

INSTRUCTIONS

A. Question Paper Format

- The question paper consists of three parts (Physics, Chemistry and Mathematics). Each part consists of three sections.
Section 1 contains 8 multiple choice questions. Each question has four choices (a), (b), (c) and (d) out of which ONE OR MORE are correct
- Section 2 contains 4 paragraphs each describing theory, experiment, data etc. Eight questions relate to four paragraphs with two questions on each paragraph. Each question of a paragraph has ONLY ONE correct answer among the four choices (a), (b), (c) and (d).
- Section 3 contains 4 multiple choice questions relate to four paragraphs with two questions on each paragraph. Each question of a paragraph has ONLY ONE CORRECT ANSWER among the four choices (a), (b), (c) and (d).

B. Marking Scheme

- For each question in Section 1, you will be awarded 3 marks if you darken all the bubble(s) corresponding to only the correct answer(s) and zero mark if no bubbles are darkened. In all other cases, minus one (-1) mark will be awarded.
- For each question Section 2 and 3, you will be awarded 3 marks if you darken the bubble corresponding to only the correct answer and zero mark if no bubbles are darkened. In all other cases, minus one (-1) mark will be awarded.

PART - I: PHYSICS

SECTION - 1

(One or more options correct Type)

This section contains 8 multiple choice questions. Each question has four choices (a), (b), (c) and (d) out of which ONE or MORE are correct.

- Two bodies, each of mass M , are kept fixed with a separation $2L$. A particle of mass m is projected from the midpoint of the line joining their centres, perpendicular to the line. The gravitational constant is G . The correct statement(s) is (are)**

(a) The minimum initial velocity of the mass m to escape the gravitational field of the two bodies is $4\sqrt{\frac{GM}{L}}$

(b) The minimum initial velocity of the mass m to escape the gravitational field of the two bodies is $2\sqrt{\frac{GM}{L}}$

(c) The minimum initial velocity of the mass m to escape the gravitational field of the two bodies is $\sqrt{\frac{2GM}{L}}$

(d) The energy of the mass m remains constant.

- A particle of mass m is attached to one end of a mass-less spring of force constant k , lying on a frictionless horizontal plane. The other end of the spring is fixed. The particle starts moving horizontally from its equilibrium position at time $t = 0$ with an initial velocity u_0 . When the speed of the particle is $0.5 u_0$. It collides elastically with a rigid wall. After this collision,**

(a) the speed of the particle when it returns to its equilibrium position is u_0 .

(b) the time at which the particle passes through the equilibrium position for the first time is

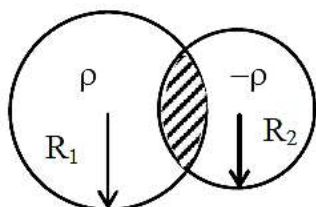
$$t = \pi \sqrt{\frac{m}{k}}$$

(c) the time at which the maximum compression of the spring occurs is $t = \frac{4\pi}{3} \sqrt{\frac{m}{k}}$

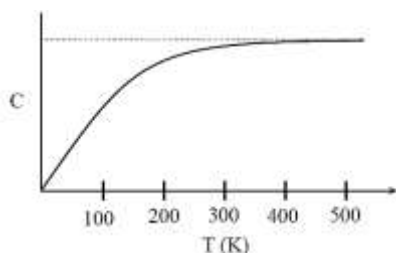
(d) the time at which the particle passes through the equilibrium position for the second time

$$\text{is } t = \frac{5\pi}{3} \sqrt{\frac{m}{k}}$$

3. A steady current I flows along an infinitely long hollow cylindrical conductor of radius R . This cylinder is placed coaxially inside an infinite solenoid of radius $2R$. The solenoid has n turns per unit length and carries a steady current I . Consider a point P at a distance r from the common axis. The correct statement(s) is (are)
- In the region $0 < r < R$, the magnetic field is non-zero
 - In the region $R < r < 2R$, the magnetic field is along the common axis.
 - In the region $R < r < 2R$, the magnetic field is tangential to the circle of radius r , centered on the axis.
 - In the region $r > 2R$, the magnetic field is non-zero.
4. Two vehicles, each moving with speed u on the same horizontal straight road, are approaching each other. Wind blows along the road with velocity w . One of these vehicles blows a whistle of frequency f_1 . An observer in the other vehicle hears the frequency of the whistle to be f_2 . The speed of sound in still air is V . The correct statement(s) is (are)
- If the wind blows from the observer to the source, $f_2 > f_1$.
 - If the wind blows from the source to the observer, $f_2 > f_1$.
 - If the wind blows from observer to the source, $f_2 < f_1$.
 - If the wind blows from the source to the observer $f_2 < f_1$.
5. Using the expression $2d \sin \theta = \lambda$, one calculates the values of d by measuring the corresponding angles θ in the range θ to 90° . The wavelength λ is exactly known and the error in θ is constant for all values of θ . As θ increases from 0° ,
- the absolute error in d remains constant.
 - the absolute error in d increases
 - the fractional error in d remains constant.
 - the fractional error in d decreases.
6. Two non-conducting spheres of radii R_1 and R_2 and carrying uniform volume charge densities $+\rho$ and $-\rho$, respectively, are placed such that they partially overlap, as shown in the figure.
- At all points in the overlapping region,



- the electrostatic field is zero
 - the electrostatic potential is constant
 - the electrostatic field is constant in magnitude
 - the electrostatic field has same direction
7. The figure shows the variation of specific heat capacity (c) of a solid as a function of temperature (T). The temperature is increased continuously from 0 to 500 K at a constant rate. Ignoring any volume change, the following statement(s) is (are) correct to a reasonable approximation.
- the rate at which heat is absorbed in the range 0-100 K varies linearly with temperature T .
 - heat absorbed in increasing the temperature from 0-100 K is less than the heat required for increasing the temperature from 400 – 500 K.
 - there is no change in the rate of heat absorption in range 400 – 500 K.
 - the rate of heat absorption increases in the range 200 – 300 K.



8. The radius of the orbit of an electron in a Hydrogen-like atom is $4.5 a_0$ where a_0 is the Bohr radius. Its orbital angular momentum is $\frac{3h}{2\pi}$. It is given that h is Planck's constant and R is Rydberg constant. The possible wavelength(s), when the atom de-excites, is (are)
- (a) $\frac{9}{32R}$ (b) $\frac{9}{16R}$
(c) $\frac{9}{5R}$ (d) $\frac{4}{3R}$

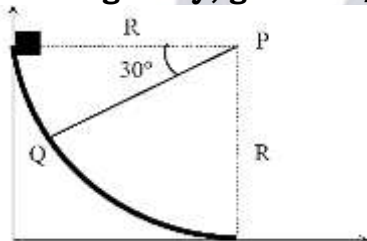
SECTION - 2 (PARAGRAPH TYPE)

This section contains 4 paragraphs each describing theory, experiment, data etc. Eight questions relate to four paragraphs with two questions on each paragraph. Each question of paragraph has only one correct answer along the four choice (a), (b), (c) and (d).

PARAGRAPH FOR QUESTIONS (i) TO (ii)

9. A small block of mass 1 kg is released from rest at the top of a rough track. The track is circular arc of radius 40 m.

The block slides along the track without toppling and a frictional force acts on it in the direction opposite to the instantaneous velocity. The work done in overcoming the friction up to the point Q, as shown in the figure, below, is 150 J. (Take the acceleration due to gravity, $g = 10 \text{ m/s}^2$).



- (i) The speed of the block when it reaches the point Q is
(a) 5 ms^{-1} (b) 10 ms^{-1}
(c) $10\sqrt{3} \text{ ms}^{-1}$ (d) 20 ms^{-1}
- (ii) The magnitude of the normal reaction that acts on the block at the point Q is
(a) 7.5 N (b) 8.6 N
(c) 11.5 N (d) 22.5 N

PARAGRAPH FOR QUESTIONS (i) TO (ii)

10. A thermal power plant produces electric power of 600 kW at 4000 V, which is to be transported to a place 20 km away from the power plant for consumers' usage. It can be transported either directly with a cable of large current carrying capacity or by using a combination of step-up and step-down transformers at the two ends. The drawback of the direct transmission is the large energy dissipation. In the method using transformers, the dissipation is much smaller. In this method, a step-up transformer is used at the plant side so that the current is reduced to a smaller value. At the consumers' end, a step-down transformer is used to supply power to the consumers at the specified lower voltage. It is reasonable to assume that the power cable is purely resistive and the

transformers are ideal with the power factor unity. All the currents and voltage mentioned are rms values.

- (i) If the direct transmission method with a cable of resistance $0.4 \Omega \text{ km}^{-1}$ is used, the power dissipation (in %) during transmission is
 (a) 20 (b) 30
 (c) 40 (d) 50
- (ii) In the method using the transformers, assume that the ratio of the number of turns in the primary to that in the secondary in the step-up transformer is 1 : 10. If the power to the consumers has to be supplied at 200 V, the ratio of the number of turns in the primary to that in the secondary in the step-down transformer is
 (a) 200: 1 (b) 150: 1
 (c) 100: 1 (d) 50: 1

PARAGRAPH FOR QUESTIONS (i) TO (ii)

11. A point Q is moving in a circular orbit of radius R in the x-y plane with an angular velocity ω . This can be considered as equivalent to a loop carrying a steady current $\frac{Q\omega}{2\pi}$.

A uniform magnetic field along the positive z-axis is now switched on, which increases at a constant rate from 0 to B in one second. Assume that the radius of the orbit remains constant. The application of the magnetic field induces an emf in the orbit. The induced emf is defined as the work done by an induced electric field in moving a unit positive charge around closed loop. It is known that, for an orbiting charge, the magnetic dipole moment is proportional to the angular momentum with a proportionality constant γ .

- (i) The magnitude of the induced electric field in the orbit at any instant of time during the time interval of the magnetic field change, is
 (a) $\frac{BR}{4}$ (b) $\frac{BR}{2}$
 (c) BR (d) 2BR
- (ii) The change in the magnetic dipole moment associated with the orbit, at the end of time interval of the magnetic field change, is
 (a) $-\gamma BQR^2$ (b) $-\gamma \frac{BQR^2}{2}$
 (c) $\gamma \frac{BQR^2}{2}$ (d) γBQR^2

PARAGRAPH FOR QUESTIONS (i) TO (ii)

12. The mass of nucleus A_ZX is less than the sum of the masses of (A-Z) number of neutrons and Z number of protons in the nucleus. The energy equivalent to the corresponding mass difference is known as the binding energy of the nucleus. A heavy nucleus of mass M can break into two light nuclei of mass m_1 and m_2 only if $(m_1 + m_2) < M$. Also two light nuclei of masses m_3 and m_4 can undergo complete fusion and form a heavy nucleus of mass M' only if $(m_3 + m_4) > M'$. The masses of some neutral atoms are given in the table below:

${}^1_1\text{H}$	1.007825u	${}^2_1\text{H}$	2.014102u	${}^3_1\text{H}$	3.016050u	${}^4_2\text{He}$	4.002603u
${}^6_3\text{Li}$	6.015123u	${}^7_3\text{Li}$	7.016004u	${}^{70}_{30}\text{Zn}$	69.925325u	${}^{82}_{34}\text{Se}$	81.916709u
${}^{152}_{64}\text{Gd}$	151.919803u	${}^{206}_{82}\text{Pb}$	205.97445u	${}^{209}_{83}\text{Bi}$	208.980388u	${}^{210}_{84}\text{Po}$	209.982876u

- (i) The correct statement is
 (a) The nucleus ${}^6_3\text{Li}$ can emit an alpha particle
 (b) The nucleus ${}^{210}_{84}\text{Po}$ can emit a proton.
 (c) Deuteron and alpha particle can undergo complete fusion.

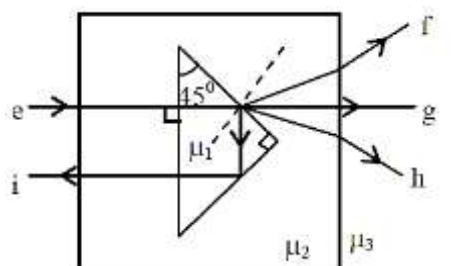
- (d) The nuclei ${}_{30}^{70}\text{Zn}$ and ${}_{34}^{82}\text{Se}$ can undergo complete fusion.
- (ii) The kinetic energy (in keV) of the alpha particle, when the nucleus ${}_{84}^{210}\text{Po}$ at rest undergoes alpha decay, is
- (a) 5319 (b) 5422
(c) 5707 (d) 5818

SECTION - 3

(Matching List Type)

This section contains 4 multiple choice questions. Each question has matching lists. The codes for the lists have choices (a), (b), (c) and (d) out of which ONLY ONE is correct.

13. A right angled prism of refractive index μ_1 is placed in a rectangular block of refractive index μ_2 , which is surrounded by a medium of refractive index μ_3 , as shown in the figure. A ray of light 'e' enters the rectangular block at normal incidence. Depending upon the relationships between μ_1, μ_2 and μ_3 , it takes one of the four possible paths 'ef', 'eg', 'eh', or 'ei'.



Match the paths in List I with conditions of refractive indices in List II and select the correct answer using the codes given below the lists:

List I

- P. $e \rightarrow f$
Q. $e \rightarrow g$
R. $e \rightarrow h$
S. $e \rightarrow i$

Codes:

P Q R S

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

List II

1. $\mu_1 > \sqrt{2}\mu_2$
2. $\mu_2 > \mu_1$ and $\mu_2 > \mu_3$
3. $\mu_1 = \mu_2$
4. $\mu_2 < \mu_1 < \sqrt{2}\mu_2$ and $\mu_2 > \mu_3$

14. Match List I with List II and select the correct answer using the codes given below the lists:

List I

- P. Boltzmann Constant
Q. Coefficient of viscosity
R. Planck Constant
S. Thermal conductivity

Codes:

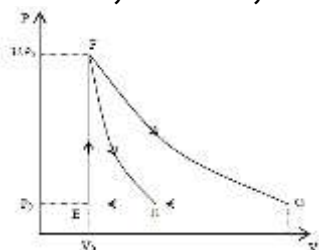
P Q R S

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

List II

1. $[\text{ML}^2\text{T}^{-1}]$
2. $[\text{ML}^{-1}\text{T}^{-1}]$
3. $[\text{MLT}^{-3}\text{K}^{-1}]$
4. $[\text{ML}^2\text{T}^{-2}\text{K}^{-1}]$

15. One mole of mono-atomic ideal gas is taken along two cyclic processes $E \rightarrow F \rightarrow G \rightarrow E$ and $E \rightarrow F \rightarrow H \rightarrow E$ as shown in the PV diagram. The processes involved are purely isochoric, isobaric, isothermal or adiabatic.



Match the paths in List I with the magnitudes of the work done in List II and select the correct answer using the codes given below the lists.

List I

P. $G \rightarrow E$

Q. $G \rightarrow H$

R. $F \rightarrow H$

S. $F \rightarrow G$

List II

1. $160 P_0 V_0 \ln 2$

2. $36 P_0 V_0$

3. $24 P_0 V_0$

4. $31 P_0 V_0$

Codes:

P Q R S

(a) 4 3 2 1

(b) 4 3 1 2

(c) 3 1 2 4

(d) 1 3 2 4

16. Match List I of the nuclear processes with List II containing parent nucleus and one of the end products of each process and then select the correct answer using the codes given below the lists:

List I

P. Alpha decay

Q. β^+ decay

R. Fission

S. Proton emission

List II

1. $^{15}_8\text{O} \rightarrow ^{15}_7\text{N} + \dots$

2. $^{238}_{92}\text{U} \rightarrow ^{234}_{90}\text{Th} + \dots$

3. $^{185}_{83}\text{Bi} \rightarrow ^{184}_{82}\text{Pb} + \dots$

4. $^{239}_{94}\text{Pu} \rightarrow ^{140}_{57}\text{La} + \dots$

Codes:

P Q R S

(a) 4 2 1 3

(b) 1 3 2 4

(c) 2 1 4 3

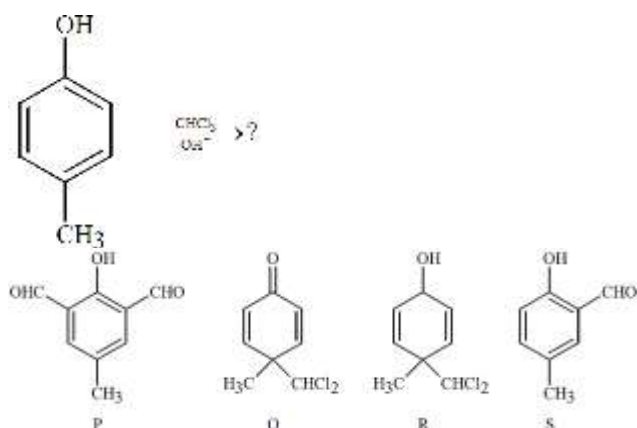
(d) 4 3 2 1

PART - II CHEMISTRY SECTION -1

(One or more options correct Type)

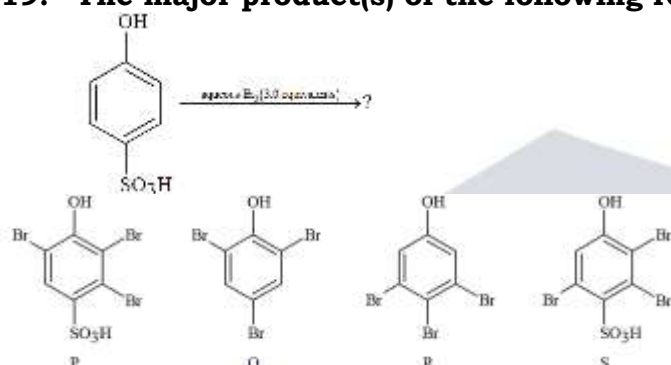
This section contains 8 multiple choice questions. Each question has four choices (a), (b), (c) and (d) out of which ONE or MORE are correct.

17. The K_{sp} of Ag_2CrO_4 is 1.1×10^{-12} at 298K. The solubility (in mol/L) of Ag_2CrO_4 in a 0.1M AgNO_3 solution is
- (a) 1.1×10^{-11} (b) 1.1×10^{-10}
(c) 1.1×10^{-12} (d) 1.1×10^{-9}
18. In the following reaction, the product(s) formed is(are)



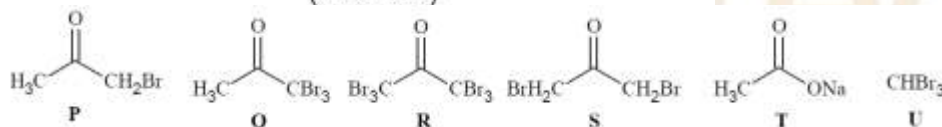
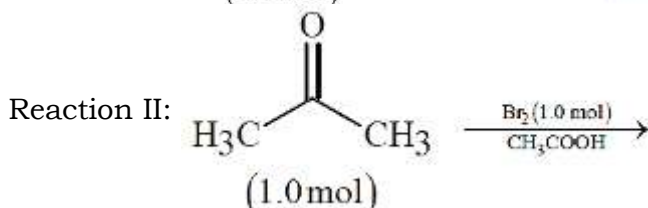
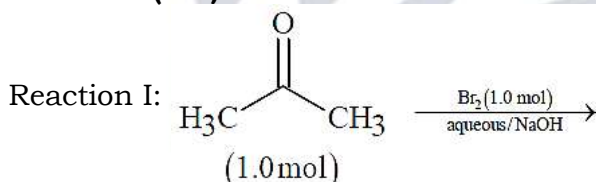
- (a) P(major) (b) Q(minor)
(c) R(minor) (d) S(major)

19. The major product(s) of the following reaction is (are)



- (a) P (b) Q
(c) R (d) S

20. After completion of the reactions (I and II), the organic compound(s) in the reaction mixtures is(are)

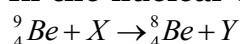


- (a) Reaction I: P and Reaction II : P
(b) Reaction I: U, acetone and Reaction II:Q, acetone
(c) Reaction I : T, U, acetone and Reaction II : P
(d) Reaction I : R, acetone and Reaction II : S, acetone

21. The correct statement(s) about O_3 is(are)

- (a) O-O bond lengths are equal.
(b) Thermal decomposition of O_3 is endothermic.
(c) O_3 is diamagnetic in nature.
(d) O_3 has a bent structure.

22. In the nuclear transmutation



(X, Y) is (are)

- (a) (γ , n) (b) (p, D)
(c) (n, D) (d) (γ , p)

23. The carbon-based reduction method is NOT used for the extraction of

- (a) tin from SnO_2
(b) iron from Fe_2O_3
(c) aluminium from Al_2O_3
(d) magnesium from $\text{MgCO}_3 \cdot \text{CaCO}_3$

24. The thermal dissociation equilibrium of $\text{CaCO}_3(\text{s})$ is studied under different conditions.



For this equilibrium, the correct statement(s) is(are)

- (a) ΔH is dependent on T
(b) K is independent of the initial amount of CaCO_3
(c) K is dependent on the pressure of CO_2 at a given T
(d) ΔH is independent of the catalyst, if any

SECTION-2

(Paragraph Type)

This section contains 4 paragraphs each describing theory, experiment, data etc. Eight questions relate to four paragraphs with two questions on each paragraph. Each question of a paragraph has only one correct answer among the four choices (a), (b), (c) and (d).

PARAGRAPH FOR QUESTION NOS. (i) AND (ii)

25. An aqueous solution of a mixture of two inorganic salts, when treated with dilute HCl, gave a precipitate (P) and a filtrate (Q). The precipitate P was found to dissolve in hot water. The filtrate (Q) remained unchanged, when treated with H_2S in a dilute mineral acid medium. However, it gave a precipitate (R) with H_2S in an ammoniacal medium. The precipitate R gave a coloured solution (S), when treated with H_2O_2 in an aqueous NaOH medium.

(i) The precipitate P contains

- (a) Pb^{2+} (b) Hg_2^{2+}
(c) Ag^+ (d) Hg^{2+}

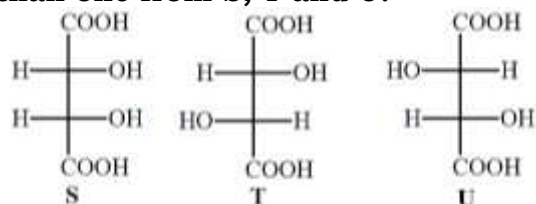
(ii) The coloured solution S contains

- (a) $\text{Fe}_2(\text{SO}_4)_3$ (b) CuSO_4
(c) ZnSO_4 (d) Na_2CrO_4

PARAGRAPH FOR QUESTION NOS. (I) TO (II)

26. P and Q are isomers of dicarboxylic acid $\text{C}_4\text{H}_4\text{O}_4$. Both decolorize $\text{Br}_2/\text{H}_2\text{O}$. On heating, P forms the cyclic anhydride.

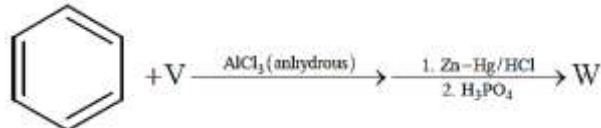
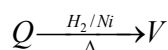
Upon treatment with dilute alkaline KMnO_4 , P as well as Q could produce one or more than one from S, T and U.

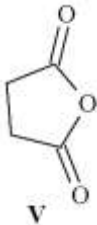
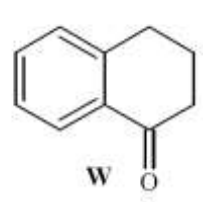
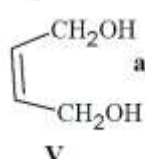
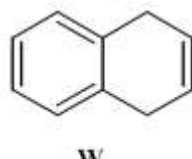
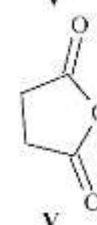
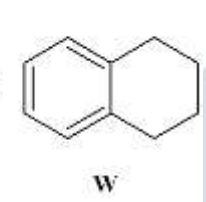
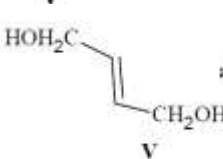
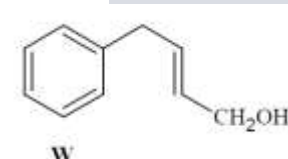


(i) Compounds formed from P and Q are, respectively

- (a) Optically active S and optically active pair (T, U)
(b) Optically inactive S and optically inactive pair (T, U)
(c) Optically active pair (T, U) and optically active S
(d) Optically inactive pair (T, U) and optically inactive S

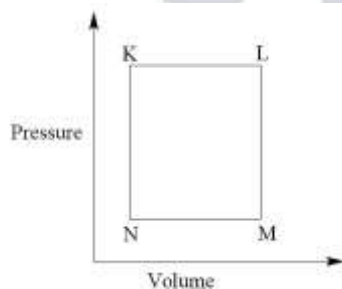
(ii) In the following reaction sequences V and W are, respectively



- (a)  and 
- (b)  and 
- (c)  and 
- (d)  and 

PARAGRAPH for Question Nos. (i) to (ii)

27. A fixed mass 'm' of a gas is subjected to transformation of states from K to L to M to N and back to K as shown in the figure



- (i) The succeeding operations that enable this transformation of states are
- Heating, cooling, heating, cooling
 - Cooling, heating, cooling, heating
 - Heating, cooling, cooling, heating
 - Cooling, heating, heating, cooling
- (ii) The pair of isochoric processes among the transformation of states is
- K to L and L to M
 - L to M and N to K
 - L to M and M to N
 - M to N and N to K

PARAGRAPH FOR QUESTION NOS. (i) TO (ii)

28. The reactions of Cl_2 gas with cold-dilute and hot-concentrated NaOH in water give sodium salts of two (different) oxoacids of chlorine, P and Q, respectively. The Cl_2 gas

reacts with SO_2 gas, in presence of charcoal, to give a product R. R reacts with white phosphorus to give a compound S. On hydrolysis, S gives an oxoacid of phosphorus, T.

(i) P and Q, respectively, are the sodium salts of

- hypochlorous and chloric acids
- hypochlorous and chlorus acids
- chloric and perchloric acids
- chloric and hypochlorous acids

(ii) R, S and T, respectively, are

- SO_2Cl_2 , PCl_5 and H_3PO_4
- SO_2Cl_2 , PCl_3 and H_3PO_3
- SOCl_2 , PCl_3 and H_3PO_2
- SOCl_2 , PCl_5 and H_3PO_4

SECTION - 3

(Matching List Type)

This section contains 4 multiple choice questions. Each question has matching lists. The codes for the lists have choices (a), (b), (c) and (d) out of which ONLY ONE is correct.

29. The unbalanced chemical reactions given in List - I show missing reagent or condition (?) which are provided in List - II. Match List - I with List - II and select the correct answer using the code given below the lists:

List - I

List - II

(P) $\text{PbO}_2 + \text{H}_2\text{SO}_4 \xrightarrow{?} \text{PbSO}_4 + \text{O}_2 + \text{other product}$ (1) NO

(Q) $\text{Na}_2\text{S}_2\text{O}_3 + \text{H}_2\text{O} \xrightarrow{?} \text{NaHSO}_4 + \text{other product}$ (2) I_2

(R) $\text{N}_2\text{H}_4 \xrightarrow{?} \text{N}_2 + \text{other product}$ (3) Warm

(S) $\text{XeF}_2 \xrightarrow{?} \text{Xe} + \text{other product}$ (4) Cl_2

Codes:

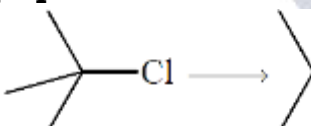
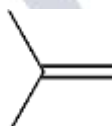
P Q R S

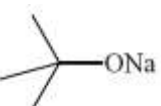
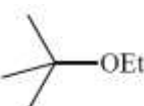
- 4 2 3 1
- 3 2 1 4
- 1 4 2 3
- 3 4 2 1

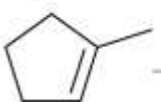
30. Match the chemical conversions in List - I with appropriate reagents in List - II and select the correct answer using the code given below the lists:

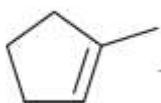
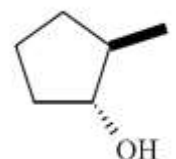
List - I

List - II

(P)  $\longrightarrow$  (1) (i) $\text{Hg}(\text{OAc})_2$; (ii) NaBH_4

(Q)  $\longrightarrow$  (2) NaOEt

(R)  $\longrightarrow$  (3) Et-Br

(S)  $\longrightarrow$  (4) (i) BH_3 ; (ii) $\text{H}_2\text{O}_2/\text{NaOH}$

Codes:

P Q R S

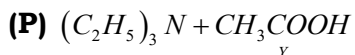
- 2 3 1 4
- 3 2 1 4

- (c) 2 3 4 1
(d) 3 2 4 1

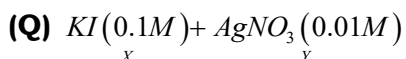
31. An aqueous solution of X is added slowly to an aqueous solution of Y as shown in List – I. The variation in conductivity of these reactions in List – II. Match List – I with List – II and select the correct answer using the code given below the lists:

List – I

List – II



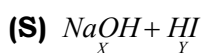
(1) Conductivity decreases and then increases



(2) Conductivity decreases and then does not change much



(3) Conductivity increases and then does not change much



(4) Conductivity does not change much and then increases

Codes:

P Q R S

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

32. The standard reduction potential data at 25°C is given below:

$$E^0(Fe^{3+}, Fe^{2+}) = +0.77V;$$

$$E^0(Fe^{2+}, Fe) = -0.44V$$

$$E^0(Cu^{2+}, Cu) = +0.34V,$$

$$E^0(Cu^+, Cu) = +0.52V$$

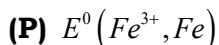
$$E^0[O_2(g) + 4H^+ + 4e^- \rightarrow 2H_2O] = +1.23V;$$

$$E^0[O_2(g) + 2H_2O + 4e^- \rightarrow 4OH^-] = +0.40V$$

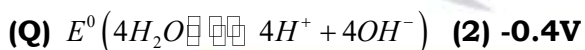
$$E^0(Cr^{3+}, Cr) = -0.74V;$$

$$E^0(Cr^{2+}, Cr) = -0.91V$$

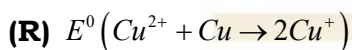
Match E^0 of the redox pair in List – I with the values given in List – II and select the correct answer using the code given below the lists:



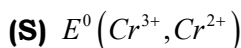
(1) -0.18 V



(2) -0.4V



(3) -0.04V



(4) -0.83 V

Codes:

P Q R S

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

PART – III: MATHEMATICS

SECTION - 1

(One or more option correct Type)

This section contains 8 multiple choice questions. Each question has four choices (a), (b), (c) and (d) out of which ONE or MORE are correct.

33. For $a \in \mathbf{R}$ (the set of all real numbers), $a \neq -1$,

$$\lim_{n \rightarrow \infty} \frac{(1^a + 2^a + \dots + n^a)}{(n+1)^{a-1} [(na+1) + (na+2) + \dots + (na+n)]} = \frac{1}{60}.$$

Then $a =$

- (a) 5 (b) 7
(c) $\frac{-15}{2}$ (d) $\frac{-17}{2}$

34. Circle(s) touching x -axis at a distance 3 from the origin and having an intercept of length $2\sqrt{7}$ on y -axis is (are)

- (a) $x^2 + y^2 - 6x + 8y + 9 = 0$
(b) $x^2 + y^2 - 6x + 7y + 9 = 0$
(c) $x^2 + y^2 - 6x - 8y + 9 = 0$
(d) $x^2 + y^2 - 6x - 7y + 9 = 0$

35. Two lines $L_1: x = 5$, $\frac{y}{3-\alpha} = \frac{z}{-2}$ and $L_2: x = \alpha$, $\frac{y}{-1} = \frac{z}{2-\alpha}$ are coplanar. Then α can take value(s)

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

36. In a triangle PQR, P is the largest angle and $\cos P = \frac{1}{3}$. Further the incircle of the triangle touches the sides PQ, QR and RP at N, L and M respectively, such that the lengths of PN, QL and RM are consecutive even integers. Then possible length(s) of the side(s) of the triangle is (are)

- (a) 16 (b) 18
(c) 24 (d) 22

37. $w = \frac{\sqrt{3}+i}{2}$ and $P = \{w^n : n = 1, 2, 3, \dots\}$. Further $H_1 = \left\{z \in \mathbf{C} : \operatorname{Re} z > \frac{1}{2}\right\}$ and

$H_2 = \left\{z \in \mathbf{C} : \operatorname{Re} z < \frac{-1}{2}\right\}$, where $\mathbf{C}$ is the set of all complex numbers. If $z_1 \in P \cap H_1, z_2 \in P \cap H_2$ and

O represents the origin, then $\angle z_1 O z_2 =$

- (a) $\frac{\pi}{2}$ (b) $\frac{\pi}{6}$
(c) $\frac{2\pi}{3}$ (d) $\frac{5\pi}{6}$

38. If $3^x = 4^{x-1}$, then $x =$

- (a) $\frac{2 \log_3 2}{2 \log_3 2 - 1}$ (b) $\frac{2}{2 - \log_2 3}$
(c) $\frac{1}{1 - \log_4 3}$ (d) $\frac{2 \log_2 3}{2 \log_2 3 - 1}$

39. Let ω be a complex cube root of unity with $\omega \neq 1$ and $P = [p_{ij}]$ be a $n \times n$ matrix with $p_{ij} = \omega^{i+j}$. Then $P^2 \neq 0$, when $n =$

- (a) 57 (b) 55
(c) 58 (d) 56

40. The function $f(x) = 2|x| + |x+2| - ||x+2| - 2|x||$ has a local minimum or a local maximum at $x =$

- (a) -2 (b) $\frac{-2}{3}$
(c) 2 (d) 2

SECTION - 2
(Paragraph Type)

This section contains 6 multiple choice questions relating to three paragraphs with two questions on each paragraph.

Each question has four choices (a), (b), (c) and (d) out of which ONLY ONE is correct.

PARAGRAPH FOR QUESTIONS (i) AND (ii)

41. Let $f : [0, 1] \rightarrow \mathbb{R}$ (the set of all real numbers) be a function. Suppose the function f is twice differentiable, $f(0) = f(1) = 0$ and satisfies $f''(x) - 2f'(x) + f(x) \geq e^x$, $x \in [0, 1]$.

(i) Which of the following is true for $0 < x < 1$?

- (a) $0 < f(x) < \infty$ (b) $-\frac{1}{2} < f(x) < \frac{1}{2}$
(c) $-\frac{1}{4} < f(x) < 1$ (d) $-\infty < f(x) < 0$

(ii) If the function $e^{-x} f(x)$ assumes its minimum in the interval $[0, 1]$ at $x = \frac{1}{4}$, which of the following is true?

- (a) $f'(x) < f(x), \frac{1}{4} < x < \frac{3}{4}$
(b) $f'(x) > f(x), 0 < x < \frac{1}{4}$
(c) $f'(x) < f(x), 0 < x < \frac{1}{4}$
(d) $f'(x) < f(x), \frac{3}{4} < x < 1$

PARAGRAPH FOR QUESTIONS (i) AND (ii)

42. Let PQ be a focal chord of the parabola $y^2 = 4ax$. The tangents to the parabola at P and Q meet at a point lying on the line $y = 2x + a$, $a > 0$.

(i) Length of chord PQ is

- (a) $7a$ (b) $5a$
(c) $2a$ (d) $3a$

(ii) If chord PQ subtends an angle θ at the vertex of $y^2 = 4ax$, then $\tan \theta =$

- (a) $\frac{2}{3}\sqrt{7}$ (b) $\frac{-2}{3}\sqrt{7}$
(c) $\frac{2}{3}\sqrt{5}$ (d) $\frac{-2}{3}\sqrt{5}$

PARAGRAPH FOR QUESTIONS (i) AND (ii)

43. Let $S = S_1 \cap S_2 \cap S_3$, where

$$S_1 = \{z \in \mathbb{C} : |z| < 4\}, S_2 = \left\{z \in \mathbb{C} : \operatorname{Im} \left[\frac{z-1+\sqrt{3}i}{1-\sqrt{3}i} \right] > 0 \right\} \text{ and } S_3 = \{z \in \mathbb{C} : \operatorname{Re} z > 0\}$$

(i) Area of S =

- (a) $\frac{10\pi}{3}$ (b) $\frac{20\pi}{3}$
(c) $\frac{16\pi}{3}$ (d) $\frac{32\pi}{3}$

(ii) $\min_{z \in S} |1 - 3i - z| =$

- (a) $\frac{2-\sqrt{3}}{2}$ (b) $\frac{2+\sqrt{3}}{2}$
(c) $\frac{3-\sqrt{3}}{2}$ (d) $\frac{3+\sqrt{3}}{2}$

PARAGRAPH FOR QUESTIONS (i) AND (ii)

44. A box B_1 contains 1 white ball, 3 red balls and 2 black balls. Another box B_2 contains 2 white balls, 3 red balls and 4 black balls. A third box B_3 contains 3 white balls, 4 red balls and 5 black balls.

(i) If 1 ball is drawn from each of the boxes B_1 , B_2 and B_3 , the probability that all 3 drawn balls are of the same colour is

- (a) $\frac{82}{648}$ (b) $\frac{90}{648}$
(c) $\frac{558}{648}$ (d) $\frac{566}{648}$

(ii) If 2 balls are drawn (without replacement) from a randomly selected box and one of the balls is white and the other ball is red, the probability that these 2 balls are drawn from box B_2 is

- (a) $\frac{116}{181}$ (b) $\frac{126}{181}$
(c) $\frac{65}{181}$ (d) $\frac{55}{181}$

SECTION - 3 (Matching list Type)

This section contains 4 multiple choice questions. Each question has matching lists. The codes for the lists have choices (a), (b), (c) and (d) out of which ONLY ONE is correct.

45. Match List I with List II and select the correct answer using the code given below the lists:

	List - I		List - II
P.	$\left(\frac{1}{y^2} \left(\frac{\cos(\tan^{-1} y) + y \sin(\tan^{-1} y)}{\cot(\sin^{-1} y) + \tan(\sin^{-1} y)} \right) + y^4 \right)^{1/2}$ takes value	1.	$\frac{1}{2} \sqrt{\frac{5}{3}}$
Q.	If $\cos x + \cos y + \cos z = 0 = \sin x + \sin y + \sin z$ then possible value of $\cos \frac{x-y}{2}$ is	2.	$\sqrt{2}$
R.	If $\cos\left(\frac{\pi}{4} - x\right) \cos 2x + \sin x \sin 2x \sec x = \cos x \sin 2x \sec x + \cos\left(\frac{\pi}{4} + x\right) \cos 2x$ then possible value of $\sec x$ is	3.	$\frac{1}{2}$
S.	If $\cot(\sin^{-1} \sqrt{1-x^2}) = \sin(\tan^{-1}(x\sqrt{6})), x \neq 0$, then possible value of x is	4.	1

Codes:

P Q R S

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

46. A line $L : y = mx + 3$ meets y -axis at $E(0, 3)$ and the arc of the parabola $y^2 = 16x$, $0 \leq y \leq 6$ at the point $F(x_0, y_0)$. The tangent to the parabola at $F(x_0, y_0)$ intersects the y -axis at $G(0, y_1)$. The slope m of the line L is chosen such that the area of the triangle EFG has a local maximum.

Match List I with List II and select the correct answer using the code given below the lists:

List - I

List - II

P. $m =$

1. $\frac{1}{2}$

Q. Maximum area of $\triangle EFG$ is

2. 4

R. $y_0 =$

3. 2

S. $y_1 =$

4. 1

Codes:

P Q R S

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

47. Match List I with List II and select the correct answer using the code given below the lists:

	List		List II
P.	Volume of parallelepiped determined by vectors $\vec{a}, \vec{b}$ and $\vec{c}$ is 2. Then the volume of the parallelepiped determined by vectors $2(\vec{a} \times \vec{b}), 3(\vec{b} \times \vec{c})$ and $(\vec{c} \times \vec{a})$ is	1.	100
Q.	Volume of parallelepiped determined by vectors $\vec{a}, \vec{b}$ and $\vec{c}$ is 5. Then the volume of the parallelepiped determined by vectors $3(\vec{a} + \vec{b}), 3(\vec{b} + \vec{c})$ and $2(\vec{c} + \vec{a})$ is	2.	30
R.	Area of a triangle with adjacent sides determined by vectors $\vec{a}$ and $\vec{b}$ is 20. Then the area of the triangle with adjacent sides determined by vectors $(\vec{a} + \vec{b})$ and $\vec{a}$ is	4.	60

Codes:

P Q R S

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

48. Consider the lines $L_1 : \frac{x-1}{2} = \frac{y}{-1} = \frac{z+3}{1}$, $L_2 : \frac{x-4}{1} = \frac{y+3}{1} = \frac{z+3}{2}$ and the planes $P_1 : 7x + y + 2z = 3$, $P_2 : 3x + 5y - 6z = 4$. Let $ax + by + cz = d$ be the equation of the plane passing through the point of intersection of lines L_1 and L_2 , and perpendicular to planes P_1 and P_2 .

Match List I with List II and select the correct answer using the code given below the lists:

List - I

List - II

P. $a =$

1. 13

Q. $b =$

2. -3

R. $c =$

3. 1

S. $d =$

4. -2

Codes:

P Q R S

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

