

## Part I Mathematics

## Question Number : 1

The number of triples  $(x, y, z)$  of real numbers satisfying the equation

$$x^4 + y^4 + z^4 + 1 = 4xyz$$

is

- A. 0                      B. 4                      C. 8                      D. more than 8

## Question Number : 2

Let  $P(x)$  be a polynomial with real coefficients such that  $P(\sin^2 x) = P(\cos^2 x)$ , for all  $x \in [0, \pi/2]$ . Consider the following statements:

- I.  $P(x)$  is an even function.  
 II.  $P(x)$  can be expressed as a polynomial in  $(2x - 1)^2$ .  
 III.  $P(x)$  is a polynomial of even degree.

Then

- A. all are false                      B. only I and II are true  
 C. only II and III are true                      D. all are true

## Question Number : 3

For any real number  $r$ , let  $A_r = \{e^{inr}; n \text{ is a natural number}\}$  be a set of complex numbers. Then,

- A.  $A_1, A_{\frac{1}{\pi}}, A_{0.3}$  are all infinite sets  
 B.  $A_1$  is a finite set and  $A_{\frac{1}{\pi}}, A_{0.3}$  are infinite sets  
 C.  $A_1, A_{\frac{1}{\pi}}, A_{0.3}$  are all finite sets  
 D.  $A_1, A_{0.3}$  are finite sets and  $A_{\frac{1}{\pi}}$  is an infinite set

Question Number : 4

The number of integers  $k$  for which the equation  $x^3 - 27x + k = 0$  has at least two distinct integer roots is

- A. 1      B. 2      C. 3      D. 4

Question Number : 5

Suppose the tangent to the parabola  $y = x^2 + px + q$  at  $(0, 3)$  has slope  $-1$ . Then  $p + q$  equals

- A. 0      B. 1      C. 2      D. 3

Question Number : 6

Let  $O = (0, 0)$ ; let  $A$  and  $B$  be points respectively on  $x$ -axis and  $y$ -axis such that  $\angle OBA = 60^\circ$ . Let  $D$  be a point in the first quadrant such that  $OAD$  is an equilateral triangle. Then the slope of  $DB$  is

- A.  $\sqrt{3}$       B.  $\sqrt{2}$   
C.  $\frac{1}{\sqrt{2}}$       D.  $\frac{1}{\sqrt{3}}$

Question Number : 7

Suppose the parabola  $(y - k)^2 = 4(x - h)$ , with vertex  $A$ , passes through  $O = (0, 0)$  and  $L = (0, 2)$ . Let  $D$  be an end point of the latus rectum. Let the  $y$ -axis intersect the axis of the parabola at  $P$ . Then  $\angle PDA$  is equal to

A.  $\tan^{-1} \frac{1}{19}$

B.  $\tan^{-1} \frac{2}{19}$

C.  $\tan^{-1} \frac{4}{19}$

D.  $\tan^{-1} \frac{8}{19}$

Question Number : 8

In a circle with centre  $O$ , suppose  $A, P, B$  are three points on its circumference such that  $P$  is the mid-point of minor arc  $AB$ . Suppose when  $\angle AOB = \theta$ ,

$$\frac{\text{area}(\Delta AOB)}{\text{area}(\Delta APB)} = \sqrt{5} + 2,$$

If  $\angle AOB$  is doubled to  $2\theta$ , then the ratio  $\frac{\text{area}(\Delta AOB)}{\text{area}(\Delta APB)}$  is

A.  $\frac{1}{\sqrt{5}}$

B.  $\sqrt{5} - 2$

C.  $2\sqrt{3} + 3$

D.  $\frac{\sqrt{5}-1}{2}$

Question Number : 9

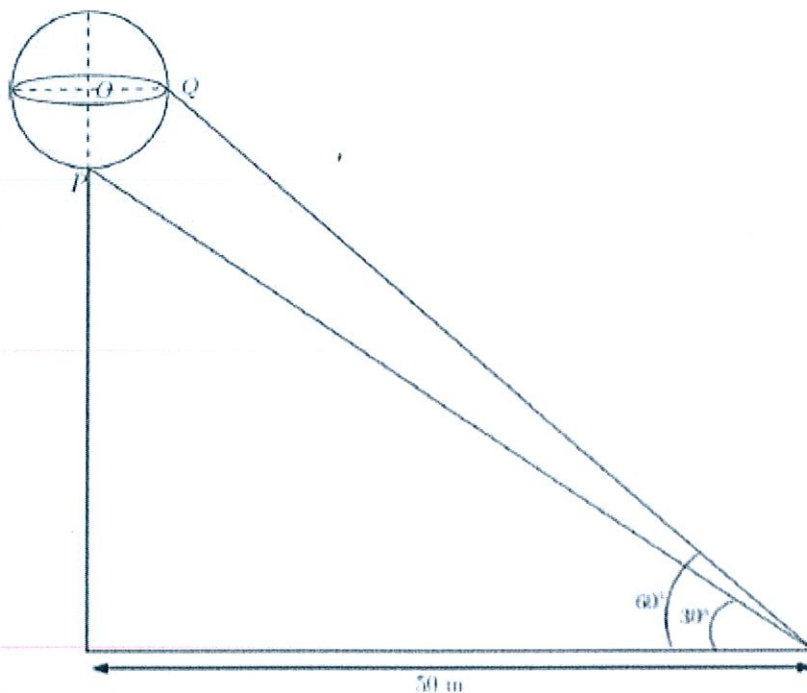
Let  $X = \{x \in \mathbb{R} : \cos(\sin x) = \sin(\cos x)\}$ . The number of elements in  $X$  is

- A. 0                      B. 2                      C. 4                      D. not finite

Question Number : 10

A sphere with centre  $O$  sits atop a pole as shown in the figure. An observer on the ground is at a distance  $50m$  from the foot of the pole. She notes that the angles of elevation from the observer to points  $P$  and  $Q$  on the sphere are  $30^\circ$  and  $60^\circ$ , respectively. Then, the radius of the sphere in meters is

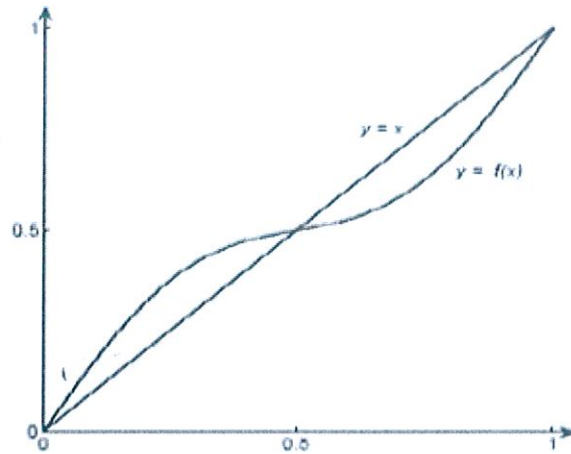
- A.  $100 \left(1 - \frac{1}{\sqrt{3}}\right)$                       B.  $\frac{50\sqrt{6}}{3}$   
C.  $50 \left(1 - \frac{1}{\sqrt{3}}\right)$                       D.  $\frac{100\sqrt{6}}{3}$



Question Number : 11

The graph of the function  $f(x) = x + \frac{1}{8}\sin(2\pi x)$ ,  $0 \leq x \leq 1$  is shown below. Define

$$f_1(x) = f(x), \quad f_{n+1}(x) = f(f_n(x)), \quad \text{for } n \geq 1.$$



Which of the following statements are true?

- I. There are infinitely many  $x \in [0,1]$  for which  $\lim_{n \rightarrow \infty} f_n(x) = 0$ .
- II. There are infinitely many  $x \in [0,1]$  for which  $\lim_{n \rightarrow \infty} f_n(x) = \frac{1}{2}$ .
- III. There are infinitely many  $x \in [0,1]$  for which  $\lim_{n \rightarrow \infty} f_n(x) = 1$ .
- IV. There are infinitely many  $x \in [0,1]$  for which  $\lim_{n \rightarrow \infty} f_n(x)$  does not exist.

- A. I and III only
- B. II only
- C. I, II, III only
- D. I, II, III and IV

Question Number : 12

The limit  $\lim_{x \rightarrow \infty} x^2 \int_0^x e^{t^3 - x^3} dt$  equals

- A.  $\frac{1}{3}$
- B. 2
- C.  $\infty$
- D.  $\frac{2}{3}$

Question Number : 13

The polynomial equation  $x^3 - 3ax^2 + (27a^2 + 9)x + 2016 = 0$  has

- A. exactly one real root for any real  $a$
- B. three real roots for any real  $a$
- C. three real roots for any  $a \geq 0$ , and exactly one real root for any  $a < 0$
- D. three real roots for any  $a \leq 0$ , and exactly one real root for any  $a > 0$

Question Number : 14

The area of the region bounded by the curve  $y = |x^3 - 4x^2 + 3x|$  and the  $x$ -axis,  $0 \leq x \leq 3$ , is

- A.  $\frac{37}{6}$
- B.  $\frac{9}{4}$
- C.  $\frac{37}{12}$
- D. 0

Question Number : 15

The number of continuous functions  $f: [0,1] \rightarrow [0,1]$  such that  $f(x) < x^2$  for all  $x$  and  $\int_0^1 f(x) dx = \frac{1}{3}$  is

- A. 0
- B. 1
- C. 2
- D. infinite

Question Number : 16

On the real line  $\mathbb{R}$ , we define two functions  $f$  and  $g$  as follows:

$$f(x) = \min \{x - [x], 1 - x + [x]\},$$

$$g(x) = \max \{x - [x], 1 - x + [x]\},$$

where  $[x]$  denotes the largest integer not exceeding  $x$ . The positive integer  $n$  for which

$$\int_0^n (g(x) - f(x))dx = 100$$

is

- A. 100      B. 198      C. 200      D. 202

Question Number : 17

Let  $\vec{v}$  be a vector in the plane such that  $|\vec{v} - \vec{i}| = |\vec{v} - 2\vec{i}| = |\vec{v} - \vec{j}|$ . Then  $|\vec{v}|$  lies in the interval

- A.  $(0, 1]$       B.  $(1, 2]$       C.  $(2, 3]$       D.  $(3, 4]$

Question Number : 18

A box contains  $b$  blue balls and  $r$  red balls. A ball is drawn randomly from the box and is returned to the box with another ball of the same colour. The probability that the second ball drawn from the box is blue is

- A.  $\frac{b}{r+b}$       B.  $\frac{b^2}{(r+b)^2}$   
C.  $\frac{b+1}{r+b+1}$       D.  $\frac{b(b+1)}{(r+b)(r+b+1)}$

The number of noncongruent integer-sided triangles whose sides belong to the set  $\{10, 11, 12, \dots, 22\}$  is

- A. 283                      B. 446                      C. 448                      D. 449

Question Number : 20

Suppose we have to cover the  $xy$ -plane with identical tiles such that no two tiles overlap and no gap is left between the tiles. Suppose that we can choose tiles of the following shapes: equilateral triangle, square, regular pentagon, regular hexagon. Then the tiling can be done with tiles of

- A. all four shapes  
B. exactly three of the four shapes  
C. exactly two of the four shapes  
D. exactly one of the four shapes



Question Number : 21

Physical processes are sometimes described visually by lines. Only the following can cross:

- A. Streamlines in fluid flow.
- B. Lines of forces in electrostatics.
- C. Rays in geometrical optics.
- D. Lines of force in magnetism.

Question Number : 22

A uniform ring of radius  $R$  is moving on a horizontal surface with speed  $v$  and then climbs up a ramp of inclination  $30^\circ$  to a height  $h$ . There is no slipping in the entire motion. Then  $h$  is

- A.  $v^2/2g$
- B.  $v^2/g$
- C.  $3v^2/2g$
- D.  $2v^2/g$

Question Number : 23

A gas at initial temperature  $T$  undergoes sudden expansion from volume  $V$  to  $2V$ . Then

- A. the process is adiabatic.
- B. the process is isothermal.
- C. the work done in this process is  $nRT \ln_e(2)$  where  $n$  is the number of moles of the gas.
- D. the entropy in the process does not change.

Photons of wavelength  $\lambda$  are incident on a metal. The most energetic electrons ejected from the metal are bent into a circular arc of radius  $R$  by a perpendicular magnetic field having a magnitude  $B$ . The work function of the metal is (where symbols have their usual meanings)

A.  $\frac{hc}{\lambda} - m_e c^2 + \frac{e^2 B^2 R^2}{2m_e}$

B.  $\frac{hc}{\lambda} + 2m_e \left(\frac{eBR}{2m_e}\right)^2$

C.  $\frac{hc}{\lambda} - m_e c^2 - \frac{e^2 B^2 R^2}{2m_e}$

D.  $\frac{hc}{\lambda} - 2m_e \left(\frac{eBR}{2m_e}\right)^2$

Question Number : 25

A container is divided into two equal parts I and II by a partition with a small hole of diameter  $d$ . The two partitions are filled with same ideal gas, but held at temperatures  $T_I = 150$  K and  $T_{II} = 300$  K by connecting to heat reservoirs. Let  $\lambda_I$  and  $\lambda_{II}$  be the mean free paths of the gas particles in the two parts such that  $d \gg \lambda_I$  and  $d \gg \lambda_{II}$ . Then  $\lambda_I/\lambda_{II}$  is close to

A. 0.25

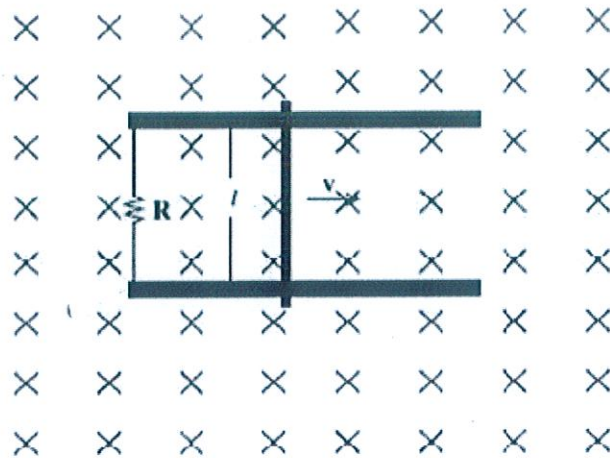
B. 0.5

C. 0.7

D. 1.0

Question Number : 26

A conducting bar of mass  $m$  and length  $l$  moves on two frictionless parallel rails in the presence of a constant uniform magnetic field of magnitude  $B$  directed into the page as shown in the figure. The bar is given an initial velocity  $v_0$  towards the right at  $t = 0$ . Then the



- A. induced current in the circuit is in the clockwise direction.
- B. velocity of the bar decreases linearly with time.
- C. distance the bar travels before it comes to a complete stop is proportional to  $R$ .
- D. power generated across the resistance is proportional to  $l$ .

Question Number : 27

A particle with total mechanical energy, which is small and negative, is under the influence of a one dimensional potential  $U(x) = x^4/4 - x^2/2$  J where  $x$  is in meters. At time  $t = 0$  s, it is at  $x = -0.5$  m. Then at a later time it can be found

- A. anywhere on the  $x$  axis.
- B. between  $x = -1.0$  m to  $x = 1.0$  m.
- C. between  $x = -1.0$  m to  $x = 0.0$  m.
- D. between  $x = 0.0$  m to  $x = 1.0$  m.

Question Number : 28

A nurse measures the blood pressure of a seated patient to be 190 mm of Hg.

- A. the blood pressure at the patient's feet is less than 190 mm of Hg.
- B. the actual pressure is about 0.25 times the atmospheric pressure.
- C. the blood pressure at the patient's neck is more than 190 mm of Hg.
- D. the actual pressure is about 1.25 times the atmospheric pressure.

Question Number : 29

A particle at a distance of 1 m from the origin starts moving such that  $dr/d\theta = r$ , where  $(r, \theta)$  are polar coordinates. Then the angle between resultant velocity and tangential velocity component is

- A. 30 degrees.
- B. 45 degrees.
- C. 60 degrees.
- D. dependent on where the particle is.

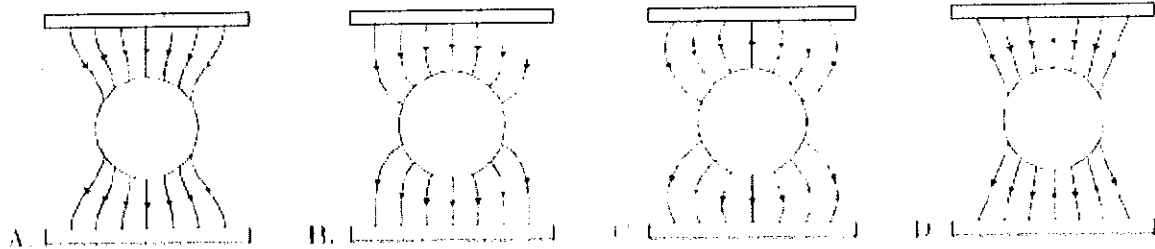
Question Number : 30

Electrons accelerated from rest by an electrostatic potential are collimated and sent through a Young's double slit setup. The fringe width is  $w$ . If the accelerating potential is doubled then the width is now close to

- A.  $0.5 w$
- B.  $0.7 w$
- C.  $1.0 w$
- D.  $2.0 w$

Question Number : 31

A metallic sphere is kept in between two oppositely charged plates. The most appropriate representation of the field lines is



Question Number : 32

An electron with kinetic energy  $E$  collides with a hydrogen atom in the ground state. The collision will be elastic

- A. for all values of  $E$ .
- B. for  $E < 10.2$  eV.
- C. for  $10.2$  eV  $< E < 13.6$  eV only.
- D. for  $0 < E < 3.4$  eV only.

Question Number : 33

The continuous part of X-ray spectrum is a result of the

- A. photoelectric effect.
- B. Raman effect.
- C. Compton effect.
- D. inverse photoelectric effect.

Question Number : 34

Thermal expansion of a solid is due to the

- A. symmetric characteristic of the inter atomic potential energy curve of the solid.
- B. asymmetric characteristic of the inter atomic potential energy curve of the solid.
- C. double well nature of the inter-atomic potential energy curve of the solid.
- D. rotational motion of the atoms of the solid.

Question Number : 35

An electron and a photon have same wavelength of  $10^{-9}$  m. If  $E$  is the energy of the photon and  $p$  is the momentum of the electron, the magnitude of  $E/p$  in SI units is

- A.  $1.00 \times 10^{-9}$
- B.  $1.50 \times 10^8$
- C.  $3.00 \times 10^8$
- D.  $1.20 \times 10^7$

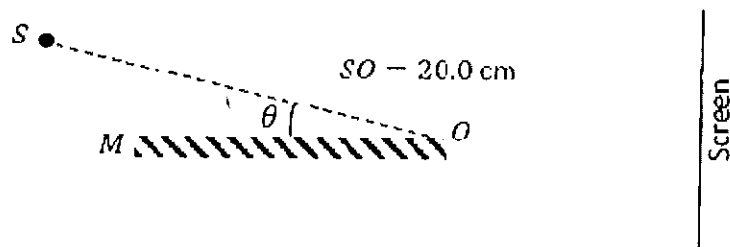
Question Number : 36

If one takes into account finite mass of the proton, the correction to the binding energy of the hydrogen atom is approximately (mass of proton =  $1.60 \times 10^{-27}$  kg, mass of electron =  $9.10 \times 10^{-31}$  kg)

- A. 0.06%
- B. 0.0006%
- C. 0.02%
- D. 0.00%

Question Number : 37

A monochromatic light source  $S$  of wavelength  $440 \text{ nm}$  is placed slightly above a plane mirror  $M$  as shown. Image of  $S$  in  $M$  can be used as a virtual source to produce interference fringes on the screen. The distance of source  $S$  from  $O$  is  $20.0 \text{ cm}$ , and the distance of screen from  $O$  is  $100.0 \text{ cm}$  (figure is not to scale). If the angle  $\theta = 0.50 \times 10^{-3}$  radians, the width of the interference fringes observed on the screen is



- A.  $2.20 \text{ mm}$
- B.  $2.64 \text{ mm}$
- C.  $1.10 \text{ mm}$
- D.  $0.55 \text{ mm}$

Question Number : 38

A nuclear fuel rod generates energy at a rate of  $5 \times 10^8 \text{ Watt/m}^3$ . It is in the shape of a cylinder of radius  $4.0 \text{ mm}$  and length  $0.20 \text{ m}$ . A coolant of specific heat  $4 \times 10^3 \text{ J/(kg-K)}$  flows past it at a rate of  $0.2 \text{ kg/s}$ . The temperature rise in this coolant is approximately

- A.  $2^\circ \text{ C}$
- B.  $6^\circ \text{ C}$
- C.  $12^\circ \text{ C}$
- D.  $30^\circ \text{ C}$

A hearing test is conducted on an aged person. It is found that her threshold of hearing is 20 decibels at 1 kHz and it rises linearly with frequency to 60 decibels at 9 kHz. The minimum intensity of sound that the person can hear at 5 kHz is

- A. 10 times than that at 1 kHz
- B. 100 times than that at 1 kHz
- C. 0.5 times than that at 9 kHz
- D. 0.05 times than that at 9 kHz

Question Number : 40

Two infinitely long parallel wires carry currents of magnitude  $I_1$  and  $I_2$  and are at a distance 4 cm apart. The magnitude of the net magnetic field is found to reach a non-zero minimum value between the two wires and 1 cm away from the first wire. The ratio of the two currents and their mutual direction is

- A.  $\frac{I_2}{I_1} = 9$ , antiparallel
- B.  $\frac{I_2}{I_1} = 9$ , parallel
- C.  $\frac{I_2}{I_1} = 3$ , antiparallel
- D.  $\frac{I_2}{I_1} = 3$ , parallel



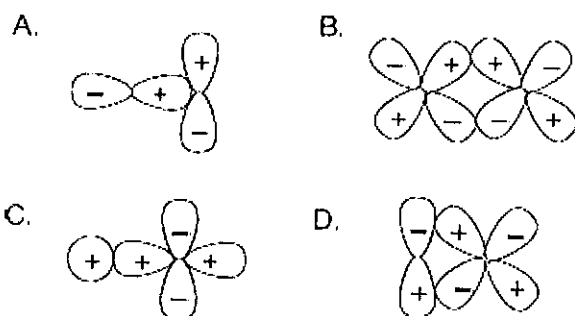
Question Number : 41

The shape of  $\text{SCl}_4$  is best described as a

- A. square
- B. tetrahedron
- C. square pyramid
- D. see-saw

Question Number : 42

Among the following atomic orbital overlaps, the non-bonding overlap is



Question Number : 43

Among the following complexes, the one that can exhibit optical activity is

- A.  $[\text{CoCl}_6]^{3-}$
- B.  $[\text{Co}(\text{en})\text{Cl}_4]^-$
- C.  $\text{cis}-[\text{Co}(\text{en})_2\text{Cl}_2]^+$
- D.  $\text{trans}-[\text{Co}(\text{en})_2\text{Cl}_2]^+$

Question Number : 44

The  $pK_a$  of oxoacids of chlorine in water follows the order

- A.  $\text{HClO} < \text{HClO}_3 < \text{HClO}_2 < \text{HClO}_4$
- B.  $\text{HClO}_4 < \text{HClO}_3 < \text{HClO}_2 < \text{HClO}$
- C.  $\text{HClO}_4 < \text{HClO}_2 < \text{HClO}_3 < \text{HClO}$
- D.  $\text{HClO}_2 < \text{HClO} < \text{HClO}_3 < \text{HClO}_4$

Question Number : 45

The packing efficiency of the face centered cubic (fcc), body centered cubic (bcc) and simple/primitive cubic (pc) lattices follows the order

- A.  $\text{fcc} > \text{bcc} > \text{pc}$
- B.  $\text{bcc} > \text{fcc} > \text{pc}$
- C.  $\text{pc} > \text{bcc} > \text{fcc}$
- D.  $\text{bcc} > \text{pc} > \text{fcc}$

Question Number : 46

The ratio of root mean square velocity of hydrogen at 50 K to that of nitrogen at 500 K is closest to

- A. 1.18
- B. 0.85
- C. 0.59
- D. 1.40

Question Number : 47

The molecule with the highest dipole moment among the following is

- A.  $\text{NH}_3$
- B.  $\text{NF}_3$
- C.  $\text{CO}$
- D.  $\text{HF}$

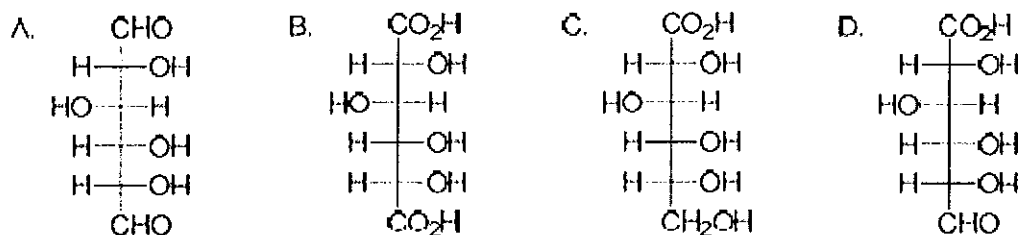
Question Number : 48

The most stable Lewis acid-base adduct among the following is

- A.  $\text{H}_2\text{O} \rightarrow \text{BCl}_3$
- B.  $\text{H}_2\text{S} \rightarrow \text{BCl}_3$
- C.  $\text{H}_3\text{N} \rightarrow \text{BCl}_3$
- D.  $\text{H}_3\text{P} \rightarrow \text{BCl}_3$

Question Number : 49

The reaction of D-glucose with ammoniacal  $\text{AgNO}_3$  produces



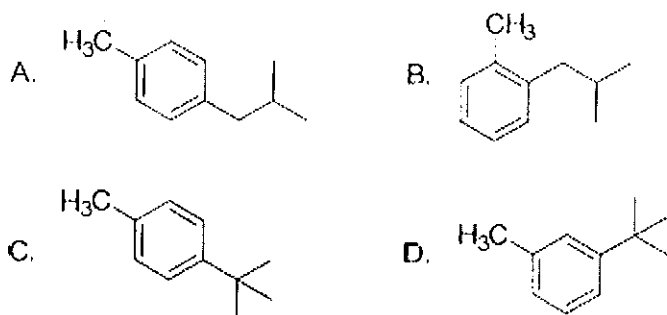
Question Number : 50

The reagent(s) used for the conversion of benzene diazonium hydrogensulfate to benzene is/are

- A.  $\text{H}_2\text{O}$
- B.  $\text{H}_3\text{PO}_2 + \text{H}_2\text{O}$
- C.  $\text{H}_2\text{SO}_4 + \text{H}_2\text{O}$
- D.  $\text{CuCl}/\text{HCl}$

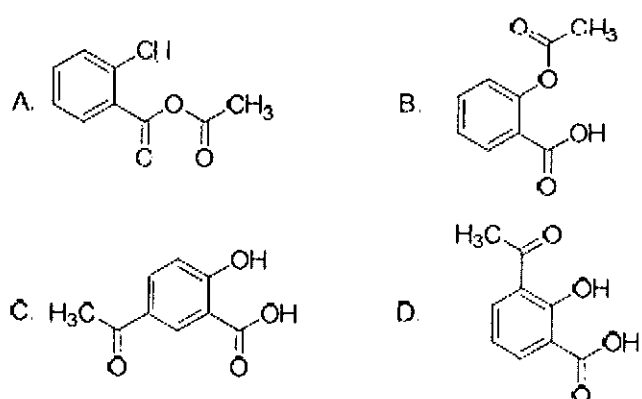
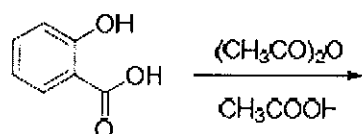
Question Number : 51

The major product obtained in the reaction of toluene with 1-bromo-2-methyl propane in the presence of anhydrous  $AlCl_3$  is



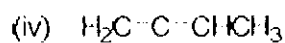
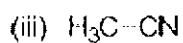
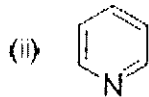
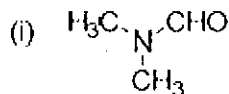
Question Number : 52

The major product in the following reaction is



Question Number : 53

The compounds containing  $sp$  hybridized carbon atom are



- A. (i) and (ii)  
B. (iii) and (iv)  
C. (ii) and (iii)  
D. (i) and (iv)

Question Number : 54

Upon heating with acidic  $\text{KMnO}_4$ , an organic compound produces hexan-1,6-dioic acid as the major product. The starting compound is

- A. benzene  
B. cyclohexene  
C. 1-methylcyclohexene  
D. 2-methylcyclohexene

Question Number : 55

It takes 1 h for a first order reaction to go to 50% completion. The total time required for the same reaction to reach 87.5% completion will be

- A. 1.75 h
- B. 6.00 h
- C. 3.50 h
- D. 3.00 h

Question Number : 56

A unit cell of calcium fluoride has four calcium ions. The number of fluoride ions in the unit cell is

- A. 2
- B. 4
- C. 6
- D. 8

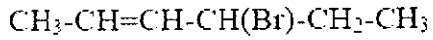
Question Number : 57

The equilibrium constant of a 2 electron redox reaction at 298 K is  $3.8 \times 10^{-3}$ . The cell potential  $E^0$  (in V) and the free energy change  $\Delta G^0$  (in  $\text{kJ mol}^{-1}$ ) for this equilibrium, respectively, are

- A.  $-0.071, -13.8$
- B.  $-0.071, 13.8$
- C.  $0.71, -13.8$
- D.  $0.071, -13.8$

Question Number : 58

The number of stereoisomers possible for the following compound is



- A. 2
- B. 3
- C. 4
- D. 8

Question Number : 59

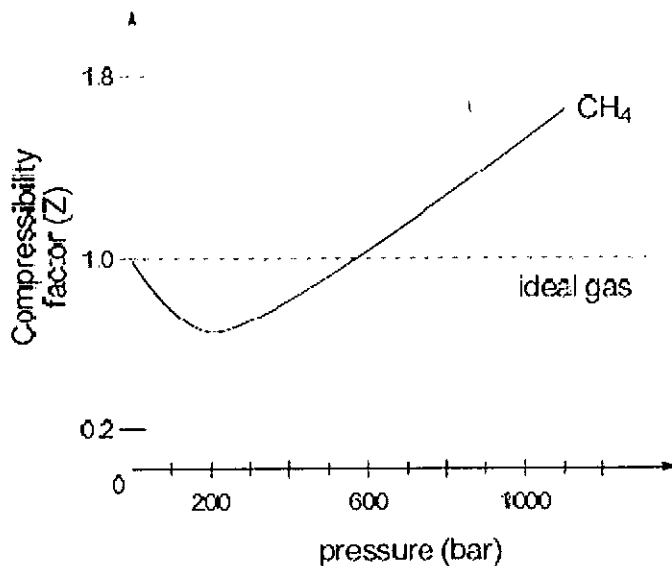
In the radioactive disintegration series  ${}_{90}^{232}\text{Th} \rightarrow {}_{82}^{208}\text{Pb}$ , involving  $\alpha$  and  $\beta$  decay, the total number of  $\alpha$  and  $\beta$  particles emitted are

- A. 6  $\alpha$  and 6  $\beta$
- B. 6  $\alpha$  and 4  $\beta$
- C. 6  $\alpha$  and 5  $\beta$
- D. 5  $\alpha$  and 6  $\beta$



Question Number : 60

In the following compressibility factor ( $Z$ ) vs. pressure graph at 300 K, the compressibility of  $\text{CH}_4$  at pressures  $< 200$  bar deviates from ideal behaviour because



- A. the molar volume of  $\text{CH}_4$  is less than its molar volume in the ideal state
- B. the molar volume of  $\text{CH}_4$  is same as that in its ideal state
- C. intermolecular interactions between  $\text{CH}_4$  molecules decreases
- D. the molar volume of  $\text{CH}_4$  is more than its molar volume in the ideal state

Part I Biology

Question Number : 61

Which of the following molecules is a primary acceptor of  $\text{CO}_2$  in photosynthesis?

- A. Pyruvate
- B. 3-phosphoglycerate
- C. Phosphoenol pyruvate
- D. Oxaloacetate

Question Number : 62

Which one of the following pairs of molecules **NEVER** forms a hydrogen bond between them?

- A. Water and water
- B. Water and glucose
- C. Water and ethanol
- D. Water and octane

Question Number : 63

Lactase hydrolyses lactose into

- A. glucose + glucose
- B. glucose + galactose
- C. galactose + galactose
- D. galactose + fructose

Question Number : 64

Which of the following statements is **INCORRECT** regarding biological membrane?

- A. It is composed of lipids and proteins
- B. Peripheral proteins are loosely associated with the membrane
- C. Integral proteins span the lipid bilayer
- D. Lipids and membrane proteins do not provide structural and functional asymmetry

Question Number : 65

The percentage of sunlight captured by plants is

- A. 2-10%
- B. 10-20%
- C. 60-80%
- D. 100%

Question Number : 66

The hard outer layer of pollens, named exine, is made of

- A. cellulose
- B. tapetum
- C. sporopollenin
- D. pectin

Question Number : 67

Insectivorous plants such as Venus fly trap catch and digest insects in order to supplement the deficiency of

- A. sulphur
- B. nitrogen
- C. potassium
- D. phosphorus

Question Number : 68

Which of the following statements about nucleosome is TRUE?

- A. It consists of only DNA.
- B. It is a nucleus-like structure found in prokaryotes.
- C. It consists of DNA and proteins.
- D. It consists of only histone proteins.

Question Number : 69

Epithelial cells in animals are held by specialized junctions, one of them being "Gap junction". Function of a "Gap junction" is to

- A. facilitate cell-cell communication by rapid transfer of small molecules
- B. cement the neighbouring cells
- C. stop substances from leaking
- D. provide gaps in the tissue to facilitate uptake of small molecules across tissues

Question Number : 70

Which of the following statements is TRUE about glandular epithelium in salivary gland?

- A. It consists of isolated single cells.
- B. It consists of multicellular cluster of cells.
- C. Its secretions are endocrine.
- D. It consists of squamous epithelial cells.

Question Number : 71

Which one of the following ion pairs is involved in nerve impulses?

- A.  $\text{Na}^+$ ,  $\text{K}^+$
- B.  $\text{Na}^+$ ,  $\text{Cl}^-$
- C.  $\text{K}^+$ ,  $\text{Cl}^-$
- D.  $\text{K}^+$ ,  $\text{Ca}^{2+}$

Question Number : 72

Which of the following hormones that controls blood pressure is secreted by human heart?

- A. Erythropoetin
- B. Atrial natriuretic factor
- C. ACTH
- D. Glucocorticoid

Question Number : 73

Oxytocin and vasopressin are synthesized in

- A. hypothalamus
- B. adrenal gland
- C. pituitary gland
- D. ovary

Question Number : 74

If you exhale multiple times into a conical flask containing lime water through a single inlet fixed through a stop cork, lime water will

- A. become cooler
- B. turn milky
- C. remain unchanged
- D. turn yellow

Question Number : 75

The path of passage of stimulus when you accidentally touch a hotplate is

- A. receptor → brain → muscles
- B. muscles → spinal cord → receptor
- C. muscles → brain → receptor
- D. receptor → spinal cord → muscles

Question Number : 76

In the presence of glucose and lactose, *Escherichia coli* utilizes glucose. However, lactose also enters the cells because

- A. low level of permease is always present in the cell
- B. it uses the same transporter as glucose
- C. it diffuses through the bacterial cell membrane
- D. it is transported through porins

Question Number : 77

Passive immunization is achieved by administering

- A. heat killed vaccines
- B. toxoids
- C. live attenuated vaccines
- D. antibodies

Question Number : 78

Which of the following anions neutralize the acidic pH of the chyme that enters into the duodenum from the stomach?

- A.  $\text{H}_2\text{PO}_4^-$
- B.  $\text{HSO}_4^-$
- C.  $\text{HCO}_3^-$
- D.  $\text{CH}_3\text{COO}^-$

Question Number : 79

If  $^{14}\text{CO}_2$  is added to a suspension of photosynthesizing chloroplasts, which of the following will be the first compound to be radioactive?

- A. ATP
- B. NADPH
- C. NADH
- D. 3-phospho glycerate

Question Number : 80

Which of the following species makes the largest true flower in the world?

- A. *Amorphophallus titanum*
- B. *Rafflesia arnoldii*
- C. *Nelumbo nucifera*
- D. *Helianthus annuus*



## Question Number : 81

The remainder when the polynomial  $1 + x^2 + x^4 + x^6 + \dots + x^{22}$  is divided by  $1 + x + x^2 + x^3 + \dots + x^{11}$  is

- A. 0  
B. 2  
C.  $1 + x^2 + x^4 + \dots + x^{10}$   
D.  $2(1 + x^2 + x^4 + \dots + x^{10})$

## Question Number : 82

The range of the polynomial  $p(x) = 4x^3 - 3x$  as  $x$  varies over the interval  $(-\frac{1}{2}, \frac{1}{2})$  is

- A.  $[-1, 1]$   
B.  $(-1, 1]$   
C.  $(-1, 1)$   
D.  $(-\frac{1}{2}, \frac{1}{2})$

## Question Number : 83

Ten ants are on the real line. At time  $t = 0$ , the  $k$ -th ant starts at the point  $k^2$  and travelling at uniform speed, reaches the point  $(11 - k)^2$  at time  $t = 1$ . The number of distinct times at which at least two ants are at the same location is

- A. 45  
B. 11  
C. 17  
D. 9



Question Number : 86

Let  $f(x)$  be a non-negative differentiable function on  $[0, \infty)$  such that  $f(0) = 0$  and  $f'(x) \leq 2f(x)$  for all  $x > 0$ . Then, on  $[0, \infty)$ ,

- A.  $f(x)$  is always a constant function
- B.  $f(x)$  is strictly increasing
- C.  $f(x)$  is strictly decreasing
- D.  $f'(x)$  changes sign

Question Number : 87

For each positive real number  $\lambda$ , let  $A_\lambda$  be the set of all natural numbers  $n$  such that  $|\sin(\sqrt{n+1}) - \sin(\sqrt{n})| < \lambda$ . Let  $A_\lambda^c$  be the complement of  $A_\lambda$  in the set of all natural numbers. Then

- A.  $A_{\frac{1}{2}}, A_{\frac{1}{3}}, A_{\frac{2}{5}}$  are all finite sets
- B.  $A_{\frac{1}{3}}$  is a finite set but  $A_{\frac{1}{2}}, A_{\frac{2}{5}}$  are infinite sets
- C.  $A_{\frac{1}{2}}^c, A_{\frac{1}{3}}^c, A_{\frac{2}{5}}^c$  are all finite sets
- D.  $A_{\frac{1}{3}}, A_{\frac{2}{5}}$  are finite sets and  $A_{\frac{1}{2}}$  is an infinite set

Let  $f$  be a continuous function defined on  $[0,1]$  such that

$$\int_0^1 f^2(x) dx = \left( \int_0^1 f(x) dx \right)^2. \text{ Then the range of } f$$

- A. has exactly two points
- B. has more than two points
- C. is the interval  $[0,1]$
- D. is a singleton

Question Number : 89

Three schools send 2, 4 and 6 students, respectively, to a summer camp. The 12 students must be accommodated in 6 rooms numbered 1, 2, 3, 4, 5, 6 in such a way that each room has exactly 2 students and both from the same school. The number of ways, the students can be accommodated in the rooms is

- A. 60
- B. 45
- C. 32400
- D. 2700

Question Number : 90

Let  $a$  be a fixed nonzero complex number with  $|a| < 1$  and

$$w = \left( \frac{z - a}{1 - \bar{a}z} \right),$$

where  $z$  is a complex number. Then

- A. there exists a complex number  $z$  with  $|z| < 1$  such that  $|w| > 1$
- B.  $|w| > 1$  for all  $z$  such that  $|z| < 1$
- C.  $|w| < 1$  for all  $z$  such that  $|z| < 1$
- D. there exists  $z$  such that  $|z| < 1$  and  $|w| = 1$

## Question Number : 91

A light balloon filled with helium of density  $\rho_{\text{He}}$  is tied to a long light string of length  $l$  and the string is attached to the ground. If the balloon is displaced slightly in the horizontal direction from the equilibrium and released then:

- A. The balloon undergoes simple harmonic motion with period  $2\pi \sqrt{\left(\frac{\rho_{\text{air}}}{\rho_{\text{air}} - \rho_{\text{He}}}\right) \frac{l}{g}}$ .
- B. The balloon undergoes simple harmonic motion with period  $2\pi \sqrt{\left(\frac{\rho_{\text{air}} - \rho_{\text{He}}}{\rho_{\text{air}}}\right) \frac{l}{g}}$ .
- C. The balloon undergoes simple harmonic motion with period  $2\pi \sqrt{\left(\frac{\rho_{\text{He}}}{\rho_{\text{air}} - \rho_{\text{He}}}\right) \frac{l}{g}}$ .
- D. The balloon undergoes conical oscillations with period  $2\pi \sqrt{\left(\frac{\rho_{\text{air}} + \rho_{\text{He}}}{\rho_{\text{air}} - \rho_{\text{He}}}\right) \frac{l}{g}}$ .

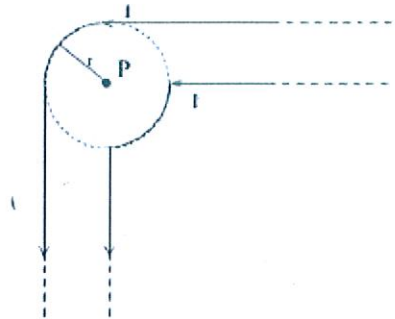
## Question Number : 92

Consider a cube of uniform charge density  $\rho$ . The ratio of electrostatic potential at the centre of the cube to that at one of the corners of the cube is

- A. 2
- B.  $\sqrt{3}/2$
- C.  $\sqrt{2}$
- D. 1

Question Number : 93

Two infinitely long wires each carrying current  $I$  along the same direction are made into the geometry as shown in the figure. The magnetic field at the point P is



- A.  $\frac{\mu_0 I}{\pi r}$
- B.  $\frac{\mu_0 I}{r} \left( \frac{1}{\pi} + \frac{1}{4} \right)$
- C. Zero
- D.  $\frac{\mu_0 I}{2\pi r}$

Question Number : 94

A photon of wavelength  $\lambda$  is absorbed by an electron confined to a box of length  $\sqrt{(35h\lambda/8mc)}$ . As a result, the electron makes a transition from state  $k = 1$  to the state  $n$ . Subsequently the electron transits from the state  $n$  to the state  $m$  by emitting a photon of wavelength  $\lambda' = 1.75\lambda$ . Then

- A.  $n = 4; m = 2$
- B.  $n = 5; m = 3$
- C.  $n = 6; m = 4$
- D.  $n = 3; m = 1$

Consider two masses with  $m_1 > m_2$  connected by a light inextensible string that passes over a pulley of radius  $R$  and moment of inertia  $I$  about its axis of rotation. The string does not slip on the pulley and the pulley turns without friction. The two masses are released from rest separated by a vertical distance  $2h$ . When the two masses pass each other, the speed of the masses is proportional to

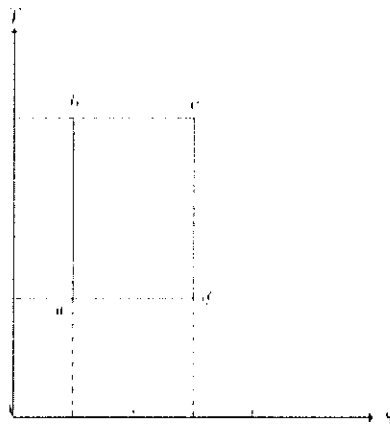
A. 
$$\sqrt{\frac{m_1 - m_2}{m_1 + m_2 + \frac{I}{R^2}}}$$

B. 
$$\sqrt{\frac{(m_1 + m_2)(m_1 - m_2)}{m_1 + m_2 + \frac{I}{R^2}}}$$

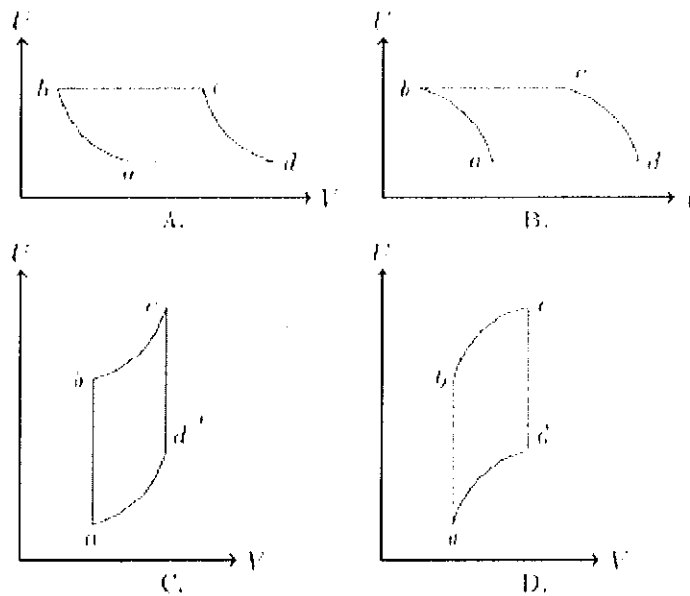
C. 
$$\sqrt{\frac{m_1 + m_2 + \frac{I}{R^2}}{m_1 - m_2}}$$

D. 
$$\sqrt{\frac{\frac{I}{R^2}}{m_1 + m_2}}$$

An ideal gas is taken reversibly around the cycle a-b-c-d-a as shown on the  $T$  (temperature) -  $S$  (entropy) diagram.



The most appropriate representation of above cycle on a  $U$  (internal energy) -  $V$  (volume) diagram is





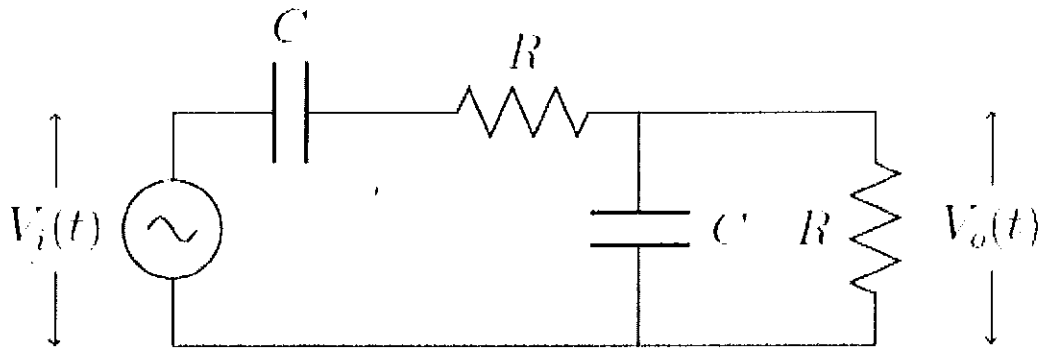
Question Number : 97

The heat capacity of one mole an ideal is found to be  $C_V = 3R(1 + aRT)/2$  where  $a$  is a constant. The equation obeyed by this gas during a reversible adiabatic expansion is

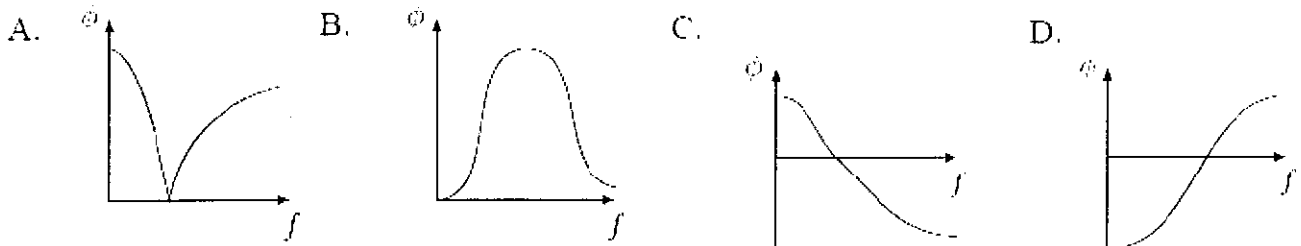
- A.  $TV^{3/2}e^{aRT} = \text{constant}$
- B.  $TV^{3/2}e^{3aRT/2} = \text{constant}$
- C.  $TV^{3/2} = \text{constant}$
- D.  $TV^{3/2}e^{2aRT/3} = \text{constant}$

Question Number : 98

If the input voltage  $V_i$  to the circuit below is given by  $V_i(t) = A \cos(2\pi ft)$ , the output voltage is given by  $V_o(t) = B \cos(2\pi ft + \phi)$ .



Which one of the following four graphs best depict the variation of  $\phi$  vs  $f$ ?

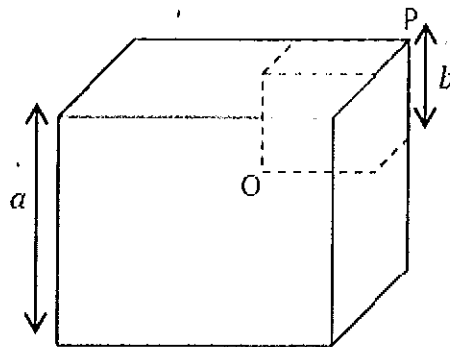


A glass prism has a right-triangular cross section  $ABC$ , with  $\angle A = 90^\circ$ . A ray of light parallel to the hypotenuse  $BC$  and incident on the side  $AB$  emerges grazing the side  $AC$ . Another ray, again parallel to the hypotenuse  $BC$ , incident on the side  $AC$  suffers total internal reflection at the side  $AB$ . Which one of the following must be true about the refractive index  $\mu$  of the material of the prism?

- A.  $\sqrt{\frac{3}{2}} < \mu < \sqrt{2}$   
 B.  $\mu > \sqrt{3}$   
 C.  $\mu < \sqrt{\frac{3}{2}}$   
 D.  $\sqrt{2} < \mu < \sqrt{3}$

Question Number : 100

A smaller cube with side  $b$  (depicted by dashed lines) is excised from a bigger uniform cube with side  $a$  as shown below such that both cubes have a common vertex  $P$ . Let  $X = a/b$ . If the centre of mass of the remaining solid is at the vertex  $O$  of smaller cube then  $X$  satisfies

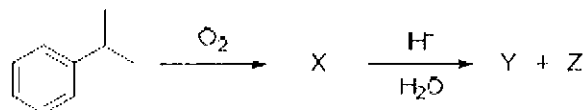


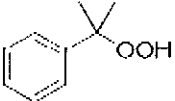


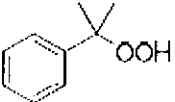
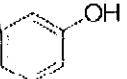

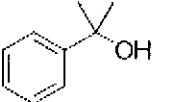
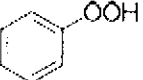

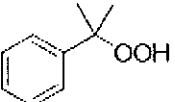
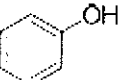

- A.  $X^3 - X^2 - X - 1 = 0$   
 B.  $X^2 - X - 1 = 0$   
 C.  $X^3 + X^2 - X - 1 = 0$   
 D.  $X^3 - X^2 - X + 1 = 0$

## PART-11 Chemistry

Question Number : 101

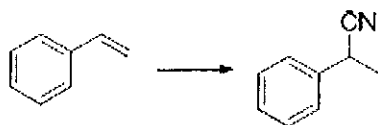
X, Y and Z in the following reaction sequence are



- A.  $X =$    $Y =$    $Z =$  
- B.  $X =$    $Y =$    $Z =$  
- C.  $X =$    $Y =$    $Z =$  
- D.  $X =$    $Y =$    $Z =$  

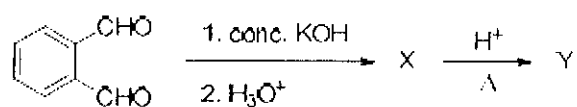
Question Number : 102

The reagents required for the following two-step transformation are

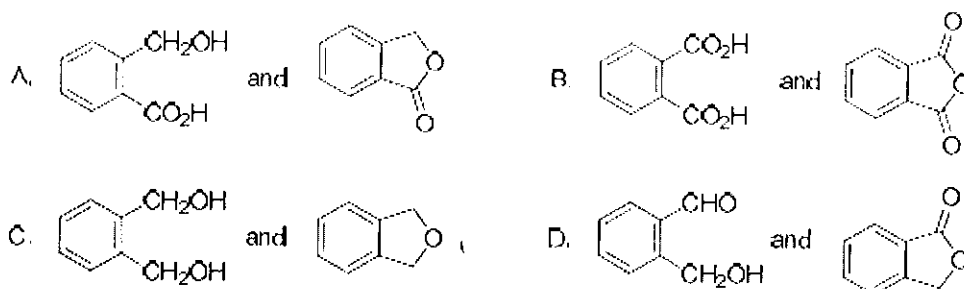


- A. (i) HBr, benzoyl peroxide; (ii)  $\text{CH}_3\text{CN}$
- B. (i) HBr; (ii) NaCN
- C. (i)  $\text{Br}_2$ ; (ii) NaCN
- D. (i) NaBr; (ii) NaCN

In the reaction sequence

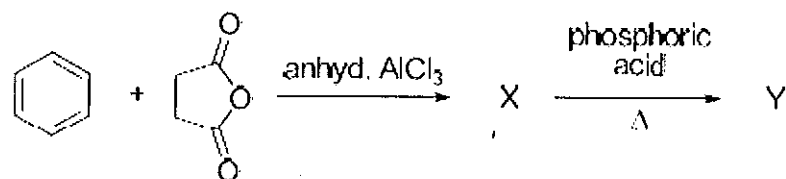


the major products X and Y, respectively, are

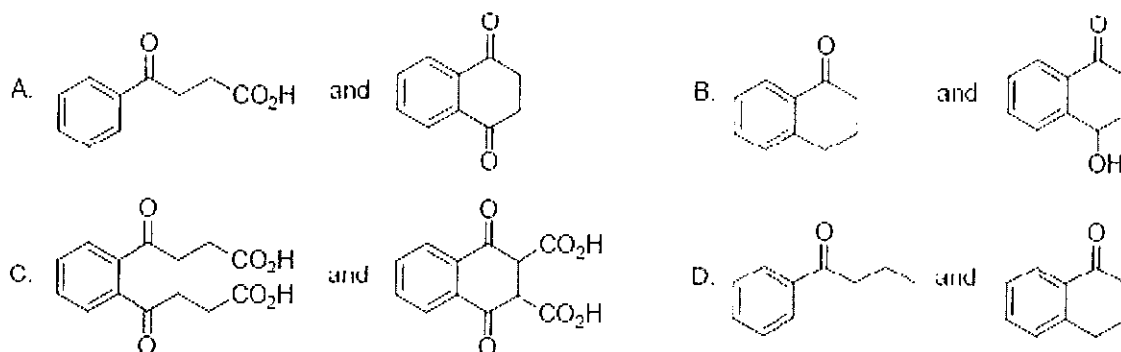


Question Number : 104

In the following reactions



X and Y, respectively, are

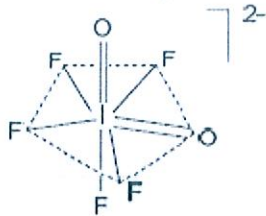




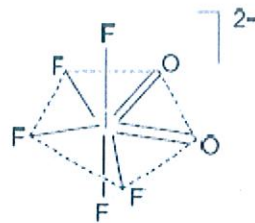
Question Number : 108

The hybridization of the central atom and the shape of  $[\text{IO}_2\text{F}_5]^{2-}$  ion, respectively, are

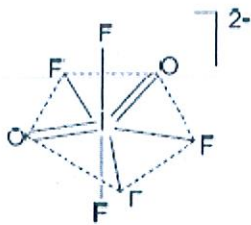
A.  $sp^3d^3$



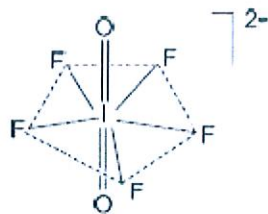
B.  $sp^2d^4$



C.  $sp^2d^4$



D.  $sp^3d^3$



Question Number : 109

2.33 g of compound X (empirical formula  $\text{CoH}_{12}\text{N}_4\text{Cl}_3$ ) upon treatment with excess  $\text{AgNO}_3$  solution produces 1.435 g of a white precipitate. The primary and secondary valences of cobalt in compound X, respectively, are

[Given: Atomic mass: Co = 59, Cl = 35.5, Ag = 108]

A. 3, 6

B. 3, 4

C. 2, 4

D. 4, 3

The specific conductance ( $\kappa$ ) of 0.02 M aqueous acetic acid solution at 298 K is  $1.65 \times 10^{-4} \text{ S cm}^{-1}$ . The degree of dissociation of acetic acid is

[Given: equivalent conductance at infinite dilution of  $\text{H}^+ = 349.1 \text{ S cm}^2 \text{ mol}^{-1}$  and  $\text{CH}_3\text{COO}^- = 40.9 \text{ S cm}^2 \text{ mol}^{-1}$ ]

- A. 0.021
- B. 0.21
- C. 0.012
- D. 0.12

Part II Biology

Question Number : 111

Match the following organelles in Group I with the structures in Group II. Choose the correct combination.

**Group I**

- P. Mitochondrion
- Q. Golgi
- R. Chloroplast
- S. Centrosome

**Group II**

- i. Cisternae
- ii. Cristae
- iii. Thylakoids
- iv. Radial spokes

- A. P-ii, Q-i, R-iii, S-iv
- B. P-iii, Q-i, R-ii, S-iv
- C. P-iv, Q-i, R-ii, S-iii
- D. P-iv, Q-ii, R-i, S-iii

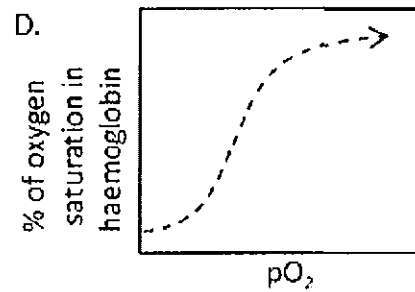
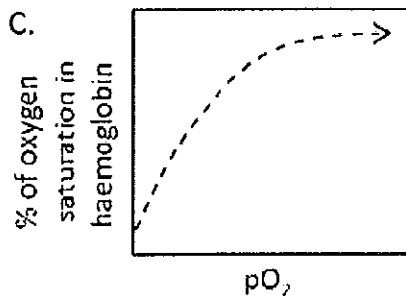
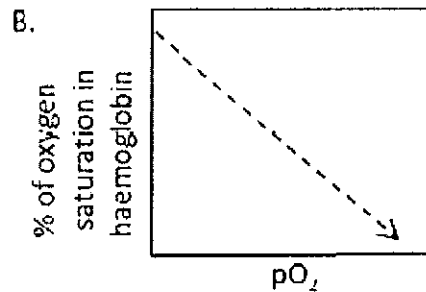
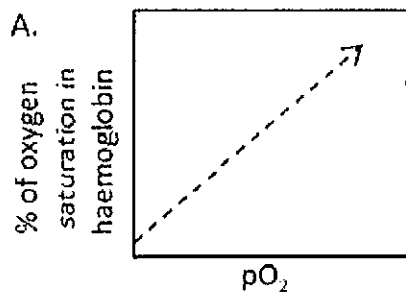
Question Number : 112

A human population containing 200 individuals has two alleles at the 'T' locus, named  $T$  &  $t$ .  $T$ , which produces tall individuals, is dominant over  $t$ , which produces short individuals. If the population has 90  $TT$ , 40  $Tt$  and 70  $tt$  genotypes, what will be the frequencies of these two alleles in this population?

- A.  $T$ , 0.50 :  $t$ , 0.50
- B.  $T$ , 0.55 :  $t$ , 0.45
- C.  $T$ , 0.45 :  $t$ , 0.35
- D.  $T$ , 0.90 :  $t$ , 0.10

Question Number : 113

Which of the following graphs best describes the oxygen dissociation curve where  $pO_2$  is the partial pressure of oxygen?



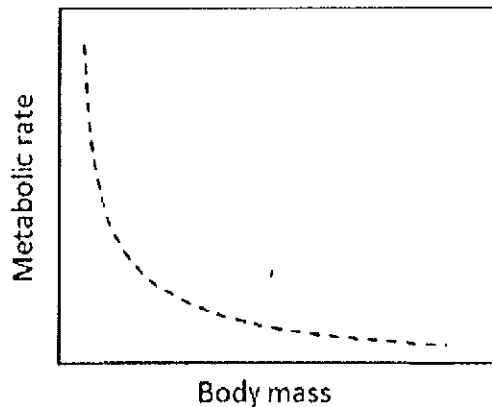


Which of the following best describes the DNA content and the number of chromosomes at the end of S and M phases of the cell cycle in mitosis, if the DNA content of the cell in the beginning of cell cycle (G1 phase) is considered as C and the number of chromosomes 2N?

- A. 2C and 2N for S phase; 2C and 2N for M phase
- B. 2C and N for S phase; 2C and N for M phase
- C. 2C and 2N for S phase; C and 2N for M phase
- D. C and N for S phase; C and 2N for M phase

Question Number : 115

Study the following graph of metabolic rate of various terrestrial mammals as a function of their body mass and choose the correct option below.



- A. Animals are distributed throughout the curve with the smaller animals towards the left and progressively bigger animals towards the right.
- B. The smaller animals below a certain critical mass cluster at the left end of the curve and the larger animals above the critical mass cluster on the right end.
- C. Animals are distributed throughout the curve with the larger animals towards the left and progressively smaller animals towards the right.
- D. The larger animals above a certain critical mass cluster at the left end of the curve and the smaller animals below the critical mass cluster on the right end.

Question Number : 116

Match the human disorders shown in Group I with the biochemical processes in Group II. Choose the correct combination.

**Group I**

- P. Phenylketonuria
- Q. Albinism
- R. Homocystinuria
- S. Argininemia

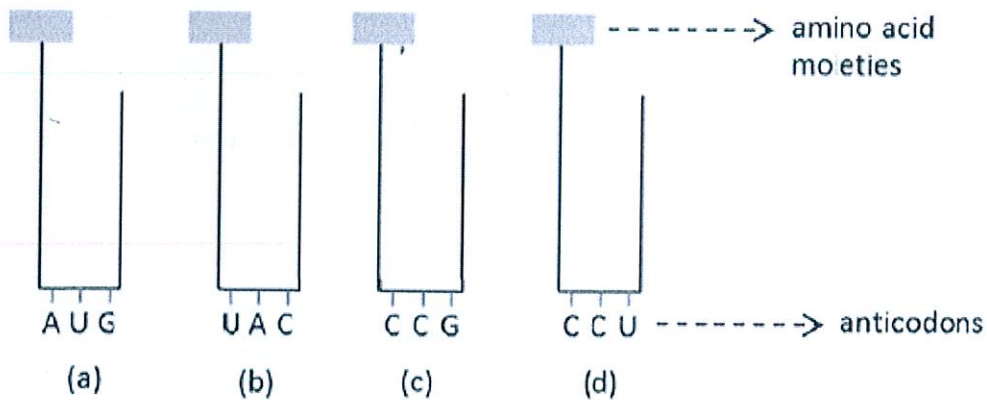
**Group II**

- i. Melanin synthesis
- ii. Conversion of Phenylalanine to Tyrosine
- iii. Tyrosine degradation
- iv. Methionine metabolism
- v. Urea Synthesis

- A. P-ii, Q-i, R-iv, S-v
- B. P-i, Q-iv, R-ii, S-v
- C. P-ii, Q-i, R-v, S-iii
- D. P-v, Q-iii, R-i, S-ii

Question Number : 117

An mRNA is transcribed from a DNA segment having the base sequence 3'-TACATGGGTCCG-5'. What will be the correct order of binding of the four amino acyl-tRNA complexes given below during translation of this mRNA?



- A. a, b, c, d
- B. b, a, c, d
- C. c, d, a, b
- D. b, a, d, c

Question Number : 118

If the initial number of template DNA molecules in a PCR reaction is 1000, the number of product DNA molecules at the end of 20 cycles will be closest to

- A.  $10^3$
- B.  $10^6$
- C.  $10^9$
- D.  $10^{12}$

Question Number : 119

The allele for black hair (B) is dominant over brown hair (b) and the allele for brown eye (E) is dominant over blue eye (e). Out of the offsprings obtained upon mating a black-haired and brown-eyed individual (BbEe) with a brown-haired and brown-eyed individual (bbEE), the ratio of brown-haired and brown-eyed individuals to black-haired and brown-eyed individuals is

- A. 2:1
- B. 3:1
- C. 1:1
- D. 1:2

In an experiment represented in the schematic below, a plant species was grown in different day and night cycles and its photoperiodic flowering behaviour was noted. This species is a

Light	Dark	Flowering
16 hrs	6 hrs	No flower
16 hrs	7 hrs	No flower
16 hrs	8 hrs	No flower
16 hrs	9 hrs	Flower
16 hrs	10 hrs	Flower
16 hrs	11 hrs	Flower
8 hrs	10 hrs	Flower
10 hrs	10 hrs	Flower
12 hrs	10 hrs	Flower
3 hrs	8 hrs	No flower
10 hrs	8 hrs	No flower
12 hrs	8 hrs	No flower

- A. short day plant and actually measures day length to flower.
- B. short day plant and actually measures night length to flower.
- C. long day plant and actually measures night length to flower.
- D. long day plant and actually measures day length to flower.