

English	(1001CJA106216240181)		Test Pattern	
	 <b>ALLEN</b> CAREER INSTITUTE KOTA (RAJASTHAN)		<b>CLASSROOM CONTACT PROGRAMME</b>	JEE(Advanced)
			(Academic Session : 2024 - 2025)	<b>FULL SYLLABUS</b>

## JEE(Main + Advanced) : ENTHUSIAST COURSE ALL STAR BATCH (SCORE-II)

Time : 3 Hours

### PAPER (OPTIONAL)

Maximum Marks : 180

**IMPORTANT NOTE :** Students having 8 digits **Form No.** must fill two zero before their Form No. in OMR. For example, if your **Form No.** is 12345678, then you have to fill **0012345678**.

### READ THE INSTRUCTIONS CAREFULLY



#### GENERAL :

1. This sealed booklet is your Question Paper. Do not break the seal till you are told to do so.
2. Use the Optical Response Sheet (ORS) provided separately for answering the questions.
3. Blank spaces are provided within this booklet for rough work.
4. Write your name, form number and sign in the space provided on the back cover of this booklet.
5. After breaking the seal of the booklet, verify that the booklet contains **28** pages and that all the **19** questions in each subject and along with the options are legible. If not, contact the invigilator for replacement of the booklet.
6. You are allowed to take away the Question Paper at the end of the examination.

#### OPTICAL RESPONSE SHEET :

7. The ORS will be collected by the invigilator at the end of the examination.
8. Do not tamper with or mutilate the ORS. **Do not use the ORS for rough work.**
9. Write your name, form number and sign with pen in the space provided for this purpose on the ORS. **Do not write any of these details anywhere else on the ORS.** Darken the appropriate bubble under each digit of your form number.

#### DARKENING THE BUBBLES ON THE ORS :

10. Use a **BLACK BALL POINT PEN** to darken the bubbles on the ORS.
11. Darken the bubble  **COMPLETELY.**
12. The correct way of darkening a bubble is as : 
13. The ORS is machine-gradable. Ensure that the bubbles are darkened in the correct way.
14. Darken the bubbles **ONLY IF** you are sure of the answer. There is **NO WAY** to erase or "un-darken" a darkened bubble.
15. Take  **$g = 10 \text{ m/s}^2$**  unless otherwise stated.

#### QUESTION PAPER FORMAT :

16. The question paper has three parts : Physics, Chemistry and Mathematics.

Please see the last page of this booklet for rest of the instructions

DO NOT BREAK THE SEALS WITHOUT BEING INSTRUCTED TO DO SO BY THE INVIGILATOR

**For More Material Join: @JEEAdvanced\_2025**

## SOME USEFUL CONSTANTS

**Atomic No. :** H = 1, B = 5, C = 6, N = 7, O = 8, F = 9, Al = 13, P = 15, S = 16, Cl = 17, Br = 35, Xe = 54, Ce = 58

**Atomic masses :** H = 1, Li = 7, B = 11, C = 12, N = 14, O = 16, F = 19, Na = 23, Mg = 24, Al = 27, P = 31, S = 32, Cl = 35.5, Ca = 40, Fe = 56, Br = 80, I = 127, Xe = 131, Ba = 137, Ce = 140

- |                                    |  |
|------------------------------------|--|
| • Boltzmann constant               | $k = 1.38 \times 10^{-23} \text{ JK}^{-1}$                   |
| • Coulomb's law constant           | $\frac{1}{4\pi\epsilon_0} = 9 \times 10^9$                   |
| • Universal gravitational constant | $G = 6.67259 \times 10^{-11} \text{ N-m}^2 \text{ kg}^{-2}$  |
| • Speed of light in vacuum         | $c = 3 \times 10^8 \text{ ms}^{-1}$                          |
| • Stefan-Boltzmann constant        | $\sigma = 5.67 \times 10^{-8} \text{ Wm}^{-2}\text{-K}^{-4}$ |
| • Wien's displacement law constant | $b = 2.89 \times 10^{-3} \text{ m-K}$                        |
| • Permeability of vacuum           | $\mu_0 = 4\pi \times 10^{-7} \text{ NA}^{-2}$                |
| • Permittivity of vacuum           | $\epsilon_0 = \frac{1}{\mu_0 c^2}$                           |
| • Planck constant                  | $h = 6.63 \times 10^{-34} \text{ J-s}$                       |

Space for Rough Work

PART-1 : PHYSICS

SECTION-I (i) : (Maximum Marks: 24)

- This section contains **SIX (06)** questions.
- Each question has **FOUR** options. **ONE OR MORE THAN ONE** of these four option(s) is (are) correct answer(s).
- For each question, choose the option(s) corresponding to (all ) the 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.

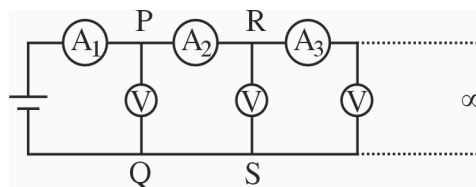
*Partial Marks* : +1 If two or more options are correct but **ONLY** one option is chosen and it is a correct option.

*Zero Marks* : 0 If none of the options is chosen (i.e. the question is unanswered).

*Negative Marks* : -2 In all other cases.

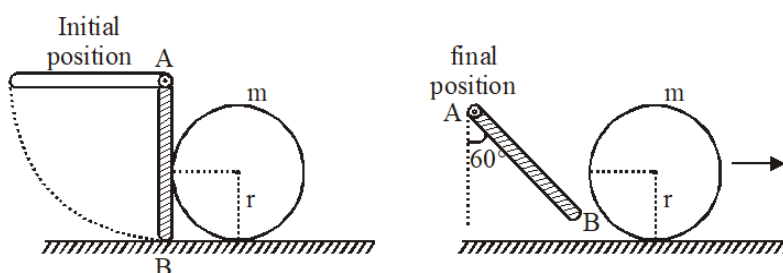
- **For Example** : If first, third and fourth are the **ONLY** three correct options for a question with second option being an incorrect option; selecting only all the three correct options will result in +4 marks. Selecting only two of the three correct options (e.g. the first and fourth options), without selecting any incorrect option (second option in this case), will result in +2 marks. Selecting only one of the three correct options (either first or third or fourth option), without selecting any incorrect option (second option in this case), will result in +1 marks. Selecting any incorrect option(s) (second option in this case), with or without selection of any correct option(s) will result in -2 marks.

1. In the circuit shown, all voltmeters are identical but ammeters are non-identical. The reading of  $A_1$  and  $A_2$  are 5 mA and 4.7 mA respectively. Reading of voltmeter connected across PQ is 9 volts.



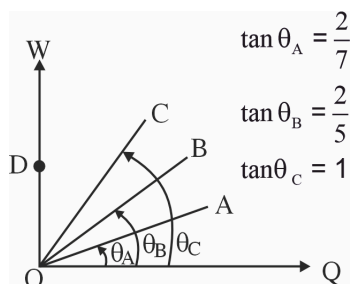
- (A) Sum of the reading of all voltmeters is 150 volts.
- (B) Sum of the reading of all voltmeters is 90 volts.
- (C) Resistance of voltmeter is  $18 \text{ k}\Omega$
- (D) Resistance of voltmeter is  $30 \text{ k}\Omega$

2.  $\text{Tc}_{43}^{99}$  radio-nuclide decays by  $\gamma$ -emission with a half-life of 6 hours and by  $\beta$ -emission with a half-life of  $2.12 \times 10^5$  years. A small quantity of solution containing  $\text{Tc}_{43}^{99}$  with an activity of  $1.0 \mu\text{Ci}$  (micro Curie) is injected into the blood stream of an adult person. The solution mixes rapidly and uniformly in the person's blood. It is excreted from the kidneys with an effective half-life of 6 hours. A 1 ml sample of the blood taken after 3.0 hours reveals an activity of 3.70 disintegrations per second on an average.  
(Note:-  $1 \text{ Ci (Curie)} = 3.70 \times 10^{10}$  disintegrations per second).
- (A) Decay constant  $\lambda_k$  for excretion from kidney is  $0.12 \text{ hr}^{-1}$   
(B) Decay constant  $\lambda_k$  for excretion from kidney is  $0.6 \text{ hr}^{-1}$   
(C) Volume of blood in person's body is 5 liter  
(D) Volume of blood in person's body is 6 liter
3. Three small identical neutral metal balls are at the vertices of an equilateral triangle. The balls are in turn connected to an isolated large conducting sphere whose centre is on the perpendicular erected from the plane of the triangle and passing through its centre. As a result the first and second balls have acquired charges  $q_1$  and  $q_2$  respectively. If  $q_1 = 4\mu\text{C}$ ,  $q_2 = 3\mu\text{C}$ , then the charge  $q_3$  in  $\mu\text{C}$  is  
(Assume that charge distributions of any ball or sphere remains uniform)
- (A)  $2 \mu\text{C}$  (B)  $3 \mu\text{C}$  (C)  $2.25 \mu\text{C}$  (D)  $1.25 \mu\text{C}$
4. A uniform rod AB of mass M is attached to a hinge at one end A, and released from rest from the horizontal position. The rod rotates about A, and when it reaches the vertical position the rod strikes a sphere of mass m and radius r initially at rest on the smooth horizontal surface as shown in the adjacent figure. The impact is along the horizontal direction and perfectly elastic. If at the moment of impact the lowest end of the rod is very close to the smooth horizontal surface. After the impact, the sphere moves along the horizontal and the rod, subsequently rises to a maximum of  $60^\circ$  with the vertical. Choose the correct statement(s) from the following, taking into account the information given above. The length of the rod equals  $\sqrt{2}r$ .  $\left(r = \frac{6\sqrt{2}}{10}m\right)$ .



- (A) The ratio  $\frac{M}{m}$  is  $\frac{3}{2}$   
(B) The ratio  $\frac{M}{m}$  is  $\frac{2}{3}$   
(C) The speed of the sphere just after collision is 6 m/s  
(D) The speed of the sphere just after collision is 3 m/s

5. Figure below shows four lines OA, OB, OC, OD (representing various processes such as isothermal, adiabatic, isobaric for a monoatomic and a diatomic ideal gas) on a work done by the gas (W) versus heat supplied (Q) graph. The initial states of both the gases are the same and so also the scales for the two axes.



- (A) OA represents isobaric process for diatomic gas  
 (B) OB represents isobaric process for diatomic gas  
 (C) OC represents isothermal process for diatomic gas  
 (D) OD represents adiabatic process for diatomic gas
6. A point object is placed at 30 cm from a convex glass lens ( $\mu_s = \frac{3}{2}$ ) of focal length 20 cm. The final image of object will be formed at infinity if
- (A) Another concave lens of focal length 60 cm is placed in contact with the previous lens  
 (B) Another convex lens of focal length 60 cm is placed at a distance of 30 cm from the first lens  
 (C) The whole system is immersed in a liquid of refractive index  $4/3$   
 (D) The whole system is immersed in a liquid of refractive index  $9/8$

## SECTION-I (ii) : (Maximum Marks: 12)

- This section contains **FOUR (04)** questions.
- This section contains **TWO** paragraphs.
- Based on each paragraph, there are **TWO** questions
- Each question has **FOUR** options (A), (B), (C) and (D). **ONLY ONE** of these four options is correct
- 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.

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**Paragraph for Questions 7 and 8**

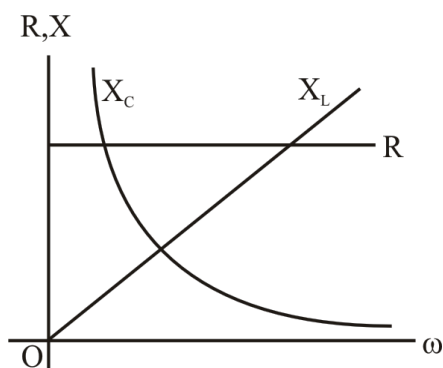
Consider the Bohr model of hydrogen atom. let  $m_e$  and  $e$  be the mass and magnitude of the charge of the electron respectively. Let  $a_0$  be the ground state radius (Bohr radius)

7. Consider a two electron system with atomic number  $Z = 4$ . use the Bohr model to obtain the ground state radius  $r$ . If  $r = \frac{ya_0}{3}$ , then the value of  $y$  is (Assume the two electrons are in the same circular orbit ( $n = 1$ ) and as far apart as possible)
- (A) 0.12  
(B) 0.40  
(C) 0.80  
(D) None
8. The first ionization energy  $I_2^{\text{th}}$  of the two electron system for  $Z = 4$  is given as  $I_2^{\text{th}} = \alpha I_H$ , the value of  $\alpha$  is (if  $I_H$  is ionization energy of hydrogen atom)
- (A) 21.7  
(B) 24.25  
(C) 12.125  
(D) 6.125

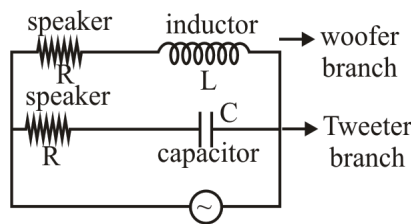
### Paragraph for Questions 9 and 10

Figure shows how the resistance of a resistor and the reactances of an inductor and a capacitor vary with angular frequency  $\omega$ . Resistance  $R$  is independent of frequency, while the reactances  $X_L$  and  $X_C$  are not. If  $\omega = 0$ , corresponding to a dc circuit, there is no current through a capacitor because  $X_C \rightarrow \infty$ , and there is no inductive effect because  $X_L = 0$ . In the limit  $\omega \rightarrow \infty$ ,  $X_L$  also approaches infinity, and the current through an inductor becomes vanishingly small; recall that the self-induced emf opposes rapid changes in current. In this same limit,  $X_C$  and the voltage across a capacitor both approach zero.

Figure shows an application of the above discussion to a loudspeaker system. Low-frequency sounds are produced by the woofer, which is a speaker with large diameter; the tweeter, a speaker with smaller diameter, produces high frequency sounds. In order to route signals of different frequency to the appropriate speaker, the woofer and tweeter are connected in parallel across the amplifier output. The capacitor in the tweeter branch blocks the low-frequency components of sound but passes the higher frequencies; the inductor in the woofer branch does the opposite.



Graphs of  $R, X_L$ , and  $X_C$  as functions of angular frequency  $\omega$ .



9. The rms current in tweeter and woofer can be equal if :-

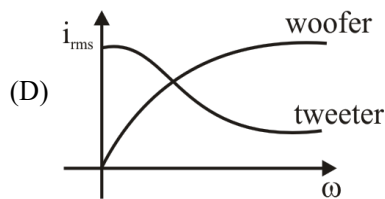
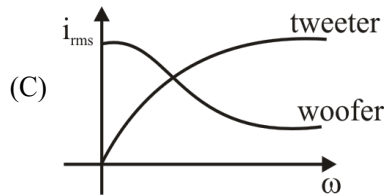
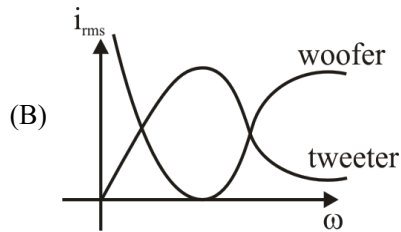
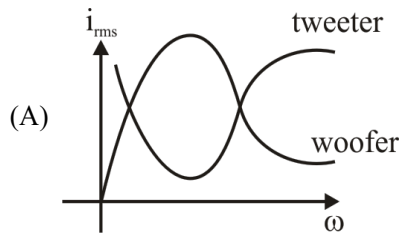
(A)  $\omega = \frac{1}{\sqrt{LC}}$

(B)  $\omega = \sqrt{\frac{1}{LC} - \frac{R^2}{4L^2}}$

(C)  $\omega = \sqrt{\frac{1}{LC} - \frac{R^2}{L^2}}$

(D)  $\omega = \sqrt{\frac{1}{LC} - \frac{R^2}{2L^2}}$

10. The correct graph for  $i_{\text{rms}}$  versus angular frequency  $\omega$  through tweeter and woofer is shown by :-





SECTION-II (i) : (Maximum Marks: 12)

- This section contains **THREE (03)** question stems.
- There are **TWO (02)** questions corresponding to each question stem.
- The answer to each question is a **NUMERICAL VALUE**.
- For each question, enter the correct numerical value corresponding to the answer in the designated place.
- 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* : +2 If ONLY the correct numerical value is entered at the designated place;

*Zero Marks* : 0 In all other cases.

Paragraph for Questions 1 and 2

**Thrust on a Rocket & Bernoulli's equation.**

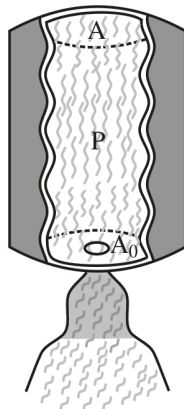
Thrust is the force which moves the rocket through the air and through space. Thrust is generated by the propulsion system. An engine does work on a gas or liquid, called a working fluid.

Consider a chamber of cross-sectional area  $A$  filled with a gas of density  $\rho$  at a pressure  $P$  as shown in figure. Let there be a small orifice of cross-sectional area  $A_0$  at the bottom of the chamber. The speed  $v_0$  with which the gas escape through the orifice can be found using Bernoulli's equation as

$$P - P_0 = \frac{1}{2} \rho (v_0^2 - v^2)$$

Where  $P_0$  represents atmospheric pressure just outside the orifice,  $v$  is the speed of the following gas inside the chamber and  $v_0$  is the speed of gas through orifice. Since the gas density is negligible, pressure variation with height in the chamber can be neglected. ( $A \gg A_0$ )

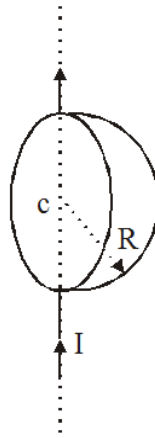
(Use  $P = 10 \times 10^5$  Pa,  $P_0 = 1 \times 10^5$  Pa,  $\rho = 0.5 \times 10^3$  kg/m<sup>3</sup>,  $A_0 = 0.5$  m<sup>2</sup>)



1. The thrust force acting on the rocket due to this will be  $F \times 10^5$  N. Write value of  $F$ .
2. For  $A \gg A_0$ , the speed of gas through the chamber will be  $v_0$  m/s. Find value of  $v_0/10$ .

### Paragraph for Questions 3 and 4

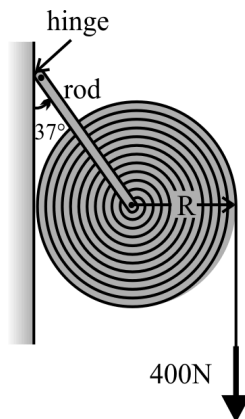
Consider a conducting, uniform, thin hemispherical shell of radius  $R$ , which is connected with two wires along its diameter, carrying current  $I$  as shown. Neglect field of connecting wire. ( $I = 2\text{ A}$ ,  $R = 1\text{ m}$ )



3. What is magnetic field due to hemisphere at its center in  $\mu\text{T}$  ?
4. If uniform magnetic field  $B$  of magnitude  $0.1\text{ T}$ , is applied in direction perpendicular to base of hemisphere, what will be force on it (in  $\text{N}$ )

### Paragraph for Questions 5 and 6

A large  $16.0\text{-kg}$  roll of paper with radius  $R = 18.0\text{ cm}$  rests against the wall and is held in place by a smooth massless axis attached to a rod through the centre of the roll as shown in figure. The moment of inertia of the paper roll about the axis is  $0.360\text{ kg}\cdot\text{m}^2$ . The other end of the rod is attached by a frictionless hinge to the wall such that the axis makes an angle of  $37^\circ$  with the wall. The weight of the rod is negligible. The coefficient of kinetic friction between the paper and the wall is  $\mu_k = 1/3$ . A constant vertical force  $F = 400\text{ N}$  is applied to the paper, and the paper unrolls. ( $g = 10\text{ m/s}^2$ )



5. The magnitude of the angular acceleration (in  $\text{rad/sec}^2$ ) of the roll is :
6. The magnitude of the tension force (in newton) that the rod exerts on the paper roll as it unrolls is :

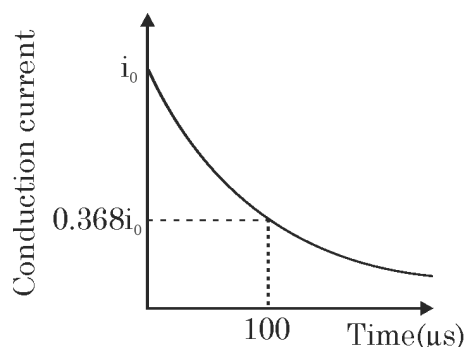
SECTION-II (ii) : (Maximum Marks: 12)

- This section contains **THREE (03)** questions.
- The answer to each question is a **NON-NEGATIVE INTEGER**
- For each question, enter the correct integer value of the answer in the place designated to enter the answer.
- For each question, marks will be awarded in one of the following categories :

Full Marks : +4 If only the correct answer is given.

Zero Marks : 0 In all other cases

7. A circular parallel plate capacitor having plate radius  $R$  is charged by means of a cell at time  $t = 0$ . The variation of the current through the connecting wires with time is shown in figure. Consider a plane circular area of radius  $R/2$  parallel to the plates and situated symmetrically between them.



Assuming  $i_0 = 5\text{A}$ , the time rate change of electric flux through the area at  $t = 100\ \mu\text{s}$  is  $\frac{n}{2} \times 10^{11} \frac{\text{N} \cdot \text{m}^2}{\text{C} \cdot \text{s}}$ , then the integer closest to  $n =$  \_\_\_\_\_.

8. A spring of spring constant  $2000\text{N/m}$  is suspended vertically in earth's gravitational field and a mass of  $0.8\text{ kg}$  is hung from it. It is hanging in equilibrium. At  $t = 0$ , a force of  $72\text{ N}$  starts acting in vertically downward direction. The force ceases to act at  $t = \frac{\pi}{2}$  sec. If the amplitude of resulting SHM (in mm) after that is given by  $N$ .  
Fill value of  $\frac{N}{24}$
9. A particle moves along a straight line path such that its magnitude of velocity is given by  $v = (3t^2 - 6t)\text{ ms}^{-1}$ , where  $t$  is the time in seconds. If it is initially located at the origin  $O$  then determine the magnitude of particle's average speed in time interval from  $t = 0$  to  $t = 4\text{s}$

**PART-2 : CHEMISTRY**  
**SECTION-I (i) : (Maximum Marks: 24)**

- This section contains **SIX (06)** questions.
- Each question has **FOUR** options. **ONE OR MORE THAN ONE** of these four option(s) is (are) correct answer(s).
- For each question, choose the option(s) corresponding to (all ) the 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 Marks* : 0 If none of the options is chosen (i.e. the question is unanswered).

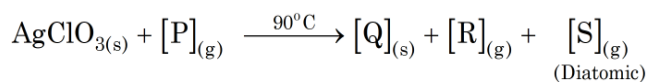
*Negative Marks* : -2 In all other cases.

- **For Example** : If first, third and fourth are the **ONLY** three correct options for a question with second option being an incorrect option; selecting only all the three correct options will result in +4 marks. Selecting only two of the three correct options (e.g. the first and fourth options), without selecting any incorrect option (second option in this case), will result in +2 marks. Selecting only one of the three correct options (either first or third or fourth option), without selecting any incorrect option (second option in this case), will result in +1 marks. Selecting any incorrect option(s) (second option in this case), with or without selection of any correct option(s) will result in -2 marks.

1. Select correct option among the following statements :  
 (P) Sol prepared by hydrolysis of  $\text{FeCl}_3$ , colloidal particles get attracted forward anode during electrophoresis.  
 (Q) A gas with higher critical temperature gets adsorbed to more extent than a gas with lower critical temperature.  
 (R) On mixing of eosin (acid dye) and haemoglobin (blood), coagulation takes place.  
 (S) Gold sol is deposited at anode in the electro osmosis process.  
 (T) CMC value of  $\text{CH}_3(\text{CH}_2)_8\text{NH}_3^+\text{Cl}^-$  will be less than that of  $\text{CH}_3(\text{CH}_2)_5\text{COONa}$ .  
 (U) Brownian motion is independent of nature of colloid but depends on viscosity of solution.

(A) PQR                      (B) QRT                      (C) RTU                      (D) QTU

2. In the given chemical reaction,

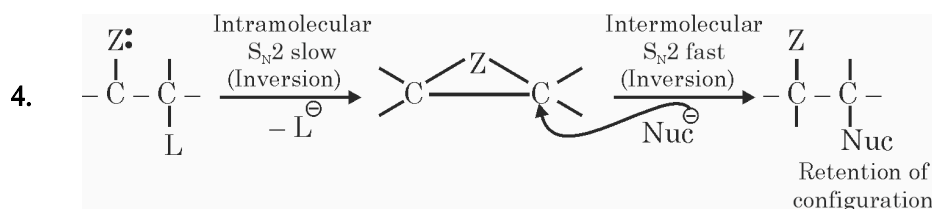
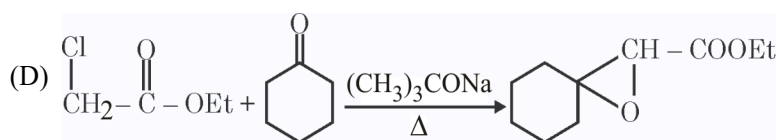
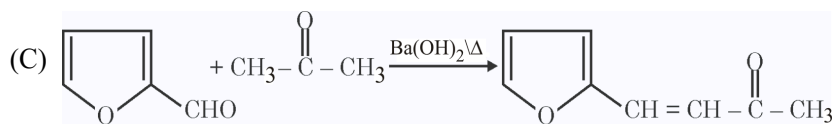
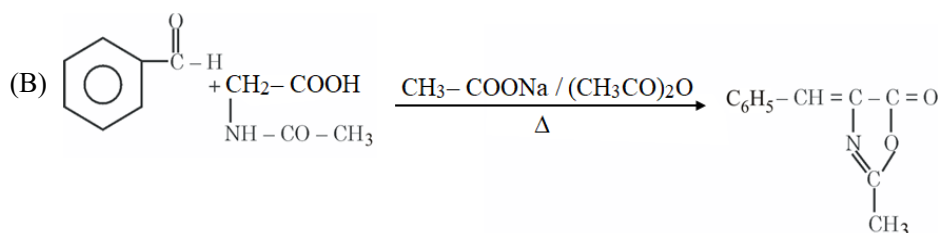
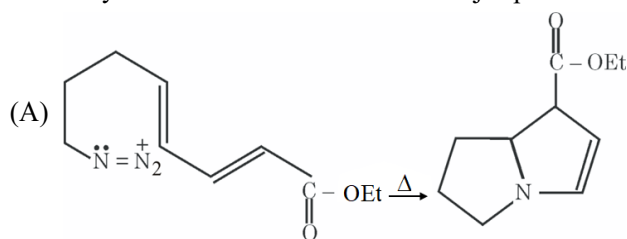


Identify [P], [Q], [R] and [S].

if gas [P] can be prepared by dissolving red lead ( $\text{Pb}_3\text{O}_4$ ) in warm hydrochloric acid?

- (A)  $[\text{P}] = \text{Cl}_2$                       (B)  $[\text{Q}] = \text{AgCl}$   
 (C)  $[\text{R}] = \text{ClO}_2$                       (D)  $[\text{S}] = \text{O}_2$

3. Correctly matched reaction with their major product.

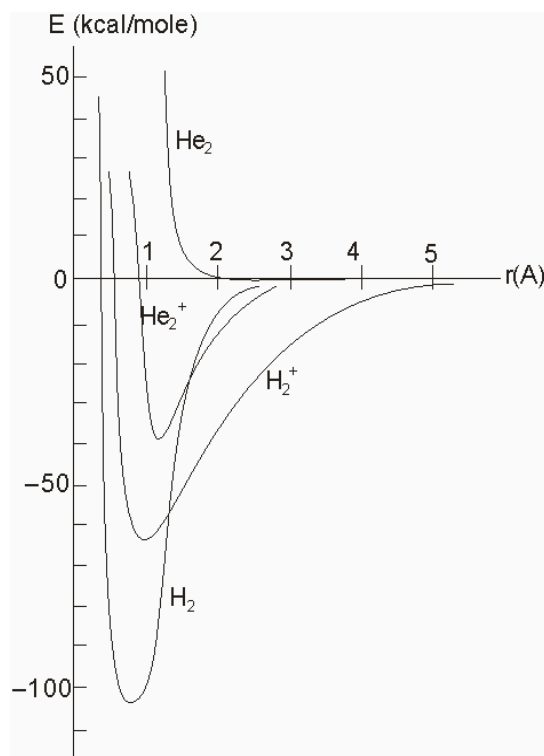


A common feature of all neighbouring group mechanisms is the formation of a cyclic intermediate. The neighbouring group acting as the nucleophile ( $\ddot{Z}$ ) is present in the same molecule and is immediately available for the attack, such reactions occur 1000 times faster than comparable internuclear nucleophilic substitution.

**True** statement among the following is/are

- (A) Rate of acetolysis of 4-methoxybutyl brosylate is nearly 650 times faster than that of n butyl brosylate.
- (B) 2-Bromopropanoic acid is treated with dil. alkali, it gives lactate anion with complete retention of configuration.
- (C) Rate of acetolysis of trans-2-iodocyclohexyl brosylate is  $1.7 \times 10^6$  times slower than that of its cis isomer.
- (D) Optically active erythro-3-Bromo-2-butanol react with HBr with retention of configuration to give Meso-dibromide.

5. The following graph is given, between total energy and distance between the two nuclei for species  $\text{H}_2^+$ ,  $\text{H}_2$ ,  $\text{He}_2^+$ , &  $\text{He}_2$ , which of the following statement/s is incorrect :



- (A)  $\text{He}_2^+$  is more stable than  $\text{H}_2^+$
- (B) Bond dissociation energy of  $\text{H}_2^+$  is more than bond dissociation energy of  $\text{He}_2^+$
- (C) Since bond orders of  $\text{He}_2^+$  and  $\text{H}_2^+$  are equal hence both will have equal bond dissociation energy.
- (D) Bond length of  $\text{H}_2^+$  is less than bond length of  $\text{H}_2$
6. Consider two 0.1 M solutions of two solutes X & Y in the same solvent. The solute X dimerises in solution while solute Y undergoes trimerisation in solution & their degree of dimerisation & trimerisation are 0.8 & 0.6 respectively then the correct statement(s) among the following is/are:
- (A) The boiling point of solution of 'X' will be higher than that of 'Y'.
- (B) The freezing point of solution 'X' will be higher than that of 'Y'.
- (C) The freezing point of solution 'X' and solution 'Y' are same.
- (D) Due to association of solute 'X' & 'Y' in solutions, the observed colligative property is less than that of calculated colligative property for both these solutions.

## SECTION-I (ii) : (Maximum Marks: 12)

- This section contains **FOUR (04)** questions.
- This section contains **TWO** paragraphs.
- Based on each paragraph, there are **TWO** questions
- Each question has **FOUR** options (A), (B), (C) and (D). **ONLY ONE** of these four options is correct
- 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.

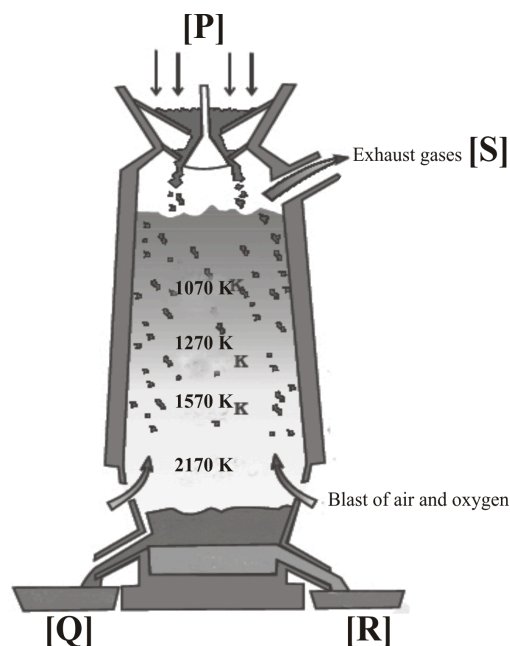
## Paragraph for Questions 7 and 8

Cast iron is prepared from haematite. The ore is roasted to remove the volatile impurities. During roasting the mass becomes porous. Iron in the form of ferrous oxide is converted to ferric oxide. Finally ferric oxide is mixed with coke and heated in a blast furnace. Pig iron is formed and is casted in the desired shape.

7. Carbon in cast iron can be represented by -

(A) FeC (B) Fe<sub>3</sub>C (C) FeC<sub>3</sub> (D) Fe<sub>2</sub>C

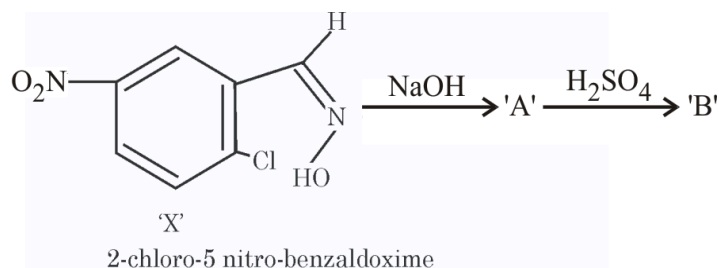
8.



Identify [P], [Q], [R] and [S] in above metallurgical diagram -

- (A) [Fe<sub>2</sub>O<sub>3</sub> + Silicate + coke], [Pig iron], [Slag], [SO<sub>2</sub>, CO<sub>2</sub>]  
 (B) [FeS + Silicate + coke], [Slag], [Pig iron], [CO, CO<sub>2</sub>]  
 (C) [Fe<sub>2</sub>O<sub>3</sub> + lime stone + coke], [Slag], [Cast iron], [CO, CO<sub>2</sub>]  
 (D) [Fe<sub>2</sub>O<sub>3</sub> + lime stone + coke], [Solid waste], [Pig iron], [CO, CO<sub>2</sub>]

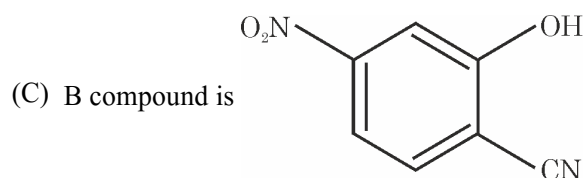
Paragraph for Questions 9 and 10



9. Incorrect statement among the following is

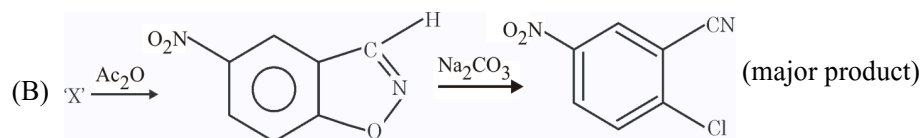
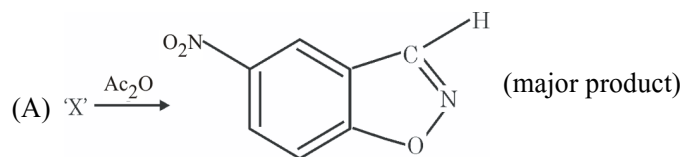
(A) Out of two isomers of 'X' only, anti isomer on treatment with NaOH readily give ring closure.

(B) Rate of conversion of 'X' to A could be increased in case of its fluoro derivative.

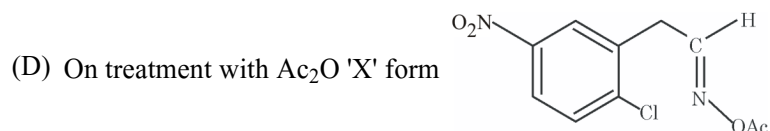


(D) During formation of A to B, rearrangement takes place.

10. Correct statement out of the following :



(C) 'X'  $\xrightarrow{\text{Ac}_2\text{O}}$  P  $\xrightarrow{\text{Na}_2\text{CO}_3}$  'Y'. Step P to Y involve Meisenheimer complex





SECTION-II (i) : (Maximum Marks: 12)

- This section contains **THREE (03)** question stems.
- There are **TWO (02)** questions corresponding to each question stem.
- The answer to each question is a **NUMERICAL VALUE**.
- For each question, enter the correct numerical value corresponding to the answer in the designated place.
- 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 : +2 If ONLY the correct numerical value is entered at the designated place;

Zero Marks : 0 In all other cases.

Paragraph for Questions 1 and 2

Values of  $\Delta_o$  (in eV/ion) for some transition metal complexes are:

$\Delta_o$  (eV /ion)

$\text{Co}^{3+}$  3.501 in  $\text{Co}(\text{NO}_2)_6^{3-}$

$\text{Co}^{2+}$  2.242 in  $\text{Co}(\text{NO}_2)_6^{4-}$

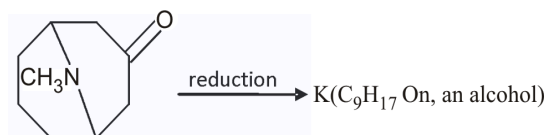
The  $t_{2g}$  orbitals are lowered by  $\frac{2}{5}\Delta_o$ , and the  $e_g$  orbitals are raised by  $\frac{3}{5}\Delta_o$ .

You are given the complex ions:  $\text{Co}(\text{NO}_2)_6^{3-}$  and  $\text{Co}(\text{NO}_2)_6^{4-}$ .

Assume all complexes can be either in the high spin (H.S.) state or the low spin (L.S.) state.

1. Calculate the wavelength,  $\lambda$  (in nm), which is absorbed by the complex  $\text{Co}(\text{NO}_2)_6^{3-}$  for d-d transition.
2. Calculate the magnitude of crystal field stabilization energy, CFSE in kJ/mole, assuming given complex  $\text{Co}(\text{NO}_2)_6^{4-}$  is a high spin complex ion.  
(Take charge on  $1e^- = -1.602 \times 10^{-19}$  C, Avogadro number =  $6.022 \times 10^{23}$ )

Paragraph for Questions 3 and 4



$\text{K} + \text{heat} \rightarrow \text{L}(\text{C}_9\text{H}_{15}\text{N})$

$\text{L} + \text{CH}_3\text{I}$ , then  $\text{Ag}_2\text{O} \rightarrow \text{M}(\text{C}_{10}\text{H}_{19}\text{ON})$

$\text{M} + \text{heat} \rightarrow \text{N}(\text{C}_{10}\text{H}_{17}\text{N})$

$\text{N} + \text{CH}_3\text{I}$ , then  $\text{Ag}_2\text{O} \rightarrow \text{O}(\text{C}_{11}\text{H}_{21}\text{ON})$

$\text{O} + \text{heat} \rightarrow \text{P}(\text{C}_8\text{H}_{10})$

$\text{P} + \text{Br}_2 \rightarrow \text{Q}(\text{C}_8\text{H}_{10}\text{Br}_2)$

$\text{Q} + (\text{CH}_3)_2\text{NH} \rightarrow \text{R}(\text{C}_{12}\text{H}_{22}\text{N}_2)$

$\text{R} + \text{CH}_3\text{I}$ , then  $\text{Ag}_2\text{O} \rightarrow \text{S}(\text{C}_{14}\text{H}_{30}\text{O}_2\text{N}_2)$

$\text{S} + \text{heat} \rightarrow \text{T}(\text{C}_8\text{H}_8)$

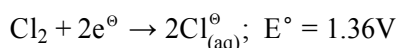
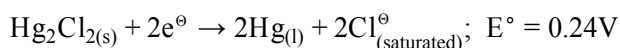
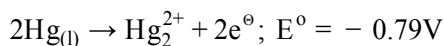
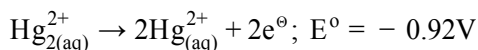
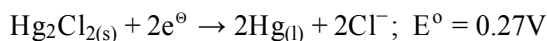
3. T reacts with Na metal (excess) to give a stable compound U. Number of  $\pi$  bonds present in T if a number of  $\pi$  electrons present in U is b then find out  $|a - b|$ .
4. Index of hydrogen deficiency in structure 'L' is

## Paragraph for Questions 5 and 6

Consider the thermodynamic data :

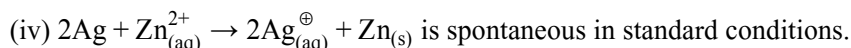
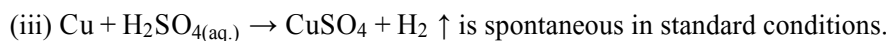
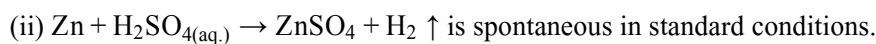
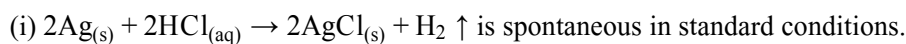
$$E_{\text{Zn}^{2+}/\text{Zn}}^0 = -0.76, E_{\text{Fe}^{2+}/\text{Fe}}^0 = -0.44 \text{ V}$$

$$E_{\text{Cu}/\text{Cu}^{2+}}^0 = -0.34 \text{ V}, E_{\text{Ag}/\text{Ag}^{\oplus}}^0 = -0.8 \text{ V}$$



$$\frac{2.303RT}{F} = 0.06$$

5. How many of the statement(s) is/are correct ?



(v) For electrolysis, only D.C. current is suitable not A.C. current

(vi) At negative electrode, oxidation takes place in both galvanic & electrolytic cell

(vii) For the galvanic cell constructed with hydrogen electrode & chlorine electrode, salt bridge may not be necessary when electrolyte is HCl.

6. How many of the following statement(s) is/are correct

(i)  $E_{\text{Hg}^{2+}/\text{Hg}}^0 = 0.855 \text{ V}$

(ii)  $E_{\text{Hg}^{2+}/\text{Hg}}^0 = -0.855 \text{ V}$

(iii) Standard reduction potential of calomel electrode is 0.27 V.

(iv) Oxidation potential of calomel electrode at 1M KCl is  $-0.27 \text{ V}$ .

(v) Reduction potential of calomel electrode at 0.1N KCl is 0.33 V.

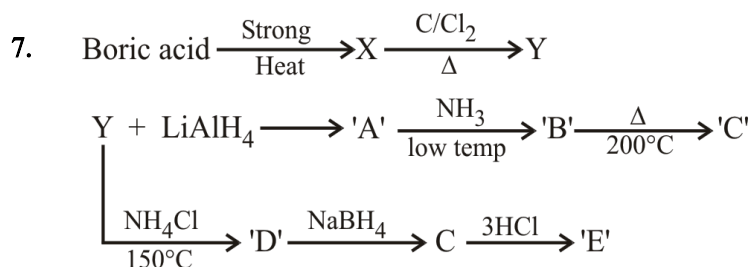
(vi)  $K_{\text{SP}}$  of  $\text{Hg}_2\text{Cl}_2$  is nearly  $10^{-17.33}$ .

## SECTION-II (ii) : (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 value of the answer in the place designated to enter the answer.
- For each question, marks will be awarded in one of the following categories :

Full Marks : +4 If only the correct answer is given.

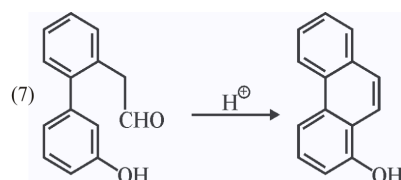
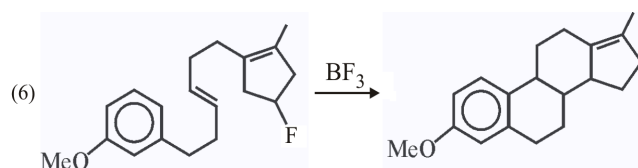
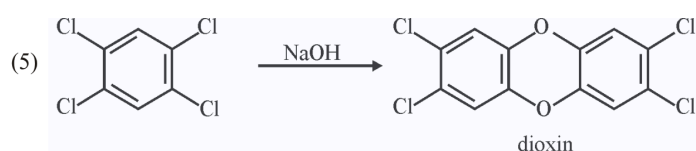
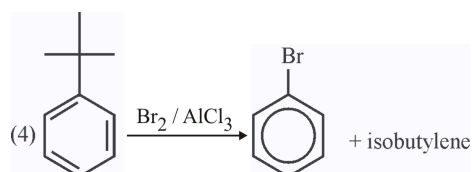
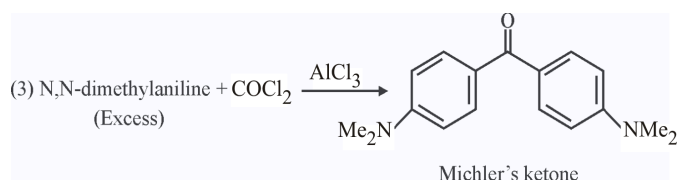
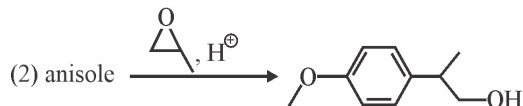
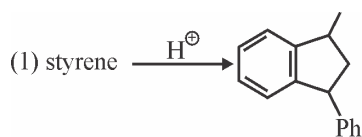
Zero Marks : 0 In all other cases



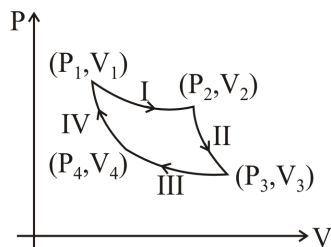
Identify the correct statement/s for the above sequence of the reactions

- (A) H<sub>3</sub>BO<sub>3</sub> is weak mono acidic Bronsted acid
- (B) H<sub>3</sub>BO<sub>3</sub> can't be titrated directly with NaOH by using Phenolphthalein indicator
- (C) H<sub>3</sub>BO<sub>3</sub> is a weak Lewis acid
- (D) Acidic strength of H<sub>3</sub>BO<sub>3</sub> solution is increases on addition of catechol.
- (E) 'X' on heating with metal oxide, gives metal metaborates
- (F) 'A' is treated with (CH<sub>3</sub>)<sub>3</sub>B gives B<sub>2</sub>(CH<sub>3</sub>)<sub>6</sub> as a product
- (G) In 'C' and 'E', boron has sp<sup>2</sup> and sp<sup>3</sup> hybridization respectively
- (H) 'C' is more reactive than C<sub>6</sub>H<sub>6</sub> towards addition reactions
- (I) 'E' has planar structure
- (J) 'D' has 2pπ-2pπ backbonding.

8. Identify number of reactions in which given major product is correct



9. 10 moles of an ideal gas is participating in the carnot cycle as shown in the figure.



Step-I : Isothermal reversible expansion with absorption of  $q_1$  amount of heat

Step-II : Adiabatic reversible expansion

Step-III : Isothermal reversible compression with rejection of  $q_2$  amount of heat

Step-IV : Adiabatic reversible compression

Given  $v_1, v_2, v_3, v_4$  are the volumes of gases in the corresponding stages, then calculate the value of  $nR \ln \frac{v_2 v_4}{v_1 v_3}$  ?

**PART-3 : MATHEMATICS**  
**SECTION-I (i) : (Maximum Marks: 24)**

- This section contains **SIX (06)** questions.
- Each question has **FOUR** options. **ONE OR MORE THAN ONE** of these four option(s) is (are) correct answer(s).
- For each question, choose the option(s) corresponding to (all ) the 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 Marks* : 0 If none of the options is chosen (i.e. the question is unanswered).

*Negative Marks* : -2 In all other cases.

- **For Example :** If first, third and fourth are the **ONLY** three correct options for a question with second option being an incorrect option; selecting only all the three correct options will result in +4 marks. Selecting only two of the three correct options (e.g. the first and fourth options), without selecting any incorrect option (second option in this case), will result in +2 marks. Selecting only one of the three correct options (either first or third or fourth option), without selecting any incorrect option (second option in this case), will result in +1 marks. Selecting any incorrect option(s) (second option in this case), with or without selection of any correct option(s) will result in -2 marks.

1. A and B are two  $n \times n$  matrices such that  $\det(A) \neq 0$ ,  $A + B = (AB)^2$  and  $BAB = A + I$ . Choose the **correct** option(s).  
 (A)  $A^{-1} = (A^4 - I)$   
 (B)  $B^5 - A^5 = A + B$   
 (C)  $A^9 = A^4 + A + I$   
 (D)  $A^2B^2 = BA^2B$
2. Let  $d(x, [a, b]) = \min \{|x - y| : a \leq y \leq b\}$  A function  $f : \mathbb{R} \rightarrow [0, 1]$  is defined by  

$$f(x) = \frac{d(x, [0, 1])}{d(x, [0, 1]) + d(x, [2, 3])}$$
, then which of the following is **not** correct?  
 (A) the function  $f$  is one-one  
 (B) the function  $f$  is onto  
 (C) the function  $f$  is a bijection  
 (D) the function  $f$  is odd

3. A parabola touches x-axis and the line  $y = x$  respectively at points  $(1, 0)$  and  $(1, 1)$ , then
- (A) slope of directrix of the parabola is  $-2$
- (B) slope of axis of the parabola is  $\frac{1}{3}$
- (C) focus of the parabola is at the point  $\left(\frac{2}{5}, \frac{4}{5}\right)$
- (D) focus of the parabola is at the point  $\left(\frac{3}{5}, \frac{1}{5}\right)$
4. Equation of curve passing through  $(3, 4)$  and satisfying the differential equation,  $y \left(\frac{dy}{dx}\right)^2 + (x - y) \frac{dy}{dx} - x = 0$  can be
- (A)  $x^2 + y^2 = 25$
- (B)  $x^2 - y^2 + 7 = 0$
- (C)  $xy = 12$
- (D)  $x - y + 1 = 0$
5. Let  $x, y, z \in \{1, 2, 3, 4, 5, 6, 7, 8, 9\}$  such that  $\sqrt{\frac{\text{XXXX...XX}}{\text{"2000" times}} - \frac{\text{YYYY...Y}}{\text{"1000" times}}} = \frac{\text{ZZZZ...ZZ}}{\text{"1000" times}}$  then
- (A)  $x + y + z$  can be 6
- (B)  $x + z$  can be 18
- (C)  $x + y + z$  can be 18
- (D)  $x$  can be 9
6. Let  $z, z_1, z_2$  be three distinct complex numbers and  $\text{Im } z \neq 0$ .  
If  $(z^2 + 1)(\bar{z}^2 + 1) = \left(1 + \left(\frac{z + \bar{z}}{2}\right)^2\right)^2$  and  $z_1 = i, z_2 = -i, (i = \sqrt{-1})$  then  
(If  $z = a + ib$  then  $\bar{z} = a - ib, a, b \in \mathbb{R}$ )
- (A)  $|z| < 3$
- (B) Locus of  $z$  may be an ellipse
- (C) Locus of  $z$  may be a hyperbola
- (D)  $|z_1 - z_2| + |z_1 - z| + |z_2 - z| = 2\sqrt{2} + 2$

## SECTION-I (ii) : (Maximum Marks: 12)

- This section contains **FOUR (04)** questions.
- This section contains **TWO** paragraphs.
- Based on each paragraph, there are **TWO** questions
- Each question has **FOUR** options (A), (B), (C) and (D). **ONLY ONE** of these four options is correct
- 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.

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**Paragraph for Questions 7 and 8**

A first order first degree differential equation can be written in the exact differential form which can be easily integrated. Example :  $x dy + y dx = d(xy)$ ,  $\frac{x dy + y dx}{xy} = d(\ln xy)$ , etc. Now answer the following using this exact differential concept or otherwise.

7. The curve C which passes through (1,1) and satisfies the differential equation  $(2x^2y - 2y^4) dx + (2x^3 + 3xy^3) dy = 0$  is given by,  $\alpha \ln |x| + \beta \ln |y| + \frac{y^3}{x^2} = \gamma$ , then  $(\alpha + \beta + \gamma)$  is equals to
- (A) 3 (B) 4  
(C) 5 (D) 6
8. A curve  $y = f(x)$  passing through the point  $\left(\frac{1}{2}, \frac{1}{4}\right)$  satisfies the differential equation,  $\frac{x}{y} \frac{dy}{dx} = \frac{3x^2 - y}{2y - x^2}$  is a conic whose length of latus rectum is
- (A) 1 (B) 2  
(C) 3 (D) 4

**Paragraph for Questions 9 and 10**

$a_1, a_2, a_3$  are three consecutive terms of an increasing A.P., where  $a_1$  and  $a_2$  are prime numbers such that their sum is minimum possible odd prime number.

Urn-1: Contains  $a_1$  red and  $a_3$  green balls

Urn-2: Contains  $a_2$  red and  $a_2$  green balls

Urn-3: Contains  $a_3$  red and  $a_1$  green balls

$P(i)$  represents the probability of choosing  $i^{\text{th}}$  urn and  $P(R)$  represents probability of choosing red ball and similarly  $P(G)$  represents the probability of choosing green ball.

9. If  $P(i) \propto i^2$  and one ball is drawn from one of these urns then  $P(R)$  is equal to

- |                     |                     |
|---------------------|---------------------|
| (A) $\frac{6}{7}$   | (B) $\frac{17}{42}$ |
| (C) $\frac{23}{42}$ | (D) $\frac{25}{42}$ |

10. If  $P(i) = 1/3$  for all  $i = 1, 2, 3$  and 2 balls are drawn randomly from one of these urns then the chance of drawing balls of different colours is

- |                   |                   |
|-------------------|-------------------|
| (A) $\frac{4}{9}$ | (B) $\frac{5}{9}$ |
| (C) $\frac{7}{9}$ | (D) $\frac{8}{9}$ |



## SECTION-II (i) : (Maximum Marks: 12)

- This section contains **THREE (03)** question stems.
- There are **TWO (02)** questions corresponding to each question stem.
- The answer to each question is a **NUMERICAL VALUE**.
- For each question, enter the correct numerical value corresponding to the answer in the designated place.
- 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* : +2 If ONLY the correct numerical value is entered at the designated place;

*Zero Marks* : 0 In all other cases.

## Paragraph for Questions 1 and 2

A ten - sided regular polygon is inscribed in a circle  $|z| = 1$ ,  $A_{10}, A_1, A_2, \dots, A_9$  be its vertices in anticlockwise with  $A_{10} = (1,0)$ .  $G_1$  is centroid of  $\Delta A_1A_4A_8$ ,  $G_2$  be centroid of  $\Delta A_2A_6A_9$  and  $G_3$  be centroid of  $\Delta A_3A_5A_7$ . P is centroid  $\Delta G_1G_2G_3$ . If 'O' is the centre of circle.

1. Angle  $\angle POA_1$  is equal to  $k\pi$ , then k is equal to
2.  $90 \times |OP|$  is equal to

## Paragraph for Questions 3 and 4

If  $L = \lim_{x \rightarrow 0} \frac{\sqrt{1+x^2} \tan \sin \tan^{-1}x + 2\sqrt{1-x^2} \sin \tan \sin^{-1}x - 3x}{x^p}$  exists finitely and takes non-zero value ( $p \geq 2, p \in \mathbb{N}$ ), then

3. The value of p is
4. The value of  $60|L|$  is

## Paragraph for Questions 5 and 6

From the set of n number  $\{1, 3, 5, \dots, 2n-1\}$  five consecutive numbers are removed and the mean of remaining numbers is  $\frac{393}{5}$ .

5. The value of n is
6. The mean of removed numbers is

SECTION-II (ii) : (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 value of the answer in the place designated to enter the answer.
- For each question, marks will be awarded in one of the following categories :

Full Marks : +4 If only the correct answer is given.

Zero Marks : 0 In all other cases

7. Consider a function  $f(x)$  which satisfies  $f'(x) - \tan x \cdot f(x) = \int_{-\pi/6}^{\pi/6} f(x) dx \quad \forall x \in \left(-\frac{\pi}{2}, \frac{\pi}{2}\right)$  and  $f(0) = 1$ . The

value of  $\left(f\left(\frac{\pi}{3}\right) - \sqrt{3} \ln 3\right)$  is

8. Consider the following three planes

$$p_1 : 2x + y + z = 1$$

$$p_2 : x - y + z = 2$$

$$p_3 : kx - y + 3z = 5$$

The three planes intersect each other at point R on XOY plane and at the point S on YOZ plane 'O' is Origin.

If the coordinates of point 'P' situated at minimum distance from point 'O' on the RS are  $(\alpha, \beta, \gamma)$ . Then the

value of  $\left(\frac{\alpha}{2} - 180\beta + 2\gamma\right)$  is a three digit number abc then  $a + b - c$  is equal to

9. Let  $n \in \mathbb{N}$ ,  $A^n = \begin{bmatrix} 2 & 1 \\ 1 & 0 \end{bmatrix}^n = \begin{bmatrix} a_{11}(n) & a_{12}(n) \\ a_{21}(n) & a_{22}(n) \end{bmatrix}$ . If  $\lim_{n \rightarrow \infty} \frac{a_{12}(n)}{a_{22}(n)} = \ell$ , where  $\ell^2 = \sqrt{a} + \sqrt{b}$  ( $a, b \in \mathbb{N}$ ,  $a > b$ ).

Then  $(a + b)$  is equal to

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FORM NO. ....

I have read all the instructions  
and shall abide by them.

\_\_\_\_\_  
Signature of the Candidate

I have verified the identity, name and Form  
number of the candidate, and that question  
paper and ORS codes are the same.

\_\_\_\_\_  
Signature of the Invigilator

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