

PHYSICS, CHEMISTRY & MATHEMATICS

Pattern - CPT-1

QP Code:

TEST - 13

Time Allotted: 3 Hours

Maximum Marks: 198

- Please read the instructions carefully. You are allotted 5 minutes specifically for this purpose.
- You are not allowed to leave the Examination Hall before the end of the test.

INSTRUCTIONS

Caution: Question Paper CODE as given above MUST be correctly marked in the answer OMR sheet before attempting the paper. Wrong CODE or no CODE will give wrong results.

A. General Instructions

1. Attempt ALL the questions. Answers have to be marked on the OMR sheets.
2. This question paper contains **Three Sections**.
3. **Section-I** is Physics, **Section-II** is Chemistry and **Section-III** is Mathematics.
4. Each **Section** is further divided into **Two Parts: Part-A & B** in the OMR.
5. Rough spaces are provided for rough work inside the question paper. No additional sheets will be provided for rough work.
6. Blank Papers, clip boards, log tables, slide rule, calculator, cellular phones, pagers and electronic devices, in any form, are not allowed.

B. Filling of OMR Sheet

1. Ensure matching of OMR sheet with the Question paper before you start marking your answers on OMR sheet.
2. On the OMR sheet, darken the appropriate bubble with HB pencil for each character of your Enrolment No. and write in ink your Name, Test Centre and other details at the designated places.
3. OMR sheet contains alphabets, numerals & special characters for marking answers.

C. Marking Scheme For All Two Parts.

- (i) **Part-A (01-06)** – Contains six (06) multiple choice questions which have **ONLY ONE CORRECT** answer. Each question carries **+3 marks** for correct answer and **-1 marks** for wrong answer.
- (ii) **Part-A (07-12)** – Contains seven (06) multiple choice questions which have **One or More** correct answer.
Full Marks: +4 If only the bubble(s) corresponding to all the correct option(s) is (are) darkened.
Partial Marks: +1 For darkening a bubble corresponding to **each correct option**, provided **NO** incorrect option is darkened.
Zero Marks: 0 If none of the bubbles is darkened.
Negative Marks: -2 In all other cases.
For example, if **(A), (C) and (D)** are all the correct options for a question, darkening all these three will result in **+4 marks**; darkening only **(A) and (D)** will result in **+2 marks**; and darkening **(A) and (B)** will result in **-2 marks**, as a wrong option is also darkened.
- (ii) **Part-B (01-06)** contains Six (06) Numerical based questions, the answer of which maybe positive or negative numbers or decimals (e.g. 6.25, 7.00, -0.33, -.30, 30.27, -127.30) and each question carries **+4 marks** for correct answer and **there will be no negative marking**.

Name of the Candidate : _____

Batch : _____ Date of Examination : _____

Enrolment Number : _____

SECTION-1 : PHYSICS**PART – A****(Single Correct Choice Type)**

This section contains **6 multiple choice questions**. Each question has four choices (A), (B), (C) and (D) out of which **ONLY ONE is correct**.

1. Let V and E be the potential and the field respectively at a point. Which of the following assertions are correct?
 (A) If $V = 0$, E must be zero. (B) If $V \neq 0$, E cannot be zero
 (C) If $E \neq 0$, V cannot be zero. (D) None of these.

1. **D**

2. There is a quarter ring of radius R in the yz -plane having linear charge density λ , then electric field at point P will be

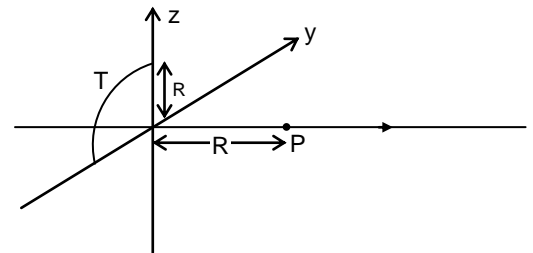
(A) $\frac{k\lambda}{2^{3/2}} \left(\frac{\pi}{2} \hat{j} + \frac{1}{\sqrt{2}} \hat{j} - \frac{1}{\sqrt{2}} \hat{k} \right)$

(B) $\frac{k\lambda}{2^{3/2}} (\hat{j} + \hat{j} - \hat{k})$

(C) $\frac{k\lambda}{2^{3/2}} \left(\frac{\pi}{2} \hat{j} + \hat{j} - \hat{k} \right)$

(D) None of these

2. **D**



3. Consider a non-conducting hemisphere of radius R having charge per unit area equal to σ . Electric field at point P will be

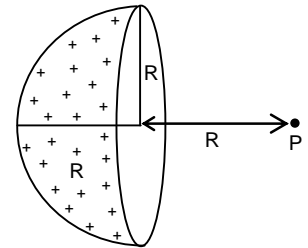
(A) $\frac{\sigma}{4\epsilon_0}$

(B) $\frac{\sigma}{2\epsilon_0} \left(1 - \frac{1}{\sqrt{2}} \right)$

(C) $\frac{\sigma}{4\epsilon_0} \times \frac{1}{\sqrt{2}}$

(D) $\frac{\sigma}{4\epsilon_0} \left(1 - \frac{1}{\sqrt{2}} \right)$

3. **B**



4. There is a uniformly charged cube of charge density ρ . Then consider two points A and B in the cube (A is at centre and B is at the corner)

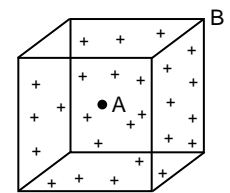
(A) $\frac{E_A}{E_B} = 0$ and $\frac{V_A}{V_B} = \frac{1}{2}$

(B) $\frac{E_A}{E_B} = 0$ and $\frac{V_A}{V_B} = 8$

(C) $\frac{E_A}{E_B} = 0$ and $\frac{V_A}{V_B} = 2$

(D) $\frac{E_A}{E_B} = 0$ and $\frac{V_A}{V_B} = 4$

4. **C**



5. Consider a non-conducting hemisphere of radius R having charge per unit area equal to σ find electric potential at point P due to the hemisphere

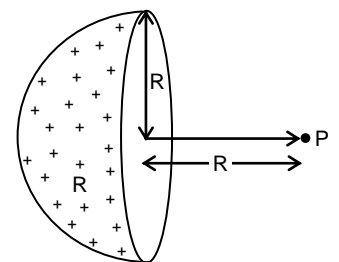
(A) $\frac{\sigma}{2\epsilon_0} \left(1 - \frac{1}{\sqrt{2}} \right) R$

(B) $\frac{\sigma}{2\epsilon_0} \left(1 - \frac{1}{\sqrt{2}} \right) \sqrt{2} R$

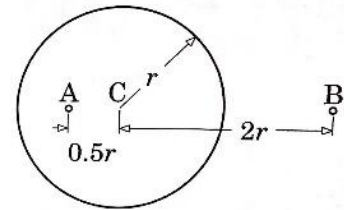
(C) $\frac{\sigma}{\epsilon_0} \left(1 - \frac{1}{\sqrt{2}} \right) R$

(D) $\frac{\sigma}{4\epsilon_0} R$

5. **B**



6. Consider a thin conducting shell of radius r carrying total charge q . Two point charges q and $2q$ are placed on points A and B, which are at distances $0.5r$ and $2r$ from the centre C of the shell respectively. If the shell is earthed, how much charge will flow to the earth?
 (A) $2q$
 (B) $3q$
 (C) $4q$
 (D) More than $2q$ and less than $3q$



6. **B**

(Multi Correct Choice Type)

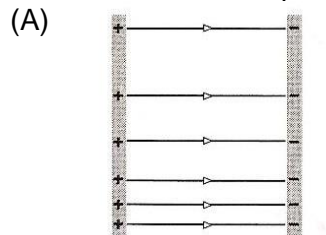
This section contains 6 **multiple choice questions**. Each question has four choices (A), (B), (C) and (D) out of which **ONE OR MORE** may be correct.

7. When a charge of amount Q is given to an isolated metal plate X of surface area A , its surface charge density becomes σ_1 . When an isolated identical plate Y is brought close to X, the surface charge density on X becomes σ_2 . When Y is earthed, the surface charge density becomes σ_3

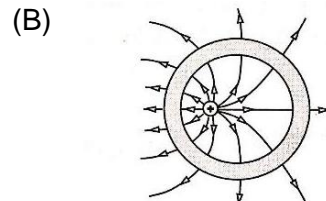
(A) $\sigma_1 = \frac{Q}{A}$ (B) $\sigma_1 = \frac{Q}{2A}$ (C) $\sigma_1 = \sigma_2$ (D) $\sigma_3 = \frac{Q}{A}$

7. **BC**

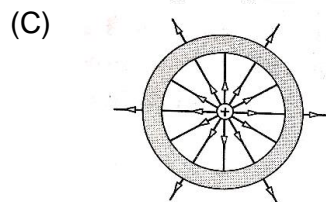
8. In the following figures, electric field lines of some electrostatic fields are shown. Which of them are incorrect representations?



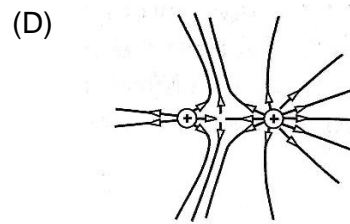
Two infinitely large charged layers



Point charge in a neutral conducting shell



Point charge in a neutral conducting shell



Two unequal point charges

8. **ABC**

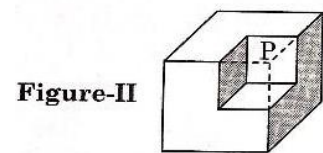
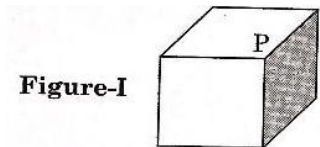
9. Three identical electric dipoles are arranged parallel to each other at equal separations as shown in the figure. The separation between the charges of a dipole is negligible as compared to the separation between the dipoles. In the given configuration, total electrostatic interaction energy of these dipoles is U_0 . Now one of the end dipole is gradually reversed, how much work is done by the electric forces?



- (A) $\frac{17U_0}{18}$ (B) $-\frac{17U_0}{18}$ (C) $\frac{18U_0}{17}$ (D) $-\frac{18U_0}{17}$

9. **C**

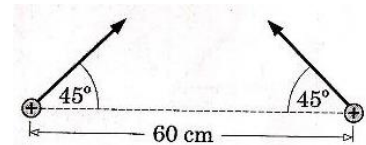
10. Consider a cube as shown in the figure-I, with uniformly distributed charge in its entire volume. Intensity of electrical field and potential at one of its vertex P are E_0 and V_0 respectively. A portion of half the size (half edge length) of the original cube is cut and removed as shown in the figure-II. Find modulus of electric field and potential at the point P in the new structure.



- (A) $\frac{E_0}{2}$ and $\frac{3V_0}{4}$ (B) $\frac{3E_0}{4}$ and $\frac{V_0}{2}$
 (C) $\frac{3E_0}{4}$ and $\frac{7V_0}{8}$ (D) $\frac{7E_0}{8}$ and $\frac{7V_0}{8}$

10. **A**

11. Two identical point charges are moving in free space, when they are 60 cm apart their velocity vectors are equal in modulus and make angles of 45° from the line joining them as shown in the figure. If at this instant, their total kinetic energy is equal to their potential energy, what will be the distance of closest approach between them?



- (A) 20 cm (B) 30 cm
 (C) 40 cm (D) 45 cm

11. **C**

12. A capacitor of capacitance C is charged by a cell of emf ' V '. Then work done by an agent to double the separation between the plates is

- (A) $\frac{1}{4}CV^2$ when the cell is not removed (B) $\frac{1}{2}CV^2$ when the cell is not removed
 (C) $\frac{1}{4}CV^2$ when the cell is removed (D) $\frac{1}{2}CV^2$ when the cell is removed

12. **AD**

PART – B (Numerical based)

1. Two point charges $+8q$ and $-2q$ are located at $x = 0$ and $x = L$ respectively the location of a point on the x -axis at which the electric field due to these point change in zero is equal to nL . Find the value of ' n '.

1. **2**

2. A capacitor is made by stacking 10 equally spaced plates connected alternatively. If the capacitance between any two adjacent plates is C then the resultant capacitance is nC . Find the value of ' n '.

2. **9**

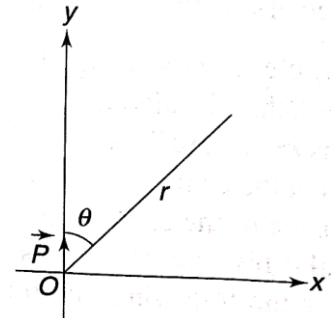
3. Two identical positive charges Q each, are placed on the x axis at points $(-a, 0)$ and $(a, 0)$. A point charge of magnitude q is placed at the origin. For small displacement along x axis, the charge q executes simple harmonic motion if it is positive and its time period is T_1 . If the charge q is negative, it performs oscillations when displaced along y axis. In this case the time period of small oscillation is T_2 . Find $\frac{T_2}{T_1}$.

3. **1.41**
Range: 1.40 to 1.42

4. Three conducting concentric spherical shell of radii R , $2R$ and $3R$ carry some charge on them. The potential at the centre is 50 V and that of middle and outer shell is 20 V and 10 V respectively. Find the potential of the inner shell.

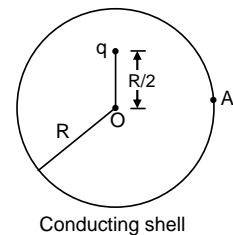
4. **50**

5. A short electric dipole is placed at the origin of the Co-ordinate system with its dipole moment P along y direction. Give answer to following questions for points which are at large distance r from the origin in x - y plane. [r is large compared to length of the dipole]. For $(0 < \theta < 90^\circ)$ all the points, where electric field due to the dipole is parallel to x -axis, fall on a straight line. Find the slope of the line.



5. **0.707**
Range: 0.70 to 0.71

6. As shown in figure. The value of $\int_0^A \vec{E} \cdot d\vec{l}$ be
 ($q = 10^{-9}$ C and $R = 4$ m)

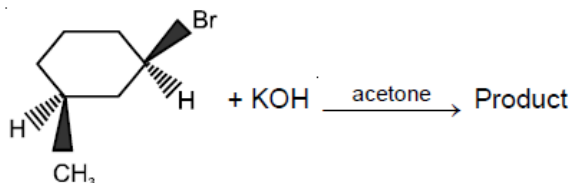


6. **2.25**

SECTION-2 : CHEMISTRY**PART – A****(Single Correct Choice Type)**

This section contains 6 multiple choice questions. Each question has four choices (A), (B), (C) and (D) out of which **ONLY ONE** is correct.

1.



(1R, 3S)-Cis-1-Bromo-3-methylcyclohexane.

The product formed in the reaction is

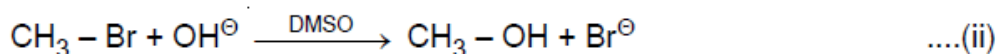
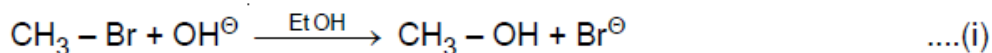
- (A) (1R, 3S)-Cis-3-methyl cyclohexanol (B) (1S, 3S)-Cis-3-methyl cyclohexanol
(C) (1S, 3S)-Trans-3-methyl cyclohexanol (D) (1R, 3R)-Trans-3-methyl cyclohexanol

1.

C

2.

Consider the following reactions, which are carried out at the same temperature.



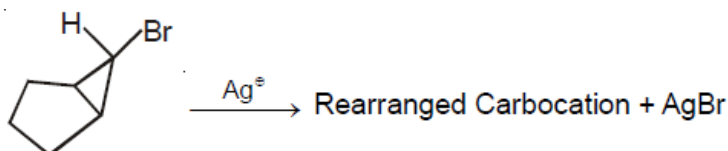
Which of the following statement is correct about these reactions.

- (A) Both the reactions take place at the same rate
(B) The first reaction takes place faster than second reaction.
(C) The second reaction takes place faster than first reaction.
(D) Both the reactions take place by $\text{S}_{\text{N}}1$ mechanism

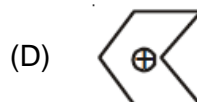
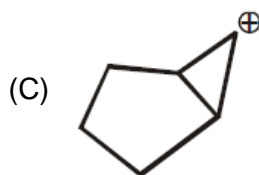
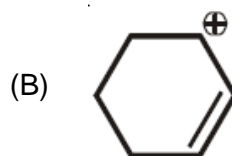
2.

C

3.



Rearranged carbocation is :

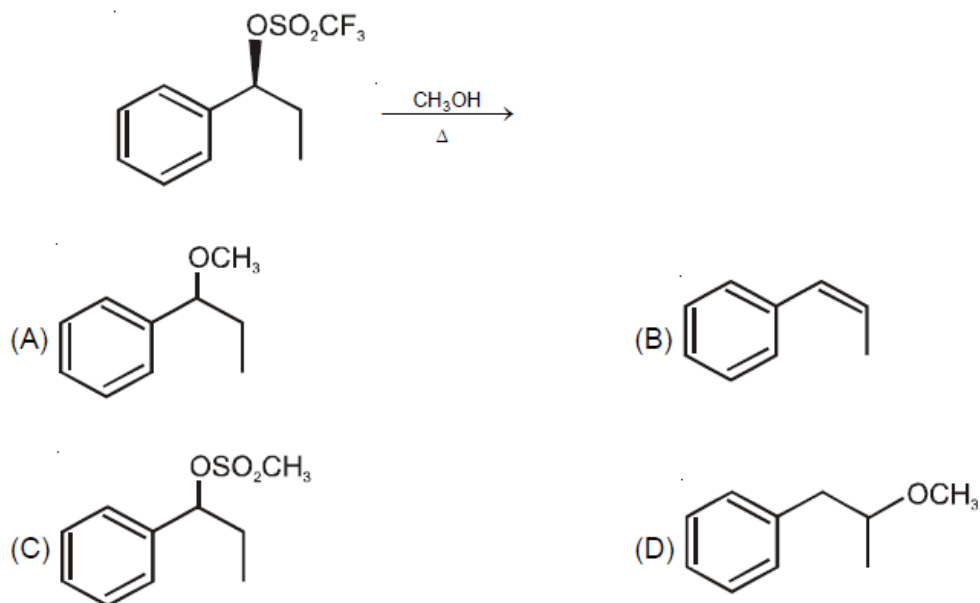


3.

B

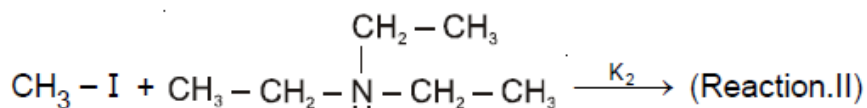
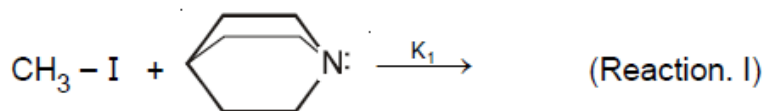
4.

Which product would be expected to predominate in the given reaction ?



4. A

5.

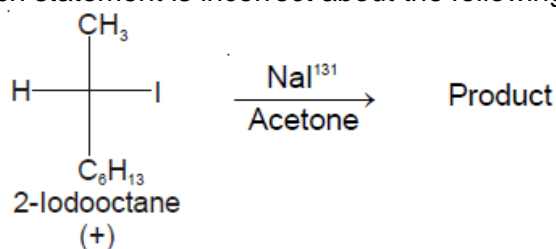


Which of the following statement is correct. ?

- (A) Rate of reaction in I is less than reaction II.
 (B) Rate of reaction in I is more than reaction II.
 (C) Rate of reaction is equal in both reaction.
 (D) Rate does not depend upon concentration of nucleophile.

5. B

6. Which statement is incorrect about the following reaction?

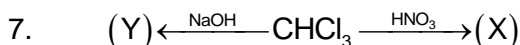


- (A) The rate of these reaction depends on both $[\text{R-I}]$ and $[\text{}^{131}\text{I}^-]$
 (B) Loss of optical activity was twice as fast as gain of radioactivity.
 (C) Each molecule undergoing substitution, suffers Inversion of configuration
 (D) Final solution has radioactive iodine only

6. D

(Multi Correct Choice Type)

This section contains 6 **multiple choice questions**. Each question has four choices (A), (B), (C) and (D) out of which **ONE OR MORE** may be correct.

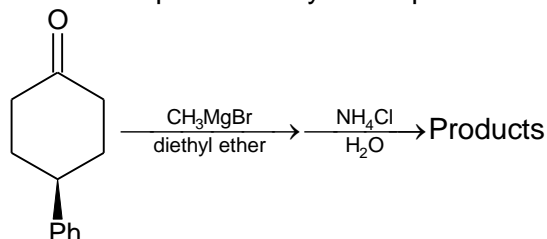


Choose correct statement(s) regarding the product(s) 'X' and 'Y'

- (A) 'X' is used as a tear gas
 (B) Heating of 'Y' in presence of sodalime produces H_2 gas
 (C) 'Y' contains alcoholic functional group
 (D) Formula of 'X' is CH_2Cl_2

7. AB

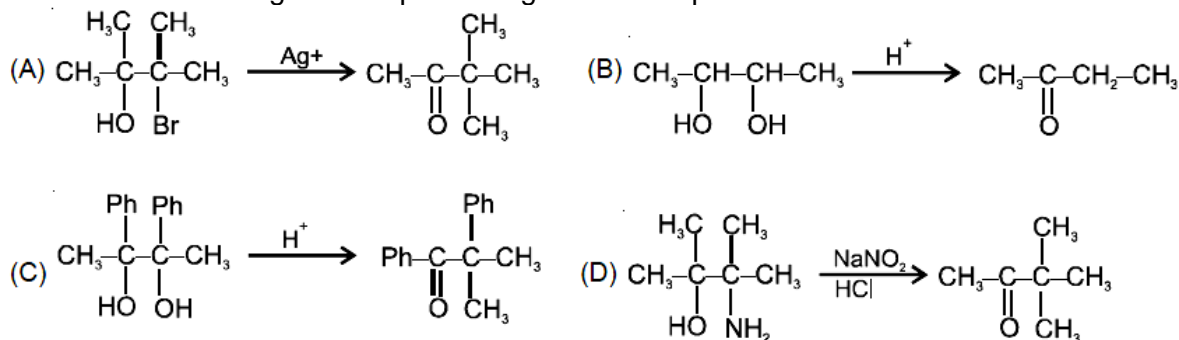
8. Comment on optical activity of the products of the following reaction:



- (A) They form a racemic mixture
 (B) They are meso forms
 (C) They are diastereomers
 (D) They are optically inactive due to absence of

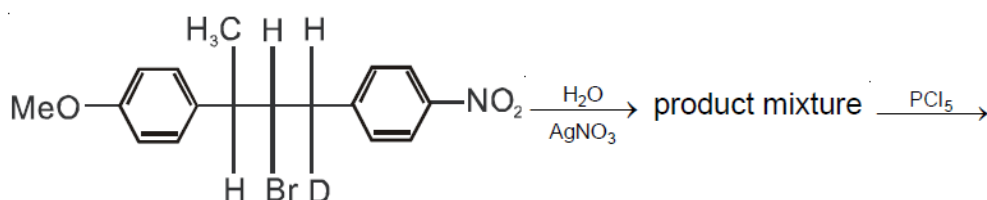
8. BD

9. Which of the following is/are representing the correct product?



9. ABD

10.

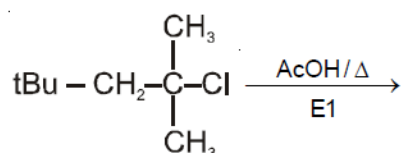


No of product 'm' (Total isomers) $\xrightarrow[\text{fractional distillation}]{}$ No. of Fractions 'n'.

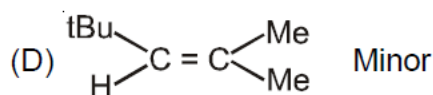
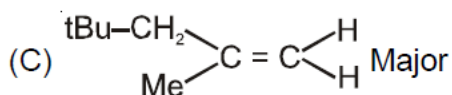
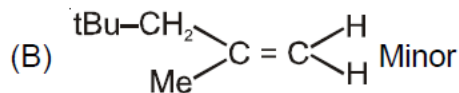
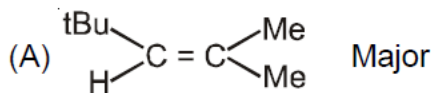
- (A) Value of m & n are 4, 2 respectively.
 (B) Product mixture, and all fractions are optically active.
 (C) Value of m & n are 4, 4 respectively.
 (D) Reaction of product mixture with PCl_5 is $\text{S}_{\text{N}}2$ mechanism

10. BD

11.

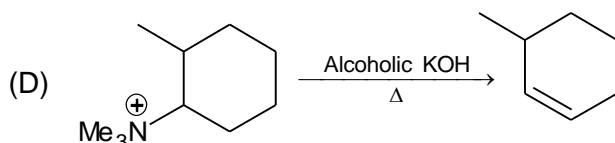
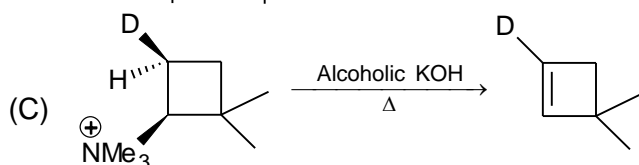
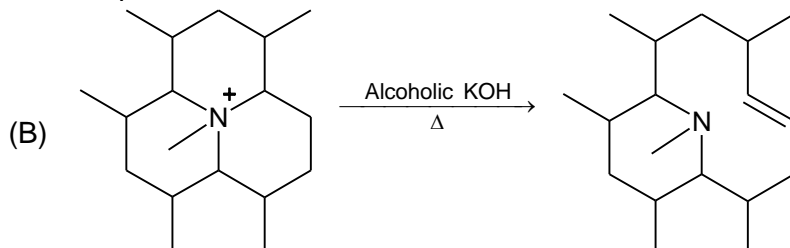
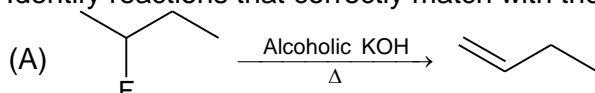


The products of the above reaction?



11. CD

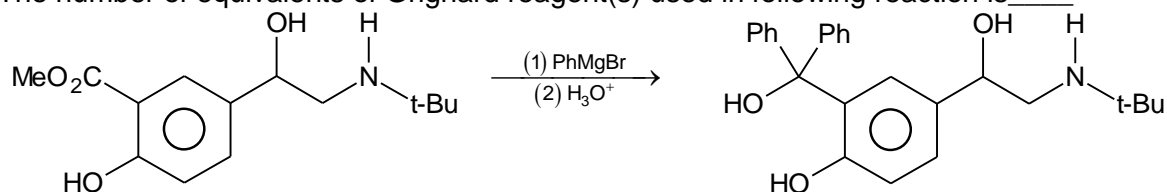
12. Identify reactions that correctly match with their products



12. ABCD

PART – B (Numerical based)

1. The number of equivalents of Grignard reagent(s) used in following reaction is _____



1. 5

2. When (S)-2-chloropentane reacts with NaOH in 75 percent EtOH and 25 percent acetone follows rate law:

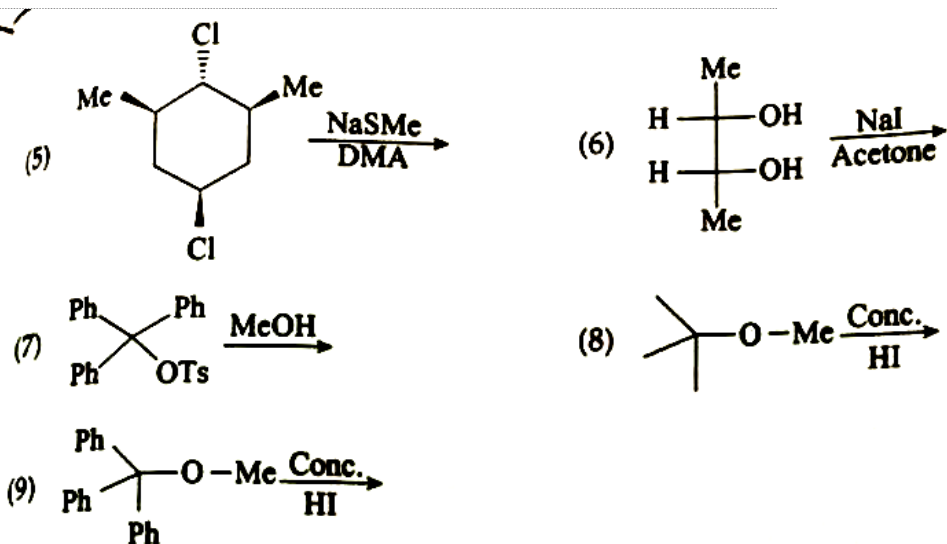
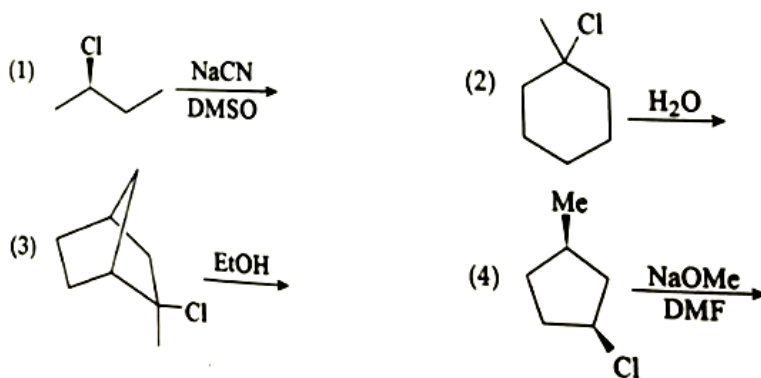
$$\text{Rate} = 2.35 \times 10^{-5} \left[\text{Structure of (S)-2-chloropentane} \right] \cdot [\text{OH}^-] + 5.30 \times 10^{-6} \left[\text{Structure of (R)-2-chloropentane} \right]$$

Then, calculate percentage of S_N1 product when concentration of $[\text{OH}^-] = 1.5$ molar. If percentage of S_N1 product = X, then calculate value of Y is

$$Y = X - 5$$

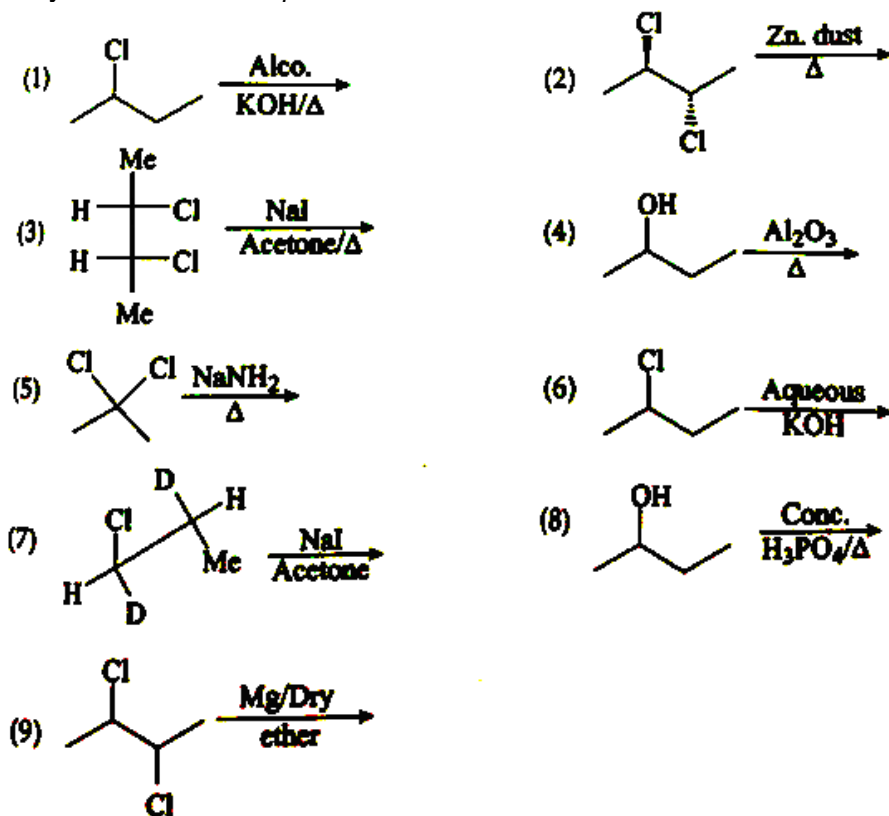
2. 8.23

3. Identify total number of S_N1 reactions



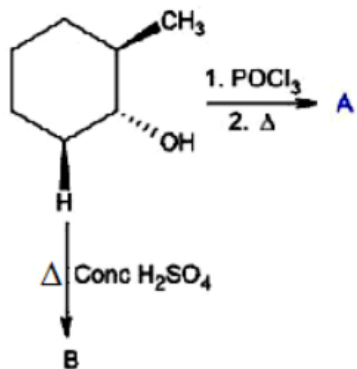
3. 5

4. Identify total number of 'β'-elimination reactions.



4. 6

5. The total number of alkenes excluding stereoisomers obtained in the given reaction are A & B then A + B is equal to



5. 4

6. A compound(A) having molecular formula C₇H₁₁Br is optically active. A reacts with HBr in the absence of peroxide to give isomeric products (B) and (C). Treating(A) with potassium-t-butoxide gives (D). (D) on reductive ozonolysis gives two moles of formaldehyde and one mole of 1, 3 cyclopentane diene. (A) in the presence of peroxide reacts with HBr to give(E). The total number of chiral centres in the above reaction sequence from (A) to (E) are

6. 5

SECTION-3 : MATHEMATICS**PART – A****(Single Correct Choice Type)**

This section contains 6 multiple choice questions. Each question has four choices (A), (B), (C) and (D) out of which **ONLY ONE** is correct.

1. Let $f(x) = x^{11} + x^9 - x^7 + x^3 + 1$ and $f(\sin^{-1}(\sin 8)) = \alpha$, (α is constant).

If $f(\tan^{-1}(\tan 8)) = \lambda - \alpha$, then the value of λ is:

- (A) 2 (B) 3
(C) 4 (D) 1

1. A

2. The solution set of $(\cot^{-1} x)(\tan^{-1} x) + \left(2 - \frac{\pi}{2}\right)\cot^{-1} x - 3\tan^{-1} x - 3\left(2 - \frac{\pi}{2}\right) > 0$, is

- (A) $x \in (\tan 2, \tan 3)$ (B) $x \in (\cot 3, \cot 2)$
(C) $x \in (-\infty, \tan 2) \cup (\tan 3, \infty)$ (D) $x \in (-\infty, \cot 3) \cup (\cot 2, \infty)$

2. B

3. If $\sum_{i=1}^9 (x_i - 5) = 9$ and $\sum_{i=1}^9 (x_i - 5)^2 = 45$, then the standard deviation of the 9 items

x_1, x_2, \dots, x_9 is

- (A) 9 (B) 4
(C) 3 (D) 2

3. D

4. Find median of the following data:

Class Interval	Frequency
130 – 139	4
140 – 149	9
150 – 159	18
160 – 169	28
170 – 179	24
180 – 189	10
190 – 199	7

- (A) 166 (B) 166.5
(C) 167 (D) 166.3

4. D

5. If x_1, x_2, x_3, x_4 are positive roots of the equation $x^4 - 8x^3 + ax^2 - bx + 16 = 0$, then

$\tan^{-1}(x_1) + \tan^{-1}(x_2) + \tan^{-1}(x_3) + \tan^{-1}(x_4)$ is equal to

- (A) $\pi + 4 \tan^{-1} 2$ (B) $4 \tan^{-1} 2$
(C) $\pi - 4 \tan^{-1} 2$ (D) $2 \tan^{-1} 4$

5. B

6. Let $S_n = \cot^{-1}\left(3x + \frac{2}{x}\right) + \cot^{-1}\left(6x + \frac{2}{x}\right) + \cot^{-1}\left(10x + \frac{2}{x}\right) + \dots + n$ terms where $x > 0$. If $\lim_{n \rightarrow \infty} S_n = 1$ then x equals
- (A) $\frac{\pi}{4}$ (B) 1
(C) $\tan 1$ (D) $\cot 1$

6. D

(Multi Correct Choice Type)

This section contains 6 **multiple choice questions**. Each question has four choices (A), (B), (C) and (D) out of which **ONE OR MORE** may be correct.

7. If $f(n) = \cot^{-1}(n+3) - 2\cot^{-1}(n+1) + \cot^{-1}(n-1)$, $n \in \mathbb{N}$, then $\sum_{n=1}^{\infty} f(n)$ is equal to:
- (A) $\sum_{k=1}^3 \tan^{-1}\left(\frac{1}{k}\right)$ (B) $\lim_{x \rightarrow \pi} \frac{-\sin(x)}{\pi - x}$
(C) $\lim_{x \rightarrow 0^+} \cot^{-1}\left(\frac{1}{x}\right)$ (D) $\lim_{x \rightarrow \pi} \frac{\pi(x - \pi)^2}{4(\cos x + 1)}$

7. **AD**

8. Consider, $f(x) = \tan^{-1}\left(\frac{2}{x}\right)$, $g(x) = \sin^{-1}\left(\frac{2}{\sqrt{4+x^2}}\right)$ and $h(x) = \tan(\cos^{-1}(\sin x))$. Identify the correct statement(s):
- (A) For $x > 0$, $(h(f(x)) + h(g(x)))$ is equal to $\frac{4}{x}$
(B) For $x < 0$, $(h(f(x)) + h(g(x)))$ is equal to 0
(C) For $x > 0$, $(h(f(x)) + h(g(x)))$ is equal to x
(D) For $x < 0$, $(h(f(x)) + h(g(x)))$ is equal to $\frac{x}{4}$

8. **BC**

9. Let $\alpha = 3\cos^{-1}\left(\frac{5}{\sqrt{28}}\right) + 3\tan^{-1}\left(\frac{\sqrt{3}}{2}\right)$ and $\beta = 4\sin^{-1}\left(\frac{7\sqrt{2}}{10}\right) - 4\tan^{-1}\left(\frac{3}{4}\right)$, then which of the following does not hold (s) good?
- (A) $\alpha < \pi$ but $\beta > \pi$ (B) $\alpha > \pi$ but $\beta < \pi$
(C) Both α and β are equal (D) $\cos(\alpha + \beta) = 0$

9. **ABD**

10. If $f(x) = \sin^{-1} \sqrt{\frac{\sqrt{1+x^2}-1}{2\sqrt{1+x^2}}}$, then which of the following is (are) correct?
- (A) $f'(-1) = \frac{-1}{4}$ (B) Range of $f(x)$ is $\left[0, \frac{\pi}{2}\right]$
- (C) $f'(x)$ is an odd function (D) $\lim_{x \rightarrow 0} \frac{f(x)}{x} = \frac{1}{2}$
10. AC
11. If $f(r)$ is the minimum value of $\left[\left[\sin^{-1} \left(\frac{2x}{1+x^2} \right) \right] + r \right]$, $x, r \in \mathbb{R}$ where $[k]$ denotes greatest integer less than or equal to k , then
- (A) $\sum_{p=1}^3 f\left(\frac{2p-1}{4}\right) = \frac{3}{4}$
- (B) $\int_{-1}^1 f(x) dx = \frac{1}{2}$
- (C) $y = f(x)$ is non – derivable at exactly 5 points
- (D) area enclosed by $y = f(x)$ and the x – axis is $\frac{3}{4}$ sq. units.
11. ABD
12. If $[y], 2$ and x are the first three terms of a G. P. where x is in the domain of $f(x) = \sec^{-1} x$ and $[k]$ denotes greatest integer less than or equal to k , then identify the correct statement(s)
- (A) Number of such G.P. s are 3
- (B) Number of such G.P. s are 6
- (C) The set of values of y is $[-4, 5] - \{0\}$
- (D) The set of values of y is $[-4, -3] \cup [-2, 0] \cup [1, 3] \cup [4, 5]$
12. BD

PART – B
(Numerical based)

1. Find the number of ordered pairs (x, y) of real numbers satisfying simultaneously the equations $\tan^{-1} x \cdot \sin^{-1} y = \frac{\pi^2}{18}$, $\cot^{-1} x + \cos^{-1} y = \frac{\pi}{2}$
1. 2
2. Let $t(x) = \cot^{-1} \left(\log \left(\sin^{-1} x \cdot \sin^{-1} 2x \cdot \sin \pi x \cdot \sin 2\pi x \cdot \sin 3\pi x \cdot \sin 4\pi x \right) \right)$. If domain of $f(x)$ contains exactly n disjoint open intervals, then find the value of n .
2. 4

3. Let $f(x) = \tan^{-1}(\cot x - 2\cot 2x)$ and $\sum_{r=1}^5 f(r) = a - b\pi$, where $a, b \in \mathbb{N}$. Find the value of $(a+b)$

3. 20

4. If $f(x) = \operatorname{sgn}(kx^2 + (k-3)x + k)$ and $g(x) = \lim_{n \rightarrow \infty} \frac{2}{\pi} \tan^{-1}\left(\left(kx^2 + (k+1)x + k\right)n\right)$ are identical functions, then find the least positive integral value of k .
Note: $\operatorname{sgn}(x)$ denote signum function of x .

4. 2

5. If the solution set of the inequality $\tan^{-1} x + \sin^{-1} x \geq \frac{\pi}{2}$ is $\left[\sqrt{\frac{\lambda-1}{\mu}}, 1\right]$, then find the value of $(\lambda + \mu)$.

5. 7

6. If $\alpha = \lim_{x \rightarrow 0} \cos^{-1}\left(\frac{\{-x^2\}}{x^2 + 2x + 2}\right)$ and $\beta = \lim_{x \rightarrow \infty} \tan^{-1}\left(\frac{e^{-x^2} - e^x}{2e^{-x^2} + e^x}\right)$, then find the value of $\left(1 - \frac{\tan \beta}{\cos \alpha}\right)$.

Note: $\{k\}$ denotes the fractional part function of k .

6. 3

ANSWERS

SECTION-1 : PHYSICS

PART – A

PART – B

SECTION – 2 : CHEMISTRY

PART – A

PART – B

SECTION – 3 : MATHEMATICS

PART – A

PART – B