CBSE MAINS

MEDICAL ENTRANCE

SOLVED PAPER 2004

PAPER–I

Physics

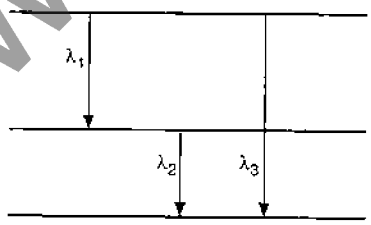
1. (a) If velocity varies with time as $v = 4t$, find the distance travelled by the body in the interval of 2 s to 4 s.

(b) Prove that two particles moving in parallel direction with equal and opposite momentum have total angular momentum about any point remains constant.

2. (a) How resistance varies in semiconductors with temperature?

(b) Sketch the circuit diagram of a diode showing forward and reverse biased.

(c) Find the relation between the three wavelengths λ_1, λ_2 and λ_3 from the energy level diagram shown in the figure.

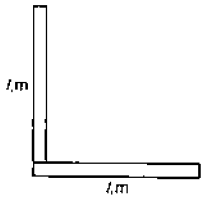


3. (a) Find the relation between torque and

(i) angular acceleration,

(ii) angular momentum,

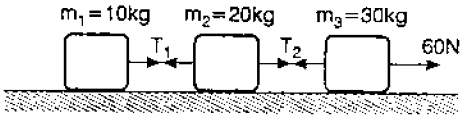
(b) Two rods of length l and mass m are in L shape. Find the moment of inertia about an axis passing through the point of joining and perpendicular to the plane of the L-section.



(c) Find the direction of angle between angular momentum and linear momentum.

4. (a) The distance s along Z-axis varies with time as $s = 2t^3 - 3t^2 - 6t + 8$. Find the time t after which acceleration becomes zero.

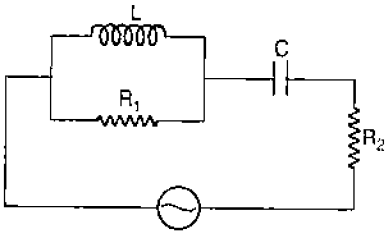
(b) Three masses connected by massless string as shown in figure, are placed on a horizontal frictionless surface. Find tensions T_1 and T_2.



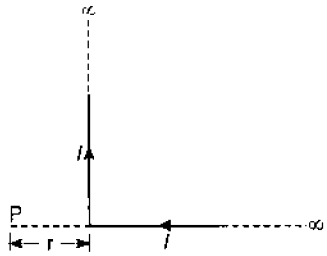
5. (a) In the circuit shown :

(i) Find the phase difference between the currents through L and R_1.

(ii) Find the phase difference between potential difference across C and R_2.



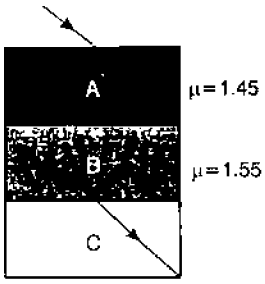
(b) Two infinite conductors are perpendicular to each other carrying current I as shown in figure. Find the induced magnetic field at that point P at a distance r along one of the conductors.



(c) Inductive resistance 25Ω and capacitive resistance 75Ω are connected across 250 V mains in series. Find the rms potential difference across inductor and capacitor. How can you reconcile this in terms of mains voltage ?

6. (a) When a force F_1 acts on a particle, frequency is 6 Hz and when a force F_2 acts, frequency is 8 Hz. What is the frequency when both the forces act simultaneously in same direction?

(b) As shown in the figure a ray is incident on medium A, find μ



for the block C, such that the ray through this medium will be parallel to the incident ray on A.

7. (a) Light of wavelength $\lambda = 4000$ Å and intensity 100 W/m^2 is incident on a plate of threshold frequency 5.5×10^{14} Hz. Find the maximum kinetic energy of photoelectron and number of photons incident per m^2 per sec.

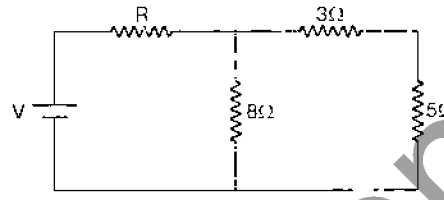
(b) When electron is accelerated between 500 keV, what is the percentage increase in mass?

(c) From the concept of binding energy, explain how energy is liberated during fission and fusion reactions.

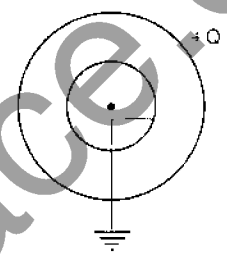
8. (a) An ideal gas has molar specific heat $5R/2$ at constant pressure. If 300 J of heat is given to two moles of gas at constant pressure, find the change in temperature.

(b) Define (i) steady state and (ii) temperature gradient.

9. (a) In the given circuit for what values of R the power dissipated in R is same as the rest of the circuit?



(b) Two concentric hollow spheres are arranged as shown in figure. If a charge + Q is given to the outer sphere, find charge induced in the inner sphere.



(c) Can potential at a point be zero with a non-zero electric field at that point? Give an example.

10. (a) If the fundamental quantities are velocity (v), mass (M), time (T), what will be the dimensions of η in the equation $V = \pi P r^4 / 8 \eta l$.

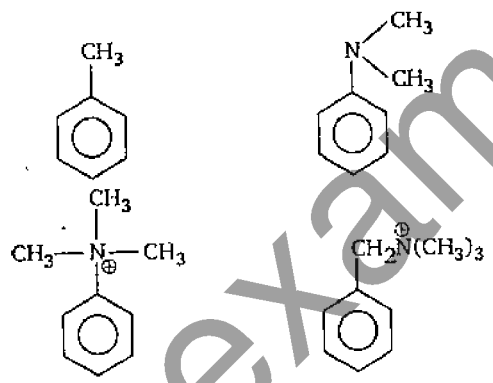
(b) A body of mass m falls from a height h and collides with another body of same mass. After collision the two bodies combine and move through distance till they come to rest. Find the work done against the resistive force.

Chemistry

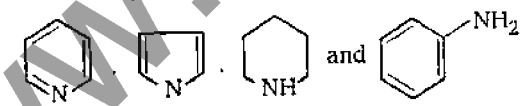
1. (a) For aqueous solution of NH_4Cl prove that
$$[H_3O^+] = \sqrt{K_h C}$$
(b) pH = 7.40, K_1 of $H_2CO_3 = 4.5 \times 10^{-7}$. What will be the ratio of $[HCO_3^-]$ to $[H_2CO_3]$?

2. (a) Why BBr_3 is a stronger Lewis acid as compared to BF_3 though F is more electronegative than Br ?
(b) Why SF_4 undergoes hydrolysis but not SF_6 ?
(c) Why $(CH_3)_3COH$ is less acidic than $(CH_3)_3SiOH$ although C is more electronegative than Si ?
(d) Why HF forms H-bonding with ethyne even though it is non-polar in nature ?

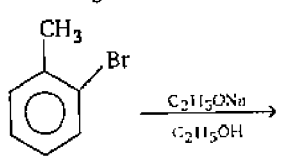
3. (a) Give increasing order towards electrophilic substitution of the following compounds :



(b) Which of the following is the strongest base and why ?



4. (a) Identify the organic products obtained in the following reactions :

(i) 

(ii) $CH_3-C(CH_3)_2-CH_2-Br \xrightarrow[\Delta]{EtOH}$

(iii) 2, 3-dimethylbutane-2-ol $\xrightarrow{conc.\ H_2SO_4}$

(b) Why acetonitrile is used as organic solvent ?

5. (a) Why aniline does not show Friedel-Crafts reaction ?
(b) Why it is necessary to add excess of mineral acids to diazotisation of amines ?

6. (a) $Cr_2O_7^{--} + 14H^+ + 6e^- \rightarrow Cr^{+++} + 7H_2O$; $E^\circ = 1.33$
$3 \times [2I^- \rightarrow I_2 + 2e^-]$ $E^\circ = -0.54$
Find out the value of equilibrium constant and Gibb's free energy change in the reaction given above.
(b) $A + B \rightarrow C + D$
$\Delta H = -10{,}000\ J\ mol^{-1}$; $\Delta S = -33.3\ J\ mol^{-1}K^{-1}$
(i) At what temperature the reaction will occur spontaneously from left to right ?
(ii) At what temperature the reaction will reverse ?

7. (a) $E_a = 80$ kJ. What will be the ratio of rate constants when temperature varies from 273 K to 323 K ?
(b) A mixture of ethane and ethene occupies 40 lit. at 1 atm. and 400 K. The mixture reacts completely with 4.06 mole O_2 to produce CO_2 and H_2O. Calculate the mole fractions of ethane and ethene in the mixture.

8. (a) Write all the important conformations of *n*-butane.
(b) Write the enantiomeric and diastereomeric forms of 2-bromo-3-chloro butane.

9. (a) Write all the geometrical isomers of $[Pt(NH_3)(Cl)(Py)(Br)]$ and how many of these will exhibit optical isomerism ?
(b) On the basis of valence bond theory explain geometry, nature of hybridisation, magnetic property and optical isomerism of $[Co(ox)_3]^{3-}$ and $[CoF_6]^{3-}$.

10. (a) How bond energy varies from N_2^- to N_2^+ and why ?

(b) On the basis of molecular orbital theory what is similarity between :

(i) F_2, O_2^-

(ii) CO, N_2, NO^+

(c) Like CO why its analog "SiO" is not stable ?

PAPER-II

Biology

1. (i) Define cloning and write their significance.

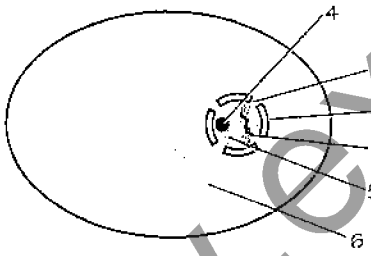
(ii) Write down the significance of embryo culture.

2. Each word in Column-I has minimum one and maximum three matching in Column-II. Arrange them.

	Column-I		Column-II
(i)	Agar	(a)	Fungi
(ii)	Biofertilizer	(b)	Algae
(iii)	Abiotic	(c)	Bacteria
(iv)	Prokaryotic	(d)	Cyanobacteria
(v)	Carbendazol	(e)	Stress
		(f)	Edaphic
		(g)	Culture medium
		(h)	*Anabaena, Azolla*
		(i)	*Bacillus thurin genesis*
		(j)	Insecticide
		(k)	Fungicide

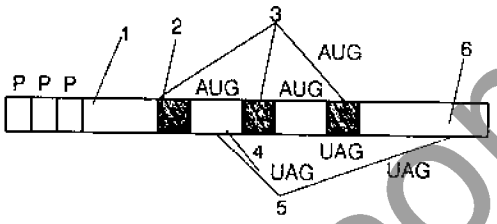
3. (i) Label the parts of interphase nucleus (1, 2, 5, 6).

(ii) Write the function of 3 and 4.



4. (i) Label the diagram in the question (1, 2, 3, 4, 5, 6)

(ii) State whether the above diagram is of Prokaryotes or Eukaryotes.



5. (i) Draw a sketch diagram of conducting system of the heart

(ii) Draw a sketch diagram of nephrone showing Glomerulus and Bowman's capsule.

6. Match the Column-I with Column-II (at least ten).

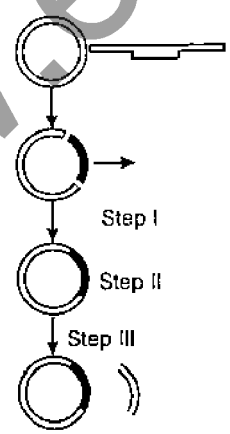
	Column-I		Column-II
(i)	Centromere	(a)	Small DNA fragments formed on lagging strand during DNA replication.
(ii)	Kinetochore	(b)	Breaking of DNA at specific site
(iii)	Telomere	(c)	Major protein of chromatin
(iv)	Exon	(d)	Sub-unit of chromatin
(v)	Intron	(e)	Highly condensed, non transcribing part of chromosome
(vi)	Heterochromatin	(f)	None-coding sequence of eukaryotic chromosome
(vii)	Nucleosome	(g)	Sister-chromatids attached to a point at interphase
(viii)	Histone	(h)	Protein helps in binding with microtubules
(ix)	Topoisomerase	(i)	Which seals ends of chromosomes
(x)	Okazaki fragment	(j)	coding sequence of eukaryotic chromosome
(xi)	Operon reading frame	(k)	functional gene

7. (i) Name three unusual bases present in *t*-RNA and name the bases from which these are developed.
   (ii) Name three nucleotides which are not constituent of DNA/RNA but takes part in metabolic activities ? Also name their bases.
   (iii) Name the achiral amino acids, symmetric with no side chain.
   (iv) Name five amino acids with non-polar side chains.

8. The nucleus of the egg is fertilized by the nucleus of the pollen grain, which is supposed to possess the DNA denaturating genes. The egg develops a denatured chlorophyll. The inheritance of chloroplast is cytoplasmic but the above result is due to which reason.

9. (i) Name the first cloned animal.
   (ii) Name the first biopesticide.
   (iii) Name an eco-friendly bioherbicide which interferes with amino acid synthesis and resistance to which has been obtained through transgenic culture.
   (iv) What is commonly used to produce virus resistant plants ?

10. Refer the adjoining diagram and answer the following questions :
   (i) From which organism Ti plasmid is obtained ?
   (ii) Name the enzyme which is involved in step-I
   (iii) What happens in step-III ?
   (iv) The plant produced is called hybrid or transgenic
   (v) Will the plant produced have other genes alongwith desired gene. Yes or No explain.



11. (i) C_4 plants have ..... anatomy.
   (ii) The light photons are absorbed by ligh harvesting complex (LHC) converted t chemical energy by ..... centre.
   (iii) ..... is an *ex – situ* conservation wher embryo are cultured in ..... mediu and at ..... temperature.

12. The gene sequence in the DNA of a cell to b transcribed is as given below. Write th sequences of *m*-RNA after transcription an amino acids coded in *m*-RNA.
   DNA sequence → TAC TTC AAA CCA ATT
   m-RNA sequences → .....
   Amino acids sequence → .....

13. There is five underlined sentences in the give paragraph. All underlined statements a wrong. Read the paragraph carefully and recti the underlined statements.
   The acceptance of evolution as an explanation present day biological diversity is comparative recent. Many respected biologists of t nineteenth and early twentieth centuries befo Darwin believed in the dynamics of species.
   (1)
   Even Charles. Darwin only reluctantly came accept evolution as an explanation for t diversity of life. An understanding of t mechanism of evolutionary change is only little more than a century old. In 1801 Charl Darwin proposed the first comprehensi explanation for the mechanism of evolution.
   (2)
   Lamarck believed that an adult organis acquired new characteristics in direct respon to survival needs and then passed these ne characteristics on to its offsprings. We kno now that inheritance is determined by genes, acquired characters can be passed on offspring.
   (3)
   Today the mechanism of evolution is believed be inheritance of acquired characters, a conce out lined by Charles Darwin
   (4)
   in his book 'Philosophique Zoologique'
   (5)
   published in 1859. In the book Darw presented a cogent series of arguments f evolution being the prevading theme of life.

14. There is five wrong statements given belc rectify them and write the correct statements.
   (i) Pyramid of energy is always inverted.
   (ii) The flow of energy in nature is cyclic.

(iii) Plants obtained carbon from atmosphere in the form of CH_4 which takes part in the CO_2 fixation during dark reaction of photosynthesis.

(iv) Term 'Ecosystem' was coined by R. Mishra.

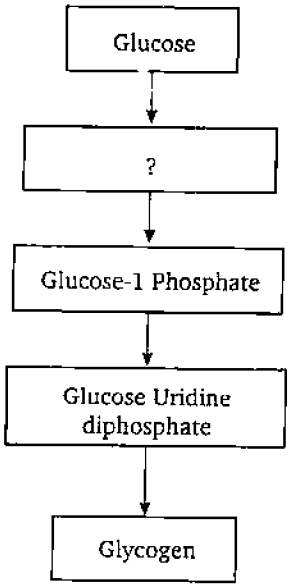
(v) R. Mishra was a famous Indian Pathologist.

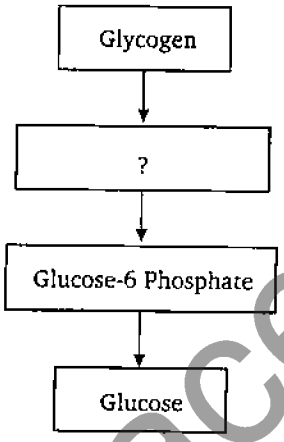
15. At the beginning of the present century plant anatomists noted that a seed plant native to hot dry climates, rather than exhibiting a palisade mesophyll, has a ring of mesophyll cells surrounding the bundle sheath cells. The arrangement has the appearance of a crown. This ring of Kranz cells exhibits a high level of C_4 activity what might the function of the Kranz structure be?

16. There is a flow chart showing the generalized events in DNA replication, write the name of enzymes involved in the reaction.

DNA double helix $\xrightarrow{(1)}$ Nicking of strand $\xrightarrow{(2)}$ Unwinding $\xrightarrow{(3)}$ Destabilization and relief of pressure $\xrightarrow{(4)}$ Initiation $\xrightarrow{(5)}$ Elongation $\xrightarrow{\text{DNA ligase}}$ closing of nicks

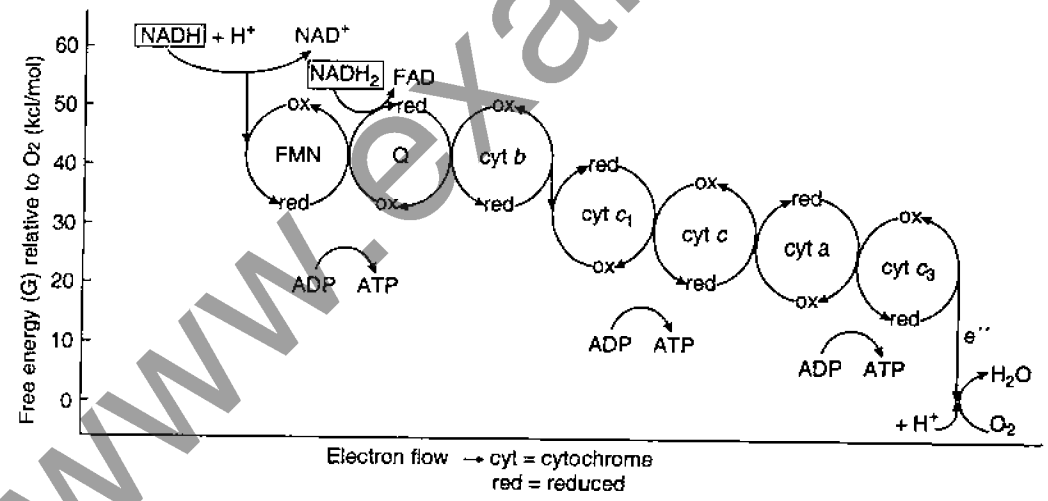
17. The main steps of glycogenesis and glycogenolysis reactions are given below but one step for each question is missed. Mention the missed steps.





18. There is a mechanism of electron transport chain in the diagram given below.

Give the answer of following questions based on this diagram.



(i) Name the terminal acceptor of electrons in respiratory chain.
(ii) How many ATP are produced by the oxidation of NADH + H.
(iii) How many ATP are produced by the oxidation of $FADH_2$.
(iv) Name two reactions to which chemiosmotic theory is involved

19. Create a flow chart showing the movement of blood from the aorta, through the various blood vessels associated with the kidney, to the posterior vena cava.

20. There are 5 articles in Column–I and 16 in Column–II. One article of Column–I concerned with more than one articles of Column–II. Match the articles of Column–I with concerned articles of Column–II.

Column–I	**Column–II**
(a) Intergeneric hybridization	(1) Micropropagation
(b) Biofertilizers	(2) Polymerase chain reaction
(c) Conservation	(3) Taq polymerase
(d) Tissue culture	(4) *Triticale*
(e) PCR	(5) Amplification of DNA
	(6) *Rhizobium leguminosarum*
	(7) Seed banks
	(8) Bromato
	(9) Distant cross
	(10) *Anabaena*
	(11) *Azotobacter*
	(12) *Bacillus polymyxa*
	(13) Cryopreservation
	(14) Somaclonal variation
	(15) Rabbage
	(16) Kary Mullis

HINTS & SOLUTIONS

Physics

PAPER-I

1. (a) As given

$$v = 4t$$

$$\Rightarrow \quad \frac{dx}{dt} = 4t$$

$$\therefore \quad \int_0^x dx = \int_2^4 4t\, dt$$

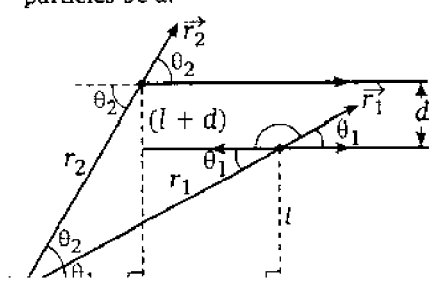
$$\Rightarrow \quad x = 4\left[\frac{t^2}{2}\right]_2^4$$

$$\Rightarrow \quad x = 2[(4)^2 - (2)^2]$$

$$\Rightarrow \quad x = 2(16 - 4)$$

So, $x = 24\text{m}$

(b) Let O be the point (reference point) about which total angular momentum is to be found and the distance between the two particles be d.



Since, the two particles have equal and opposi momentum, so they move oppositely to eac other.

The angular momentum of point mass is

$$\vec{\mathbf{L}} = \vec{\mathbf{r}} \times \vec{\mathbf{p}}$$

For the given system

$$\vec{\mathbf{L}} \rightarrow = \vec{\mathbf{L}}_1 + \vec{\mathbf{L}}_2$$

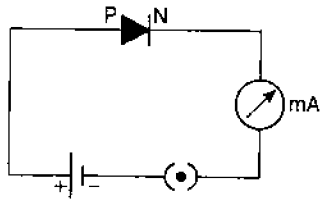
$$\Rightarrow \quad L = r_1 p_1 \sin(180^\circ - \theta_1) + r_2 p_2 \sin\theta_2$$
$$= r_1 p \sin\theta_1 - r_2 p \sin\theta_2$$
$$= p(r_1 \sin\theta_1 - r_2 \sin\theta_2)$$
$$= p[l - (l + d)] = p \times -d$$
$$= -p\,d \text{ (constant)}$$

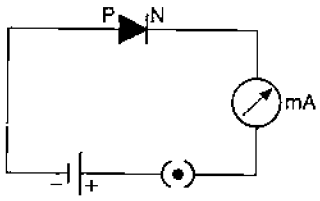
Hence, the total angular momentum is constan

2. (a) In semiconductor, valence band an conduction band are separated by a sma energy gap called the forbidden gap. A room temperature, electrons in valence ban due to their thermal agitation, have som reasonable probability of being able to jum to conduction band leaving an equal numbe of holes in the valence band. Whe temperature of semiconductor increase more electrons in valence band acqui much energy to cross the forbidden gap an

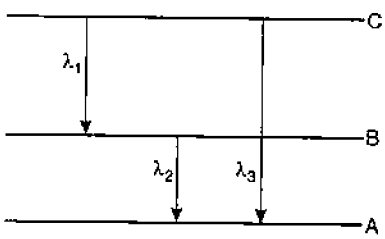
much energy to cross the forbidden gap and reach the conduction band. Hence, as temperature increases more electrons move to conduction band thereby decreasing the resistance of semiconductor.

(b) The diode under forward biasing is sketched in Fig. (i) and the diode under reverse biasing in Fig. (ii).





(c) From the diagram.



$$E_{CA} = E_{CB} + E_{BA}$$

or $$\frac{hc}{\lambda_3} = \frac{hc}{\lambda_1} + \frac{hc}{\lambda_2}$$

or $$\frac{1}{\lambda_3} = \frac{1}{\lambda_1} + \frac{1}{\lambda_2}$$

or $$\lambda_3 = \frac{\lambda_1\lambda_2}{\lambda_1 + \lambda_2}$$

(a) (i) Let us consider a body having a torque (τ) acting on it, is rotating about an axis passing through a point O. If a force F acts on a particle of mass m of that body then,

$$\tau = \text{force} \times \text{distance} = F \times r$$

$$= ma \times r \qquad (\because F = ma)$$

$$= mr\alpha \times r = mr^2\alpha$$

where α is angular acceleration

$$\therefore \quad \tau = mr^2\alpha$$

In general for a system consisting of many particles

$$\tau = (\Sigma mr^2\alpha)$$

$$\tau = I\alpha \qquad \ldots(1)$$

where I = moment of inertia about axis of rotation $= \Sigma mr^2$

(ii) From Eq. (1)

$$\tau = I\alpha$$

and $$\alpha = \frac{d\omega}{dt}$$

(rate of change of angular velocity)

$$\therefore \quad \tau = \frac{Id\omega}{dt} \qquad \ldots(2)$$

Now angular momentum of a body about axis of rotation

$$L = I\omega$$

$$\rightarrow \quad \frac{dL}{dt} = \frac{Id\omega}{dt} \qquad (\because I = \text{constant})$$

Therefore, Eq. (2) becomes

$$\tau = \frac{dL}{dt}$$

(b) Moment of inertia of a rod passing through the edge and perpendicular to the length

$$= \frac{Ml^2}{12} + M\left(\frac{l}{2}\right)^2 = \frac{Ml^2}{12} + \frac{Ml^2}{4} = \frac{Ml^2}{3}$$

So, net moment of inertia of system of both rods

$$= \frac{2}{3}Ml^2$$

(c) If $\vec{r}$ is the position vector of a particle and $\vec{p}$ is linear momentum, then angular momentum about origin

$$\vec{L} = \vec{r} \times \vec{p}$$

This implies that $\vec{L} \perp \vec{r}$ and $\vec{L} \perp \vec{p}$. Hence, the angle between angular momentum and linear momentum is 90°

4. (a) As given $s = 2t^3 - 3t^2 - 6t + 8$

Velocity, $v = \frac{dv}{dt} = \frac{d}{dt}(2t^3 - 3t^2 - 6t + 8)$

$$v = 6t^2 - 6t - 6$$

and acceleration

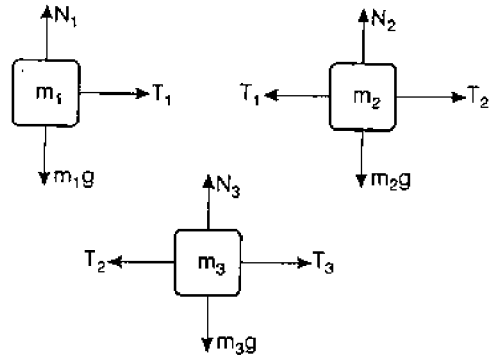
$$\Rightarrow \quad a = \frac{dv}{dt} = \frac{d}{dt}(6t^2 - 6t - 6)$$

$$a = 12t - 6$$

But $a = 0$ (given), $\therefore 12t - 6 = 0$

$$\Rightarrow \quad t = \frac{6}{12} = 0.5\text{ s}$$

(b) Let N_1, N_2, N_3 be normal reactions on masses m_1, m_2 and m_3 respectively. The free body diagrams of m_1, m_2 and m_3 are as shown below



For masses m_1, m_2 and m_3 to be in vertical equilibrium

$N_1 = m_1 g$, $N_2 = m_2 g$ and $N_3 = m_3 g$

Now, $T_1 = m_1 a$ ...(1)

$T_2 - T_1 = m_2 a$ ...(2)

$T_3 - T_2 = m_3 a$ ...(3)

where a be the common acceleration of the system.

Now adding Eq. (1), (2) and (3), we get

$$a = \frac{T_3}{m_1 + m_2 + m_3} \quad ...(4)$$

Given : $T_3 = 60$ N, $m_1 = 10$ kg, $m_2 = 20$ kg and $m_3 = 30$ kg.

Putting the given values in Eq. (4), we get

$$\therefore \quad a = \frac{60}{10 + 20 + 30} = \frac{60}{60} = 1 \text{ m/s}^2$$

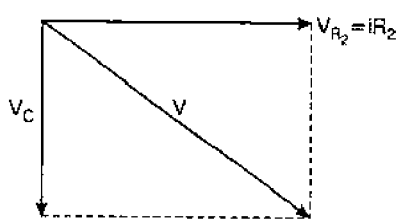
$\therefore$ From Eq. (1),

$$T_1 = m_1 a = 10 \times 1 = 10 \text{ N}$$

Again from Eq. (2),

$$T_2 = T_1 + m_2 a$$
$$= 10 + 20 \times 1 = 10 + 20 = 30 \text{ N}$$

5. (a) (i) Let at any instant, current I_1 flows in the branch of inductance and I_2 flows in the branch of resistance. Since, potential difference will be same across the two parallel branches, the current I_1 lags behind the applied potential difference by $\frac{\pi}{2}$ (*i. e.*, 90°) and I_2 is in phase with applied potential. Hence, phase difference between the currents through L and R_1 is 90°.



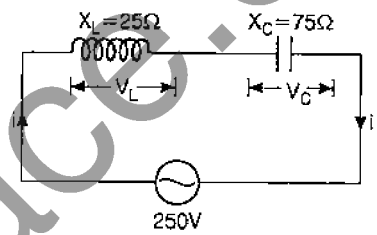
(ii) The potential difference V_{R_2} across resistance R_2 and current I are in same phase, but the potential difference V_C across the condenser C lags behind the current I in phase by 90°. Hence the phase difference between V_{R_2} and V_C will be 90°.

(b) The induced magnetic field at the point P at a distance r along a conductor

= magnetic field (B_x) at the point lies along the current direction + magnetic field (B_y) at end point of infinite conductor

$$= 0 + \frac{\mu_0 I}{4\pi r} = \frac{\mu_0 I}{4\pi r}$$

(c) We can draw the diagram according to the information given in problem, as



Net resistance of the circuit

$$Z = X_C - X_L = 75 - 25 = 50\Omega$$

So, current through the circuit

$$i = \frac{V}{Z} = \frac{250}{50} = 5\text{A}$$

$\therefore \quad V_L = iX_L = 5 \times 25 = 125$ V

and $\quad V_C = iX_C = 5 \times 75 = 375$ V

Now, $\quad V_L = 125\text{V} = \frac{1}{2}(125 \times 2) = \frac{1}{2} V_{\text{mains}}$

and $\quad V_C = 375 = \frac{3}{2}\left(\frac{2}{3} \times 375\right) = \frac{3}{2} V_{\text{mains}}$

6. Force, $F = mr\omega^2$

$$= mr \times (2\pi n)^2 = 4\pi^2 mrn^2$$

$$\therefore \quad F \propto n^2$$

where n is the frequency.

When forces F_1 and F_2 act on the particle simultaneously in same direction, then net force

$$F = F_1 + F_2$$

$$\therefore \quad n^2 = n_1^2 + n_2^2$$

$$\Rightarrow \quad n = \sqrt{n_1^2 + n_2^2}$$

$$\therefore \quad n = \sqrt{6^2 + 8^2} = \sqrt{100} = 10 \text{ Hz}$$

(b) For the final emergent ray to be parallel to the incident ray, the mediums of both the rays should be same. Therefore, the refractive index of block C should be same as that of air.

7. (a) From Einstein's photoelectric equation

$$KE_{max} = \frac{hc}{\lambda} - h\nu$$

$$= \left[\frac{6.6 \times 10^{-34} \times 3 \times 10^{8}}{4000 \times 10^{-10}} - 6.6 \times 10^{-34} \times 5.5 \times 10^{14}\right]$$

$$= 4.95 \times 10^{-19} - 3.6 \times 10^{-19}$$

$$= 1.35 \times 10^{-19} \text{ J}$$

Now, let no. of photons emitted per sec be n. Then, intensity $= 100 \text{ W/m}^2$

$$\Rightarrow \quad \frac{nhc}{\lambda} = 100$$

$$\Rightarrow \quad n = \frac{100 \times \lambda}{hc} = \frac{100 \times 4000 \times 10^{-10}}{6.6 \times 10^{-34} \times 3 \times 10^{8}}$$

$$= 2.02 \times 10^{20}$$

(b) Kinetic energy of photoelectron

$$KE = 500 \text{ keV} = 500 \times 10^3 \text{ eV}$$

But $\quad KE = mc^2 - m_0c^2$

$$\Rightarrow \quad \frac{KE}{m_0c^2} = \left(\frac{mc^2 - m_0c^2}{m_0c^2}\right)$$

$$\Rightarrow \quad \frac{m - m_0c^2}{m_0} = \frac{\Delta m}{m_0}$$

or $\quad \frac{\Delta m}{m} = \frac{KE}{m_0c^2}$

Hence, % increase in mass is

$$= \frac{\Delta m}{m_0} \times 100 = \frac{KE}{m_0c^2} \times 100$$

$$= \frac{500 \times 10^3 \text{ eV}}{0.511 \times 10^6 \text{ eV}} \times 100$$

$$(\because \; m_0c^2 = 0.511 \times 10^6 \text{ eV})$$

$$= \frac{5}{5.11} \times 100 = 97.85\%$$

(c) The binding energy of nucleus is the energy released in formation of nucleus by combining its nucleons or it is the external energy which is required to isolate the nucleons of the nucleus from one another.

Nuclear fission is a process in which a heavy nucleus is split into middle weight nuclei by bombarding it with neutrons. In each fission reaction, a tremendous amount of energy is released. This is due to the mass defect occurs, when a nucleus splits into two nuclei. In other words we can say that the binding energy per nucleon of the nuclei obtained as a result of fission is more as compared to the binding energy per nucleon of the parent nucleus.

Nuclear fusion is the process in which two light weight nuclei come close to each other with in the range of attractive force (≈ 1 fm). These may combine to form a heavy nucleus. This process is possible from an energy point of view because the binding energy per nucleon is small for light nuclei and increases with atomic mass A until A is about 50. Also, in this reaction a large amount of energy is released. This energy appears in the form of kinetic energy or in some other form.

8. (a) The heat required at constant pressure

$$Q = nC_p\Delta T$$

$\therefore$ Change in temperature

$$\Delta T = \frac{Q}{nC_p}$$

Here : $Q = 300\text{J}$, $n = 2$ moles, $C_p = \frac{5}{2}R$

R, being the gas constant

$$= 8.31 \text{ J mole}^{-1}\text{ C}^{-1}$$

$$\Delta T = \frac{300}{2 \times \frac{5}{2} \times 8.31} = \frac{300}{5 \times 8.31} = 7.22°\text{C}$$

(b) (i) When a bar is heated continuously, initially the temperature of various sections of the bar increases, a state known as the variable state but after some time, the temperature of any part of rod does not change. In this state heat is not absorbed by the cross-section but is partly conducted to next cooler section and is partly radiated. Therefore, this state of the rod is known as the steady state.

(ii) Between two isolated surfaces, the fall of temperature per unit distance along the direction of flow of heat is called the temperature gradient. If the temperatures of two isolated spheres are θ and $\theta - \Delta\theta$ and the perpendicular distance between them is Δx, then temperature gradient

$$= \frac{\text{change in temperature}}{\text{perpendicular distance}}$$

$$= \frac{(\theta - \Delta\theta) - \theta}{\Delta x} = -\frac{\Delta\theta}{\Delta x}$$

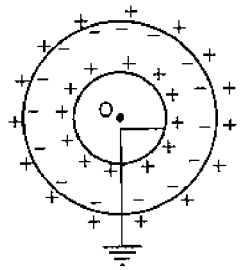
9. (a) The net resistance of second circuit

$$\frac{1}{R'} = \frac{1}{8} + \frac{1}{(3+5)}$$

$$\therefore \quad R' = \frac{8 \times 8}{8 + 8} = \frac{64}{16} = 4\Omega$$

If the value of R in the first circuit becomes equal to net resistance of second circuit, then power dissipated in both the circuits will be same. Hence, $R = R' = 4\Omega$.

(b) If a charge $+Q$ is given to outer sphere, then a charge $-Q$ will be induced on the inner surface of outer sphere. As a result $+Q$ charge will be induced on the outer surface of inner sphere and consequently $-Q$ charge on the inner surface of inner sphere which will be grounded as shown in the figure.



Hence, only the charge $+Q$ appears on inner sphere.

(c) It is possible that at such a point the potential is zero, electric field is not zero at that point. For example; in the case of electric dipole consisting of two equal and opposite charges placed at two ends, at the mid point of the dipole potential is zero but electric field is not zero.

10. (a) Given,

$$V = \frac{\pi P r^4}{8\eta l} \qquad \therefore \ \eta = \frac{\pi P r^4}{8Vl}$$

Here, V stands for rate of flow per unit time.

So, dimensions of

$$\eta = \frac{\text{dimensions of P} \times \text{dimensions of r}^4}{\text{dimensions of V} \times \text{dimension of l}}$$

$$= \frac{[ML^{-1}T^{-2}][L^4]}{[L^3T^{-1}][L]} = [ML^{-1}T^{-1}]$$

But distance = velocity × time

$$\therefore \qquad [L] = [vT]$$

Hence, dimensions of η (in the notations of

$$M, v, T) = [Mv^{-1}T^{-1}T^{-1}] = [Mv^{-1}T^{-2}]$$

(b) Final velocity of first body of mass m in falling a height h

$$v^2 = 0 + 2gh$$

$$\Rightarrow \qquad v = \sqrt{2gh}$$

Using the law of conservation of momentum initial momentum = final momentum

$$mv + 0 = (m + m)v'$$

$$m\sqrt{2gh} = 2mv'$$

$$\Rightarrow \qquad v' = \frac{\sqrt{2gh}}{2} = \sqrt{\left(\frac{gh}{2}\right)}$$

Thus, work done against resistive force

$$= \frac{1}{2} \times (2m)v'^2 + (2m)gd$$

d = distance with which the combined mass moves on the ground

v' = velocity of combined mass

$$\therefore \text{Work done} = m\left(\frac{gh}{2}\right) + 2mgd$$

$$= mg\left(\frac{h}{2} + 2d\right) = \frac{1}{2}mg\,(h + 4d)$$

Chemistry

1. (a) For the dissociation of NH_4Cl in aqueous solution, there will be excess of H^+ ions as it is a salt of weak base and strong acid.

$$NH_4^+ + 2H_2O \rightleftharpoons NH_4OH + H_3O^+$$

$$\therefore \qquad K_h = \frac{[NH_4OH][H_3O^+]}{[NH_4^+]}$$

or $\qquad K_h\,[NH_4^+] = [NH_4OH][H_3O^+]$

or $\qquad K_h\,[NH_4^+] = [H_3O^+]^2$

$$(\because \ [NH_4OH] = [H_3O^+])$$

$$\therefore \qquad [H_3O^+] = \sqrt{K_h C}$$

(b) Given that, pH = 7.40

We know that, $-\log[H^+] = \text{pH}$

$$\therefore \qquad \log[H^+] = -7.40$$

$$[H^+] = \text{antilog} -7.40 = \text{antilog}\,(-8 + 0.60)$$

$$= 3.9811 \times 10^{-8}$$

The dissociation of H_2CO_3 can be represented as follows :

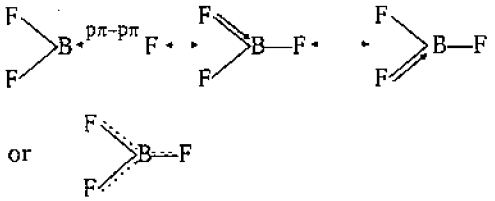
$$H_2CO_3 \rightleftharpoons HCO_3^- + H^+$$

$$\therefore \qquad K_1 = \frac{[HCO_3^-][H^+]}{[H_2CO_3]}$$

$$\therefore \qquad \frac{[HCO_3^-]}{[H_2CO_3]} = \frac{K_1}{[H^+]} = \frac{4.5 \times 10^{-7}}{3.9811 \times 10^{-8}} = 11.303$$

2. (a) In boron halides (BF_3, BCl_3, BBr_3 etc.) sp^2 hybridisation takes place due to which these have trigonal planar geometry but in all of these, the filled p-orbital of halogen atom remains over

lapped with vacant p-orbital of boron. Thus, these have following structure :



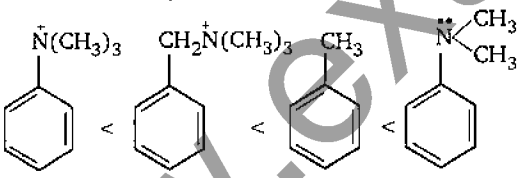
This is called $p\pi - p\pi$ back bonding which is most effective in BF_3 as in it, this overlapping occurs between $2p$ (of F) and $2p$ (of B) orbitals. This is the reason why BF_3 has least tendency to accept lone pair of electron. Hence, BBr_3 is stronger Lewis acid than BF_3.

(b) Sulphur belongs to 3rd period, hence, it has maximum covalency equal to 6. Therefore, SF_4 can be hydrolysed as it can form hexa covalent intermediate complex with two H_2O molecules. But SF_6 cannot be hydrolysed as it cannot form such intermediate complex.

(c) In $(CH_3)_3SiOH$, Si-atom form $p\pi - d\pi$ bonding with O-atom as it has vacant d-orbitals (unlike C) hence O — H bond is weaker in $(CH_3)_3SiOH$ than that in $(CH_3)_3COH$. Therefore, $(CH_3)_3SiOH$ is more acidic than $(CH_3)_3COH$.

(d) Ethyne is acidic in nature, hence, its hydrogen forms hydrogen bonding with hydrogen fluoride.

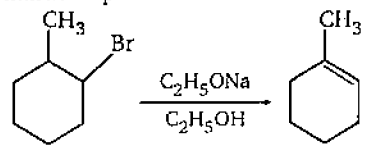
3. (a) The groups which increase electron density in ring (*i.e.*, + I group) activate benzene ring towards electrophilic substitution. $-N^+(CH_3)_3$ and $-CH_2N^+(CH_3)_3$ both groups decrease electron density in benzene ring, therefore, deactivate ring towards electrophilic substitution. $-\ddot{N}(CH_3)_2$ group (even though N is electron withdrawing) stabilises σ complex as N-atom has a lone pair of electron, therefore, if activates the ring.



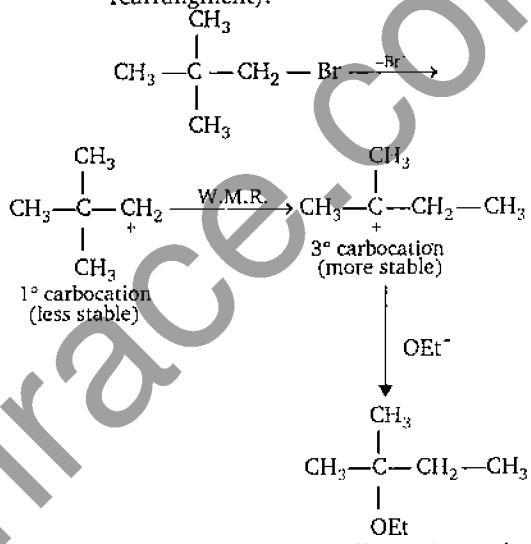
Thus, the correct order of reactivity towards electrophilic substitution is :

(b) Piperidine  is the strongest base among these. Pyridine and pyrrole are aromatic compounds in which due to the delocalisation of lone pair of electron (present on N-atom), N-atom has less tendency to donate electron. Aniline is also weakly basic due to similar reason. Piperidine is a secondary amine and it has much tendency to lose electron, hence, is strongly basic.

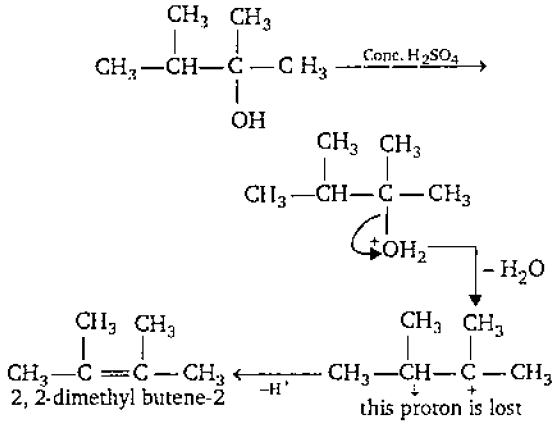
4. (a) (i) It is simple dehydrohalogenation of halide in presence of alcoholic alkali.



(ii) This reaction is an example of nucleophilic substitution involving methyl-shift (Wagner- Meerwein rearrangment).



(iii) According to Saytzeff rule, the deprotonation occurs from more substituted carbon.

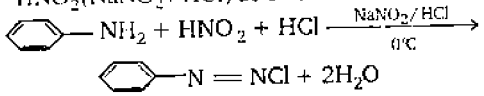


(b) Acetonitrile $\left(CH_3-\overset{\delta^+}{C}\equiv\overset{\delta^-}{N}\right)$ act as a polar solvent for a variety of organic compounds. It is also less reactive in mild acidic or basic conditions.

5. (a) Aniline does not show Friedel-Craft reaction because amino group of aniline act as a base and form salt with Lewis acid ($AlCl_3$) *i.e.*,

$C_6H_5\overset{+}{N}H_2AlCl_3^-$

(b) Benzene diazonium chloride is prepared by diazotisation of aniline in presence of HNO_2($NaNO_2$ / HCl) at 0°C.



Benzene diazonium chloride show coupling with activated benzene rings (like aniline) if excess of mineral acid is not used. So, excess of HCl is used to prevent the coupling.

6. $\overset{+6}{Cr_2}O_7^- + 14H^+ + 6e^- \rightarrow Cr^{3+} + 7H_2O$

$E° = 1.33$

$2I^- \rightarrow I_2 + 2e \quad E° = -0.54$

For the cell, $E°\text{cell} = E°_{\text{cathode}} - E°_{\text{anode}}$

$= (1.33) - (0.54)$

$(\because E°_{I_2/I^-} = -E°_{I^-/I_2})$

$= 0.79$ V

We know that,

$$E°\text{cell} = \frac{0.059}{n}\log K,$$

$$\therefore \quad 0.79 = \frac{0.059}{6}\log K$$

$$\log K = 80.34$$

$$\therefore \quad K = \text{antilog } 80.34 \approx 10^{80}$$

Free energy change ($\Delta G°$)

$= -nFE°_{\text{cell}} = -6 \times 96500 \times 0.79$

$= -457.41$ kJ mol^{-1}

(b) $A + B \rightarrow C + D$

Given that, $\Delta H = -10000$ J mol^{-1},

$\Delta S = -33.3$ J mol^{-1}K^{-1}

From Gibbs-Helmholtz equation :

$$\Delta G = \Delta H - T \cdot \Delta S$$

At equilibrium ($\Delta G = 0$), $\Delta H = T \cdot \Delta S$

$$\therefore \quad T = \frac{\Delta H}{\Delta S} = \frac{-10000}{-33.3} = 300.3\text{K}$$

Hence,

(i) For spontanity from left to right, $T < 300.3$ K (ΔG must be negative)

(ii) For spontanity of reverse reaction, $T > 300.3$ K

7. (a) From Arrhenius equation, we have

$$\log\frac{k_1}{k_2} = \frac{E_a}{2.303R}\left(\frac{T_1 - T_2}{T_1T_2}\right)$$

Given that, $E_a = 80 \times 10^3$ J, $T_1 = 273$ K, $T_2 = 323$ K

$$\therefore \log\frac{k_1}{k_2} = \frac{80 \times 10^3}{2.303 \times 8.31}\left(\frac{273 - 323}{273 \times 323}\right) = -2.37$$

$$\therefore \quad \frac{k_1}{k_2} = \text{antilog } (-2.37) = \text{antilog } (-3 + 0.63)$$

$$= 4.2 \times 10^{-3}$$

(b) Total moles in the mixture,

$$n = \frac{PV}{RT} = \frac{1 \times 40}{0.0821 \times 400} = 1.218 \text{ mol}$$

The combustion reactions of ethane and ethene are as follows :

$$C_2H_6 + 3.5\,O_2 \longrightarrow 2CO_2 + 3H_2O$$

$$C_2H_4 + 3O_2 \longrightarrow 2CO_2 + 2H_2O$$

Let, C_2H_6 be 'x' mol and C_2H_4 be 'y' mol, then :

Total O_2 used

$= 3.5x + 3y = 4.06$ mol (given) ...(i)

Also $x + y = 1.218$ ...(ii)

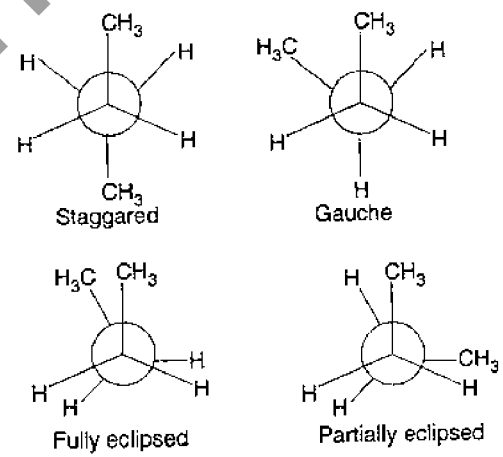
Solving Eqs. (i) and (ii), we get :

$x = 0.812$ mol

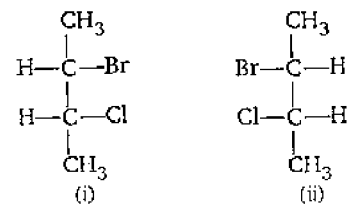
$\therefore$ mole fraction of $C_2H_6 = \frac{0.812}{1.218} = 0.67$

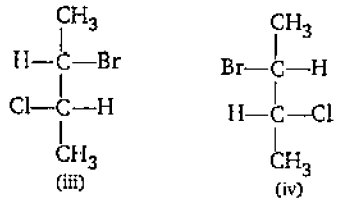
$\therefore$ mole fraction of $C_2H_4 = 1 - 0.67 = 0.33$

8. (a) *n*-butane has following four types of conformers :



(b) 2-bromo-3-chloro butane has 2 chiral carbon atoms. Its four optical isomers are as follows :

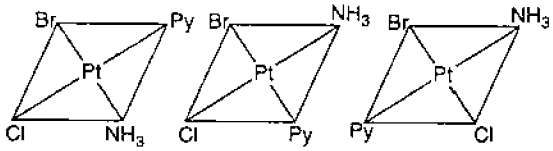




Structures (i) and (iii) are enantiomers. Similarly structures (iii) and (iv) are also enantiomers.

Structures (i) and (iii) [or (iv)] and structures (ii) and (iii) [or (iv)] are diastereomers.

9. (a) There are three geometrical isomers possible for $[Pt(NH_3)(Cl)(Py)(Br)]$ as it has square planar structure.



None of these isomers show optical isomerism.

(b) $[Co(ox)_3]^{3-}$: In this complex ion, cobalt is in + 3 oxidation state.

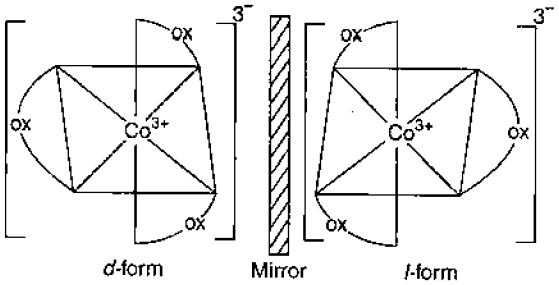
$Co = [Ar]\ 3d^7 4s^2 4p^0$

$Co^{3+} =$ [↑↓] [↑] [↑] [↑] [↑] [ ] [ ] [ ] [ ]

Oxalate is weaker ligand, hence, sp^3d^2 hybridisation takes place so that resulting ion is paramagnetic (due to presence of four unpaired electrons).

This ion shows optical isomerism and it has two optical isomers.

$[CoF_6]^{3-}$: This ion is also octahedral and paramagnetic due to sp^3d^2 hybridisation. But this ion cannot shows optical isomerism due to presence of plane and centre of symmetry.



10. (a) Molecular orbital configurations of these species are as follows :

$N_2^+(13\,e^-) = KK^*(\sigma 2s)^2(\sigma^* 2s)^2(\pi 2p_y)^2(\pi 2p_z)^2(\sigma 2p_x)^1$

$\therefore$ bond order $= \frac{1}{2}(9-4) = 2.5$

$N_2^-(15e^-) = KK^*(\sigma 2s)^2(\sigma^* 2s)^2(\sigma 2p_x)^2(\pi 2p_y)^2(\pi 2p_z)^2(\pi^* 2p_y)^1$

$\therefore$ Bond order $= \frac{1}{2}(10-5) = 2.5$

As the bond order of these species are same, hance, their bond energy will also be equal.

(b) (i) F_2 and O_2^{2-} are isoelectronic ($18\,e^-$ in each) species, hence, their bond length and bond order will be same.

(ii) CO, N_2 and NO^+ are also isoelectronic ($14e^-$ in each) species, hence, their bond order and bond lengths will also be same.

(c) Carbon and oxygen are in the same period having close proximity in their size, therefore, these can form multiple bond to give arise to CO molecule ($C \equiv O$). Whereas Si is quite larger in size, therefore, its multiple bond with oxygen is not so stable. Thus, SiO molecule is not stable.

PAPER–II

Biology

1. **(i) Cloning** : The process of producing genetically similar molecules, cells or organisms, from a common ancestor by asexual reproduction *in vitro* or *in vivo* is called cloning.

Significance of Cloning :

- Microbial cloning is involved in the production of various important products like, enzymes, hormones, acids, antibiotics, vaccines etc.

- Gene cloning is involved in the production of transgenic plants and animals like Bt-cotton, Bt-tobacco etc.
- 'Dolly' was the first mammal to be successfully cloned from an adult cell by Ian Wilmut of Roslin institute. Edinburg, U.K. Cloning of Dolly rise a hope in the production of artificial organs which can be used to replace damage organs of the body.
- Cloning is a quick method of multiplication of animals belonging to endangered species.
- Cloning is useful technique for maintaining superior breeds.
- Hybrid vigour can be continued indefinitely.
- Even sterile interspecific hybrids can be multiplied through cloning.

(ii) Significance of Embryo Culture : Embryo rescue *i.e.*, taking out the fragile embryos from fertilized ovules of interspecific crosses before their abortion and culturing them to form viable hybrid seedlings *e.g.*, Bean, Rice, Jute, Tomato etc.

Embryo culture helps in developing seedlings in orchid seeds because orchid seeds lack stored food. Embryo culture is useful in the multiplication of some rare plants *e.g.* Makapuno nut. Embryo culture is useful for growing seedlings in dormant seeds.

2. (i) Agar → Algae, Culture medium

(ii) Biofertilizer → Anabaena, Azola, Bacteria, Cyanobacteria

(iii) Abiotic → Edaphic

(iv) Prokaryotes → Bacteria, Cyanobacteria, Bacillus thuringenesis

(v) Carbendazol → Insecticide, Fungicide

3. (i) The correct labelling of 1, 2, 5 and 6 is as follows :

1. Nuclear pore
2. Nuclear membrane
5. Nucleoplasm
6. Cytoplasm

(ii) The functions of 3 and 4 are as follows :

3. Chromatin network :

- Chromatin is the interphase chromoso- mal material *i.e.*, a complex of DNA and histone proteins.
- In nucleus hereditary material is contained in chromatin.
- The major proteins of chromatin are the histones that facilitates binding with negatively charged DNA molecule.

4. Nucleolus : Nucleolus is a non- membrane bound, conspicuous spherical structure associated with inner nuclear envelope. A nucleolus contain large amount of RNA though it contain DNA too. The chief function of nucleolus is the synthesis of ribosomal RNA by which ribosomes are synthesised.

4. (i) (1) Non coding region at 5′

(2) Initiation codon.

(3) Exons (*i.e.*, intermediate coding regions)

(4) Stopping signal (UAG). Termination codon

(5) Introns (*i.e.*, intermediate non-coding regions)

(6) Noncoding region at 3′

(ii) The above diagram is of eukaryotic DNA because in eukaryotic DNA splitting genes (*i.e.*, exons and introns) are present which remain absent in prokaryotic DNA.

5. (i)

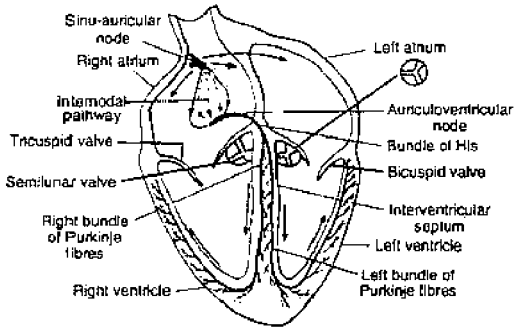


Fig. Sketch diagram of conducting system of heart

(ii)

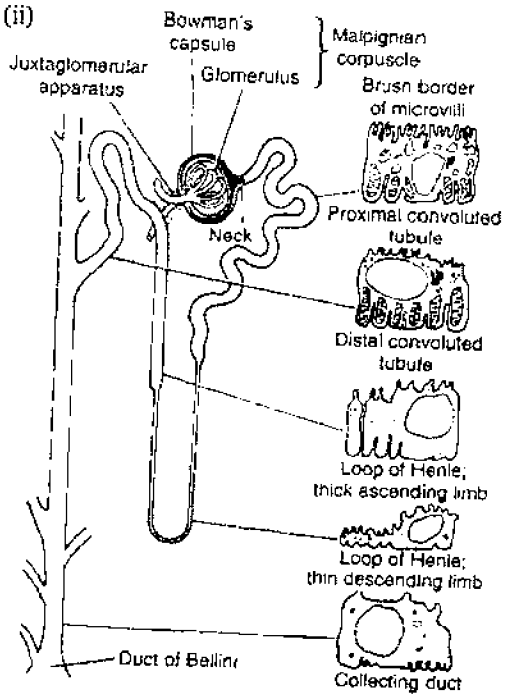


Fig. Naphron showing glomerulus and Bowman's capsule

6.

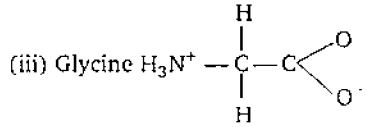
(I)	—	(g)
(II)	—	(h)
(III)	—	(i)
(IV)	—	(j)
(V)	—	(f)
(VI)	—	(e)
(VII)	—	(d)
(VIII)	—	(c)
(IX)	—	(b)
(X)	—	(a)
(XI)	—	(k)

7. (i) Unusual base

(a) Pseudouridine develops from Uracil
(b) Inosine develops from Adenine
(c) Dihydrouridine develops from Uracil
Dihydrouridine develops from Uracil

(ii)

Nucleotides		Bases present
ATP	—	Adenine
NAD	—	Adenine
FAD	—	Adenine

(iii) Glycine  is a simplest, achiral, symmetric amino acid with no side chain.

(iv) Alanine, valine, leucine, isoleucine, methionine.

8. Chloroplast is a semiautonomous organelle where extrachromosomal or cytoplasmic hereditary units are present which function either independently or in collaboration with nuclear genetic system. In above case some of its characters are regulated through nuclear genes. DNA destroying agents of male plants can also destroy the DNA of nucleus of female plant. Hence, the chloroplast of progeny is ill developed.

9. (i) 'Dolly' was the first successfully cloned mammal.

(ii) First bioherbicide was developed in 1961 and it was a mycoherbicide derived from a fungus *phytophthora palmivora*. Divine was first bioinsecticide. Divine and collego are fungal spores which can be sprayed over weeds for their elimination.

(iii) *Bacillus thuringenesis*. (iv) Shoot tip culture.

10. (i) Ti plasmid is obtained from crown gall disease causing bacterium *Agrobacterium tumifaciens*

(ii) DNA ligase (iii) Transfection (iv) Transgenic

(v) Yes, plant contains antibiotic resistance gene along with transgene.

11. (i) C_4 plants have Kranz anatomy

(ii) The light photons are absorbed by light harvesting complex (LHC) converted to chemical energy by **reaction** centre.

(iii) Cryopreservation is an ex-situ conserva- tion, where embryo are cultured in **liquid nitrogen medium** and at **– 196°C temperature.**

12.

DNA sequences :	TAC	TTC	AAA	CCA	ATT
m-RNA sequences :	AUG ↓	AAG ↓	UUU ↓	GGU ↓	UAA ↓
Amino acid sequences	Met	Lys	Phe	Gly	Stop

13. (i) Before Darwin believed in the fixity of species.

(ii) In 1801 Jean Baptiste de Lamarck proposed the first comprehensive explanation for the mechanism of evolution.

(iii) Inheritance is determined by genes, so, acquired characters can not be passed on to off spring.

(iv) Today the mechanism of evolution is believed to be Natural selection concept out lined by Charles Darwin.

(v) In his book 'On the origin of species by means of Natural selection.

14. (i) The pyramid of energy is always upright

(ii) The flow of energy in nature is unidirectional

(iii) Plants obtained carbon from atmosphere in the form of CO_2 which takes part in the CO_2 fixation during dark reaction of photosynthesis.

(iv) Term 'Ecosystem' was coined by Tenslay.

(v) R. Mishra was a famous Indian ecologist.

15. The C_4 plants possess Kranz anatomy in which vascular bundles are surrounded by two rings of cells. The inner ring (bundle sheath cells) contain starch rich, agranal chloroplasts which differ from mesophyll cells making the outer ring. Kranz anatomy maximizes contact between the mesophyll and bundle sheath cells and therefore, maximizes the pumping of CO_2 into the bundle sheath cells so that photosynthesis may continue under the adverse conditions of a hot, dry, environment.

16. DNA double helix $\xrightarrow{\text{Topoisomerase}}$ Nicking of strand $\xrightarrow{\text{Helicases}}$ Unwinding $\xrightarrow[\text{Topoisomerase}]{\text{SSB protein}}$ Destabilization and relief of pressure $\xrightarrow{\text{Primase}}$ Initiation $\xrightarrow{\text{DNA polymerase}}$ Elongation $\xrightarrow{\text{DNA ligase}}$ closing of nicks.

17. Glycogenesis → Glucose-6-phosphate

Glycogenolysis →Glucose-1-phosphate

18. (i) Oxygen (ii) Three (iii) Two

(iv) Chemiosmotic theory is involved with photophosphorylation and oxidative phosphorylation. Chemiosmotic theory consists of following postulates :

(1) The mitochondrial respiratory chain in the inner membrane is proton translocating, it pumps H^+ out of the matrix space when electrons are transported along the chain.

(2) The mitochondrial ATP synthase also translocates protons across the inner membrane. Being reversible, it can use the energy of ATP hydrolysis to pump H^+ across the membrane.

19. Aorta → renal artery → arteriole → capillaries of glomerulus → arteriole from Bowman's capsule → peritubular capillaries → venule → renal vein → posterior vena cava.

20. (a) : (4), (8), (9), (15) (b) : (6), (10), (11), (12),

(c) : (7), (13) (d) : (1), (14) (e) (2), (3), (5), (16)

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