VMC Vidyamandir Classes SINCE 1986
IIT JEE | MEDICAL | FOUNDATION

CODE A

JEE Advanced-2 | Paper–1 | XII Pass - JEE 2024

Date: 19th November 2023 **Maximum Marks: 180**

Timing: 10:00 AM to 1:00 PM **Duration : 3.0 Hours**

General Instructions

1. The question paper consists of 3 Subject (Subject I: **Physics**, Subject II: **Chemistry**, Subject III: **Mathematics**). Each Part has **three** sections (Section 1, Section 2 & Section 3).

2. **Section 1** contains **6 Multiple Correct Answers Type Questions**. Each question has 4 choices (A), (B), (C) and (D), out of which **ONE OR MORE THAN ONE CHOICE** is correct.

   Section 2 contains **FOUR (04)** Matrix match type. Each set has **TWO** Columns: **Column I** and **Column II**. Each question has **FOUR** options (A), (B), (C) and (D). **ONLY ONE** of these four options is the correct answer.

   Section 3 contains **8 Numerical Value Type Questions**. For each question, enter the correct numerical value of the answer using the mouse and the onscreen virtual numeric keypad in the place designated to enter the answer. If the numerical value has more than two decimal places, **truncate/roundoff** the value to **TWO** decimal places.

3. For answering a question, an ANSWER SHEET (OMR SHEET) is provided separately. Please fill your **Test Code, Roll No.** and **Group** properly in the space given in the ANSWER SHEET.

Name of the Candidate (In CAPITALS) : _____

Roll Number : _____

OMR Bar Code Number : _____

Candidate's Signature : _____ **Invigilator's Signature** _____

Syllabus

Physics : Rotational Motion, Electrostatics, Gravitation, DC Circuits, Capacitors, Magnetic Effects of current, Magnetism and Matter

Chemistry : Ionic Equilibrium, Solid States, Liquid Solutions, Surface chemistry Electrochemistry, Chemical Kinetics, IOC, Hydrogen, Environmental Chemistry

Mathematics : DC – I & II, IC – I & II, Differential Equation, Vectors, Three-Dimensional Geometry

MARKING SCHEME

SECTION – 1 | (Maximum Marks: 24)

- This section consists of **Six (06)** Questions. Each question has **FOUR** options. **ONE OR MORE THAN ONE** of these four option(s) is(are) correct answer(s).
- 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 Mark:	0 if none of the options is chosen (i.e. the question is unanswered)
Negative Marks:	–2 In all other cases.

SECTION – 2 | (Maximum Marks: 12)

- This section contains **Four (04**) Matrix match type. Each set has **TWO** columns: **Column I** and **Column II**.
- Each question has **FOUR** options (A), (B), (C) and (D). **ONLY ONE** of these four options is the correct answer.
- For each question, choose the option corresponding to the correct answer.
- 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 – 3 | (Maximum Marks: 24)

- This section contains **Eight (08) Numerical Value Type Questions**. For each question, enter the correct numerical value of the answer using the mouse and the onscreen virtual numeric keypad in the place designated to enter the answer. If the numerical value has more than two decimal places, **truncate/roundoff** the value to **TWO** decimal places.
- Answer to each question will be evaluated according to the following marking scheme:

Full Marks:	+3 **ONLY** if the correct numerical value is entered.
Zero Mark:	0 In all other cases.

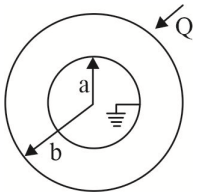
SUBJECT I : PHYSICS 60 MARKS

SECTION 1

MULTIPLE CORRECT ANSWERS TYPE

This Section contains **6 Multiple Correct Answers Type Questions**. Each question has 4 choices (A), (B), (C) and (D), out of which **ONE OR MORE THAN ONE CHOICE** is correct.

1. Two concentric thin spherical shells are having radius a and b respectively $(b > a)$. Inner sphere is grounded and outer sphere is given a charge Q. ($b = 2a$):



(A) Charge appearing on inner surface of outer shell is $\frac{Q_0}{2}$

(B) Potential over outer sphere is $\frac{Q}{16\pi\varepsilon_0 a}$

(C) Ratio of magnitude of electric field at outer surfaces of inner and outer shell is 4

(D) Potential of inner sphere is zero

2. In a certain region $V = \frac{-x^3}{3} volt.$ then the electric field intensity and charge density at distance x = 2m from origin is :

(A) $\vec{E} = 4\hat{i}$ **(B)** $\vec{E} = -2\hat{i}$ **(C)** $\rho = 4\varepsilon_0$ **(D)** $\rho = -6\varepsilon_0$

3. A conducting rod of length l and area A is connected to a battery such that uniform electric field E develops inside the rod along its length. If resistance along its length is R:

(A) Current density in the rod is $\frac{El}{AR}$

(B) Emf of battery is El or less

(C) Rate of heat loss in rod is $\frac{E^2l^2}{2R}$

(D) Rate of decrease of energy of battery is more than $\frac{E^2l^2}{R}$

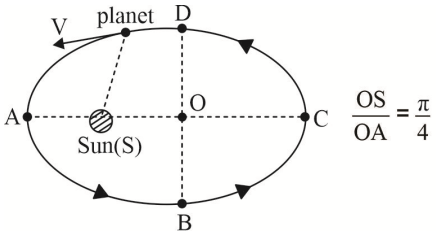
SPACE FOR ROUGH WORK

4. A spherical metal shell A of radius R_A and a solid metal sphere B of radius $R_B(< R_A)$ are kept far apart and each is given charge $+Q$. Now, they are connected by a thin metal wire. Then:

(A) $E_A^{inside} = 0$ **(B)** $Q_A > Q_B$

(C) $\dfrac{\sigma_A}{\sigma_B} = \dfrac{R_B}{R_A}$ **(D)** $E_A^{on\ surface} < E_B^{on\ surface}$

5. A planet revolves around sun in elliptical path such that its time period of revolution is 16 yrs and its path is as shown. $(\pi \simeq 22/7)$.



(A) Time taken by planet to travel from A to B is 5 yrs

(B) Time taken by planet to travel from A to B is 2 yrs

(C) Ratio of maximum to minimum velocity is 3

(D) Ratio of maximum to minimum velocity is 25/3

6. A long rod of uniform mass distribution having total mass m_0 and length $l(l = 0.01R)$, where R is radius of earth. Take acceleration due to gravity at surface of earth as g_s. Rod is held vertically via some mechanism:

(A) Center of mass of rod is at a distance of $\dfrac{l^2}{6R}$ from center of gravity

(B) Center of gravity is nearer to surface of earth than center of mass

(C) Weight of rod is $m_0 g_s\left(1 - \dfrac{2l}{R}\right)$

(D) Percentage difference between acceleration due to gravity at ends of rod is $\dfrac{2l}{R} \times 100$

SPACE FOR ROUGH WORK

SECTION - 2

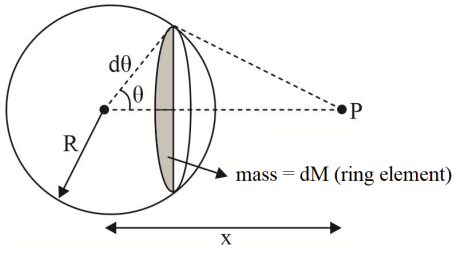
MATRIX MATCH TYPE

This section contains **FOUR (04)** Matching Columns sets. Each set has **TWO** Columns: **Column I** and **Column II**. Each question has **FOUR** options (A), (B), (C) and (D). **ONLY ONE** of these four options is the correct answer.

7. While calculating gravitational field and potential for hollow sphere at any outside point, it is assumed as point mass placed at it center. The result can be derived using calculus considering hollow sphere to be made of thin rings which subtend angle $d\theta$ at center as shown in figure:

If $dE = \dfrac{GdM(x - R\cos\theta)}{(x^2 + R^2 - 2Rx\cos\theta)^{\alpha}}$

$dV = \dfrac{GdM}{(x^2 + R^2 - 2Rx\cos\theta)^{\beta}}$ and $dM = \dfrac{3M}{\delta}\sin^{\gamma}\theta\, d\theta$



M : Mass of hollow sphere

R : Radius

X : distant point P from center

Then :

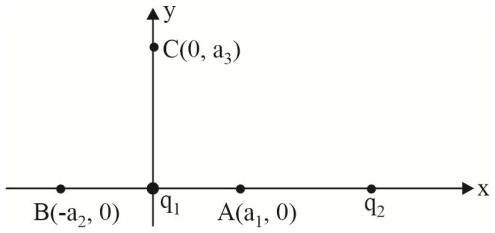
Column I		Column II	
I.	$\dfrac{\alpha}{\beta} = ?$	**P.**	1
II.	$\dfrac{\delta + \gamma}{\alpha - \beta} = ?$	**Q.**	3
III.	$\dfrac{\delta}{\gamma} = ?$	**R.**	5
IV.	$\dfrac{\delta + \alpha}{\beta + \gamma} = ?$	**S.**	7
		T.	6

(A) I – Q ; II – S ; III – R ; IV – P **(B)** I – Q ; II – S ; III – T ; IV – R

(C) I – T ; II – R ; III – Q ; IV – P **(D)** I – Q ; II – P ; III – S ; IV – T

SPACE FOR ROUGH WORK

8. Consider the arrangement of two charges q_1 & q_2 as shown. q_1 & q_2 can be like or unlike charges as per situation. $\left|\frac{q_2}{q_1}\right| = n$, a_1, a_2, a_3 are positive numbers. [E, V are electric field and electrostatic potential].



Column I		Column II	
I.	$V_A = V_B = 0 \quad (q_1 q_2 < 0)$ then $\frac{a_2}{a_1} =$	**P.**	$\frac{\sqrt{n}+1}{\sqrt{n}-1}$
II.	$E_A = 0 \quad (q_1 q_2 > 0)$ and $E_B = 0 \quad (q_1 q_2 < 0)$ then $\frac{a_2}{a_1} =$	**Q.**	$\sqrt{\frac{n+1}{n-1}}$
III.	$V_A = V_C = 0 \quad (q_1 q_2 < 0)$ then $\frac{a_3}{a_1} = ?$	**R.**	$\frac{n+1}{n-1}$
IV.	$E_A = 0 \quad (q_1 q_2 > 0)$ and $v_0 = 0 \quad (q_1 q_2 < 0)$ then $\frac{a_1}{a_2} = ?$	**S.**	$\sqrt{n}+1$
		T.	$\sqrt{n}-1$

(A) I – P ; II – R ; III – Q ; IV – T **(B)** I – R ; II – P ; III – Q ; IV – T

(C) I – R ; II – P ; III – T ; IV – S **(D)** I – P ; II – Q ; III – R ; IV – S

SPACE FOR ROUGH WORK

9. A particle having velocity v_0 along +ve X-axis is projected into a space with magnetic field $\vec{B}$ as given.

$$\vec{B} = \begin{cases} -B_0\hat{k}, & 0 \le x \le \dfrac{2mv_0}{qB_0} \\ -2B_0\hat{k}, & x > \dfrac{2mv_0}{qB_0} \end{cases}$$ where m = mass of proton and q = charge on proton

The particle can be either proton, deuteron, single ionized helium and alpha particle as given in column I and column II contain the distance of point of emergence back into region of zero magnetic field.

Column I		**Column II**	
I.	Proton	**P.**	$\dfrac{8m_0v_0}{qB_0}$
II.	Deuteron	**Q.**	$\dfrac{2mv_0}{qB_0}$
III.	He^+ (singly ionized helium)	**R.**	$\dfrac{2mv_0}{qB_0}(4-\sqrt{3})$
IV.	Alpha particle	**S.**	$\dfrac{4mv_0}{qB_0}$
		T.	$\dfrac{\pi mv_0}{6qB_0}$

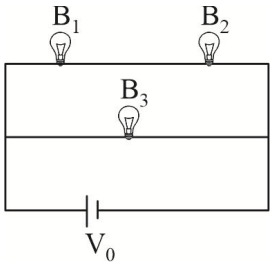
(A) I – Q ; II – S ; III – T ; IV – S **(B)** I – Q ; II – S ; III – R ; IV – S

(C) I – P ; II – S ; III – R ; IV – Q **(D)** I – S ; II – Q ; III – T ; IV – R

SPACE FOR ROUGH WORK

10. Consider the circuit shown below with rated voltage and power of each bulb in table.

Bulb	Rated Power	Rated Voltage
B1	100W	200V
B2	100W	200V
B3	50W	100V



Column I		Column II	
I.	Maximum voltage V_0 such that all bulb are safe is $50x$ volt, x = ?	**P.**	3
II.	$\frac{\text{Power of Bulb 3}}{\text{Power of Bulb 1}} = ?$ if $V_0 = 50V$	**Q.**	2
III.	Total power output at $V_0 = 100V$ of all three bulb is $\frac{5^x}{2}W$. x = ?	**R.**	4
IV.	Current from battery if $V_0 = 100V$ is $5^x mA$. x = ?	**S.**	8
		T.	16

(A) I – Q ; II – S ; III – P ; IV – R **(B)** I – S ; II – P ; III – Q ; IV – R

(C) I – S ; II – Q ; III – R ; IV – T **(D)** I – Q ; II – R ; III – P ; IV – T

SPACE FOR ROUGH WORK

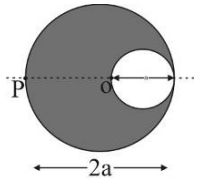
SECTION 3
NUMERICAL VALUE TYPE

This section contains **8 Numerical Value Type Questions**. For each question, enter the correct numerical value of the answer. If the numerical value has more than two decimal places, **truncate/roundoff** the value to **TWO** decimal places.

1. A conductor is in shape of cylindrical rod of radius 5mm and length 10cm. On connecting it to a source an uniform electric field develops along its length given by $\vec{E} = 2\hat{i} + 3\hat{j} + 6\hat{k}$ V/m. If resistivity of conductor is $10^{-5}\Omega m$, the current through it is _____ Ampere. (take $\pi = 22/7$)

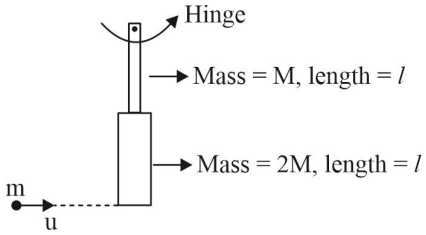
2. A voltmeter of range (0 – 50)V is to be converted into an ammeter of range (0 – 10)A. If the resistance of coil of voltmeter is 25Ω, then shunt resistance needed to make required ammeter is _____Ω. .

3. A cylindrical cavity of diameter *a* exists inside a cylinder of diameter 2a as shown in the figure. Both the cylinder and the cavity are infinitely long. A uniform current density *J* flows along the length. If the magnitude of the magnetic field at the point *P* is given by $\frac{N}{12}\mu_0\ aJ$, then the value of *N* is:



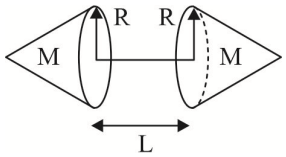
4. Consider a composite rod as shown. It is hinged at one end and free to rotate in smooth horizontal plane and initially at rest. A particle of mass $m\left(m = \frac{M}{2}\right)$ strikes the lower end of rod and stops. Find $\frac{u}{\omega l}$.

(where *u* = initial velocity of particle, ω = Angular velocity or rod after impact)



SPACE FOR ROUGH WORK

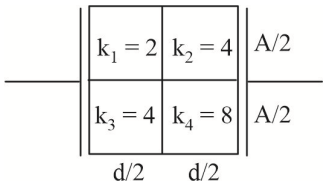
5. A dumbbell is made of two conical weights each of mass M and base radius R are connected by a light rod as shown.



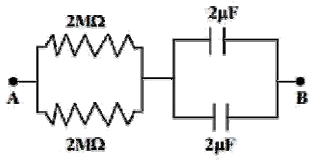
If the dumbbell is rolled on sufficiently rough surface with linear velocity 'v', (velocity being normal to rod and horizontal then its kinetic energy in ηMv^2. Find η.

6. A satellite is orbiting in an elliptical orbit & its velocity at farthest position in $\sqrt{5}$ km/sec. Distance of satellite from earth at nearest and farthest position are 1 lakh km and 3 lakh km respectively. When velocity and radius vector make an angle of $\sin^{-1}\frac{2}{\sqrt{5}}$, satellite is at distance of 1.5 lakh km. Find it speed at this position in km/sec.

7. A capacitor of capacitance $5\mu F$ is filled with dielectric as shown. Find new capacitance in μF.



8. At time $t = 0$, a battery of $10V$ is connected across points A and B in the given circuit. If the capacitors have no charge initially, at what time (in seconds) does the voltage across them becomes 4 volt_____? [Take $\ell n\,5 = 1.6$, $\ell n\,3 = 1.1$] 3 = 1.1]



SPACE FOR ROUGH WORK

SUBJECT II : CHEMISTRY 60 MARKS

SECTION 1

MULTIPLE CORRECT ANSWERS TYPE

This Section contains **6 Multiple Correct Answers Type Questions**. Each question has 4 choices (A), (B), (C) and (D), out of which **ONE OR MORE THAN ONE CHOICE** is correct.

1. A 2.5 g impure sample containing weak monoacidic base (Molecular weight = 45) is dissolved in 100 mL water and titrated with 0.5 M HCl at 25°C. When $1/5^{th}$ of the base was neutralized, the pH was found to be 9 and at equivalent point, the pH of solution is 4.5 (log 2 = 0.3). Choose the correct statements:

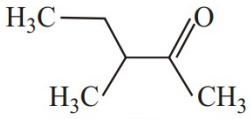
(A) K_b of base is less than 10^{-6}

(B) Concentration of salt at equivalent point is 0.25 M

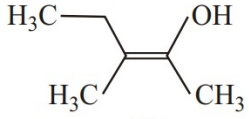
(C) Volume of HCl used at equivalent point is 100 mL

(D) K_b of base is more than 10^{-6}

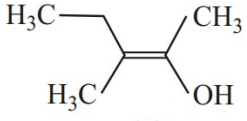
2. The correct statement(s) concerning the structures E, F and G is/are:



(*E*)



(*F*)



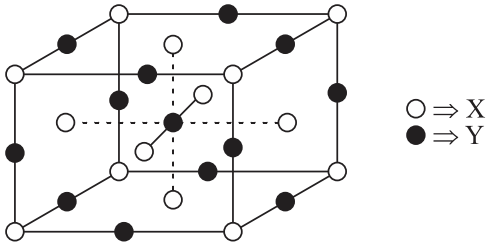
(*G*)

(A) E, F and G are resonance structures **(B)** E, F and E, G are tautomers

(C) F and G are geometrical isomers **(D)** F and G are diastereomers

SPACE FOR ROUGH WORK

3. Consider the figure given for solid XY.



Which of the following is/are correct?

(A) Y atoms occupy octahedral voids

(B) This arrangement is of rock salt type crystal

(C) The next nearest neighbour of X atoms are 12

(D) The co-ordination number of X-atoms and Y-atoms are same

4. The following experimental data is obtained for the osmotic pressure of the solution by adding different moles of $C_{17}H_{35}COONa$ in sufficient water to get 1.0 L solution in each case.

Moles of $C_{17}H_{35}COONa$	0	0.01	0.02	0.03	0.04
$\frac{\pi}{RT}$ (moles/litre)	0	0.02	0.04	0.058	0.076

Select the correct information(s) regarding the nature of solution.

(A) At 0.02 M concentration, the solution behaves as true solution

(B) At 0.04 M concentration, the solution behaves as true solution

(C) The critical micelle concentration (CMC) of $C_{17}H_{35}COONa$ is in between 0.02 M and 0.03 M

(D) At 0.05 M concentration, the mixture of $C_{17}H_{35}COONa$ and water will be homogeneous

SPACE FOR ROUGH WORK

5. According to Arrhenius equation the correct option(s) among the following is(are):

(A) When $T = \infty$; $k = A$, here A is pre-exponential factor

(B) For an exothermic reaction, rate of forward reaction increases with temperature

(C) The reaction with higher E_a value is more temperature sensitive

(D) Rate constant increases with increase in temperature

6. Consider the following electrodes with their E° values:

$E^{\circ}_{Cu^{2+}/Cu} = +0.34\,V,\ E^{\circ}_{Ni^{2+}/Ni} = -0.25\,V$

$E^{\circ}_{Ag^{+}/Ag} = +0.80\,V,\ E^{\circ}_{Zn^{2+}/Zn} = -0.76\,V$

Which of the following reaction(s) is/are spontaneous?

(A) $Cu(s) + Ni^{2+}(aq) \longrightarrow Ni(s) + Cu^{2+}(aq)$

(B) $Cu(s) + 2Ag^{+}(aq) \longrightarrow Cu^{2+}(aq) + 2Ag(s)$

(C) $Cu(s) + 2H^{+}(aq) \longrightarrow Cu^{2+}(aq) + H_2(g)$

(D) $Zn(s) + 2H^{+}(aq) \longrightarrow Zn^{2+}(aq) + H_2(s)$

SPACE FOR ROUGH WORK

SECTION - 2

MATRIX MATCH TYPE

This section contains **FOUR (04)** Matching Columns sets. Each set has **TWO** Columns: **Column I** and **Column II**. Each question has **FOUR** options (A), (B), (C) and (D). **ONLY ONE** of these four options is the correct answer.

7. An aqueous solution of 'X' is added slowly to an aqueous solution of 'Y' as shown in Column I. The variation in conductivity of these reactions is given in Column II. Match Column I with Column II.

Column I (X + Y)		Column II	
I.	$(C_2H_5)_3N + CH_3COOH$	**P.**	Conductivity decreases and then increases
II.	$KI(0.1M) + AgNO_3(0.01M)$	**Q.**	Conductivity decreases and then does not change much
III.	$CH_3COOH + KOH$	**R.**	Conductivity increases and then does not change much
IV.	$NaOH + HI$	**S.**	Conductivity does not change much and then increases

(A) I-R; II-S; III-Q; IV-P **(B)** I-P; II-Q; III-R; IV-S

(C) I-S; II-P; III-Q; IV-R **(D)** I-Q; II-S; III-P; IV-R

SPACE FOR ROUGH WORK

8. Match the column I and II, and choose the correct combination from the option given

Column I (Reaction)		**Column II (Suitable enzyme catalyst)**	
I.	Starch $\rightarrow$ Maltose	**P.**	Urease
II.	Sucrose $\rightarrow$ Glucose + Fructose	**Q.**	Diastase
III.	Urea $\rightarrow$ Ammonia + CO_2	**R.**	Zymase
IV.	Glucose $\rightarrow$ Ethanol + CO_2	**S.**	Invertase

(A) I-P; II-Q; III-R; IV-S **(B)** I-Q; II-S; III-P; IV-R

(C) I-S; II-P; III-R; IV-Q **(D)** I-R; II-S; III-Q; IV-P

9. For the reaction : $A \rightarrow$ Product, $t_{x/y}$ represents the time in which x/y fraction of reactant is converted into products.

Column I		**Column II**	
I.	$t_{5/9}$	**P.**	Equal to 54 s, if $t_{1/3}$ is 18 s in case of first-order reaction
II.	$t_{19/27}$	**Q.**	Equal to 32 s, if $t_{1/4}$ is 16 s in case of first-order reaction
III.	$t_{7/8}$	**R.**	Equal to 56 s, if $t_{1/3}$ is 4 s in case of second-order reaction
IV.	$t_{7/16}$	**S.**	Equal to 30 s, if $t_{1/3}$ is 18 s in case of zero-order reaction
		T.	Equal to 28 s, if $t_{1/2}$ is 16 s in case of zero-order reaction

(A) I-P; II-Q; III-R; IV-S, T **(B)** I-P, Q; II-R; III-S; IV-T

(C) I-S; II-P; III-R, T; IV-Q **(D)** I-R, S; II-P; III-Q; IV-T

SPACE FOR ROUGH WORK

10. Match the column I and II, and choose the correct combination from the option given.

Column I (Colligative properties)		**Column II (Aqueous solution ; molality = molarity)**	
I.	$\Delta T_f = 0.3\,K_f$	**P.**	0.1 M $Ca(NO_3)_2$
II.	$\Delta T_b = 0.28 K_b$	**Q.**	0.14 M NaBr
III.	$\pi = 0.19\,RT$	**R.**	0.1 M $MgCl_2(\alpha = 0.9)$
IV.	$\dfrac{P^\circ - P}{P^\circ} = \dfrac{\left(\dfrac{\Delta T_f}{K_f}\right)}{\dfrac{1000}{18} + \left(\dfrac{\Delta T_f}{K_f}\right)}$	**S.**	0.28 M urea
		T.	0.1 M HA (monobasic acid, $K_a = 0.81$)

(A) I-Q, R, S, T; II-P; III-R, S; IV-Q **(B)** I-P, Q; II-R; III-S, T; IV-P

(C) I-P; II-Q, R; III-S, T; IV-Q **(D)** I-P; II-Q, R, S; III-T; IV-P, Q, R, S, T

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SECTION 3

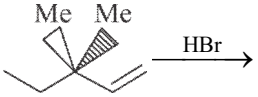
NUMERICAL VALUE TYPE

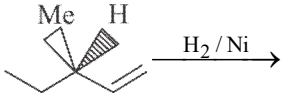
This section contains **8 Numerical Value Type Questions**. For each question, enter the correct numerical value of the answer. If the numerical value has more than two decimal places, **truncate/roundoff** the value to **TWO** decimal places.

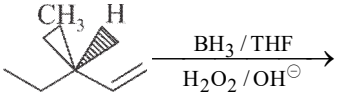
1. How many of the following metals have greater 'maximum prescribed concentration' in drinking water as compared to Manganese (Mn)?

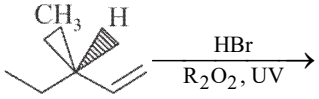
Fe, Al, Cu, Zn, Cd

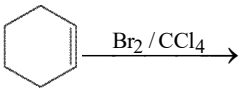
2. Which of the following reactions will produce racemic mixture?

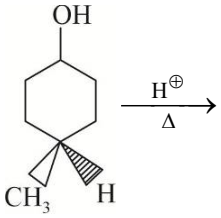
(a) 

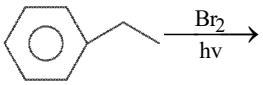
(b) 

(c) 

(d) 

(e) 

(f) 

(g) 

3. On dissolving a non-volatile, non-ionic solute to 35 g of benzene, its vapour pressure decreases from 630 mm of Hg to 620 mm Hg, The depression of freezing point of benzene (in K) upon addition of the solute is _____. [Given data : Molar mass and molal freezing point depression constant of benzene are 78 g mol^{-1} and 5.12 K kg mol^{-1}, respectively]

4. One mole of ethylene glycol was dissolved in 640.8 g water and the resulting solution was cooled to –3.72°C temperature. How many grams of ice is formed due to freezing of water? (K_f = 1.86 K kg mol^{-1})

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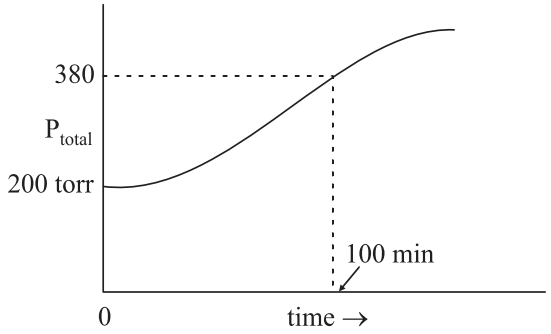
5. First order gas phase thermal decomposition of N_2O_5 occur as follows:

$$N_2O_5(g) \longrightarrow 2NO_2(g) + \frac{1}{2}O_2(g)$$

If total pressure varies with time as given in the figure then half life of the reaction is _____. (In minutes) [Take : $\log_{10} 2 = 0.30, \log_{10} 5 = 0.70$]



6. An aqueous solution contains 10% ammonia by mass and has a density of 0.85 g/ml. If $[H_3O^+]$ in this solution is xM, then the value of $x \times 10^{-12}$ is _____. (K_a for $NH_4^+ = 5.0 \times 10^{-10}$ M)

7. A metal 'M' (atomic mass = 31.25) crystallizes in CCP but it has some vacancy defect. If the edge length of the unit cell is 500 pm and the density of the metal is 1.6075 g/cm^3, then the number of moles of metal atoms missing per litre of the crystal is _____. (1 amu $= 1.67 \times 10^{-24}$ g)

8. By passing a certain amount of charge through NaCl solution, 9.08 L of chlorine gas were liberated at STP. When the same amount of charge is passed through a nitrate solution of metal M, 52.8 g of the metal was deposited. If the atomic mass of metal is 200 amu, the valency of metal is _____. (Assume 1 mol of gas occupy 22.7 L at STP)

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SUBJECT III : MATHEMATICS 60 MARKS

SECTION 1

MULTIPLE CORRECT ANSWERS TYPE

This Section contains **6 Multiple Correct Answers Type Questions**. Each question has 4 choices (A), (B), (C) and (D), out of which **ONE OR MORE THAN ONE CHOICE** is correct.

1. Assume that $\lim_{\theta\to -1} f(\theta)$ exists and $\frac{\theta^2+\theta-2}{\theta+3} \le \frac{f(\theta)}{\theta^2} \le \frac{\theta^2+2\theta-1}{\theta+3}$ holds for certain interval containing the point $\theta = -1$ then $\lim_{\theta\to -1} f(\theta)$.

(A) is equal to $f(-1)$ **(B)** is equal to 1

(C) is non existent **(D)** is equal to –1

2. Which of the following inequalities always hold good in (0, 1).

(A) $x > \tan^{-1} x$ **(B)** $\cos x < 1 - \frac{x^2}{2}$

(C) $1 + x\ln\left(x + \sqrt{1+x^2}\right) > \sqrt{1+x^2}$ **(D)** $x - \frac{x^2}{2} < \ln(1+x)$

3. For the function $f(x) = \ln(1 - \ln x)$ which of the following do not hold good?

(A) increasing in (0, 1) and decreasing in (1, e)

(B) decreasing in (0, 1) and increasing in (1, e)

(C) $x = 1$ is a critical point for $f(x)$

(D) f has two asymptotes

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4. If $I = \int (\sqrt{\tan x} + \sqrt{\cot x})\,dx = f(x) + c,$ then $f(x)$ is equal to:

(A) $\sqrt{2}\sin^{-1}(\sin x - \cos x)$ **(B)** $-\sqrt{2}\cos^{-1}(\sin x - \cos x)$

(C) $\sqrt{2}\tan^{-1}\left(\dfrac{\tan x - 1}{\sqrt{2}\sqrt{\tan x}}\right)$ **(D)** $\dfrac{\pi}{\sqrt{2}} + \sqrt{2}\cos^{-1}(\sin x - \cos x)$

5. Suppose f is defined from $R \to [-1, 1]$ as $f(x) = \dfrac{x^2 - 1}{x^2 + 1}$ where R is the set of real number. Then the statement which does not hold is:

(A) f is many one onto

(B) f increases for $x > 0$ and decreases for $x < 0$

(C) minimum value is not attained even though f is bounded

(D) the area included by the curve $y = f(x)$ and the line $y = 1$ is π sq. units

6. Which of the following pair(s) is/are orthogonal?

(A) $16x^2 + y^2 = c$ and $y^{16} = kx$ **(B)** $y = x + ce^{-x}$ and $x + 2 = y + ke^{-y}$

(C) $y = cx^2$ and $x^2 + 2y^2 = k$ **(D)** $x^2 - y^2 = c$ and $xy = k$

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SECTION - 2

MATRIX MATCH TYPE

This section contains **FOUR (04)** Matching Columns sets. Each set has **TWO** Columns: **Column I** and **Column II**. Each question has **FOUR** options (A), (B), (C) and (D). **ONLY ONE** of these four options is the correct answer.

7. Match the column I and II, and choose the correct combination from the option given

Column I		Column II	
I.	$\lim_{n\to\infty} \cos^2\left(\pi\left(\sqrt[3]{n^3+n^2+2n}\right)\right)$ where n is an integer, equals	**P.**	$\frac{1}{2}$
II.	$\lim_{n\to\infty} n\sin\left(2\pi\sqrt{1+n^2}\right)(n\in N)$ equals	**Q.**	$\frac{1}{4}$
III.	$\lim_{n\to\infty} (-1)^n \sin\left(\pi\sqrt{n^2+0.5n+1}\right)\left(\sin\frac{(n+1)\pi}{4n}\right)$ is (where $n\in N$)	**R.**	π
IV.	If $\lim_{x\to\infty}\left(\frac{x+a}{x-a}\right)^x = e$ where 'a' is some real constant then the value of 'a' is equal to	**S.**	Non existent

(A) I – Q ; II – R ; III – P ; IV – P **(B)** I – P ; II – Q ; III – R ; IV – S

(C) I – S ; II – P ; III – R ; IV – Q **(D)** I – R ; II – P ; III – S ; IV – Q

SPACE FOR ROUGH WORK

8. Match the column I and II, and choose the correct combination from the option given:

Column I		Column II	
I.	If $f(x)=\int_0^{g(x)}\frac{dt}{\sqrt{1+t^3}}$, where $g(x)=\int_0^{\cos x}(1+\sin t^2)\,dt$, then value of $f'\left(\frac{\pi}{2}\right)$ is	**P.**	-2
II.	If $f(x)$ is a non-zero differentiable function such that $\int_0^x f(t)\,dt=(f(x))^2,\ \forall x\in R$, then $f(2)$ is equal to	**Q.**	2
III.	If $\int_a^b(2+x-x^2)\,dx$ is maximum, then $a+b$ is equal to	**R.**	1
IV.	If $\lim_{x\to 0}\left(\frac{\sin 2x}{x^3}+a+\frac{b}{x^2}\right)=0$, then $3a+b$ has the value	**S.**	-1

(A) I – P ; II – Q ; III – R ; IV – S **(B)** I – S ; II – R ; III – R ; IV – Q

(C) I – Q ; II – P ; III – S ; IV – R **(D)** I – R ; II – S ; III – P ; IV – Q

SPACE FOR ROUGH WORK

9. Match the column I and II, and choose the correct combination from the option given:

Column I		Column II	
I.	The differential equation of the family of curves $y = e^x(A\cos x + B\sin x)$, where A, B are arbitrary constants, has the degree n and order m. Then, the values of n and m are, respectively	**P.**	2, 1
II.	The degree and order of the differential equation of the family of all parabolas whose axis is the x-axis, are respectively	**Q.**	1, 1
III.	The order and degree of the differential equations of the family of circles touching the x-axis at the origin, are respectively	**R.**	2, 2
IV.	The degree and order of the differential equation of the family of ellipse having the same foci, are respectively	**S.**	1, 2

(A) I – P ; II – Q ; III – R ; IV – Q **(B)** I – P ; II – S ; III – Q ; IV – S

(C) I – S ; II – S ; III – Q ; IV – P **(D)** I – P ; II – Q ; III – Q ; IV – R

SPACE FOR ROUGH WORK

10. Match the column I and II, and choose the correct combination from the option given.

Column I		Column II	
I.	If a and b are two unit vectors inclined at $\frac{\pi}{3}$, then $16[\vec{a}\ \vec{b}+(\vec{a}\times\vec{b})\ \vec{b}]$ is	**P.**	–12
II.	If b and c are orthogonal unit vectors and $\vec{b}\times\vec{c}=\vec{a}$, then $[\vec{a}+\vec{b}+\vec{c}\ \ \vec{a}+\vec{b}\ \ \vec{b}+\vec{c}]$ is	**Q.**	1
III.	If $\lvert\vec{a}\rvert=\lvert\vec{b}\rvert=\lvert\vec{c}\rvert=2$ and $\vec{a}\cdot\vec{b}=\vec{b}\cdot\vec{c}=\vec{c}\cdot\vec{a}=2$, then $[\vec{a}\,\vec{b}\,\vec{c}]\cos 45°$ is equal to	**R.**	3
IV.	$\vec{a}=2\hat{i}+3\hat{j}-\hat{k}, \vec{b}=-\hat{i}+2\hat{j}-4\hat{k}, \vec{c}=\hat{i}+\hat{j}+\hat{k}$ and $\vec{d}=3\hat{i}+2\hat{j}+\hat{k}$, then $\frac{1}{7}(\vec{a}\times\vec{b})\cdot(\vec{c}\times\vec{d})$ is equal to	**S.**	4

(A) I – P ; II – R ; III – Q ; IV – S

(B) I – Q ; II – P ; III – R ; IV – S

(C) I – S ; II – P ; III – Q ; IV – R

(D) I – P ; II – Q ; III – S ; IV – R

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SECTION 3
NUMERICAL VALUE TYPE

This section contains **8 Numerical Value Type Questions**. For each question, enter the correct numerical value of the answer. If the numerical value has more than two decimal places, **truncate/roundoff** the value to **TWO** decimal places.

1. Let $\vec{\alpha} = 4\hat{i} + 3\hat{j} + 5\hat{k}$ and $\vec{\beta} = \hat{i} + 2\hat{j} - 4\hat{k}$. Let $\vec{\beta}_1$ be parallel to $\vec{\alpha}$ and $\vec{\beta}_2$ be perpendicular to $\vec{\alpha}$. If $\vec{\beta} = \vec{\beta}_1 + \vec{\beta}_2$, then the value of $5\vec{\beta}_2 \cdot (\hat{i} + \hat{j} + \hat{k})$ is _____.

2. Let $\vec{a} = \hat{i} + 2\hat{j} + \lambda\hat{k},\ \vec{b} = 3\hat{i} - 5\hat{j} - \lambda\hat{k},\ \vec{a} \cdot \vec{c} = 7,\ 2\vec{b} \cdot \vec{c} + 43 = 0,\ \vec{a} \times \vec{c} = \vec{b} \times \vec{c}$. Then $\left|\vec{a} \cdot \vec{b}\right|$ is equal to.

3. If a plane passes through the points $(-1, k, 0), (2, k, -1), (1, 1, 2)$ and is parallel to the line $\frac{x-1}{1} = \frac{2y+1}{2} = \frac{z+1}{-1}$, then the value of k is _____.

4. If $\vec{a}, \vec{b}, \vec{c}$ are three non-zero vectors and $\hat{n}$ is a unit vector perpendicular to $\vec{c}$ such that $\vec{a} = \alpha\vec{b} - \hat{n}, (\alpha \neq 0)$ and $\vec{b} \cdot \vec{c} = 12$, then $\left|\vec{c} \times \left(\vec{a} \times \vec{b}\right)\right|$ is equal to_____.

5. Let $\vec{a}, \vec{b}, \vec{c}$ be three vectors such that $|\vec{a}| = \sqrt{31},\ 4|\vec{b}| = |\vec{c}| = 2$ and $2\left(\vec{a} \times \vec{b}\right) = 3\left(\vec{c} \times \vec{a}\right)$. If the angle between $\vec{b}$ and $\vec{c}$ is $\frac{2\pi}{3}$, then $\left(\frac{\vec{a} \times \vec{c}}{\vec{a} \cdot \vec{b}}\right)^2$ is equal to _____.

SPACE FOR ROUGH WORK

6. Let f be a real valued function satisfying $f\left(\frac{x}{y}\right)=f(x)-f(y)$ and $\lim\limits_{x\to 0}\frac{f(1+x)}{x}=3.$ If the area bounded by the curve $y=f(x)$ the *Y*-axis and the line $y=3,$ where $x,y\in R^{+}$ is A then the value of A/e is _____.

7. A real valued function, $f(x),\ f:\left(0,\frac{\pi}{2}\right)\to R^{+}$ satisfies the differential equation $xf'(x)=1+f(x)\cdot\left\{x^2f(x)-1\right\}$ and $f\left(\frac{\pi}{4}\right)=\frac{4}{\pi},\ \lim\limits_{x\to 0}f(x),$ is _____.

8. If the area bounded by $y=f(x),\ x=\frac{1}{2},\ x=\frac{\sqrt{3}}{2}$ and the *X*-axis is A sq.units where $f(x)=x+\frac{2}{3}x^3+\frac{2}{3}\cdot\frac{4}{5}x^5+\frac{2}{3}\cdot\frac{4}{5}\cdot\frac{6}{7}x^7+....\infty,\ |x|<1$, then the value of [4A] is (where $[\cdot]$ is G.I.F).

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End of JEE Advanced-2_Paper -1| XII PASS [JEE 2024]