2024

(CBCS)

(2nd Semester)

CHEMISTRY

SECOND PAPER

(Organic Chemistry—I)

Full Marks : 75

Time : 3 hours

The figures in the margin indicate full marks for the questions

(SECTION : A—OBJECTIVE)

(*Marks* : 10)

Tick (✓) the correct answer in the brackets provided : 1×10=10

1. A temporary displacement of π-electron in a multiple bond towards the atom where the attacking species attached is called

   (a) $+I$ ( )

   (b) $+M$ ( )

   (c) $+E$ ( )

   (d) $-E$ ( )

2. For a concerted endothermic reaction

(a) $\Delta E_{rev} > \Delta E_{for}$ ( )

(b) $\Delta E_{rev} < \Delta E_{for}$ ( )

(c) $\Delta E_{rev} = \Delta E_{for}$ ( )

(d) ΔH is –ve ( )

3. Which of the following is not aromatic?

(a) Cyclopentadienyl anion ( )

(b) Azulene ( )

(c) Cycloheptatriene ( )

(d) [18]Annulene ( )

4. Which type of reaction intermediate is involved in the formation of side chain halogenation of aromatic compound?

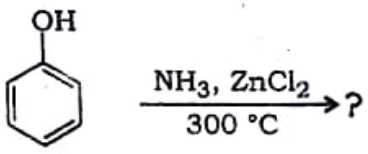
(a) Carbanion ( )

(b) Free radical ( )

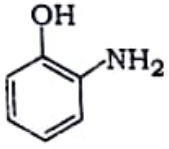
(c) Carbocation ( )

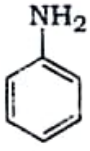
(d) Benzyne ( )

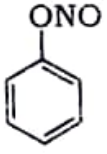
5. The product obtained from the following reaction is



(a) 

(b) 

(c) 

(d) 

6. When phenol is substituted by electron withdrawing group at the *para*-position, acidity will

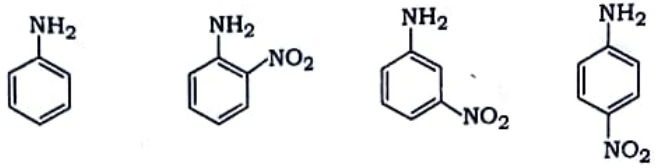
(a) remain the same ( )

(b) increase ( )

(c) decrease ( )

(d) None of the above ( )

7. The increasing order of basicity among the following compounds is



(*I*) (*II*) (*III*) (*IV*)

(a) *I* > *II* > *III* > *IV* ( )

(b) *IV* > *III* > *II* > *I* ( )

(c) *I* > *III* > *IV* > *II* ( )

(d) *III* > *II* > *IV* > *I* ( )

8. Schiff base is obtained by the reaction of aldehyde with

(a) 1°-amine ( )

(b) 2°-amine ( )

(c) 3°-amine ( )

(d) 1°-alcohol ( )

9. S_N2 reaction is favoured by

(a) polar aprotic solvent ( )

(b) polar protic solvent ( )

(c) tertiary alkyl halide ( )

(d) weak nucleophile ( )

10. The reaction of primary alkyl halide with hydroxide generally follows

(a) S_N1 mechanism ( )

(b) S_N2 mechanism ( )

(c) *E*1 mechanism ( )

(d) *E*2 mechanism ( )

(SECTION : B—SHORT ANSWERS)

(*Marks* : 15)

Answer the following : 3×5=15

UNIT—I

1. "Electrophilic substitution of toluene takes place primarily at *ortho-* and *para*-position of the benzene ring." Explain.

OR

2. Explain heterolytic and homolytic bond cleavage by taking suitable examples.

UNIT—II

3. "Cyclooctatetraene is not aromatic but cyclooctatrienyl dianion is aromatic." Explain.

OR

4. What will happen when benzene is treated with formaldehyde and HCl in the presence of $ZnCl_2$ catalyst? Write the chemical reaction.

UNIT—III

5. Draw the structure of carbonyl group (MO diagram) indicating the hybridization involved in them.

OR

6. "Aldehydes are more reactive than ketones towards nucleophile." Explain.

UNIT—IV

7. "Aniline is a weaker base than methyl amine." Explain.

OR

8. What happens when ethyl amine reacts with acetyl chloride? Write the mechanism of the reaction.

UNIT—V

9. Write a note on S_Ni reaction taking suitable example.

OR

10. Explain S_N2 reaction in terms of—

(a) alkyl halide;

(b) molecularity/kinetics;

(c) stereochemistry.

(SECTION : C—DESCRIPTIVE)

(*Marks* : 50)

Answer the following : 10×5=50

UNIT—I

1. *(a)* Draw the electron movement with suitable arrow for the following reactions :

(i) $H_3C-Br \longrightarrow \overset{+}{C}H_3 + Br^-$

(ii) $H-H \longrightarrow 2\dot{H}$

Indicate which one involves heterolytic and homolytic bond breaking. 2+1=3

(b) Which of the following is more acidic and why? 1+3=4

CH_3-COOH *or* O_2N-CH_2-COOH

(c) Draw the potential energy diagram for a simple-concerted exothermic and endothermic reaction with suitable notation. 1½×2=3

OR

2. *(a)* Arrange the following in order of their increasing stability and explain : 1+3=4

$(CH_3)_3\overset{\oplus}{C}$, $(CH_3)_2\overset{\oplus}{C}H$, $CH_3\overset{\oplus}{C}H_2$, $\overset{\oplus}{C}H_3$

(b) "Alcohols are soluble in water but alkanes are not." Explain. 3

(c) What are carbenes? Explain singlet and triplet carbene. 1+2=3

UNIT—II

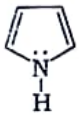
3. *(a)* Explain the stability of benzene and draw its MO picture. 3

(b) State Hückel's rule of aromaticity and indicate whether the following compounds are aromatic or not. Explain : 2+4=6

(i) 

(ii) 

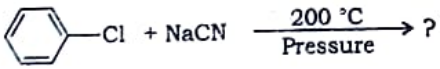
(iii) 

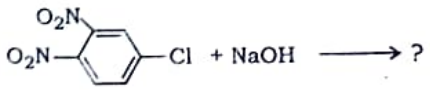
(iv) 

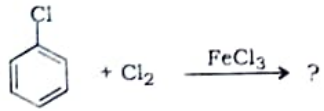
(c) Define resonance energy. 1

OR

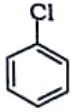
4. *(a)* Predict the products of the following reactions : 2×3=6

(i) 

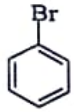
(ii) 

(iii) 

(b) Complete the following reactions with suitable mechanisms (any one) : 4

(i) 

$+ HNO_3 \xrightarrow{H_2SO_4} ?$

(ii) 

$+ SO_3 \xrightarrow{H_2SO_4} ?$

UNIT—III

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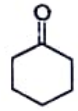
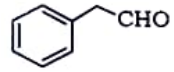
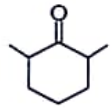
(i) 

$+ HCN \xrightarrow{H^{\oplus}} ?$

(ii) 

$+ NaHSO_3 \longrightarrow ?$

(iii) 

$+ NH_2NH_2 \xrightarrow{H_3O^{\oplus}} ?$

(b) What will happen when acetic acid reacts with ethyl alcohol in acidic medium? Write the chemical reactions. 2

OR

6. (a) How will you obtain carboxylic acid from the following? Write down the chemical equation involved (any *two*) : 2×2=4

(i) Primary alcohols

(ii) Esters

(iii) Carbon dioxide

(b) Explain why *p*-nitrophenol is more acidic than *m*-nitrophenol. 3

(c) Explain *ortho*-effect in the acidity of aromatic carboxylic acids by giving suitable examples. 3

UNIT—IV

7. *(a)* Explain why electrophilic substitution of aniline takes place primarily at *ortho*- and *para*-position of the benzene. 3

(b) Write the nitrous acid test to distinguish between 1°-, 2°- and 3°-amines. 4

(c) Arrange the following amines in their increasing order of basicity. Explain : 3

$$CH_3NH_2,\ (CH_3)_2NH,\ (CH_3)_3N$$

OR

8. *(a)* Describe the Hinsberg's test to distinguish between 1°-, 2°- and 3°-amines. 4

(b) Complete the following reactions : 2×3=6

(i) $R-\dot{N}H_2 + CS_2 \xrightarrow{\Delta} ?$
1°-amine

(ii) $C_2H_5-\dot{N}H_2 + CHCl_3 \xrightarrow[EtOH]{KOH} ?$
Ethyl amine Chloroform

(iii)  $+ \text{aq.}Br_2 \longrightarrow ?$
bromine-water

UNIT—V

9. *(a)* The reaction of *tert*-butyl bromide with hydroxide ion follows *E*2 reaction. Explain the reaction with suitable mechanism. 5

(b) Explain *E*2 reaction in terms of regioselectivity and stereoselectivity. 5

OR

10. *(a)* Differentiate between nucleophile and bases. 3

(b) Explain Saytzeff rule with suitable example of elimination reaction. 3

(c) Explain the mechanisms of *E*1 and *E*2 reactions by taking suitable examples. 4

★ ★ ★

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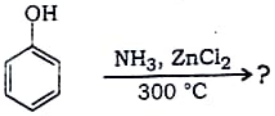
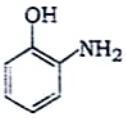
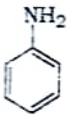
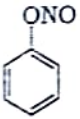


(a) 

(b) 

(c) 

(d) 

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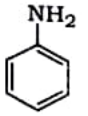
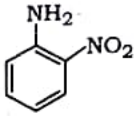
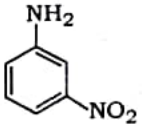


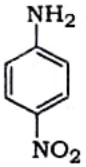
(*I*)



(*II*)



(*III*)



(*IV*)

(a) *I* > *II* > *III* > *IV* ( )

(b) *IV* > *III* > *II* > *I* ( )

(c) *I* > *III* > *IV* > *II* ( )

(d) *III* > *II* > *IV* > *I* ( )

8. Schiff base is obtained by the reaction of aldehyde with

(a) 1°-amine ( )

(b) 2°-amine ( )

(c) 3°-amine ( )

(d) 1°-alcohol ( )

9. S_N2 reaction is favoured by

(a) polar aprotic solvent ( )

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(c) tertiary alkyl halide ( )

(d) weak nucleophile ( )

10. The reaction of primary alkyl halide with hydroxide generally follows

(a) S_N1 mechanism ( )

(b) S_N2 mechanism ( )

(c) *E*1 mechanism ( )

(d) *E*2 mechanism ( )

(SECTION : B—SHORT ANSWERS)

(*Marks* : 15)

Answer the following : 3×5=15

UNIT—I

1. "Electrophilic substitution of toluene takes place primarily at *ortho*- and *para*-position of the benzene ring." Explain.

OR

2. Explain heterolytic and homolytic bond cleavage by taking suitable examples.

UNIT—II

3. "Cyclooctatetraene is not aromatic but cyclooctatrienyl dianion is aromatic." Explain.

OR

4. What will happen when benzene is treated with formaldehyde and HCl in the presence of $ZnCl_2$ catalyst? Write the chemical reaction.

UNIT—III

5. Draw the structure of carbonyl group (MO diagram) indicating the hybridization involved in them.

OR

6. "Aldehydes are more reactive than ketones towards nucleophile." Explain.

UNIT—IV

7. "Aniline is a weaker base than methyl amine." Explain.

OR

8. What happens when ethyl amine reacts with acetyl chloride? Write the mechanism of the reaction.

UNIT—V

9. Write a note on S_Ni reaction taking suitable example.

OR

10. Explain S_N2 reaction in terms of—

(a) alkyl halide;

(b) molecularity/kinetics;

(c) stereochemistry.

(SECTION : C—DESCRIPTIVE)

(*Marks* : 50)

Answer the following : 10×5=50

UNIT—I

1. *(a)* Draw the electron movement with suitable arrow for the following reactions :

(i) $H_3C-Br \longrightarrow \overset{+}{C}H_3 + Br^-$

(ii) $H-H \longrightarrow 2\dot{H}$

Indicate which one involves heterolytic and homolytic bond breaking. 2+1=3

(b) Which of the following is more acidic and why? 1+3=4

CH_3-COOH *or* O_2N-CH_2-COOH

(c) Draw the potential energy diagram for a simple-concerted exothermic and endothermic reaction with suitable notation. 1½×2=3

OR

2. *(a)* Arrange the following in order of their increasing stability and explain : 1+3=4

$(CH_3)_3\overset{\oplus}{C}$, $(CH_3)_2\overset{\oplus}{C}H$, $CH_3\overset{\oplus}{C}H_2$, $\overset{\oplus}{C}H_3$

(b) "Alcohols are soluble in water but alkanes are not." Explain. 3

(c) What are carbenes? Explain singlet and triplet carbene. 1+2=3

UNIT—II

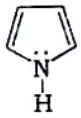
3. *(a)* Explain the stability of benzene and draw its MO picture. 3

(b) State Hückel's rule of aromaticity and indicate whether the following compounds are aromatic or not. Explain : 2+4=6

(i) 

(ii) 

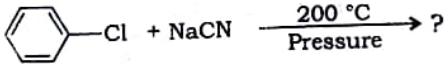
(iii) 

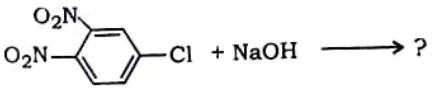
(iv) 

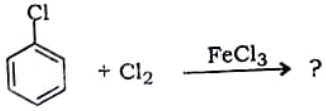
(c) Define resonance energy. 1

OR

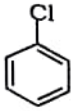
4. *(a)* Predict the products of the following reactions : 2×3=6

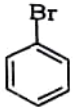
(i) 

(ii) 

(iii) 

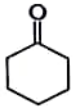
(b) Complete the following reactions with suitable mechanisms (any *one*) : 4

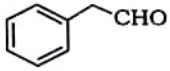
(i)  + HNO_3 $\xrightarrow{H_2SO_4}$?

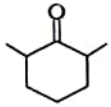
(ii)  + SO_3 $\xrightarrow{H_2SO_4}$?

UNIT—III

5. (a) Complete the following reactions with proper mechanisms (any *two*) : 4×2=8

(i)  + HCN $\xrightarrow{H^{\oplus}}$?

(ii)  + $NaHSO_3$ ⟶ ?

(iii)  + NH_2NH_2 $\xrightarrow{H_3O^{\oplus}}$?

(b) What will happen when acetic acid reacts with ethyl alcohol in acidic medium? Write the chemical reactions. 2

OR

6. (a) How will you obtain carboxylic acid from the following? Write down the chemical equation involved (any *two*) : 2×2=4

(i) Primary alcohols

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(iii) Carbon dioxide

(b) Explain why *p*-nitrophenol is more acidic than *m*-nitrophenol. 3

(c) Explain *ortho*-effect in the acidity of aromatic carboxylic acids by giving suitable examples. 3

UNIT—IV

7. *(a)* Explain why electrophilic substitution of aniline takes place primarily at *ortho*- and *para*-position of the benzene. 3

(b) Write the nitrous acid test to distinguish between 1°-, 2°- and 3°-amines. 4

(c) Arrange the following amines in their increasing order of basicity. Explain : 3

$$CH_3NH_2,\ (CH_3)_2NH,\ (CH_3)_3N$$

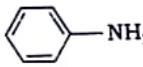
OR

8. *(a)* Describe the Hinsberg's test to distinguish between 1°-, 2°- and 3°-amines. 4

(b) Complete the following reactions : 2×3=6

(i) $R-\dot{N}H_2 + CS_2 \xrightarrow{\Delta} ?$
1°-amine

(ii) $C_2H_5-\dot{N}H_2 + CHCl_3 \xrightarrow[EtOH]{KOH} ?$
Ethyl amine Chloroform

(iii)  $+ \text{aq.}Br_2 \longrightarrow ?$
bromine-water

UNIT—V

9. *(a)* The reaction of *tert*-butyl bromide with hydroxide ion follows *E*2 reaction. Explain the reaction with suitable mechanism. 5

(b) Explain *E*2 reaction in terms of regioselectivity and stereoselectivity. 5

OR

10. *(a)* Differentiate between nucleophile and bases. 3

(b) Explain Saytzeff rule with suitable example of elimination reaction. 3

(c) Explain the mechanisms of *E*1 and *E*2 reactions by taking suitable examples. 4

★★★

2024

(NEP–2020)

(2nd Semester)

MATHEMATICS (MAJOR/MINOR)

(Algebra)

Full Marks : 75

Time : 3 hours

The figures in the margin indicate full marks for the questions

(SECTION : A—OBJECTIVE)

(*Marks* : 10)

Tick (✓) the correct answer in the brackets provided : 1×10=10

1. If $f(x)$ and $g(x)$ are polynomials of degrees m and n respectively, then degree of $f(x) \cdot g(x)$ is

   (a) $m \cdot n$ ( )

   (b) m / n ( )

   (c) $m + n$ ( )

   (d) $m - n$ ( )

2. The value of k for which a polynomial $x^4 - x^3 + kx + 5$ is divisible by $(x+1)$ is

(a) 4 ( )

(b) 5 ( )

(c) 6 ( )

(d) 7 ( )

3. The polynomial $x^2 - x + 1$ is

(a) reducible over R ( )

(b) irreducible over Q ( )

(c) irreducible over C ( )

(d) None of the above ( )

4. The equation

$$x^5 + 2x^4 + 2x^3 + 4x^2 + x + 2 = 0$$

has

(a) no multiple root ( )

(b) one multiple root ( )

(c) two multiple roots ( )

(d) three multiple roots ( )

5. Every algebraic equation of odd degree has

(a) at least one real root ( )

(b) at least one complex root ( )

(c) at least one surd root ( )

(d) None of the above ( )

6. If the signs of the terms of an equation are all positive, then

(a) it has at least one positive root ( )

(b) it cannot have a positive root ( )

(c) it cannot have a negative root ( )

(d) it cannot have any real root ( )

7. The roots of the equation $x^3 - 5x^2 - 4x + 20 = 0$, given that two of its roots are equal in magnitude but are of opposite signs, are

(a) 4, 5 and –5 ( )

(b) –4, 20 and –20 ( )

(c) 5, 4 and –4 ( )

(d) 5, 2 and –2 ( )

8. If α, β, γ are the roots of the equation $x^3 + px^2 + qx + r = 0$, then $\alpha^2 + \beta^2 + \gamma^2$ equals

(a) $-p^2 + 2q$ ( )

(b) $p^2 + 2q$ ( )

(c) $p^2 - 2q$ ( )

(d) $-p^2 - 2q$ ( )

9. If $n = 5$ and $\theta = \frac{\pi}{10}$, then the value of $(\cos\theta + i\sin\theta)^n$ is

(a) i ( )

(b) $-i$ ( )

(c) 0 ( )

(d) 1 ( )

10. The expansion of $\sin n\theta$ in powers of $\cos\theta$ and $\sin\theta$, n being a positive integer, is

(a) $n\cos^{n-1}\theta\sin\theta - \frac{n(n-1)(n-2)}{3!}\cos^{n-3}\theta\sin^3\theta + \frac{n(n-1)(n-2)(n-3)(n-4)}{5!}\cos^{n-5}\theta\sin^5\theta - \cdots$ ( )

(b) $n\cos^{n-1}\theta\sin\theta + \frac{n(n-1)(n-2)}{3!}\cos^{n-3}\theta\sin^3\theta + \frac{n(n-1)(n-2)(n-3)(n-4)}{5!}\cos^{n-5}\theta\sin^5\theta + \cdots$ ( )

(c) $n\cos^{n-1}\theta\sin\theta - \frac{n(n-1)(n-2)}{3!}\cos^{n-3}\theta\sin^3\theta - \frac{n(n-1)(n-2)(n-3)(n-4)}{5!}\cos^{n-5}\theta\sin^5\theta - \cdots$ ( )

(d) $n\cos^{n-1}\theta\sin\theta + \frac{n(n-1)(n-2)}{3!}\cos^{n-3}\theta\sin^3\theta - \frac{n(n-1)(n-2)(n-3)(n-4)}{5!}\cos^{n-5}\theta\sin^5\theta + \cdots$ ( )

(SECTION : B—SHORT ANSWERS)

(*Marks* : 15)

Answer *five* questions, taking at least *one* from each Unit : 3×5=15

UNIT—I

1. If a polynomial $f(x)$ of degree $n > 2$ is divided by $(x-\alpha)^2$, prove that the remainder is $(x-\alpha)f'(\alpha) + f(\alpha)$.

2. Show that $g(x) = 3x^4 + 15x^2 + 10$ is irreducible over the field of rational numbers.

UNIT—II

3. Show that 2 is a multiple root of $x^3 + x^2 - 16x + 20 = 0$ of multiplicity 2.

4. Solve the equation $x^4 - 10x^3 + 29x^2 - 22x + 4 = 0$, given that one root is $(2 + \sqrt{3})$.

UNIT—III

5. Prove that the equation $x^{10} - 4x^6 + x^4 - 2x - 3 = 0$ has at least four imaginary roots.

6. If the sum of two roots of the equation $x^3 + a_1x^2 + a_2x + a_3 = 0$ be zero, show that $a_1a_2 - a_3 = 0$.

UNIT—IV

7. Find the values of the expression $(1 + i)^{1/7}$ using De Moivre's theorem.

8. Expand $\cos 5\theta$ in powers of $\cos\theta$.

(SECTION : C—DESCRIPTIVE)

(*Marks* : 50)

Answer *five* questions, taking at least *one* from each Unit : 10×5=50

UNIT—I

1. *(a)* State and prove the division algorithm for polynomials. 1+7=8

   (b) Find the quotient polynomial and the remainder when $x^3 + 3x^2 - 2x + 5$ is divided by $(x - 2)$. 2

2. *(a)* State and prove the remainder theorem. 1+2=3

   (b) If a polynomial $f(x)$ is divided by $(x - \alpha)(x - \beta)$, $\alpha \neq \beta$, prove that the remainder is

$$\frac{(x - \beta)f(\alpha) - (x - \alpha)f(\beta)}{(\alpha - \beta)}$$

   Using this result, find the remainder when $x^5 - 3x^4 + 4x^2 + x + 4$ is divided by $(x + 1)(x - 2)$. 5+2=7

UNIT—II

3. State the fundamental theorem of algebra. Using it, prove that every algebraic equation of n-th degree has n roots, real or imaginary, and no more. 1+9=10

4. *(a)* Show that if an equation $f(x) = 0$, whose coefficients are all rational quantities, has a surd root of the form $(\alpha + \sqrt{\beta})$, then the conjugate surd $(\alpha - \sqrt{\beta})$ is also a root of the same equation. 5

(b) Show that if an equation $f(x) = 0$ whose coefficients are all real quantities, has a complex number of the form $(\alpha + i\beta)$ as one of its roots, then the conjugate complex number $(\alpha - i\beta)$ is also a root of the same equation. 5

UNIT—III

5. *(a)* Prove that the equation $x^3 + x^2 - 5x - 1 = 0$ has one positive root lying in $(1, 2)$ and two negative roots lying in $(-1, 0)$ and $(-3, -2)$. 4

(b) Show that if the equation $x^3 - ax^2 + bx - c = 0$ has a pair of roots of the form $\alpha(1 \pm i)$, where α is real and $i = \sqrt{-1}$, then $(a^2 - 2b)(b^2 - 2ac) = c^2$. 6

6. *(a)* If $\alpha, \beta, \gamma, \delta$ are the roots of the equation $x^4 + px^3 + qx^2 + rx + s = 0$, show that $(1 + \alpha^2)(1 + \beta^2)(1 + \gamma^2)(1 + \delta^2) = (1 - q + s)^2 + (p - r)^2$. 5

(b) If α, β, γ are the roots of the equation $2x^3 + x^2 + x + 1 = 0$, find the equation whose roots are $\frac{1}{\beta^3} + \frac{1}{\gamma^3} - \frac{1}{\alpha^3}, \frac{1}{\gamma^3} + \frac{1}{\alpha^3} - \frac{1}{\beta^3}, \frac{1}{\alpha^3} + \frac{1}{\beta^3} - \frac{1}{\gamma^3}$. 5

UNIT—IV

7. State and prove De Moivre's theorem. 1+9=10

8. *(a)* Solve $x^3 - 30x + 133 = 0$ by Cardan's method. 5

(b) Solve the cubic equation $x^3 - 6x - 9 = 0$ by Cardan's method. 5

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