VMC Vidyamandir Classes SINCE 1986
IIT JEE | MEDICAL | FOUNDATION

CODE A

JEE Advanced Home Practice Test -5 | Paper -2 | JEE 2024

Date: 3/05/2024 **Maximum Marks: 180**

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 **four** sections (Section 1, Section 2, Section 3, Section 4).

2. **Section 1** contains **SIX (06) 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 **THREE (03) Paragraphs.** There are **TWO (02)** questions corresponding to each Paragraph. The answer to each question is a **NUMERICAL VALUE**. For each question, enter the correct numerical value of the answer. If the answer is a decimal numerical value, then round-off the value to TWO decimal places. If the answer is an Integer value, then do not add zero in the decimal places. *In the OMR, do not bubble the ⊕ sign for positive values. However, for negative values, ⊖ sign should be bubbled*. (Example: 6, 81, 1.50, 3.25, 0.08)

Section 3 contains **TWO (02) paragraphs**. Based on each paragraph, there are **TWO (02)** questions. Each question has **FOUR** options (A), (B), (C) and (D). **ONLY ONE** of these four options is the correct answer.

Section 4 contains **THREE (03)** Questions. The answer to each question is a **NON-NEGATIVE INTEGER**. For each question, enter the correct integer corresponding to the answer.

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** _____

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 **THREE (03)** Paragraphs. There are **TWO (02)** questions corresponding to each Paragraph. The answer to each question is a **NUMERICAL VALUE**. For each question, enter the correct numerical value of the answer. If the answer is a decimal numerical value, then round-off the value to TWO decimal places. If the answer is an Integer value, then do not add zero in the decimal places. *In the OMR, do not bubble the ⊕ sign for positive values. However, for negative values, Θ sign should be bubbled*. (Example: 6, 81, 1.50, 3.25, 0.08)
- Answer to each question will be evaluated according to the following marking scheme:

Full Marks: +2 If **ONLY** the correct numerical value is entered at the designated place.

Zero Marks: 0 In all other cases.

SECTION – 3 | (Maximum Marks: 12)

- This section contains **TWO (02) paragraphs**. Based on each paragraph, there are **TWO (02)** 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 - 4 | (Maximum Marks: 12)

- This section contains **THREE (03)** Questions. The answer to each question is a NON-NEGATIVE INTEGER. For each question, enter the correct integer corresponding to the answer.
- Answer to each question will be evaluated according to the following marking scheme:

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

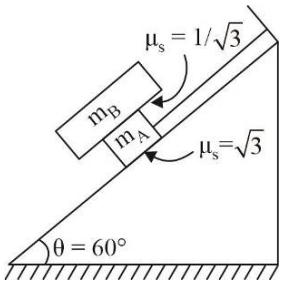
Zero Marks: 0 In all other cases.

SUBJECT I : PHYSICS 60 MARKS

SECTION 1

This section consists of 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. The system is released from rest. Choose the correct options:



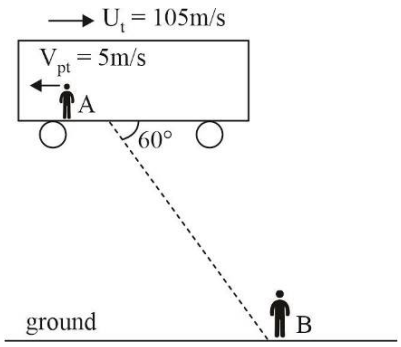
(A) Tension in string is zero

(B) Friction between block A and inclined plane is equal to $(m_A + m_B)g\sin 60°$

(C) Friction between block A and block B is $m_B g \sin 60°$

(D) Block 'B' will be in motion

2. A person A is moving with a velocity of 5m/s with respect to train in opposite direction of train. He produces sound with a frequency f_0. There is a person on ground. At a moment the line connecting person A and B makes an angle 60° from train's motion as shown. Ignore trains noise. Speed of sound is 350m/s. Distance between train and person B is small. Choose the correct statements.



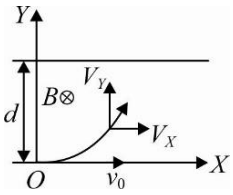
(A) The frequency of sound heard by a person 'C' who is standing in train just behind person 'A' is $\left(\frac{70}{71}f_0\right)$

(B) The frequency of sound heard by a person 'C' who is standing in train just behind person 'A' is $\left(\frac{50}{51}f_0\right)$

(C) The frequency of sound heard by the person 'B' at the moment described in question is, $\frac{7}{6}f_0$

(D) The frequency of sound heard by the person 'B' at the moment described in question is $\frac{5}{4}f_0$

3. A non-uniform magnetic field $\vec{B} = B_0\left(1+\frac{y}{d}\right)(-\hat{k})$ is present in region of space in between $y = 0$ and $y = d$. A particle of mass *m* and positive charge *q* has velocity $\vec{v} = v_0\hat{i}$ at the origin *O*. The *x*-component of velocity of the particle is $v_x = v_0 - \frac{kqB_0d}{2m}$ when it leaves the field, then which of the following options are correct?



(A) Value of *k* is 3

(B) Value of *k* is 2

(C) Work done by magnetic field on the charge is non-zero

(D) Radius of curvature of trajectory of charge just before it comes out of magnetic field is $\frac{mV_0}{2qB_0}$

4. A physical quantity $\bar{X}$ is defined as $\bar{X} = \varepsilon_0 A \frac{d\bar{E}}{dt}$ where $\bar{E}$ is electric field, A is area and ε_0 is permittivity of free space. The dimensions of $\bar{X}$ are same as the dimensions of the following quantity (ies)?

(A) $\frac{\text{Electric potential} \times \text{time}}{\text{self inductance}}$ **(B)** $\frac{\text{Electric flux}}{\text{volume}}$

(C) $\frac{\text{Energy}}{\text{volume}}$ **(D)** $\frac{\text{Torque}}{\text{magnetic field} \times \text{Area}}$

5. A nucleus X undergoes β^- decay as shown $X \rightarrow Y^* + e^- + \bar{\nu}$, where Y is in an excited state Y can de-excite through gamma decay or it can return to its ground state by losing its energy to an atomic electron through a process called internal conversion.

Given : M_x & M_y are masses of X and Y

E_y is the excitation energy of Y^*

M_e is the mass of e^-

c is speed of light

Which of the following options is/are correct?

(A) The maximum kinetic energy of β^- particle emitted can be $(M_x - M_y - M_e)c^2 - E_y$

(B) Any photon emitted in gamma decay of Y^* cannot have wavelength less than $\frac{hc}{E_y}$

(C) Photon emitted in gamma decay will always have wavelength equal to $\frac{hc}{E_y}$

(D) The atomic e^- emitted through the internal conversion process will have KE equal to E_y

6. A circular loop of radius R is placed in the x-y plane with its centre at origin. It is carrying current *i*. Which of the following options is/are correct?

(A) Magnetic field at any point in the *x-y* plane only depends upon the radial distance of the point from the centre

(B) There will be points outside the loop in the *x-y* plane having the same magnitude of $\bar{B}$ as that at origin

(C) Magnitude of magnetic field increases as we move from center of loop to its circumference

(D) There are points inside the loop in the *x-y* plane where magnetic field strength is zero

SECTION-2

This Section contains **THREE (03) Paragraphs.** There are **TWO (02)** questions corresponding to each Paragraph. The answer to each question is a **NUMERICAL VALUE**. For each question, enter the correct numerical value of the answer. If the answer is a decimal numerical value, then round-off the value to TWO decimal places. If the answer is an Integer value, then do not add zero in the decimal places. *In the OMR, do not bubble the ⊕ sign for positive values. However, for negative values, Θ sign should be bubbled.* (Example: 6, 81, 1.50, 3.25, 0.08)

PARAGRAPH FOR Q-7 & 8

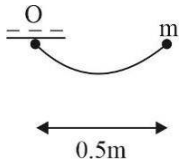
A solid aluminium sphere and a solid lead sphere of same radius are heated to the same temperature and allowed to cool under identical surrounding temperatures. The specific heat capacity of aluminium = 900 J/kg°C and that of lead = 130 J/kg °C. The density of aluminium $= 10^4\, kg/m^3$ and that of lead $= 2.7\times10^3\, kg/m^3$. Assume that the emissivity of both the spheres is the same.

7. The ratio of rate of heat loss from the aluminium sphere to the rate of heat loss from the lead sphere is x : 1. The value of x is _____.

8. The ratio of rate of fall of temperature of the aluminum sphere to the rate of fall of temperature of the lead sphere is Y : 1000. The value of Y is _____.

PARAGRAPH FOR Q-9 & 10

A pendulum bob of mass $m = 2kg$ and a massless inextensible string of length $l = 1.0m$ is held as shown in the figures, at the same height as the point of suspension and 0.5m away from it. Now the bob is released and allowed to fall under gravity. (Take $\sqrt{3} = 1.73$).

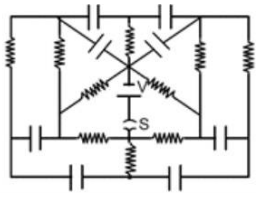


9. Angular momentum of the bob about the point of suspension just before string becomes taut is _____ $kg\,m^2/s$.

10. Kinetic energy of bob just after string becomes taut is _____ joules.

PARAGRAPH FOR Q-11 & 12

A system of capacitors and resistors are connected to an ideal battery of emf V as shown in figure. Initially all the capacitors are uncharged and switch is open. Now switch S is closed at t = 0. (Capacitance of each capacitor is 'C' and resistance of each resistor is R and all of the symbols have their usual meaning)



11. Current through battery just after switch is closed, is $n\frac{V}{R}$, where n is_____.

12. Current through battery after long time of closing switch is, $m\frac{V}{R}$, where m is_____.

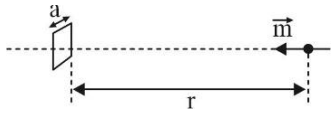
SECTION-3

This section consists of TWO (02) paragraphs. Based on each paragraph, there are **TWO (02)** questions. Each question has **FOUR** options (A), (B), (C) and (D). **ONLY ONE** of these four options is the correct answer.

PARAGRAPH FOR Q-13 & 14

A special metal *S* conducts electricity without any resistance. A closed square loop, made of *S*, does not allow any change in flux through itself by inducing a suitable current to generate a compensating flux. The induced current in the loop cannot decay due to its zero resistance. This current gives rise to a magnetic moment which in turn repels the source of magnetic field or flux. Consider such a loop, of side a, with its centre at the origin. A magnetic dipole of moment *m* is brought along the axis of this loop from infinity to a point at distance $r(>> a)$ from the center of the loop with its north pole always facing the loop, as shown in the figure below.

The magnitude of magnetic field of a dipole *m*, at a point on its axis at distance *r*, is $\frac{\mu_0}{2\pi}\frac{m}{r^3}$, where μ_0 is the permeability of free space. The magnitude of the force between two magnetic dipoles with moments, $m_1 \& m_2$, separated by a distance *r* on the common axis, with their north poles facing each other, is $\frac{km_1m_2}{r^4}$, where *k* is a constant of appropriate dimensions. The direction of this force is along the line joining the two dipoles.



13. When the dipole *m* is placed at a distance *r* from the centre of the loop (as shown in the figure), then the induced current produces dipole moment M in the loop. The value of *M* will be proportional to :

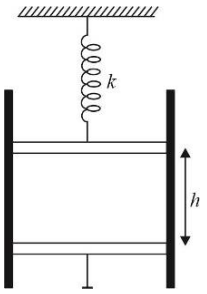
(A) m^2 / r^3 **(B)** m / r^3 **(C)** m / r^2 **(D)** m^2 / r^2

14. The magnitude of repulsive force between dipoles *m* and *M* will be proportional to :

(A) m / r^5 **(B)** m^2 / r^5 **(C)** m^2 / r^6 **(D)** m^2 / r^7

PARAGRAPH FOR Q-15 & 16

An ideal gas at NTP is enclosed in an adiabatic vertical cylinder having an area of cross section $A = 27 cm^2$ between two light movable adiabatic pistons as shown in figure. Spring with force constant *k* = 3700 N/m is in a relaxed state initially. Now the lower piston is moved upwards a distance *h*/2, *h* being the initial length of gas column. It is observed that the upper piston moves up by a distance *h*/16. Final temperature of gas $= 4/3 \times 273 K$.



15. Which of the following statement is correct?

(A) Work done in compression is used to do work against elastic force only

(B) Work done in compression is used to do work against elastic force and atmospheric force

(C) No work is done during compression

(D) There is no change in internal energy

16. The value of *h* is :

(A) 1 m **(B)** 1.4 m **(C)** 1.6 m **(D)** 2 m

SECTION - 4

This section contains **THREE (03)** Questions. The answer to each question is a **NON-NEGATIVE INTEGER**. For each question, enter the correct integer corresponding to the answer.

17. A block of mass m is kept on a horizontal ruler. The friction coefficient between the ruler and the block is μ. The ruler is fixed at one end and the block is at a distance L from the fixed end. The ruler is rotated about the fixed end in the horizontal plane through the fixed end.
If the angular speed of the ruler is uniformly increased from zero at an angular acceleration α, the block slips at angular speed $\left[\left(\frac{\mu g}{L}\right)^2 - \left(\frac{k\alpha}{2}\right)^2\right]^{1/4}$. The value of k is _____.

18. A particle of mass m is subjected to an attractive central force of magnitude k / r^2, k being a constant. If at the instant when the particle is at an extreme position in its closed orbit, at a distance a from the centre of force, its speed is $\sqrt{(k / 2ma)}$, if the distance of other extreme position is 'b'. Find a / b.

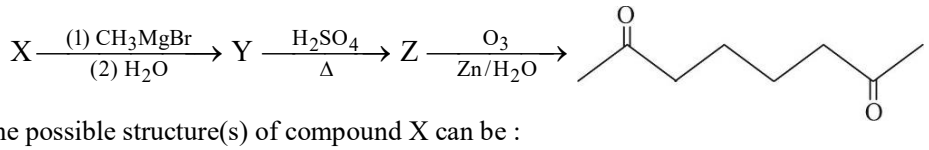
19. A metal plate is placed 5 m from a monochromatic light source whose power output is $10^{-3}W$. Consider that a given ejected photoelectron may collect its energy from a circular area of the plate as large as ten atomic diameters $(10^{-9}m)$ in radius. The energy required to remove an electron through the metal surface is about 5.0 eV. Assuming light to be a wave, how long would it take for such a 'target' to soak up this much energy from such a light source. Give answer in hours. (Round off to nearest integer).

SUBJECT I : CHEMISTRY 60 MARKS

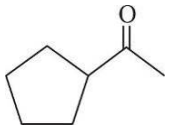
SECTION 1

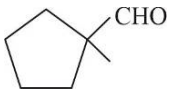
This section consists of 6 Multiple Correct Answers Type Questions. Each question has 4 choices (A), (B), (C) and (D), out of which **ONE OR MORE THAN ONE CHOICE** is correct.

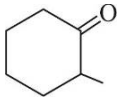
1. Consider the following sequence of reaction.

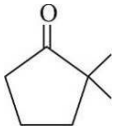


The possible structure(s) of compound X can be :

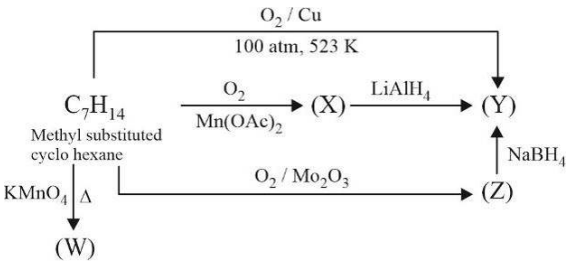
(A) 

(B) 

(C) 

(D) 

2.



The correct statement(s) is/are :

(A) Y & W are constitutional isomers

(B) Y & W are configurational isomers

(C) Z is an aldehyde

(D) X is a carboxylic acid

3. Consider the kinetic data given in the following table for the reaction X + Y + Z → Product

Experiment No.	[X] (mol dm^{-3})	[Y] (mol dm^{-3})	[Z] (mol dm^{-3})	Rate of reaction $(\text{mol dm}^{-3}\,\text{s}^{-1})$
1	0.04	0.01	0.04	1.60×10^{-7}
2	0.16	0.01	0.04	3.20×10^{-7}
3	0.04	0.02	0.04	3.20×10^{-7}
4	0.16	0.01	0.16	2.56×10^{-6}

The rate expression is $r = k[X]^a[Y]^b[Z]^c$,

The rate of reaction for [X] = 0.25M, [Y] = 0.02M & [Z] = 0.09M is $R\times10^{-7}\,\text{M s}^{-1}$. Then the correct statement(s) is/are :

(A) Overall order of reaction is 2.5

(B) Order of reaction with respect to Y is 1

(C) The value of a = 1.5, b = 1, c = 0

(D) The value of $\sqrt[3]{R} = 3$

4. The standard redox potentials E° of the following systems are

	System	E° (volts)
(i)	$MnO_4^- + 8H^+ + 5e^- \longrightarrow Mn^{2+} + 4H_2O$	1.51
(ii)	$Sn^{2+} \longrightarrow Sn^{4+} + 2e^-$	-0.15
(iii)	$Cr_2O_7^{2-} + 14H^+ + 6e^- \longrightarrow 2Cr^{3+} + 7H_2O$	1.33
(iv)	$Ce^{3+} \longrightarrow Ce^{4+} + e^-$	-1.61

The oxidising power of the various species are related as :

(A) $Cr_2O_7^{2-} > MnO_4^-$ **(B)** $Ce^{4+} > Sn^{4+}$

(C) $Ce^{4+} > MnO_4^-$ **(D)** $MnO_4^- > Sn^{4+}$

5. Which of the following statements regarding the pair of complexes is/are incorrect?

(A) Both $K_2[PdCl_4]$ and $K_2[Pt(ox)_3]$ are optically inactive

(B) Both $K_2[PdCl_4]$ and $K_2[Pt(ox)_3]$ do not form diastereomers

(C) $K_2[Ni(CN)_4]$ and $Co[Hg(SCN)_4]$ have same hybridization of central atom

(D) $K_2[Ni(CN)_4]$ and $Co[Hg(SCN)_4]$ both can show same type of structural isomerism and are diamagnetic

6. Which of the following statements is(are) correct?

(A) Presence of HCl do not give satisfactory results in permanganate titrations

(B) MnO_4^{2-} disproportionates to yield MnO_4^- and MnO_2 in presence of H^+ ions.

(C) In $Cr_2O_7^{2-}$ each Cr is linked to four oxygen atoms

(D) Ti^{2+} is coloured while Ti^{4+} is colourless in aqueous solution

SECTION-2

This Section contains **THREE (03) Paragraphs.** There are **TWO (02)** questions corresponding to each Paragraph. The answer to each question is a **NUMERICAL VALUE**. For each question, enter the correct numerical value of the answer. If the answer is a decimal numerical value, then round-off the value to TWO decimal places. If the answer is an Integer value, then do not add zero in the decimal places. *In the OMR, do not bubble the ⊕ sign for positive values. However, for negative values, ⊖ sign should be bubbled.* (Example: 6, 81, 1.50, 3.25, 0.08)

PARAGRAPH FOR Q-7 & 8

The molar conductance of NaCl varies with the concentration as shown in the following table and all values follows the equation.

$$\lambda_m^c = \lambda_m^\infty - b\sqrt{C}$$

Where λ_m^c : Molar specific conductance

λ_m^∞ : Molar specific conductance at infinite dilution

C : Molar concentration

Molar concentration of NaCl	Molar conductance in $ohm^{-1}cm^2\,mole^{-1}$
4×10^{-4}	107
9×10^{-4}	97
16×10^{-4}	87

When a certain conductivity cell (C) was filled with 25×10^{-4} M NaCl solution, the resistance of the cell was found to be 1000 ohm. At infinite dilution, conductance of Cl^- & SO_4^{2-} are 80 $ohm^{-1}cm^2mole^{-1}$ & 160 $ohm^{-1}cm^2\,mole^{-1}$ respectively.

7. What is the cell constant (in cm^{-1}) of the conductivity cell (C)? (Round off to second decimal place)

8. If the cell (C) is filled with 5×10^{-3} N Na_2SO_4, the observed resistance was 400 ohm. What is the molar conductance (in $ohm^{-1}cm^2\,mole^{-1}$) of Na_2SO_4?

PARAGRAPH FOR Q-9 & 10

The CO in a 20 L sample of gas was converted to CO_2 by passing the gas over iodine pentoxide heated to 150°C.

$$I_2O_5(s) + 5CO(g) \rightarrow 5CO_2(g) + I_2(g)$$

The iodine distilled at this temperature and was collected in an absorber containing 10 mL of 0.011 M $Na_2S_2O_3$. The excess hypo was back-titrated with 5 mL of 0.001 M I_2 solution. (Atomic mass of I = 127)

9. What must be the milligrams of CO in the original gas sample?

10. What is the weight (in mg) of iodine produced due to the reaction with $I_2O_5(s)$ when it reacted with CO(g) in 10 L sample of gas?

PARAGRAPH FOR Q-11 & 12

Titration is process of chemical analysis in which the quantity of some constituent of a sample is determined by addition to the measured sample an exactly known quantity of another substance with which the desired constituent reacts in a definite, known proportion. The process is usually carried out by gradually adding a standard solution (i.e., a solution of known concentration) of titrating reagent, or titrant, from a burette, essentially a long, graduated measuring tube with a stopcock. Titration is also used to calculate percentage purity of sample. Some examples of redox titration are given below :

(1) $HCN + I_3^-(aq) \rightarrow ICN(aq) + 2I^-(aq) + H^+(aq)$

(2) $H_3AsO_3(aq) + I_3^-(aq) \rightarrow AsO_4^{3-}(aq) + 3I^-(aq)$

11. In the presence of chloride ion Mn^{2+} can be titrated with MnO_4^-, both reactants being converted to a complex of Mn(III). A 0.458 g sample containing Mn_3O_4 was dissolved and all manganese was converted to Mn^{2+}. Titration in presence of chloride ion consumed 25 ml of $KMnO_4$ that was 0.15 N against oxalate. Calculate the percentage of Mn_3O_4 in the sample. (Atomic mass of Mn = 55)

12. To determine the concentration of HCN in blood of a patient a doctor decided to titrate a dilute sample of the blood with I_3^-. A diluted blood sample of 15 ml was titrated with 5.21 ml of an I_3^- solution. 10.42 ml of this I_3^- needed 1.32 gm sample of As_4O_6 for complete reaction.

Calculate the molar concentration of HCN in blood? (round off the answer to two decimal place)

Atomic weight of $As = 75, I = 127$

It is also given As_4O_6 converts into H_3AsO_3 in solution

SECTION-3

This section consists of TWO (02) paragraphs. Based on each paragraph, there are **TWO (02)** questions. Each question has **FOUR** options (A), (B), (C) and (D). **ONLY ONE** of these four options is the correct answer.

PARAGRAPH FOR Q-13 & 14

Hydrolysis of cumene hydroperoxide is an important reaction in organic chemistry. This reaction involves migration of phenyl group to electron-deficient oxygen.

Another reaction which involves group migration is the Schmidt reaction in which isocyanate intermediate formed.

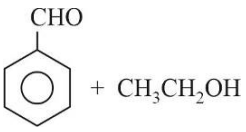
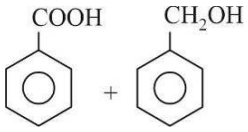
$$RCOOH \xrightarrow[(ii)\ NaN_3]{(i)\ PCl_5} R-\underset{\underset{O}{\|}}{C}-N_3 \xrightarrow{\Delta} R-N=C=O\ (\text{isocyanate}) \xrightarrow{EtOH} RNHCOOC_2H_5$$

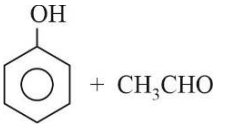
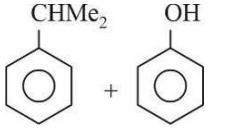
Now consider the following scheme of reaction and answer the following questions

$$+ CH_3CH=CH_2 \xrightarrow{H^+} X \xrightarrow{H^+/K_2Cr_2O_7} Y \xrightarrow[(ii)\ NaN_3]{(i)\ PCl_5} Z \xrightarrow{\Delta} W \xrightarrow{C_3H_7OH} P$$

$$X \xrightarrow[(ii)\ H_3O^+]{(i)\ O_2} X_1 + (CH_3)_2C=O$$

13. What are X and X_1 :

(A)  **(B)** 

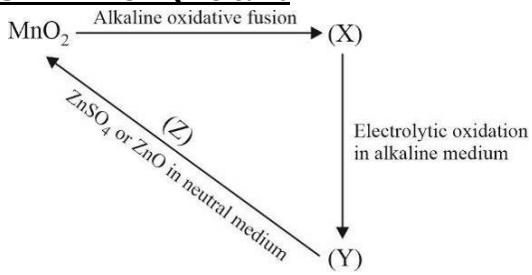
(C)  **(D)** 

14. The product P should be :

(A) $C_6H_5NH_2$ **(B)** $C_6H_5NHC(=O)-NH_2$

(C) $C_6H_5NH-C(=O)-NHC_2H$ **(D)** $C_6H_5NHCOOC_3H_7$

PARAGRAPH FOR Q-15 & 16



15. What is (Z) ?

(A) It is a salt of Fe^{3+} **(B)** It is a salt of Sn^{4+}

(C) It is a salt of Mn^{2+} **(D)** It is a salt of Cr^{6+}

16. Which of the following products are formed when potassium bromide reacts with (Y) in alkaline pH?

(A) BrO_3^-, MnO_2 **(B)** BrO_4^-, Mn^{2+} **(C)** Br_2, MnO_2 **(D)** BrO^-, MnO_4^{2-}

SECTION - 4

This section contains **THREE (03)** Questions. The answer to each question is a NON-NEGATIVE INTEGER. For each question, enter the correct integer corresponding to the answer.

17. 0.5 moles of SO_2 gas at 27°C is expanded in reversible adiabatic condition to make volume 8 times. The final temperature (in K) and modulus of work done by gas (in Cal) respectively are x and y. Therefore the value of $\frac{y}{x}$ is _____. (Take ideal behaviour of gas, R = 2 Cal/K mol)

18. Consider a Lithium (Li) atom that absorbs a photon of wavelength (990/7) nm. The change in the velocity (in cms^{-1}) of Li atom after the photon absorption is _____. (Nearest integer)
(Assume : Momentum is conserved when photon is absorbed.
Use : Planck constant $= 6.6\times10^{-34}$ J s, Avogadro number $= 6\times10^{23}\ mol^{-1}$, Molar mass of Li = 7 g mol^{-1})

19. Ostwald's process is carried out through the following sequence of reactions for the industrial preparation of the compound 'D' as shown below :

1. $A(g) + O_2(g) \xrightarrow[227°C,\ 9\,bar]{Pt/Rh\ gauge\ catalyst} B(g) + H_2O(g)$

2. $B(g) + O_2(g) \rightleftharpoons C(g)$

3. $C(g) + H_2O(\ell) \longrightarrow D(aq) + B(g)$

The number of lone pairs on central atom of A is x, number of unpaired electrons in B is y & oxidation state on the central atom of C is z, then find the value of $x + y + z$.

SUBJECT I : MATHEMATICS 60 MARKS

SECTION 1

This section consists of 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. Which of the following statements are correct

(A) Number of words that can be formed with only 6 letters of the word "CENTRIFUGAL" if each word must contain all the vowels is $3 \cdot 7!$

(B) There are 15 balls of which some are white and the rest black. If the number of ways in which the balls can be arranged in a row, is maximum then the number of white balls must be equal to 7 or 8. Assume balls of the same colour to be alike.

(C) There are 12 things, 4 alike of one kind, 5 alike and of another kind and the rest are all different. The total number of ways to select 1 or more is 240.

(D) Number of selections that can be made of 6 letters from the word "COMMITTEE" is 35.

2. In a ΔABC, a semicircle is inscribed, whose diameter lies on the side c. If x is the length of the angle bisector through angle C then the radius of the semicircle is (If Δ is the area of triangle ΔABC and s is semi-perimeter)

(A) $\dfrac{abc}{4R^2(\sin A+\sin B)}$ **(B)** $\dfrac{\Delta}{x}$

(C) $x\sin\dfrac{C}{2}$ **(D)** $\dfrac{2\sqrt{s(s-a)(s-b)(s-c)}}{s}$

3. Let T be the triangle with vertices $(0,0), (0,c^2)$ & (c,c^2) and let R be the region between $y=cx$ & $y=x^2$ where $c>0$ then

(A) Area $(R)=\dfrac{c^3}{6}$ **(B)** Area of $(R)=\dfrac{c^3}{3}$

(C) $\lim\limits_{c\to 0^+}\dfrac{Area(T)}{Area(R)}=3$ **(D)** $\lim\limits_{c\to 0^+}\dfrac{Area(T)}{Area(R)}=\dfrac{3}{2}$

4. Let $\dfrac{dy}{dx}+y=f(x)$, where y is a continuous function of x with $y(0)=1$ and $f(x)=\begin{cases}e^{-x}, \text{ if } 0\le x\le 2\\ e^{-2}, \text{ if } x>2\end{cases}$. Which of the following hold(s) good?

(A) $y(1)=2e^{-1}$ **(B)** $y'(1)=-e^{-1}$

(C) $y(3)=-2e^{-3}$ **(D)** $y'(3)=-2e^{-3}$

5. If $A(\bar{a})$; $B(\bar{b})$; $C(\bar{c})$ & $D(\bar{d})$ are four points such that

$\bar{a} = -2\hat{i} + 4\hat{j} + 3\hat{k}$; $\bar{b} = 2\hat{i} - 8\hat{j}$; $\bar{c} = \hat{i} - 3\hat{j} + 5\hat{k}$; $\bar{d} = 4\hat{i} + \hat{j} - 7\hat{k}$

d is the shortest distance between the lines AB and CD, then which of the following is True?

(A) $d = 0$, hence AB and CD intersect **(B)** $d = \dfrac{\left[\overrightarrow{AB}\ \overrightarrow{CD}\ \overrightarrow{BD}\right]}{\left|\overrightarrow{AB} \times \overrightarrow{CD}\right|}$

(C) AB and CD are skew lines and $d = \dfrac{23}{13}$ **(D)** $d = \dfrac{\left[\overrightarrow{AB}\ \overrightarrow{CD}\ \overrightarrow{AC}\right]}{\left|\overrightarrow{AB} \times \overrightarrow{CD}\right|}$

6. TP and TQ are tangents to parabola $y^2 = 4x$ and normal at P and Q intersect at a point R on the curve. The locus of the centre of the circle circumscribing ΔTPQ is a parabola whose

(A) Vertex is (1, 0)

(B) Foot of perpendicular from focus to directrix is $\left(\dfrac{7}{8}, 0\right)$

(C) Length of latus-rectum is $\dfrac{1}{4}$

(D) Focus is $\left(\dfrac{9}{8}, 0\right)$

SECTION-2

This Section contains **THREE (03) Paragraphs.** There are **TWO (02)** questions corresponding to each Paragraph. The answer to each question is a **NUMERICAL VALUE**. For each question, enter the correct numerical value of the answer. If the answer is a decimal numerical value, then round-off the value to TWO decimal places. If the answer is an Integer value, then do not add zero in the decimal places. *In the OMR, do not bubble the ⊕ sign for positive values. However, for negative values, ⊖ sign should be bubbled*. (Example: 6, 81, 1.50, 3.25, 0.08)

PARAGRAPH FOR Q-7 & 8

The line $3x + 6y = k$ intersects the curve $2x^2 + 2xy + 3y^2 = 1$ at points A and B. The circle on AB as diameter passes through the origin.

7. The sum of possible values of k is _____.

8. If k_1 & k_2 are the possible values of k, then $(k_1 k_2)^2$ is _____.

PARAGRAPH FOR Q-9 & 10

Consider the cubic $f(x) = 8x^3 + 4ax^2 + 2bx + a$ where $a, b \in R$.

9. For $b = 1$, if $y = f(x)$ is non monotonic then the sum of all the integral values of $a \in [1,100]$, is _____.

10. If x_1, x_2 & x_3 are the roots of $f(x)$ & $\log_2 x_1 + \log_2 x_2 + \log_2 x_3 = 5$, then the value of '$-a$' is _____.

PARAGRAPH FOR Q-11 & 12

Consider two curves $y = f(x)$ passing through (0,1) and the curve $g(x) = \int_{-\infty}^{x} f(t)\,dt$ passing through (0, 1/2). The tangents drawn to both curves at the point with equal abscissas intersect on the x-axis.

11. $\lim_{x\to 0} \dfrac{f^2(x)-1}{x}$ equals _____.

12. The area bounded by the x-axis, the tangent and normal to the curve $y = f(x)$ at the point where it cuts the y-axis, is $\dfrac{a}{b}$ (HCF of a, b is 1), then $a+b$ is _____.

SECTION-3

This section consists of TWO (02) paragraphs. Based on each paragraph, there are **TWO (02)** questions. Each question has **FOUR** options (A), (B), (C) and (D). **ONLY ONE** of these four options is the correct answer.

PARAGRAPH FOR Q-13 & 14

Let $f(x) = \begin{cases} e^{\{x^2\}} - 1, & x > 0 \\ \dfrac{\sin x - \tan x + \cos x - 1}{2x^2 + \ln(2+x) + \tan x}, & x < 0 \\ 0, & x = 0 \end{cases}$ where { } represents fractional part function. Suppose lines L_1 & L_2 represent tangent and normal to curve $y = f(x)$ at $x = 0$. Consider the family of circles touching both the lines L_1 & L_2.

13. Ratio of radii of two circles belonging to this family cutting each other orthogonally is :

(A) $2+\sqrt{3}$ **(B)** $\sqrt{3}$ **(C)** $2+\sqrt{2}$ **(D)** $2-\sqrt{2}$

14. A circle having radius unity is inscribed in the triangle formed by L_1 & L_2 and a tangent to it. Then the minimum area of the triangle possible is :

(A) $3+\sqrt{2}$ **(B)** $2+\sqrt{3}$ **(C)** $3+2\sqrt{2}$ **(D)** $3-2\sqrt{2}$

PARAGRAPH FOR Q-15 & 16

Let $a_m (m = 1, 2, ..., p)$ be the possible integral values of a for which the graphs of $f(x) = ax^2 + 2bx + b$ and $g(x) = 5x^2 - 3bx - a$ meets at some point for all real values of b. Let $t_r = \prod_{m=1}^{p} (r - a_m)$ & $S_n = \sum_{r=1}^{n} t_r,\ n \in N.$

15. The sum of values of n for which S_n vanishes is :

(A) 8 **(B)** 9 **(C)** 10 **(D)** 15

16. The value of $\sum_{r=5}^{\infty} \dfrac{1}{t_r}$ is equal to :

(A) $\dfrac{1}{3}$ **(B)** $\dfrac{1}{6}$ **(C)** $\dfrac{1}{15}$ **(D)** $\dfrac{1}{18}$

SECTION - 4

This section contains **THREE (03)** Questions. The answer to each question is a NON-NEGATIVE INTEGER. For each question, enter the correct integer corresponding to the answer.

17. Nine tiles are numbered 1,2,3,4,5,6,7,8,9 respectively. Each of the three players A, B and C randomly selects 3 tiles (without replacement) and they sum up those three values as marked on the tiles. The probability that all three players obtain an odd sum is $\frac{m}{n}$, where m and n are relatively prime positive integers, then the value of $(m+n)$ is _____.

18. If three distinct chords of the ellipse $\frac{x^2}{2a^2}+\frac{y^2}{a^2}=1$ (other than its diameter) passing through the point $P\left(11a,-\frac{a^2}{4}\right)$ are bisected by the parabola $y^2=4ax,$ then the number of integral values of parameter 'a' is _____.

19. The value of $\lim\limits_{n\to\infty}\sum\limits_{r=1}^{r=4n}\frac{\sqrt{n}}{\sqrt{r}\left(3\sqrt{r}+4\sqrt{n}\right)^2}$ is $\frac{m}{n}$, where m and n are relatively prime positive integers, then the value of $(m+n)$ is _____.