

Question Paper

Physics Multiple Correct (Maximum Marks: 32)

Question No. 1

One or More Options Correct Type

The question has multiple options out of which ONE or MORE is/are correct.

Ionization energy of a hydrogen-like ion A is greater than that of another hydrogen-like ion B. Let r , u , E and L represent the radius of the orbit, speed of the electron, energy of the atom and orbital angular momentum of the electron respectively. In ground state choose the incorrect option.

- A. $r_A > r_B$
- B. $u_A > u_B$
- C. $E_A > E_B$
- D. $L_A > L_B$

Question No. 2

One or More Options Correct Type

The question has multiple options out of which ONE or MORE is/are correct.

A thin copper tube of outer radius 0.5 cm carries a liquid flowing at $T = 100^\circ\text{C}$. The copper tube loses heat according to Newton's law with constant of proportionality $3 \times 10^{-3} \text{ cal/cm}^2\text{sec}^\circ\text{C}$. The temperature of surrounding is 20°C . Now we coat a layer with thermal conductivity $2.8 \times 10^{-3} \text{ cal/cm}^\circ\text{Csec}$. The layer is 0.5 cm thick. Assume that outer surface of layer loses heat with same constant of proportionality : (Take : $\ln 2 = 0.7$)

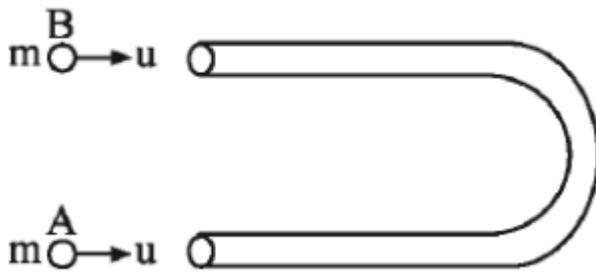
- A. The rate of heat loss becomes $\frac{8}{7}$ times.
- B. The rate of heat loss becomes $\frac{7}{8}$ times.
- C. The temperature T of outer surface of layer is approximately 65.7°C .
- D. The temperature T of outer surface of layer is approximately 42.2°C .

Question No. 3

One or More Options Correct Type

The question has multiple options out of which ONE or MORE is/are correct.

A U shaped smooth tube of mass $2m$ is placed on a smooth horizontal surface. Two identical spherical balls each of mass m and of diameter slightly less than the inner diameter of tube enters into the tube with a velocity u as shown : (Assume no loss of energy anywhere and all collisions to be elastic).



A. Speed of each ball, just before their collision is $\frac{u}{\sqrt{2}}$

At the time of collision, angle between direction of motion of spherical balls

B. A and B is $2\tan^{-1}\sqrt{2}$ as observed in the ground frame

C. Speed of each ball just before their collision is $\frac{\sqrt{3}u}{2}$

At the time collision angle between direction of motion of balls as observed

D. in ground frame is $2\tan^{-1}\sqrt{3}$

Question No. 4

One or More Options Correct Type

The question has multiple options out of which ONE or MORE is/are correct.

A charge distribution generates a radial electric field $\vec{E} = \frac{a}{r^2} e^{-\frac{r}{k}} \hat{r}$, where \hat{r} is distance from the origin, is a unit vector in radial direction away from the origin and a and k are positive constants. The electric field extends around the origin up to a large distance.

The charge that must be located at the origin to create such a field is '

A. $-4\pi\epsilon_0 a$ '

The quantity of charge that must be spread around the charge at origin to

B. create such a field ' $4\pi\epsilon_0 a$ '

The charge that must be located at the origin to create such a field is ' $4\pi\epsilon_0 a$

C. '

The quantity of charge that must be spread around the charge at origin to

D. create such a field ' $-4\pi\epsilon_0 a$ '

Question No. 5

One or More Options Correct Type

The question has multiple options out of which ONE or MORE is/are correct.

Consider a Vernier callipers in which each 1 cm on the main scale is divided into 8 equal divisions and a screw gauge with 100 divisions on its circular scale. In the Vernier callipers, 5 divisions of the Vernier scale coincide with 4 divisions on the main scale and in the screw gauge, one complete rotation of the circular scale moves it by two divisions on the linear scale. Then :

A. The least count of the Vernier callipers is 0.25 mm .

If the pitch of the screw gauge is twice the least count of the Vernier

B. callipers, the least count of the screw gauge is 0.005 mm .

If the least count of the linear scale of the screw gauge is twice the least count of the Vernier callipers, the least count of the screw gauge is

C. 0.01 mm .

If the least count of the linear scale of the screw gauge is twice the least count of the Vernier callipers, the least count of the screw gauge is

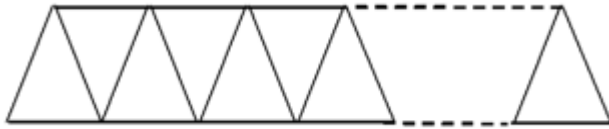
D. 0.005 mm .

Question No. 6

One or More Options Correct Type

The question has multiple options out of which ONE or MORE is/are correct.

n number of identical equilateral prism are kept in contact as shown in figure. If deviation through a single prism is δ . Then - (n, m are integers)



A. If $n = 2m$, deviation through n prisms is zero.

B. If $n = 2m + 1$, deviation through system of n prisms is δ .

C. If $n = 2m$, deviation through system of n prisms is δ .

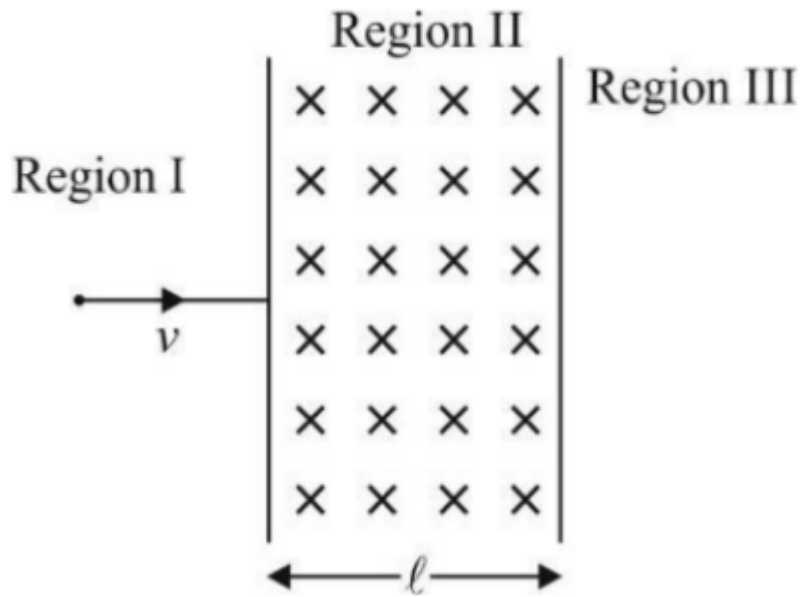
D. If $n = 2m + 1$, deviation through system of n prisms is zero.

Question No. 7

One or More Options Correct Type

The question has multiple options out of which ONE or MORE is/are correct.

A particle of mass m and charge q moving with a velocity V enters region II normal to the boundary as shown in figure. Region II has a uniform magnetic field B perpendicular to the plane of paper and length of region II is ℓ . Choose the correct choice.



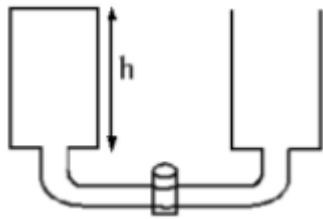
- A. Particle enters region III only if its velocity $v > \frac{B\ell q}{m}$
- B. Particle enters region III only if its velocity $v < \frac{B\ell q}{m}$
- C. Path length of particle in region II is maximum when $v = \frac{B\ell q}{m}$
- D. Time spent in region II is same for any velocity as long as particle returns to region I

Question No. 8

One or More Options Correct Type

The question has multiple options out of which ONE or MORE is/are correct.

Two identical cylindrical tanks are connected by a narrow tube with a cork at its middle (fig). The radius of a tank is $R = 20.0 \text{ cm}$, the radius of the tube is $r = 1.0 \text{ mm}$. The length of the tube is $\ell = 1 \text{ m}$. Water ($\rho = 1000 \text{ kg/m}^3$) is poured into one of the tanks to a height of $h = 50 \text{ cm}$, while the second tank is empty. At the instant $t = 0$, the cork is opened. [Both the tanks are open at top]



(viscosity of water $\eta = 1 \times 10^{-3} \text{ Pa-s}$)

Given poiseuille eqn for volume flow rate of fluid in a tube $\frac{dV}{dt} = \frac{\Delta P \pi r^4}{8\eta L}$

$\Delta P \rightarrow$ pressure difference across ends of the tube

$r \rightarrow$ radius of tube

$L \rightarrow$ length of tube

The difference between the levels of the water in the tanks decreases e times

A. in time $1.6 \times 10^4 \text{ s}$

The difference between the levels of the water in the tanks decreases e times

B. in time $3.2 \times 10^4 \text{ s}$

C. Total mechanical energy of the fluid is conserved during the process

D. Water level in the two containers cannot become equal in a finite time

Physics Numerical (Maximum Marks: 24)

Question No. 1

Numerical Type

The answer has to be filled into the input box provided below.

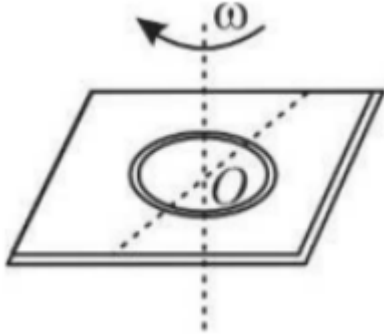
Assume that a frictionless tunnel is made in the earth along its diameter. A particle is projected in the tunnel from the surface of the earth with an initial speed $v_0 = \sqrt{gR}$, where g is acceleration due to gravity on the earth's surface and R is the radius of the earth. If the time taken by the particle to reach the centre of the earth is $\frac{\pi}{n} \sqrt{\frac{4R}{g}}$ the value of n is:

Question No. 2

Numerical Type

The answer has to be filled into the input box provided below.

An uniform ring of mass m is placed on a rough horizontal fixed surface as shown in the figure. The coefficient of friction between the left part of the ring and left part of the horizontal surface is $\mu_1 = 0.6\pi$ and between right half and the surface is $\mu_2 = 0.2\pi$. At the instant shown, now the ring has been imparted an angular velocity in clockwise sense in the figure shown. At this moment magnitude of acceleration of centre O of the ring (in m/s^2) is _____. (Take $g = 10 \text{ m/s}^2$)

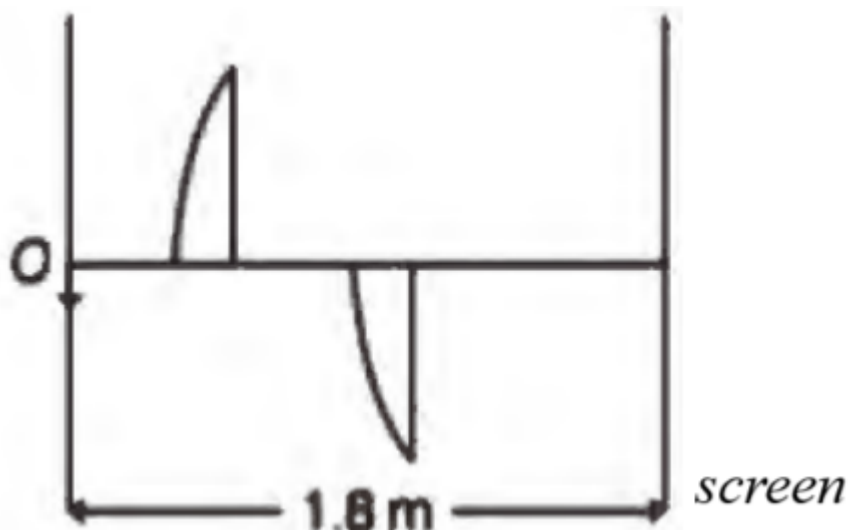


Question No. 3

Numerical Type

The answer has to be filled into the input box provided below.

A thin plano-convex lens of focal length f is split into two halves. One of the halves is shifted along the optical axis. The separation between object and image planes is 1.8 m . The magnification of the image formed by one of the half lens is 2 . Find the separation between the halves (images are formed by both halves at screen).

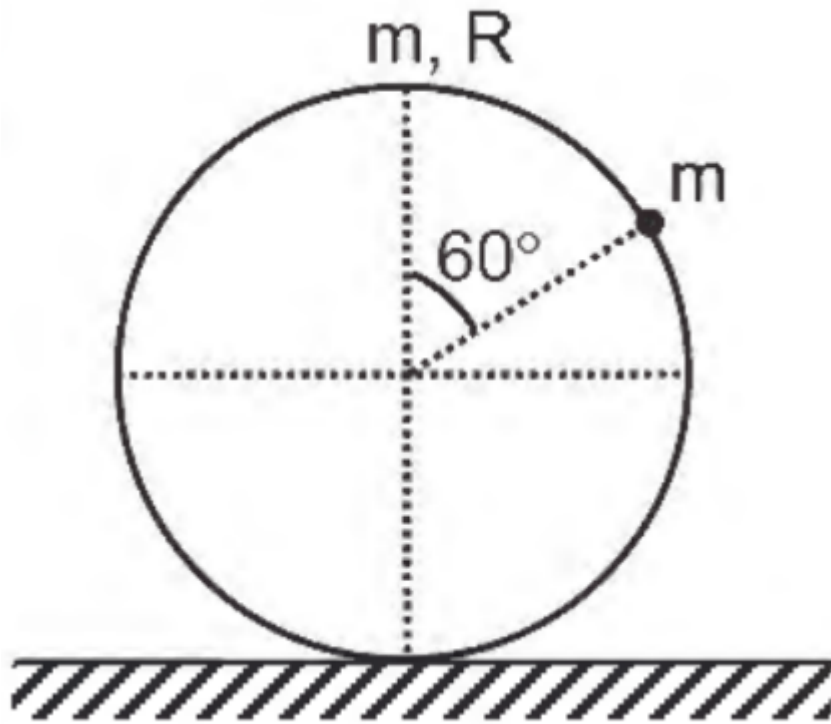


Question No. 4

Numerical Type

The answer has to be filled into the input box provided below.

A particle of mass m is rigidly attached to the circumference of a uniform circular ring of mass m and radius R and placed on a rough horizontal surface. The ring is released from rest from the initial position as shown in the figure and it starts rolling without slipping on the rough horizontal surface. If the frictional force acting on the ring due to horizontal surface when the particle is getting at the end of the horizontal diameter is $k(\frac{mg}{8})$. Find the value of k .



Question No. 5

Numerical Type

The answer has to be filled into the input box provided below.

A non-conducting cylindrical vessel of length $3l$ is placed horizontally and is divided into three parts by two easily moving piston having low thermal conductivity as shown. Three parts contain H_2 , He and CO_2 gas at initial temperatures $\theta_1 = 372^\circ C$, $\theta_2 = -15^\circ C$, $\theta_3 = 157^\circ C$ respectively. If initial length and pressure of each part are ℓ and P_0 respectively. If the length of middle part finally is $\frac{3\ell}{n}$, then find n .

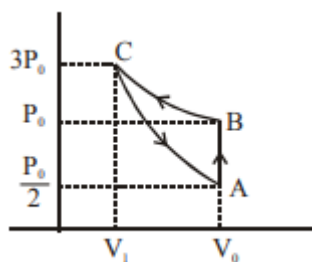


Question No. 6

Numerical Type

The answer has to be filled into the input box provided below.

One mole of an ideal gas undergoes a thermodynamic cyclic process as shown in the figure. The cyclic process consists of an isochoric, an isothermal and an adiabatic process. Adiabatic exponent of gas is $\frac{\ln 2\alpha}{\ln \alpha}$. Here α is an integer. Find α .



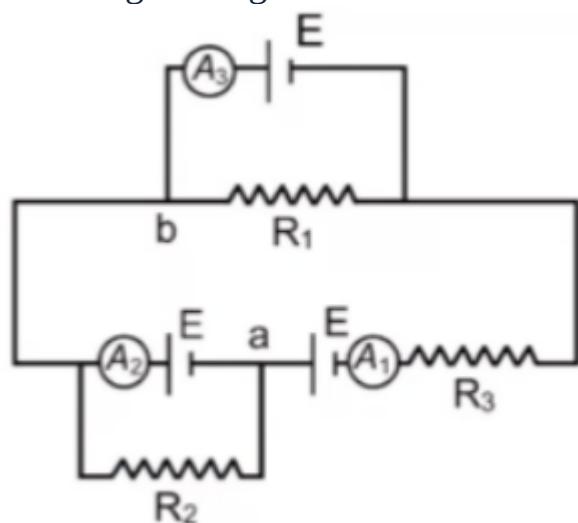
Physics Paragraph Type (Maximum Marks: 12)

Question No. 1

Only One Option Correct Type

Each question has multiple options out of which ONLY ONE is correct.

Referring to the given circuit match List-I with List-II in question



	List-I		List-II
(I)	Reading of ammeter A_1 in ampere is	(P)	4/3
(II)	Reading of ammeter A_2 in ampere is	(Q)	8/3
(III)	Reading of ammeter A_3 in ampere is	(R)	4
(IV)	Potential difference between point a and point b in volt is	(S)	zero
		(T)	2
		(U)	-1

In the above circuit, $R_1 = R_2 = R_3 = 3\Omega$ and e.m.f. of each cell is $E = 4V$ and negligible internal resistance. All ammeters are ideal. Match the following:

A. I \rightarrow , II \rightarrow Q, III \rightarrow R, IV \rightarrow S

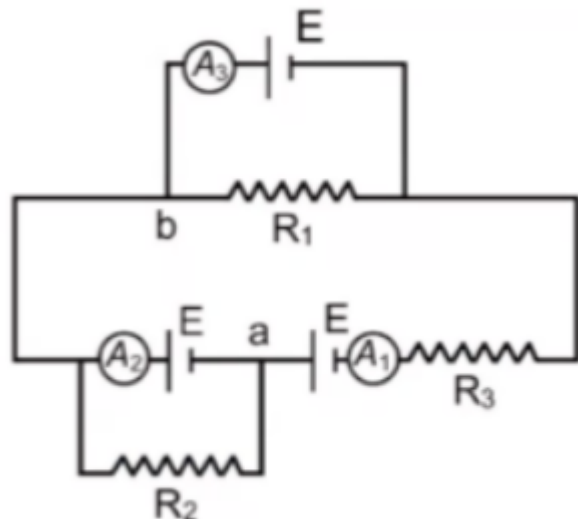
- B. $I \rightarrow T, II \rightarrow P, III \rightarrow S, IV \rightarrow Q$
 C. $I \rightarrow P, II \rightarrow Q, III \rightarrow S, IV \rightarrow R$
 D. $I \rightarrow S, II \rightarrow R, III \rightarrow T, IV \rightarrow U$

Question No. 2

Only One Option Correct Type

Each question has multiple options out of which ONLY ONE is correct.

Referring to the given circuit match List-I with List-II in question



	List-I		List-II
(I)	Reading of ammeter A_1 in ampere is	(P)	$4/3$
(II)	Reading of ammeter A_2 in ampere is	(Q)	$8/3$
(III)	Reading of ammeter A_3 in ampere is	(R)	4
(IV)	Potential difference between point a and point b in volt is	(S)	zero
		(T)	2
		(U)	-1

In the above circuit if R_2 is removed and $R_1 = R_3 = 4\Omega$

- A. $I \rightarrow P, II \rightarrow P, III \rightarrow S, IV \rightarrow R$
 B. $I \rightarrow U, II \rightarrow U, III \rightarrow S, IV \rightarrow R$
 C. $I \rightarrow T, II \rightarrow P, III \rightarrow S, IV \rightarrow Q$
 D. $I \rightarrow S, II \rightarrow R, III \rightarrow T, IV \rightarrow U$

Question No. 3

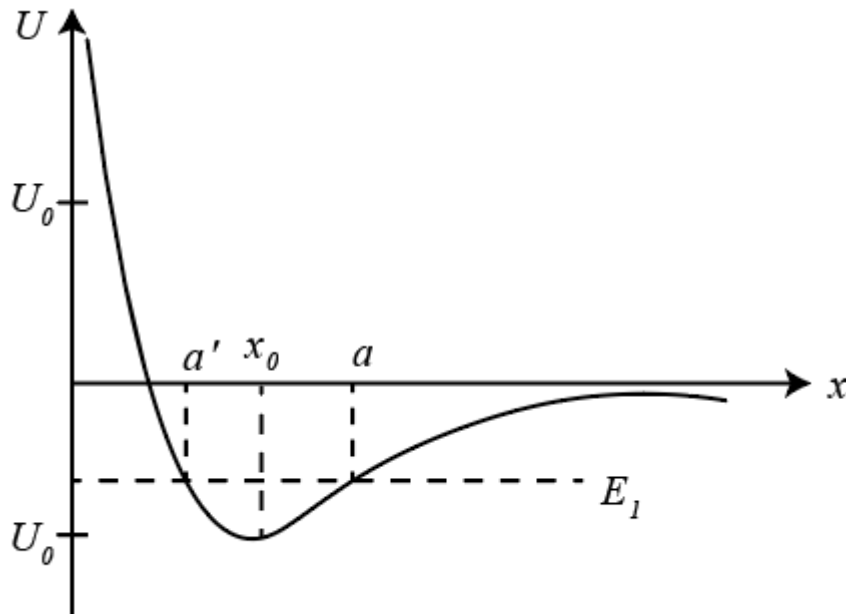
Only One Option Correct Type

Each question has multiple options out of which ONLY ONE is correct.

In a diatomic molecule the atoms can move relative to one another within certain limits. According to a simple theory of interatomic forces, the potential energy for the motion of each atom is

$$U(x) = U_0(e^{-2(x-x_0)/b} - 2e^{-(x-x_0)/b})$$

Here $e = 2.718 \dots$; U_0 , x_0 and b are constants; and x is the distance from the one atom to the midpoint of the molecule.



According to eq. $v^2 = \frac{2}{m} [E - U(x)]$, v^2 is directly proportional to $E - U(x)$; thus, v^2 is large wherever the difference between E and $U(x)$ is large. We can therefore gain some insights into the qualitative features of the motion by drawing a graph of potential energy on which it is possible to display the difference between E and $U(x)$. For example, Figure shows the curve of potential energy for an atom in a diatomic molecule

On this graph, we indicate the value of the energy of the particle by a horizontal line. We will call this horizontal line the energy level of the particle. At any point x , we can then see the difference between E and $U(x)$ at a glance.

Mark the incorrect statement.

- For the given graph equilibrium of molecule exists where slope of graph is
- zero.
 - For $x > x_0$ interatomic force is towards mean position.
 - For $x < x_0$ interatomic force is towards mean position.
 - As particle moves away from equilibrium position, magnitude of intermolecular force decreases.

Question No. 4

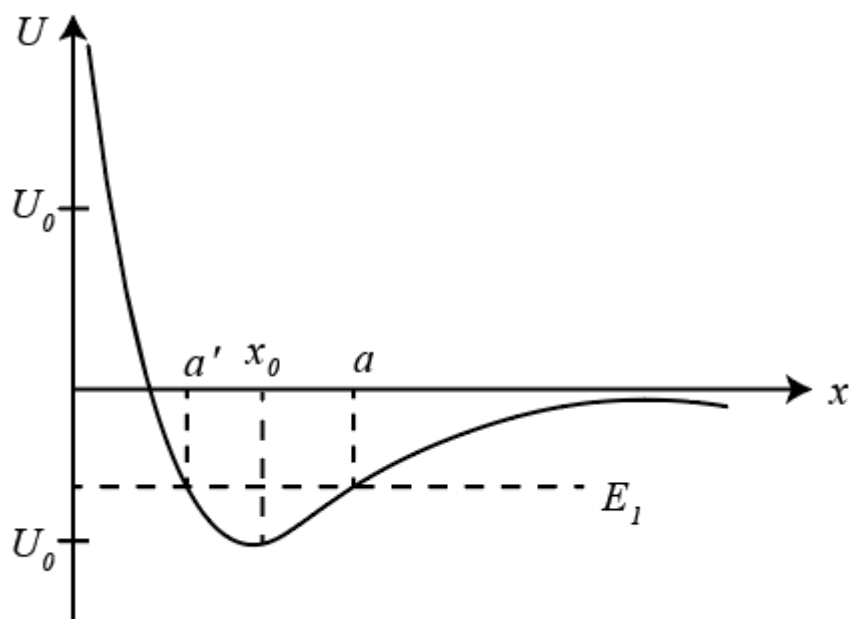
Only One Option Correct Type

Each question has multiple options out of which ONLY ONE is correct.

In a diatomic molecule the atoms can move relative to one another within certain limits. According to a simple theory of interatomic forces, the potential energy for the motion of each atom is

$$U(x) = U_0(e^{-2(x-x_0)/b} - 2e^{-(x-x_0)/b})$$

Here $e = 2.718 \dots$; U_0 , x_0 and b are constants; and x is the distance from the one atom to the midpoint of the molecule.



According to eq. $v^2 = \frac{2}{m} [E - U(x)]$, v^2 is directly proportional to $E - U(x)$; thus, v^2 is large wherever the difference between E and $U(x)$ is large. We can therefore gain some insights into the qualitative features of the motion by drawing a graph of potential energy on which it is possible to display the difference between E and $U(x)$. For example, Figure shows the curve of potential energy for an atom in a diatomic molecule

On this graph, we indicate the value of the energy of the particle by a horizontal line. We will call this horizontal line the energy level of the particle. At any point x , we can then see the difference between E and $U(x)$ at a glance.

In the vicinity of equilibrium position $x = x_0$, for a small displacement, force is proportional to the displacement. What is value of proportionality constant k .

- A. $k = \frac{3U_0}{b^2}$
- B. $k = \frac{2U_0}{b^2}$
- C. $k = \frac{6U_0}{b^2}$
- D. $k = \frac{b^2}{3U_0}$

Question No. 1

One or More Options Correct Type

The question has multiple options out of which ONE or MORE is/are correct.

Which of the following is/are correct?

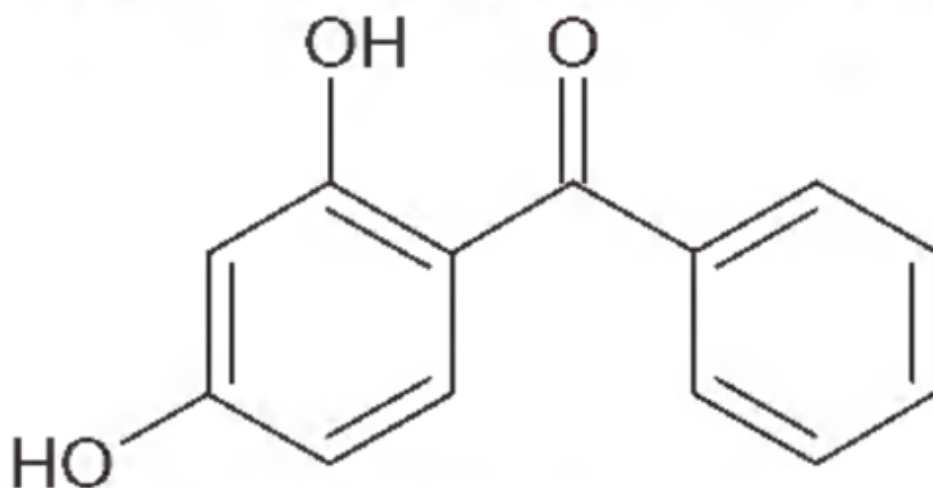
- A. $\Delta H = \Delta U + \Delta(PV)$ when P and V both changes
- B. $\Delta H = \Delta U + P\Delta V$ when pressure is constant
- C. $\Delta H = \Delta U + V\Delta P$ when volume is constant
- D. $\Delta H = \Delta U + P\Delta V + V\Delta P$ when P and V both changes

Question No. 2

One or More Options Correct Type

The question has multiple options out of which ONE or MORE is/are correct.

A sunburn prevention agent must be non-toxic, non-staining, non-volatile, reasonably water soluble. It should filter of the burning rays of sunlight. Given structure is one such compound:



which method/s for synthesis of above compound starting from m-dimethoxybenzene:

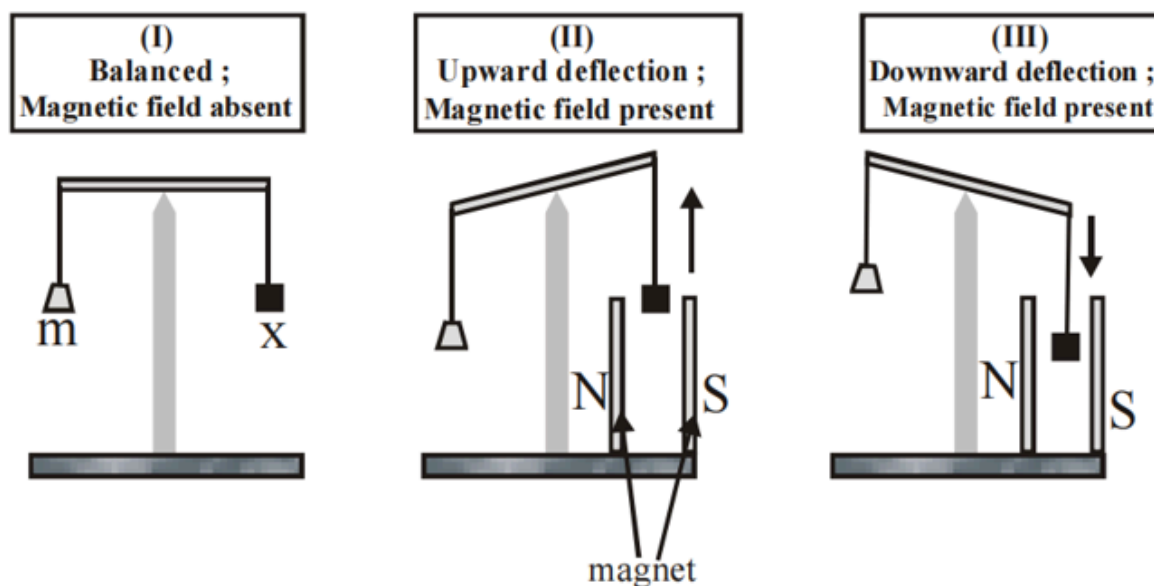
- A. (i) Ph - COCl , (ii) dil. NaOH
- B. (i) Conc. HI(ii) Ph - COCl, AlCl₃
- C. (i) Ph - COCl, AlCl₃ (ii) conc. HI
- D. All of these

Question No. 3

One or More Options Correct Type

The question has multiple options out of which ONE or MORE is/are correct.

In an experiment, m grams of a compound X (gas/liquid/solid) taken in a container is loaded in a balance as shown in figure I below. In the presence of a magnetic field, the pan with X is either deflected upwards (figure II), or deflected downwards (figure III), depending on the compound X . Identify the correct statement(s)



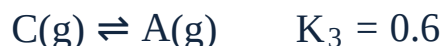
- A. If X is $H_2O(l)$, deflection of the pan is upwards.
- B. If X is $K_4[Fe(CN)_6](s)$, deflection of the pan is upwards.
- C. If X is $O_2(g)$, deflection of the pan is downwards.
- D. If X is $C_6H_6(l)$, deflection of the pan is downwards.

Question No. 4

One or More Options Correct Type

The question has multiple options out of which ONE or MORE is/are correct.

The equilibrium between three gaseous isomers A , B and C can be represented as:



If initially one mole of A is taken in a closed vessel of volume 1 litre, then which of the following is/are correct statements?

- A. $[A] + [B] + [C] = 1M$ at any time during the reaction.
- B. Concentration of $[C]$ is $\frac{1}{2.1} M$ at equilibrium.
- C. $K_1 = \frac{1}{0.24}$
- D. Isomer (A) is least stable thermodynamically.

Question No. 5

One or More Options Correct Type

The question has multiple options out of which ONE or MORE is/are correct.

Which of the following statement(s) is/are correct? When a mixture of NaCl and $K_2Cr_2O_7$ is gently heated with conc. H_2SO_4 ?

A. Deep red vapours are evolved

The vapours when passed into NaOH solution gives yellow solution of

B. Na_2CrO_4

C. Chlorine gas is evolved

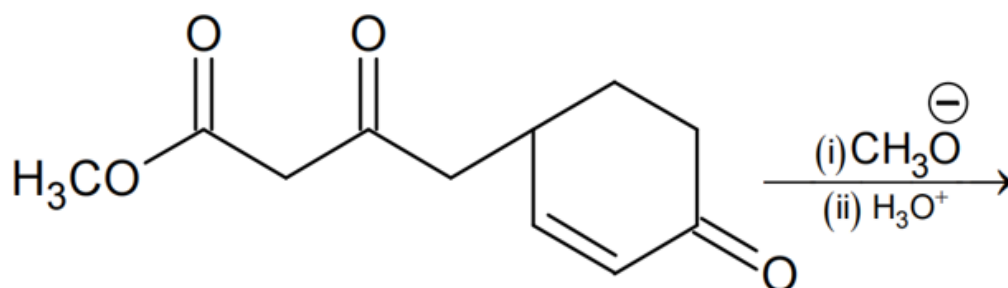
D. Chromyl chloride is formed

Question No. 6

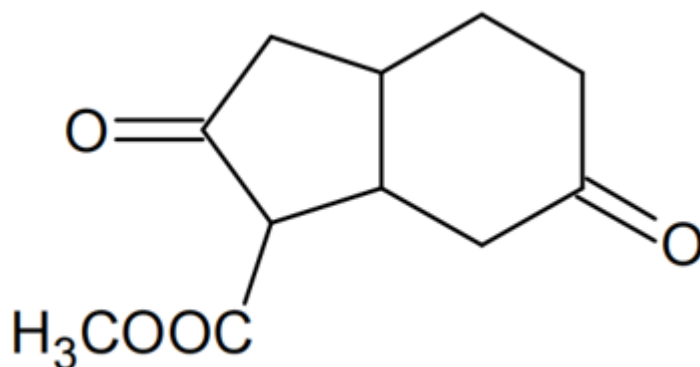
One or More Options Correct Type

The question has multiple options out of which ONE or MORE is/are correct.

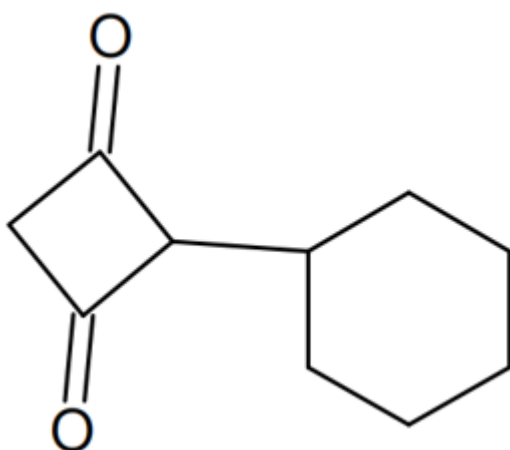
Find out major product of following reaction:

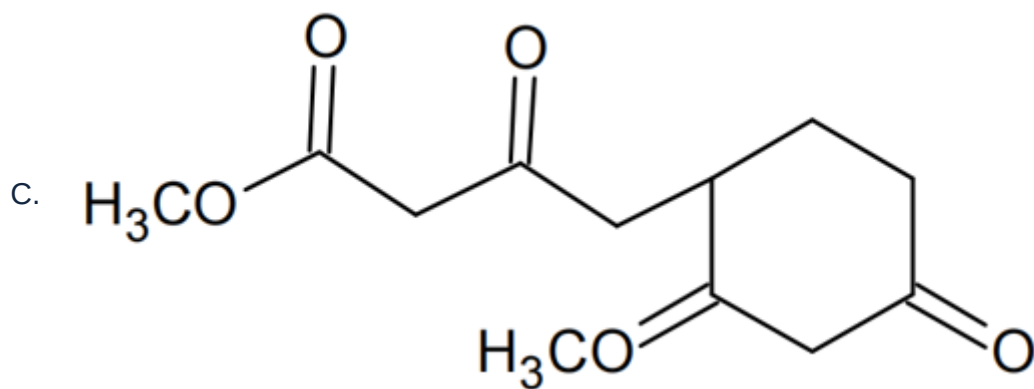


A.



B.





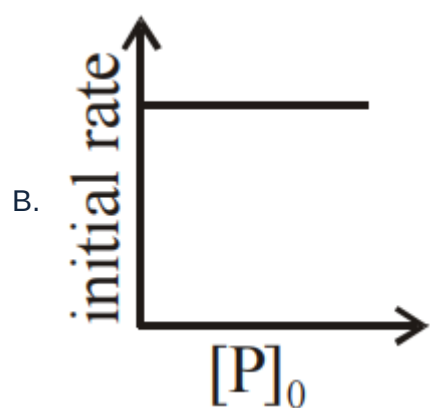
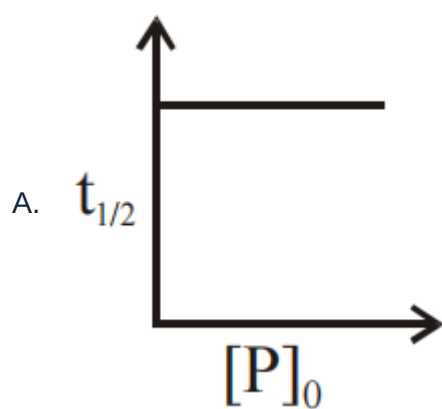
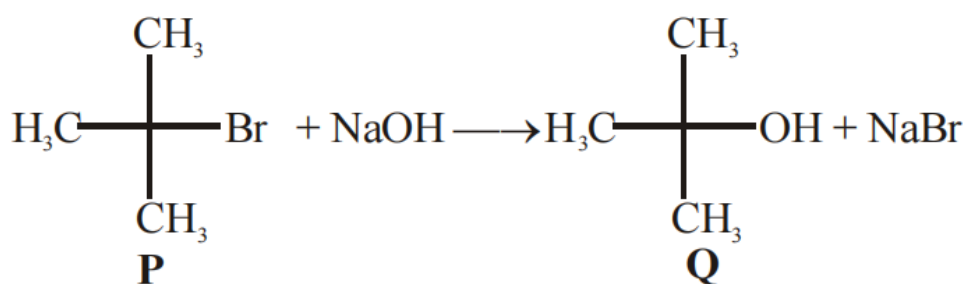
D. None of these

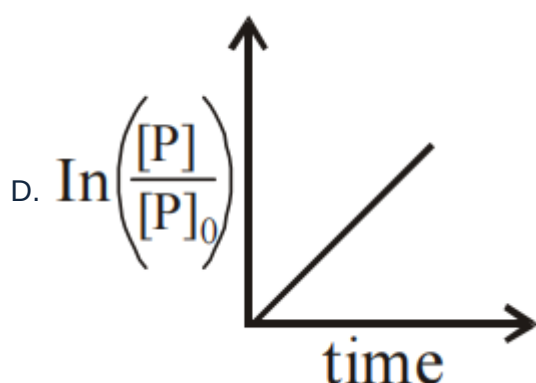
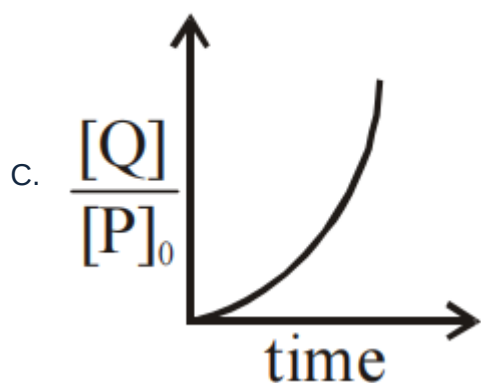
Question No. 7

One or More Options Correct Type

The question has multiple options out of which ONE or MORE is/are correct.

Which of the following plots is(are) correct for the given reaction? ($[P]_0$ is the initial concentration of **P**)





Question No. 8

One or More Options Correct Type

The question has multiple options out of which ONE or MORE is/are correct.

Select the correct statement with respect to Na_2O_2

A. It decolourises acidified KMnO_4

It is obtained along with Na metal when Na_2O is heated to a temperature

B. more than 400°C

C. On heating with oxygen at 450°C and 300 atm it becomes paramagnetic

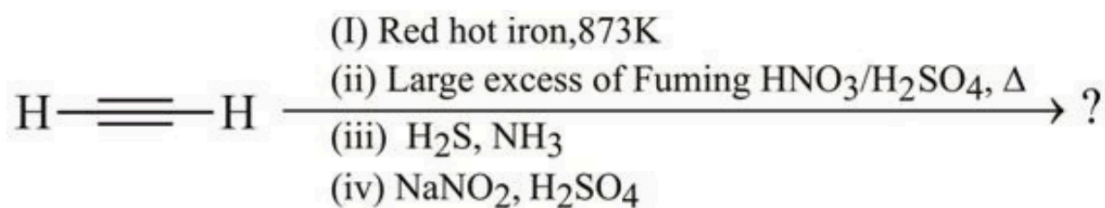
D. It gives both H_2O_2 and O_2 with water

Chemistry Numerical (Maximum Marks: 24)

Question No. 1

Numerical Type

The answer has to be filled into the input box provided below.



Find the number of nitrogen atoms in the final product.

Question No. 2

Numerical Type

The answer has to be filled into the input box provided below.

The solubility product constant of a metal carbonate MCO_3 is 2×10^{-12} at 25°C . A solution is 0.1 M in $\text{M}(\text{NO}_3)_2$ and it is saturated with 0.01M CO_2 .

Also the ionization constant of CO_2 are : $K_{a_1} = 4 \times 10^{-7}$ and

$K_{a_2} = 5 \times 10^{-11}$ at 25°C . The minimum pH that must be maintained to start any precipitation is

Question No. 3

Numerical Type

The answer has to be filled into the input box provided below.

Consider the table given, which shows both the diagonal relationship between lithium and magnesium, and also the typical behaviour of lithium in group-I. We have filled for one metal(s) to give you an idea of the amount of detail you need.

Fill the blank column as (✓)

if given property is similar as given in one column and (×)

if given property is different as given in one column.

Property	Li	Rest of Group I metals	Mg
Combustion with excess oxygen	O^{2-} containing anion is main product	-----	-----
Heating with nitrogen gas	-----	-----	Nitride formation
Effect of heat on nitrates	-----	Brown gas NOT Produces	-----
Effect of heat on carbonates	-----	-----	Metal oxide with CO_2
Heating of metal chloride in oxidizing flame	-----	Colour on flame	-----
Physical state of hydrogen carbonates	bicarbonate does not exist as a solid	-----	-----
Solubility of carbonates	Sparingly soluble/ insoluble	-----	-----

Find total number of (✓)

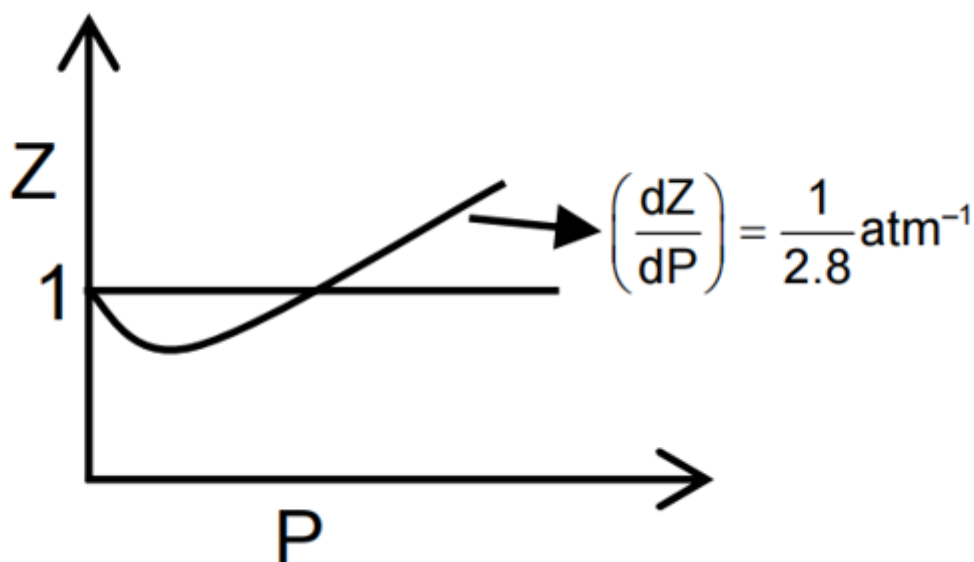
in given table after filling of blank columns.

Numerical Type

The answer has to be filled into the input box provided below.

The graph of compressibility factor (Z) v/s P for 1 mol of a real gas is shown in following diagram. The graph is plotted at 273 K temperature. If slope of graph at very high pressure ($\frac{dZ}{dP}$) is $(\frac{1}{2.8}) \text{ atm}^{-1}$ then calculate volume of 1 mol of real gas molecules in (L/mol) .

[Given $N_A = 6 \times 10^{23}$ and $R = \frac{22.4}{273} \text{ L atm K}^{-1} \text{ mol}^{-1}$]



Question No. 5

Numerical Type

The answer has to be filled into the input box provided below.

How many of the following underlined element are sp^3 hybridized.

$[\underline{C}u(NH_3)_4]^{+2}$, $\underline{P}Cl_3$, $\underline{B}Cl_3$, $[\underline{P}t(en)_2]^{+2}$, $[\underline{N}i(CO)_4]$, $\underline{C}S_2$,

$\underline{S}O_4^{2-}$, $\underline{S}nCl_2$, $\underline{S}nCl_4$, $\underline{H}gCl_2$, $\underline{C}lO_4^-$, \underline{C}_2H_4 , $\underline{C}H_3^+$, $\underline{C}H_3^-$,

$\underline{N}H_4^+$, $\underline{C}l/F_3$, $\underline{N}O_3^-$, $\underline{C}lO_3^-$, $\underline{P}H_3$, $[\underline{N}i(CN)_4]^{2-}$, $\underline{P}Cl_5$,

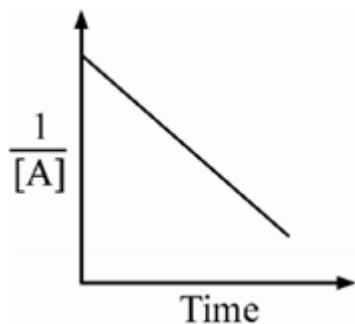
$\underline{C}H_2O$, $\underline{S}F_6$, $Cl_2\underline{C}O$, \underline{I}_3^- , $H_2\underline{S}$

Question No. 6

Numerical Type

The answer has to be filled into the input box provided below.

For the n^{th} order reaction following graph is obtained.



Half life for reaction of 1M reactant concentration is 10 min. What is the value of half life for 2M reactant in minutes.

Chemistry Paragraph Type (Maximum Marks: 12)

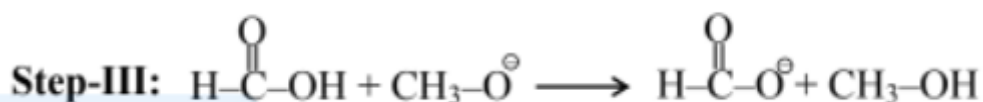
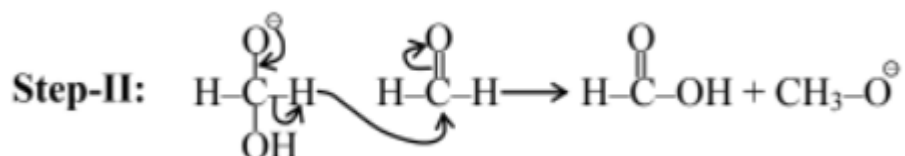
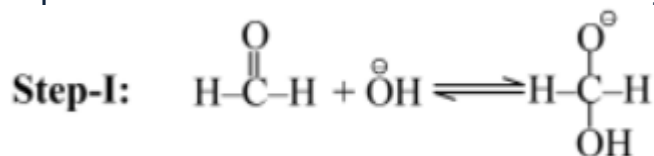
Question No. 1

Only One Option Correct Type

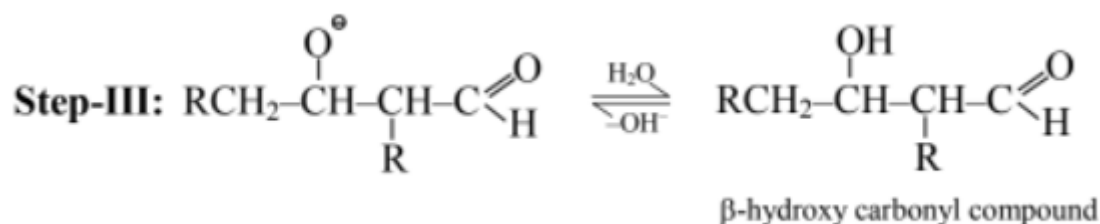
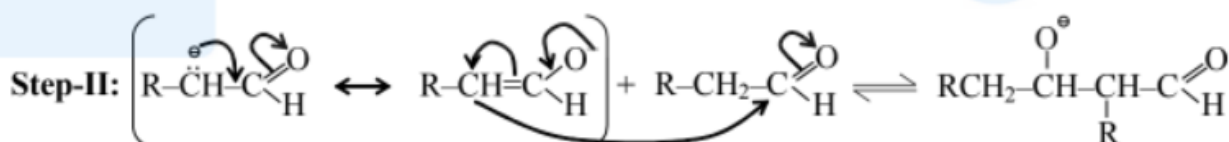
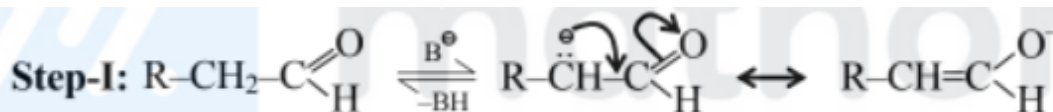
Each question has multiple options out of which ONLY ONE is correct.

Paragraph:

The conversion of an aldehyde having no α -hydrogen atom to a mixture of carboxylic acid salt and an alcohol is known as Cannizzaro's reaction. The most important feature of this reaction is the conjugate base of hydrate of aldehyde.

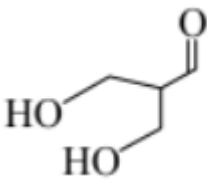
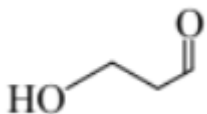
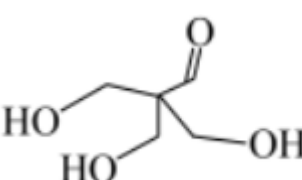
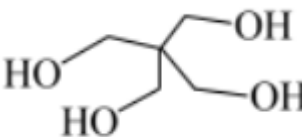


An aldehyde having acidic hydrogen undergoes aldol condensation in the presence of a dilute base as shown below:



Question:

The reaction between acetaldehyde and excess of formaldehyde in presence of dil. OH^- will result in the formation of

- A. 
- B. 
- C. 
- D. 

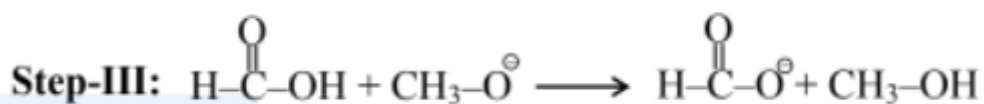
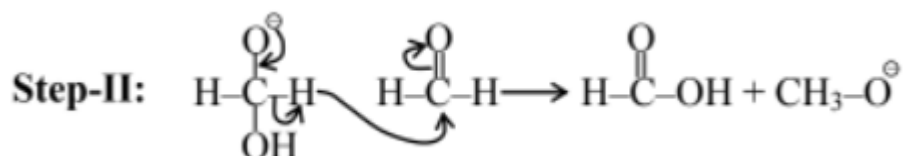
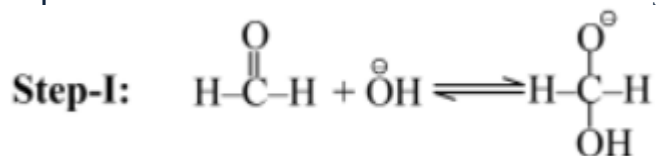
Question No. 2

Only One Option Correct Type

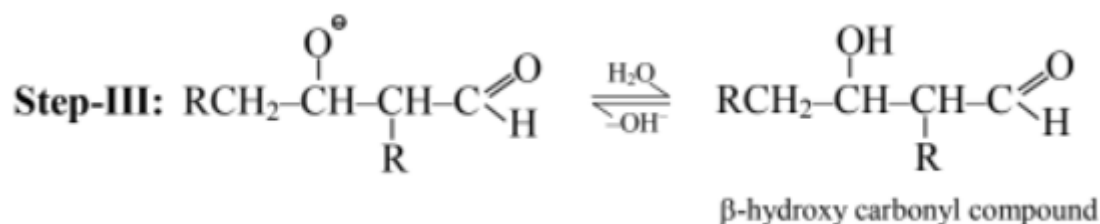
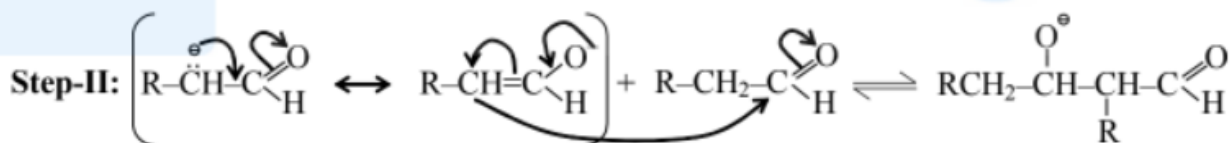
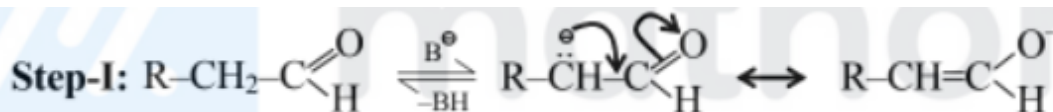
Each question has multiple options out of which ONLY ONE is correct.

Paragraph:

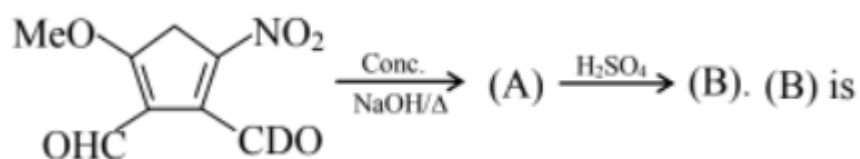
The conversion of an aldehyde having no α -hydrogen atom to a mixture of carboxylic acid salt and an alcohol is known as Cannizzaro's reaction. The most important feature of this reaction is the conjugate base of hydrate of aldehyde.

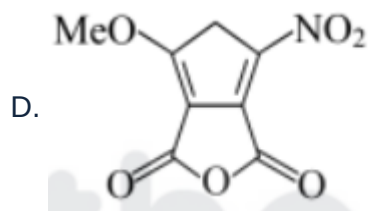
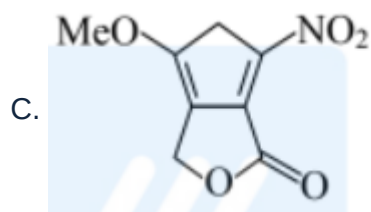
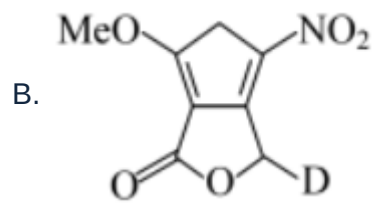
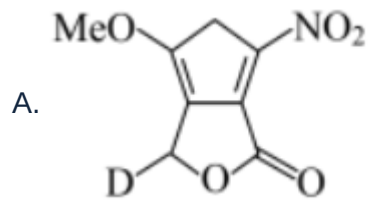


An aldehyde having acidic hydrogen undergoes aldol condensation in the presence of a dilute base as shown below:



Question:





Question No. 3

Only One Option Correct Type

Each question has multiple options out of which ONLY ONE is correct.

Paragraph:

A solution is prepared by dissolving CH_3COONa (8.2 g) acetic acid (30 g) and FeCl_2 (0.05 g) in 1 L of distilled water. To this solution H_2S is bubbled up to the point of saturation, which for this gas corresponds to 0.10M, knowing the following constants answer to the following questions acid dissociation constant (K_a)

$$\text{Acetic acid} = 2 \times 10^{-5}$$

$$\text{H}_2\text{S} : K_{a1} = 10^{-7}, K_{a2} = 10^{-14}$$

Solubility product K_{sp}

$$\text{Fe}(\text{OH})_2 = 4 \times 10^{-15}$$

$$\text{FeS} = 8 \times 10^{-19}$$

$$\text{Molar mass of FeCl}_2 = 127 \text{ g}$$

(Assume volume of solution remain 1 litre and no hydrolysis of Fe^{2+} in solution)

Question:

Which of the following statements regarding precipitation reaction is true?

- Some $\text{Fe}(\text{OH})_2$ will precipitate out since ionic product of $\text{Fe}(\text{OH})_2$ is
- A. greater than its K_{sp} .
- Some FeS will precipitate out since ionic product of FeS is greater than its
- B. K_{sp} .
- Both FeS and $\text{Fe}(\text{OH})_2$ will precipitate out to some extent since both
- C. $[\text{OH}^-]$ and $[\text{S}^{2-}]$ are greater than that required for precipitation.
- Neither $\text{Fe}(\text{OH})_2$ nor FeS will precipitate out since ionic product of both in
- D. solution are less than their respective solubility products.

Question No. 4

Only One Option Correct Type

Each question has multiple options out of which ONLY ONE is correct.

Paragraph:

A solution is prepared by dissolving CH_3COONa (8.2 g) acetic acid (30 g) and FeCl_2 (0.05 g) in 1 L of distilled water. To this solution H_2S is bubbled up to the point of saturation, which for this gas corresponds to 0.10M, knowing the following constants answer to the following questions acid dissociation constant (K_a)

$$\text{Acetic acid} = 2 \times 10^{-5}$$

$$\text{H}_2\text{S} : K_{a1} = 10^{-7}, K_{a2} = 10^{-14}$$

Solubility product K_{sp}

$$\text{Fe}(\text{OH})_2 = 4 \times 10^{-15}$$

$$\text{FeS} = 8 \times 10^{-19}$$

$$\text{Molar mass of FeCl}_2 = 127 \text{ g}$$

(Assume volume of solution remain 1 litre and no hydrolysis of Fe^{2+} in solution)

Question:

What will be the approximate concentration of free $\text{Fe}(\text{II})$ ion in the resulting solution?

- A. 10^{-5} M
- B. $9 \times 10^{-10} \text{ M}$
- C. $6.3 \times 10^{-8} \text{ M}$
- D. $8 \times 10^{-5} \text{ M}$

Mathematics Multiple Correct (Maximum Marks: 32)

Question No. 1

One or More Options Correct Type

The question has multiple options out of which ONE or MORE is/are correct.

Let $f(x)$ be a twice differentiable function such that $f''(x) < 0$ in $[0, 2]$. Then :

- A. $f(0) + f(2) = 2f(c), 0 < c < 2$
- B. $f(0) + f(2) = 2f(1)$
- C. $f(0) + f(2) > 2f(1)$
- D. $f(0) + f(2) < 2f(1)$

Question No. 2

One or More Options Correct Type

The question has multiple options out of which ONE or MORE is/are correct.

The line $x + 2y + a = 0$ intersects the circle $x^2 + y^2 - 4 = 0$ at two distinct points A and B . Another line $12x - 6y - 41 = 0$ intersects the circle $x^2 + y^2 - 4x - 2y + 1 = 0$ at two distinct points C and D . Let the circle passing through A, B, C, D is $S = 0$.

- A. The value of $a = 1$
- B. The value of $a = 2$
- C. Equation of circle $S : 5x^2 + 5y^2 - 8x - 16y - 36 = 0$
- D. Equation of circle $S : 5x^2 + 5y^2 + 8x + 16y - 36 = 0$

Question No. 3

One or More Options Correct Type

The question has multiple options out of which ONE or MORE is/are correct.

If $\left| \frac{z-\alpha}{z-\beta} \right| = k, k > 0$ where, $z = x + iy$ and $\alpha = \alpha_1 + i\alpha_2, \beta = \beta_1 + i\beta_2$ are fixed complex numbers. Then which of the following are true

- A. if $k \neq 1$ then locus is a circle whose centre is $\left(\frac{k^2\beta - \alpha}{k^2 - 1} \right)$
- B. if $k \neq 1$ then locus is a circle whose radius is $\left| \frac{k(\alpha - \beta)}{1 - k^2} \right|$
if $k = 1$ then locus is perpendicular bisector of line joining $\alpha = \alpha_1 + i\alpha_2$
- C. and $\beta = \beta_1 + i\beta_2$
- D. if $k \neq 1$ then locus is a circle whose centre is $\left(\frac{k^2\alpha - \beta}{k^2 - 1} \right)$

Question No. 4

One or More Options Correct Type

The question has multiple options out of which ONE or MORE is/are correct.

Let \vec{a}, \vec{b} and \vec{c} be three non-coplanar vectors and \vec{d} be a non-zero vector perpendicular to $\vec{a} + \vec{b} + \vec{c}$. Now $\vec{d} = (\vec{a} \times \vec{b}) \sin x + (\vec{b} \times \vec{c}) \cos y + 2(\vec{c} \times \vec{a})$, then which of the following options is/are CORRECT

- A. $\frac{\vec{d} \cdot (\vec{a} + \vec{c})}{[\vec{a} \vec{b} \vec{c}]} = 2$
- B. $\frac{\vec{d} \cdot (\vec{a} + \vec{c})}{[\vec{a} \vec{b} \vec{c}]} = -2$
- C. minimum value of $x^2 + y^2 = \frac{\pi^2}{4}$
- D. minimum value of $x^2 + y^2 = \frac{5\pi^2}{4}$

Question No. 5

One or More Options Correct Type

The question has multiple options out of which ONE or MORE is/are correct.

Let $f : (0, \infty) - \{1\} \rightarrow R$ be a differentiable function such that $f'(x) = 1 - \frac{f(x)}{x-1}$ for all $x \in \text{domain of the function}$ and $f(2) \neq \frac{1}{2}$, then:

- A. $\lim_{x \rightarrow 0^+} f'(\frac{1}{x}) = \frac{1}{2}$
- B. $\lim_{x \rightarrow 0^+} xf(\frac{1}{x}) = \frac{1}{2}$
- C. $\lim_{x \rightarrow 0^+} x^2 f'(x) = 1$
- D. $|f(x)| \leq 2$ for all $x \in (0, 2)$

Question No. 6

One or More Options Correct Type

The question has multiple options out of which ONE or MORE is/are correct.

Let $f(x)(x \geq 1)$ be a differentiable function satisfying

$$f(x) = (\log_e x)^2 - \int_1^e \frac{f(t)}{t} dt$$

Area bounded by tangent line of $y = f(x)$ at the point $[e, f(e)]$, the curve $y = f(x)$ and the line $x = 1$, is :

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

Question No. 7

One or More Options Correct Type

The question has multiple options out of which ONE or MORE is/are correct.

Let $A = \begin{bmatrix} 0 & -2 \\ 1 & 3 \end{bmatrix}$ and $N(k)$ denotes the absolute difference of diagonal

entries of matrix A^k , where $k \in \{1, 2, 3, 4, \dots\}$. Then identify incorrect option(s)?

- A. $N(5)$ is divisible by 9
- B. $N(6)$ is divisible by 9
- C. $N(10) - N(9), N(11) - N(10), N(12) - N(11)$ are in A.P.
- D. $N(7) = 381$

Question No. 8

One or More Options Correct Type

The question has multiple options out of which ONE or MORE is/are correct.

Person A randomly selects 4 distinct numbers from the set $\{1, 2, 3, 4, 5, 6, 7, 8, 9\}$ and arrange them in descending order to form a 4 digit number and person B randomly selects 4 distinct numbers from set $\{1, 2, 3, 4, 5, 6, 7, 8\}$ and also arranges them in descending order to form a 4 digit number. Then which of the following is/are correct?

- probability that person A's 4 digit number is greater than person B's number
- A. is ${}^8C_3 + \frac{1}{9} \left(1 - \frac{1}{9C_4}\right)$
- B. probability that person A and B have same 4 digit number is $\frac{1}{9C_4}$
- probability that person A's 4 digit number is greater than person B's number
- C. is $\frac{2 \cdot {}^8C_3 + {}^8C_4 - 1}{2^9 C_4}$
- D. probability that person A and B have same 4 digit number is $\frac{{}^8C_4}{9C_4}$

Mathematics Numerical (Maximum Marks: 24)

Question No. 1

Numerical Type

The answer has to be filled into the input box provided below.

Let $f(x) = ax^2 + bx + c$, where $a \neq 0$, a, b, c are integers and $f(1) = 1, 6 < f(3) < 8$ and $18 < f(5) < 22$. Then the number of solutions of equation $f(x) = e^x$ is

Question No. 2

Numerical Type

The answer has to be filled into the input box provided below.

Let on the graph of $y = f(x)$ where $f(x) = \begin{cases} 4x\sqrt{3} + a, & x \leq 0 \\ (7 + b)x + 5\sqrt{2}, & x > 0 \end{cases}$,

the points with abscissae $-1, 0, 1, 10$ are collinear then the maximum value of $[a+b]$? where $[]$ denotes the G.I.F., is

Question No. 3

Numerical Type

The answer has to be filled into the input box provided below.

If the equation $\sec \theta + \operatorname{cosec} \theta = c$ has two real roots between 0 and 2π , and $c^2 < b$ then least integral value of b is

Question No. 4

Numerical Type

The answer has to be filled into the input box provided below.

Number of ways in which 30 identical balls can be partitioned in three groups of unequal size is N then sum of digits of N is

Question No. 5

Numerical Type

The answer has to be filled into the input box provided below.

Let $f(x)$ be a real quadratic polynomial with leading coefficient 1. If x_1, x_2, x_3, x_4, x_5 be \times - coordinates of 5 distinct points where $g(x) = |f(|x|)|$ is non-differentiable and $\sum_{i=1}^5 |x_i| = 8$, then $\frac{1}{5} \lim_{x \rightarrow \infty} \frac{x^2 - f(x)}{x}$ equals

Question No. 6

Numerical Type

The answer has to be filled into the input box provided below.

A differentiable function f satisfies the relation $f(x+y) = f(x) + f(y) + 2xy(x+y) - \frac{1}{3} \forall x, y \in R$ and $\lim_{h \rightarrow 0} \left(\frac{3f(h)-1}{6h} \right) = \frac{2}{3}$ then value of $[f(2)]$ is, where $[.]$ denote GIF

Mathematics Paragraph Type (Maximum Marks: 12)

Question No. 1

Only One Option Correct Type

Each question has multiple options out of which ONLY ONE is correct.

Paragraph:

Consider a $\triangle ABC$ on circle $|z| = r$ in the argand plane with A, B, C be represented by complex numbers a, b, c respectively. The foot of altitudes from A, B, C meet the opposite side at D, E and F represented by complex numbers d, e, f respectively. Then

Question: Which of the following is incorrect?

A. The mirror image of orthocentre of $\triangle ABC$ in side BC lies on $|z| = r$

- B. The mirror image of orthocentre of $\triangle ABC$ in side BC is $-\frac{bc}{a}$
 C. The mirror image of orthocentre of $\triangle ABC$ in side BC is $-\frac{ca}{b}$
 D. none of these

Question No. 2

Only One Option Correct Type

Each question has multiple options out of which ONLY ONE is correct.

Paragraph:

Consider a $\triangle ABC$ on circle $|z| = r$ in the argand plane with A, B, C be represented by complex numbers a, b, c respectively. The foot of altitudes from A, B, C meet the opposite side at D, E and F represented by complex numbers d, e, f respectively. Then

Question: The altitudes when produced meet the circle $|z| = r$ at A_1, B_1 and C_1 respectively, then orthocentre of $A_1B_1C_1$ is

- A. $a + b + c$
 B. $-abc(\frac{1}{a^2} + \frac{1}{b^2} + \frac{1}{c^2})$
 C. $-abc(\frac{1}{a^2} - \frac{1}{b^2} + \frac{1}{c^2})$
 D. none of these

Question No. 3

Only One Option Correct Type

Each question has multiple options out of which ONLY ONE is correct.

Let P_0 is the parabola $y^2 = 4x$ with vertex $K(0, 0)$, A and B are points on P_0 where tangents drawn intersect at right angles. Let C be the centroid of $\triangle ABK$. The locus of C is another parabola P_1 . Now the process is repeated with P_1 then $P_2, P_3 \dots$ etc. Then the length of latus rectum of P_{10} can be expressed as $\frac{a}{b}$ where a, b are co-prime natural numbers. Find the value of a .

- A. 1
 B. 2
 C. 3
 D. 4

Question No. 4

Only One Option Correct Type

Each question has multiple options out of which ONLY ONE is correct.

Let P_0 is the parabola $y^2 = 4x$ with vertex $K(0, 0)$, A and B are points on P_0 where tangents drawn intersect at right angles. Let C be the centroid of $\triangle ABK$. The locus of C is another parabola P_1 . Now the process is repeated with P_1 then $P_2, P_3 \dots$ etc. Then the length of latus rectum of P_{10} can be expressed as $\frac{a}{b}$ where a, b are co-prime natural numbers. Find the value of $(a + \log_3 b)$.

- A. 14
- B. 12
- C. 11
- D. 18