1. The volume \( V \) of a monoatomic gas varies with its temperature \( T \), as shown in the graph. The ratio of work done by the gas, to the heat absorbed by it, when it undergoes a change from state \( A \) to state \( B \), is

(\( \frac{1}{3} \)  \( \frac{2}{3} \)  \( \frac{2}{5} \)  \( \frac{2}{7} \))

2. The fundamental frequency in an open organ pipe is equal to the third harmonic of a closed organ pipe. If the length of the closed organ pipe is 20 cm, the length of the open organ pipe is

(\( \text{a) 12.5 cm} \)  \( \text{b) 8 cm} \)  \( \text{c) 13.3 cm} \)  \( \text{d) 16 cm} \))

3. At what temperature will the rms speed of oxygen molecules become just sufficient for escaping from the Earth’s atmosphere?

(Given:

mass of oxygen molecule,

\( m = 2.76 \times 10^{-26} \text{ kg} \),

Boltzmann’s constant \( k_B = 1.38 \times 10^{-23} \text{ J K}^{-1} \))

(\( \text{a) 5.016 \times 10^4 \text{ K} } \)  \( \text{b) 8.326 \times 10^4 \text{ K} } \)  \( \text{c) 2.508 \times 10^4 \text{ K} } \)  \( \text{d) 1.254 \times 10^4 \text{ K} } \))

4. The efficiency of an ideal heat engine working between the freezing point and boiling point of water, is

(\( \text{a) 6.25\%} \)  \( \text{b) 20\%} \)  \( \text{c) 26.8\%} \)  \( \text{d) 12.5\%} \))

5. A carbon resistor of \( (47 \pm 4.7) \text{ k}\Omega \) is to be marked with rings of different colours for its identification. The colour code sequence will be

(a) Yellow - Green - Violet - Gold
(b) Yellow - Violet - Orange - Silver
(c) Violet - Yellow - Orange - Silver
(d) Green - Orange - Violet - Gold

6. A set of ‘\( n \)’ equal resistors, of value ‘\( R \)’ each, are connected in series to a battery of emf ‘\( E \)’ and internal resistance ‘\( R’ \). The current drawn is \( I \). Now, the ‘\( n’ \) resistors are connected in parallel to the same battery. Then, the current drawn from battery becomes \( 10I \). The value of ‘\( n’ \) is

(\( \text{a) 20} \)  \( \text{b) 11} \)  \( \text{c) 10} \)  \( \text{d) 9} \))

7. A battery consists of a variable number ‘\( n \)’ of identical cells (having internal resistance ‘\( r’ \) each) which are connected in series. The terminals of the battery are short-circuited and the current \( I \) is measured. Which of the graphs shows the correct relationship between \( I \) and \( n \)?

(a)  \( (a) \)  \( (b) \)  \( (c) \)  \( (d) \)
8. Unpolarised light is incident from air on a plane surface of a material of refractive index \( \mu \). At a particular angle of incidence \( \theta \), it is found that the reflected and refracted rays are perpendicular to each other. Which of the following options is correct for this situation?
   (a) \( i = \sin^{-1} \left( \frac{1}{\mu} \right) \)
   (b) Reflected light is polarised with its electric vector perpendicular to the plane of incidence
   (c) Reflected light is polarised with its electric vector parallel to the plane of incidence
   (d) \( i = \tan^{-1} \left( \frac{1}{\mu} \right) \)

9. In Young’s double slit experiment, the separation \( d \) between the slits is 2 mm, the wavelength \( \lambda \) of the light used is 5896 Å and distance \( D \) between the screen and slits is 100 cm. It is found that the angular width of the fringes is 0.20°. To increase the fringe angular width to 0.21° (with same \( \lambda \) and \( D \)) the separation between the slits needs to be changed to
   (a) 2.1 mm
   (b) 1.9 mm
   (c) 1.8 mm
   (d) 1.7 mm

10. An astronomical refracting telescope will have large angular magnification and high angular resolution, when it has an objective lens of
   (a) large focal length and large diameter
   (b) large focal length and small diameter
   (c) small focal length and large diameter
   (d) small focal length and small diameter

11. The ratio of kinetic energy to the total energy of an electron in a Bohr orbit of the hydrogen atom, is
   (a) 2 : 1
   (b) 1 : 1
   (c) 1 : 2
   (d) 2 : 1

12. An electron of mass \( m \) with a velocity \( \mathbf{v} = v_o \hat{\mathbf{a}} \) enters a constant electric field \( \mathbf{E} = -E_0 \hat{\mathbf{a}} \) at \( t = 0 \). If \( \lambda_o \) is its de-Broglie wavelength initially, then its de-Broglie wavelength at time \( t \) is
   (a) \( \lambda_o t \)
   (b) \( \lambda_o \left( 1 + \frac{E_0 t}{m v_o} \right) \)
   (c) \( \frac{\lambda_o}{1 + \frac{E_0 t}{m v_o}} \)
   (d) \( \lambda_o \)

13. For a radioactive material, half-life is 10 minutes. If initially there are 600 number of nuclei, the time taken (in minutes) for the disintegration of 450 nuclei is
   (a) 30
   (b) 10
   (c) 20
   (d) 15

14. When the light of frequency \( 2\nu_o \) (where, \( \nu_o \) is threshold frequency), is incident on a metal plate, the maximum velocity of electrons emitted is \( v_1 \). When the frequency of the incident radiation is increased to \( 5\nu_o \), the maximum velocity of electrons emitted from the same plate is \( v_2 \). The ratio of \( v_1 \) to \( v_2 \) is
   (a) 4 : 1
   (b) 1 : 4
   (c) 1 : 2
   (d) 2 : 1

15. In the circuit shown in the figure, the input voltage \( V_i \) is 20 V, \( V_{BE} = 0 \) and \( V_{CE} = 0 \). The values of \( I_B, I_C \) and \( \beta \) are given by

   ![Circuit Diagram]

   (a) \( I_B = 20 \mu A, I_C = 5 mA, \beta = 250 \)
   (b) \( I_B = 25 \mu A, I_C = 5 mA, \beta = 200 \)
   (c) \( I_B = 40 \mu A, I_C = 10 mA, \beta = 250 \)
   (d) \( I_B = 40 \mu A, I_C = 5 mA, \beta = 125 \)

16. In a \( p-n \) junction diode, change in temperature due to heating
   (a) does not affect resistance of \( p-n \) junction
   (b) affects only forward resistance
   (c) affects only reverse resistance
   (d) affects the overall \( V-I \) characteristics of \( p-n \) junction
17. In the combination of the following gates the output $Y$ can be written in terms of inputs $A$ and $B$ as

(a) $\overline{A \cdot B} + A \cdot B$  
(b) $A \cdot \overline{B} + \overline{A} \cdot B$  
(c) $A \cdot \overline{B}$  
(d) $\overline{A} + B$

18. An EM wave is propagating in a medium with a velocity $v=\frac{v}{c^2}$. The instantaneous oscillating electric field of this EM wave is along $+y$-axis. Then, the direction of oscillating magnetic field of EM wave will be

(a) $-y$-direction  
(b) $+z$-direction  
(c) $-z$-direction  
(d) $-x$-direction

19. The refractive index of the material of a prism is $\sqrt{2}$ and the angle of the prism is $30^\circ$. One of the two refracting surfaces of the prism is made a mirror inwards, by silver coating. A beam of monochromatic light entering the prism from the other face will retrace its path (after reflection from the silvered surface) if its angle of incidence on the prism is

(a) $30^\circ$  
(b) $45^\circ$  
(c) $60^\circ$  
(d) zero

20. An object is placed at a distance of 40 cm from a concave mirror of focal length 15 cm. If the object is displaced through a distance of 20 cm towards the mirror, the displacement of the image will be

(a) 30 cm towards the mirror  
(b) 36 cm away from the mirror  
(c) 30 cm away from the mirror  
(d) 36 cm towards the mirror

21. The magnetic potential energy stored in a certain inductor is 25 mJ, when the current in the inductor is 60 mA.

This inductor is of inductance

(a) 1.389 H  
(b) 138.88 H  
(c) 0.138 H  
(d) 13.89 H

22. An electron falls from rest through a vertical distance $h$ in a uniform and vertically upward directed electric field $E$. The direction of electric field is now reversed, keeping its magnitude the same. A proton is allowed to fall from rest in it through the same vertical distance $h$. The time of fall of the electron, in comparison to the time of fall of the proton is

(a) 10 times greater  
(b) 5 times greater  
(c) smaller  
(d) equal

23. The electrostatic force between the metal plates of an isolated parallel plate capacitor $C$ having a charge $Q$ and area $A$, is

(a) proportional to the square root of the distance between the plates  
(b) linearly proportional to the distance between the plates  
(c) independent of the distance between the plates  
(d) inversely proportional to the distance between the plates

24. A tuning fork is used to produce resonance in a glass tube. The length of the air column in this tube can be adjusted by a variable piston. At room temperature of $27^\circ C$, two successive resonances are produced at 20 cm and 73 cm of column length. If the frequency of the tuning fork is 320 Hz, the velocity of sound in air at $27^\circ C$ is

(a) 350 m/s  
(b) 339 m/s  
(c) 330 m/s  
(d) 300 m/s

25. A pendulum is hung from the roof of a sufficiently high building and is moving freely to and fro like a simple harmonic oscillator. The acceleration of the bob of the pendulum is $20 \text{ m/s}^2$ at a distance of 5 m from the mean position. The time period of oscillation is

(a) 2 s  
(b) $\pi$ s  
(c) $2\pi$ s  
(d) 1 s
26. A metallic rod of mass per unit length $0.5 \text{ kg m}^{-1}$ is lying horizontally on a smooth inclined plane which makes an angle of $30^\circ$ with the horizontal. The rod is not allowed to slide down by flowing a current through it when a magnetic field of induction $0.25 \text{ T}$ is acting on it in the vertical direction. The current flowing in the rod to keep it stationary is
- (a) $14.76 \text{ A}$
- (b) $5.98 \text{ A}$
- (c) $7.14 \text{ A}$
- (d) $11.32 \text{ A}$

27. A thin diamagnetic rod is placed vertically between the poles of an electromagnet. When the current in the electromagnet is switched on, then the diamagnetic rod is pushed up, out of the horizontal magnetic field. Hence, the rod gains gravitational potential energy. The work required to do this comes from
- (a) the lattice structure of the material of the rod
- (b) the magnetic field
- (c) the current source
- (d) the induced electric field due to the changing magnetic field

28. An inductor $20 \text{ mH}$, a capacitor $100 \mu\text{F}$ and a resistor $50 \Omega$ are connected in series across a source of emf, $V(t) = 10 \sin 314 t$. The power loss in the circuit is
- (a) $2.74 \text{ W}$
- (b) $0.43 \text{ W}$
- (c) $0.79 \text{ W}$
- (d) $1.13 \text{ W}$

29. Current sensitivity of a moving coil galvanometer is $5 \text{ div mA}$ and its voltage sensitivity (angular deflection per unit voltage applied) is $20 \text{ div V}$. The resistance of the galvanometer is
- (a) $250 \Omega$
- (b) $25 \Omega$
- (c) $40 \Omega$
- (d) $500 \Omega$

30. A body initially at rest and sliding along a frictionless track from a height $h$ (as shown in the figure) just completes a vertical circle of diameter $AB = D$. The height $h$ is equal to
- (a) $\frac{7}{5}D$
- (b) $D$
- (c) $\frac{3}{2}D$
- (d) $\frac{5}{4}D$

31. Three objects, $A$ (a solid sphere), $B$ (a thin circular disk) and $C$ (a circular ring), each have the same mass $M$ and radius $R$. They all spin with the same angular speed $\omega$ about their own symmetry axes. The amounts of work ($W$) required to bring them to rest, would satisfy the relation
- (a) $W_A > W_B > W_C$
- (b) $W_B > W_A > W_C$
- (c) $W_C > W_B > W_A$
- (d) $W_A > W_C > W_B$

32. A moving block having mass $m$, collides with another stationary block having mass $4m$. The lighter block comes to rest after collision. When the initial velocity of the lighter block is $v$, then the value of coefficient of restitution ($e$) will be
- (a) 0.8
- (b) 0.25
- (c) 0.5
- (d) 0.4

33. Which one of the following statements is incorrect?
- (a) Frictional force opposes the relative motion
- (b) Limiting value of static friction is directly proportional to normal reaction
- (c) Rolling friction is smaller than sliding friction
- (d) Coefficient of sliding friction has dimensions of length

34. A toy car with charge $q$ moves on a frictionless horizontal plane surface under the influence of a uniform electric field $E$. Due to the force $qE$, its velocity increases from 0 to 6 m/s in one second duration. At that instant, the direction of the field is reversed. The car continues to move for two more seconds under the influence of this field. The average velocity and the average speed of the toy car between 0 to 3 seconds are respectively
- (a) $1 \text{ m/s}, 3.5 \text{ m/s}$
- (b) $1 \text{ m/s}, 3 \text{ m/s}$
- (c) $2 \text{ m/s}, 4 \text{ m/s}$
- (d) $1.5 \text{ m/s}, 3 \text{ m/s}$

35. A block of mass $m$ is placed on a smooth inclined wedge $ABC$ of inclination $\theta$ as shown in the figure. The wedge is given an acceleration $a$ towards the right. The relation between $a$ and $\theta$ for the block to remain stationary on the wedge is
- (a) $a = g \cos \theta$
- (b) $a = \frac{g}{\sin \theta}$
- (c) $a = \frac{g}{\cos \theta}$
- (d) $a = g \tan \theta$
36. The moment of the force, \( F = 4\hat{i} + 5\hat{j} - 6\hat{k} \) at \((2, 0, -3)\), about the point \((2, -2, -2)\), is given by
(a) \(-7\hat{i} - 8\hat{j} - 4\hat{k}\)
(b) \(-\hat{i} - \hat{j} - 8\hat{k}\)
(c) \(-8\hat{i} - 4\hat{j} - 7\hat{k}\)
(d) \(-7\hat{i} - 4\hat{j} - 8\hat{k}\)

37. A student measured the diameter of a small steel ball using a screw gauge of least count 0.001 cm. The main scale reading is 5 mm and zero of circular scale division coincides with 25 divisions above the reference level. If screw gauge has a zero error of \(-0.004\) cm,
(a) 0.053 cm
(b) 0.525 cm
(c) 0.521 cm
(d) 0.529 cm

38. A solid sphere is rotating freely about its symmetry axis in free space. The radius of the sphere is increased keeping its mass same. Which of the following physical quantities would remain constant for the sphere?
(a) Rotational kinetic energy
(b) Moment of inertia
(c) Angular velocity
(d) Angular momentum

39. The kinetic energies of a planet in an elliptical orbit about the Sun, at positions \(A, B\) and \(C\) are \(K_A, K_B\) and \(K_C\), respectively. \(AC\) is the major axis and \(SB\) is perpendicular to \(AC\) at the position of the Sun \(S\) as shown in the figure. Then
(a) \(K_B < K_A < K_C\)
(b) \(K_A > K_B > K_C\)
(c) \(K_A < K_B < K_C\)
(d) \(K_B > K_A > K_C\)

40. If the mass of the Sun were ten times smaller and the universal gravitational constant were ten times larger in magnitude, which of the following is not correct?
(a) Time period of a simple pendulum on the Earth would decrease
(b) Walking on the ground would become more difficult
(c) Raindrops will fall faster
(d) ‘\(g\)’ on the Earth will not change

41. A solid sphere is in rolling motion. In rolling motion, a body possesses translational kinetic energy \((K_t)\) as well as rotational kinetic energy \((K_r)\) simultaneously. The ratio \(K_t : (K_t + K_r)\) for the sphere is
(a) 10 : 7
(b) 5 : 7
(c) 7 : 10
(d) 2 : 5

42. A small sphere of radius \(r\) falls from rest in a viscous liquid. As a result, heat is produced due to viscous force. The rate of production of heat when the sphere attains its terminal velocity, is proportional to
(a) \(r^5\)
(b) \(r^2\)
(c) \(r^3\)
(d) \(r^4\)

43. The power radiated by a black body is \(P\) and it radiates maximum energy at wavelength, \(\lambda_0\). If the temperature of the black body is now changed, so that it radiates maximum energy at wavelength \(\frac{3}{4}\lambda_0\), the power radiated by it becomes \(nP\). The value of \(n\) is
(a) \(\frac{256}{81}\)
(b) \(\frac{4}{3}\)
(c) \(\frac{3}{4}\)
(d) \(\frac{81}{256}\)

44. Two wires are made of the same material and have the same volume. The first wire has cross-sectional area \(A\) and the second wire has cross-sectional area \(3A\). If the length of the first wire is increased by \(\Delta l\) on applying a force \(F\), how much force is needed to stretch the second wire by the same amount?
(a) \(4F\)
(b) \(6F\)
(c) \(9F\)
(d) \(F\)

45. A sample of 0.1 g of water at 100°C and normal pressure \((1.013 \times 10^5\) Nm\(^{-2}\)) requires 54 cal of heat energy to convert to steam at 100°C. If the volume of the steam produced is 167.1 cc, the change in internal energy of the sample, is
(a) 42.2 J
(b) 208.7 J
(c) 104.3 J
(d) 84.5 J
46. The correct order of N-compounds in its decreasing order of oxidation states is
(a) HNO₃, NH₄Cl, NO, N₂
(b) HNO₃, NO, NH₄Cl, N₂
(c) HNO₃, NO, N₂, NH₄Cl
(d) NH₄Cl, N₂, NO, HNO₃

47. Which one of the following elements is unable to form MF₅⁻ ion?
(a) B (b) Al (c) Ga (d) In

48. Considering Ellingham diagram, which of the following metals can be used to reduce alumina?
(a) Mg (b) Zn (c) Fe (d) Cu

49. The correct order of atomic radii in group 13 elements is
(a) B < Ga < Al < Ti < In
(b) B < Al < Ga < In < Ti
(c) B < Al < In < Ga < Ti
(d) B > Ga < Al < In < Ti

50. Which of the following statements is not true for halogens?
(a) All but fluorine show positive oxidation states
(b) All are oxidising agents
(c) All form monobasic oxyacids
(d) Chlorine has the highest electron-gain enthalpy

51. In the structure of ClF₃, the number of lone pairs of electrons on central atom ‘Cl’ is
(a) four (b) two (c) one (d) three

52. Identify the major products P, Q and R in the following sequence of reactions:

\[
P \xrightarrow{\text{CH}_{3}\text{CH}_{2}\text{CH}_{2}\text{Cl}} \xrightarrow{\text{ArH}} \xrightarrow{\text{C}_{2}\text{H}_{5} \text{O}} Q \xrightarrow{\text{H}_{2} \text{O} \text{H}^{+}} R
\]

53. Which of the following compounds can form a Zwitter ion?
(a) Benzoic acid (b) Acetanilide (c) Aniline (d) Glycine

54. Regarding cross-linked or network polymers, which of the following statements is incorrect?
(a) Examples are bakelite and melamine
(b) They are formed from bi- and tri-functional monomers
(c) They contain covalent bonds between various linear polymer chains
(d) They contain strong covalent bonds in their polymer chains

55. Nitration of aniline in strong acidic medium also gives m-nitroaniline because
(a) in absence of substituents nitro group always goes to m-position
(b) in electrophilic substitution reactions amino group is meta directive
(c) in spite of substituents nitro group always goes to only m-position
(d) in acidic (strong) medium aniline is present as anilinium ion
56. The difference between amylose and amylopectin is
(a) amylopectin have 1→4 α-linkage and 1→6 β-linkage
(b) amylose have 1→4 α-linkage and 1→6 β-linkage
(c) amylopectin have 1→4 α-linkage and 1→6 α-linkage
(d) amylose is made up of glucose and galactose

57. A mixture of 2.3 g formic acid and 4.5 g oxalic acid is treated with conc. H_2SO_4. The evolved gaseous mixture is passed through KOH pellets. Weight (in g) of the remaining product at STP will be
(a) 2.8 (b) 3.0 (c) 1.4 (d) 4.4

58. Which of the following oxides is most acidic in nature?
(a) BaO (b) BeO (c) MgO (d) CaO

59. Which oxide of nitrogen is not a common pollutant introduced into the atmosphere both due to natural and human activity?
(a) N_2O (b) NO_2 (c) N_2O_5 (d) NO

60. The compound A on treatment with Na gives B, and with PCl_5 gives C. B and C react together to give diethyl ether. A, B and C are in the order
(a) C_2H_5Cl, C_2H_5OH, C_2H_5Cl
(b) C_2H_5OH, C_2H_5Cl, C_2H_5ONa
(c) C_2H_5OH, C_2H_5Cl, C_2H_5Cl
(d) C_2H_5OH, C_2H_5Cl, C_2H_5Cl

61. The compound C_6H_6 undergoes the following reactions :

\[ \text{C}_6\text{H}_6 + \text{Cl}_2/\Delta \rightarrow \text{A} \rightarrow \text{B} \rightarrow \text{C} \]

The product ‘C’ is
(a) 3-bromo-2, 4, 6-trichlorotoluene
(b) o-bromotoluene
(c) m-bromotoluene
(d) p-bromotoluene

62. Hydrocarbon (A) reacts with bromine by substitution to form an alkyl bromide which by Wurtz reaction is converted to gaseous hydrocarbon containing less than four carbon atoms. A is
(a) CH_3—CH_3 (b) CH_2=CH_2 (c) CH≡CH (d) CH_4

63. Which of the following molecules represents the order of hybridisation sp^2, sp^3, sp, sp from left to right atoms?
(a) CH_3—CH—CH=CH_2 (b) CH_2=CH—C=CH (c) CH=CH—C=CH (d) CH_3—CH=CH—CH_3

64. Which of the following carbocations is expected to be most stable?
(a) (b) (c) (d)

65. Which of the following is correct with respect to –I effect of the substituents? (R = alkyl)
(a) –NH_2 > –OR > –F (b) –NR_2 < –OR < –F (c) –NH_2 < –OR < –F (d) –NH_2 > –OR > –F

66. In the reaction

\[ \text{C}_6\text{H}_6 + \text{Cl}_2/\Delta \rightarrow \text{A} \rightarrow \text{B} \rightarrow \text{C} \]

the electrophile involved is
(a) dichloromethyl anion (C HCl_2^-) (b) formyl cation (CHO) (c) dichloromethyl cation (C HCl_2) (d) dichlorocarbene (C Cl_2)

67. Carboxylic acids have higher boiling points than aldehydes, ketones and even alcohols of comparable molecular mass. It is due to their
(a) more extensive association of carboxylic acid via van der Waals’ force of attraction (b) formation of carboxylate ion (c) formation of intramolecular H-bonding (d) formation of intermolecular H-bonding
68. Compound $A$, $C_6H_9O_8$, is found to react with NaOI (produced by reacting $Y$ with NaOH) and yields a yellow precipitate with characteristic smell. $A$ and $Y$ are respectively.

(a) \[
\begin{array}{c}
\text{O} \\
\text{H} \\
\text{CH}_3 \\
\text{OH} \\
\text{I}_2
\end{array}
\]
(b) \[
\begin{array}{c}
\text{OH} \\
\text{CH}_2 \\
\text{CH}_2 \\
\text{I}_2 \\
\text{OH}
\end{array}
\]
(c) \[
\begin{array}{c}
\text{CH}_3 \\
\text{CH}_2 \\
\text{OH} \\
\text{I}_2 \\
\text{I}_2
\end{array}
\]
(d) \[
\begin{array}{c}
\text{CH}_3 \\
\text{CH}_2 \\
\text{OH} \\
\text{I}_2 \\
\text{I}_2
\end{array}
\]

69. Match the metal ions given in Column I with the spin magnetic moments of the ions given in Column II and assign the correct code:

<table>
<thead>
<tr>
<th>Column I</th>
<th>Column II</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. $\text{Co}^{3+}$</td>
<td>i. $\sqrt{8}$ BM</td>
</tr>
<tr>
<td>2. $\text{Cr}^{3+}$</td>
<td>ii. $\sqrt{35}$ BM</td>
</tr>
<tr>
<td>3. $\text{Fe}^{3+}$</td>
<td>iii. $\sqrt{3}$ BM</td>
</tr>
<tr>
<td>4. $\text{Ni}^{2+}$</td>
<td>iv. $\sqrt{24}$ BM</td>
</tr>
<tr>
<td>v.</td>
<td>$\sqrt{75}$ BM</td>
</tr>
</tbody>
</table>

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

70. Which one of the following ions exhibits $d-d$ transition and paramagnetism as well?

(a) $\text{MnO}_4^-$
(b) $\text{Cr}_2\text{O}_7^{2-}$
(c) $\text{CrO}_4^{2-}$
(d) $\text{MnO}_4^-$

71. Iron carbonyl, Fe(CO)$_3$ is

(a) trinuclear
(b) mononuclear
(c) tetranuclear
(d) dinuclear

72. The type of isomerism shown by the complex [COCl$_2$(en)$_2$] is

(a) ionisation isomerism
(b) coordination isomerism
(c) geometrical isomerism
(d) linkage isomerism

73. The geometry and magnetic behaviour of the complex [Ni(CO)$_4$] are

(a) square planar geometry and paramagnetic
(b) tetrahedral geometry and diamagnetic
(c) square planar geometry and diamagnetic
(d) tetrahedral geometry and paramagnetic

74. Following solutions were prepared by mixing different volumes of NaOH and HCl of different concentrations:

I. 60 mL $\frac{M}{10}$ HCl + 40 mL $\frac{M}{10}$ NaOH
II. 55 mL $\frac{M}{10}$ HCl + 45 mL $\frac{M}{10}$ NaOH
III. 75 mL $\frac{M}{5}$ HCl + 25 mL $\frac{M}{5}$ NaOH
IV. 100 mL $\frac{M}{10}$ HCl + 100 mL $\frac{M}{10}$ NaOH

pH of which one of them will be equal to 1?

(a) IV (b) I (c) II (d) III

75. On which of the following properties does the coagulating power of an ion depend?

(a) Both magnitude and sign of the charge on the ion
(b) Size of the ion alone
(c) The magnitude of the charge on the ion alone
(d) The sign of charge on the ion alone

76. Given van der Waals’ constant of $\text{NH}_3$, $\text{H}_2$, $\text{O}_2$ and $\text{CO}_2$ are respectively 4.17, 0.244, 1.36 and 3.59, which one of the following gases is most easily liquefied?

(a) $\text{O}_2$ (b) $\text{H}_2$ (c) $\text{NH}_3$ (d) $\text{CO}_2$

77. The solubility of $\text{BaSO}_4$ in water is $2.42 \times 10^{-3}$ g L$^{-1}$ at 298 K. The value of its solubility product ($K_w$) will be (Given molar mass of $\text{BaSO}_4 = 233$ g mol$^{-1}$)

(a) $1.08 \times 10^{-14}$ mol$^2$L$^{-2}$ (b) $1.08 \times 10^{-12}$ mol$^2$L$^{-2}$
(c) $1.08 \times 10^{-10}$ mol$^2$L$^{-2}$ (d) $1.08 \times 10^{-9}$ mol$^2$L$^{-2}$

78. In which case is the number of molecules of water maximum?

(a) 0.00224 L of water vapours at 1 atm and 273 K
(b) 0.18 g of water
(c) 18 mL of water
(d) $10^{-3}$ mol of water
79. The correct difference between first-and second-order reactions is that (a) a first-order reaction can be catalysed; a second-order reaction cannot be catalysed (b) the half-life of a first-order reaction does not depend on [A]₀; the half-life of a second-order reaction does depend on [A]₀ (c) the rate of a first-order reaction does not depend on reactant concentrations; the rate of a second-order reaction does depend on reactant concentrations (d) the rate of a first-order reaction does depend on reactant concentrations; the rate of a second-order reaction does not depend on reactant concentrations

80. Among CaH₂, BeH₂, BaH₂, the order of ionic character is (a) BeH₂ < BaH₂ < CaH₂ (b) CaH₂ < BeH₂ < BaH₂ (c) BeH₂ < CaH₂ < BaH₂ (d) BaH₂ < BeH₂ < CaH₂

81. Consider the change in oxidation state of bromine corresponding to different emf values as shown in the diagram below.

\[
\begin{align*}
\text{BrO}_4^- &\xrightarrow{1.82 \text{ V}} \text{BrO}_3^- \xrightarrow{1.5 \text{ V}} \text{HBrO} \\
&\quad \xrightarrow{1.595 \text{ V}} \text{Br}_2 \xrightarrow{1.0652 \text{ V}} \text{Br}^-
\end{align*}
\]

Then the species undergoing disproportionation is (a) Br₂ (b) BrO₃⁻ (c) BrO₄⁻ (d) HBrO

82. For the redox reaction
\[\text{MnO}_4^- + \text{C}_2\text{O}_4^{2-} + \text{H}^+ \rightarrow \text{Mn}^{2+} + \text{CO}_2 + \text{H}_2\text{O}\]
the correct coefficients of the reactants for the balanced equation are \(\text{MnO}_4^-\) \(\text{C}_2\text{O}_4^{2-}\) \(\text{H}^+\) (a) 2 16 5 (b) 2 5 16 (c) 16 5 2 (d) 5 16 2

83. Which one of the following conditions will favour maximum formation of the product in the reaction, \(A_2(g) + B_2(g) \rightarrow X_2(g)\); \(\Delta H = -X \text{ KJ}\) (a) High temperature and high pressure (b) Low temperature and low pressure (c) Low temperature and high pressure (d) High temperature and low pressure

84. When initial concentration of the reactant is doubled, the half-life period of a zero order reaction (a) is tripled (b) is doubled (c) is halved (d) remains unchanged

85. The bond dissociation energies of \(X_2, Y_2\) and \(XY\) are in the ratio of 1 : 0.5 : 1. \(\Delta H\) for the formation of \(XY\) is \(-200 \text{ KJ mol}^{-1}\). The bond dissociation energy of \(X_3\) will be (a) 800 KJ mol⁻¹ (b) 100 KJ mol⁻¹ (c) 200 KJ mol⁻¹ (d) 400 KJ mol⁻¹

86. The correction factor 'a' to the ideal gas equation corresponds to (a) electric field present between the gas molecules (b) volume of the gas molecules (c) density of the gas molecules (d) forces of attraction between the gas molecules

87. Consider the following species \(\text{CN}^-, \text{CN}^+, \text{NO}\) and \(\text{CN}^\cdot\)
Which one of these will have the highest bond order? (a) \(\text{CN}^\cdot\) (b) \(\text{CN}^+\) (c) \(\text{NO}\) (d) \(\text{CN}^\cdot\)

88. Magnesium reacts with an element \(X\) to form an ionic compound. If the ground state electronic configuration of \((X)\) is \(1s^22s^22p^3\), the simplest formula for this compound is (a) \(\text{Mg}_2\text{X}\) (b) \(\text{Mg}_3\text{X}_2\) (c) \(\text{Mg}_2\text{X}_3\) (d) \(\text{Mg}_3\text{X}_2\)

89. Iron exhibits bcc structure at room temperature. Above 900°C, it transforms to fcc structure. The ratio of density of iron at room temperature to that at 900°C (assuming molar mass and atomic radii of iron remains constant with temperature) is (a) \(\frac{3\sqrt{3}}{4\sqrt{2}}\) (b) \(\frac{4\sqrt{3}}{3\sqrt{2}}\) (c) \(\frac{\sqrt{3}}{\sqrt{2}}\) (d) \(\frac{1}{2}\)

90. Which one is a wrong statement? (a) The electronic configuration of N-atom is (b) An orbital is designated by three quantum numbers while an electron in an atom is designated by four quantum numbers (c) Total orbital angular momentum of electron in 's' orbital is equal to zero (d) The value of \(m\) for \(d_{z^2}\) is zero

**NEET Solved Paper 2018 9**
91. Oxygen is **not** produced during photosynthesis by
   (a) Cycas
   (b) Nostoc
   (c) Green sulphur bacteria
   (d) Chara

92. Double fertilisation is
   (a) fusion of two male gametes with one egg
   (b) fusion of one male gamete with two polar nuclei
   (c) fusion of two male gametes of pollen tube with two different eggs
   (d) syngamy and triple fusion

93. Which one of the following plants shows a very close relationship with a species of moth, where none of the two can complete its life cycle without the other?
   (a) Banana
   (b) Yucca
   (c) Hydrilla
   (d) Viola

94. Pollen grains can be stored for several years in liquid nitrogen having temperature of
   (a) $-196^\circ C$
   (b) $-80^\circ C$
   (c) $-120^\circ C$
   (d) $-160^\circ C$

95. Which one of the following elements is responsible for maintaining turgor in cells?
   (a) Potassium
   (b) Sodium
   (c) Magnesium
   (d) Calcium

96. What is the role of NAD$^+$ in cellular respiration?
   (a) It is a nucleotide source of ATP synthesis
   (b) It functions as an electron carrier
   (c) It functions as an enzyme
   (d) It is the final electron acceptor for anaerobic respiration

97. In which of the following forms is iron absorbed by plants?
   (a) Free element
   (b) Ferrous
   (c) Ferric
   (d) Both ferric and ferrous

98. Which of the following is commonly used as a vector for introducing a DNA fragment in human lymphocytes?
   (a) $\lambda$ phage
   (b) Ti-plasmid
   (c) Retrovirus
   (d) pBR 322

99. Use of bioresources by multinational companies and organisations without authorisation from the concerned country and its people is called
   (a) biodegradation
   (b) biopiracy
   (c) bio-infringement
   (d) bioexploitation

100. In India, the organisation responsible for assessing the safety of introducing genetically modified organisms for public use is
   (a) Research Committee on Genetic Manipulation (RCGM)
   (b) Council for Scientific and Industrial Research (CSIR)
   (c) Indian Council of Medical Research (ICMR)
   (d) Genetic Engineering Appraisal Committee (GEAC)

101. The correct order of steps in Polymerase Chain Reaction (PCR) is
   (a) Denaturation, Extension, Annealing
   (b) Annealing, Extension, Denaturation
   (c) Extension, Denaturation, Annealing
   (d) Denaturation, Annealing, Extension

102. Select the correct match
   (a) TH Morgan – Transduction
   (b) $F_2 \times$ Recessive parent – Dihybrid cross
   (c) Ribozyme – Nucleic acid
   (d) G Mendel – Transformation

103. A ‘new’ variety of rice was patented by a foreign company, though such varieties have been present in India for a long time. This is related to
   (a) Lerma Rojo
   (b) Sharbati Sonora
   (c) Co-667
   (d) Basmati

104. Which one of the following pairs is wrongly matched?
   (a) XO type sex-determination – Grasshopper
   (b) ABO blood grouping – Codominance
   (c) Starch synthesis in pea – Multiple alleles
   (d) TH Morgan – Linkage

105. Select the correct statement.
   (a) Spliceosomes take part in translation
   (b) Punnett square was developed by a British scientist
   (c) Franklin Stahl coined the term ‘linkage’
   (d) Transduction was discovered by S. Altman.
106. The experimental proof for semiconservative replication of DNA was first shown in a
(a) plant (b) bacterium (c) fungus (d) virus

107. Which one of the following flowers only once in its lifetime?
(a) Mango (b) Jackfruit (c) Bamboo species (d) Papaya

108. Offsets are produced by
(a) parthenocarpy (b) mitotic divisions (c) meiotic divisions (d) parthenogenesis

109. Select the correct match.
(a) Matthew Meselson and F. Stahl : Pisum sativum
(b) Alfred Hershey and Martha Chase : TMV
(c) Alec Jeffreys : Streptococcus pneumoniae
(d) Francois Jacob and Jacques Monod : Lac operon

110. Which of the following has proved helpful in preserving pollen as fossils?
(a) Oil content (b) Cellulosic intine (c) Pollenkitt (d) Sporopollenin

111. Natality refers to
(a) number of individuals leaving the habitat (b) birth rate (c) death rate (d) number of individuals entering a habitat

112. World Ozone Day is celebrated on
(a) 16th September (b) 21st April (c) 5th June (d) 22nd April

113. Which of the following is a secondary pollutant?
(a) SO₂ (b) CO₂ (c) CO (d) O₃

114. Niche is
(a) the range of temperature that the organism needs to live (b) the physical space where an organism lives (c) all the biological factors in the organism’s environment (d) the functional role played by an organism where it lives

115. What type of ecological pyramid would be obtained with the following data?
Secondary consumer : 120 g
Primary consumer : 60 g
Primary producer : 10 g
(a) Upright pyramid of numbers (b) Pyramid of energy (c) Inverted pyramid of biomass (d) Upright pyramid of biomass

116. In stratosphere, which one of the following elements acts as a catalyst in degradation of ozone and release of molecular oxygen?
(a) Fe (b) Cl (c) Carbon (d) Oxygen

117. Which two functional groups are characteristic of sugars?
(a) Carbonyl and phosphate (b) Carbonyl and methyl (c) Hydroxyl and methyl (d) Carbonyl and hydroxyl

118. Which among the following is not a prokaryote?
(a) Nostoc (b) Mycobacterium (c) Saccharomyces (d) Oscillatoria

119. The Golgi complex participates in
(a) respiration in bacteria (b) formation of secretory vesicles (c) fatty acid breakdown (d) activation of amino acid

120. Which of the following is not a product of light reaction of photosynthesis?
(a) NADPH (b) NADH (c) ATP (d) Oxygen

121. Which of the following is true for nucleolus?
(a) It takes part in spindle formation (b) It is a membrane-bound structure (c) Larger nucleoli are present in dividing cells (d) It is a site for active ribosomal RNA synthesis

122. Stomatal movement is not affected by
(a) O₂ concentration (b) Light (c) Temperature (d) CO₂ concentration

123. The stage during which separation of the paired homologous chromosomes begins is
(a) diakinesis (b) diplotene (c) pachytene (d) zygotene
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124. Stomata in grass leaf are
   (a) rectangular  (b) kidney-shaped
   (c) dumb-bell-shaped  (d) barrel-shaped

125. Secondary xylem and phloem in dicot stem are produced by
   (a) phellogen  (b) vascular cambium
   (c) apical meristems  (d) axillary meristems

126. Pneumatophores occur in
   (a) carnivorous plants  (b) free-floating hydrophytes
   (c) halophytes  (d) submerged hydrophytes

127. Casparian strips occur in
   (a) cortex  (b) pericycle
   (c) epidermis  (d) endodermis

128. Plants having little or no secondary growth are
   (a) conifers  (b) deciduous angiosperms
   (c) grasses  (d) cycads

129. Sweet potato is a modified
   (a) tap root  (b) adventitious root
   (c) stem  (d) rhizome

130. Which one of the following statements is correct?
   (a) Horsetails are gymnosperms
   (b) Selaginella is heterosporous, while Salvinia is homosporous
   (c) Ovules are not enclosed by ovary wall in gymnosperms
   (d) Stems are usually unbranched in both Cycas and Cedrus.

131. Select the wrong statement.
   (a) Pseudopodia are locomotory and feeding structures in sporozoans
   (b) Mushrooms belong to Basidiomycetes
   (c) Cell wall is present in members of Fungi and Plantae
   (d) Mitochondria are the powerhouse of the cell in all kingdoms except Monera

132. After karyogamy followed by meiosis, spores are produced exogenously in
   (a) Agaricus  (b) Alternaria
   (c) Neurospora  (d) Saccharomyces

133. Match the items given in Column I with those in Column II and select the correct option given below

<table>
<thead>
<tr>
<th>Column-I</th>
<th>Column-II</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Herbarium</td>
<td>i. It is a place having a collection of preserved plants and animals.</td>
</tr>
<tr>
<td>2. Key</td>
<td>ii. A list that enumerates methodically all the species found in an area with brief description aiding identification.</td>
</tr>
<tr>
<td>3. Museum</td>
<td>iii. It is a place where dried and pressed plant specimens mounted on sheets are kept.</td>
</tr>
<tr>
<td>4. Catalogue</td>
<td>iv. A booklet containing a list of characters and their alternates which are helpful in identification of various taxa.</td>
</tr>
</tbody>
</table>

134. Winged pollen grains are present in
   (a) mango  (b) Cycas
   (c) mustard  (d) Pinus

135. Which one is wrongly matched?
   (a) Gemma cups – Marchantia
   (b) Biflagellate zoospores – Brown algae
   (c) Uniflagellate gametes – Polysiphonia
   (d) Unicellular organism – Chlorella

136. Which one of the following options correctly represents the lung conditions in asthma and emphysema, respectively?
   (a) Increased respiratory surface; Inflammation of bronchioles
   (b) Increased number of bronchioles; Increased respiratory surface
   (c) Inflammation of bronchioles; Decreased respiratory surface
   (d) Decreased respiratory surface; Inflammation of bronchioles
137. Match the items given in Column I with those in Column II and select the correct option given below

<table>
<thead>
<tr>
<th>Column I</th>
<th>Column II</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Tricuspid valve</td>
<td>i. Between left atrium and left ventricle</td>
</tr>
<tr>
<td>2. Bicuspid valve</td>
<td>ii. Between right ventricle and pulmonary artery</td>
</tr>
<tr>
<td>3. Semilunar valve</td>
<td>iii. Between right atrium and right ventricle</td>
</tr>
</tbody>
</table>

1. (a) i ii iii (b) i iii ii (c) iii i ii (d) ii i iii

138. Match the items given in Column I with those in Column II and select the correct option given below

<table>
<thead>
<tr>
<th>Column I</th>
<th>Column II</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Tidal volume</td>
<td>i. 2500–3000 mL</td>
</tr>
<tr>
<td>2. Inspiratory reserve volume</td>
<td>ii. 1100–1200 mL</td>
</tr>
<tr>
<td>3. Expiratory reserve volume</td>
<td>iii. 500–550 mL</td>
</tr>
<tr>
<td>4. Residual volume</td>
<td>iv. 1000–1100 mL</td>
</tr>
</tbody>
</table>

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

139. The transparent lens in the human eye is held in its place by
(a) smooth muscles attached to the iris
(b) ligaments attached to the iris
(c) ligaments attached to the ciliary body
(d) smooth muscles attached to the ciliary body

140. Which of the following is an amino acid derived hormone?
(a) Estradiol
(b) Ecdysone
(c) Epinephrine
(d) Estriol

141. Which of the following hormones can play a significant role in osteoporosis?
(a) Estrogen and parathyroid hormone
(b) Progesterone and aldosterone
(c) Aldosterone and prolactin
(d) Parathyroid hormone and prolactin

142. Which of the following structures or regions is incorrectly paired with its function?
(a) Hypothalamus - Production of releasing hormones and regulation of temperature, hunger and thirst.
(b) Limbic system - Consists of fibre tracts that interconnect different regions of brain; controls movement.
(c) Medulla oblongata - Controls respiration and cardiovascular reflexes.
(d) Corpus callosum - Band of fibres connecting left and right cerebral hemispheres.

143. The amnion of mammalian embryo is derived from
(a) mesoderm and trophoblast
(b) endoderm and mesoderm
(c) ectoderm and mesoderm
(d) ectoderm and endoderm

144. Hormones secreted by the placenta to maintain pregnancy are
(a) hCG, HPL, progestogens, estrogens
(b) hCG, HPL, estrogens, relaxin, oxytocin
(c) hCG, HPL, progestogens, prolactin
(d) hCG, progestogens, estrogens, glucocorticoids

145. The difference between spermiogenesis and spermiation is
(a) In spermiogenesis, spermatozoa from Sertoli cells are released into the cavity of seminiferous tubules, while in spermiation spermatozoa are formed
(b) In spermiogenesis, spermatozoa are formed, while in spermiation spermatids are formed
(c) In spermiogenesis, spermatids are formed, while in spermiation spermatozoa are formed
(d) In spermiogenesis, spermatozoa are formed, while in spermiation spermatozoa are released from Sertoli cells into the cavity of seminiferous tubules

146. The contraceptive ‘SAHELI’
(a) is an IUD
(b) increases the concentration of estrogen and prevents ovulation in females
(c) blocks estrogen receptors in the uterus, preventing eggs from getting implanted
(d) is a post-coital contraceptive

147. Ciliates differ from all other protozoans in
(a) using pseudopodia for capturing prey
(b) having a contractile vacuole for removing excess water
(c) using flagella for locomotion
(d) having two types of nuclei
148. Identify the vertebrate group of animals characterised by crop and gizzard in its digestive system.
(a) Aves (b) Reptilia (c) Amphibia (d) Osteichthyes

149. Which of the following features is used to identify a male cockroach from a female cockroach?
(a) Forewings with darker tegmina (b) Presence of caudal styles (c) Presence of a boat-shaped sternum on the 9th abdominal segment (d) Presence of anal cerci

150. Which one of these animals is not a homeotherm?
(a) Camelus (b) Chelone (c) Macropus (d) Psittacula

151. Which one of the following animals does not undergo metamorphosis?
(a) Moth (b) Tunicate (c) Earthworm (d) Starfish

152. Which of the following organisms are known as chief producers in the oceans?
(a) Cyanobacteria (b) Diatoms (c) Dinoflagellates (d) Euglenoids

153. Which one of the following population interactions is widely used in medical science for the production of antibiotics?
(a) Parasitism (b) Mutualism (c) Commensalism (d) Amensalism

154. All of the following are included in ex-situ conservation except
(a) botanical gardens (b) sacred groves (c) wildlife safari parks (d) seed banks

155. Match the items given in Column I with those in Column II and select the correct option given below.

<table>
<thead>
<tr>
<th>Column-I</th>
<th>Column-II</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Eutrophication</td>
<td>i. UV-B radiation</td>
</tr>
<tr>
<td>2. Sanitary landfill</td>
<td>ii. Deforestation</td>
</tr>
<tr>
<td>3. Snow blindness</td>
<td>iii. Nutrient enrichment</td>
</tr>
<tr>
<td>4. Jhurn cultivation</td>
<td>iv. Waste disposal</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>1 2 3 4</th>
<th>1 2 3 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) ii iv i ii</td>
<td>(b) i iii iv ii</td>
</tr>
<tr>
<td>(c) ii i ii iv</td>
<td>(d) i ii iv iii</td>
</tr>
</tbody>
</table>

156. In a growing population of a country,
(a) reproductive and pre-reproductive individuals are equal in number
(b) reproductive individuals are less than the post-reproductive individuals
(c) pre-reproductive individuals are more than the reproductive individuals
(d) pre-reproductive individuals are less than the reproductive individuals

157. Which part of poppy plant is used to obtain the drug Smack?
(a) Roots (b) Latex (c) Flowers (d) Leaves

158. All of the following are parts of an operon except
(a) an enhancer (b) structural genes (c) an operator (d) a promoter

159. A woman has an X-linked condition on one of her X chromosomes. This chromosome can be inherited by
(a) only grand children (b) only sons (c) only daughters (d) Both (b) and (c)

160. According to Hugo de Vries, the mechanism of evolution is
(a) phenotypic variations (b) saltation (c) multiple step mutations (d) minor mutations

161. AGGTATCGCAT is a sequence from the coding strand of a gene. What will be the corresponding sequence of the transcribed mRNA?
(a) ACCUAUGCGAU (b) UGGTUTCGCAT (c) AGGUAUCGCAU (d) UCCAUAGCGUA

162. Match the items given in Column I with those in Column II and select the correct option given below.

<table>
<thead>
<tr>
<th>Column-I</th>
<th>Column-II</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Proliferative phase</td>
<td>i. Breakdown of endometrial lining</td>
</tr>
<tr>
<td>2. Secretory phase</td>
<td>ii. Follicular phase</td>
</tr>
<tr>
<td>3. Menstruation</td>
<td>iii. Luteal phase</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>1 2 3</th>
<th>1 2 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) ii iii i</td>
<td>(b) i iii ii</td>
</tr>
<tr>
<td>(c) iii i i</td>
<td>(d) iii i i</td>
</tr>
</tbody>
</table>
163. Match the items given in Column I with those in Column II and select the correct option given below

<table>
<thead>
<tr>
<th>Column-I</th>
<th>Column-II</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Glycosuria</td>
<td>i. Accumulation of uric acid in joints.</td>
</tr>
<tr>
<td>2. Gout</td>
<td>ii. Mass of crystallised salts within the kidney,</td>
</tr>
<tr>
<td>3. Renal calculi</td>
<td>iii. Inflammation in glomeruli</td>
</tr>
</tbody>
</table>

1 2 3 4 1 2 3 4
(a) i ii iii i v (b) i ii iii iv (c) iii i iv i (d) iv i ii iii

164. Match the items given in Column I with those in Column II and select the correct option given below

<table>
<thead>
<tr>
<th>Column-I (Function)</th>
<th>Column-II (Part of Excretory System)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Ultrafiltration</td>
<td>i. Henle’s loop</td>
</tr>
<tr>
<td>2. Concentration of urine</td>
<td>ii. Ureter</td>
</tr>
<tr>
<td>3. Transport of urine</td>
<td>iii. Urinary bladder</td>
</tr>
<tr>
<td>4. Storage of urine</td>
<td>iv. Malpighian corpuscle</td>
</tr>
<tr>
<td></td>
<td>v. Proximal convoluted tubule</td>
</tr>
</tbody>
</table>

1 2 3 4 1 2 3 4
(a) v iv i ii (b) iv i ii iii (c) iv v ii iii (d) v iv i iii

165. Which of the following gastric cells indirectly help in erythropoiesis?
(a) Goblet cells
(b) Mucous cells
(c) Chief cells
(d) Parietal cells

166. Match the items given in Column I with those in Column II and select the correct option given below

<table>
<thead>
<tr>
<th>Column-I</th>
<th>Column-II</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Fibrinogen</td>
<td>i. Osmotic balance</td>
</tr>
<tr>
<td>2. Globulin</td>
<td>ii. Blood clotting</td>
</tr>
<tr>
<td>3. Albumin</td>
<td>iii. Defence mechanism</td>
</tr>
</tbody>
</table>

1 2 3 1 2 3
(a) i iii ii (b) i ii iii (c) iii i i (d) ii iii i

167. Which of the following is an occupational respiratory disorder?
(a) Botulism
(b) Silicosis
(c) Anthracis
(d) Emphysema

168. Calcium is important in skeletal muscle contraction because it
(a) detaches the myosin head from the actin filament
(b) activates the myosin ATPase by binding to it
(c) binds to troponin to remove the masking of active sites on actin for myosin
(d) prevents the formation of bonds between the myosin cross bridges and the actin filament

169. Nissl bodies are mainly composed of
(a) nucleic acids and SER
(b) DNA and RNA
(c) proteins and lipids
(d) free ribosomes and RER

170. Which one of these statements is incorrect?
(a) Glycolysis operates as long as it is supplied with NAD that can pick up hydrogen atoms.
(b) Glycolysis occurs in cytosol
(c) Enzymes of TCA cycle are present in mitochondrial matrix
(d) Oxidative phosphorylation takes place in outer mitochondrial membrane

171. Select the incorrect match.
(a) Submetacentric chromosomes – L-shaped chromosomes
(b) Allosomes – Sex chromosomes
(c) Lampbrush chromosomes – Diplotene bivalents
(d) Polytene chromosomes – Oocytes of amphibians

172. Which one of the following terms describe human dentition?
(a) Pleurodont, Monophyodont, Homodont
(b) Thecodont, Diphyodont, Heterodont
(c) Thecodont, Diphyodont, Homodont
(d) Pleurodont, Diphyodont, Heterodont

173. Which one of the following events does not occur in rough endoplasmic reticulum?
(a) Cleavage of signal peptide
(b) Protein glycosylation
(c) Protein folding
(d) Phospholipid synthesis
174. Many ribosomes may associate with a single mRNA to form multiple copies of a polypeptide simultaneously. Such strings of ribosomes are termed as
(a) plastidome (b) polyhedral bodies (c) polysome (d) nucleosome

175. In which disease does mosquito transmitted pathogen cause chronic inflammation of lymphatic vessels?
(a) Ringworm disease (b) Ascariasis (c) Elephantiasis (d) Amoebiasis

176. Which of the following is not an autoimmune disease?
(a) Alzheimer’s disease (b) Rheumatoid arthritis (c) Psoriasis (d) Vitiligo

177. Among the following sets of examples for divergent evolution, select the incorrect option.:
(a) Brain of bat, man and cheetah (b) Heart of bat, man and cheetah (c) Forelimbs of man, bat and cheetah (d) Eye of Octopus, bat and man

178. Conversion of milk to curd improves its nutritional value by increasing the amount of
(a) vitamin-B_{12} (b) vitamin-A (c) vitamin-D (d) vitamin-E

179. The similarity of bone structure in the forelimbs of many vertebrates is an example of
(a) convergent evolution (b) analogy (c) homology (d) adaptive radiation

180. Which of the following characteristics represents ‘Inheritance of blood groups’ in humans?
1. Dominance  
2. Codominance  
3. Multiple allele  
4. Incomplete dominance  
5. Polygenic inheritance
(a) 2, 4 and 5 (b) 1, 2 and 3 (c) 2, 3 and 5 (d) 1, 3 and 5

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**Answers**

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Physics

1. (c) According to the given graph,
   \[ \text{Volume (V)} \propto \text{Temperature (T)} \]
   or \[ \frac{V}{T} = \text{constant} \]
   Thus, the process is isobaric.

   . Work done, \[ \Delta W = p \Delta V = nR(T_B - T_A) \] \( \ldots (i) \)
   Heat absorbed, \[ \Delta Q = nC_p \Delta T = nC_p(T_B - T_A) \] \( \ldots (ii) \)
   As, \[ C_p = \frac{\gamma R}{\gamma - 1} \]
   For a monatomic gas, \( f = 3 \)
   \[ \Rightarrow \quad C_p = \left( R + \frac{3}{2} R \right) = \frac{5}{2} R \]
   Substituting the value of \( C_p \) in Eq. (ii), we get
   \[ \Delta Q = n \left( \frac{5}{2} R \right) (T_B - T_A) \]
   Hence,
   \[ \frac{\Delta W}{\Delta Q} = \frac{nR(T_B - T_A)}{n \left( \frac{5}{2} R \right) (T_B - T_A)} = \frac{2}{5} \]

2. (c) Fundamental frequency for an open organ pipe is given as
   \[ f_1 = \frac{v}{2L} \]
   where, \( L \) is the length of the open organ pipe.

   Third harmonic for a closed organ pipe is given as
   \[ f'' = \frac{3v}{4L} \]
   where, \( L' \) is the length of closed organ pipe.

   According to the question,
   \[ \frac{v}{2L} = \frac{3v}{4L'} \]
   \[ \Rightarrow \frac{L'}{L} = \frac{2}{3} \]

   Given,
   \[ L' = 20 \text{ cm} \]
   \[ \Rightarrow \quad L = \frac{2}{3} \times 20 \text{ cm} = \frac{40}{3} \text{ cm} = 13.3 \text{ cm} \]

3. (b) **Key Concept** The minimum velocity with which the body must be projected vertically upwards, so that it could escape from the Earth’s atmosphere, is its escape velocity \( (v_e) \).

   As,
   \[ v_e = \sqrt{2gR} \]
   Substituting the value of \( g \) \( (9.8 \text{ m s}^{-2}) \) and radius of Earth \( (R = 6.4 \times 10^6 \text{ m}) \), we get
   \[ v_e = \sqrt{2 \times 9.8 \times 6.4 \times 10^6} \]
   \[ \approx 11.2 \text{ km s}^{-1} = 11200 \text{ m s}^{-1} \]

   Let the temperature of molecule be \( T \) when it attains \( v_e \).

   According to the question,
   \[ v = v_{rms} = v_e \]
   where, \( v_{rms} \) is the rms speed of the oxygen molecule.

   \[ \Rightarrow \frac{M_p v_e^2}{2} \left( \frac{m_{O_2}}{R} \right) = \frac{(3k_B)}{2} \]
   Substituting the given values, i.e.,
   \[ R = 1.38 \times 10^{-23} \text{ JK}^{-1} \text{and} \]
   \[ m_{O_2} = 2.76 \times 10^{-26} \text{ kg} \]

   We get,
   \[ T = \frac{(11.2 \times 10^3)^2 \left( 2.76 \times 10^{-26} \right)}{(3 \times 1.38 \times 10^{-23})} \]
   \[ = 8.3626 \times 10^4 \text{ K} \]

4. (c) Efficiency of an ideal heat engine is given as
   \[ \eta = 1 - \frac{T_1}{T_2} \]
   where, \( T_1 \) is the temperature of the source and \( T_2 \) is the temperature of the sink.

   Here,
   \[ T_1 = 100 + 273 = 373 \text{ K} \]
   \[ T_2 = 0 + 273 = 273 \text{ K} \]

   \[ \Rightarrow \quad \eta = 1 - \frac{273}{373} \]
   \[ = \frac{373 - 273}{373} = \frac{100}{373} = 0.268 \]

   . \[ \eta % = 0.268 \times 100 = 26.8 \% \]
5. (b) Given, \( R = (47 \pm 4.7) \, k\Omega \)
\[ R = 47 \times 10^3 \pm 10\% \, \Omega \]
As per the colour code for carbon resistors, the colour assigned to numbers,
4 – Yellow
7 – Violet
3 – Orange
For ±10% accuracy, the colour is silver. Hence, the bands of colours on carbon resistor in sequence are yellow, violet, orange and silver.

**Note:** To remember the colour code sequence for carbon resistor, the following sentence should be kept in memory. B B Roy of Great Britain has a Very Good Wife.

6. (c) When \( n \) equal resistors of resistance \( R \) are connected in series, then the current drawn is given as
\[ I = \frac{E}{nR + r} \]
where,
\( nR \) = equivalent resistance of \( n \) resistors in series
\( r \) = internal resistance of battery.
Given, \( r = R \)
\[ \Rightarrow \quad I = \frac{E}{nR + R} = \frac{E}{R(n + 1)} \quad \ldots (i) \]
Similarly, when \( n \) equal resistors are connected in parallel, then the current drawn is given as
\[ I' = \frac{E}{\frac{nR}{n} + R} \]
where, \( \frac{nR}{n} \) = equivalent resistance of \( n \) resistors in parallel.
Given,
\[ 10I' = \frac{E}{\frac{nR}{n} + R} = \frac{nE}{R(n + 1)} \quad \ldots (ii) \]
Substituting the value of \( I \) from Eq. (i) in Eq. (ii), we get
\[ 10 \left( \frac{E}{R(n + 1)} \right) = \frac{nE}{R(n + 1)} \]
\[ \Rightarrow \quad n = 10 \]

7. (c) If \( n \) identical cells are connected in series, then Equivalent emf of the combination,
\[ E_{eq} = nE \]
Equivalent internal resistance,
\[ r_{eq} = nr \]
:. Current,
\[ I = \frac{E_{eq}}{r_{eq}} = \frac{nE}{nr} \]

or
\[ I = \frac{E}{r} = \text{constant} \]

Thus, current \( I \) is independent of the number of cells \( n \) present in the circuit.
Therefore, the graph showing the relationship between \( I \) and \( n \) would be as shown below.

8. (b) The figure shown below represents the course of path an unpolarised light follows when it is incident from air on plane surface of material of refractive index \( \mu \).

When the beam of unpolarised light is reflected from a medium (refractive index = \( \mu \)) and if reflected and refracted light are perpendicular to each other. Then, the reflected light is completely plane polarised at a certain angle of incidence. This means, the reflected light has electric vector perpendicular to incidence plane.

9. (b) In a YDSE, angular width of a fringe is given as
\[ \theta = \frac{\lambda}{d} \]
where, \( \lambda \) is the wavelength of the light source and \( d \) is the distance between the two slits.
\[ \Rightarrow \quad \theta = \frac{1}{d} \]
\[ \text{or} \quad \frac{\theta_1}{\theta_2} = \frac{d_2}{d_1} \quad \ldots (i) \]
Here, \( \theta_1 = 0.20^\circ, \theta_2 = 0.21^\circ, \quad d_1 = 2 \, \text{mm} \)
Substituting the given values in Eq. (i), we get
\[
\frac{0.20}{0.21} = \frac{d_2}{2} \quad \Rightarrow \quad d_2 = 2 \times \frac{0.20}{0.21} = 0.40
\]
\[
\therefore \quad d_2 = 0.21 \, \text{mm}
\]

10. (c) Angular magnification of an astronomical refracting telescope is given as
\[
M = \frac{f_0}{f_e}
\]
where, \( f_0 \) and \( f_e \) are the focal length of objective and eye-piece, respectively.
From the given relation, it is clear that for large magnification either \( f_0 \) has to be large or \( f_e \) has to be small.
Angular resolution of an astronomical refracting telescope is given as
\[
R_a = \frac{1.22 \lambda}{a}
\]
where, \( a \) is the diameter of the objective.
Thus, to have large resolution, the diameter of the objective should be large.
Hence, from the above objective lens should have large focal length \( (f_0) \) and large diameter \( (a) \).

11. (b) Kinetic energy of an electron in a Bohr orbit of a hydrogen atom is given as
\[
KE_n = \frac{Rhc}{n^2} \quad \text{...(i)}
\]
Total energy of an electron in a Bohr orbit of a hydrogen atom is given as
\[
TE_n = \frac{-Rhc}{n^2} \quad \text{...(ii)}
\]
Dividing Eq. (i) by Eq. (ii), we get
\[
\frac{KE_n}{TE_n} = \left( \frac{Rhc}{n^2} \right) \left( \frac{n^2}{Rhc} \right)
\]
\[
\therefore \quad KE_n: TE_n = 1: -1
\]

12. (c) According to the question,
\[
v = v_0 \hat{i}, \quad E = -E_0 \hat{i}
\]
\[
\therefore \quad F = eE_0
\]

From Newton’s second law of motion,
\[
F = ma
\]
\[
\therefore \quad F = ma = eE_0
\]
\[
\Rightarrow \quad a = \frac{eE_0}{m} \quad \text{...(i)}
\]
or
\[
a = \left( -e \right) \left( \frac{eE_0}{m} \right) = \frac{eE_0}{m}
\]
From first equation of motion,
\[
v = u + at
\]
Here, \( u \) (initial velocity) = \( v_0 \)
\[
\Rightarrow \quad v = v_0 + \left( \frac{eE_0}{m} \right) t
\]
\[
\text{...(ii)}
\]
(from Eq. (i))
Initial de-Broglie wavelength of the electron is given as
\[
\lambda_0 = \frac{h}{mv_0} \Rightarrow h = \lambda_0 mv_0 \quad \text{...(iii)}
\]
After time \( t \), de-Broglie wavelength is given as
\[
\lambda = \frac{h}{mv}
\]
Substituting the value of \( v \) from Eq. (ii), we get
\[
\lambda = \frac{h}{m} \left( v_0 + \left( \frac{eE_0}{m} \right) t \right)
\]
\[
\Rightarrow \quad \lambda = \frac{h}{mv_0} \left[ 1 + \left( \frac{eE_0}{mv_0} \right) t \right]
\]
\[
\Rightarrow \quad \lambda = \frac{\lambda_0}{1 + \left( \frac{eE_0}{mv_0} \right) t}
\]
\[
\text{...(iii)}
\]
13. (c) Key Concept After \( n \) half-life, the number of nuclei left undecayed is given as
\[
N = N_0 \left( \frac{1}{2} \right)^n
\]
where, \( n = \frac{t}{t_{1/2}} \)
Here, initially number of nuclei, \( N_0 = 600 \)
After disintegration, number of nuclei, \( N' = 450 \)
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∴ Number of nuclei left undecayed,
\[ N = N_0 - N' = 600 - 450 = 150 \]

Half-life, \( t_{1/2} = 10 \text{ min} \)

As,
\[ \frac{N}{N_0} = \left( \frac{1}{2} \right)^{t/t_{1/2}} \]

Substituting the given values, we get
\[ \frac{150}{600} = \left( \frac{1}{2} \right)^{t/10} \]

or
\[ \frac{1}{4} = \left( \frac{1}{2} \right)^{t/10} \]

or
\[ \left( \frac{1}{2} \right)^2 = \left( \frac{1}{2} \right)^{t/10} \]

or
\[ \frac{t}{10} = 2 \]

\[ \Rightarrow t = 20 \text{ min} \]

15. (d) Given, \( V_{BE} = 0 \text{ V} \), \( V_{CE} = 0 \text{ V} \) and \( V_i = 20 \text{ V} \)

Applying Kirchhoff’s law to the base-emitter loop, we get
\[ V_i = V_B + V_{BE} \]

Substituting the values, we get
\[ 20 = I_B \times (500 \times 10^3) + 0 \]

\[ \Rightarrow I_B = \frac{20}{500 \times 10^3} = 0.04 \times 10^{-3} \]

\[ = 40 \times 10^{-6} = 40 \mu \text{A} \] \( \cdots \text{(i)} \)

Similarly, \( V_{CC} = I_C R_C + V_{CE} \)

Substituting the given values, we get
\[ 20 = I_C \times (4 \times 10^3) + 0 \]

\[ \Rightarrow I_C = \frac{20}{4 \times 10^3} = 5 \times 10^{-3} = 5 \text{ mA} \] \( \cdots \text{(ii)} \)

Current gain is given as
\[ \beta = \frac{I_C}{I_B} \]

Substituting the value of \( I_B \) and \( I_C \) from Eqs. (i) and (ii), we get
\[ \Rightarrow \beta = \frac{5 \times 10^{-3}}{40 \times 10^{-6}} = 0.125 \times 10^3 \]

\[ = 125 \]

16. (d) Due to increase in temperature because of heating, thermal collision between the electron and holes increases. Thus, net electron-hole pairs increase.

This leads to increase in the current in diode and overall resistance of the diode changes.

This in turn changes both the forward biasing and the reverse biasing.

Thus, the overall \( I-V \) characteristics of p-n junction diode gets affected.
17. (b) According to the question, the figure of combination of gates in terms of inputs and outputs can be given as

\[ Y = A \cdot \overrightarrow{E} + \overrightarrow{A} \cdot \overrightarrow{B} \]

Thus,

\[ Y = A \cdot C + \overrightarrow{B} \cdot \overrightarrow{C} + \overrightarrow{A} \cdot \overrightarrow{D} \]

18. (b) Here, velocity of EM wave,

\[ v_i = \frac{v}{c^3} \]

Instantaneous oscillating electric field,

\[ E_j = \frac{E}{c^3} \]

As we already know that, during the propagation of EM waves through a medium oscillating electric and magnetic field vectors are mutually perpendicular to each other and to the direction of propagation of the wave \((\overrightarrow{E} \times \overrightarrow{B})\)

i.e.

\[ (\overrightarrow{E} \times \overrightarrow{B}) = \overrightarrow{v} \]

As we know that from vector algebra,

\[ \hat{j} \times \hat{k} = \hat{i} \]

Comparing Eqs. (i) and (ii), we get

\[ \overrightarrow{B} = \hat{k} \]

where \(B\) (say) be the magnitude of magnetic field.

Thus, we can say that the direction of oscillating magnetic field of the EM wave will be along \(+z\) direction.

19. (b) According to the question, the figure of mentioned prism is given as

(since, there is no refraction at the face AC)

Given,

Refractive index of the material of prism, \(\mu = \sqrt{2}\)

Angle of prism, \(A = 30^\circ\)

If the ray \(OR\) has to retrace its path after reflection (as per the given condition), then the ray has to fall normally on the surface \(AC\).

This means

\[ \angle ARO = \angle ORC = 90^\circ \]

In \(\Delta AOR\),

\[ \angle AOR + \angle ARO + \angle OAR = 180^\circ \]

\[ \Rightarrow \angle AOR + 90^\circ + 30^\circ = 180^\circ \]

\[ \Rightarrow \angle AOR = 180^\circ - 120^\circ = 60^\circ \]

As we know,

\[ \angle AOR + \angle \tau_1 = 90^\circ \]

\[ \Rightarrow \angle \tau_1 = 90^\circ - 60^\circ = 30^\circ \] [from Eq. (i)]

Applying Snell’s law at the face \(AB\), we get

\[ \mu = \frac{\sin i}{\sin \tau_1} \]

Substituting the given values, we get

\[ \sqrt{2} = \frac{\sin i}{\sin 30^\circ} \]

\[ \Rightarrow \sin i = \sin 30^\circ \times \sqrt{2} = \frac{1}{2} \times \sqrt{2} \]

\[ \Rightarrow i = \sin^{-1} \left( \frac{1}{\sqrt{2}} \right) \]

or

\[ i = \sin^{-1} \left( \frac{1}{\sqrt{2}} \right) \]

\[ \Rightarrow i = 45^\circ \]

The angle of incidence of the ray on the prism is 45°.

20. (b) **Key Concept** The net displacement of the images is equal to the difference between the image distance in both the cases.

**Case 1** When the object distance, \(u_1 = -40\) cm

Focal length of mirror, \(f = -15\) cm

Using the mirror formula, we get

\[ \frac{1}{f} = \frac{1}{v_1} + \frac{1}{u_1} \]

Substituting the given values, we get

\[ \frac{1}{15} = \frac{1}{v_1} + \frac{-1}{40} \]

\[ \Rightarrow \frac{1}{v_1} = \frac{1}{15} \cdot \frac{1}{40} = \frac{3}{120} = \frac{5}{120} \]

\[ \Rightarrow v_1 = \frac{120}{5} = -24 \text{ cm} \]
**Case 2** When the object distance, \( u_2 = 20 \) cm

Using the mirror formula, we get

\[
\frac{1}{f} = \frac{1}{v_2} + \frac{1}{u_2}
\]

Substituting the given values, we get

\[
\frac{1}{f} = \frac{1}{v_2} + \left( \frac{1}{20} \right)
\]

\[\Rightarrow \quad \frac{1}{v_2} = \frac{1}{20} - \frac{1}{15} = \frac{3 - 4}{60} = -\frac{1}{60}
\]

\[\Rightarrow \quad v_2 = -60 \text{ cm}
\]

\[\therefore \text{The displacement of the image is} \quad v = -v_2 = -60 \text{ cm}
\]

\[\text{or} \quad = -36 \text{ cm, away from the mirror}
\]

22. (d) Given, magnetic potential energy stored in an inductor,

\[ U = 25 \text{ mJ} = 25 \times 10^{-3} \text{ J} \]

Current in an inductor, \( I_0 = 60 \text{ mA} = 60 \times 10^{-3} \text{ A} \)

As, the expression for energy stored in an inductor is given as

\[ U = \frac{1}{2} L I_0^2 \]

where, \( L \) is the inductance of the inductor.

Substituting the given values in above equation, we get

\[ (25 \times 10^{-3}) = \frac{1}{2} 	imes L \times (60 \times 10^{-3})^2 \]

\[\Rightarrow \quad L = \frac{2 \times 25 \times 10^{-3}}{500 \times 3600 \times 10^{-6}} = 13.89 \text{ H} \]

or

\[ L = 13.89 \text{ H} \]

22. (c) Force on a charged particle in the presence of an electric field is given as

\[ F = qE \quad \ldots (i) \]

where, \( q \) is the charge on the charged particle and \( E \) is the electric field.

From Newton’s second law of motion, force on a particle with mass \( m \) is given as

\[ F = ma \quad \ldots (ii) \]

where, \( a \) is the acceleration.

From Eqs. (i) and (ii), we get

\[ F = ma = qE \]

\[\Rightarrow \quad a = \frac{qE}{m} \quad \ldots (iii) \]

Now, consider that a particle falls from rest through a vertical distance \( h \). Therefore, \( u = 0 \) and the second equation of motion becomes

\[ s = ut + \frac{1}{2} a t^2 \]

or \[ h = 0 \times t + \frac{1}{2} a t^2 \]

\[= \frac{1}{2} \times \frac{qE}{m} t^2 \quad \text{[from Eq. (iii)]} \]

\[\Rightarrow \quad t^2 = \frac{2hm}{qE} \]

\[\text{or} \quad t = \sqrt{\frac{2hm}{qE}} \]

Since, the particles given in the question is electron and proton; and the quantity \( \sqrt{\frac{2m}{qE}} \) (here, \( q_e = q_p = e \)) for both of them is constant. Thus, we can write

\[ t = k \sqrt{\frac{m}{qE}} \]

where,

\[ k = \sqrt{\frac{2m}{qE}} \]

\[\text{or} \quad t \propto \sqrt{\frac{m}{qE}} \]

As, mass of proton \( (m_p) \) >> mass of electron \( (m_e) \).

Thus, the time of fall of an electron would be smaller than the time of fall of a proton.

23. (c) As we know that, the total work done in transferring a charge to a parallel plate capacitor is given as

\[ W = \frac{Q^2}{2C} \quad \ldots (i) \]

where, \( C \) is the capacitance of the capacitor.

We can also write a relation for work done as,

\[ W = F \cdot d \quad \ldots (ii) \]

where, \( F \) is the electrostatic force between the plates of capacitor and \( d \) is the distance between the plates.

From Eqs. (i) and (ii), we get

\[ W = \frac{Q^2}{2C} = Fd \]

\[\Rightarrow \quad F = \frac{Q^2}{2C \cdot d} \quad \ldots (iii) \]
As, the capacitance of a parallel plate is given as
\[ C = \varepsilon_0 \frac{A}{d} \]
Substituting the value of \( C \) in Eq. (iii), we get
\[ F = \frac{Q^2}{2\varepsilon_0 Ad} \]
This means, electrostatic force is independent of the distance between the plates.

24. (b) For first resonance, \( l_1 = \frac{\lambda}{4} \)
For second resonance, \( l_2 = \frac{3\lambda}{4} \)
\[ \therefore (l_2 - l_1) = \frac{3\lambda}{4} - \frac{\lambda}{4} \]
or \[ \lambda = 2(l_2 - l_1) \] ... (i)
As, velocity of sound wave is given as,
\[ v = \nu \lambda \]
where, \( \nu \) is the frequency.
\[ \Rightarrow v = \nu \frac{2(l_2 - l_1)}{\lambda} \] [ from Eq. (i)]
Here, \( v = 320 \text{ Hz} \), \( l_2 = 0.73 \text{ m} \), \( l_1 = 0.20 \text{ m} \)
\[ \Rightarrow v = 2(320(0.73 - 0.20)) \]
\[ = 2 \times 320 \times 0.53 \]
\[ = 339.2 \text{ m s}^{-1} \approx 339 \text{ m s}^{-1} \]

25. (b) The acceleration of particle/body executing SHM at any instant (at position \( x \)) is given as
\[ a = -\omega^2 x \]
where, \( \omega \) is the angular frequency of the body.
\[ \Rightarrow |a| = \omega^2 x \] ... (i)
Here, \( x = 5 \text{ m} \), \( |a| = 20 \text{ m s}^{-2} \)
Substituting the given values in Eq. (i), we get
\[ 20 = \omega^2 \times 5 \]
\[ \Rightarrow \omega^2 = \frac{20}{5} = 4 \]
or \[ \omega = 2 \text{ rad s}^{-1} \]
As, we know that
Time period,
\[ T = \frac{2\pi}{\omega} \] ... (ii)
\[ \therefore \text{Substituting the value of } \omega \text{ in Eq. (ii), we get} \]
\[ T = \frac{2\pi}{2} = \pi \text{ s} \]

26. (d) **Key Concept** Firstly, make a free body diagram of the system and indicate the magnitude and direction of all the forces acting on the body. Then, choose any two mutually perpendicular axes say \( X \) and \( Y \) in the plane of forces in case of coplanar forces.
28. (c) Here, inductance, \( L = 20 \times 10^{-3} \) H
Capacitance, \( C = 100 \mu F = 100 \times 10^{-6} \) F
Resistance, \( R = 50 \) Ω
emf, \( V = 10 \sin 314t \) \( \cdots \) (i)
∴ The general equation of emf is given as
\[ V = V_0 \sin \omega t \] \( \cdots \) (ii)
Comparing Eqs. (i) and (ii), we get
\[ V_0 = 10, \omega = \frac{314}{1} \text{ rad s}^{-1} \]
The power loss associated with the given AC circuit is given as
\[ P = \frac{V}{V} \mu \text{B} \cos \phi \]
Substituting the given values in the above equation, we get
\[ h = \left( \frac{\sqrt{2} \times 56}{2} \right)^2 \times 50 \]
\[ = \frac{500}{2 \times 3136} \times 50 \]
\[ = 0.79 \) W
Thus, power loss in the circuit is 0.79 W.

29. (a) Current sensitivity of a moving coil galvanometer is the deflection \( \theta \) per unit current \( I \) flowing through it, i.e.
\[ I_s = \frac{\theta}{I} = \frac{NAB}{k} \] \( \cdots \) (i)
where, \( N = \) number of turns in the coil,
\( A = \) Area of each turn of coil,
\( B = \) magnetic field
\( k = \) restoring torque per unit twist of the fibre strip.

Similarly, voltage sensitivity is the deflection per unit voltage, i.e.
\[ V_s = \frac{\theta}{V} = \left( \frac{NAB}{k} \right) \frac{I}{R} = \frac{NAB}{kR_G} \] \( \cdots \) (ii)
where, \( R_G \) is the resistance of the galvanometer.
From Eqs. (i) and (ii), we get
\[ R_G = \frac{I_s}{V_s} \] \( \cdots \) (iii)
Here, \( I_s = 5 \) div/mA = \( 5 \times 10^{-3} \) div/A and \( V_s = 20 \) V/div
Substituting the given values in Eq. (iii), we get
\[ R_G = 250 \] Ω
∴ The resistance of the galvanometer is 250 Ω.

30. (d) Key Concept If a body is moving on a frictionless surface, then its total mechanical energy remains conserved.
According to the conservation of mechanical energy,
\[ (TE)_{\text{initial}} = (TE)_{\text{final}} \]
\[ \Rightarrow (KE)_i + (PE)_i = (KE)_f + (PE)_f \]
\[ 0 + mgh = \frac{1}{2}mv^2 + 0 \]
\[ \Rightarrow gh = \frac{v^2}{2} \]
or
\[ h = \frac{v_A^2}{2g} \] \( \cdots \) (i)
In order to complete the vertical circle, the velocity of the body at point \( A \) should be
\[ v_A = v_{\text{min}} = \sqrt{2gh} \]
where, \( R \) is the radius of the body.
Here,
\[ R = \frac{AB}{2} \]
\[ \Rightarrow v_{\text{min}} = v_A = \frac{\sqrt{2gh}}{2} \]
Substituting the value of \( v_A \) in Eq. (i), we get
\[ h = \left( \frac{\sqrt{2gD}}{2} \right)^2 \]
\[ = \frac{2gD}{2} \times \frac{5}{4} \] Ω
31. (c) Work done required to bring an object to rest is given as 
\[ W = \frac{1}{2} I \omega^2 \]
where, \( I \) is the moment of inertia and \( \omega \) is the angular velocity.
Since, here all the objects spin with the same \( \omega \), this means,
\[ W \propto I \]
As, \( I_A \) (for a solid sphere) = \( \frac{2}{5} MR^2 \)
\( I_B \) (for a thin circular disk) = \( \frac{1}{2} MR^2 \)
\( I_C \) (for a circular ring) = \( MR^2 \)
\[ \therefore \frac{W_A}{W_B} = \frac{2}{5} \]
\[ \frac{W_A}{W_B} = \frac{4}{5} \]
\[ \frac{W_A}{W_B} = \frac{10}{5} \]
⇒ \( W_A < W_B < W_C \)

32. (b) Since, the collision mentioned is an elastic head-on collision. Thus, according to the law of conservation of linear momentum, we get
\[ m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2 \]
where, \( m_1 \) and \( m_2 \) are the masses of the two blocks, respectively and \( u_1 \) and \( u_2 \) are their initial velocities and \( v_1 \) and \( v_2 \) are their final velocities, respectively.
Here,
\[ m_1 = m, m_2 = 4m \]
\[ u_1 = u, u_2 = 0 \text{ and } v_1 = 0 \]
\[ mv + 4mv = 0 + 4mv \]
\[ \Rightarrow \quad mv = 4mv_2 \]
or
\[ v_2 = \frac{v}{4} \quad ...(i) \]
As, the coefficient of restitution is given as,
\[ \varepsilon = \frac{\text{relative velocity of separation after collision}}{\text{relative velocity of approach}} \]
\[ = \frac{v_2 - u_1}{u_2 - u_1} \]
\[ = \frac{v - 0}{0 - v} \]
\[ = \frac{\frac{v}{4}}{v} \quad [\text{from Eq. (i)}] \]
\[ = \frac{1}{4} \]
\[ \therefore \quad \varepsilon = 0.25 \]

33. (d) The opposing force that comes into play when one body is actually sliding over the surface of the other body is called sliding friction.
The coefficient of sliding is given as
\[ \mu_s = \frac{N}{F_{sliding}} \]
where, \( N \) is the normal reaction and \( F_{sliding} \) is the sliding force.
As, the dimensions of \( N \) and \( F_{sliding} \) are same. Thus, \( \mu_s \) is a dimensionless quantity.
Hence, statement (d) is incorrect.

34. (b) According to the question,
For the time duration \( 0 < t < 1 \text{s} \), the velocity increase from 0 to \( 6 \text{ ms}^{-1} \) as the direction of field has been reversed for, \( 1 < t < 2 \text{s} \). The velocity firstly decreases from \( 6 \text{ ms}^{-1} \) to 0.
Then, for \( 2 < t < 3 \text{s} \); as the field strength is same; the magnitude of acceleration would be same, but velocity increases from 0 to \( -6 \text{ ms}^{-1} \).
Net displacement, \( s = s_1 + s_2 + s_3 = 3 \text{ m} + 3 \text{ m} - 3 \text{ m} = 3 \text{ m} \)

Hence, average velocity \( = \frac{\text{Net displacement}}{\text{Total time}} \)

\[ = \frac{3}{3} = 1 \text{ m s}^{-1} \]

Total distance travelled, \( d = 9 \text{ m} \)

Hence, average speed \( = \frac{\text{Total distance}}{\text{Total time}} \)

\[ = \frac{9}{3} = 3 \text{ m s}^{-1} \]

**Alternative Method**

Given condition can be represented through graph also as shown below.

\[ \therefore \text{Displacement in three seconds} = \text{Area under the graph} = \text{Area of } \Delta OAO' + \text{Area of } \Delta AO'B - \text{Area of } \Delta BCD \]

\[ = \frac{1}{2} \times 1 \times 6 + \frac{1}{2} \times 1 \times 6 - \frac{1}{2} \times 6 \times 1 \]

\[ = 3 \text{ m} \]

\[ \therefore \text{Average velocity} = \frac{3}{3} = 1 \text{ m s}^{-1} \]

Total distance travelled, \( d = 9 \text{ m} \)

\[ \therefore \text{Average speed} = \frac{9}{3} = 3 \text{ m s}^{-1} \]

35. (d) According to the question, the FBD of the given condition will be

Since, the wedge is accelerating towards right with \( a \), thus a pseudo force acts in the left direction in order to keep the block stationary. As, the system is in equilibrium.

\[ \therefore \quad \Sigma F_x = 0 \]

or \( \Sigma F_y = 0 \)

\[ \Rightarrow \quad R \sin \theta = ma \]

or \( mg \sin \theta = ma \) \quad ...(i)

Similarly, \( R \cos \theta = mg \)

or \( mg \cos \theta = mg \) \quad ...(ii)

Dividing Eq. (i) by Eq (ii), we get

\[ \frac{mg \sin \theta}{mg \cos \theta} = \frac{ma}{mg} \]

\[ \Rightarrow \quad \tan \theta = \frac{a}{g} \]

or \( a = g \tan \theta \)

\[ \therefore \] The relation between \( a \) and \( g \) for the block to remain stationary on the wedge is \( a = g \tan \theta \).

36. (d) **Key Concept**

Moment of force is defined as the cross product of the force and the force arm.

Given,

\[ \mathbf{F} = 4\mathbf{i} + 5\mathbf{j} - 6\mathbf{k} \]

\[ r_1 = 2\mathbf{i} + 0\mathbf{j} - 3\mathbf{k} \]

\[ r_2 = 2\mathbf{i} - 2\mathbf{j} - 2\mathbf{k} \]

Moment of force \( = \mathbf{r} \times \mathbf{F} \)

\[ = (r_1 - r_2) \times \mathbf{F} \]

\[ = [-2\mathbf{i} - 2\mathbf{j} - 2\mathbf{k}] \times [4\mathbf{i} + 5\mathbf{j} - 6\mathbf{k}] \]

\[ = [0\mathbf{i} + 2\mathbf{j} - 1\mathbf{k}] \times [4\mathbf{i} + 5\mathbf{j} - 6\mathbf{k}] \]

\[ = \begin{vmatrix} \mathbf{i} & \mathbf{j} & \mathbf{k} \\ 0 & 2 & -1 \\ 4 & 5 & -6 \end{vmatrix} \]

\[ = \mathbf{i}(0 - 2) - \mathbf{j}(0 - 4) + \mathbf{k}(0 + 2) \]

\[ = -2\mathbf{i} + 4\mathbf{j} + 2\mathbf{k} \]

37. (d) Given, least count of screw gauge, \( LC = 0.001 \text{ cm} \)

Main scale reading, MSR = 5 mm = 0.5 cm

Number of coinciding divisions on the circular scale, i.e. Vernier scale reading, VSR = 25

Here, zero error = -0.004 cm

Final reading obtained from the screw gauge is given as = MSR + VSR \times LC - zero error

Final reading from the screw gauge

\[ = 0.5 + 25 \times 0.001 - (-0.004) \]

\[ = 0.5 + 0.025 + 0.004 \]

\[ = 0.5 + 0.029 = 0.529 \text{ cm} \]

Thus, the diameter of the ball is 0.529 cm.
38. (d) Moment of inertia of a rotating solid sphere about its symmetrical (diametric) axis is given as,
\[ I = \frac{2}{5} mR^2 \]

Rotational kinetic energy of solid sphere is
\[ K_I = \frac{1}{2} I \omega^2 = \frac{1}{2} \times \frac{2}{5} mR^2 \omega^2 = \frac{1}{5} mR^2 \omega^2 \]

Angular velocity, \( \omega = \omega \)

As, we know that external torque,
\[ \tau_{\text{ext}} = \frac{dL}{dt} \]

where, \( L \) is the angular momentum.

Since, in the given condition, \( \tau_{\text{ext}} = 0 \)
\[ \Rightarrow \frac{dL}{dt} = 0 \]
or \( L = \text{constant} \)

Hence, when the radius of the sphere is increased keeping its mass same, only the angular momentum remains constant. But other quantities like moment of inertia, rotational kinetic energy and angular velocity changes.

39. (b) According to the question,

\[ \begin{array}{c}
A & B & C \\
\downarrow & \downarrow & \downarrow \\
v_A & v_B & v_C
\end{array} \]

The figure above shows an ellipse traced by a planet around the Sun, S. The closed point A is known as perihelion (perigee) and the farthest point C is known as aphelion (apogee).

Since, as per the result the Kepler’s second law of area, that the planet will move slowly (\( v_{\text{per}} \)) only when it is farthest from the Sun and more rapidly (\( v_{\text{max}} \)) when it is nearest to the Sun.

Thus, \( v_A = v_{\text{max}}, v_C = v_{\text{min}} \)

Therefore, we can write
\[ v_A > v_B > v_C \] ...

Kinetic energy of the planet at any point is given as,
\[ K = \frac{1}{2} mv^2 \]

Thus, at A, \( K_A = \frac{1}{2} mv_A^2 \)

At B, \( K_B = \frac{1}{2} mv_B^2 \)

At C, \( K_C = \frac{1}{2} mv_C^2 \)

From Eq. (i), we can write
\[ K_A > K_B > K_C \]

40. (d) Let the original mass of Sun was \( M_s \) and gravitational constant \( G \).

According to the question,

New mass of Sun, \( M'_s = \frac{M_s}{10} \)

New gravitational constant, \( G' = 10G \)

As, the acceleration due to gravity is given as
\[ g = \frac{GM}{R^2} \] ...

where, \( M_e \) is the mass of Earth and \( R \) is the radius of the Earth.

Now, new acceleration due to gravity,
\[ g' = \frac{G'M}{R^2} = \frac{10M_sG}{R^2} \] ...

\[ \therefore \ g' = 10g \] [from Eqs. (i) and (ii)]

This means the acceleration due to gravity has been increased. Hence, force of gravity acting on a body placed on or surface of the Earth increases.

Due to this, rain drops will fall faster, walking on ground would become more difficult.

As, time period of the simple pendulum is
\[ T = 2\pi \sqrt{\frac{L}{g}} \]

Or \[ T \propto \frac{1}{\sqrt{g}} \]

Thus, time period of the pendulum also decreases with the increase in \( g \).

41. (b) Translational kinetic energy of a rolling body is
\[ K_t = \frac{1}{2} mv_{CM}^2 \] ...

Total kinetic energy of a rolling body
\[ = K_t + K_r = \text{Rotational KE + Translational KE} \]
\[ = \frac{1}{2} I \omega^2 + \frac{1}{2} mv_{CM}^2 \] ...

For a solid sphere, moment of inertia about its
diametric axis, \( I = \frac{2}{5} MR^2 \)

Substituting the value of \( I \) in Eq. (ii), we get

\[
K_i + K_r = \frac{1}{2} MR^2 \alpha^2 + \frac{1}{2} mv^2_{CM}
\]

\[
= \frac{1}{2} \left( \frac{2}{5} \right) MR^2 \left( \frac{v_{CM}}{R} \right)^2 + \frac{1}{2} mv^2_{CM} \quad \text{[\( v_{CM} = R\omega \)]}
\]

\[
= \frac{1}{5} mv^2_{CM} + \frac{1}{2} mv^2_{CM}
\]

\[
= \left( \frac{1}{5} + \frac{1}{2} \right) mv^2_{CM}
\]

\[
= \frac{7}{10} mv^2_{CM}
\]

\[
\therefore \text{Ratio, } \frac{K_i}{K_i + K_r} = \frac{10}{7} \quad \text{(iii)}
\]

\[
\therefore \quad K_i : K_i + K_r = 5 : 7
\]

Alternate Method

Suppose, moment of inertia,

\[
I = xMR^2 \quad \text{(i)}
\]

For solid sphere, moment of inertia,

\[
I = \frac{2}{5} MR^2 \quad \text{(ii)}
\]

Thus, from Eqs. (i) and (ii), we get

\[
x = \frac{2}{5}
\]

Since, the ratio of translational energy to the total energy can be written as

\[
\frac{K_i}{K_i + K_r} = \frac{\frac{1}{2} mv^2_{CM}}{\frac{1}{2} \left( \frac{2}{5} \right) (xR)^2 \left( \frac{v_{CM}}{R} \right)^2 + \frac{1}{2} mv^2_{CM}}
\]

\[
= \frac{1}{5} \left( \frac{2}{5} \right) \left( \frac{v_{CM}}{R} \right)^2 + \frac{1}{2} \left( \frac{v_{CM}}{R} \right)^2 \quad \text{[\( v_{CM} = R\omega \)]}
\]

\[
= \frac{1}{5} \left( \frac{1}{5} + \frac{1}{2} \right) \left( \frac{v_{CM}}{R} \right)^2
\]

\[
= \frac{7}{10} \left( \frac{v_{CM}}{R} \right)^2
\]

\[
\therefore K_i : K_i + K_r = \frac{7}{10} : \frac{17}{10} = 5 : 7\]

Substituting the value of \( K^2 \) in Eq. (iii), we get

\[
\frac{K_i}{K_i + K_r} = \frac{1}{\left( 1 + \frac{xR^2}{R^2} \right)} = \frac{1}{1 + x}
\]

Here,

\[
x = \frac{2}{5}
\]

\[
\Rightarrow \quad \frac{K_i}{K_i + K_r} = \frac{1}{1 + 2/5} = \frac{5}{7}
\]

42. (a) Key Concept The rate of heat generation is equal to the rate of work done by the viscous force which in turn is equal to its power.

Rate of heat produced, \( \frac{dQ}{dt} = F \times v_T \)

where, \( F \) is the viscous force and \( v_T \) is the terminal velocity.

As,

\[
F = 6\pi\eta\nu_T
\]

\[
\Rightarrow \quad \frac{dQ}{dt} = 6\pi\eta\nu_T \times v_T
\]

\[
= 6\pi\eta\nu_T^2
\]

\[
\quad \text{...}(i)
\]

From the relation for terminal velocity,

\[
\nu_T = \frac{2}{9} \left( \frac{\rho - \sigma}{\eta} \right) g, \quad \text{we get}
\]

\[
\nu_T \propto r^2
\]

\[
\quad \text{...}(ii)
\]

From Eq. (ii), we can rewrite Eq. (i) as

\[
\frac{dQ}{dt} \propto r^5
\]

or

\[
\frac{dQ}{dt} \propto r^5
\]

43. (a) According to Wien’s law,

\[
\lambda_{\text{max}} \propto \frac{1}{T}
\]

i.e.

\[
\lambda_{\text{max}} T = \text{constant}
\]

where, \( \lambda_{\text{max}} \) is the maximum wavelength of the radiation emitted at temperature \( T \).

\[
\therefore \quad \lambda_{\text{max}} T_{\text{1}} = \lambda_{\text{max}} T_{\text{2}}
\]

or

\[
\frac{T_1}{T_2} = \frac{\lambda_{\text{max}}}{\lambda_{\text{max}}}
\]

\[
\quad \text{...}(i)
\]

Here, \( \lambda_{\text{max}} T_{\text{1}} = \lambda_0 \) and \( \lambda_{\text{max}} T_{\text{2}} = \frac{3}{4} \lambda_0 \)

Substituting the above values in Eq. (i), we get

\[
\frac{T_1}{T_2} = \frac{3}{4} \frac{\lambda_0}{\lambda_0} = \frac{3}{4}
\]

or

\[
\frac{T_1}{T_2} = \frac{3}{4}
\]

... (ii)
As we know that, from Stefan’s law, the power radiated by a body at temperature $T$ is given as

$$P = \sigma A \epsilon T^4$$

i.e.

$$P \propto T^4$$

(∵ the quantity $\sigma \epsilon$ is constant for a body)

$$\Rightarrow \frac{P_1}{P_2} = \left( \frac{T_1}{T_2} \right)^4 = \frac{81}{256}$$

From Eq. (i), we get

$$\frac{P_1}{P_2} = \frac{3}{4}$$

Given, $P_1 = P$ and $P_2 = nP$

$$\Rightarrow \frac{P_1}{P_2} = \frac{P}{nP} = \frac{81}{256}$$

or

$$n = \frac{256}{81}$$

44. (c) According to the question,

For wire 1

Area of cross-section $= A_1$

Force applied $= F_1$

Increase in length $= \Delta l$

From the relation of Young’s modulus of elasticity,

$$Y = \frac{F_1}{A_1 \Delta l}$$

Substituting the values for wire 1 in the above relation, we get

$$\Rightarrow Y_1 = \frac{F_1}{A_1 \Delta l}$$

... (i)

For wire 2

Area of cross-section $= A_2$

Force applied $= F_2$

Increase in length $= \Delta l$

Similarly,

$$Y_2 = \frac{F_2}{A_2 \Delta l}$$

∴ Volume, $V = Al$

or $l = \frac{V}{A}$

Substituting the value of $l$ in Eqs. (i) and (ii), we get

$$Y_1 = \frac{F_1 V}{A_1 \Delta l} \quad \text{and} \quad Y_2 = \frac{F_2 V}{A_2 \Delta l}$$

As it is given that the wires are made up of same material, i.e. $Y_1 = Y_2$

$$\Rightarrow \frac{F_1 V}{A_1 \Delta l} = \frac{F_2 V}{A_2 \Delta l}$$

$$\Rightarrow \frac{F_1}{F_2} = \frac{A_2}{A_1} = \frac{A^2}{9A^2} \quad (\because A_1 = A \text{ and } A_2 = 3A)$$

$$= \frac{1}{9}$$

or $F_2 = 9F_1 = 9F$ (given, $F_1 = F$)

45. (b) According to the question,

Heat spent during the conversion of sample of water at 100°C to steam is,

$$\Delta Q = 54 \text{cal} = 54 \times 4.18 \text{J} = 225.72 \text{ J}$$

Normal pressure, $p = 1.013 \times 10^5 \text{ Nm}^{-2}$

Net work done during the conversion would be given as

$$\Delta W = p \Delta V$$

Here, $V_{\text{steam}} = 1671 \text{ cc} = 167.1 \times 10^{-6} \text{ m}^3$

$$V_{\text{water}} = 0.1 \text{ g} = 0.1 \text{ cc} = 0.1 \times 10^{-6} \text{ m}^3$$

∴

$$\Delta W = 1.013 \times 10^5 \left(167.1 - 0.1\right) \times 10^{-6}$$

$$= 1.013 \times 167 \times 10^{-1}$$

$$= 16.917 \text{ J}$$

Now, by the first law of thermodynamics,

$$\Delta Q = \Delta U + \Delta W$$

where, $\Delta U$ is the change in internal energy of the sample.

$$\Rightarrow \Delta U = \Delta Q - \Delta W$$

Substituting the values in the above equation, we get

$$\Delta U = 225.72 - 16.917$$

$$= 208.7 \text{ J}$$
46. (c) Let the oxidation state of nitrogen in each of the given N-compounds be $x$.
   (i) $\text{HNO}_3 : ( ) + +1 + 3 \cdot (−2) = 0$
   $x = 5$
   $\therefore$ Oxidation state of N in $\text{HNO}_3$ is +5
   (ii) $\text{NO} : x + 1(−2) = 0$
   $x = 2$
   $\therefore$ Oxidation state of N in NO is +2
   (iii) $\text{NH}_3 \cdot \text{Cl} : x + 4(1+) + 1(−1) = 0$
   $x = −3$
   $\therefore$ Oxidation state of N in $\text{NH}_3 \cdot \text{Cl}$ is −3.
   (iv) $N_2 : x = 0$ [N$_2$ is present in elemental state]
   $\therefore$ Oxidation state of N in N$_2$ is 0.

Thus, the correct decreasing order of oxidation states of given N-compounds will be

$$
\text{HNO}_3 > \text{NO} > \text{NH}_3 \cdot \text{Cl} > N_2
$$

47. (a) Boron belongs to 2nd period of the periodic table with electronic configuration $1s^2, 2s^2 2p^1$. It does not have vacant $d$-orbitals, thus cannot increase its covalency above four.

Therefore, boron (B) cannot form $\text{MBe}_{5}^-$ ion. In contrast, aluminium (Al), gallium (Ga), indium (In) have the vacant $3t$-orbitals, thus can increase their covalency above four and form $\text{MBe}_{5}^-$ ion.

48. (a) **Key Concept** Ellingham diagrams help us in predicting the feasibility of thermal reduction of an ore. The criterion of feasibility is that at a given temperature, Gibbs energy of the reaction must be negative.

Gibbs energy $\Delta G^o$ vs $T$ plots (schematic) for formation of some oxides (Ellingham diagram). According to Ellingham diagram, the temperature at which two lines intersect shows that the metal will reduce the oxide of other metals which lie above it in Ellingham diagram. In other words, the metal oxide having more negative value of $\Delta G_f$ can reduce the oxide having less negative $\Delta G_f$. As, Mg has more $−\Delta G^o$ value than alumina, so it will be in lower part of Ellingham diagram. Hence, Mg will be used to reduce alumina.

49. (d) The atomic radii as well as ionic radii increases on moving down the group 13 elements because of the successive addition of one extra shell of electrons.

However, there is an anomaly at gallium in case of atomic radii. Atomic radii of Ga is lesser as compared to Al. Gallium (Ga) with electronic configuration, [Ar] $3d^10 4s^2 4p^1$ has an extra $d$-electrons which do not screen the nucleus effectively. Consequently, electrons of Ga are more attracted by nucleus.

Thus, the increasing order of atomic radii of the group 13 elements is B (85 pm) < Ga (133 pm) < Al (143 pm) < In (167 pm) < Tl (170 pm).

50. (a) Fluorine is the most electronegative element and cannot exhibit any positive oxidation state.

Other halogens have $d$-orbitals and therefore, can expand their octets and show $+1, +3, +5$ and $+7$ oxidation states. Thus, option (a) is incorrect.

Fluorine can form an oxoacid, $\text{HOF}$ in which oxidation state of $F$ is $+1$. But $\text{HOF}$ is highly unstable compound.

(b) All halogens are strong oxidising agents as they have strong tendency to accept an electron. Thus, option (b) is correct.

(c) All halogens form monobasic oxyacids.

Thus, option (c) is also correct.

(d) Electron gain enthalpy of halogens become less negative down the group. However, the negative electron gain enthalpy of fluorine is less than chlorine due to small size of fluorine atom.

Thus, option (d) is also correct.
51. (b) The central atom Cl has seven electrons in the valence shell. Three of these will form electron pair bonds with three fluorine atoms leaving behind four electrons.

\[ \text{F} - 
\]

Thus, there are three bond pairs and two lone pairs of electrons.

52. (d) The given reaction takes place as follows:

**Mechanism**

**Step I** Formation of Carbocation

\[ \text{CH}_3\text{CCH}_2\text{Cl} + \text{AlCl}_3 \rightarrow \text{CH}_2\text{CCH}_2\text{CH}_2 + \text{AlCl}_4 \]

**Step II** Electrophilic substitution reaction.

**Step III** Formation of peroxide

\[ \text{CH}_3\text{CCH}_2\text{OH} \rightarrow \text{CH}_3\text{CCH}_2\text{H} + \text{H}_2\text{O} \]

**Step IV** Hydrolysis of oxidised product formed in step III.

53. (d) **Key Concept** Ion containing positive as well as negative charge is called Zwitter ion.

Among the given options, only glycine (H\text{N}\text{—CH}_2\text{—COOH}) is an amino acid which contains both acidic (acquiring negative charge) and basic group (acquiring positive charge).

Glycine can form a Zwitter ion. It is because glycine behave like salts rather than simple amines or carboxylic acids. In aqueous solution, the carboxyl group can lose a proton and amino group can accept a proton giving rise to a dipolar ion known as Zwitter ion.

\[ \text{H} - \text{C} - \text{COO}^- + \text{NH}_3 + \text{H}_2\text{O} \rightarrow \text{H} - \text{C} - \text{COO}^- \text{H} + \text{NH}_4^+ \]

Zwitter ion is a cation in acidic medium and migrates to cathode on passing electric current. It is an anion in basic medium and migrates to anode on passing electric current.
Thus, amino acid bears a positive charge in acidic solution (low pH) and a negative charge in basic solution (high pH). The pH at which the amino acid has no net charge is called isoelectric point. The isoelectric point of glycine is 5.97.

54. (d) Cross-linked or network polymers are formed from bi-functional and tri-functional monomers and contain strong covalent bonds between various linear polymer chains. These are hard, rigid and brittle due to cross-links e.g. bakelite, melamine etc. Thus, option (d) is incorrect.

55. (d) In strongly acidic medium, aniline is protonated to form the anilinium ion.

Since, anilinium ion so formed is meta directing, thus besides ortho and para derivatives, significant amount of meta derivative is also formed.

56. (c) Starch contains two components amylose and amylopectin. Chemically, amylose is a long unbranched chain with 200-1000 α-D- (+)-glucose units held by C₁-C₄ glycosidic linkage.

Amylopectin is a branched chain polymer of α-D-glucose units in which chain is formed by C₁-C₄ glycosidic linkage where branching occurs by C₁-C₆ glycosidic linkage.

57. (a) Key Concept firstly, write the reaction of formic acid and oxalic acid with conc. H₂SO₄, respectively. Then, find the gaseous products formed and identify the remaining gaseous product after passing through KOH. Finally, calculate the total number of moles of gaseous product.

\[
\text{HCOOH} \xrightarrow{\text{Conc. H}_2\text{SO}_4} \text{CO(g)} + \text{H}_2\text{O(l)}
\]
Initial moles \(2.3 \text{ mol} \), Final moles \(0\)

\[
\text{Initial moles} \quad \frac{4.5}{90} \quad \frac{1}{20} \quad \text{Final moles} \quad 0 \quad 0 \quad \frac{1}{20} \quad \frac{1}{20}
\]
Now, \( \text{H}_2\text{O}(l) \) gets absorbed by conc. \( \text{H}_2\text{SO}_4 \). Gaseous mixture \( \text{CO} \) and \( \text{CO}_2 \) when passed through KOH, only \( \text{CO}_2 \) gets absorbed. Thus, CO is the remaining gas.

Total number of moles of CO formed in the above equations = \( \frac{1}{20} + \frac{1}{20} = \frac{1}{10} \)

\( \therefore \) Moles = \( \frac{\text{Weight of CO formed}}{\text{Molar mass}} \)

\( \therefore \) Weight of CO formed = \( \frac{1}{10} \times 28 = 2.8 \text{ g} \)

Thus, weight of the remaining product at STP will be 2.8 g.

### 58. (b) Basic strength of the oxides of alkaline earth metals increases from \( \text{BeO} \) to \( \text{BaO} \). In fact, \( \text{BeO} \) is amphoteric while all other oxides are basic. It is because all the alkaline earth metals are ionic in nature but \( \text{BeO} \) in addition to ionic character shows some covalent character also. Thus, \( \text{BeO} \) being amphoteric in nature behaves both as an acid and base.

<table>
<thead>
<tr>
<th>( \text{BeO} )</th>
<th>( \text{MgO} )</th>
<th>( \text{CaO} )</th>
<th>( \text{SrO} )</th>
<th>( \text{BaO} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amphoteric</td>
<td>Weak base</td>
<td>Strong base</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note** Degree of Covalent character and concept of polarisation is put forwarded by fajan’s rule.

### 59. (c) Nitrous oxide (\( \text{N}_2\text{O} \)), nitrogen dioxide (\( \text{NO}_2 \)) and nitric oxide (\( \text{NO} \)) are the common pollutant introduced into the atmosphere.

\( \text{N}_2\text{O} \) occurs naturally in environment. \( \text{NO} \) and \( \text{NO}_2 \) causes considerable amount of air pollution. They are given off in car exhaust fumes and when fossil fuels are burnt as well as produced during thunderstorms. In each case NO is formed first and then \( \text{NO}_2 \).

### 60. (d) According to given question and options (A) must be \( \text{C}_2\text{H}_5\text{OH} \), as it reacts with \( \text{Na} \) to give \( \text{C}_2\text{H}_5\text{ONa} \). The reaction sequence is as follows.

(i) \( \text{C}_2\text{H}_5\text{OH} \) (Ethanol) \( \xrightarrow{(A)} \) \( \text{C}_2\text{H}_5\text{ONa} \) (Sodium ethoxide) \( \xrightarrow{(B)} \) \( \text{C}_2\text{H}_5\text{Cl} \) (Ethyl chloride)

(ii) \( \text{C}_2\text{H}_5\text{ONa} + \text{CH}_2\text{Cl}_2 \xrightarrow{\text{NaCl}} \text{C}_2\text{H}_4\text{OCl} \) (Diethyl ether)

The above reaction is known as Williamson’s ether synthesis. It involves nucleophilic attack of alkoxide ion on alkyl halide according to Stone-2 mechanism.

\[ \text{C}_2\text{H}_5\text{O}^- + \text{CH}_2\text{Cl} \xrightarrow{\text{Nucleophile} (\text{Alkoxide ion})} \xrightarrow{\text{Substrate} (\text{Alkyl halide})} \text{C}_2\text{H}_4\text{O}^- + \text{C}_2\text{H}_5^- + \text{Cl}^- \]

**61. (c) Given**, \( \text{C}_2\text{H}_8 \xrightarrow{3\text{Cl}_2/\text{A}} \text{Br}_2/\text{Fe} \xrightarrow{\text{Zn/HCl}} \)

The reaction in the above road map can be explained by the following steps.

**Step I** Toluene (A) undergoes side chain halogenation with excess of chlorine to give benzotrichloride (A).

**Step II** In compound (A), the substituent \( \text{CCl}_3 \) is an electron withdrawing group, so the electrophile will attack at \( m \)-position. Thus, benzotrichloride reacts with bromine in presence of \( \text{Fe} \) catalyst to give \( m \)-bromobenzotrichloride (B).

**Step III** \( m \)-bromobenzotrichloride undergoes reduction with \( \text{Zn} \) in presence of \( \text{HCl} \) to give \( m \)-bromotoluene (C).

### 62. (d) The given reaction takes place as follows:

\( \text{CH}_4 \xrightarrow{\text{Br}_2/\text{by} \text{Step I}} \text{CH}_3\text{Br} \xrightarrow{\text{Na/\text{dry ether} \text{Wurtz reaction}}} \text{CH}_3\text{CH}_3 \)

**Step I** Alkyl halide is formed by free radical halogenation of alkane in the presence of UV-light.

**Step II** The formed alkyl halide reacts with sodium in presence of dry ether to form alkane containing double number of carbon atoms present in alkyl halide.

This reaction is known as Wurtz reaction.

From the above mechanism, it is concluded that option (d) is correct as in all other cases the hydrocarbon formed in step 2 will contain more than four carbon atoms.
63. **Key Idea** While judging the hybridisation in the given type of organic molecules always look for the number of $\sigma$ and $\pi$ bonds formed by C-atom involved.

The hybridisation of the given molecules are:

(i) $\text{CH}_2\text{CH}=\text{CH}=\text{CH}_2$ \[\text{sp}^3 \quad \text{sp} \quad \text{sp} \quad \text{sp}\]

(ii) $\text{CH}_3\text{CH}=\text{C}=\text{CH}$ \[\text{sp}^3 \quad \text{sp}^2 \quad \text{sp} \quad \text{sp}\]

(iii) $\text{CH}=\text{C}=\text{C}=\text{CH}$ \[\text{sp} \quad \text{sp}^2 \quad \text{sp}^2 \quad \text{sp}^3\]

(iv) $\text{CH}_3\text{C}=\text{CH}=\text{CH}_3$ \[\text{sp} \quad \text{sp}^2 \quad \text{sp}^2 \quad \text{sp}^3\]

Therefore, the correct option is (b).

64. *(a)* $\text{NO}_2$ group is an electron withdrawing group and exhibit $-I$ effect. This effect increases with decrease in distance of positive charge present on C-atom and hence lesser is the stability of carbocation.

In option (a), the positive charge is at maximum distance to $\text{NO}_2$ group, so $-I$ effect due to $\text{NO}_2$ group will be minimum and stability will be maximum.

\[
\text{NO}_2
\]

In option (b) and (d) the positive charges is at minimum distance to $\text{NO}_2$ group hence the stability will be minimum.

\[
\begin{array}{c}
\text{H} \\
\text{NO}_2 \\
\text{H}
\end{array}
\quad
\begin{array}{c}
\text{H} \\
\text{NO}_2 \\
\text{H}
\end{array}
\]

Also, in option (c) the distance of positive charge to $\text{NO}_2$ group is more than ortho but less than para, so it will be less stable as compared to option (a).

65. *(b, c)* $-I$ effect is related to the ability of substituent for the electron attraction capacity from the attached carbon atom.
67. (d) Carboxylic acids have higher boiling points than aldehyde, ketones and even alcohols of comparable molecular mass because of the extent of intermolecular-hydrogen bonding with water, due to which they exist as associated molecules. The hydrogen bonds are not completely broken in the vapour state. In fact mostly carboxylic acids exist as dimer in the vapour state or aprotic solvent.

68. (a) Iodoform reaction with sodium hypoidote is used for the detection of CH₂CO₃ group. Also compounds containing CH₂CH(OH)₃ group shows positive iodoform test as it produces CH₂CO₃ group on oxidation. Since, among the compounds, CH₂CH(OH)₃ group is given only in the substrate of option (a) hence, it is correct. The reaction of compound A with NaOI is given as follows:

\[ 2\text{NaOH} + \text{I}_2 \rightarrow \text{NaOI} + \text{NaI} + \text{H}_2\text{O} \]

69. (c) Key Concept Spin magnetic moment can be calculated as

\[ \mu = \sqrt{n(n+2)} \text{ BM} \]

where, \( \mu \) = magnetic moment
BM = Bohr Magneton (unit of \( \mu \))
\( n \) = number of unpaired electrons in \( d \)-orbital.

The electronic configuration of Co³⁺ is [Ar] 3d⁶.

Here, \( n = 4 \)
\[ \mu = \sqrt{4(4+2)} = \sqrt{24} \text{ BM} \]

The electronic configuration of Cr³⁺ is [Ar] 3d⁶.
Here, \( n = 3 \)
\[ \mu = \sqrt{3(3+2)} = \sqrt{15} \text{ BM} \]

The electronic configuration of Fe³⁺ is [Ar] 3d⁶.
Here, \( n = 5 \)
\[ \mu = \sqrt{5(5+2)} = \sqrt{35} \text{ BM} \]

The electronic configuration of Ni²⁺ is [Ar] 3d⁸.
Here, \( n = 2 \)
\[ \mu = \sqrt{2(2+2)} = \sqrt{8} \text{ BM} \]

So, the correct option is (c).

70. (d) Key Concept In \( d-d \) transition, an electron in a \( d \)-orbital of the metal is excited by a photon to another \( d \)-orbital of higher energy.

Paramagnetism The complex compound which contains unpaired electrons shows paramagnetism while which contains paired electrons shows diamagnetism.

The complex which contains unpaired electrons exhibit \( d-d \) transition and paramagnetism.

(i) In \( \text{MnO}_4^- \),

The electronic configuration of \( \text{Mn}^{2+} \) is [Ar] 3d⁵.
Number of unpaired electrons = 0
Therefore, it will be diamagnetic and will not show \( d-d \) transition.

(ii) In \( \text{CrO}_4^{2-} \),

The electronic configuration of \( \text{Cr}^{4+} \) is [Ar] 3d⁶.
Number of unpaired electrons = 0
So, it will be diamagnetic and will not show \( d-d \) transition.

(iii) In \( \text{CrO}_4^{2-} \),

The electronic configuration of \( \text{Cr}^{6+} \) is [Ar] 3d⁶.
Number of unpaired electrons = 0
Therefore, it is also diamagnetic and will not show \( d-d \) transition.

(iv) In \( \text{MnO}_4^{2-} \), The electronic configuration of \( \text{Mn}^{5+} \) is [Ar] 3d⁹.
Number of unpaired electrons = 1
Since, it contains one unpaired electron so it will exhibit both \( d-d \) transition and paramagnetism.
Compounds of transition metal with carbonyls (carbon monoxide) are known as metal carbonyls. These are classified into mononuclear, dinuclear, trinuclear and so on based on the number of central metal atoms/ions present in a complex.

Effective atomic number (EAN) of the metal in a complex is given by

\[
\text{EAN} = \text{Atomic number (} Z \text{)} - \text{Oxidation number (O.N)} + 2(\text{Coordination number})
\]

Thus, Fe(CO)\textsubscript{5} is a stable complex/ion. Since, there is only one central metal atom present in iron carbonyl, Fe(CO)\textsubscript{5}, thus it is mononuclear. The structure of Fe(CO)\textsubscript{5} is shown below:

The examples of dinuclear, trinuclear complexes are Co\textsubscript{2}(CO)\textsubscript{8}, Fe\textsubscript{2}(CO)\textsubscript{12} respectively.

Isomers in which the atoms or ligands occupy different positions around central metal/ion are called geometrical isomers. Complexes having coordination number of central atom/ion 6 with formula \(M(AA)\textsubscript{2}B\textsubscript{2}\) exhibit geometrical isomerism [where, \(AA\) is a bidentate ligand]. In \([CoCl\textsubscript{2}(en)\textsubscript{2}]\), coordination number of Co is 6 with octahedral geometry.

Thus, \([CoCl\textsubscript{2}(en)\textsubscript{2}]\) show geometrical isomerism.

The complexes having \(sp^3\)-hybridisation are tetrahedral while having \(dsp^2\)-hybridisation are square planar. The magnetic behaviour of complexes can be paramagnetic and diamagnetic based on the presence and absence of unpaired electrons, respectively.

The example of tetrahedral and square planar complexes are Ni(CO)\textsubscript{4} and Fe(CO)\textsubscript{5} respectively.

Electronic configuration of Ni\((Z=28)\) is \([Ar]\textsubscript{18}3d\textsubscript{10}4s\textsubscript{2}\). Due to presence of CO (neutral ligand), oxidation state of Ni in \([Ni(CO)\textsubscript{4}]\) is 0.

\[
\begin{array}{c|c|c|c|c}
\text{Ni-atom} & 3d & 4s & 4p & \text{Electron}\textsubscript{chart} \\
\hline
\text{Ni} & \text{10} & \text{0} & \text{0} & \text{Ni} \text{atom}
\end{array}
\]

Since, CO is a strong field ligand, it pair up the unpaired electrons of Ni.

\[
\begin{array}{c|c|c|c|c}
\text{Ni(CO)}\textsubscript{4} & 3d & 4s & 4p & \text{Electron} \text{chart} \\
\hline
\text{Ni(CO)}\textsubscript{4} & \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \time
According to this rule “greater the valency of the coagulating ion/flocculating ion (oppositely charged ion) added, the greater is its power to cause coagulation.
To coagulate a positively charged sol, the order of coagulating power of positive ion is
\[ I^- < SO_4^{2-} < PO_4^{3-} < [Fe(CN)_6]^{4-} \]
Similarly, to coagulate a negatively charged sol, the order of coagulating power of positive ions is
\[ Ag^+ < Pb^{2+} < Fe^{3+} < Si^{4+} \]

76. (c) In the van der Waals’ equation,
\[ \left( V - nb \right) = nRT \]

‘a’ and ‘b’ are known as van der Waals’ constant.
‘a’ is the measure of force of attraction between gas molecules. Greater the value of a, easier the liquefaction of the gas.
Thus, among \( NH_4(4.17) \), \( H_2O(0.244) \), \( O_2(1.36) \) and \( CO_2(5.99) \), the value of a is greatest in \( NH_4 \) hence it is most easily liquefied.

77. (c) For a general reaction,
\[ A_b B_g \rightleftharpoons xA^{y+} + yB^{z-} \]
Solubility product \( K_{sp} = \left[ A^{y+} \right]^x \left[ B^{z-} \right]^y \)
For \( BaSO_4 \) (binary solute giving two ions)
\[ BaSO_4(s) \rightleftharpoons Ba^{2+}(aq) + SO_4^{2-}(aq) \]
\[ K_{sp} = [Ba^{2+}] \left[ SO_4^{2-} \right] = (S)^2 \quad \cdots (i) \]

[where, \( S = \text{Solubility} \)]
Given, \( S = 2.42 \times 10^{-3} \) g L\(^{-1} \)
Molar mass of \( BaSO_4 \) = 233 g mol\(^{-1} \)
\[ s = \frac{2.42 \times 10^{-3}}{233} \text{mol} \text{ L}^{-1} \]
\[ = 1.04 \times 10^{-5} \text{mol} \text{ L}^{-1} \]
On substituting the value of \( S \) in Eq. (i), we get
\[ K_{sp} = (1.04 \times 10^{-5} \text{mol} \text{ L}^{-1})^2 \]
\[ = 1.08 \times 10^{-10} \text{mol}^2 \text{ L}^{-2} \]

78. (c) Number of molecules = Mole \times Avogadro’s number \((N_A)\)
The number of molecules of water in each of the given options is calculated as
(i) 18 mL of water
Number of moles \( n_{H_2O} \)
\[ = \frac{\text{Mass of substance in g}}{\text{Molar mass in g mol}^{-1}} \]
\[ w_{H_2O} = 18 \text{g} \]
\[ \text{Density of water} \left( d_{H_2O} \right) = 1 \text{ g L}^{-1} \]
\[ \therefore \]
\[ n_{H_2O} = \frac{18}{18} = 1 \]
Number of molecules of water = \( 1 \times N_A \)
(ii) 0.18 g of water
\[ n_{H_2O} = \frac{w_{H_2O}}{M_{H_2O}} = \frac{0.18}{18} = 0.01 \]
Number of molecules of water = \( 0.01 \times N_A \)
(iii) 0.00224 L of water vapours at 1 atm and 273 K. At STP [1 atm and 273 K],
Number of moles [with reference to volume]
\[ = \frac{\text{Volume of gas in litres}}{22.4} \]
\[ = \frac{0.00224}{22.4} = 0.0001 \]
Number of molecules of water = \( 0.0001 \times N_A \)
(iv) 10\(^{-3} \) mol of water
Number of molecules of water = \( 10^{-3} \times N_A \)
\[ \therefore \]
\[ \text{Among the given options, option (i) contains the maximum number of water molecules.} \]

79. (b) For first order reactions, the rate of reaction is proportional to the first power of the concentration of the reactant.
For, \( A \rightarrow B \)
\[ \text{Rate} = -\frac{d[A]}{dt} = k[A] \quad \cdots \quad \text{[where, } k = \text{constant}] \]
Half-life \( (t_{1/2}) = \frac{0.693}{k} \)
\[ \therefore \]
\[ \text{Rate of first order reaction depends upon reactant concentrations and half life does not depend upon initial concentration of reactant, } [A]_0. \]
For second order reactions, the rate of reaction is proportional to the second power of the concentration of the reactant.
For, \( 2A \rightarrow B \)
\[ \text{Rate} = k[A]^2 \]
Half-life \( (t_{1/2}) = \frac{1}{k[A]_0} \)
\[ \therefore \]
\[ \text{Rate of second order reaction depends upon reactant concentration and half life also does depend on } [A]_0. \]
80. (c) **Key Concept** The covalent character in an ionic bond can be decided by Fajan’s rule.

According to this rule, compounds with small cation, large anion, more charge on cation or anion shows more covalent character. As the above conditions opposes, it shows ionic character.

Since, the size of cation decreases in the order

\[ \text{Ba}^{2+} > \text{Ca}^{2+} > \text{Be}^{2+} \]

Therefore, the correct order of ionic character will be

\[ \text{BeH}_2 < \text{CaH}_2 < \text{BaH}_2 \]

BeH₂ has some covalent character. It is because of the effect of polarisation. According to Fajan’s rule, smaller the size of cation and more the charge on the cation, greater is its polarising power. Thus, BeH₂ has some covalent character also.

81. (d) **Key Concept** The reaction in which same species is oxidised as well as reduced is called disproportionation reaction. Firstly, calculate the value of \( E^{\text{cell}} \) of each species undergoing disproportionation reaction. The reaction whose \( E^{\text{cell}} \) value is positive will be feasible (spontaneous).

(i) Given, \( \text{BrO}_3^- \rightarrow \text{HBrO} ; \quad E^{\text{HBrO}/\text{HBO}} = 1.5 \text{ V} \)

\[ \text{BrO}_3^- \rightarrow \text{BrO}_4^- ; \quad E^{\text{BrO}_4^-/\text{BrO}_3^-} = -1.82 \text{ V} \]

\[ \therefore \quad 2\text{BrO}_3^- \rightarrow \text{HBrO} + \text{BrO}_4^- \quad E^{\text{cell}} = E^{\text{cal}} + E^{\text{an}} \]

\[ = E^{\text{BrO}_3^-/\text{HBrO}} + E^{\text{BrO}_4^-/\text{BrO}_3^-} \]

\[ = 1.5 - 1.82 = -0.32 \text{ V} \quad \text{[Non-spontaneous]} \]

(ii) \( \text{HBrO} \rightarrow \text{Br}_2 ; \quad E^{\text{HBrO}/\text{Br}_2} = 1.595 \text{ V} \)

\[ \text{HBrO} \rightarrow \text{BrO}_3^- ; \quad E^{\text{BrO}_3^-/\text{HBrO}} = -1.5 \text{ V} \]

\[ 2\text{HBrO} \rightarrow \text{Br}_2 + \text{BrO}_3^- \quad E^{\text{cell}} = E^{\text{HBrO}/\text{Br}_2} + E^{\text{BrO}_3^-/\text{HBrO}} \]

\[ = 1.595 - 1.5 = 0.095 \text{ V} \quad \text{[Spontaneous]} \]

(iii) \( \text{Br}_2 \rightarrow \text{Br}^- ; E^{\text{Br}_2/\text{Br}^-} = 1.0652 \text{ V} \)

\[ \text{Br}_2 \rightarrow \text{HBrO} ; E^{\text{Br}_2/\text{HBrO}} = -1.595 \text{ V} \]

\[ 2\text{Br}_2 \rightarrow \text{Br}^- + \text{HBrO} \quad E^{\text{cell}} = E^{\text{Br}_2/\text{Br}^-} + E^{\text{Br}_2/\text{HBrO}} \]

\[ = 1.0652 - 1.595 = -0.5298 \text{ V} \]

\[ \therefore \quad \text{Among the given options, only HBrO undergoes disproportionation.} \]

82. (b) The given redox reaction is

\[ \text{MnO}_4^- + C_2O_4^{2-} + H^+ \rightarrow \text{Mn}^{2+} + CO_2 + H_2O \]

The reaction can be balanced by considering the following steps

**Step I** Balance the atoms except H and O.

\[ \text{MnO}_4^- + C_2O_4^{2-} + H^+ \rightarrow \text{Mn}^{2+} + 2CO_2 + H_2O \]

**Step II** Write the oxidation number of each atom

\[ \begin{align*}
\text{MnO}_4^- & \rightarrow \text{Mn}^{2+} \quad 5e^- \text{ gain} \\
\text{C}_2\text{O}_4^{2-} & \rightarrow 2\text{CO}_2 \quad 2e^- \text{ loss} \\
2\text{MnO}_4^- + 5\text{C}_2\text{O}_4^{2-} + H^+ & \rightarrow 2\text{Mn}^{2+} + 10\text{CO}_2 + H_2O
\end{align*} \]

**Step III** Cross multiply by change in oxidation number

\[ \begin{align*}
\text{MnO}_4^- & \rightarrow \text{Mn}^{2+} \quad 5e^- \text{ gain} \\
\text{C}_2\text{O}_4^{2-} & \rightarrow 2\text{CO}_2 \quad 2e^- \text{ loss} \\
2\text{MnO}_4^- + 5\text{C}_2\text{O}_4^{2-} + H^+ & \rightarrow 2\text{Mn}^{2+} + 10\text{CO}_2 + H_2O
\end{align*} \]

\[ \therefore \quad \text{The coefficients of the reactants, MnO}_4^-, \text{C}_2\text{O}_4^{2-} \text{ad H}^+ \text{ are 2, 5 and 16, respectively.} \]

83. (c) **Key Concept** The given question is based upon Le-Chatelier’s principle. According to this principle, if a stress is applied to a reaction mixture at equilibrium, reaction proceeds in such a direction that relieves the stress.

The given reaction is

\[ A_2(g) + B_2(g) \rightleftharpoons X_2(g) ; \quad \Delta H = -X \text{kJ} \]

According to Le-Chatelier’s principle, with increase in temperature the equilibrium shifts in the direction of endothermic reaction (i.e., heat is absorbed).

Alternatively, the decrease in temperature shifts the equilibrium towards the direction of exothermic reaction (i.e., heat is produced).

\[ \therefore \quad A_2(g) + B_2(g) \rightleftharpoons X_2(g) \]
Similarly, an increase in pressure will shift the equilibrium in that direction which leads to an increase in total number of gaseous moles. Whereas, a decrease in the pressure will shift the equilibrium in that direction which leads to a decrease in total number of gaseous moles.

For, \[ A(g) + B(g) \rightleftharpoons X(g) + Y(g) \]
\[ \Delta n_f = 1 - 2 = -1 \]
Thus, low temperature and high pressure will favour maximum formation of the product in the given reaction.

84. (b) For zero order reaction,
\[ t_{1/2} = \frac{[R_0]}{k} \]
where, \([R_0]\) = Initial concentration of the reactant.
\(k\) = Rate constant.
Thus, \(t_{1/2}\) for zero order reaction is directly proportional to the initial concentration of the reactant.
\[ t_{1/2} \propto [R_0] \]
.: For zero order reaction, when the concentration of reactant is doubled, the half-life \(t_{1/2}\) will also get doubled.

85. (a) **Key Concept** Relation between heat of reaction \((\Delta H)\) and bond energies \((BE)\) of reactants and products is given by
\[ \Delta H = \Sigma BE_{\text{Reactants}} - \Sigma BE_{\text{Products}} \]
The reaction of formation for \(XY\) is
\[ \frac{1}{2}X_2(g) + \frac{1}{2}Y_2(g) \rightarrow XY(g); \]
\[ \Delta H = -200\text{kJ mol}^{-1} \]
Given, the bond dissociation energies of \(X_2\), \(Y_2\) and \(XY\) are in the ratio \(1:0.5:1\). Let the bond dissociation energies of \(X_2\), \(Y_2\) and \(XY\) are \(a\) kJ mol\(^{-1}\), \(0.5a\) kJ mol\(^{-1}\) and \(a\) kJ mol\(^{-1}\), respectively.

\[ \Delta H = \Sigma BE_{\text{Reactants}} - \Sigma BE_{\text{Products}} \]
\[ = \left[ \frac{1}{2} \times a + \frac{1}{2} \times 0.5a \right] - \left[ a \times 1 \right] \]
\[ = -200 = \frac{a}{2} + \frac{a}{4} - a \]
\[ = -200 = \frac{2a + a - 4a}{4} = -a \]
\[ a = 800\text{kJ mol}^{-1} \]
.: The bond dissociation energy of \(X_2\) is \(a\) kJ mol\(^{-1}\).

86. (d) According to van der Waals’ equation,
\[ P + \frac{a}{V^2} = RT \]
where, \(a\) and \(b\) are called van der Waals’ constant. \(\frac{a}{V^2}\) is called internal pressure of the gas
\[ \begin{align*}
' a' \ &= \text{a measure of force of attraction between gas molecules.} \\
' b' \ &= \text{also called co-volume or excluded volume.} \\
\text{The constants 'a' and 'b' are expressed in atm L}^2\text{ mol}^{-2} \text{ and L mol}^{-1}, \text{respectively.}
\end{align*} \]

87. (b) The formula of bond order is given as
\[ \text{B.O.} = \frac{\text{No. of electrons in bonding}}{2} - \frac{\text{No. of electrons in antibonding}}{2} \]
Energy level pattern for molecular orbitals of different molecules depends upon their central atom.

**NO**: Central atom is \(N\)
\[ \text{(Total number of electrons = 15)} \]
\[ \sigma 1s^2, \sigma^*1s^2, \sigma 2s^2, \sigma^*2s^2, (\pi 2p_x^2 = \pi 2p_y^2, \sigma 2p_z^2), (\pi 2p_x^2 = \pi 2p_y^2, \sigma 2p_z^2) \]
\[ \text{B.O.} = \frac{10 - 5}{2} = 2.5 \]

**CN**⁻: Central atom is \(C\)
\[ \text{(Total number of electrons = 14)} \]
\[ \sigma 1s^2, \sigma^*1s^2, \sigma 2s^2, \sigma^*2s^2, (\pi 2p_x^2 = \pi 2p_y^2, \sigma 2p_z^2) \]
\[ \text{B.O.} = \frac{10 - 4}{2} = 3 \]

**CN**²⁺: Central atom is \(C\)
\[ \text{(Total number of electrons = 13)} \]
\[ \sigma 1s^2, \sigma^*1s^2, \sigma 2s^2, \sigma^*2s^2, (\pi 2p_x^2 = \pi 2p_y^2, \sigma 2p_z^2) \]
\[ \text{B.O.} = \frac{9 - 4}{2} = 2.5 \]
Therefore, option (b) is correct.

88. (d) Given, electronic configuration of \(X\) is \(1s^22s^22p^3\)
\[ \therefore \text{The valency of } X \text{ will be 3.} \]

The valency of Mg is +2.
\[ \therefore \text{Magnesium reacts with element } X \text{ to form an ionic compound with formula } Mg_3X_2. \]
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89. (a) Density of unit cell
\[ d = \frac{Z \times M}{N_A \times a^3} \]
where, \( Z \) = Number of atoms per unit cell
\( M \) = Molar mass
\( a^3 \) = Volume of unit cell [\( a \) = edge length]
\( N_A \) = Avogadro’s number = \( 6.022 \times 10^{23} \)

For bcc, \( Z = 2 \), radius \( r = \frac{\sqrt{3}a}{4} \)
\[ a = 4r \]
For fcc, \( Z = 4 \), \( r = \frac{a}{2\sqrt{2}} \)
\[ a = 2\sqrt{2}r \]

According to question
\[ \frac{d_{\text{room}}} {d_{900°C}} = \frac{\frac{Z \times M}{N_A \times a^3} \text{bcc}} {\frac{Z \times M}{N_A \times a^3} \text{fcc}} \]

Biology

91. (c) Green sulphur bacteria are anaerobic bacteria. They do not evolve oxygen during photosynthesis. Such type of photosynthesis is known as anoxygenic photosynthesis. They do not use water as a source of reducing power. Instead, hydrogen is obtained from hydrogen sulphide.
\[ \text{H}_2\text{S} \xrightarrow{\text{Hydrogen sulphide}} 2[\text{H}] + \text{S} \]
\[ 6\text{CO}_2 + 12\text{H}_2 \xrightarrow{\text{Light}} \text{C}_6\text{H}_12\text{O}_6 + 6\text{H}_2\text{O} \]

Concept Enhancer Green sulphur bacteria, e.g. \( \text{Chlorobium limicola} \), possesses bacteriochlorophyll as photosynthetic pigment.

Cycas is a gymnosperm, \( \text{Nostoc} \) is a blue-green algae and \( \text{Chara} \) is a green algae. All of these produce oxygen during photosynthesis.

92. (d) Double fertilisation is the fusion of two male gametes to two different cells of the same female gametophyte. It consists of following two events
(i) Syngamy Fusion of the egg nucleus with one male gamete is called syngamy.
(ii) Triple fusion It is the fusion of second male gamete and central cell.

On substituting the given values, we get
\[ \frac{d_{\text{room}}} {d_{900°C}} = \frac{2 \times M}{N_A \times \left( \frac{4r}{\sqrt{3}} \right)} \]
\[ = \frac{2 \times 3\sqrt{3}}{64r^3} \times \frac{16\sqrt{2}r^3}{4} \]
\[ = \frac{3 \sqrt{2}}{4\sqrt{12}} \]

90. (a) According to Hund’s rule “the pairing of electrons in the orbitals of a particular subshell does not take place until all the orbitals of a subshell are singly occupied. Moreover, the singly orbitals must have the electrons with parallel spin. i.e.
\[
\begin{array}{cccc}
1s^2 & \quad 2s^2 & \quad 2p^6 & \quad 3p^2 \\
1s & \quad 2s & \quad 3p^2 & \quad 3p^2
\end{array}
\]
\[ \therefore \text{Option (a) is the incorrect option.} \]
93. (b) **Yucca gloriosa** has developed an obligate symbiotic relationship with **Pronuba yuccasella** moth. The moth cannot complete its life cycle with the association of Yucca flowers and in turn **Yucca** has no other pollinator.

**Concept Enhancer** The female moth visits the **Yucca** flowers at night and collects pollen in the form of balls. The moth, then inserts its ovipositor into ovary of the flower to lay eggs. The temperature of the ovary is suitable for hatching of Pronuba's eggs and works as an incubator. After that, it climbs to the top of the style and pushes the pollen ball into stylar canal. Thus, pollination occurs. Some seeds are eaten by larvae which escape after piercing the ovary wall.

94. (a) Pollen grains can be stored for several years in liquid nitrogen having a temperature of −196°C. Pollen grains can be later used in plant breeding programmes.

95. (a) Among the given elements, potassium (K⁺) is responsible for maintaining turgor pressure in cell because it regulates the proton pumps involved in opening and closing of stomata. Magnesium (Mg²⁺) is a constituent of chlorophyll pigment which helps in photosynthesis in green plants. Calcium (Ca²⁺) provides selective permeability to the cell membrane. All of these, i.e., K⁺, Ca²⁺ and Mg²⁺ are essential elements. Sodium (Na⁺) is involved in membrane permeability. It is a non-essential element.

96. (b) NAD⁺ functions as an **electron carrier** in cellular respiration. NAD is an oxidising agent which accept electrons and then transfer them to the Electron Transport System (ETS). As a result, 3ATP molecules are formed.

97. (c) According to NCERT, plants absorb iron mostly in the form of **ferric** (Fe³⁺) ions. However, plants in acidic soil can absorb iron in **ferrous** (Fe²⁺) as well as ferric (Fe³⁺) form. It is an important constituent of proteins involved in the transfer of electrons like ferredoxin and cytochromes. It is reversibly oxidised from Fe²⁺ to Fe³⁺ during electron transfer. It activates catalase enzyme. It is essential for the formation of chlorophyll.

98. (c) Usually a **retrovirus** is used as a vector for introducing a DNA fragment in human cells. They are used as vector in gene therapy to introduce the desired gene so as to replace the functioning of a defected gene, e.g. Severe Combined Immune Deficiency (SCID) is caused due to defect in the gene for the enzyme adenosine deaminase.

In gene therapy against it, lymphocytes are extracted from the bone marrow of the patient. These are grown in a culture outside the body. A functional ADA cDNA, using a retroviral vector, is then introduced into these lymphocytes. These are reinjected into the patient’s bone marrow.

**λ-phage** allows cloning of DNA fragments up to 23 Kb lengths. **Ti-plasmid** is usually used for plants. **pBR-322** is an artificial cloning vector, usually used for bacteria.

99. (b) **Biopiracy** is referred to the use of biocatalysts by multinational companies and other organisations without proper authorisation from the countries and people concerned without compensatory payment. Bio-infringement is the commission of a prohibited act with respect to a patented invention without permission from the patent holder. Bio-exploitation means taking advantage of biological resources of other country without permission. Biodegradation is biological breakdown of organic material by bacteria, fungi, etc.

100. (d) In India, **Genetic Engineering Approval Committee**, i.e., GEAC (NCERT) is responsible for assessing the safety of introducing genetically modified organisms for public use. GEAC comes under the Ministry of Environment and Forests (MOE & F) while the **Review Committee on Genetic Manipulation** (RCGM) comes under the Department of Biotechnology. The **Council of Scientific and Industrial Research** (CSIR) is the largest research and development organisation in India. The **Indian Council of Medical Research** (ICMR) is the apex body in India for the formulation, coordination and promotion of biomedical research.

The name of GEAC is changed to **Genetic Engineering Appraisal Committee** from Genetic Engineering Approval Committee in 2010.

101. (d) The **Polymerase Chain Reaction** (PCR) involves three basic steps: denaturation, annealing and extension. In the **denaturation** step, DNA is heated at high temperature (94°C to 96°C) to separate the two strands. In the next step (annealing), the two oligo-nucleotide primers anneal to each single-stranded template DNA.
This step is carried out at a lower temperature (40°C to 60°C). The final step is extension, wherein Taq DNA polymerase synthesises the DNA region between the primers, using dNTPs (deoxynucleoside triphosphates) and Mg²⁺ ions.

102. **Ribozymes** are RNA molecules having enzymatic activity, i.e. they are capable of catalysing specific biochemical reactions. Hence, they are nucleic acids with enzymatic function.

**TH Morgan** is known as the ‘Father of Experimental Genetics’. He worked on linkage, crossing over, linkage maps, etc.

In dihybrid cross, two allelic pairs are used for crossing.

**Mendel** is considered as the ‘Father of Genetics’. He proposed the laws of inheritance.

103. **(d)** In 1997, an American company got patent rights on Basmati rice through the US Patent and Trademark office. This ‘new’ variety of Basmati had actually been derived from Indian farmer’s varieties. This ‘new’ variety was produced by crossing Indian Basmati with semi-dwarf varieties. **Lerma Rojo** and **Sharbat Sonora** are high yielding varieties of wheat. **Co-667** is a variety of soyabean.

104. **(c)** In the given pairs, option (c) is wrongly matched. Starch synthesis in pea is an example of pleiotropy. A pleiotropic gene is a single gene which produces many or multiple unrelated phenotypes. Rest of the pairs are correctly matched.

**Concept Enhancer** The gene for starch synthesis in pea seeds has two alleles B and b. In BB genotype, large starch grains are produced. After maturation the seeds are round. In bb homozygous condition, smaller starch grains are produced and mature seeds are wrinkled. Bb heterozygotes form round seeds so that B seems to be dominant allele. However, Bb seeds have starch grains of intermediate size, showing incomplete dominance.

105. **(b)** **Punnett Square** is a checker-board used to show the result of a cross between two organisms. The checker board was devised by a British geneticist, **Regnald Punnett** (1927). It depicts both genotypes and phenotypes of the progeny.

**Franklin Stahl with Matthew Meselson** proved the semi-conservative replication of DNA. **Spliceosome** is formed during post-transcriptional changes in eukaryotes. It is a complex, formed between 5' end (GU) and 3' end (AG) of intron to remove it.

**Transduction** is a method of sexual reproduction in bacteria. It involves the transfer of foreign genes by means of viruses. It was discovered by **Zinder** and his teacher **Lederberg** (1952) in Salmonella typhimurium.

106. **(b)** The experimental proof for semiconservative replication of DNA was first shown in a bacterium, **Escherichia coli**. It was discovered by Meselson and Stahl (1958).
In this mode of replication, one strand of parent DNA is conserved in the progeny while the second is freshly synthesised. Meselson and Stahl proved this by using heavy isotope of Nitrogen (\( ^{15}N \)).

107. (c) Bamboo plants are perennial, monocarpic plants. They flower only once in their lifetime, usually after 50–100 years. They produce large number of fruits and die. Mango, Jackfruit and Papaya are polycarpic plants, i.e. they flower repeatedly at regular intervals every year.

108. (b) Offsets are produced by mitotic divisions. They are one internode long runners that occur in some aquatic plants. Breaking of offsets helps in vegetative propagation. They give rise to new plants, e.g. Eichhornia. Meiotic divisions occur in only germ cells. Parthenocarpy is the development of seedless fruits. Parthenogenesis can be defined as the development of an egg into a complete individual without fertilisation.

109. (d) Jacob and Monod (1916) discovered the lac operon. An operon is a part of genetic material or DNA which acts as a single regulated unit. It possesses one or more structural genes, an operator gene, a promoter gene, a regulator gene, a repressor gene and an inducer or corepressor.

Matthew Meselson and F Stahl discovered the semi-conservative mode of DNA replication in E. coli. Alfred Hershey and Martha Chase use T\(_2\) Bacteriophage in their experiments to infect E. coli and proved that DNA is the genetic material. Alec Jeffreys (1984) invented the DNA fingerprinting technique. This technique determines nucleotide sequences of certain areas of DNA which are unique to each individual.

110. (d) Sporopollenin has proved helpful in preserving pollen as fossils. The covering of pollen grain, sporoderm is consist of two layers, viz., exine and intine. Exine is made of a highly resistant fatty substance called sporopollenin. It could not be degraded by any enzyme. It is not affected by high temperature, strong acid or strong alkali. Thus, it keeps the pollen grains well-preserved as fossils.

Pollenkitt is a yellowish, viscous, sticky and oily layer that covers exine of some insect pollinated pollen grains. Intine of pollen grains is made up of pectin and cellulose.

111. (b) Natality is birth rate. It refers to the number of births during a given period in the population that are added to the initial density. Death rate is termed as mortality. It refers to the number of deaths in the population during a given period. Immigration is the number of individuals of the same species that have come into the habitat, on the other hand emigration is the number of individuals of the population who left the habitat.

112. (a) ‘World Ozone Day’ is celebrated on 16th September to control O\(_3\) depletion. Ozone layer is a fragile shield of gas that protects earth from harmful UV-rays. On 21st April the Civil Service Day and National Yellow Bat Day is celebrated. 5th June of every year is celebrated as World Environment Day. Earth Day is an annual event, celebrated on 22nd April of every year.

113. (d) Ozone (O\(_3\)) is a secondary pollutant as it is formed by the reaction amongst the primary pollutants. On the other hand, SO\(_2\) is a primary pollutant. These pollutants persist in the environment in the form they are passed into it. CO is qualitative pollutant. It is considered as pollutant only when its concentration reaches beyond a threshold value in the environment. CO\(_2\) is a quantitative as well as a primary pollutant.

114. (d) Niche is an ecological component of habitat which is delimited by functioning of an organism. A species may live in more than one niche in different stages of its life cycle.
An inverted pyramid of biomass will be obtained from the given data. The biomass is continuously decreasing from secondary consumer (120 g) to primary consumer (60 g) to primary producer (10 g). Therefore, upright pyramid of biomass cannot be obtained. The data is given in the form of biomass, therefore pyramid of number and energy cannot be obtained. Further, pyramid of energy is always upright.

In stratosphere, Cl acts as a catalyst in the degradation of ozone and release of molecular oxygen. It is released by action of UV rays on chlorofluorocarbon. Chlorine reacts with ozone in a series of chain reaction, converting it into oxygen. One active chlorine can destroy 5000 molecules of ozone in one month.

\[
\begin{align*}
\text{CFCl}_3 & \xrightarrow{\text{UV}} \text{CFCl}_2 + \text{Cl} \\
\text{CFCl}_2 & \xrightarrow{\text{UV}} \text{CFCl} + \text{Cl} \\
\text{Cl} + \text{O}_2 & \rightarrow \text{ClO} + \text{O}_2 \\
\text{ClO} + \text{O}_2 & \rightarrow \text{Cl} + 2\text{O}_2
\end{align*}
\]

Iron (Fe), carbon (C) and oxygen (O) are not Ozone Depleting Substances (ODS).

Sugars are chemically carbohydrates. They are polyhydroxy aldoses, ketoses and their condensation products. Aldoses bear a terminal aldehyde or \(-\text{CHO}\) group while ketoses have an internal ketone or \(-\text{CO}\) group. Thus, they possess two functional groups, i.e. carbonyl and hydroxyl.

Among the given options, Saccharomyces is a fungus, i.e. it is a eukaryote. They possess a well defined nucleus and other cell organelles. Nostoc and Oscillatoria are cyanobacteria while Mycobacterium is a true bacterium. Cyanobacteria and bacteria both are prokaryotes as they lack a well-defined nucleus and other cell organelles.

Golgi complex participates in the formation of secretory vesicles. It is a cytoplasmic structure found in eukaryotic cells. It is made up of four parts; cisternae, tubules, vesicles and vacuoles.

The forming face or cisternae receives vesicles from endoplasmic reticulum. Their contents pass through various cisternae with the help of coated vesicles and intercisternal connectives. They ultimately reach the maturing face where they are budded off as, coated secretory or Golgian vesicles or vacuoles.

In bacteria, respiration occurs with the help of mesosomes. The breakdown of fatty acid occurs in peroxisomes and mitochondria. Activation of amino acid is an important step of protein synthesis and it occurs in cytoplasm. In this process, amino acids get attached to tRNA molecules.

During light reaction of photosynthesis NADPH, ATP and oxygen are formed. Oxygen is liberated by the photolysis of water.

\[
\begin{align*}
4\text{H}_2\text{O} & \rightleftharpoons 4\text{H}^+ + 4\text{OH}^- \\
4\text{OH}^- & \xrightarrow{\text{Oxygen Evolving complex}} 2\text{H}_2\text{O} + \text{O}_2 + 4\text{e}^- \\
\text{Mn}^{2+}, \text{Ca}^{2+}, \text{Cl}^{-}
\end{align*}
\]

The electrons released during photolysis of water are picked up by P$_{680}$ photocentre of PS-II. On receiving light energy photocentre expels an electron which passes over a series of carriers. As a result assimilatory power, i.e. ATP and NADPH is produced. NADH is formed during respiration.

Nucleolus is a naked, round or slightly irregular structure in nucleus. It lacks a membrane and its contents are in direct contact with the nucleoplasm. It is a site for active ribosomal RNA (rRNA) synthesis. Microtubules take part in the spindle formation. Mitochondria, vacuoles and plastids, etc. are membrane-bound structures. The dividing cells possess a large number of mitochondria.

Stomatal movement is not affected by O$_2$ concentration. Stomata are tiny pore complexes found in the epidermis of leaves and other soft
aerial parts. They are meant for the gaseous exchange but are also the main source of transpiration. Stomatal movements are affected by many factors like light, temperature and CO$_2$ concentration. In the majority of plants, the stomata are open in light and close in darkness. Normally high temperature above 30°C reduces stomatal opening in many species. Low CO$_2$ concentration usually induces opening of stomata while high CO$_2$ concentration closes the same.

123. (b) The separation of the paired homologous chromosomes begins in diplotene stage. In this phase, the dissolution of synaptonemal complex begins. The recombined homologous chromosomes of the bivalents separate from each other except at the sites of crossovers. **Zygotene** is the second state of prophase I of meiosis. It is associated with the formation of synapsis. Next stage is **pachytene** during which crossing over occurs between non-sister chromatids of the homologous chromosomes. **Diakinesis** is the final stage of meiotic prophase-I. This is marked by terminalisation of chiasmata.

124. (c) Epidermis of all green aerial parts of plants contain minute opening called stomata. It is surrounded by guard cells and neighbouring subsidiary cells collectively termed as stomatal apparatus. Kidney-shaped or bean-shaped guard cells are present in dicots only, while in monocots like grasses, these cells are dumb-bell shaped. Guard cells differ from rest of the cells in shape, size and thickenings. It divides to form secondary phloem on outer side and secondary xylem on the inner side. Interfascicular cambium arises secondarily from the cells of medullary rays. **Phellogen** or **cork cambium** is produced in the outer cortical cells of dicot stems. It is helpful in increasing the girth. **Apical meristems** are present at the tips of stem, root and their branches. They are responsible for increase in length of the plant. **Auxiliary meristem** is found in axillary buds. These cells are left behind from shoot apical meristem during the formation of leaves and elongation of stems.

125. (b) Secondary vascular tissues, i.e., secondary xylem and phloem are formed by the **vascular cambium**. It is produced by two types of meristems; fascicular or intrafascicular and interfascicular cambium. Intrafascicular cambium is a primary meristem which occurs as strips in vascular bundles. **Casparian strips** are found in endodermis of roots. It is a band of thickening which runs along the radial and tangential walls of endodermal cells. It is made up of suberin and lignin. Casparian strips prevent plasmolysis of endodermal cells. **Cortex** is found below epiblema. It is made up of thin-walled parenchymal cells. **Epidermis** is the outermost layer made up of thin-walled flattened and slightly elongated parenchymal cells. **Pericycle** is found below endodermis and it is made of parenchymatous cells.

126. (c) Pneumatophores are breathing or respiratory roots which are found in halophytes like mangroves. Halophytes grow in saline swamps, therefore respiratory roots come out of water and pick up oxygen for respiration. Excess CO$_2$ is also given out. It occurs through small pores, called lenticles. **Carnivorous plants, free-floating hydrophytes** and **submerged hydrophytes** do not possess pneumatophores.

127. (d) Secondary growth occurs due to the presence of vascular cambium. **Grasses** are monocot and lacks vascular cambium. Therefore, they do not show secondary growth. **Deciduous angiosperms** are usually woody dicot plants and show secondary growth. **Conifers** and **cycads** are gymnosperms and usually show anomalous secondary growth.

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129. (b) Sweet potato is a **modified adventitious root** which is meant for storage of food. It does not assume a definite shape and occurs singly. **Tap roots** develop from the radicle of the embryo. They gradually become narrow towards the tip. **Stem** is usually the above-ground erect ascending part of the plant body. It bears leaves and flowers. **Rhizome** is modified underground stem, e.g., Zingiber officinale.
130. (c) In gymnosperms, ovules are not enclosed by ovary wall. Seeds do not occur inside a fruit. They are naked. Horsetail is the common name of Equisetum. Pteridophytes like Selaginella and Salvinia are heterosporous and possess two types of spores, i.e., microspores and megaspores. Cycas has an unbranched columnar stem while Cedrus possess branched stem. Therefore, only statement (c) is correct.

131. (a) Sporozoans are endoparasites. They lack locomotory organelles like cilia, flagella, pseudopodia, etc., e.g., Plasmodium. Pseudopodia are found in amoeboid protozoans, e.g., Amoeba, Entamoeba, etc. Therefore, statement (a) is wrong while rest of the statements are correct.

132. (a) Agaricus Meiospores are produced exogenously after karyogamy and meiosis. It belongs to Basidiomycetes. Alternaria belongs to the Deuteromycetes class of fungi. The fungi of this class lack sexual reproduction. Therefore, sexual spores are not formed. Neurospora and Saccharomyces belong to Ascomycetes class of fungi. They produce ascospores as meiospores. Their ascospores are produced endogenously.

133. (d) Herbarium is a place where dried and pressed plant specimens, mounted on sheets are kept systematically. It is a repository or store house for future use. Key is a booklet containing list of characters and their alternates which are helpful in identification of various taxa-class, order, family, genus and species. Museum is an institution where artistic and educational materials are exhibited to the public. The materials available for observation and study are called a collection.

134. (d) Winged pollen grains are present in Pinus. These wings are spirally arranged microsporophylls that arise from the lateral side and help in pollination. The sperms (pollen grains) of Cucurbita are top-shaped. The pollen grains of mango are spheroidal, while that of mustard are prolate to subspheroidal.

135. (c) Polysiphonia is a red algae. In it sexual reproduction is of oogamous type. The male sex organ, spermatangium produces non-flagellate male gametes. In Brown algae, sexual reproduction varies from isogamy, anisogamy to oogamy. In isogamy and anisogamy both the gametes are motile while in oogamy only male gametes are motile. These motile gametes have two unequal laterally attached flagella.

Chlorella is a unicellular organism. It is green algae belonging to class Chlorophyta. In Marchantia, gemma cups are found on its dorsal surface. It contains gammae which help in vegetative propagation.

136. (c) Asthma is inflammation of bronchioles. Its symptoms include wheezing, coughing and difficulty in breathing mainly during expiration. Emphysema is an inflation or abnormal distension of the bronchioles or alveolar sacs of the lungs. Many of the septa between the alveoli are destroyed and much of the elastic tissue of the lungs is replaced by connective tissue. As a result, alveolar septa collapse and the surface area get greatly reduced.
137. (c) The atrioventricular opening between the left atrium and left ventricle is guarded by the bicuspid valve. It is also called as mitral valve. The right atrioventricular opening is guarded by the tricuspid valve. It has three flaps. The semilunar valve is found in right ventricle and pulmonary artery. Therefore, option (c) is correct.

138. (b) Tidal Volume (TV) is the volume of air inspired or expired during normal breath. It is about 500–550 mL. Inspiratory Reserve Volume (IRV) is the extra amount of air that can be inspired directly after a normal inspiration. It is about 2500–3000 mL. Expiratory Reserve Volume (ERV) is the extra amount of air that can be expired forcibly after a normal expiration. It is about 1000–1100 mL. Residual Volume (RV) is the volume of air which remains still in the lung after the most forceful expiration. It is about 1100–1200 mL. Therefore, option (b) is correct.

139. (c) The lens in the human eye is held in place by the suspensory ligaments attached to the ciliary body. The function of other components are as follows

- The smooth muscles attached to the ciliary body helps to control the shape of lens.
- Smooth muscles of iris help in regulating the diameter of pupil.
- Pactinate ligament attached to iris is involved in the drainage of aqueous humor because it contains spaces between the fibres.

140. (c) Among the following, epinephrine is an amino acid derived hormone. It is a catecholamine which is produced in the chromaffin cells of adrenal medulla from amino acids tyrosine. On the other hand, estradiol and estriol are steroid hormone that are involved in the regulation of estrous and menstrual cycles. Ecdysone is also a steroid hormone that controls moulting in insects.

141. (a) Estrogen and parathyroid hormone can play significant role in osteoporosis. It is caused due to the deficiency of estrogen and excessive activity of parathormones. Estrogen helps to promote the activity of osteoblast (helps in the formation of bone cells) and inhibits osteoclast (destroys the bones). On the other hand, parathormone promotes the mobilisation of calcium from bones into blood hence causes demineralisation.

The other listed hormones also contribute to osteoporosis but their effects are insignificant or very less. e.g., low level of progesterone and aldosterone causes bone loss whereas raised level of prolactin have been linked with osteoporosis.

142. (b) Limbic system consists of four major components namely hippocampus, amygdala, septal nuclei and mamillary bodies. It controls the emotional behaviour, food habits and sexual behaviour of an organism. It is not involved in controlling movements. The rest three options are correctly paired with their functions.

143. (c) Amnion of mammalian embryo is derived from ectoderm and mesoderm. It is one of the extraembryonic membrane which is formed by the amnionic cells of ectodermal origin on inner side and somatopleuric extraembryonic mesoderm on outer side. This membrane acts as a shock absorber for the foetus, regulates foetal body temperature and prevents desiccation. The origin of other extraembryonic membranes is as follows

- Chorion Trophoectoderm and mesoderm.
- Allantois and Yolk sac Outer mesoderm and inner endoderm.

144. (a) The hormones secreted by the placenta to maintain pregnancy are hCG, hPL, progestogens and estrogens. Placenta is the intimate connection between the foetus and uterine wall of the mother to exchange the materials. It has endocrine function and secretes the following hormones

(i) Human Chorionic Gonadotropins (hCG) It stimulates and maintains the corpus luteum to secrete progesterone until the end of pregnancy.

(ii) Human Placental Lactogen (hPL) It is also known Human Chorionic Somatomammotropin (HCS), it stimulates the growth of mammary glands during pregnancy.

(iii) Progesterone and estrogen support foetal growth, maintain pregnancy, inhibit uterine contractions, etc.

On the other hand, the sources of other hormones are as follows

- Oxytocin Secreted by posterior lobe of pituitary gland during foetal ejection reflex.
- Glucocorticoid Secreted by adrenal gland of foetus to induce foetal ejection reflex.
Relaxin Secreted by corpus luteum to increase flexibility of pubis symphysis.

Prolactin Secreted by anterior lobe of pituitary, helps in the secretion of milk.

145. (d) Spermiogenesis is the process of transformation of spermatids (n) into spermatooza (n) or sperms. It involves the differentiation phase in which one spermatid develops into one spermatoozoan.
Spermiation involves the release of sperms from seminiferous tubules through Sertoli cells.

146. (c) The contraceptive ‘SAHELI’ blocks estrogen receptors in the uterus preventing eggs from getting implanted. It is a type of mini pill that contains a monosteroidal preparation centchroman. It is taken once in a week after an initial intake of twice a week dose for 3 months. This non-hormonal preparation contains progesterin only and no estrogen. It modulates the estrogen receptors selectively and has high contraceptive value.

147. (d) Ciliates differ from all other protozoans in having two types of nuclei. These two nuclei are usually of different size, i.e. one is meganucleus and the other is micronucleus. The former controls metabolism whereas the latter is concerned with reproductions, e.g. paramecium.
In other protozoans, like Amoeba, single nucleus is present which is involved in metabolism and reproduction.
Other options are incorrect because Ciliates use filter feeding mechanism for obtaining food. Like other protozoans, they also possess contractile vacuoles.
Ciliates use cilia for locomotion.

148. (a) Crop and gizzard are found in the digestive tract of birds (Aves).
Crop helps in storage and softening of food particles whereas gizzard (muscular stomach) helps in its crushing and chewing.

149. (b) In male cockroach, the 9th sternite bears a pair of small and spine-like unjointed caudal or anal styles which are absent in female cockroach. The anal styles are believed to function as motion detector.
Besides this, the other three characters, i.e. anal cerci, boat-shaped sternum on 9th abdominal segment and forewings with darker tegmina are found in both male and female cockroaches.

150. (b) Among the given animals Chelone is not a homeotherm. It is green sea turtle belonging to class–Reptilia which are ectotherms or cold-blooded and their internal body temperature varies according to the ambient environment.
In contrast, Camelus and Macropus belonging to class–Mammalia and Psittacula belonging to class–Aves are homeotherms. They can maintain constant body temperature irrespective of surrounding temperature.

151. (c) All the given animals except earthworm undergoes metamorphosis. Earthworm exhibits direct development where no larval stage is involved.
Metamorphosis is usually seen in animals exhibiting indirect development, involving a larval stage which later transformed into an adult.
Larval form of moth is caterpillar and that of tunicates is tadpole.
In starfish, bipinneria larva occurs.

152. (b) Diatoms are chief producers in the oceans and they contribute 40% of marine primary productivity. They constitute a major group of unicellular eukaryotic microalgae and are among the most common types of phytoplanktons.
The other given organisms also exhibit autotrophic mode of nutrition.

153. (d) Amensalism is widely used in medical science for the production of antibiotics.
It involves, the secretion of chemicals called allochemics by one microbial group to harm other microbes, e.g., Penicillium secretes chemicals to inhibit the growth of Staphylococcus bacteria. These chemicals can be used in medical science for the production of antibiotics.
On the other hand, no such chemicals are secreted in parasitism, mutualism and commensalism.

154. (b) Sacred groves is a mode of in situ conservation in which forest fragments of varying size are protected by religious communities. It helps to protect the biota of that area on site.
On the other hand, botanical gardens, seed banks and wildlife safari parks are the examples of ex situ conservation in which the biota is protected outside its natural habitat.
155. (a) **Eutrophication** is the nutrient enrichment of water bodies containing excessive population of phytoplanktons.

**Sanitary landfill** is a method of solid waste disposal in which the waste material is buried in the pits dug on the ground and later they get covered by soil.

**Snow blindness** is caused due to UV-B radiations exposure. These radiations can reach the earth surface due to the depletion of ozone layer.

In **Jhum cultivation**, land is cultivated temporarily and then abandoned so that, it can revert to its natural vegetation. It is a long term process and usually leads to deforestation.

156. (c) In a growing population, younger population (or pre-reproductive individuals) size is larger than that of reproductive individuals. Such population is represented by a triangular-shaped age pyramid.

Whereas, the equal number of reproductive and pre-reproductive individuals represents a stable population and the age pyramid is bell-shaped.

Less number of pre-reproductive individuals than reproductive individuals represents declining population and age pyramid appears urn-shaped.

157. (b) The latex of poppy plant *Papaver somniferum* is used to obtain ‘Smack’. It is a white crystalline, odourless, bitter compound. It acts as a depressant and slows down the body functions.

158. (a) Except *enhancer*, all the given components are parts of an operon. Enhancer sequences are present in eukaryotes that, when bound by specific proteins or transcription factors, enhance the transcription of an associated gene.

On the other hand, operon is a regulatory unit of DNA containing a cluster of genes in prokaryotes.

The *promoter* of operon is the site where RNA polymerase binds. The *operator* acts as an-off switch to control transcription. The *structural genes* code for enzymes involved in metabolic pathway.

159. (d) In the given problem, woman is the carrier of X-linked condition and she can transmit the carrier allele to both **her son** and **daughter**. The resulting son will become diseased because X-linked disorder always affect males due to the presence of single X-chromosome.

The daughter offspring will become carrier but not diseased because females are affected by X-linked disorder in homozygous recessive condition, i.e. two recessive alleles are required.

Hence, 50% son are diseased and 50% are normal.

Similarly, 50% daughter are carrier and 50% are normal.

160. (b) According to Hugo de Vries, the mechanism of evolution is **salutation**.

Hugo de Vries (1901) proposed mutation theory of evolution and stated that evolution is a jerky process in which new species are evolved due to discontinuous sudden variations or salutation. These are the single step large mutations occurring in population.

161. (c) Coding strand is the one that codes for *mRNA*. It has same nucleotide sequence as that of *mRNA* except thymine (T) is replaced by uracil (U) in *mRNA*.

Hence, the corresponding sequence of transcribed *mRNA* by template or non-coding strand (complementary to RNA) is AGGUAUCGCAU.

162. (a) During **proliferative phase**, the follicles start growing in size under the influence of Follicle stimulating Hormone (FSH). Hence, this phase is also called follicular phase.

During **secretory phase**, corpus luteum secretes progesterone that helps to thicken the endometrial lining. Due to the persistence of corpus luteum, this phase is also called luteal phase.

**Menstruation** or bleeding occurs due to the breakdown of endometrial lining in the absence of pregnancy. During this phase, corpus luteum regresses and progesterone level decreases.
Calcium plays a key regulatory role in muscle contraction. The myosin cross-bridges are able to bind to these active sites on F-actin are exposed. Due to this, myosin cross-bridges are able to bind to these active sites and muscle contraction occurs.

Globulins are simple proteins that form a large fraction of blood serum proteins involved in the defence mechanism. There are four main types of globulins that are manufactured in liver, namely alpha-1, alpha-2, beta and gamma. Albumin is a plasma protein that is manufactured by the liver. It helps in maintaining osmotic pressure which prevents the fluid-leakage out into the tissues from the bloodstream.

Silicosis is an occupational respiratory disorder which is caused due to excessive inhalation of silica dust. It usually affects the workers of grinding or stone breaking industries. The long-term exposure can cause lung fibrosis (or stiffening), leading to breathing difficulties. Anthracis or Anthrax is a bacterial infection caused by Bacillus anthracis. Botulism is food poisoning infection caused by Clostridium botulinum. Its symptoms include diarrhoea, vomiting, abdominal distention, etc. Emphysema is a lung disease, that damages the air sacs and causes shortness of breathe. It may be caused by smoking, deficiency of enzymes alpha-1-antitrypsin and air pollution.

Calcium plays a key regulatory role in muscle contraction. 

163. (d) Increased level of glucose in blood which may be caused due to untreated diabetes mellitus results in glycosuria. In this condition, glucose is present in the urine.

Gout is a form of arthritis characterised by severe pain and tenderness in joints. It is caused due to the accumulation of uric acid crystals in joints.

Renal calculi or kidney stones are small masses of crystalline salts within the kidneys. These stones can be of calcium, uric acid, struvite (magnesium ammonium phosphate), etc.

Glomerular nephritis is the inflammation of filtering unit, i.e. glomerulus of kidney. It is also known as Bright’s disease. It may cause haematuria (blood in urine) and proteinuria (proteins in blood).

(b) Ultrafiltration or Glomerular filtration is carried out in the glomerular capillaries found in Malpighian corpuscle. This process is carried out under high pressure. Henle’s loop continuously absorbs the water from glomerular filtrate, because of the hyperosmolarity created by counter-current mechanism. This helps in the concentration of urine and hence, it becomes hypertonic.

Ureter are narrow, tubular structures that convey or transport urine from kidney to urinary bladder. Urinary bladder is pear-shaped, muscular, sac-like structure that temporarily stores urine.

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Parietal cells (oxyntic cells) secrete hydrochloric acid and castle intrinsic factor. HCl converts iron (in diet) from ferric to ferrous form which can be easily absorbed and used during erythropoiesis (formation of RBCs).

Castle intrinsic factor helps in absorbing vitamin-H_{12} and its deficiency causes pernicious anaemia.

The functions of other cells are as follows
- Mucous or Goblet cells secrete mucus that lines the stomach and protects it from the acid present in stomach.
- Chief cells secrete gastric digestive enzymes as proenzymes orzymogens.

Fibrinogen is a soluble plasma protein that is stimulated by thrombin and gets converted into insoluble form fibrin. The latter helps in the formation of blood clot to seal the wound and stop bleeding.

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The Lampbrush chromosomes are highly elongated special kind of synapsed mid-prophase or diplotene chromosome that are bivalents. Sex chromosomes are also called as allosomes. They determine the sex of an organism. Submetacentric chromosomes have a submedian centromere. They appear L-shaped during metaphase. Therefore, except option (d), all are correctly matched.

172. (b) The terms, thecodont, diphodont and heterodont describe human dentition. In men, two types of teeth are found, milk or deciduous teeth and permanent teeth. Thus, they have diphodont teeth. The teeth are thecodont, i.e. they remain embedded in the sockets of the jaw bones. Men have four types of teeth; incisors, canine, premolars and molars, i.e., heterodont teeth.

173. (d) Phospholipid synthesis does not occur in RER. It occurs inside Smooth Endoplasmic Reticulum (SER). A signal peptide is a short peptide present at the N-terminus of the newly synthesised proteins. It targets them to the ER and is then cleaved off. RER synthesises proteins. It bears enzymes for modifying polypeptides synthesised by attached ribosomes, e.g. glycosylation.

174. (c) Polysome is a string of ribosomes associated with a single mRNA. Polysome helps to produce a number of copies of the same polypeptide. Nucleosome is the unit of eukaryotic DNA that consists of a DNA segment wrapped around a core of eight histone proteins. Nucleosome chain gives a ‘beads on string’ appearance under electron microscope. Plastidome refers to all the plastids of a cell which work as a functional unit. Polyhedral bodies or carboxysomes are present in several groups of autotrophic bacteria that assimilate inorganic carbon via Calvin cycle, e.g. Cyanobacteria.

175. (c) Elephantiasis is a helminthic disease caused by Wuchereria bancrofti. The infestation is transmitted by female Qules mosquitoes from one individual to the others. The worms live in the lymphatic system. Ascariasis is caused by Ascaris lumbricoides. It is an endoparasite of the small intestine of human beings. Amoebiasis is caused by Entamoeba histolytica. It lives in the large intestine of humans. Ringworm is a fungal skin disease.

176. (a) Alzheimer’s disease is not an autoimmune disease. It is caused due to the destruction of vast number of neurons in the Hippocampus. It occurs due to a combination of genetic factors, environmental or lifestyle factors and the ageing process. There is loss of neurotransmitter acetylcholine. Individuals with this disease have trouble remembering recent events. Rheumatoid arthritis, vitiligo and psoriasis all are autoimmune diseases. In rheumatoid arthritis, antibodies are produced against the synovial membrane and cartilage. Vitiligo causes white patches on skin while psoriasis causes itch-skin.

177. (d) Divergent evolution results in homologous structures. These organs have the same fundamental structure but are different in functions. Structural homology is seen in brain, heart and forelimbs of man, bat and cheetah. Eyes of Octopus, bat and man are examples of analogous organs which show convergent evolution. Therefore, option (d) is incorrect.

178. (a) Conversion of milk to curd improves its nutritional value by increasing the amount of vitamin-B12. Vitamin-A is found in milk, carrot, tomato, etc. Skin can synthesise vitamin-D in the presence of sunlight. Vitamin-E is found in wheat, green leafy vegetables, etc.

179. (c) The similarity of bone structure in the forelimbs of many vertebrates is an example of homology. The homologous organs have the same fundamental structure but are adapted to perform different functions, e.g. forelimbs of man, cheetah, whale and bat. Analogous organs show convergent evolution. These organs have similar functions but are different in their structural details and origin. Development of different functional structures from a common ancestral form is called adaptive radiation.

180. (b) Dominance, codominance and multiple alleles are the characteristics that represent ‘inheritance of blood groups’ in humans. ABO blood groups are determined by the gene I. There are multiple (three) alleles; I^A, I^B and I^0 of this gene. Allele I^A and I^B are dominant over I^0. However, when I^A and I^B alleles are present together, they show codominance. Therefore, option (b) is correct.