac{h}{p} = \frac{h}{\sqrt{2mKE}} \]

\[ \Rightarrow \Delta e = 1.437 \times 10^{-27} \text{ C} \]

22. (b) Thinking Process For dispersion without deviation, net deviation produced by the combination of prisms must be zero.

Let, prism angle of the first and second prisms are \( \alpha_1 \) and \( \alpha_2 \) respectively. Similarly, their refractive indices are \( \mu_1 \) and \( \mu_2 \).

Condition for dispersion without deviation is

\[ \delta_1 - \delta_2 = 0 \]

\[ \Rightarrow (\mu_1 - 1) \alpha_1 - (\mu_2 - 1) \alpha_2 = 0 \]

\[ \Rightarrow A_2 = \left( \frac{\mu_1 - 1}{\mu_2 - 1} \right) \alpha_1 = \left( \frac{1.42 - 1}{1.7 - 1} \right) (10^8) \]

\[ \Rightarrow A_2 = 6^8 \]

23. (b) In isochoric process, the curve is parallel to \( y \)-axis because volume is constant. Isobaric is parallel to \( x \)-axis because pressure is constant.

Along the curve, it will be isothermal because temperature is constant.

So,

\[ P \rightarrow c \]

\[ C \rightarrow a \]

\[ R \rightarrow d \]

\[ S \rightarrow b \]

24. (d) Thinking Process Pressure of two points lie in the same horizontal level should be same and \( p = \frac{h \rho g}{S} \)

Both ends of the U tube are open, so the pressure on both the free surfaces must be equal.

i.e., \( \rho_1 = \rho_2 \)

\[ h_1 \cdot S_1 \cdot g = h_2 \cdot S_2 \cdot g \]

\[ S_2 = \frac{h_2 \cdot S_1 \cdot g}{h_1 \cdot g} \]

From figure, \( S_{oil} = \frac{(65 + 65) \times 1000}{(65 + 65 + 10)} \)

\[ = 928 \text{ kg m}^{-3} \]

25. (c) When the spring is cut into pieces, they will have the new force constant. The spring is divided into \( 1 : 2 : 3 \) ratio.

When the pieces are connected in series, the resultant force constant

\[ \frac{1}{k'} = \frac{1}{k_1} + \frac{1}{k_2} + \frac{1}{k_3} \]
\[
\frac{1}{\nu'} = \frac{1}{x} + \frac{1}{2x} + \frac{1}{3x}
\]
\[
\nu' = \frac{6x}{11}
\]

In parallel, the net force constant
\[
K'' = x + 2x + 3x = 6x = 11K
\]
The required ratio \(\frac{K}{K''} = \frac{6x}{11} = 1:11\)

26. (b) (a) Usually the centre of gravity coincides with the centre of mass for bodies when the gravity field is uniform for bodies of small height.

(b) Since, the gravitational force can be taken to be centered or confined at the centre of gravity of body, so the torque of gravitational force about the centre of

In the mechanics, usually we deal with the objects of small height for which torque of gravitational force about the centre of mass will also be zero. So, option (b) is correct.

27. (a) According to the question \(L = \text{Light source}\)

When the light beams incidents normally on the plane mirror, it is reflected back to the point from which it was coming. When the plane mirror is rotated by an angle \(\theta\), the reflected ray or beam of light must rotate by angle \(2\theta\), from refraction at plane surface theory.

\[
\tan 2\theta = \frac{BS}{SO} = \frac{y}{x}
\]
If the angle is small
\[
\tan 2\theta \approx 2\theta
\]
So,
\[
2\theta = \frac{y}{x}
\]
\[
\theta = \frac{y}{2x}
\]

28. (d) Total internal energy of system = Internal energy of oxygen molecules + Internal energy of argon molecules
\[
= \frac{1}{2} n_{2RT} + \frac{5}{2} n_{2RT}
\]
\[
= \frac{5}{2} \times 2RT + \frac{3}{2} \times 4RT
\]
\[
= 11RT
\]

29. (d) Thinking Process By work-KE theorem, we have

Work done by gravitational force,
\[
W_g = mgh
\]
\[
= 10^{-3} \times 10 \times 1 \times 10^3
\]
\[
= 10 \text{ J}
\]
Now, from work-KE theorem, we have
\[
\Delta K = W_{\text{gravity}} + W_{\text{air resistance}}
\]
\[
\Rightarrow \frac{1}{2} mv^2 = mgh + W_{\text{air resistance}}
\]
\[
\Rightarrow W_{\text{air resistance}} = \frac{1}{2} mv^2 - mgh
\]
\[
= 10^{-3} \left( \frac{1}{2} \times 50 \times 50 - 10 \times 10^3 \right)
\]
\[
= -8.75 \text{ Joules}
\]

30. (b) Consider schematic diagram for a Carnot engine as shown below.

In case of engine,

engine efficiency = \(\frac{\text{work}}{\text{heat absorbed}} = \frac{W}{q_1}\)

\[
\therefore \quad \frac{W}{q_1} = \frac{10}{10}
\]
\[
\Rightarrow \frac{10 \text{ J}}{q_1} = \frac{1}{10}
\]
or \[ q_1 = 100 \text{ J} \]  
When this engine is reversed, it takes in work \( W \) and heat \( q_2 \) from cold reservoir and ejects 100 J of heat to hot reservoir. 
\[ \therefore W + q_2 = q_1 \]  
\[ \Rightarrow 10 + q_2 = 100 \]  
or \[ q_2 = 90 \text{ J} \]

31. (d) As force on wire \( B \) due to \( A \) and \( C \) are attractive, so we have following condition 
\[ F = \frac{\mu_1 \mu_2}{2\pi d^2} \]  
Resultant force on \( B \) 
\[ F = \sqrt{F_1^2 + F_2^2} \]  
\[ = \sqrt{2} \times \frac{\mu_1 \mu_2}{2\pi d} = \frac{\mu_1 \mu_2}{\sqrt{2}\pi d} \]  
32. (c) Given, \( x = 5t - 2t^2 \)  
Velocity of the particle, 
\[ v_x = \frac{dx}{dt} = \frac{d}{dt}(5t - 2t^2) = 5 - 4t \]  
Acceleration, 
\[ a_x = \frac{dv_x}{dt} = -4 \text{ ms}^{-2} \]  
Also, 
\[ y = 10t \]  
Velocity, 
\[ v_y = \frac{dy}{dt} = 10 \]  
\[ \therefore \text{Acceleration} \ a_y = \frac{dv_y}{dt} = 0 \]  
\[ \text{Net acceleration of the particle,} \ a_{\text{net}} = a_x \hat{i} + a_y \hat{j} = (-4 \text{ ms}^{-2}) \hat{i} \]  
or \[ a_{\text{net}} = -4 \hat{i} \text{ ms}^{-2} \]
33. (c) As, resolving power of a microscope, 
\[ (RP) \propto \frac{1}{\lambda_{\text{(wavelength)}}} \]  
\[ \therefore \frac{RR}{RR'} = \frac{\lambda_2}{\lambda_1} = \frac{6000}{4000} = \frac{3}{2} \]  
34. (c) Speed of walking \[ \frac{h}{t_1} = v_1 \]  
Speed of escalator \[ \frac{h}{t_2} = v_2 \]  
Time taken when she walks over running escalator 
\[ \Rightarrow t = \frac{h}{v_1 + v_2} \]  
\[ \Rightarrow \frac{1}{t} = \frac{v_1}{h} + \frac{v_2}{h} = \frac{1}{t_1} + \frac{1}{t_2} \]  
\[ \Rightarrow t = \frac{t_1 t_2}{t_1 + t_2} \]
35. (d) Radiated power of a black body, 
\[ P = \sigma AT^4 \]  
where, \( A = \) surface area of the body \[ T = \) temperature of the body and \( \sigma = \) Stefan’s constant  
When radius of the sphere is halved, new area, 
\[ A' = \frac{A}{4} \]  
\[ \therefore \text{Power radiated,} \]  
\[ P' = \sigma \left( \frac{A}{4} \right)^2 (2T)^4 = \frac{16}{4} \cdot (\sigma AT^4) \]  
\[ = 4P = 4 \times 450 = 1800 \text{ watts} \]
36. (c) When a cell is balanced against potential drop across a certain length of potentiometer wire, no current flows through the cell  
\[ \therefore \text{emf of cell} = \text{potential drop across balance length of potentiometer wire.} \]  
So, potentiometer is a more accurate device for measuring emf of a cell or no current flows through the cell during measurement of emf.  
37. (c) Truth table for given network is 
\[ \begin{array}{cccccc} 
A & B & Y_1 & Y_2 & \text{Y} \\
0 & 0 & 1 & 0 & 1 \\
1 & 0 & 0 & 1 & 0 \\
0 & 1 & 0 & 1 & 0 \\
1 & 1 & 0 & 1 & 0 \\
\end{array} \]  
Output \( Y \) of network matches with that of NOR gate.  
38. (c) Collector current \[ i_C = \frac{V}{R} \]  
\[ = \frac{3}{3 \times 10^3} = 10^{-3} \text{ A} \]  
Now, base current \[ i_B = \frac{i_C}{B} = 10^{-3} \times 10^{-5} \text{ A} \]
As, voltage
\[ V_{\text{in}} = I_{\text{f}} R_0 \]
\[ V_{\text{in}} = 10^{-6} \times 2 \times 10^3 \]
\[ = 2 \times 10^{-2} \text{ volts} \]

So, voltage gain
\[ A_V = \frac{V_{\text{out}}}{V_{\text{in}}} = \frac{3}{2 \times 10^{-2}} = 150 \]

Power gain
\[ = A_V \times \beta = 150 \times 100 = 15000 \]

39. (b) **Thinking Process:** When no external torque acts on system then, angular momentum of system remains constant.

Angular momentum before contact
\[ = I_1 \omega_1 + I_2 \omega_2 \]

Angular momentum after the discs brought into contact
\[ = I_{\text{net}} \omega = (I_1 + I_2) \omega \]

So, final angular speed of system = \[ \omega = \frac{I_1 \omega_1 + I_2 \omega_2}{I_1 + I_2} \]

Now, to calculate loss of energy, we subtract initial and final energies of system.

⇒ Loss of energy
\[ = \frac{1}{2} I_1 \omega_1^2 + \frac{1}{2} I_2 \omega_2^2 - \frac{1}{2} (2I) \omega^2 \]
\[ = \frac{1}{4} I (\omega_1 - \omega_2)^2 \]

40. (d) According to question, 5th dark fringe in air = 8 bright fringe in the medium
\[ (2 \times 5 - 1) \frac{\lambda D}{2d} = \frac{8 \lambda D}{\mu d} \]
\[ \frac{9 \lambda D}{2d} = \frac{8 \lambda D}{\mu d} \]
\[ \frac{9}{2} = \frac{8}{\mu} \]
\[ \Rightarrow \mu = \frac{8 \times 2}{9} \]
\[ \Rightarrow \mu = \frac{16}{9} = 1.7777 \approx 1.78 \]

41. (a) In the forward biasing of P-N junction, p side of junction diode is connected to higher potential and n side of junction diode is connected to lower potential. Hence, the option (a) is correct answer.
44. (a) Let the $B_H$ and $B_V$ be the horizontal and vertical component of earth’s magnetic field.

$$\tan \theta = \frac{B_B}{B_V} \Rightarrow \cot \theta = \frac{B_V}{B_B} \quad \text{...(i)}$$

Let, plane 1 and 2 are mutually perpendicular planes making angle $\theta$ and $(90^\circ - \theta)$ with magnetic meridian. The vertical component of earth’s magnetic field remain same in two plane but effective horizontal components in the two planes is given by

$$B_H^1 = B_H \cos \theta \quad \text{...(ii)}$$

and

$$B_H^2 = B_H \sin \theta \quad \text{...(iii)}$$

Then, $\tan \theta_1 = \frac{B_H}{B_V} = \frac{B_H}{B_H \cos \theta}$

Let, plane 1 and 2 are mutually perpendicular planes making angle $\theta$ and $(90^\circ - \theta)$ with magnetic meridian.

Similarly,

$$\Rightarrow \tan \theta_2 = \frac{B_H}{B_V} = \frac{B_H \sin \theta}{B_V} \quad \text{...(v)}$$

From Eq. (iv) and Eq. (v)

$$\Rightarrow \cot \theta_1 + \cot \theta_2 = \frac{B_B^1 \cos^2 \theta'}{B_V} + \frac{B_B^2 \sin^2 \theta'}{B_V}$$

$$\Rightarrow \cot \theta_1 + \cot \theta_2 = \frac{B_B^1 (\cos^2 \theta' + \sin^2 \theta' \Delta \theta)}{B_V}$$

$$\Rightarrow \cot \theta_1 + \cot \theta_2 = \cot^2 \theta$$

45. (b) We know that,

Work done $(W) = q \Delta V$

$\Delta V$ is same in all the cases. So, work done will be same in the all cases.

Chemistry

1. (c) The reason for greater range of oxidation states in actinoid is attributed to the 5f, 6d and 7s levels having comparable energies. The 5f-orbitals extend into space beyond the 7s and 6 p-orbitals and participate in bonding. This is in direct contrast to the lanthanides where the 4f-orbitals are buried deep inside the atom, totally shielded by outer orbitals and thus unable to take part in bonding.

2. (b) The organometallic compounds having sigma bond between carbon and metal are sigma bonded organometallic. An example of a sigma bonded organometallic compound is Grignard’s reagent.

$$R-Mg \longrightarrow X$$

Whereas, ruthenocene, ferrocene and cobaltocene are not sigma bonded organometallic compound.

3. (d)(a) According to de-Broglie’s equation,

Wavelength $(\lambda) = \frac{h}{mv}$

where, $h =$ Planck’s constant.

Thus, statement (a) is correct.

(b) According to Heisenberg uncertainty principle, the uncertainties of position $(\Delta x)$ and momentum $(p = m\Delta v)$ are related as

$$\Delta x \cdot \Delta p \geq \frac{h}{4\pi}$$

and

$$\Delta x \cdot m \Delta v \geq \frac{h}{4\pi}$$

$$\Delta x \cdot m \Delta \tau \geq \frac{h}{4\pi}$$

Ruthenocene Ferrocene Cobaltocene
\[
\left[ \frac{\Delta v}{\Delta t} \right] = a, \quad a = \text{acceleration}
\]

or, \( \Delta x \cdot F \cdot \Delta t \geq \frac{h}{4\pi} \) \( \therefore F = m \cdot \Delta a \)

or, \( \Delta E \cdot \Delta t \geq \frac{h}{4\pi} \)

\( \therefore \Delta E = F \cdot \Delta x, \quad E = \text{energy} \)

Thus, statement (b) is correct.

(c) The half and fully filled orbitals have greater stability due to greater exchange energy, greater symmetry and more balanced arrangement. Thus statement (c) is correct.

(d) For a single electronic species like H, energy depends on value of \( n \) and does not depend on \( l \). Hence energy of 2s-orbital and 2p-orbital is equal in case of hydrogen like species. Therefore, statement (d) is incorrect.

4. (b) The medicines which are used to reduce pain are known as analgesics. For example paracetamol, ibuprofen, morphine, etc.

(b) The chemicals which either prevent the growth of microorganisms or kill them but are not harmful to the living tissues are known as antiseptics. e.g. savlon, dettol. Dettol is one of the most commonly used antiseptics. It is a mixture of chloroxylenol and \( \alpha \)-terpineol.

(c) The chemical substances which are used to bring down body temperature during fever are called antipyretics, e.g. aspirin, novalgin, etc.

(d) The chemicals which are obtained from microorganisms such as bacteria, fungi, etc., or by synthetic methods and used to inhibit the growth or even kill the microorganisms are called antibiotics, e.g. penicillin, chloramphenicol, etc.

5. (b) The element with atomic number, \( Z = 114 \) is flerovium (Fl). It is a super heavy artificial chemical element. In the periodic table of the elements, it is a transactinide element in the p-block. It is a member of the 7th period and is the heaviest known member of the carbon family.

Electronic configuration for \( Z = 114 \) is \( [Rn]_{86} \ 5f^{14} \ 6d^{10} \ 7s^2 \ 7p^2 \)

6. (a) For the reaction, \( \text{SrCO}_3(s) \xrightarrow{\Delta} \text{SrO}(s) + \text{CO}_2(g) \),

\[ K_p = 16 \text{ atm} = P_{\text{CO}_2} = \text{maximum pressure of CO}_2 \]

Given, \( p_1 = 0.4 \text{ atm}, \ V_1 = 20 \text{ L}, \ T_1 = 400 \text{ K} \)
\( p_2 = 16 \text{ atm}, \ V_2 = ?, \ T_2 = 400 \text{ K} \)

At constant temperature, \( p_1V_1 = p_2V_2 \)
\[ 0.4 \times 20 = 16 \times V_2 \]
\[ V_2 = \frac{0.4 \times 20}{16} = 5 \text{ L} \]

7. (d)

\[ \text{CH}_3 \quad \equiv \quad \text{CH} \quad \xrightarrow{\text{H}_2\text{O},\text{H}_2\text{SO}_4} \quad \text{CH}_3 \quad \equiv \quad \text{CH}_2 \]

Intermediate (Enol) (A)

\[ \text{OH} \quad \text{Tautomerisation} \quad \text{O} \]

\[ \text{CH}_3 \quad \equiv \quad \text{CH}_2 \]

(Acetone) (B)

Therefore, \( A = \text{CH}_3=\text{C} \equiv \text{CH}_2 \)

\( B = \text{CH}_3=\text{C} \equiv \text{CH}_3 \)

8. (b) Microorganisms present in the soil act as biggest source and sink. A sink is a natural or artificial reservoir that accumulates and stores some carbon containing chemical compound for an indefinite period.

9. (b) The conversion of amide with no substituent on nitrogen to an amine containing one carbon less by the action of alkaline hypobromide. It involves the migration of alkyl or aryl group with its electron pair to electron deficient N from adjacent carbon. The reaction involves the intermediates of isocyanate.

\[ \text{CH}_3=\text{C} \equiv \text{NH}_2 + \text{Br}_2 + 4\text{NaOH} \]

Acetamide

\[ \xrightarrow{\Delta} \quad \text{CH}_2=\text{NH}_2 + 2\text{NaBr} + 2\text{Na}_2\text{CO}_3 + \text{H}_2\text{O} \]

Methanamine

\[ \text{O} \quad \text{Step I} : \text{CH}_3=\text{C} \equiv \text{NH}_2 + \text{Br}_2 \]

\[ \xrightarrow{\Delta} \quad \text{CH}_2=\text{C} \equiv \text{N} = \text{Br} \]

\[ \text{H} \]
Step II: \( \text{CH}_3\text{C}_\text{O}\text{N} - \text{Br} + \text{OH}^- \xrightarrow{\text{+}} \text{CH}_3\text{C}_\text{O}\text{N} - \text{Br} + \text{H}_2\text{O} \)

Step III: \( \text{CH}_3\text{C}_\text{O}\text{N} + \text{Br} \xrightarrow{\text{intermolecular}} \text{CH}_3\text{C}_\text{O}\text{N}\text{Br} \)

Step IV: \( \text{CH}_3\text{C}_\text{O}\text{N}_\text{Br} \xrightarrow{\text{alkyl migration}} \text{CH}_3\text{C}_\text{O}\text{Br} \)

Step V: \( \text{CH}_3\text{NCO} + 2\text{OH}^- \xrightarrow{\Delta} \text{CH}_3\text{NH}_2 + \text{CO}_2\text{^-} \)

10. (d) The species having bond angles of 120° is \( \text{BCl}_3 \). It is \( \text{sp}^2 \)-hybridised and central atom does not have any lone pair of electrons.

<table>
<thead>
<tr>
<th>Chemical formula</th>
<th>Species</th>
<th>Bond angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \text{PH}_3 )</td>
<td>(Pyramidal)</td>
<td>93.5°</td>
</tr>
<tr>
<td>( \text{ClF}_3 )</td>
<td>(T-shaped)</td>
<td>90°</td>
</tr>
<tr>
<td>( \text{NCl}_3 )</td>
<td>(Pyramidal)</td>
<td>107.8°</td>
</tr>
<tr>
<td>( \text{BCl}_3 )</td>
<td>(Trigonal planar)</td>
<td>120°</td>
</tr>
</tbody>
</table>

11. (c) According to Werner’s theory,

\( \text{CoCl}_3 \cdot 6\text{NH}_3 \rightarrow [\text{Co(NH}_3)_3\text{Cl}^+]3\text{Cl}^- \)

\( \text{CoCl}_3 \cdot 5\text{NH}_3 \rightarrow [\text{Co(NH}_3)_3\text{Cl}^2+]2\text{Cl}^- \)

\( \text{CoCl}_3 \cdot 4\text{NH}_3 \rightarrow [\text{Co(NH}_3)_3\text{Cl}_2^+]\text{Cl}^- \)

When \( \text{AgNO}_3 \) in excess is treated with these complexes then following reactions take place:

\[ [\text{Co(NH}_3)_3\text{Cl}^+]3\text{Cl}^- + \text{AgNO}_3 \rightarrow 3\text{AgCl} \] (Excess) + [Co(NH$_3$)$_3$]$^{3+}$

\[ [\text{Co(NH}_3)_2\text{Cl}^+]2\text{Cl}^- + \text{AgNO}_3 \rightarrow 2\text{AgCl} \] (Excess) + [Co(NH$_3$)$_2$Cl]$^{2+}$

\[ [\text{Co(NH}_3)_2\text{Cl}_3^- + \text{AgNO}_3 \rightarrow \text{AgCl} \] (excess) + [Co(NH$_3$)$_2$Cl$_2$]$^+$

12. (b) According to Gibbs-Helmholtz equation,

\[ \Delta G = \Delta H - T\Delta S \]

where, \( \Delta H = \) Enthalpy change

\( \Delta S = \) Entropy change

\( T = \) Temperature

For a reaction to be spontaneous \( \Delta G < 0 \).

.: Gibbs -Helmholtz equation becomes,

\[ \Delta G = \Delta H - T\Delta S < 0 \]

or, \( \Delta H < T\Delta S \)

or, \( T > \frac{\Delta H}{\Delta S} \)

\[ \frac{35.5 \text{ kJ mol}^{-1}}{83.6 \text{ J K}^{-1} \text{ mol}^{-1}} = 425 \text{ K} \]

13. (b) Two different halogens may react to form interhalogen compounds as

\[ \text{XX'}^-(\text{ClF}, \text{BrF}, \text{BrCl}, \text{IF}, \text{ICl}) \] Linear

\[ \text{XX'}^+ (\text{ClF}_2, \text{BrF}_2, \text{IF}_2) \] Bent T-shaped

\[ \text{XX'}^+ (\text{ClF}_3, \text{BrCl}_3, \text{IF}_3) \] Square-pyramidal

\[ \text{XX'}^- (\text{IF}_2) \] Pentagonal bipyramidal

14. (a) According to direct substitution and cine substitution:
If nucleophile occupies same position of the leaving group, product is called **direct substitution product**.

If nucleophile occupies adjacent position of the leaving group, product is called **cine substitution product**. Intermediate is benzyne.

15. (b) For a reversible reaction, it accelerates the speed of forward as well as backward reaction to the same extent. Hence, it does not disturb the equilibrium, i.e. does not change the equilibrium constant of the reaction but helps to attain the equilibrium faster.

16. (b) SO₂ gas can readily oxidise acidified KMnO₄ solution because KMnO₄ is an oxidising agent that easily oxidises SO₂.

\[ 2\text{MnO}_4^- + 5\text{SO}_2 + 2\text{H}_2\text{O} \rightarrow 2\text{Mn}^{2+} + 5\text{SO}_4^{2-} + 4\text{H}^+ \]

While other options such as NO₂ (strong oxidising agent), CO₂ (neither oxidising agent nor reducing agent) cannot decolourise acidified KMnO₄ Solution.

17. (d) Thinking process This type of problem can be solved by application of electron- withdrawing and electron donating group.

In III, —CH₃ group is an electron donating and o/p directing group which increases the electron density on benzene ring at ortho or para position while in II, —NO₂ group is an electron withdrawing group which decreases the electron density on benzene ring. Hence, the III is more basic than II. In I, there is no any substituent attached. due to this I is more basic then II and less basic then III.

Therefore, the correct order of basic strength of above compounds is II < I < III.

18. (d) For a dilute solution, the depression in freezing point (\(\Delta T_f\)) is directly proportional to molality (\(m\)) of the solution.

\[ \Delta T_f \propto m \text{ or } \Delta T_f = K_f m \]

where, \(K_f\) is called molal depression constant or freezing point depression constant or cryoscopic constant.

The value of \(K_f\) depends only on nature of the solvent and independent of composition of solute particles, i.e. does not depend on the concentration of solution.

19. (b) Aldehydes and ketones containing \(\alpha-\)H atoms undergo aldol condensation in presence of dilute alkali as catalyst and gives \(\alpha, \beta\) unsaturated compound with the elimination of H₂O molecule.
20. (b) Given, \( N + 3H \rightleftharpoons 2NH_2 \frac{K_1}{\text{at}} \) …(i)

\( N + O \rightleftharpoons 2NO \frac{K_2}{\text{at}} \) …(ii)

\( H + \frac{1}{2}O \rightleftharpoons H_2O \frac{K_3}{\text{at}} \) …(iii)

To calculate, \( 2NH_2 + \frac{5}{2}O \rightleftharpoons 2NO + 3H_2O \frac{K}{\text{at}} \) …(iv)

On reversing the equation (i) and multiplying the equation (iii) by 3, we get

\( 2NH_2 \rightleftharpoons N_2 + 3H_2 \frac{1}{K_1} \) …(v)

\( 3H_2 + \frac{3}{2}O \rightleftharpoons 3H_2O \frac{K_3^3}{\text{at}} \) …(vi)

Now, add equation (ii), (v) and (vi), we get the resultant equation (iv).

\( 2NH_2 + \frac{5}{2}O \rightleftharpoons 2NO + 3H_2O \)

\( \therefore K = \frac{K_3^3}{K_1} \)

21. (d) An electrophile is defined as electron deficient species which attacks on electron rich areas. Being electron deficient, the electrophiles behaves an Lewis acids.

\( \text{e.g.} \quad H^+, \text{Cl}^+, \text{Br}^+, \text{NO}_2^+, \text{NO}^+ \text{etc.} \)

The electrophiles can be seen in the form of neutral molecules also e.g. \( \text{CR}_2^+, \text{NR}_2, \text{BF}_3 \text{etc.} \)

Thus, we can say that electrophile can be either neutral or positively charged species and can form a bond by accepting a pair of electrons from a nucleophile.

22. (c) Key concept According to first law of thermodynamics,

\[ \Delta U = q + w \]

where, \( \Delta U \) = internal energy
\( q \) = heat absorbed or evolved, \( w \) = work done.

Also, work done against constant external pressure (irreversible process).

\[ w = -p_{\text{ext}} \Delta V. \]

Work done in irreversible process,

\[ w = -p_{\text{ext}} \Delta V = -p_{\text{ext}} (V_2 - V_1) \]

\[ = -2.5 \text{ atm} (45 \text{ L} - 2.5 \text{ L}) \]

\[ = -5 \text{ L atm} = -5 \times 1013 \text{ J} \]

\[ = -505 \text{ J} \]

Since, the system is well insulated, \( q = 0 \).

\[ \therefore \Delta U = w = -505 \text{ J} \]

Hence, change in internal energy, \( \Delta U \) of the gas is \( -505 \text{ J} \).

23. (c) Key concept Isoelectronic species have equal number of valence electrons.

Both IBr\(_2\)- and XeF\(_2\)- are linear and number of valence electrons present in both the species is same, i.e. they are also isoelectronic.

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Compounds</th>
<th>Number of valence electrons</th>
<th>Geometry</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>BeCl(_2)</td>
<td>2 + 14 = 16</td>
<td>Linear</td>
</tr>
<tr>
<td>2.</td>
<td>XeF(_2)</td>
<td>8 + 14 = 22</td>
<td>Linear</td>
</tr>
<tr>
<td>3.</td>
<td>TeI(_2)</td>
<td>6 + 14 = 20</td>
<td>Bent V-shape</td>
</tr>
<tr>
<td>4.</td>
<td>IBr(_2)</td>
<td>7 + 14 + 1 = 22</td>
<td>Linear</td>
</tr>
<tr>
<td>5.</td>
<td>IF(_3)</td>
<td>7 + 21 = 28</td>
<td>T-shape</td>
</tr>
</tbody>
</table>

24. (a,b,d) (a) FeO\(_{0.98}\) has non-stoichiometric metal excess defect. It occurs due to missing of a negative ion from its lattice site, thus leaving a hole which is occupied by an electron. Non-stoichiometric ferrous oxide is FeO\(_{0.93-0.96}\) and it is due to metal deficiency defect. Thus, statement (a) is incorrect.

(b) In an ionic crystal of \(A^+B^-\) type, if equal number of cations and anions are missing from their lattice sites, the defect is called Schottky defect. Due to such defect, density of solid decreases. Thus, statement (b) is correct.

(c) NaCl-insulator; Silicon (Si) - semiconductor, Silver (Ag) - conductor; Quartz - piezoelectric crystal. Thus, statement (c) is correct.
In an ionic crystal when an ion is missing from its lattice site and occupies interstitial site, the defect is called Frenkel’ defect. This type of defect is seen in those crystals where the difference in the size of cations and anions is very large and their coordination number is low. Thus, statement (d) is incorrect.

25. (c) Thinking Process This problem is based on the resonance stabilisation. In anisol, methyl phenyl oxonium ion is formed by protonation of ether. The bond between O — CH₃ is weaker than the bond between O — C₆H₅, because the carbon of phenyl group is sp²-hybridised and there is a partial double bond character. Thus, the reaction yields phenol and alkyl halide.

26. (a) Key concept Wavelength (λ) of absorption is inversely proportional to CFSE (Δo) value of ligands attached with the central metal ion i.e.

\[ \lambda \propto \frac{1}{\Delta o} \]

According to spectrochemical series:

\[ \Gamma^− < Br^− < S^{2−} < SCN^− < Cl^− < F^− < OH^− \]

\[ < C₆H₅OH < O₃H < NSS^− < NH₃ < en < NO₂^− < CN^− \]

The CFSE of ligands attached with Co³⁺ ion is in the order

en > NH₃ > H₂O (From spectrochemical series)

\( \therefore \) Wavelength of absorbed light (λ) \propto \frac{1}{\Delta o}

\( \therefore \) The order of wavelength of absorption in the visible region will be: en < NH₃ < H₂O or, [Co(en)]³⁺ < [Co(NH₃)³⁺] < [Co(H₂O)³⁺]

27. (c) [Mn(CN)₆]³⁻ is d⁵sp³-hybridised and octahedral In [Mn(CN)₆]³⁻, Mn is in +3 oxidation state Mn³⁺ = 3d⁵ 4s⁰

28. (d) Isomers which are possible by rotation about single bonds without cleavage of any bond are called conformation. In ethane, an infinite number of conformations are possible. There are two extreme forms, the staggered conformation, which is the most stable and the eclipsed conformation which is least stable. Among the conformers of ethane, bond angle and bond length remain same while their energy, stability and dihedral angle are different.

29. (b) Molarity and normality are temperature dependent because they involve volume of solutions. Volume is dependent on temperature. Molarity (M) = \[ \frac{\text{Moles of solute}}{\text{Volume of solution (in L)}} \]

Molarity, mole fraction and weight percentage do not depend on temperature because they involve masses of solute and solvent.

30. (d) When protein is subjected to physical change like change in temperature or chemical change like change in pH, the hydrogen bonds are disturbed. As a result, globules unfolds and helix get uncoiled and protein losses its biological activity. Hence, the denaturation of protein makes the protein inactive.

31. (a) —CHO group gets higher priority over >C == C group in numbering of principal carbon chain.

IUPAC name = 3-keto-2-methylhex-4-enal.

32. (c) HgCl₂ and I₂ both when dissolved in water containing I⁻ ions, the pair of species formed is Hg₂Cl²⁺ and I⁻.

In aqueous solution, I₂ reacts with I⁻ and maintains the following equilibrium.

\[ I₂ + I⁻ \rightleftharpoons I₃⁻ \]

Hg₂²⁺ gives ppt. of Hgl₂ on reaction with I⁻.
But HgI₂ is soluble in excess of I⁻

\[ \text{Hg}^{2+} + 2\text{I}^{-} \rightarrow \text{HgI}_2 \downarrow + 2\text{Cl}^{-} \]

Red ppt.

HgI₂ + 2I⁻ \( \rightarrow \) [HgI₂]²⁻

33. (b) The inability of ns² electrons of the valence shell to participate in bonding is called as inert pair effect. Due to this effect, the lower oxidation state becomes more stable on descending the group. Thus, Sn²⁺ is a reducing agent while Pb³⁺ acts as an oxidising agent.

34. (d) We know that, slowest step is the rate determining step.

\[ \text{Rate}(r) = K_r[X]^i [Y]^j \] (i)

Now, from equation. (i), i.e.

\[ X_j \rightarrow 2X [\text{fast}] \]

\[ K_{eq} = \frac{[X]^2}{[X]^2} \Rightarrow [X] = (K_{eq}[X]^2)^{1/2} \] (ii)

Now, substitute the value of [X] from equation. (ii) in equation. (i), we get

\[ \text{Rate} = K_{eq}^{1/2}[X_j^{1/2}^2] \]

\[ \therefore \text{Order of reaction} = \frac{1}{2} + 1 = \frac{3}{2} = 1.5 \]

35. (d) **Key concept** For a sparingly soluble salt, if S is the molar solubility,

\[ A_x B_y (s) + aH_2O \rightarrow xA^{y+} + yB^{z-} \]

At saturation,

\[ K[A_x B_y] = [A^{y+}]^x \times [B^{z-}]^y = [xS]^x \times [yS]^y \]

or

\[ K_{sp} = x^y \times y^z S^{x+y} \]

where, the constant \( K_{sp} \) is called solubility product.

\[ \text{Ag}_2\text{C}_2\text{O}_4 (s) \rightarrow 2\text{Ag}^{+} + \text{C}_2\text{O}_4^{2-} \]

\[ 2S \quad S \]

\[ K_{sp} = [\text{Ag}^{+}]^2 \times [\text{C}_2\text{O}_4^{2-}] = [2S]^2 \times [S] \]

Given, \( 2S = 2.2 \times 10^{-3} \text{ M} \) or \( S = 1.1 \times 10^{-4} \text{ M} \)

\[ \therefore K_{sp} = [2.2 \times 10^{-3}]^2 \times [1.1 \times 10^{-4}] = 5.3 \times 10^{-12} \]

36. (d) Extraction of gold and silver involves leaching with CN⁻ ion. Silver is later recovered by distillation of Zn.

In the metallurgy of silver or gold, the respective metal is leached with a dilute solution of NaCN or KCN in the presence of air to obtain the metal in solution as complex. From the complex, metal is obtained later by replacement.

In general, \( 4\text{M} (s) + 8\text{CN}^- (aq) + 2\text{H}_2\text{O} (aq) + \text{O}_2 (g) \rightarrow 4[\text{M(CN)}_2^- (aq) + 4\text{OH}^- (aq)] \)

\[ 2[\text{M(CN)}_2^- (aq) + \text{Zn}(s) \rightarrow [\text{Zn(CN)}_2^- (aq)] \quad + 2\text{M}(s) \]

\( M = \text{Ag or Au} \)

This method is known as Mac-Arthur Forest cyanide process.

37. (b) Greater the s-character of C-atom in hydrocarbons, greater the electronegativity of that carbon and thus greater the acidic nature of the H attached to electronegative carbon.

CH \( \equiv \) CH \( \equiv \) CH₂ \( \equiv \) CH₃

Hybridisation: \( sp \quad sp^2 \quad sp^3 \)

s-character: 50% 33% 25%

Electronegativity: \( \text{Max.} \)

Acidic character \( \text{Max.} \)

of terminal H

Thus, CH \( \equiv \) CH \( > \) CH₂ \( = \) CH \( > \) CH₃

CH₂ \( \equiv \) CH₃ \( \equiv \) CH₄

38. (d) **Key concept** More the extent of hydration, lesser is the ionic mobility.

Ionic mobility of alkali metal ions is lowest when aqueous solutions of their salts are put under an electric field.

In all the alkalis metals, Li⁺ ion is smallest thus, extent of hydration is maximum in Li⁺ ion

e.i. The dissolution of Li⁺ in water occurs and gets hydrated. Smaller the size of a cation, greater is the extent of hydration and lesser is the ionic mobility.

39. (c) Aldehydes gives silver mirror test so, ‘X’ may be alcohol which is oxidised by Cu gives aldehydes.

Therefore,

\[ \text{C}_2\text{H}_5\text{OH} \rightarrow \text{C}_2\text{H}_5\text{CHO} \quad \text{or} \quad A = \text{CH}_2\text{CHO} \]

\[ \text{C}_2\text{H}_5\text{OH} \overset{\text{Cu}/573 K}{\text{oxidation}} \rightarrow \text{CH}_3\text{CHO} \quad \text{Acetaldehyde} \]

\[ \overset{(A)}{\therefore} \frac{\text{[Ag(NH}_3)_2]^+}{\text{OH}} \rightarrow \text{Silver} \quad \text{monaobserved} \]

Tollen’s reagent
40. (b) $\text{SO}_4^{2-}$ and $\text{SO}_2^{3-}$ have S—S bond

41. (d) Thinking process This problem is based on the acidic character of phenol. Electron-drawing group at $\text{o}$ and $\text{p}$-position w.r.t. —OH group of phenol, increase the acidic strength.

Picric acid (2, 4, 6-trinitrophenol) is extremely more acidic than given compounds due to the presence of three strong electron withdrawing groups (—$\text{NO}_2$ group) at $\text{o}$- and $\text{p}$-positions, picric is more acidic compound.

42. (c) Thinking process Calculate the value of $E_{\text{cell}}$ i.e. $E_1$ and $E_2$ by substituting the respective given values in the Nernst equation,

$$E_{\text{cell}} = E^\circ - \frac{0.059}{n} \log \frac{[\text{Zn}^{2+}]}{[\text{Cu}^{2+}]}$$

Compare the calculated values of $E_1$ and $E_2$ and find the correct relation.

For the electrochemical cells,

**Zn | ZnSO$_4$ (0.01M) | CuSO$_4$ (1M) | Cu**

Cell reaction:

$$\text{Zn} + \text{Cu}^{2+} \rightarrow \text{Zn}^{2+} + \text{Cu}; n = 2$$

$$E_1 = E^\circ - \frac{0.059}{2} \log \frac{[\text{Zn}^{2+}]}{[\text{Cu}^{2+}]}$$

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$$E_1 = E^\circ - \frac{0.059}{2} \log \frac{1}{100}$$

$$E_2 = E^\circ - \frac{1}{2} \log \frac{1}{100} = (E^\circ - 0.059)$$

For cell,

$$\text{Zn} | \text{ZnSO}_4 (1M) || \text{CuSO}_4 (0.01M) | \text{Cu}$$

$$E_2 = E^\circ - \frac{0.059}{2} \log \frac{1}{0.01}$$

$$E_2 = E^\circ - \frac{0.059}{2} \log 100 = (E^\circ - 0.059)$$

∴ $E_1 > E_2$

43. (b) For a first order reaction,

Rate constant ($k$) = \[ \frac{2.303}{t} \log \frac{a}{a - x} \]

where, \(a = \text{initial concentration}\)
\(a - x = \text{concentration after time } t'\)
\(t = \text{time in sec.}\)

Given, \(a = 20 \text{ g},\)
\(a - x = 5 \text{ g},\)
\(k = 10^{-2}\)

∴ \[ t = \frac{2.303}{10^{-2}} \log \frac{20}{5} = 138.6 \text{ s} \]

Alternatively,

Half-life for the first order reaction,

$$t_{1/2} = \frac{0.693}{k}$$

$$t_{1/2} = \frac{0.693}{10^{-2}} = 69.3 \text{ s}$$

Two half-lives are required for the reduction of 20 g of reactant into 5 g.

20 g \(\rightarrow\) 10 g \(\rightarrow\) 5 g

∴ Total time = \(2t_{1/2}\)

= \(2 \times 69.3\)

= \(138.6 \text{ s}\)

44. (d) Steam distillation is used to purify the substances which

(i) are volatile in steam but are immiscible with water.

(ii) possess sufficiently high vapour pressure at the boiling point of water.
The process of steam distillation can also be used to separate a mixture of two organic compounds one of which is steam volatile while the other is not. In ortho and para-nitrophenols, the latter is non-volatile, hence they are separated by steam distillation.

45. (c) **Key concept** The species that have same number of electrons have same bond order.

<table>
<thead>
<tr>
<th>Species</th>
<th>Number of electrons</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO</td>
<td>6 + 8 = 14</td>
</tr>
<tr>
<td>NO</td>
<td>7 + 8 = 15</td>
</tr>
<tr>
<td>O₂</td>
<td>8 + 8 = 16</td>
</tr>
<tr>
<td>NO⁺</td>
<td>7 + 8 − 1 = 14</td>
</tr>
<tr>
<td>CN⁻</td>
<td>6 + 7 + 1 = 14</td>
</tr>
<tr>
<td>O₂⁻</td>
<td>8 + 8 + 1 = 17</td>
</tr>
</tbody>
</table>

Thus, both CN⁻ and CO have equal number of electrons. So, their bond order will be same.

### Biology

1. (b) **Holoenzyme** It is a conjugate complete catalytically active enzyme together with its coenzyme.

   **Apoenzyme** The protein part of catabolically active enzyme is called apoenzyme.

   **Coenzyme** Some enzymes require additional organic or metallo-organic molecules for their activity. These molecules are called coenzyme.

   So, holoenzyme is apoenzyme together with coenzyme hence option (b) is correct.

2. (b) The mucosa present in between the bases of villi of small intestine (Crypts of Lieberkuhn) contain paneth cells, which secrete antibacterial lysozyme.

   **Concept Enhancer** Kupffer cells are phagocytic cells of liver.

   Zymogen cells produce enzyme.

   Argentaffin cells produce hormones.

3. (b) Phosphoenol Pyruvate (PEP) is found in the mesophyll cell, which accepts the atmospheric CO₂ in C₄-plants and converts it to oxaloacetate—a C₄ compound. It is the first stable compound of C₄-plants.

   **Concept Enhancer** C₄-plants possess special adaptation anatomy in their leaves to cope up the photorespiratory losses. There are dimorphic chloroplast present in them—agranal in bundle sheath cells and granal in mesophyll cells.

4. (a)

<table>
<thead>
<tr>
<th>Column I</th>
<th>Column II</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A) Gonorrhea</td>
<td>(i) Neisseria Gonorrhoeas</td>
</tr>
<tr>
<td>(B) Syphilis</td>
<td>(ii) Treponema Pallidium</td>
</tr>
<tr>
<td>(C) Genital Warts</td>
<td>(iii) Human Papilloma Virus</td>
</tr>
<tr>
<td>(D) AIDS</td>
<td>(iv) HIV</td>
</tr>
</tbody>
</table>

5. (c) **Mycoplasma** is triple layered smallest living cells. It does not have definite cell wall. It is an anaerobic organism. It cause diseases in plants (little leaf of brinjal) as well as in animals (pleuromorphic pneumonia in man).

   **Concept Enhancer** Lipoprotein membrane (Three layers)

   Soluble protein

   dsDNA

   Ribosomes

   Soluble RNA
6. (a) Mendel was a great Mathematician and was Austrian Monk. He became interested in genetics and conducted experiments in pea plant \((Pisum sativum)\). He hybridised the contrasting characters of the plant and conducted his experiments for more than 10 years between 1856-1863; this experimental data was published in 1865.

7. (c) The flowers with packed inflorescence and single ovary are air pollinated. These flower have pollen grains produced in large numbers, which are light weighted, sometimes winged, e.g. cereals and grasses.

8. (b) When \(K = N\) in a logististics growth curve, it is asymptote. It means a population growing in a habitat with limited resources show initially a lag phase, followed by phase of acceleration and deceleration and finally an equilibrium, i.e. when the population density \((N)\) reaches the carrying capacity \((K)\)

![Population growth curve](image)

Population growth curve is logistic, when responses are limiting the growth, here \(K\) is carrying capacity and \(N\) is population density.

**Time Saver** For logistic growth

\[
\frac{dN}{dt} = rN \left( \frac{K - N}{K} \right)
\]

if, \(K = N\), then \(K - N = 0\)

\(\therefore\) \(\frac{dN}{dt} = 0\)

the population reaches asymptote.

9. (a) In the rib cage, the true ribs are those which are attached to the sternum in the front and vertebral column at back. These are 7 in numbers. Although there are total 12 ribs in the rib cage. The 11th and 12th ribs are attached to the vertebral column and keep floating in the thoracic cavity, so are called floating ribs.

10. (a) MALT is mucosa associated lymphoid tissue located within the lining of the major tracts like respiratory, digestive and urinogenital tracts. It is nearly 50% of the total lymphoid tissue in the human body.

11. (a) When closely related species of same organisms are crossed continuously for few successive generations, it results in accumulation of recessive characters thus homozygous purelines are obtained.

12. (b) Trichomes are the epidermal tissues structure. When epidermal cells become glandular hair, it is called trichome. This character was not amongst the seven characters of pea, which mendel selected for his hybridisation experiments.

![Different types of trichomes](image)

(a) Glandular  (b) Stellate  (c) Urticating  (d) Stinging

13. (d) Mitochondria is referred as ‘Power house of the cell’. It contains the enzymes for cellular respiration. It oxidises carbohydrate to produce ATP molecules in the process of aerobic respiration.

14. (c) 33 codons will be altered if the 901st base is deleted and RNA has only 998 bases instead of 999 bases. Total bases present in RNA = 999

\[\text{Bases left after deletion of 901st base in RNA} = 999 - 901 = 98\]

Number of codon present in 98 = 33 
(Approximately as three codons code for one amino acid).

15. (a) Archaeabacteria are the most primitive form of bacteria. These live in diverse habitat, e.g. extreme hot temperature, saline condition, variable pH, etc. Saline bacteria are called Halophiles (e.g., Halobacterium, Halococcus).
The ability of archaebacteria to survive in harsh conditions is due to the presence of branched lipid chain in their membrane, which reduces the fluidity of their membrane.

16. (d) The post synaptic membrane of the synapse of a neuron contains the receptors or neurotransmitters.

17. (b) The directional selection leads to change in the phenotypic characters of a population in one direction. In the case of artificial selection, it is intentionally done to increase the milk production, so directional selection operates.

18. (d) In the hepatic portal system, the hepatic veins takes blood from intestine to the liver. This way, it takes all the nutrients absorbed from intestine to the liver first, where screening and storing of nutrition takes place.

Concept Enhancer

The portal system is a system, in which vein takes blood to some organ/tissue of the body other than heart. In this, the vein has capillary network at it’s both ends.

There is one more portal system in human body named hypophyseal portal system present in the hypothalamus, which brings neuro secretions of hypothalamus to pituitary gland.

The renal portal system is found in fishes and amphibians. It supplies blood from posterior region of the body to the kidneys by renal portal veins to remove waste products before sending it to heart via renal veins and post canal veins.

19. (a) The value of water potential of pure water is highest and it is zero. Water molecules possess kinetic energy. Greater the concentration of water in a system, greater is its kinetic energy or its water potential. If we add solute in water, the solution has fewer free water molecule and concentration of water decreases thus reducing its water potential.

20. (b) Order being the higher taxon of classification exhibit the few similar characters of families. The order of horse is perissodactyla.

Concept Enhancer

The order perissodactyla includes odd toed mammals. For example, Equus asinus (donkey), Rhinoceros indicus (the great one horned rhinoceros).

21. (c) Alexander von Humbolt was a great German naturalist and geographer. He did extensive explorations in the wilderness of South American forests. He established species area relationship. He observed that with in a region, species richness increase with increasing explored area, but upto a certain limit. Infact, the relationship between species richness and area for a variety of taxa turns out to be a rectangular hyperbola as shown in figure below.
Note that on log scale the relationship becomes linear. On a logarithmic scale, the relationship is a straight line described by the equation.

\[ \log S = \log C + Z \log A \]

where,
\[ S = \text{Species richness} \]
\[ A = \text{Area} \]
\[ Z = \text{Slope of the line (regression coefficient)} \]
\[ C = \text{Y-intercept} \]

22. (b) DNA fragments are negatively charged molecules. The reason why DNA is negatively charged is the phosphate (PO\(^4^-\)) group that constitutes every nucleotide.

**Thinking process** During the formation of phosphodiester bond, nucleotides retain one of the two negative charge, while the other is lost to form ester bond to new pentose.

23. (c) In human beings, after birth the first set of teeth that develops are deciduous teeth or temporary teeth. These are 20 in number. The dental formula of child is 2102/2102.

Thus, they have 2 incisors, 1 canine, 0 premolars and 2 molars. Therefore, the baby boy would not have premolars.

24. (c) If anaphase promoting complex is defective in a human cell, the chromosomes will not segregate during anaphase of mitosis. APC triggers the transition from metaphase to anaphase by tagging specific proteins for degradation.

**Concept Enhancer** Anaphase stage of meiosis is characterised by two events

(a) Splitting of centromeres and segregation of chromosomes.

(b) Movement of chromatids towards the opposite poles.

25. (c) The important characteristic that hemichordates share with chordates is pharynx with gill slits. These gill slits are narrow openings in the pharynx. The position of these pharyngeal gill slits is lateral in chordates, while dorsal in hemichordates.

26. (c) A cross between two individuals, one with AB blood group and other with A blood group will produce four genotypes and three phenotypes.

<table>
<thead>
<tr>
<th>Husband</th>
<th>Wife</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>i^a</td>
</tr>
<tr>
<td>i^a</td>
<td>I^a</td>
</tr>
<tr>
<td>i</td>
<td>I</td>
</tr>
</tbody>
</table>

Offsprings Genotypes : 4(i^aI^a, i^aI^b, I^a i, I^b i)

Phenotypes : 3 (A, B, AB)

27. (b) Transplantation of tissue/organs may fail, when that tissue is rejected by the recipients immune system leading to its destruction. Tissue rejection is a function of cell-mediated immune response that involves T-cells. These cells have the ability to distinguish between self and non-self. After the recognition of non-self tissue, the killer T-cells induce apoptosis of the target tissue.

28. (a) The absence of nucleus in RBC is an adaptation that allows it to contain more haemoglobin and carry more oxygen by providing empty space. This adaptation also aids in effective diffusion of oxygen.

**Concept Enhancer** RBC's are initially produced in bone marrow with a nucleus. They, then undergo enucleation at maturity, in which their nucleus is removed.

29. (a) In lungs, even after the most forceful expiration, some of the volume of air remains. This volume is termed Residual Volume (RV). Due to this, lungs do not collapse even after the most forceful expiration. RV is about 1100 mL to 1200 mL.

30. (d) Zygotic meiosis is represented in the Chaplontic life cycle of many algae including Chlamydomonas. In such a life cycle, all cells are haploid except zygote. This is because meiosis occurs in the zygote itself resulting into four haploid cells that give rise to haploid plants.
31. (d) In male frogs, germinal epithelium of seminiferous tubules produce sperms, which are transferred to kidney via vasa efferentia, from the kidney, these enter into Bidder’s canal from where, the sperms are carried to the transverse collecting tubules, longitudinal collecting tubule and then to urinogenital duct. The later carries the sperms to seminal vesical, where, they are stored temporarily. From here, sperms are carried to cloaca and then these shed into water. 

Thus, the correct route of sperms passage is:

Testes $\rightarrow$ vasa efferentia $\rightarrow$ kidney $\rightarrow$ cloaca $\rightarrow$ urinogenital duct $\rightarrow$ Bidder’s canal

32. (c) Aerosol refers to the suspended particulate matter of less than 1 µm size. These are kind of air pollutants that are suspended in our atmosphere. They have a measurable effect on climate change as they can modify the amount energy reflected by clouds. As a result, they can change the atmospheric circulation patterns and affect agriculture negatively. These also affect human health by causing breathing problems.

33. (d) Viroids differ from viruses in having RNA molecules without protein coat. Viruses on the other hand possess DNA or RNA with a protein coat as their genetic material. Viruses can infect a wide range of organisms including plants, animals or bacteria, while viroids infect only plants.

34. (d) Okazaki fragments are short segments of replicating DNA. These have 1000-2000 bp in prokaryotes and 100-200 bp in eukaryotes. These fragments are used to elongate the lagging strand away from the replication fork.

Concept Enhancer

During replication the leading strand with polarity $3' \rightarrow 5'$ forms its complementary strand continuously, because $3'$ end of the latter is always open for elongation. On the other hand replication in lagging strand with polarity $5' \rightarrow 3'$ is discontinuous, because only a short segment of DNA can be built in $5' \rightarrow 3'$ direction at a time. As a result of this, okazaki fragments are formed, which are later joined by DNA ligase.

35. (b) Plants that produce pneumatophores, i.e. negatively geotropic roots and show vivipary, i.e. germination of seeds inside the fruits are halophytes. These plants are adapted to grow in highly saline areas such as mangroves. Pneumatophores help these plants in respiration as they do not get sufficient oxygen from the soil. On the other hand vivipary aids in perennation.

36. (b) The process of separation and purification of expressed protein before marketing is called downstream processing. In this process, a whole range of biochemical separation and purification techniques are used such as drying, chromatography, solvent extraction and distillation. After purification quality control testings are done.

37. (c) Heartwood also called duramen is the central dead wood of trees. It comprises of dead, lignified cells containing organic compounds, e.g. tannins or other substances. These substances make it darker in colour and aromatic. Heartwood is strong durable and resistant to decay. It does not conduct water and minerals because of the presence of dead elements.

Thinking Process

The conduction of water and minerals is carried out by sapwood, because it contains living cells.

38. (d) Spliceosome is a large molecular complex found in nucleus of eukaryotic cells of plants, animals and fungi, etc. It is assembled from snRNAs and protein complexes that plays an important role in splicing of introns. Spliceosome is absent in cells of bacteria.

39. (a) The ascending limb of loop of Henle is impermeable to water and permeable to $K^+$, $Cl^-$ and $Na^+$ and partially permeable to urea. Due to this, sodium, potassium, calcium, magnesium and chloride are reabsorbed here making the filtrate hypotonic.

40. (a) Biomass refers to the amount of living organic matter. Forest ecosystem have the maximum biomass, because it includes organisms of all trophic levels as compared to pond, lake or grassland ecosystem. In forest ecosystems productivity is also high that contributes to maximum biomass.
41. (b) The final proof that DNA is the genetic material came from the experiments of Alfred Hershey and Martha Chase (1952). Griffith’s experiment proved the existence of genetic material while Avery, MacLeod and Mcarty worked to determine the biochemical nature of transforming principle. 

**Concept Enhancer** Hershey and Chase during their experiment, grew viruses in two mediums, one containing $^{32}$P and other $^{35}$S, when these were allowed to infect bacteria, they observed that viruses containing $^{32}$P DNA were radioactive while those with $^{35}$S protein were not radioactive. Hence, DNA not protein coat entered bacterial cells from viruses.

42. (a) An intrauterine device is a small, often T-shaped birth control device that is inserted into a woman’s uterus to prevent pregnancy. The copper releasing IUD’s primarily work by disrupting sperm motility and damaging sperm. Copper acts as a spermicide. It can also alter the endometrial lining, preventing implantation.

43. (b) Volvox is a fresh water green hollow ball-like colonial alga. Its colony has a fixed number of cells (500 to 60000). It is called coenobium.

44. (d) The root is covered at the apex by a thimble-like structure called the root cap. It protects the tender apex of the root as it makes its way through the soil. A few millimetres above the root cap is the region of meristematic activity. The cells of this region are very small, thin-walled and with dense protoplasm. They divide repeatedly. The cell proximal to this region undergo rapid elongation and enlargement and are responsible for the growth of the root in length. This region is called the region of elongation. The cells of the elongation zone gradually differentiate and mature. Hence, this zone, proximal. From this region, some of the epidermal cells form very fine and delicate, thread-like structure called root hairs. These root hairs absorb water and minerals from the soil.

45. (b) Chronic hypersecretion of Growth Hormone (GH) leads to gigantism or acromegaly depending on the age of the individual. If its hypersecretion occurs before the ossification of epiphyseal plates, it causes exaggerated and prolonged growth in long bones. It results in gigantism. In adults, hypersecretion of GH leads to acromegaly. No increase in height occurs because of the ossified epiphyseal plate.

**Thinking Process** Epiphyseal plate is responsible for the growth of bone. It closes after adolescence.

46. (c) In sewage treatment, suspended solids are removed during primary treatment. It is also known as physical treatment. It consists of shredding, churning, screening and sedimentation. Sequential filtration removes floating and large suspended solids.

47. (a) Among the given options, option (a) is mismatched. Pinus is a monoecious plant as it bears male and female cones on the same plant.

**Concept Enhancer:** The male pollen cones of Pinus occur in clusters subterminally on lower long branches. The female or seed cones develop in groups of 2 – 6 on upper long branches of the tree.

48. (b) Gel electrophoresis is used for the separation of molecules of similar electric charge on the basis of their size. Hence, smaller the DNA fragment size the farther it moves.

**Thinking Process** Agarose gel matrix functions as sieve. Smaller DNA fragments easily move and larger fragments take time to move in gel matrix.

49. (c) In Bougainvillea, thorns are the modifications of stem. They are stiff, sharp structures, which have lost their growing point and become hard. They reduce transpiration as well as browsing by animals.

50. (c) The association of H$_1$ histone with nucleosome indicates that DNA remains in its condensed form.

**Concept Enhancer** In eukaryotes, DNA packaging is carried out with the help of histone proteins. Nucleosome is the unit of compaction. Its core consists of four pairs of histones (H$_{A}$, H$_{B}$, H$_{3}$ and H$_{4}$). The linker DNA, consisting of H$_1$ histone connects two adjacent nucleosomes.
They together constitute chromatosome. It gives rise to a chromatin fibre after further condensation.

51. (c) Corpus luteum is a temporary endocrine gland in the human body. It secretes small amount of estradiol and significant amount of progesterone hormone. In the absence of fertilisation, the corpus luteum degenerates.

52. (b) Among the given options, only option (b) is mismatched. *Rhodospirillum* is a free living nitrogen-fixing bacteria. Mycorrhiza is the symbiotic association of a fungus with the root of a higher plant.

53. (b) GnRH is a hypothalamic hormone. It stimulates the anterior lobe of pituitary gland to secrete LH and FSH.

54. (a) A gene whose expression helps to identify transformed cell is known as selectable marker. Usually, the genes encoding resistance to antibiotics, such as tetracycline, ampicillin, etc. are useful selectable markers for e.g. *E. coli*.

**Concept Enhancer:** Plasmid pBR322 has two resistance genes; ampicillin resistance (ampR) and tetracyclin resistance (tetR). These are considered as useful selectable markers.

55. (b) Tropical rain forests show stratification. It can be defined as the grouping of plants into two or more well defined layers depending upon their height. These layers are called strata or storeys. There storeys consist of respectively very tall emergent trees, tall trees, small trees, a shrub layer and a ground layer of ferns, mosses and herbs.

56. (c) In angiosperms, functional megaspore develops into an embryo sac. The functional megaspore is the first cell of female gametophyte.

57. (c) The cell cycle is a series of events that take place in cell leading to its division and duplication of its DNA. Bacteria lack a cell nucleus. Due to their primitive nature they lack a well marked S-phase. In bacteria DNA replication occurs before fission.

58. (c) Among the given options, option (c) contains all aquatic mammals. Whales are inhabitants of the open sea, while seal (*Phoca*) is a marine carnivore. Dolphins are found in rivers. Trygon and sharks are fishes, which belong to chondrichthyes class of superclass–Pisces.

59. (a) Coconut fruit is a drupe. It has a membranous epicarp, fibrous mesocarp and a stony endocarp. Tomato is a berry, litchi is a nut. Capsular fruits are found in cotton.

60. (d) Double fertilisation is the characteristic feature of angiosperms. In this type of fertilisation one male gamete fuses with an egg and forms zygote. The second male gamete fuses with diploid secondary nucleus of central cell to form a triploid primary endosperm nucleus.

61. (d) Glycocalyx is the outer most mucilage layer of the cell envelope. It gives sticky character to the bacterial cell.

62. (c) *Ectocarpus* and *Fucus* respectively show haplodiplontic and diplontic life cycle.

**Concept Enhancer:** In *Ectocarpus* sporic meiosis occurs and haploid biflagellate meiozoospores are formed. They germinate to produce gametophytic thalli. The gametophytes liberate gametes, which fuse to form diploid zygote, which gives rise to a diploid plant.
In *Fucus*, there is a single somatic phase. It is diploid and produces haploid gametes. The fusion during fertilisation to give rise to diploid individual.

63. (a) Wildlife safari parks are used for the *ex situ* conservation of threatened animals and plants. They are taken out from their natural habitat and placed in special settings (wildlife safari park, zoo). Here they are protected and given special cage.

64. (b) Vitamin-A is a group of unsaturated nutritional organic compounds that includes retinol, retinal, retinoic acid and β-carotene. Vitamin-A is needed by the retina of eye in the form of retinal, which combines with protein opsin to form rhodopsin, the light absorbing molecule.

65. (c) Thalassemia is an autosomal recessive disease, which occurs due to mutation in genes. This results in reduced rate of synthesis of the globin chains of haemoglobin. Anaemia is the main feature of this disease. There are two forms of Thalassemia, i.e. α-thalassemia (production of affected α-globin chain, which is governed by genes on 16th chromosome), and β-thalassemia (production of affected β-chain, which is governed by a gene on 11th chromosome).

**Concept Enhancer** Thalassemia differs from sickle-cell anaemia in that the former is a quantitative problem of synthesising few globin molecules, while the latter is a qualitative problem of synthesising an incorrectly functioning globin.

66. (d) Among the given options except lipids all are polymers. These are formed by the polymerisation of monomers. The basic unit of lipid are fatty acids and glycerol molecules that do not form repetitive chains. Instead they form triglycerides from three fatty acids and one glycerol molecules.

67. (a) Non-disjunction is the failure of chromosomes to disjoin or separate and move away to opposite poles. Non-disjunction of 21st chromosome during oogenesis is the cause of down’s syndrome. It occurs due to the presence of an additional copy of chromosome no. 21 (trisomy of 21st chromosome) in humans.

68. (c) In C₄-plants, the initial fixation of CO₂ occurs in mesophyll cells. The primary acceptor of CO₂ is Phosphoenol Pyruvate (PEP). It combines with CO₂ in the presence of enzyme PEP carboxylase to form the first stable product, i.e. oxaloacetic Acid (OAA). C₃ plants lack PEP carboxylase enzyme. They possess RuBisCO enzyme. This enzyme can work as both carboxylase (fixation of CO₂) and oxygenase (fixation of O₂). RuBisCO has a much greater affinity for CO₂ than for O₂ and the binding is competitive. At higher temperature, its affinity for CO₂ decrease and it works as oxygenase. Therefore, at higher temperature photosynthesis decrease in C₃-plants, while in C₄-plants it increases.

69. (c) Auxin delay abscission of leaves and fruits at early stages. Whenever leaf or fruit fall occurs, the organ concerned stops producing auxin. However, it promotes abscission of older, mature leaves and fruits.

70. (a) Biosphere reserve consists of three zones, i.e. core, buffer and transition zone. **Core zone** comprises an undisturbed and legally protected ecosystem, where no human activity is allowed. **Buffer zone** surrounds the core area and transitions zone is the outermost area of the **biosphere reserve**, where active cooperation between reserve management and the local people occur.
71. (c) The body wall of a common sponge consists of three layers, i.e. **pinacoderm**, **choanoderm** and **mesophyll layer**. Choanoderm is inner cellular layer which consists of highly specialised flagellated cells called choanocytes. The beating of their flagella creates water current.

72. (b) A decrease in blood pressure/volume stimulates the hypothalamus to release ADH (Anti diuretic Hormone) as well as JGA (Juxtaglomerular Apparatus) cells to release renin. Renin by **renin angiotensin** mechanism activates the adrenal cortex to release aldosterone. **Atrial Natriuretic Factor** (ANF) is produced by atria of heart during increased blood pressure/volume. It can cause vasodilation and there by, decrease the blood pressure, therefore, option (b) is correct.

73. (b) Dioecious flowering plants contain unisexual flowers. In dioecious condition two types of unisexual flowers occur on different plants. Hence, it does not favour autogamy and geitonogamy because autogamy takes place in bisexual flowers and geitonogamy takes place between different flower of the same plant.

74. (c) Stomata are tiny pore complexes. Each stoma is surrounded by two specialised green epidermal cells called guard cells. The opening of the stoma is facilitated by the orientation of the microfibril in the cell walls of the guard cells. Cellulose microfibrils are oriented radially rather than longitudinally making it easier for the stoma to open.

75. (d) The DNA fragments separated on an agarose gel can be visualised after staining with **ethidium bromide**. It is intercalating agent and a fluorescent agent. The stained DNA fragments are seen bright orange coloured band under UV-light.

76. (d) Option (d) is incorrect, which can be corrected as:

Krebs' cycle starts with the condensation of acetyl group with oxaloacetic acid and water to yield citric acid.

During conversion of succinic acid to fumaric acid $\text{FAD}^+$ is reduced to $\text{FADH}_2$. During conversion of pyruvic acid to acetyl Co-A, isocitrate to oxalosuccinic acid and $\alpha$-ketoglutaric acid to succinyl Co-A $\text{NAD}^+$ is reduced to $\text{NADPH +H}^+$.

77. (d) **Mutualism** is an association of two species in which both species are benefitted. **Mycorrhiza** is a mutualistic relationship between fungal hyphae and roots of higher plants. The fungus helps in mineral nutrition absorption for the plants with, which they are associated and obtained in turn, nutrients from plants.

**Concept Enhancer**

**Amensalism** is an interaction between different species, in which one species is harmed and other is neither benefitted nor harmed, e.g. **Penicillium**.

**Antibiosis** It is an antagonistic association between two or more organism, in which one is adversely affected, e.g. antibiotic includes the relationship between antibiotic and bacteria.

**Fungistasis** inhibits the growth of fungi.

78. (c) The joint between atlas and axis is a type of synovial joint. A considerable movement is allowed at all synovial joints. They are surrounded by tubular articular capsule. The capsule consists of two layers, i.e. outer fibrous capsule and inner synovial membrane, which secretes synovial fluid lubricates and providing nourishment to articular cartilage.

**Concept enhancer**

**Fibrous joint** They do not allow movement because the bones are held firmly by bundles of white fibrous tissue, e.g. joint between the bones of skull.

**Cartilaginous joints** They allow slight movement because of the elastic pads of fibrocartilage present between the ends of the bones taking part in the joints, e.g. pubic symphysis of pubis.

**Saddle joints** This is the type of synovial joints. This type of joint is like ball and socket joint, but not developed fully, e.g. joint between carpal of hand.

79. (d) **Acetobacter aceti** produces acetic acid.

- **Methanobacterium** produces Methane.
- **Penicillium notatum** produces Penicillin.
- **Saccharomyces cerevisiae** produces ethanol.
80. (d) Frog heart is myogenic and autoexcitable. In this condition, contraction of the heart originates within the muscles itself. When muscles are contracting, they are releasing heat, which keeps the electrochemical reactions in muscles going so that muscles of heart keep contracting after the removal of heart from the body.

81. (a) The myelin sheath is a greatly extended and modified plasma membrane wrapped around the nerve axon in a spiral fashion. It is originated from Schwann cells in the peripheral nervous system and oligodendroglial cells in the central nervous system.

82. (d) Capacitation is a process, where the spermatozoa acquire the capacity to fertilise the eggs. It occurs in female reproductive tract. Concept Enhancer

Capacitation involves following changes
(i) Dilution of inhibitory factors of semen.
(ii) Removal of cholesterol vesicles covering sperm head and acrosome.
(iii) Increase in the permeability of acrosome.

83. (c) The edible part of coconut is endosperm. Coconut water is free nuclear endosperm and white kernel is the cellular endosperm.

84. (c) Phellem or cork is a tissue formed on the outer side of cork cambium. It is composed of dead cells. The cell wall become impermeable due to suberisation.

85. (c) Vascular cambium located between xylem and phloem in the stems and roots of vascular plants. It produces secondary xylem towards the pith and secondary phloem towards the bark. Phellogen is made of narrow thin-walled and nearly rectangular cells. Phellogen cuts off cells on both sides. The outer cells differentiate into cork or phellem while inner cells differentiate into secondary cortex or phelloderm. The phellogen, phellem and phelloderm are collectively known as periderm.

86. (a) There are three main types of RNA, i.e. rRNA, tRNA and mRNA. rRNA is the most abundant form of RNA; because it is responsible for coding and protein synthesis in the cell and associated with ribosomes. mRNA provides the template for translation. tRNA brings amino acids and reads the genetic code.

87. (c) Vascular cambium located between xylem and phloem in the stems and roots of vascular plants. It produces secondary xylem towards the pith and secondary phloem towards the bark. Phellogen is made of narrow thin-walled and nearly rectangular cells. Phellogen cuts off cells on both sides. The outer cells differentiate into cork or phellem while inner cells differentiate into secondary cortex or phelloderm. The phellogen, phellem and phelloderm are collectively known as periderm.

88. (b) During mitosis following events occurs as their is condensation of chromosomal material, which takes place at an early prophase stage. During late prophase nuclear membrane disintegrates. Then chromosomes get arranged at equator in the metaphase stage. After that splitting of centromere and segregation of chromosomes occur in the anaphase stage. In telophase stage chromosomes move to opposite poles of the cell. It is last stage of mitosis.

89. (d) Pancreas consist of exocrine and endocrine part. Exocrine part secretes alkaline pancreatic juice. This juice contains trypsinogen, chymotrypsinogen, procarboxypeptidase, lipase, amylase, elastase. Concept Enhancer Renin and pepsin enzymes are present in gastric juice. Maltase is present in the intestinal juice.

90. (b) Attractant and rewards are required for entomophily (insect pollination). Flowers produce specific odour and nectar to attract the insect for effective pollination. Entomophilous flowers are large with bright colours.