VMC Vidyamandir Classes SINCE 1986

IIT JEE | MEDICAL | FOUNDATION

JEE ADVANCED 2025 | PAPER – 1

Date: 18 May 2025

Maximum Marks: 180

Timing: 9:00 AM to 12:00 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 Subject has **Four** sections (Section 1, Section 2, Section 3 and Section 4).

2. **Section 1** contains **4 Multiple Choice Questions**. Each question has 4 choices (A), (B), (C) and (D), out of which **ONLY ONE CHOICE** is correct.

    Section 2 contains **3 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 3 contains **6 Numerical Value Type Questions**. For each question, enter the correct numerical value of the answer using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer. If the numerical value has more than two decimal places, **truncate/round-off** the value to **TWO** decimal places.

    Section 4 contains **3** Matching List sets. Each set has **TWO** lists: **List I** and **List II**. **List-I** has **Four** entries (P), (Q), (R) and (S) and **List-II** has **Five** entries (1), (2), (3), (4) and (5). **FOUR** options are given in each Multiple-Choice Question based on **List-I** and **List-II** and **ONLY ONE** of these four options satisfies the condition asked in the Multiple-Choice Question.

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.

MARKING SCHEME

SECTION – 1 | (Maximum Marks: 12)

- ➤ This section contains **Four (04)** Multiple Choice Questions.
- ➤ 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 – 2 | (Maximum Marks: 12)

- ➤ This section consists of **Three (03)** 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 – 3 | (Maximum Marks: 24)

- ➤ This section contains **SIX (06)** Questions.

    The answer to each question is a **NUMERICAL VALUE.**

- ➤ For each question, enter the correct integer corresponding to 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/round-off** the value to **TWO** decimal places.
- ➤ Answer to each question will be evaluated according to the following marking scheme.

    Full Marks   : +4 If ONLY the correct integer is entered;

    Zero Marks   : 0 In all other cases.

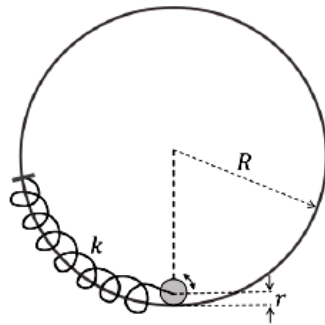### SECTION – 4 | (Maximum Marks: 12)

- ➤ This section contains **THREE (03)** Matching List sets. Each set has **TWO** lists: **List I** and **List II**. **List-I** has **Four** entries (P), (Q), (R) and (S) and **List-II** has **Five** entries (1), (2), (3), (4) and (5).
- ➤ **FOUR** options are given in each Multiple Choice Question based on **List-I** and **List-II** and **ONLY ONE** of these four options satisfies the condition asked in the Multiple Choice Question.
- ➤ Answer to each question will be evaluated according to the following marking scheme.

    Full Marks   : +4 ONLY if the option corresponding to the correct combination 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.

SUBJECT I : PHYSICS   60 MARKS

SECTION-1

This section consists of 4 Multiple Choice Questions. Each question has 4 choices (A), (B), (C) and (D), out of which **ONLY ONE CHOICE** is correct.

1.   The center of a disk of radius r and mass m is attached to a spring of spring constant k, inside a ring of radius $R > r$ as shown in the figure. The other end of the spring is attached on the periphery of the ring. Both the ring and the disk are in the same vertical plane. The disk can only roll along the inside periphery of the ring, without slipping. The spring can only be stretched or compressed along the periphery of the ring, following the Hooke's law. In equilibrium, the disk is at the bottom of the ring. Assuming small displacement of the disc, the time period of oscillation of center of mass of the disk is written as $T = \dfrac{2\pi}{\omega}$. The correct expression for ω is (g is the acceleration due to gravity):


(A) $\sqrt{\dfrac{2}{3}\left(\dfrac{g}{R-r}+\dfrac{k}{m}\right)}$

(B) $\sqrt{\dfrac{2g}{3(R-r)}+\dfrac{k}{m}}$

(C) $\sqrt{\dfrac{1}{16}\left(\dfrac{g}{R-r}+\dfrac{k}{m}\right)}$

(D) $\sqrt{\dfrac{1}{4}\left(\dfrac{g}{R-r}+\dfrac{k}{m}\right)}$

2.   In a scattering experiment, a particle of mass $2m$ collides with another particle of mass m, which is initially at rest. Assuming the collision to be perfectly elastic, the maximum angular deviation θ of the heavier particle, as shown in the figure, in radians is:


(A) π
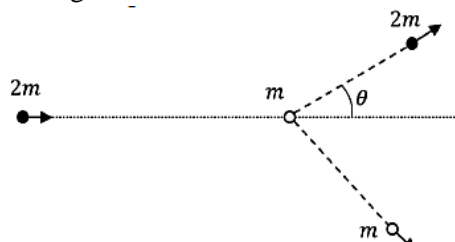
(B) $\tan^{-1}\left(\dfrac{1}{2}\right)$

(C) $\dfrac{\pi}{3}$

(D) $\dfrac{\pi}{6}$

3. A conducting square loop initially lies in the *XZ* plane with its lower edge hinged along the *X*-axis. Only in the region $y \geq 0$, there is a time dependent magnetic field pointing along the *Z*-direction, $\vec{B}(t) = B_0(\cos \omega t)k$, where B_0 is a constant. The magnetic field is zero everywhere else. At time $t = 0$, the loop starts rotating with constant angular speed ω about the *X* axis in the clockwise direction as viewed from the +*X* axis (as shown in the figure). Ignoring self-inductance of the loop and gravity, which of the following plots correctly represents the induced e.m.f. (*V*) in the loop as a function of time:

(A)

(B)

(C)

(D)
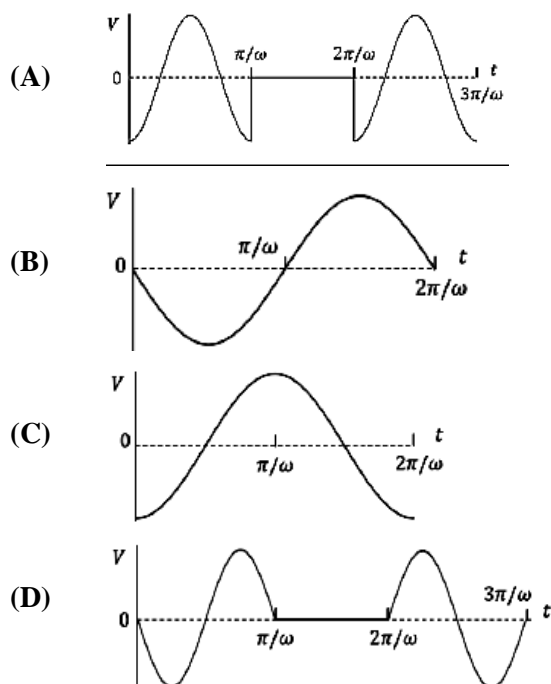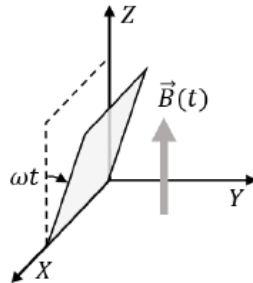
4. Figure.1 shows the configuration of main scale and Vernier scale before measurement. Figure.2 shows the configuration corresponding to the measurement of diameter *D* of a tube. The measured value of *D* is:
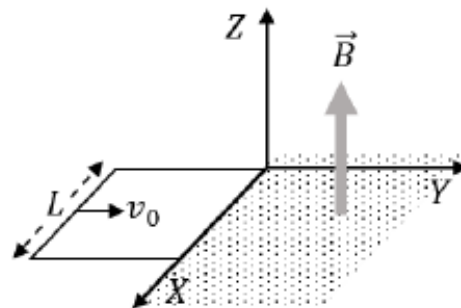

Fig. 1

Fig. 2
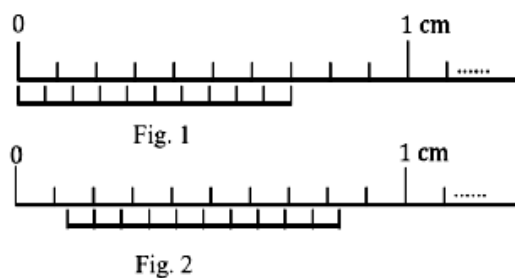
(A) 0.12 cm   **(B)** 0.11 cm   **(C)** 0.13 cm   **(D)** 0.14 cm

SECTION-2

This section consists of 3 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.

5. A. conducting square loop of side L, mass M and resistance R is moving in the XY plane with its edges parallel to the X and Y axes. The region $y \geq 0$ has a uniform magnetic field, $\vec{B} = B_0 k$. The magnetic field is zero everywhere else. At time $t = 0$, the loop starts to enter the magnetic field with an initial velocity $v_0 \, j \, m/s$, as shown in the figure. Considering the quantity $K = \dfrac{B_0^2 L^2}{RM}$ in appropriate units, ignoring self-inductance of the loop and gravity, which of the following statements is/are correct:

    (A) If $v_0 = 1.5 \, KL$, the loop will stop before it enters completely inside the region of magnetic field

    (B) When the complete loop is inside the region of magnetic field, the net force acting on the loop is zero

    (C) If $v_0 = \dfrac{KL}{10}$, the loop comes to rest at $t = \left(\dfrac{1}{K}\right) \ln\left(\dfrac{5}{2}\right)$

    (D) If $v_0 = 3KL$, the complete loop enters inside the region of magnetic filed at time $t = \left(\dfrac{1}{K}\right) \ln\left(\dfrac{3}{2}\right)$

6. Length, breadth and thickness of a strip having a uniform cross section are measured to be 10.5 cm, 0.05 mm, and $6.0 \mu m$, respectively. Which of the following option(s) give(s) the volume of the strip in cm^3 with correct significant figures:

    (A) 3.2×10^{-5} **(B)** 32.0×10^{-6} **(C)** 3.0×10^{-5} **(D)** 3×10^{-5}

7. Consider a system of three connected strings, S_1, S_2 and S_3 with uniform linear mass densities $\mu \, kg/m$, $4\mu \, kg/m$ and $16\mu \, kg/m$, respectively, as shown in the figure. S_1 and S_2 are connected at the point P, whereas S_2 and S_3 are connected at the point Q, and the other end of S_3 is connected to a wall. A wave generator O is connected to the free end of S_1. The wave from the generator is represented by $y = y_0 \cos(\omega t - kx) cm$, where y_0, ω and k are constants of appropriate dimensions.
Which of the following statements is/are correct:
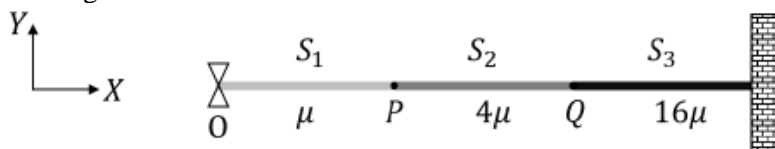
   **(A)** When the wave reflects from P for the first time, the reflected wave is represented by $y = \alpha_1 y_0 \cos(\omega t + kx + \pi) cm$, where α_1 is a positive constant

    (B) When the wave transmits through P for the first time, the transmitted wave is represented by $y = \alpha_2 y_0 \cos(\omega t - kx) cm$, where α_2 is a positive constant

    (C) When the wave reflects from Q for the first time, the reflected wave is represented by $y = \alpha_3 y_0 \cos(\omega t - kx + \pi) cm$, where α_3 is a positive constant

    (D) When the wave transmits through Q for the first time, the transmitted wave is represented by $y = \alpha_4 y_0 \cos(\omega t - 4kx) cm$, where α_4 is a positive constant

SECTION-3

This section consists of 6 Numerical Value Type Questions. If the numerical value has more than two decimal places, **truncate/round-off** the value to **TWO** decimal places.

8. A person sitting inside an elevator performs a weighing experiment with an object of mass 50 kg. Suppose that the variation of the height y (in m) of the elevator, from the ground, with time t (in s) is given by $y = 8\left[1 + \sin\left(\dfrac{2\pi t}{T}\right)\right]$, where $T = 40\pi\, s$. Taking acceleration due to gravity, $g = 10\, m/s^2$, the maximum variation of the object's weight (in N) as observed in the experiment is ___.

9. A cube of unit volume contains 35×10^7 photons of frequency $10^{15}\, Hz$. If the energy of all the photons is viewed as the average energy being contained in the electromagnetic waves within the same volume, then the amplitude of the magnetic field is $\alpha \times 10^{-9}\, T$. Taking permeability of free space $\mu_0 = 4\pi \times 10^{-7}\, Tm/A$, Planck's constant $h = 6 \times 10^{-34}\, Js$ and $\pi = \dfrac{22}{7}$, the value of α is____

10. Two identical plates P and Q, radiating as perfect black bodies, are kept in vacuum at constant absolute temperatures T_P and T_Q, respectively, with $T_Q < T_P$, as shown in Fig. 1. The radiated power transferred per unit area from P to Q is W_0. Subsequently, two more plates, identical to P and Q, are introduced between P and Q, as shown in Fig. 2. Assume that heat transfer takes place only between adjacent plates. If the power transferred per unit area in the direction from P to Q (Fig. 2) in the steady state is W_s, then the ratio $\dfrac{W_0}{W_s}$ is _____.
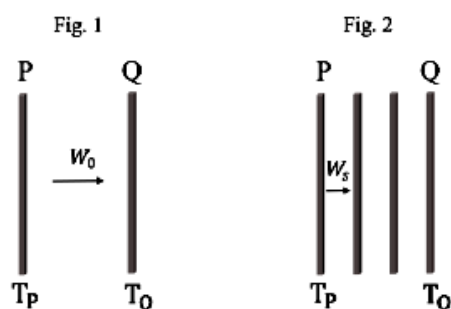
11. A solid glass sphere of refractive index $n = \sqrt{3}$ and radius R contains a spherical air cavity of radius $\dfrac{R}{2}$, as shown in the figure. A very thin glass layer is present at the point O so that the air cavity (refractive index $n = 1$) remains inside the glass sphere. An unpolarized, unidirectional and monochromatic light source S emits a light ray from a point inside the glass sphere towards the periphery of the glass sphere. If the light is reflected from the point O and is fully polarized, then the angle of incidence at the inner surface of the glass sphere is θ. The value of $\sin\theta$ is_____.
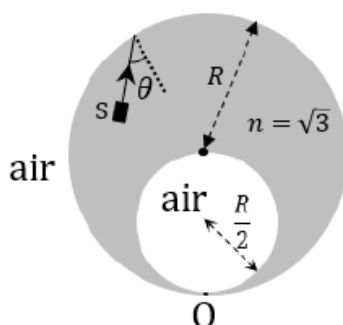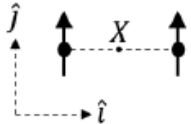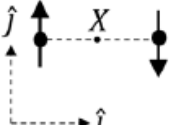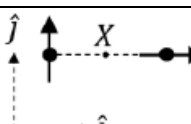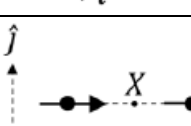
12. A single slit diffraction experiment is performed to determine the slit width using the equation, $\dfrac{bd}{D} = m\lambda$, where b is the slit width, D the shortest distance between the slit and the screen, d the distance between the mth diffraction maximum and the central maximum, and λ is the wavelength. D and d are measured with scales of least count of 1 cm and 1 mm, respectively. The values of λ and m are known precisely to be 600 nm and 3, respectively. The absolute error (in μm) in the value of b estimated using the diffraction maximum that occurs for $m = 3$ with $d = 5\ mm$ and $D = 1m$ is ___.

13. Consider an electron in the $n = 3$ orbit of a hydrogen-like atom with atomic number Z. At absolute temperature T, a neutron having thermal energy $k_B T$ has the same de Broglie wavelength as that of this electron. If this temperature is given by $T = \dfrac{Z^2 h^2}{\alpha \pi^2 a_0^2 m_N k_B}$, (where h is the Planck's constant, k_B is the Boltzmann constant, m_N is the mass of the neutron and a_0 is the first Bohr radius of hydrogen atom) then the value of α is _____.

SECTION-4

This section consists of 3 Matching List Sets. Each set has **ONE** Multiple Choice Question. Each set has **TWO** lists: **List-I** and **List-II**. **List-I** has **Four** entries (P), (Q), (R) and (S) and **List-II** has **Five** entries (1), (2), (3), (4) and (5). **FOUR** options are given in each Multiple-Choice Question based on **List-I** and **List-II** and **ONLY ONE** of these four options satisfies the condition asked in the Multiple Choice Question.

14. List-I shows four configurations, each consisting of a pair of ideal electric dipoles. Each dipole has a dipole moment of magnitude p, oriented as marked by arrows in the figures. In all the configurations the dipoles are fixed such that they are at a distance $2r$ apart along the x direction. The midpoint of the line joining the two dipoles is X. The possible resultant electric fields $\vec{E}$ at X are given in List-II.
Choose the option that describes the correct match between the entries in **List-I** to those in **List-II**.

	List-I		List-II
(P)		**(1)**	$\vec{E} = 0$
(Q)		**(2)**	$\vec{E} = -\dfrac{p}{2\pi \in_0 r^3} j$
(R)		**(3)**	$\vec{E} = -\dfrac{p}{4\pi \in_0 r^3}(\hat{i} - j)$
(S)		**(4)**	$\vec{E} = \dfrac{p}{4\pi \in_0 r^3}(2\hat{i} - j)$
		(5)	$\vec{E} = \dfrac{p}{\pi \in_0 r^3}\hat{i}$

(A) P $\to$ 3, Q $\to$ 1, R $\to$ 2, S $\to$ 4   **(B)** P $\to$ 4, Q $\to$ 5, R $\to$ 3, S $\to$ 1

(C) P $\to$ 2, Q $\to$ 1, R $\to$ 4, S $\to$ 5   **(D)** P $\to$ 2, Q $\to$ 1, R $\to$ 3, S $\to$ 5

15. A circuit with an electrical load having impedance Z is connected with an AC source as shown in the diagram. The source voltage varies in time as $V(t) = 300\sin(400t)V$, where t is time in s. **List-I** shows various options for the load. The possible currents $i(t)$ in the circuit as a function of time are given in **List-II**.

Choose the option that describes the correct match between the entries in **List-I** to those in **List-II**.

List-I		List-II	
(P)	30 Ω	**(1)**	
(Q)	30 Ω 100 mH	**(2)**	
(R)	50 μF 30 Ω 25 mH	**(3)**	
(S)	50 μF 60 Ω 125 mH	**(4)**	
		(5)	

(A) P→3, Q→5, R→2, S→1

(B) P→1, Q→5, R→2, S→3

(C) P→3, Q→4, R→2, S→1

(D) P→1, Q→4, R→2, S→5

16. **List-I** shows various functional dependencies of energy (E) on the atomic number (Z). Energies associated with certain phenomena are given in **List-II**.

Choose the option that describes the correct match between the entries in **List-I** to those in **List-II**.

	List-I		**List-II**
(P)	$E \propto Z^2$	**(1)**	Energy of characteristic x-rays
(Q)	$E \propto (Z-1)^2$	**(2)**	electrostatic part of the nuclear binding energy for stable nuclei with mass numbers in the range 30 to 170
(R)	$E \propto Z(Z-1)$	**(3)**	energy of continuous x-rays
(S)	E is practically independent of Z	**(4)**	average nuclear binding energy per nucleon for stable nuclei with mass number in the range 30 to 170
		(5)	energy of radiation due to electronic transitions from hydrogen-like atoms

(A) P $\rightarrow$ 4, Q $\rightarrow$ 3, R $\rightarrow$ 1, S $\rightarrow$ 2

(B) P $\rightarrow$ 5, Q $\rightarrow$ 2, R $\rightarrow$ 1, S $\rightarrow$ 4

(C) P $\rightarrow$ 5, Q $\rightarrow$ 1, R $\rightarrow$ 2, S $\rightarrow$ 4

(D) P $\rightarrow$ 3, Q $\rightarrow$ 2, R $\rightarrow$ 1, S $\rightarrow$ 5

SUBJECT II: CHEMISTRY   **60 MARKS**
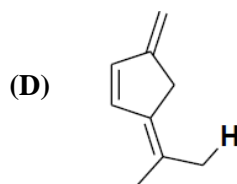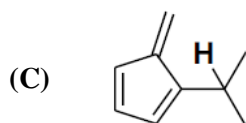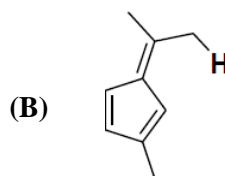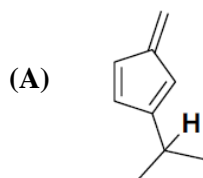
SECTION-1

This section consists of 4 Multiple Choice Questions. Each question has 4 choices (A), (B), (C) and (D), out of which **ONLY ONE CHOICE** is correct.

1. The heating of NH_4NO_2 at 60-70 °C and NH_4NO_3 at 200-250 °C is associated with the formation of nitrogen containing compounds X and Y, respectively. X and Y, respectively, are:

   (A) N_2 and N_2O **(B)** NH_3 and NO_2

   (C) NO and N_2O **(D)** N_2 and NH_3

2. The correct order of the wavelength maxima of the absorption band in the ultraviolet-visible region for the given complexes is:

   (A) $[Co(CN)_6]^{3-} < [Co(NH_3)_6]^{3+} < [Co(NH_3)_5(H_2O)]^{3+} < [Co(NH_3)_5(C_1)]^{2+}$

   (B) $[Co(NH_3)_5(Cl)]^{2+} < [Co(NH_3)_5(H_2O)]^{3+} < [Co(NH_3)_6]^{3+} < [Co(CN)_6]^{3-}$

   (C) $[Co(CN)_6]^{3-} < [Co(NH_3)_5(Cl)]^{2+} < [Co(NH_3)_5(H_2O)]^{3+} < [Co(NH_3)_6]^{3+}$

   (D) $[Co(NH_3)_6]^{3+} < [Co(CN)_6]^{3-} < [Co(NH_3)_5(Cl)]^{2+} < [Co(NH_3)_5(H_2O)]^{3+}$

3. One of the products formed from the reaction of permanganate ion with iodide ion in neutral aqueous medium is:

   (A) I_2 **(B)** IO_3^- **(C)** IO_4^- **(D)** IO_2^-

4. Consider the depicted hydrogen (H) in the hydrocarbons given below. The most acidic hydrogen (H) is:

   (A)

   (B)

   (C)

   (D)

SECTION-2

This section consists of 3 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.

5. Regarding the molecular orbital (MO) energy levels for homonuclear diatomic molecules, the INCORRECT statement(s) is(are):

(A) Bond order of Ne_2 is zero

(B) The highest occupied molecular orbital (HOMO) of F_2 is σ-type

(C) Bond energy of O_2^+ is smaller than the bond energy of O_2

(D) Bond length of Li_2 is larger than the bond length of B_2

6. The pair(s) of diamagnetic ions is(are):

(A) La^{3+}, Ce^{4+} **(B)** Yb^{2+}, Lu^{3+}

(C) La^{2+}, Ce^{3+} **(D)** Yb^{3+}, Lu^{2+}

7. For the reaction sequence given below, the correct statement(s) is(are):
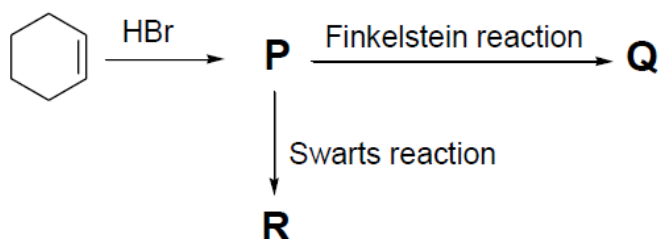
(In the options, X is any atom other than carbon and hydrogen, and it is different in P, Q and R)

(A) C – X bond length in P, Q and R follows the order $Q > R > P$

(B) C – X bond enthalpy in P, Q and R follows the order $R > P > Q$

(C) Relative reactivity toward S_N2 reaction in P, Q and R follows the order $P > R > Q$

(D) pK_a value of the conjugate acids of the leaving groups in P, Q and R follows the order $R > Q > P$

SECTION-3

This section consists of 6 Numerical Value Type Questions. If the numerical value has more than two decimal places, **truncate/round-off** the value to **TWO** decimal places.

8. In an electrochemical cell, dichromate ions in aqueous acidic medium are reduced to Cr^{3+}. The current (in amperes) that flows through the cell for 48.25 minutes to produce 1 mole of Cr^{3+} is _____.

Use: 1 Faraday = 96500 C mol^{-1}

9. At 25 °C, the concentration of H^+ ions in 1.00×10^{-3} M aqueous solution of a weak monobasic acid having acid dissociation constant (K_a) of 4.00×10^{-11} is $X \times 10^{-7}$ M. The value of X is _____.

Use: Ionic product of water $K_w = 1.00 \times 10^{-14}$ at 25 °C

10. Molar volume (V_m) of a van der Waals gas can be calculated by expressing the van der Waals equation as a cubic equation with V_m as the variable. The ratio (in mol dm^{-3}) of the coefficient of V_m^2 to the coefficient of V_m for a gas having van der Waals constants a = 6.0 dm^6 atm mol^{-2} and b = 0.060 dm^3 mol^{-1} at 300 K and 300 atm is _____.

Use: Universal gas constant $(R) = 0.082$ dm^3 atm mol^{-1} K^{-1}

11. Considering ideal gas behavior, the expansion work done (in kJ) when 144 g of water is electrolyzed completely under constant pressure at 300 K is _____.

Use: Universal gas constant $(R) = 8.3$ J K^{-1} mol^{-1}; Atomic mass (in amu): H = 1, O = 16

12. The monomer (X) involved in the synthesis of Nylon 6,6 gives positive carbylamine test. If 10 moles of X are analyzed using Dumas method, the amount (in grams) of nitrogen gas evolved is _____.

Use: Atomic mass of N (in amu) = 14

13. The reaction sequence given below is carried out with 16 moles of X. The yield of the major product in each step is given below the product in parentheses. The amount (in grams) of S produced is _____.
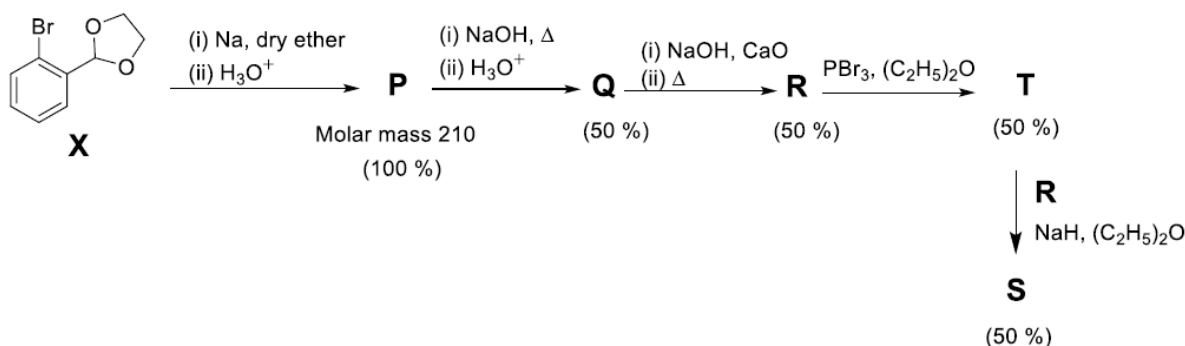
Use: Atomic mass (in amu): H = 1, C = 12, O = 16, Br = 80

SECTION-4

This section consists of 3 Matching List Sets. Each set has **ONE** Multiple Choice Question. Each set has **TWO** lists: **List-I** and **List-II**. **List-I** has **Four** entries (P), (Q), (R) and (S) and **List-II** has **Five** entries (1), (2), (3), (4) and (5). **FOUR** options are given in each Multiple-Choice Question based on **List-I** and **List-II** and **ONLY ONE** of these four options satisfies the condition asked in the Multiple Choice Question.

14. The correct match of the group reagents in **List-I** for precipitating the metal ion given in **List-II** from solutions, is:

	List-I		List-II
P.	Passing H_2S in the presence of NH_4OH	**1.**	Cu^{2+}
Q.	$(NH_4)_2 CO_3$ in the presence of NH_4OH	**2.**	Al^{3+}
R.	NH_4OH in the presence of NH_4Cl	**3.**	Mn^{2+}
S.	Passing H_2S in the presence of dilute HCI	**4.**	Ba^{2+}
		5.	Mg^{2+}

(A) P $\to$ 3; Q $\to$ 4; R $\to$ 2; S $\to$ 1
(C) P $\to$ 4; Q $\to$ 2; R $\to$ 3; S $\to$ 1
(C) P $\to$ 3; Q $\to$ 4; R $\to$ 1; S $\to$ 5
(D) P $\to$ 5; Q $\to$ 3; R $\to$ 2; S $\to$ 4

15. The major products obtained from the reactions in **List-II** are the reactants for the named reactions mentioned in **List-I**. Match each entry in **List-I** with the appropriate entry in **List-II** choose the correct option.

	List-I		List-II
P.	Stephen reaction	**1.**	Toluene $\xrightarrow[\text{(ii)}\,H_3O^+]{\text{(i)}\,CrO_2Cl_2/CS_2}$
Q.	Sandmeyer reaction	**2.**	Benzoic acid $\xrightarrow[\text{(iii)}\,P_4O_{10},\Delta]{\text{(i) }PCl_5 \;\text{(ii) }NH_3}$
R.	Hoffmann bromamide degradation reaction	**3.**	Nitrobenzene $\xrightarrow[\text{(273–278K)},H_2O]{\text{(i) }Fe,HCl \;\text{(ii) }HCl,NaNO_2}$
S.	Cannizzaro reaction	**4.**	Toluene $\xrightarrow[\text{(iv) }NH_3]{\text{(i) }Cl_2/hv,H_2O \;\text{(ii) Tollen's reagent} \;\text{(iii)}SO_2Cl_2}$
		5.	Aniline $\xrightarrow[\text{(iii) aq.NaOH}]{\text{(i) }(CH_3CO)_2O,Pyridine \;\text{(ii) }HNO_3,H_2SO_4,288K}$

(A) P $\to$ 2; Q $\to$ 4; R $\to$ 1; S $\to$ 3
(C) P $\to$ 2; Q $\to$ 3; R $\to$ 4; S $\to$ 1
(C) P $\to$ 5; Q $\to$ 3; R $\to$ 4; S $\to$ 2
(D) P $\to$ 5; Q $\to$ 4; R $\to$ 2; S $\to$ 1

16. Match the compounds in **List-I** with the appropriate observations in **List-II** and choose the correct option.

	List-I		List-II
P.	(structure: 4-hydroxyphenyl glycine dipeptide with NH_2, amide NH, OMe ester, HO on ring)	**1.**	Reaction with phenyl diazonium salt gives yellow dye.
Q.	(structure: N-acetyl phenyl glycine peptide with amide NH, OMe ester, valine side chain)	**2.**	Reaction with ninhydrin gives purple color and it also reacts with $FeCl_3$ to give violet color.
R.	(structure: $NH_3^+Cl^-$ on benzene ring — anilinium chloride)	**3.**	Reaction with glucose will give corresponding hydrazone.
S.	(structure: mesityl $NHNH_2$ — 2,4,6-trimethylphenyl hydrazine)	**4.**	Lassiagne extract of the compound treated with dilute HCl followed by addition of aqueous $FeCl_3$ gives blood red color.
		5.	After complete hydrolysis, it will give ninhydrin test and it DOES NOT give positive phthalein dye test.

(A) P $\rightarrow$ 1; Q $\rightarrow$ 5; R $\rightarrow$ 4; S $\rightarrow$ 2

(C) P $\rightarrow$ 2; Q $\rightarrow$ 5; R $\rightarrow$ 1; S $\rightarrow$ 3

(C) P $\rightarrow$ 5; Q $\rightarrow$ 2; R $\rightarrow$ 1; S $\rightarrow$ 4

(D) P $\rightarrow$ 2; Q $\rightarrow$ 1; R $\rightarrow$ 5; S $\rightarrow$ 3

SUBJECT III: MATHEMATICS   60 MARKS

SECTION-1

This section consists of 4 Multiple Choice Questions. Each question has 4 choices (A), (B), (C) and (D), out of which **ONLY ONE CHOICE** is correct.

1. Let $\mathbb{R}$ denote the set of all real numbers. Let $a_i, b_i \in \mathbb{R}$ for $i \in \{1, 2, 3\}$.

Define the functions $f : \mathbb{R} \to \mathbb{R}, g : \mathbb{R} \to R$ and $h : \mathbb{R} \to \mathbb{R}$ by

$$f(x) = a_1 + 10x + a_2 x^2 + a_3 x^3 + x^4, \quad g(x) = b_1 + 3x + b_2 x^2 + b_3 x^3 + x^4,$$

$$h(x) = f(x+1) - g(x+2).$$

If $f(x) \neq g(x)$ for every $x \in \mathbb{R}$, then the coefficient of x^3 in $h(x)$ is:

(A) 8 **(B)** 2 **(C)** -4 **(D)** -6

2. Three students S_1, S_2 and S_3 are given a problem to solve. Consider the following events:

U : At least one of S_1, S_2 and S_3 can solve the problem.

V: S_1 can solve the problem, given that neither S_2 nor S_3 can solve the problem,

W: S_2 can solve the problem and S_3 cannot solve the problem, T: S_3 can solve the problem.

For any event E, let $P(E)$ denote the probability of E. If $P(U) = \dfrac{1}{2}, P(V) = \dfrac{1}{10}, and\ P(W) = \dfrac{1}{12}$, then

$P(T)$ is equal to:

(A) $\dfrac{13}{36}$ **(B)** $\dfrac{1}{3}$ **(C)** $\dfrac{19}{60}$ **(D)** $\dfrac{1}{4}$

3. Let $\mathbb{R}$ denote the set of all real numbers. Define the function $f : \mathbb{R} \to \mathbb{R}$ by

$$f(x) = \begin{cases} 2 - 2x^2 - x^2 \sin \dfrac{1}{x} & if\ x \neq 0, \\ 2 & if\ x = 0. \end{cases}$$

Then which one of the following statements is TRUE?

(A) The function f is NOT differentiable at $x = 0$

(B) There is a positive real number δ, such that f is a decreasing function on the interval $(0, \delta)$

(C) For any positive real number δ, the function f is NOT For any positive real number $(-\delta, 0)$

(D) $x = 0$ is a point of local minima of f

4. Consider the matrix $P = \begin{pmatrix} 2 & 0 & 0 \\ 0 & 2 & 0 \\ 0 & 0 & 3 \end{pmatrix}$.

Let the transpose of a matrix X be denoted by X^T. Then the number of 3×3 invertible matrices Q with integer entries, such that $Q^{-1} = Q^T$ and $PQ = QP$ is:

(A) 32 **(B)** 8 **(C)** 16 **(D)** 24

SECTION-2

This section consists of 3 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.

5. Let L_1 be the line of intersection of the planes given by the equations $2x + 3y + z = 4$ and $x + 2y + z = 5$.

Let L_2 be the line passing through the point $P(2, -1, 3)$ and parallel to L_1. Let M denote the plane given by the equation $2x + y - 2z = 6$.

Suppose that the line L_2 meets the plane M at the point Q. Let R be the foot of the perpendicular drawn from P to the plane M. Then which of the following statements is(are) TRUE?
Then which of the following statements is (are) TRUE?

(A) The length of the line segment PQ is $9\sqrt{3}$

(B) The length of the line segment QR is 15

(C) The area of ΔPQR is $\dfrac{3}{2}\sqrt{234}$

(D) The acute angle between the line segments PQ and PR is $\cos^{-1}\left(\dfrac{1}{2\sqrt{3}}\right)$

6. Let $\mathbb{N}$ denote the set of all natural numbers, and $\mathbb{Z}$ denote the set of all integers. Consider the functions

$f : \mathbb{N} \to \mathbb{Z}$ and $g : \mathbb{Z} \to \mathbb{N}$ defined by $f(n) = \begin{cases} (n+1)/2 & \text{if } n \text{ is odd}, \\ (4-n)/2 & \text{if } n \text{ is even}, \end{cases}$ and $g(n) = \begin{cases} 3+2n & \text{if } n \geq 0 \\ -2n & \text{if } n < 0 \end{cases}$.

Define $(g \circ f)(n) = g(f(n))$ for all $n \in \mathbb{N}$, and $(f \circ g)(n) = f(g(n))$ for all $n \in \mathbb{Z}$.

Then which of the following statements is (are) TRUE?
(A) $g \circ f$ is NOT one-one and $g \circ f$ is NOT onto

(B) $f \circ g$ is NOT one-one but $f \circ g$ is onto

(C) g is one-one and g is onto

(D) f is NOT one-one but f is onto

7. Let $\mathbb{R}$ denote the set of all real numbers. Let $z_1 = 1 + 2i$ and $z_2 = 3i$ be two complex numbers, where $i = \sqrt{-1}$. Let $S = \{(x, y) \in \mathbb{R} \times \mathbb{R} : | x + iy - z_1 | = 2 | x + iy - z_2 | \}$.

Then which of the following statements is (are) TRUE?

(A) S is a circle with centre $\left(-\dfrac{1}{3}, \dfrac{10}{3}\right)$

(B) S is a circle with centre $\left(\dfrac{1}{3}, \dfrac{8}{3}\right)$

(C) S is a circle with radius $\dfrac{\sqrt{2}}{3}$

(D) S is a circle with radius $\dfrac{2\sqrt{2}}{3}$

SECTION-3

This section consists of **6 Numerical Value Type Questions**. If the numerical value has more than two decimal places, **truncate/round-off** the value to **TWO** decimal places.

8. Let the set of all relations R on the set $\{a, b, c, d, e, f\}$, such that R is reflexive an symmetric, and R contains exactly 10 elements, be denote by S.

Then the number of elements in S is_____.

9. For any two points M and N in the XY-plane, let $\overrightarrow{MN}$ denote the vector from M to N, and $\vec{0}$ denote the zero vector. Let P. Q and R be three distinct points in the XY-plane. Let S be a point inside the triangle ΔPQR such that $\overrightarrow{SP} + 5\overrightarrow{SQ} + 6\overrightarrow{SR} = \vec{0}.$

Let E and F be the mid-points of the sides PR and QR, respectively. Then the value of $\dfrac{\text{length of the line segment } EF}{\text{length of the segment } ES}$ is_____.

10. Let S be the set of all seven-digit numbers that can be formed using the digits 0, 1 and 2. For example, 2210222 is in S, but 0210222 is NOT in S. Then the number of elements x in S such that at least one of the digits 0 and 1 appears exactly twice in x, is equal to _____.

11. Let α and β be the real numbers such that $\lim\limits_{x \to 0} \dfrac{1}{x^3}\left(\dfrac{a}{2} \int_0^x \dfrac{1}{1-t^2} dt + \beta x \cos x \right) = 2.$

Then the value of $\alpha + \beta$ is_____.

12. Let $\mathbb{R}$ denote the set of all real numbers. Let $f : \mathbb{R} \to \mathbb{R}$ be a function such that $f(x) > 0$ for all $x \in \mathbb{R}$, and $f(x + y) = f(x)f(y)$ for all $x, y \in \mathbb{R}$.

Let the real numbers $a_1, a_2, ..., a_{50}$ be in an arithmetic progression. If $f(a_{31}) = 64 f(a_{25})$, and then the value of $\sum\limits_{i=1}^{50} f(a_i) = 3\left(2^{25} + 1\right)$, then the value of $\sum\limits_{i=6}^{30} f(a_i)$ is_____.

13. For all $x > 0$, let $y_1(x)$, $y_2(x)$, and $y_3(x)$ be the functions satisfying $\dfrac{dy_1}{dx} - (\sin x)^2 y_1 = 0$, $y_1(1) = 5$,

$\dfrac{dy_2}{dx} - (\cos)^2 y_2 = 0$, $y_2(1) = \dfrac{1}{3}$, $\dfrac{dy_3}{dx} - \left(\dfrac{2 - x^3}{x^3} \right) y_3 = 0$, $y_3(1) = \dfrac{3}{5e}$, respectively. Then

$\lim\limits_{x \to 0^+} \dfrac{y_1(x) y_2(x) \, y_3(x) + 2x}{e^{3x} \sin x}$ is equal to_____.

SECTION-4

This section consists of 3 Matching List Sets. Each set has **ONE** Multiple Choice Question. Each set has **TWO** lists: **List-I** and **List-II**. **List-I** has **Four** entries (P), (Q), (R) and (S) and **List-II** has **Five** entries (1), (2), (3), (4) and (5). **FOUR** options are given in each Multiple-Choice Question based on **List-I** and **List-II** and **ONLY ONE** of these four options satisfies the condition asked in the Multiple Choice Question.

14. Consider the following frequency distribution:

Value	4	5	8	9	6	12	16
Frequency	5	f_1	f_2	2	1	1	3

Suppose that the sum of the frequencies is 19 and the median of this frequency distribution is 6.

For the given frequency distribution, let α denote the mean deviation about the mean, β denote the mean deviation about the median, and σ^2 denote the variance.

Match each entry in List – I to the correct entry in List – II and choose the correct option.

	List - I		**List – II**
(P)	$7f_1 + 9f_2$ is equal to	**(1)**	146
(Q)	19α is equal to	**(2)**	47
(R)	19β is equal to	**(3)**	48
(S)	$19\sigma^2$ is equal to	**(4)**	145
		(5)	55

(A) (P) $\to$ (5) (Q) $\to$ (3) (R) $\to$ (2) (S) $\to$ (4)
(B) (P) $\to$ (5) (Q) $\to$ (2) (R) $\to$ (3) (S) $\to$ (1)
(C) (P) $\to$ (5) (Q) $\to$ (3) (R) $\to$ (2) (S) $\to$ (1)
(D) (P) $\to$ (3) (Q) $\to$ (2) (R) $\to$ (5) (S) $\to$ (4)

15. Let $\mathbb{R}$ denote the set of all real numbers. For a real number x, let $[x]$ denote the greatest integer less than or equal to x. Let n denote a natural number.

Match each entry in List-I to the correct entry in List-II and choose the correct option.

List – I		**List - II**	
(P)	The minimum value of n for which the function $f(x) = \left[\dfrac{10x^3 - 45x^2 + 60x + 35}{n} \right]$ is continuous on the interval $[1, 2]$ is	**(1)**	8
(Q)	The minimum value of n for which $g(x) = (2n^2 - 13n - 15)(x^3 + 3x)$, $x \in \mathbb{R}$, is an increasing function of $\mathbb{R}$, is	**(2)**	9
(R)	The smallest number n which is greater than 5, such that $x = 3$ is a point of local minima of $h(x) = (x^2 - 9)^n (x^2 + 2x + 3)$, is	**(3)**	5
(S)	Number of $x_0 \in \mathbb{R}$ such that $l(x) = \sum_{k=0}^{4} (\sin|x - k| + \cos|x - k + \frac{1}{2}|)$, $x \in \mathbb{R}$, is NOT differentiable at x_0, is	**(4)**	6
		(5)	10

(A) (P) $\to$ (1) (Q) $\to$ (3) (R) $\to$ (2) (S) $\to$ (5)
(B) (P) $\to$ (2) (Q) $\to$ (1) (R) $\to$ (4) (S) $\to$ (3)
(C) (P) $\to$ (5) (Q) $\to$ (1) (R) $\to$ (4) (S) $\to$ (3)
(D) (P) $\to$ (2) (Q) $\to$ (3) (R) $\to$ (1) (S) $\to$ (5)

16. Let $\vec{W} = \hat{i} + j - 2k$, and $\vec{u}$ and $\vec{v}$ be two vector, such that $\vec{u} \times \vec{v} = \vec{w}$ and $\vec{v} \times \vec{w} = \vec{u}$. Let α, β, γ, and t be real numbers such that $\vec{u} = \alpha\hat{i} + \beta j + \gamma k, \; -t\alpha + \beta + \gamma = 0, \; \alpha - t\beta + \gamma = 0$, and $\alpha + \beta - t\gamma = 0$.

Match each entry in **List-I** to the correct entry in **List-II** and choose the correct option.

	List – I		List - II
(P)	$\|\vec{v}\|^2$ is equal to	**(1)**	0
(Q)	If $\alpha = \sqrt{3}$, then γ^2 is equal to	**(2)**	1
(R)	If $\alpha = \sqrt{3}$, then $(\beta + \gamma)^2$ is equal to	**(3)**	2
(S)	If $\alpha = \sqrt{2}$, then $t + 3$ is equal to	**(4)**	3
		(5)	5

(A)   (P) $\rightarrow$ (2) (Q) $\rightarrow$ (1) (R) $\rightarrow$ (4) (S) $\rightarrow$ (5)
(B)   (P) $\rightarrow$ (2) (Q) $\rightarrow$ (4) (R) $\rightarrow$ (3) (S) $\rightarrow$ (5)
(C)   (P) $\rightarrow$ (2) (Q) $\rightarrow$ (1) (R) $\rightarrow$ (4) (S) $\rightarrow$ (3)
(D)   (P) $\rightarrow$ (5) (Q) $\rightarrow$ (4) (R) $\rightarrow$ (1) (S) $\rightarrow$ (3)