FIITJEE
ALL INDIA TEST SERIES
JEE (Advanced)-2024
OPEN TEST – I
PAPER –1
TEST DATE: 04-02-2024

Time Allotted: 3 Hours **Maximum Marks: 180**

General Instructions:

- The test consists of total 51 questions.
- Each subject (PCM) has 17 questions.
- This question paper contains **Three Parts.**
- **Part-I** is Physics, **Part-II** is Chemistry and **Part-III** is Mathematics.
- Each **Part** is further divided into **Two Sections**: **Section-A & Section-B**.

Section – A *(01 –03, 18 – 20, 35 – 37):* This section contains **NINE (9)** questions. Each question has **FOUR** options. **ONE OR MORE THAN ONE** of these four option(s) is(are) correct answer(s).

Section – A *(04 – 07, 21 – 24, 38 – 41)*: This section contains **TWELVE (12)** questions. Each question has **FOUR** options. **ONLY ONE** of these four options is the correct answer.

Section – A *(08 – 11, 25 – 28, 42 – 45):* This section contains **TWELVE (12)** Matching List Type Questions. Each question has **FOUR** statements in **List-I** entries (P), (Q), (R) and (S) and **FIVE** statements in **List-II** entries (1), (2), (3), (4) and (5). The codes for lists have choices (A), (B), (C), (D) out of which, **ONLY ONE** of these four options is correct answer.

Section – B *(12 – 17, 29 – 34, 46 – 51):* This section contains **EIGHTEEN (18)** numerical based questions. The answer to each question is a **NON-NEGATIVE INTEGER VALUE**.

MARKING SCHEME

Section – A (One or More than One Correct): Answer to each question will be evaluated according to the following marking scheme:

Full Marks	:	+4	If only (all) the correct option(s) is (are) chosen;
Partial Marks	:	+3	If all the four options are correct but ONLY three options are chosen;
Partial marks	:	+2	If three or more options are correct but ONLY two options are chosen and both of which are correct;
Partial Marks	:	+1	If two or more options are correct but ONLY one option is chosen and it is a correct option;
Zero Marks	:	0	If none of the options is chosen (i.e. the question is unanswered);
Negative Marks	:	–2	In all other cases.

Section – A (Single Correct): Answer to each question will be evaluated according to the following marking scheme:

Full Marks	:	+3	If ONLY the correct option is chosen.
Zero Marks	:	0	If none of the options is chosen (i.e. the question is unanswered);
Negative Marks	:	–1	In all other cases.

Section – B: Answer to each question will be evaluated according to the following marking scheme:

Full Marks	:	+4	If ONLY the correct numerical value is entered at the designated place;
Zero Marks	:	0	In all other cases.

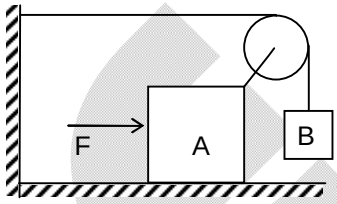
Physics

PART – I

SECTION – A
(One or More than one correct type)

*This section contains **THREE (03)** questions. Each question has **FOUR** options (A), (B), (C) and (D). **ONE OR MORE THAN ONE** of these four option(s) is (are) correct answer(s).*

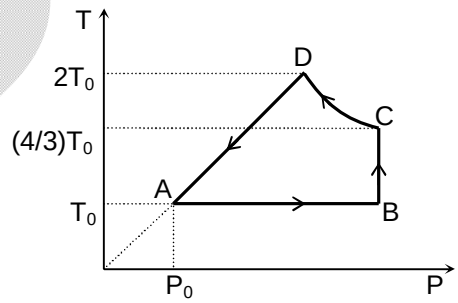
1. Wedge A and Block B is shown in the figure. A horizontal force F is applied on the wedge so that wedge A is in equilibrium. Just after force F is removed, block and wedge move with acceleration a_B and a_A respectively. Mass of wedge and block are same and equal to m. Then choose correct option(s).



(A) Value of force F is mg
(B) The value of $a_A = g$
(C) The value of $a_A = g/2$
(D) The value of $a_B = g/2$

2. A thin, uniform rod of mass 4 kg, length 2 m is moving on smooth horizontal surface with velocity of its centre of mass $v_0 = 1$ m/s and angular velocity $\omega_0 = 3$ rad/s. When velocity of its centre of mass is perpendicular to its length, the rod collides elastically at one of its end with a particle of mass m = 1 kg placed at rest on the horizontal surface such that the collision is head on and impact force is largest. The correct option(s) are
(A) Velocity of particle after collision is 4 m/s
(B) Velocity of centre of rod after collision is zero
(C) Velcoity of centre of mass of rod after collision is 1 m/s
(D) Impulse on particle during collision is 4 N-s

3. One mole of ideal monoatomic gas is taken through the cyclic process as shown in T-P diagram. Process C→D is such that PT = constant (take $\ell n3 = 1.0986$)

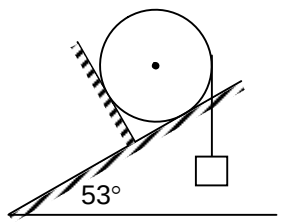


B → C isobaric process
A → B is isothermal process
(A) In process C → D heat exchange is maximum
(B) In process D → A, heat exchange is maximum
(C) Efficiency of the cyclic process is nearly 17.9%
(D) Efficiency of the cyclic process is nearly 21.3%

SECTION – A
(One Options Correct Type)

*This section contains **FOUR (04)** questions. Each question has **FOUR** options (A), (B), (C) and (D). **ONLY ONE** of these four options is the correct answer.*

4. A cylinder of mass m = 1 kg and radius (r = 1 m) is placed on inclined plane of angle $\theta = 53°$ with horizontal. Thin string is wrapped around cylinder and a bloc of mass m = 4 kg is attached with it. The cylinder is supported by a smooth wall perpendicular to inclined plane. Inclined plane is rough (coefficient of friction μ). The correct option is



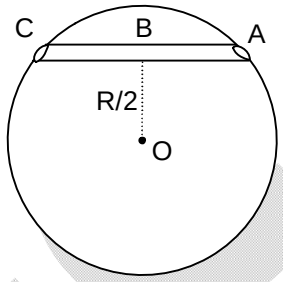
(A) When $\mu = \frac{3}{4}$, force due to wall on cylinder is non zero and block moves down

(B) When $\mu = \frac{3}{4}$, force on cylinder by wall is zero and acceleration of cylinder non zero

(C) When $\mu = \frac{3}{4}$, the cylinder and block remains at rest. Normal force due to wall on cylinder is zero.

(D) When $\mu = \frac{4}{3}$, the cylinder and block remains at rest, but normal force on cylinder by wall is non-zero.

5. In the figure shown, a thin tunnel is made in a planet of spherical shape, radius R and acceleration due to gravity is g on its surface. A block of negligible mass is pushed into tunnel at the mouth of tunnel at end A. The coefficient of friction between tunnel and block is $\mu = \frac{\sqrt{3}}{2}$. The correct option is



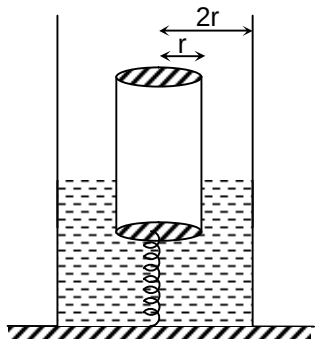
(A) The maximum speed of the block is $\frac{\sqrt{gR}}{4}$

(B) The maximum speed of the block is $\frac{\sqrt{13gR}}{4}$

(C) The maximum speed of the block is $\frac{\sqrt{3gR}}{4}$

(D) The maximum speed of the block is $\frac{\sqrt{3gR}}{2}$

6. A cylinder of mass m height h, radius r, when put in water, it floats with half of its volume submerged. The cylinder is placed in a cylindrical vessel of inner radius R = 2r, on a spring of force constant $k = \frac{mg}{\left(\frac{\sqrt{3}}{2}h\right)}$, such that cylinder is inside water by $\frac{h}{3}$ as shown in the figure. The minimum energy required to push the cylinder such that it just completely immersed in water is



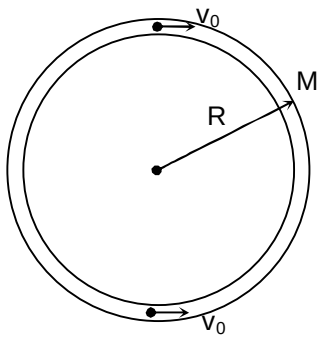
(A) $\frac{mgh}{6}$

(B) $mgh\left(\frac{\sqrt{3}+4}{12}\right)$

(C) $\frac{mgh}{2}(1+\sqrt{3})$

(D) $\frac{mgh}{6\sqrt{3}}(1+\sqrt{3})$

7. Two small beads each of mass m are placed in a smooth circular tube (M = 4 m) lying on smooth horizontal surface with its plane horizontal. The beads are at diametrically opposite of the tube and given equal velocity v_0 as shown in the figure. Collision between beads is perfect elastic. The maximum velocity of tube in subsequent motion is



(A) $\frac{2v_0}{3}$

(B) $\frac{4v_0}{3}$

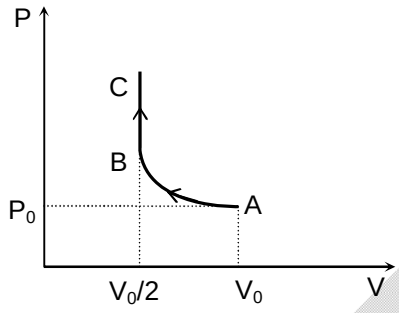
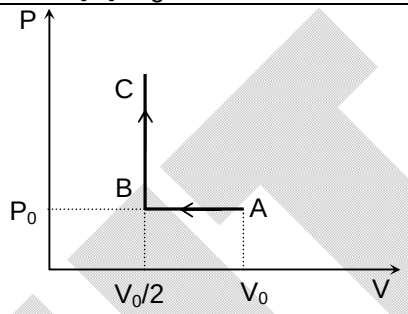
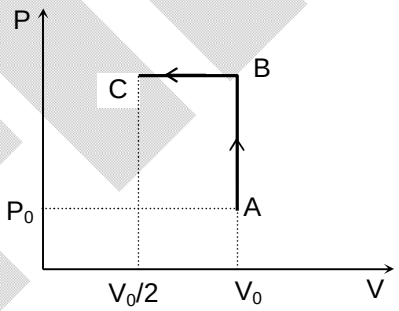
(C) $\frac{5v_0}{3}$

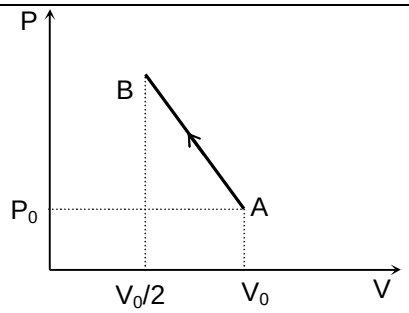
(D) $\frac{7v_0}{3}$

SECTION – A
(Matching List Type)

*This section contains **FOUR (04)** Matching List Type Questions. Each question has FOUR statements in **List-I** entries (P), (Q), (R) and (S) and FIVE statements in **List-II** entries (1), (2), (3), (4) and (5). The codes for lists have choices (A), (B), (C), (D) out of which **ONLY ONE** of these four options is correct answer.*

8. Monoatomic gas at pressure P_0, volume V_0 and temperature T_0 is taken in a piston-cylinder such that piston is free to move inside the cylinder. The gas is compressed to volume $\frac{V_0}{2}$ through various process. List-I describes four processes and List-II gives pressure of gas in final state C.

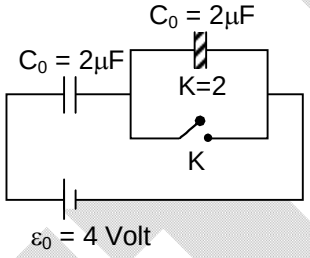
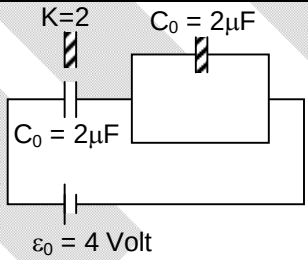
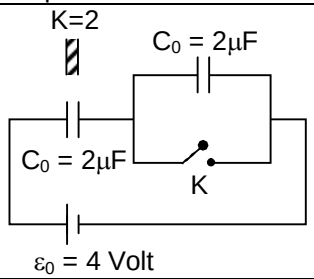
List –I		List –II	
(P)	 Gas is compressed isothermally and then heat P_0V_0 is given at constant volume	(1)	$\frac{11}{2}P_0$
(Q)	 Gas is compressed isobarically and then heat P_0V_0 is given at constant volume	(2)	$\frac{5}{3}P_0$
(R)	 Gas is given heat P_0V_0 at constant volume then compressed at constant pressure	(3)	$\frac{10}{3}P_0$

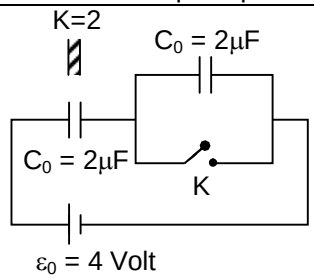
(S)	 Gas is compressed as well as heat P_0V_0 is given simultaneously	(4)	$\frac{7}{3}P_0$
		(5)	$\frac{5}{6}P_0$

The correct option is:

(A) (P) → (3) (Q) → (4) (R) → (2) (S) → (1)
(B) (P) → (3) (Q) → (2) (R) → (5) (S) → (4)
(C) (P) → (2) (Q) → (1) (R) → (4) (S) → (5)
(D) (P) → (2) (Q) → (1) (R) → (1) (S) → (3)

9. List-I describes four process and List-II gives loss of energy (in μJ) in each process. (C_0 is capacitance of capacitor free from dielectric)

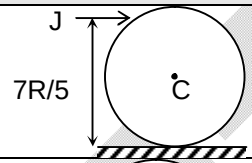
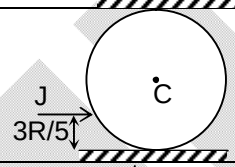
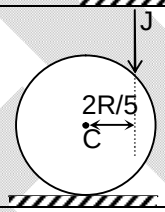
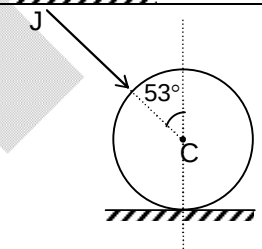
List –I		List –II	
(P)	 Circuit is in steady state and switch k is closed	(1)	$\frac{64}{3}$
(Q)	 Circuit is in steady state and then dielectric slab is inserted in the left capacitor which fills the space between plates of capacitor.	(2)	24
(R)		(3)	16

	Circuit is in steady state, first switch k is closed and then dielectric slab is inserted to fill the space between plates of left capacitor heat generated in complete process		
(S)	 Circuit is in steady state. Now left capacitor is filled with dielectric and switch k is closed	(4)	8
		(5)	$\frac{16}{3}$

The correct option is:

(A) (P) → (5) (Q) → (2) (R) → (2) (S) → (4)
(B) (P) → (3) (Q) → (2) (R) → (5) (S) → (4)
(C) (P) → (5) (Q) → (3) (R) → (2) (S) → (2)
(D) (P) → (2) (Q) → (1) (R) → (1) (S) → (3)

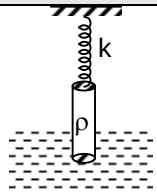
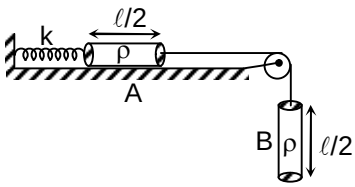
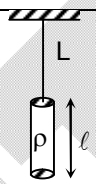
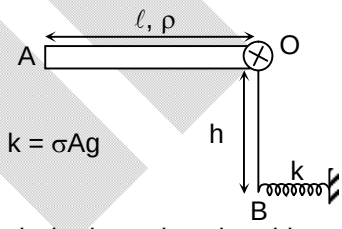
10. In List-I solid sphere of mass m is placed on rough horizontal surface and an impulse J is applied on it and List-II gives velocity of sphere when pure rolling starts.

List –I		List –II	
(P)		(1)	$\frac{2J}{7M}$
(Q)		(2)	$\frac{4J}{7M}$
(R)		(3)	$\frac{J}{M}$
(S)		(4)	$\frac{4J}{5M}$
		(5)	$\frac{3J}{7M}$

The correct option is:

(A) (P) → (3) (Q) → (2) (R) → (2) (S) → (4)
(B) (P) → (3) (Q) → (5) (R) → (1) (S) → (2)
(C) (P) → (2) (Q) → (1) (R) → (4) (S) → (5)
(D) (P) → (3) (Q) → (5) (R) → (1) (S) → (4)

11. List-I gives the situations in which a rod can oscillate. Length of rod is h, cross section area is A, density ρ, $h >> \sqrt{A}$, liquid density is σ and spring constant $k = A\sigma g$. List-II contains time period of oscillations.

List –I		List –II	
(P)	 rod oscillates in vertical direction and some part of it is always out of liquid	(1)	$2\pi\sqrt{\frac{\rho h}{2\sigma g}}$
(Q)	 Rod B gets pulled down slightly and released. So it oscillates along vertical line.	(2)	$2\pi\sqrt{\frac{\rho \ell}{\sigma g}}$
(R)	 When rod is attached with metallic wire it extends by length h. Rod oscillates vertically	(3)	$2\pi\sqrt{\frac{\rho \ell}{3\sigma g}}$
(S)	 Rod AO is horizontal and a thin vertical massless rod OB are welded. The system is hinged at O and is held in the shown position with the help of spring of spring constant k. OA is horizontal and OB is vertical. The rod is slightly pushed down and released. It oscillates in vertical plane	(4)	$2\pi\sqrt{\frac{h}{g}}$
		(5)	$2\pi\sqrt{\frac{L}{g}}$

The correct option is:

(A) (P) → (1) (Q) → (2) (R) → (4) (S) → (3)

(B) (P) → (1) (Q) → (2) (R) → (5) (S) → (4)
(C) (P) → (2) (Q) → (1) (R) → (4) (S) → (5)
(D) (P) → (2) (Q) → (1) (R) → (1) (S) → (3)

SECTION – B

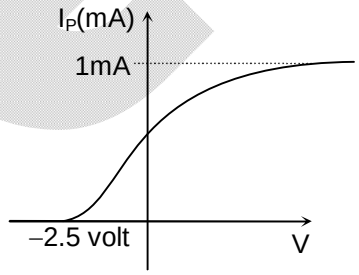
(Numerical Answer Type)

*This section contains **SIX (06)** Numerical based questions. The answer to each question is a **NON-NEGATIVE INTEGER VALUE**.*

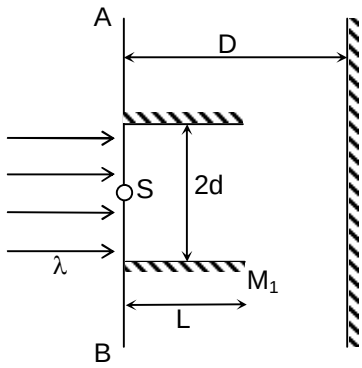
12. Two spherical bodies S_1 and S_2 of masses 9m, m and radius 3R and R respectively are initially located at a separation 14R between their centres and then released from rest. They approach towards each other due to mutual gravitational attraction between the two bodies. The velocity of the body S_2 just before it collides with the body S_1 is $n\sqrt{\frac{Gm}{28R}}$. Find the value of n.

13. A sample of hydrogen like gas has its electrons in grounds state. When this sample is radiated by photons of energy E = 204 eV. The electrons get transfer to 3rd excited state. If photons released during dexcitation to 1st excited state are being incident on a metal surface, the stopping potential is 32.22 volt. If the photons released during dexcitation to 2nd excited state are being incident on the same metal surface. The stopping potential in volt is

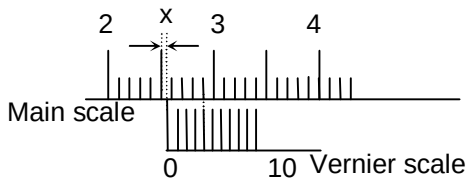
14. In a photoelectric experiment the work function of the metal plates is ϕ = 3.5 eV. Monochromatic light falls normally on the metal plate of area 15 cm^2. On the average one electron comes out of surface of the plate if 10^5 photons falls on it. The intensity of light used is $N \times 10^5$ W/m^2. The value of N is



15. In the YDSE two mirror each of length L = 15 cm are placed parallel to each other AB is opaque surface with a slit S shown in the figure. Separation between AB and screen is D. Parallel and coherent light incident as shown in the figure. Wavelength of light is λ. It is given that $d = \sqrt{D\lambda}$. Find the number of fringes on the screen. Slit is at mid point of line joining mirrors.



16. The figure shows position of vernier calipers in a particular position. The main scale is in cm and 10 division of vernier scale is equal to 9 division of main scale. The value of x is $\frac{N}{100}$ cm. Figure is not to scale, the value of N is (There is no zero error)



17. Ripples are formed on the surface of water is represented by wave equation y = A cos (ωt – kx). Where A = 10 cm and k = $\frac{10}{\sqrt{3}}$ m^{-1}. A luminous object and an observer are at height 10 m above the water surface. The maximum continuous angular spread of image due to reflection from water surface is 30 N degree. The value of N is

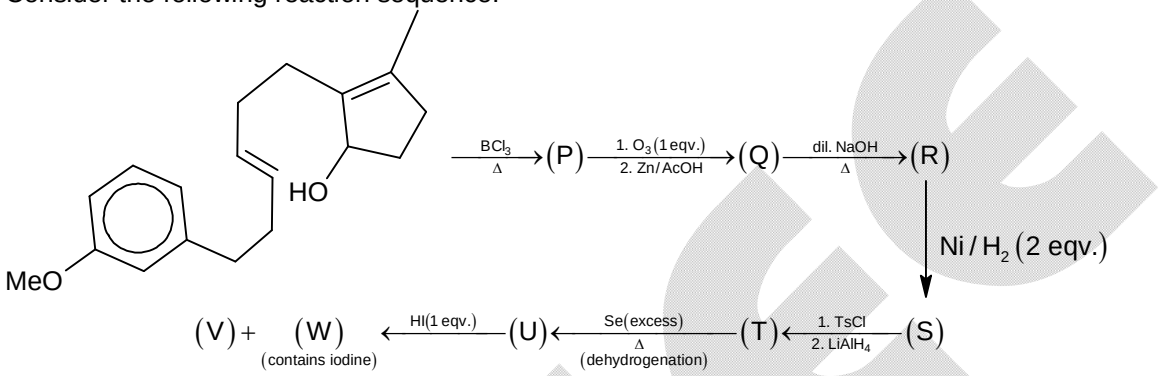
Chemistry

PART – II

SECTION – A
(One or More than one correct type)

*This section contains **THREE (03)** questions. Each question has **FOUR** options (A), (B), (C) and (D). **ONE OR MORE THAN ONE** of these four option(s) is (are) correct answer(s).*

18. Consider the following reaction sequence:



[Me = Methyl group; Ac = Acetyl group and Ts is Tosyl group and assume that 'P' to 'W' are the major organic products.]

Now, select the correct statement(s) regarding above sequence of reactions:

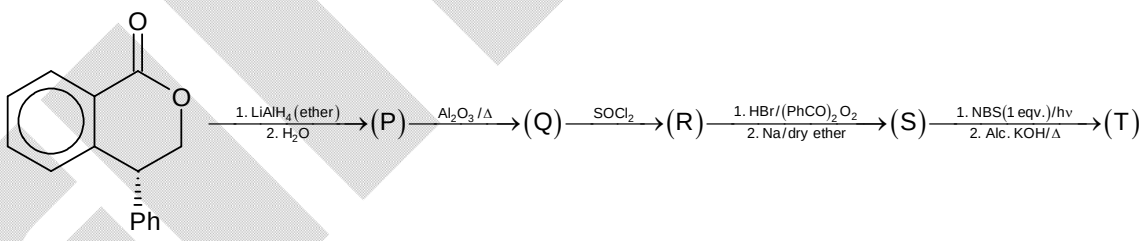
(A) sum of degree of unsaturation of (T), (U) and (V) is 33.

(B) (Q) on reaction with Mg in benzene followed by hydrolysis gives a compound which on treatment with methanal in presence of dry HCl gas, gives another product with degree of unsaturation 8.

(C) (R) contains 3 chiral carbon atoms.

(D) both (R) and (S) gives positive Lucas test.

19. With reference to the scheme given below, which of the following statement(s) is/are 'TRUE' about the major products P, Q, R, S & T?



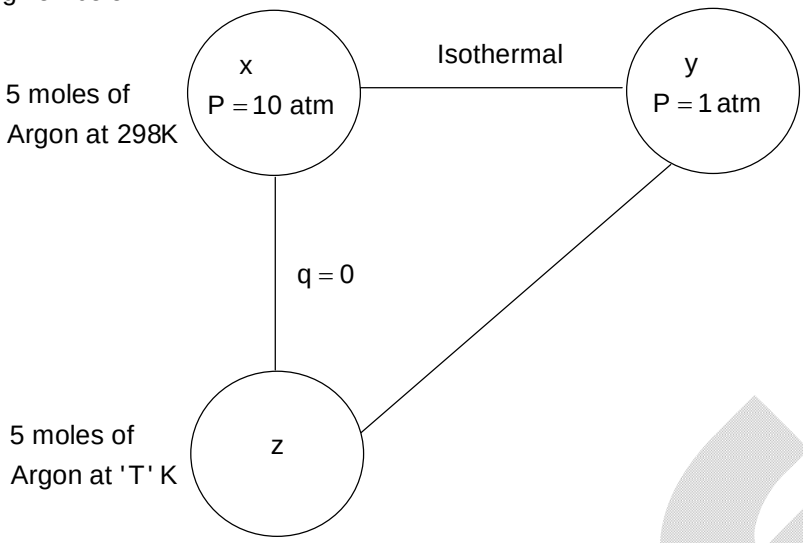
(A) Total stereoisomers of P, Q, R, S and T are three.

(B) (T) is optically active.

(C) Degree of unsaturation of (T) is 10.

(D) (R) on ozonolysis with one equivalent of ozone followed by hydrolysis gives product (A) which on treatment with 1 equivalent of $LiAlH_4$/ether may give a heterocyclic product.

20. Consider the following reversible processes and choose the correct answer(s) from the options given below:



(A) $\Delta S_{x\to y} = 95.74\ JK^{-1}$

(B) $\Delta S_{x\to z} = 0$

(C) $\Delta S_{x\to y} = \Delta S_{x\to z} + \Delta S_{z\to y} = 95.74\ JK^{-1}$

(D) $\Delta S_{x\to z\to y} = 0$

SECTION – A
(One Options Correct Type)

*This section contains **FOUR (04)** questions. Each question has **FOUR** options (A), (B), (C) and (D). **ONLY ONE** of these four options is the correct answer.*

21. A 0.1 M solution of Cu^+ ions is stirred with an excess of potassium cyanide sufficient to convert all the Cu^+ ions to the corresponding cuprocyanide complex $\left[Cu(CN)_4\right]^{3-}$ and in addition to provide the solution with an excess of CN^- equal to 0. 2 M. Calculate the maximum pH of the solution when the final solution is treated with hydrogen sulphide to maintain [H_2S] = 0.1 M and the precipitation of cuprous sulphide is prevented. The instability constant for $\left[Cu(CN)_4\right]^{3-}$ is 6.4×10^{-15}, $K_{a,\text{overall}}$ of $H_2S = 1.6\times10^{-21}$; K_{sp} of $Cu_2S = 2.56\times10^{-27}$.

(A) 10 (B) 10.8

(C) 4 (D) 3.2

22. 50 containers having volumes 3, 6, 9,……. 150 litres containing 2, 8, 18,……, 5000 moles respectively are connected with stop-cocks at the same temperature. If pressure of first container is ‘P’, then the final pressure when all the stop-cocks are opened, is:

(A) 27.66 P (B) 36.33 P

(C) 33.66 P (D) 67.33 P

23. Which of the following reaction will NOT produce any paramagnetic substance?

(A) $NaNO_2 + KI + HCl \longrightarrow$

(B) $O_3 + KOH \longrightarrow$

(C) $(NH_4)_2Cr_2O_7(s) \xrightarrow{\Delta}$

(D) $Pb(NO_3)_2 \xrightarrow{\Delta}$

24. Isomerisation of n-butane to isobutane is started by taking 1 mole of n-butane only in a container of capacity 1 L at 300 K

$$n-\text{butane} \rightleftharpoons \text{isobutane}$$

The rate constants of forward and backward reactions are $1.2\ \text{min}^{-1}$ and $0.8\ \text{min}^{-1}$, respectively.

$\left[\log 2 = 0.30; \log 3 = 0.48; \log 7 = 0.85; R = 8.314\ \text{J mol}^{-1}\text{K}^{-1}\right]$

Now, select the INCORRECT option(s):

(A) $\Delta_r G^o$ of the reaction is $-1.034\ \text{kJ mol}^{-1}$.

(B) 25% conversion of n-butane into isobutane takes 0.27 min.

(C) 75% conversion of n-butane into isobutane takes 0.69 min.

(D) After 0.345 minutes from the start, rate of conversion of n-butane to isobutane is $0.01\ \text{mol L}^{-1}\ \text{sec}^{-1}$

SECTION – A
(Matching List Type)

*This section contains **FOUR (04)** Matching List Type Questions. Each question has FOUR statements in **List-I** entries (P), (Q), (R) and (S) and FIVE statements in **List-II** entries (1), (2), (3), (4) and (5). The codes for lists have choices (A), (B), (C), (D) out of which **ONLY ONE** of these four options is correct answer.*

25. Some reactions are given in List-I. The product of each reaction (in List-I) containing the underlined element is treated with excess of PCl_5 to form one or more product(s) given in List-II. Now match List-I with List-II and choose the correct option from the codes given below:

List – I		List – II	
(P)	$\underline{P}_4(\text{White}) + O_2(\text{Excess}) \longrightarrow$	(1)	$POCl_3$
(Q)	$\underline{P}_4(\text{White, excess}) + O_2 \longrightarrow$	(2)	PCl_3
(R)	$\underline{P}_4(\text{White}) + \text{Conc. } HNO_3 \longrightarrow$	(3)	$SOCl_2$
(S)	$P_4(\text{White}) + \underline{S}O_2Cl_2 \longrightarrow$	(4)	HCl
		(5)	1 mole of the product containing underlined element (in list-I) requires at least three moles of PCl_5 to react completely

Codes:

(A) P → 1, 5; Q → 2, 5; R → 1, 4; S → 3, 5

(B) P → 1, 5; Q → 1, 2, 5; R → 1, 4, 5; S → 1, 3

(C) P → 1, 2, 5; Q → 1, 5; R → 4, 5; S → 1, 2, 3

(D) P → 1, 2, 5; Q → 1, 2, 5; R → 1, 4, 5; S → 3

26. Match the complex formed as a result of reactions given in List – I with their characteristics given in List II and choose the correct option, from the codes given below:

List – I		List – II	
(P)	$CuSO_4 + \underset{(\text{excess})}{NH_3(aq.)} \longrightarrow$	(1)	Colour of the complex is blue
(Q)	$CoCl_2 + KNO_2 \xrightarrow{CH_3COOH}$	(2)	Hybridization of central metal ion is sp^3
(R)	$CoCl_2 + NH_4SCN \longrightarrow$	(3)	Complex is paramagnetic
(S)	$CuSO_4 + \underset{(\text{excess})}{KCN} \longrightarrow$	(4)	Colour of the complex is yellow
		(5)	Spin only magnetic moment of the complex = 3.87 BM

Codes:

(A) P → 1, 3; Q → 4, 5; R → 1, 2, 3, 5; S → 2, 3

(B) P → 1, 3, 5; Q → 4; R → 1, 2, 3; S → 2

(C) P → 1, 3; Q → 4; R → 1, 2, 3, 5; S → 2

(D) P → 3, 4; Q → 1, 3; R → 2, 3, 5; S → 2, 4

27. Match the major organic product of reactions given in List I with their characteristics given in List II and choose the correct option from the codes given below:

List – I		List – II	
(P)	$\text{Hepta}-2,5-\text{dien}-4-\text{one} \xrightarrow[\text{(iii) }\Delta]{\text{(i) diethyl malonate/OH}^{-}\text{ (excess)}\ \text{(ii) }H_3O^{+}}$	(1)	It gives positive BRADY'S test
(Q)	$\text{Hexan}-2,5-\text{dione} \xrightarrow[\text{(ii) }CHBr_3/t-BuOK,\ \Delta]{\text{(i)}(NH_4)_2CO_3/\Delta}$	(2)	It is cyclic
(R)	$\text{Cyclohexan}-1,3-\text{dione} \xrightarrow{But-3-en-2-one/\text{dil. NaOH(excess)},\Delta}$	(3)	It is aromatic
(S)	$\text{Pent}-4-\text{enoic acid} \xrightarrow{I_2/NaHCO_3}$	(4)	It contains at least one six-membered ring
		(5)	Degree of unsaturation is ≥ 3

Codes:
(A) P → 1, 2, 4, 5; Q → 2, 3, 4, 5; R → 1, 2, 4, 5; S → 2, 4
(B) P → 1, 3, 4, 5; Q → 2, 4, 5; R → 2, 4; S → 1, 2, 4, 5
(C) P → 1, 2, 3, 4; Q → 2, 3, 5; R → 1, 2, 4, 5; S → 2, 3, 5
(D) P → 1, 2, 4; Q → 2, 3, 4, 5; R → 1, 2, 4, 5; S → 2, 4

28. Match the reactions given in List I with characteristics of their products given in List II and choose the correct option from the codes given below:

List – I		List – II	
(P)	$K_2Cr_2O_7 + H_2O_2 + KOH \longrightarrow$	(1)	Red-brown solid is formed
(Q)	$K_2Cr_2O_7 + H_2O_2 + H_2SO_4 \longrightarrow$	(2)	Green oily liquid is formed
(R)	$K_4\left[Fe(CN)_6\right] + \text{dil. } H_2SO_4 \xrightarrow{\Delta}$	(3)	Blue coloured solution is obtained
(S)	$KMnO_4 + \text{Conc. } H_2SO_4\,(\text{cold}) \longrightarrow$	(4)	Contains at least one peroixide linkage
		(5)	A linear triatomic gas is formed as one of the product

(A) P → 1, 5; Q → 2, 5; R → 5; S → 2
(B) P → 1, 4; Q → 3, 4; R → 5; S → 2
(C) P → 3; Q → 2; R → 3; S → 5
(D) P → 2, 4; Q → 3, 5; R → 3; S → 3, 4

SECTION – B

(Numerical Answer Type)

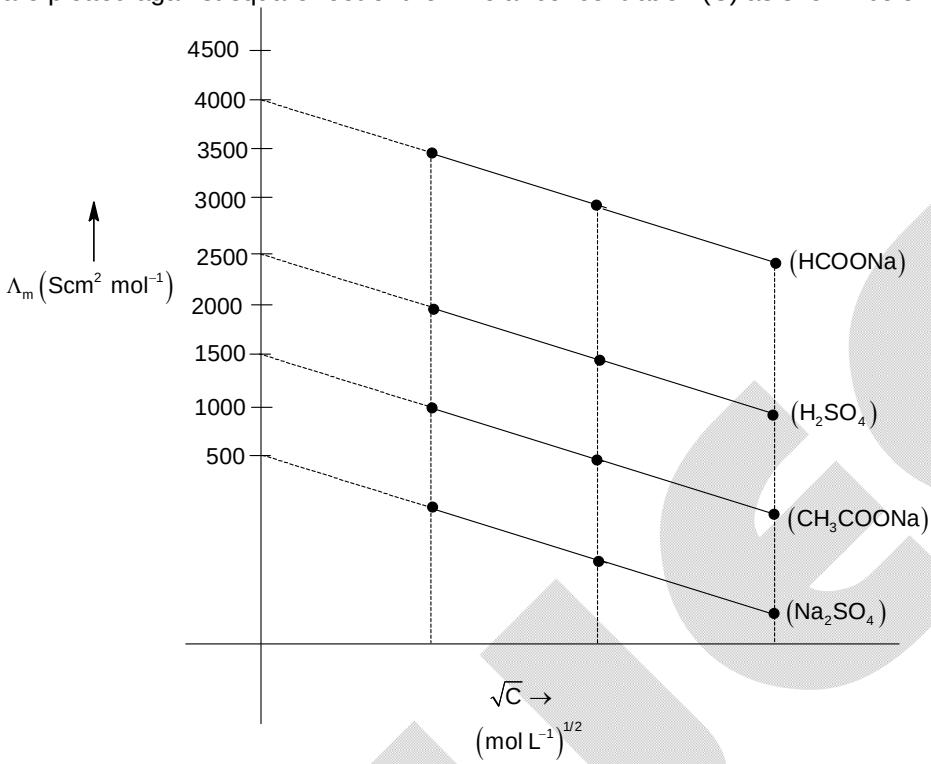
*This section contains **SIX (06)** Numerical based questions. The answer to each question is a **NON-NEGATIVE INTEGER VALUE**.*

29. 2.616 g of an element (M) is heated with NaOH and $NaNO_3$ to produce Na_2MO_2 and NH_3. Ammonia produced is absorbed in 100 mL of 1 N H_2SO_4. Excess of the acid is back titrated with NaOH solution and required 80 mL of 0.25 M NaOH solution up to the equivalence point. What is the mass (in 'g') of hydrogen gas produced when 20 moles of 'M' is treated with excess of NaOH? [Atomic mass : Cr = 52; Zn = 65.4; Fe = 56; Cu = 63.5; Ni = 28; H = 1]

30. 2.27 g of mercuric iodide is added into 100 mL, 0.2 M aqueous solution of KI. If KI is 90% dissociated and potassium tetraiodidomercurate(II) is 80% dissociated, then the osmotic pressure of this solution at 300 K is found to be 'x' atm. Calculate the value of '100x' if $R = 0.08$ L atm mol^{-1} K^{-1}. [Atomic mass : Hg = 200, I = 127]

[Assume volume of solution remains constant and formation constant of $K_2\left[HgI_4\right]$ is very large].

31. Molar conductances (Λ_m) of aqueous solutions of Na_2SO_4, CH_3COONa, H_2SO_4 and HCOONa are plotted against square root of their molar concentration (C) as shown below:



The electrical resistances of 0.1 M CH_3COOH(aq) and 0.01 M HCOOH (aq.) are measured by meter bridge experiment and are found to be 10 ohm and 20 ohm respectively when placed in a conductivity cell of cell constant $0.1\,cm^{-1}$. These aqueous solutions of HCOOH and CH_3COOH are used to construct the following Galvanic cell:

$$Pt(s)\,|\,\underset{(1\,bar)}{H_2(g)}\,|\,HCOOH(0.01\,M)\,||\,CH_3COOH(0.1\,M)\,|\,\underset{(1\,bar)}{H_2(g)}\,|\,Pt(s)$$

[Assume the temperature throughout the entire process is kept constant at 25°C and take $\frac{2.303RT}{F} = 0.06\ V, \log 2 = 0.30$]

The EMF of the above Galvanic cell in milli-volts is…….

[Note: In the above question, the values of molar conductances are purely hypothetical and bear no relation with actual values]

32. Consider the following reactions:

(i) $K + O_2(excess) \longrightarrow$

(ii) $KClO_3 \xrightarrow{\Delta}$

(iii) $O_2 \xrightarrow[\text{spark}]{\text{electric}}$

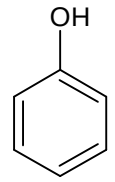
(iv) $AgNO_3 + K_2CrO_4 \longrightarrow$

(v) $ZnCO_3(s) \xrightarrow{\Delta}$

(vi) $CoCl_2 + KNO_2 + CH_3COOH \longrightarrow$

(vii) $Pb(NO_3)_2 + KI \longrightarrow$

(viii) $AgNO_3 + KI \longrightarrow$

(ix)  $\xrightarrow[\text{conc. } H_2SO_4]{\text{conc. } HNO_3}$

(x) $SbCl_3 + H_2O(\text{excess}) \xrightarrow{\Delta}$

(xi) $BiCl_3(\text{excess}) + KI \longrightarrow$

(xii) $HgCl_2(\text{excess}) + KI \longrightarrow$

(xiii) $BaCl_2 + K_2CrO_4 \longrightarrow$

(xiv) $Hg_2(NO_3)_2 + K_2CrO_4 \longrightarrow$

(xv) $Hg + O_2 \longrightarrow$

(xvi) $CuCO_3.Cu(OH)_2 \xrightarrow{\Delta}$

(xvii) $Na_3PO_4 + \text{conc. } HNO_3 + (NH_4)_2[MoO_4] \xrightarrow{\Delta}$

(xviii) $AsCl_3 + H_2S \longrightarrow$

(xix) $SnCl_4 + H_2S \longrightarrow$

(xx) $CH_3CHO + \underset{\text{(Fehling's reagnet)}}{Cu(OH)_2} \longrightarrow$

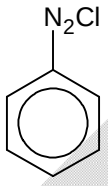
How many of the above reactions give at least one yellow colored product under hot or cold conditions?

33. Product (Z) is synthesized by following scheme:

Scheme-1

$$\underset{(1.1\,kg)}{\text{Resorcinol}} \xrightarrow[(80\%)]{NaOH+I_2} \underset{\text{(Yellow solid)}}{(A)} \downarrow \xrightarrow[(100\%)]{Ag/\Delta} (B) \xrightarrow[(90\%)]{Cu/\Delta} (C) \xrightarrow[\text{anhyd. } AlCl_3\,(100\%)]{CHCl_3/\text{air}} (D)$$

Scheme-2



$$\xrightarrow[(50\%)]{CuCl/HCl,\Delta} (E) \xrightarrow[\text{Conc. } H_2SO_4\,(50\%)]{\text{Conc. } HNO_3\,(2\text{ equivalent})} (F) \xrightarrow[(100\%)]{NH_2-NH_2/H^+,\ \Delta} (G)$$

$(281\,g)$

Scheme-3

$$(D) + (G) \xrightarrow[(100\%)]{H^+(\text{catalyst})} (Z)$$

[**Note:** Molar mass of (D) is more than the molar mass of benzoyl chloride. In the parenthesis, % yield of the product is given].

[Atomic masses : C = 12; N = 14; O = 16; H = 1]

What is the mass (in grams) of (Z) formed in the above scheme?

34. An amount of heat equal to the magnitude of the resonance energy (in kJ mol^{-1}) of benzene (liq.) at 298 K, is absorbed reversibly by 270 g of ice at 273 K and 1 atm pressure. Calculate the entropy change of the system in this process in JK^{-1}. [Round off the answer to the next nearest integer]

Enthalpy of fusion of ice $= 6\ kJ\ mol^{-1}$

Molar heat capacity of water $= 4.0\ Jg^{-1}K^{-1}$

Enthalpy of atomization of graphite $= 714\ kJ\ mol^{-1}$

Enthalpy of vaporization of benzene (liq.) $= 31\ kJ\ mol^{-1}$

Bond dissociation enthalpy of H_2 (g) $= 434\ kJ\ mol^{-1}$

Enthalpy of atomization of CH_4(g) $= 1656\ kJ\ mol^{-1}$

Enthalpy of atomization of C_2H_6(g) $= 2834\ kJ\ mol^{-1}$

Enthalpy of atomization of C_2H_4 (g) $= 2266\ kJ\ mol^{-1}$

Enthalpy of formation of benzene (liq.) $= 49\ kJ\ mol^{-1}$

[log1.18 = 0.07]

Mathematics

PART – III

SECTION – A
(One or More than one correct type)

*This section contains **THREE (03)** questions. Each question has **FOUR** options (A), (B), (C) and (D). **ONE OR MORE THAN ONE** of these four option(s) is (are) correct answer(s).*

35. Let the equation $\frac{x}{x+1}+\frac{x+1}{x}=\frac{3x+k}{x(x+1)}$, $k \in R$ has only one element in solution set, then which of the following is/are CORRECT?

(A) Number of possible values of k is 2

(B) Number of possible values of k is 3

(C) Sum of all possible values k is $\frac{47}{8}$

(D) Largest possible value of k is 4

36. Let f and g be functions continuous and differentiable in R, then which of the following is/are CORRECT?

(A) If $f(a)=f(b)=0$, then for $\beta \in R$ there exists $c \in (a, b)$ such that $\beta f(\alpha) + f'(\alpha) = 0$

(B) If f(a) = f(b) = 0, then there exists some $c \in (a, b)$ such that $n\, g'(nc)\, f(c) + f'(c) = 0$

(C) If f(x) and g(x) are non zero in [a, b] and f(a) g(b) = f(b) g(a), then there is some $c \in (a, b)$ such that $\frac{f'(c)}{f(c)}=\frac{g'(c)}{g(c)}$

(D) If $f(b)^2 - f(a)^2 = b^2 - a^2$, then the equation $f'(x) f(x) - x = 0$ has no root in (a, b)

37. Let C_1, C_2 be two circles touching each other externally with radius 3 and 4. Let C_3 be a circle touching C_1 and C_2 internally at points P and Q respectively. The tangents to C_3 at P and Q intersects at T. If TP = 5, then which of the following is/are CORRECT?

(A) The radius of circle C_3 is $\frac{175}{13}$

(B) The radius of circle C_3 is $\frac{155}{13}$

(C) The radius of circumcircle of ΔTPQ is $\frac{5}{26}\sqrt{1394}$

(D) The radius of circumcircle of ΔTPQ is $\frac{15}{26}\sqrt{1394}$

SECTION – A
(One Options Correct Type)

*This section contains **FOUR (04)** questions. Each question has **FOUR** options (A), (B), (C) and (D). **ONLY ONE** of these four options is the correct answer.*

38. The value of $\sum_{r=0}^{14} {}^{30}C_{2r} \cdot {}^{30}C_{2r+2}$ is equal to

(A) $\frac{13}{14}\left\{{}^{59}C_{27} + {}^{29}C_{13}\right\}$

(B) $\frac{15}{14}\left\{{}^{59}C_{27} + {}^{29}C_{13}\right\}$

(C) $\frac{17}{14}\left\{{}^{59}C_{27} - {}^{29}C_{13}\right\}$

(D) $\frac{17}{14}\left\{{}^{59}C_{27} + {}^{29}C_{13}\right\}$

39. Let z_1 be complex number on $|z - 25i| = 15$ with least positive argument and z_2, z_3 be two complex number lying on $|z - \alpha| = \gamma$ such that $\arg z_2 = \arg z_3 = \frac{\pi}{4}$. If $|z_2 - z_1| = |z_3 - z_1|$, then minimum value of $|\alpha|$ is $\{\alpha \in c\}$

(A) $14\sqrt{3}$ (B) $7\sqrt{2}$

(C) $14\sqrt{2}$ (D) none of these

40. Rahul writes an article. The article originally is error free. Each day Kapil introduces one new error into the article. At the end of the day, Rahul checks the article and has $\frac{3}{4}$ chance of catching each individual error still in the article. After n days, the probability that article is error free is $P_n (n \geq 2)$, then which of the following is CORRECT?

(A) $P_n = \frac{3}{4}\prod_{r=2}^{n}\left(1-\left(\frac{3}{4}\right)^r\right)$ (B) $P_4 = \frac{3}{8}$

(C) $P_2 = \frac{13}{64}$ (D) $P_n = \frac{3}{4}\prod_{r=2}^{n}\left(1-\left(\frac{1}{4}\right)^r\right)$

41. Let the equation $z^6 + (7z - 1)^6 = 0$ is satisfied by $z_1, \bar{z}_1, z_2, \bar{z}_2, z_3, \bar{z}_3$, then the value of $\frac{1}{|z_1|^2}+\frac{1}{|z_2|^2}+\frac{1}{|z_3|^2}$ is equal to

(A) 150 (B) 141

(C) 149 (D) none of these

SECTION – A
(Matching List Type)

*This section contains **FOUR (04)** Matching List Type Questions. Each question has FOUR statements in **List-I** entries (P), (Q), (R) and (S) and FIVE statements in **List-II** entries (1), (2), (3), (4) and (5). The codes for lists have choices (A), (B), (C), (D) out of which **ONLY ONE** of these four options is correct answer.*

42. Let y = x and y = 0 are tangents to the parabola at A(4, 4) and B(2, 0) respectively, then

LIST – I		LIST - II	
(P)	Coordinates of focus are	(1)	$\left(\frac{20}{13}, \frac{-4}{13}\right)$
(Q)	Coordinates of foot of perpendicular drawn from A(4, 4) on directrix are	(2)	$\left(\frac{20}{13}, \frac{4}{13}\right)$
(R)	Coordinates of foot of perpendicular drawn from B(2, 0) on directrix are	(3)	2y + 3x = 4
(S)	Equation of directrix is	(4)	$\left(\frac{4}{13}, \frac{20}{13}\right)$
		(5)	2y + 3x = 5

The correct option is:

(A) (P) → (2); (Q) → (4); (R) → (1); (S) → (3)

(B) (P) → (4); (Q) → (3); (R) → (2); (S) → (1)

(C) (P) → (4); (Q) → (3); (R) → (1); (S) → (5)

(D) (P) → (2); (Q) → (4); (R) → (5); (S) → (3)

43. Match the following List-I with List-II

LIST – I		LIST - II	
(P)	If $\alpha_1, \alpha_2, \alpha_3$ are positive real roots of the equation $x^3 - 6x^2 + 3px - 2p = 0$, $p \in R$, then $\sin^{-1}\left(\frac{1}{\alpha_1}+\frac{1}{\alpha_2}\right)+\cos^{-1}\left(\frac{1}{\alpha_2}+\frac{1}{\alpha_3}\right)-\tan^{-1}\left(\frac{1}{\alpha_3}+\frac{1}{\alpha_1}\right)$ is	(1)	$\frac{3\pi}{4}$
(Q)	Let $f:(-\infty,-1]\to\left[-\frac{\pi}{2},0\right)$ $f(x) = \text{cosec}^{-1}(-x^2 + x + a)$ be a surjective function, then the value of $\frac{5a\pi}{4}$ is equal to	(2)	$\frac{2\pi}{5}$
(R)	Let g be an odd function defined on R such that $g(1) = 2$, $g(3) = 5$, $g(-5) = -1$, then $\frac{ggg(-3)+g(g(0))}{3g(1)-2g(3)-g(5)}$ is k, then $k\pi$ is equal to	(3)	$\frac{\pi}{4}$
(S)	If $\vec{a}, \vec{b}, \vec{c}$ are non coplanar unit vectors such that $\vec{a}\times(\vec{b}\times\vec{c}) = \frac{\vec{b}+\vec{c}}{\sqrt{2}}$, then angle between $\vec{a}$ and $\vec{b}$ is	(4)	$\frac{3\pi}{5}$
		(5)	$\frac{5\pi}{4}$

The correct option is:
(A) (P) → (2); (Q) → (4); (R) → (3); (S) → (1)
(B) (P) → (3); (Q) → (5); (R) → (2); (S) → (1)
(C) (P) → (3); (Q) → (5); (R) → (4); (S) → (1)
(D) (P) → (2); (Q) → (3); (R) → (4); (S) → (3)

44. Match the following List-I with List-II

LIST – I		LIST - II	
(P)	The value of $\frac{\int_0^{4\pi}\ln\left\lvert 13\sin x+3\sqrt{3}\cos x\right\rvert dx}{\pi\ln 7}$ is	(1)	2
(Q)	If L.C.M. and greatest common division of 3 positive integers a, b, c are 360 and 30 respectively, then the possible number of ordered triplets (a, b, c) is equal to k, then $\frac{k}{12}$ is	(2)	4
(R)	Number of points where $f(x)=\left\{\frac{x}{10}\right\}+\left[\frac{x}{2}\right]$ is discontinuous in [0, 50] is k, then $\frac{k}{4}$ (where [.] represents greatest integer function)	(3)	6
(S)	Let the $f(x) = ax^4 + bx^3 + cx^2 + dx + c$ touches the $g(x) = x + k$ at x = 1, 2, and $\int_0^1 (f(x)-g(x))dx = \frac{1}{15}$, then 31a is equal to	(4)	3
		(5)	5

The correct option is:

(A) (P) → (2); (Q) → (3); (R) → (5); (S) → (4)
(B) (P) → (4); (Q) → (3); (R) → (2); (S) → (1)
(C) (P) → (4); (Q) → (3); (R) → (1); (S) → (5)
(D) (P) → (2); (Q) → (3); (R) → (5); (S) → (1)

45. Match the following List-I with List-II

LIST – I		LIST - II	
(P)	The real values of x where $f(x)=\int_{x-1}^{x+1} e^{-(t-1)^2}dt$ attains maximum value is	(1)	2
(Q)	Let g(x) be a differentiable function satisfying $g(x)=(\ln x)^2-\int_1^e \frac{g(t)}{t}dt$, $\forall\ x \geq 1$, then area bounded by tangent at y = g(x) at (e, g(e)), the curve y = g(x) and x = 1 is k, then $[k+3]$ is (where [.] represents greatest integer function)	(2)	1
(R)	Let $\frac{dy}{dx}=\frac{y^3}{e^{2x}+y^2}$, y(0) = 1, then $\left[4\left(\frac{y^2+2e^{2x}\ln y}{e^{2x}}\right)\right]$ for x = 4 is (where [.] represents greatest integer function)	(3)	5
(S)	If the value of $\int_0^{\frac{\pi}{2}}(\cos x)^{2023}\sin(2025x)dx$ is $\frac{p}{q}$ where p, q are coprime, then the value of $\frac{3(p-1)+5q}{2024}$ is	(4)	3
		(5)	4

The correct option is:
(A) (P) → (2); (Q) → (4); (R) → (3); (S) → (1)
(B) (P) → (4); (Q) → (3); (R) → (2); (S) → (1)
(C) (P) → (2); (Q) → (4); (R) → (5); (S) → (3)
(D) (P) → (4); (Q) → (3); (R) → (5); (S) → (3)

SECTION – B

(Numerical Answer Type)

*This section contains **SIX (06)** Numerical based questions. The answer to each question is a **NON-NEGATIVE INTEGER VALUE**.*

46. Let P and Q be 3×3 matrices such that $P = \text{adj } Q - Q^T$ and $Q = \text{adj } P - P^T$ (given that P is non singular matrix), then $|PQ + QP|$ is equal to k^3, then value of k is

47. 6 identical red balls and 10 identical blue balls are linearly arranged such that there are 5 runs of blue balls. If total number of such arrangements is k, then $\frac{k}{{}^9C_4 \cdot 7}$ is equal to

{The arrangement BR BB R BBB RB RBBB RR has five runs of blue balls, first has 1 blue ball, second has 2 blue balls, third has 3 blue balls, fourth has 1 blue ball and fifth has 3 blue balls}

48. $\lim\limits_{x\to 0} \dfrac{\tan^3 x - x^3 \operatorname{sgn}\left(\left[\dfrac{x}{\tan^{-1} x}\right]\right)}{x\sin^2 x(1-\cos \pi x)}$ is k, then $\pi^2 k$ is equal to
(Where sgn(x) is signum function and [.] is G.I.F.)

49. Let $g(k) = \lim\limits_{n\to\infty} n^k \int_0^{\frac{1}{n}} x^{x+k-1} dx$, $k \in N$, then $\left[\dfrac{1}{g(9)}\right]$ is

50. If $2 \sin \alpha \sin \beta + 3 \cos \beta + 5 \cos \alpha \sin \beta = \sqrt{38}$ $\forall\ \alpha, \beta \in R$, then |adj (adj A)| is equal to where $A = \begin{bmatrix} \tan\beta & -\dfrac{1}{3} \\ 1 & \sin\alpha \end{bmatrix}$ is

51. If tangent of slope 4 of the ellipse $\dfrac{x^2}{a^2} + \dfrac{y^2}{b^2} = 1$ is normal to $x^2 + y^2 + 4x + 1 = 0$, then maximum value of ab is