HYDROCARBONS - QUESTIONS COMPILATION

Class 11 Chemistry - NCERT In-text & Exercise Questions

IN-TEXT QUESTIONS

Problem 9.1

Write structures of different chain isomers of alkanes corresponding to the molecular formula C_6H_{14}. Also write their IUPAC names.

Solution:

(i) $CH_3 – CH_2 – CH_2 – CH_2 – CH_2 – CH_3$

n-Hexane

(ii)
$$CH_3 – \underset{\displaystyle CH_3}{\underset{|}{CH}} – CH_2 – CH_2 – CH_3$$

2-Methylpentane

(iii)
$$CH_3 – CH_2 – \underset{\displaystyle CH_3}{\underset{|}{CH}} – CH_2 – CH_3$$

3-Methylpentane

(iv)
$$CH_3 – \underset{\displaystyle CH_3}{\underset{|}{CH}} – \underset{\displaystyle CH_3}{\underset{|}{CH}} – CH_3$$

2,3-Dimethylbutane

(v) $CH_3 – C(CH_3) – CH_2 – CH_3$

2,2-Dimethylbutane

Problem 9.2

Write structures of different isomeric alkyl groups corresponding to the molecular formula C_5H_{11}. Write IUPAC names of alcohols obtained by attachment of –OH groups at different carbons of the chain.

Solution:

Structures of $-C_5H_{11}$ group	Corresponding alcohols	Name of alcohol
(i) $CH_3–CH_2–CH_2–CH_2–CH_2–$	$CH_3–CH_2–CH_2–CH_2–CH_2–OH$	Pentan-1-ol
(ii) $CH_3–CH(–CH_2–CH_2–CH_3)–$	$CH_3–CH(–CH_2–CH_2–CH_3)–OH$	Pentan-2-ol
(iii) $CH_3–CH_2–CH(–CH_2–CH_3)–$	$CH_3–CH_2–CH(–CH_2–CH_3)–OH$	Pentan-3-ol
(iv) $CH_3–CH(–CH_2–CH_2–)–CH_3$	$CH_3–CH(–CH_2–CH_2–OH)–CH_3$	3-Methylbutan-1-ol
(v) $CH_3–CH_2–CH(–CH_2–)–CH_3$	$CH_3–CH_2–CH(–CH_2–OH)–CH_3$	2-Methylbutan-1-ol
(vi) $CH_3–C(–CH_2–CH_3)–CH_3$	$CH_3–C(–CH_2–CH_3)(–OH)–CH_3$	2-Methylbutan-2-ol
(vii) $CH_3–C(–CH_2–)–CH_3$	$CH_3–C(–CH_2–OH)–CH_3$	2,2-Dimethylpropan-1-ol
(viii) $CH_3–CH(–CH_3)–CH(–)–CH_3$	$CH_3–CH(–CH_3)–CH(OH)–CH_3$	3-Methylbutan-2-ol

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Problem 9.3

Write IUPAC names of the following compounds:

(i) $(CH_3)_3C\ CH_2C(CH_3)_3$
(ii) $(CH_3)_2C(C_2H_5)_2$
(iii) tetra–tert-butylmethane

Solution:

(i) **2,2,4,4-Tetramethylpentane**

(ii) **3,3-Dimethylpentane**

(iii) **3,3-Di-tert-butyl-2,2,4,4-tetramethylpentane**

Problem 9.4

Write structural formulas of the following compounds:

(i) 3,4,4,5–Tetramethylheptane
(ii) 2,5-Dimethylhexane

Solution:

(i) $CH_3–CH_2–CH(CH_3)–C(CH_3)_2–CH(CH_3)–CH_2–CH_3$

(ii) $CH_3–CH(CH_3)–CH_2–CH_2–CH(CH_3)–CH_3$

Problem 9.5

Write structures for each of the following compounds. Why are the given names incorrect? Write correct IUPAC names.

(i) 2-Ethylpentane
(ii) 5-Ethyl-3-methylheptane

Solution:

(i) $CH_3–CH(C_2H_5)–CH_2–CH_2–CH_3$

Longest chain is of six carbon atoms and not that of five. Hence, correct name is **3-Methylhexane**.

(ii) $CH_3–CH_2–CH(C_2H_5)–CH_2–CH(CH_3)–CH_2–CH_3$ (7 6 5 4 3 2 1)

Numbering is to be started from the end which gives lower number to ethyl group. Hence, correct name is **3-ethyl-5-methylheptane**.

Problem 9.6

Sodium salt of which acid will be needed for the preparation of propane? Write chemical equation for the reaction.

Solution:

Butanoic acid

$CH_3CH_2CH_2COO^-Na^+ + NaOH \xrightarrow{CaO/\Delta} CH_3CH_2CH_3 + Na_2CO_3$

Problem 9.7

Write IUPAC names of the following compounds:

(i) $(CH_3)_2CH–CH=CH–CH_2–CH_3$

$CH_3–CH–CH_3$

C_2H_5

(ii) $CH_3CH_2CH_2CH_2CH=CH–CH=CH–CH=CH–CH=CH_2$

(iii) $CH_2=C(CH_2CH_2CH_3)_2$

(iv) $CH_3CH_2CH_2CH_2CH_2CH_3$

$CH_3–CHCH=C–CH_2–CHCH_3$

CH_3

Solution:

(i) **2,8-Dimethyl-3,6-decadiene**

(ii) **1,3,5,7-Octatetraene**

(iii) **2-n-Propylpent-1-ene**

(iv) **4-Ethyl-2,6-dimethyl-dec-4-ene**

Problem 9.8

Calculate number of sigma (σ) and pi (π) bonds in the above structures (i-iv).

Solution:

(i) σ bonds: **33**, π bonds: **2**

(ii) σ bonds: **17**, π bonds: **4**

(iii) σ bonds: **23**, π bonds: **1**

(iv) σ bonds: **41**, π bonds: **1**

Problem 9.9

Write structures and IUPAC names of different structural isomers of alkenes corresponding to C_5H_{10}.

Solution:

(a) $CH_2=CH–CH_2–CH_2–CH_3$

Pent-1-ene

(b) $CH_3–CH=CH–CH_2–CH_3$

Pent-2-ene

(c) $CH_3–C(CH_3)=CH–CH_3$

2-Methylbut-2-ene

(d) $CH_3–CH(CH_3)–CH=CH_2$

3-Methylbut-1-ene

(e) $CH_2=C(CH_3)–CH_2–CH_3$

2-Methylbut-1-ene

Problem 9.10

Draw cis and trans isomers of the following compounds. Also write their IUPAC names:

(i) CHCl=CHCl
(ii) $C_2H_5CCH_3=CCH_3C_2H_5$

Solution:

(i) **Cis-1,2-dichloroethene** and **Trans-1,2-dichloroethene**

(ii) **Cis-3,4-dimethylhex-3-ene** and **Trans-3,4-dimethylhex-3-ene**

Problem 9.11

Which of the following compounds will show cis-trans isomerism?

(i) $(CH_3)_2C=CH–C_2H_5$
(ii) $CH_2=CBr_2$
(iii) $C_6H_5CH=CH–CH_3$
(iv) $CH_3CH=CClCH_3$

Solution:

(iii) and (iv) will show cis-trans isomerism.

In structures (i) and (ii), two identical groups are attached to one of the doubly bonded carbon atoms.

Problem 9.12

Write IUPAC names of the products obtained by addition reactions of HBr to hex-1-ene:

(i) in the absence of peroxide
(ii) in the presence of peroxide

Solution:

(i) **2-Bromohexane** (following Markovnikov's rule)

(ii) **1-Bromohexane** (following anti-Markovnikov's rule)

Problem 9.13

Write structures of different isomers corresponding to the 5th member of alkyne series. Also write IUPAC names of all the isomers. What type of isomerism is exhibited by different pairs of isomers?

Solution:

5th member of alkyne has the molecular formula $\mathbf{C_6H_{10}}$. The possible isomers are:

(a) $HC\equiv C–CH_2–CH_2–CH_2–CH_3$
Hex-1-yne

(b) $CH_3–C\equiv C–CH_2–CH_2–CH_3$
Hex-2-yne

(c) $CH_3–CH_2–C\equiv C–CH_2–CH_3$
Hex-3-yne

(d) $HC\equiv C–CH(CH_3)–CH_2–CH_3$

CH_3

3-Methylpent-1-yne

(e) $HC\equiv C–CH_2–CH(CH_3)–CH_3$

4-Methylpent-1-yne

(f) $CH_3–C\equiv C–CH(CH_3)–CH_3$

4-Methylpent-2-yne

(g) $HC\equiv C–C(CH_3)_2–CH_3$

3,3-Dimethylbut-1-yne

Type of Isomerism: Position and chain isomerism are exhibited by different pairs.

Problem 9.14

How will you convert ethanoic acid into benzene?

Solution:

$CH_3COOH \xrightarrow{CaO/\Delta} CH_4 \xrightarrow{1773K} C_2H_2 \xrightarrow{Fe/873K} C_6H_6$

(Decarboxylation) (Pyrolysis) (Cyclic polymerization)

EXERCISE QUESTIONS

9.1

How do you account for the formation of ethane during chlorination of methane?

Answer: During chlorination of methane, ethane is formed as a by-product through the termination step of the free radical mechanism:

Termination step: $CH_3\bullet + CH_3\bullet \rightarrow CH_3–CH_3$ (Ethane)

Two methyl free radicals combine to form ethane molecule.

9.2

Write IUPAC names of the following compounds:

(a) $CH_3CH=C(CH_3)_2$
(b) $CH_2=CH-C\equiv C-CH_3$
(c) $(CH_3)_3CCH=CH_2$
(d) $–CH_2–CH_2–CH=CH_2$
(e) $CH_3(CH_2)_4CH(CH_2)_3CH_3$
|
$CH_2–CH(CH_3)_2$
(f) $CH_3CH_2CH_2CH_2CH_2CH_3$
(g) $CH_3–CH=CH–CH_2–CH=CH–CH–CH_2–CH=CH_2$
|
C_2H_5

Answer:

(a) **2-Methylprop-1-ene**
(b) **Pent-1-en-4-yne**
(c) **3,3-Dimethylbut-1-ene**
(d) **But-1-ene**
(e) **5-(3-Methylbutyl)decane**
(f) **Hexane**
(g) **7-Ethyldeca-1,5,9-triene**

9.3

For the following compounds, write structural formulas and IUPAC names for all possible isomers having the number of double or triple bond as indicated:

(a) C_4H_8 (one double bond)
(b) C_5H_8 (one triple bond)

Answer:

(a) C_4H_8 (one double bond):

1. CH_2=CH–CH_2–CH_3 (**But-1-ene**)
2. CH_3–CH=CH–CH_3 (**But-2-ene**) - shows cis-trans isomerism
3. CH_2=C(CH_3)–CH_3 (**2-Methylprop-1-ene**)

(b) C_5H_8 (one triple bond):

1. HC≡C–CH_2–CH_2–CH_3 (**Pent-1-yne**)
2. CH_3–C≡C–CH_2–CH_3 (**Pent-2-yne**)
3. HC≡C–CH(CH_3)–CH_3 (**3-Methylbut-1-yne**)

9.4

Write IUPAC names of the products obtained by the ozonolysis of the following compounds:

(i) Pent-2-ene
(ii) 3,4-Dimethylhept-3-ene
(iii) 2-Ethylbut-1-ene
(iv) 1-Phenylbut-1-ene

Answer:

(i) **Ethanal and propanal**

(ii) **Butanone and 2-methylbutanone**

(iii) **Methanal and 2-ethylpropanal**

(iv) **Benzaldehyde and propanal**

9.5

An alkene 'A' on ozonolysis gives a mixture of ethanal and pentan-3-one. Write structure and IUPAC name of 'A'.

Answer:

The alkene 'A' is: **CH_3–CH_2–CH=CH–CH_2–CH_2–CH_3**

IUPAC name: **Hept-3-ene**

9.6

An alkene 'A' contains three C–C, eight C–H σ bonds and one C–C π bond. 'A' on ozonolysis gives

two moles of an aldehyde of molar mass 44 u. Write IUPAC name of 'A'.

Answer:

Aldehyde with molar mass 44 u = **Ethanal (CH_3CHO)**

Since two moles of ethanal are formed, the alkene must be: **$CH_3–CH=CH–CH_3$**

IUPAC name: **But-2-ene**

9.7

Propanal and pentan-3-one are the ozonolysis products of an alkene? What is the structural formula of the alkene?

Answer:

The structural formula of the alkene is:

$CH_3–CH_2–CH=CH–CH_2–CH_2–CH_3$

IUPAC name: **Hept-3-ene**

9.8

Write chemical equations for combustion reaction of the following hydrocarbons:

(i) Butane
(ii) Pentene
(iii) Hexyne
(iv) Toluene

Answer:

(i) $2C_4H_{10} + 13O_2 \rightarrow 8CO_2 + 10H_2O$

(ii) $C_5H_{10} + 15/2\ O_2 \rightarrow 5CO_2 + 5H_2O$

(iii) $2C_6H_{10} + 17O_2 \rightarrow 12CO_2 + 10H_2O$

(iv) $C_7H_8 + 9O_2 \rightarrow 7CO_2 + 4H_2O$

9.9

Draw the cis and trans structures of hex-2-ene. Which isomer will have higher b.p. and why?

Answer:

Cis-hex-2-ene: $CH_3–CH_2–CH_2–CH_2–C=C–H$ (with CH_3 groups on same side)
Trans-hex-2-ene: $CH_3–CH_2–CH_2–CH_2–C=C–H$ (with CH_3 groups on opposite sides)

Cis-isomer will have higher boiling point because:

- Cis form has higher dipole moment due to polar bonds on same side
- Stronger intermolecular forces require more energy to overcome

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9.10

Why is benzene extraordinarily stable though it contains three double bonds?

Answer:

Benzene is extraordinarily stable due to:

1. **Resonance stabilization:** Six π electrons are delocalized over the entire benzene ring

2. **Equal bond lengths:** All C-C bonds are equivalent (139 pm) - intermediate between single and double bonds
3. **Aromatic character:** Follows Hückel's rule with (4n+2) = 6π electrons where n=1
4. **Planar structure:** All carbons are sp^2 hybridized, allowing maximum orbital overlap
5. **Symmetrical electron distribution:** Lower energy compared to localized double bonds

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9.11

What are the necessary conditions for any system to be aromatic?

Answer:

The necessary conditions for aromaticity are:

1. **Planarity:** All atoms must be in the same plane
2. **Cyclic conjugation:** Complete delocalization of π electrons around the ring
3. **Hückel's rule:** Must contain (4n+2)π electrons where n = 0,1,2,3...
4. **Cyclic structure:** Must be a closed ring system

9.12

Explain why the following systems are not aromatic?

(i) Cyclobutadiene
(ii) Cyclohexatriene
(iii) Cyclooctatetraene

Answer:

(i) **Cyclobutadiene (C_4H_4):** Contains 4π electrons, follows 4n rule (n=1), making it antiaromatic

(ii) **Cyclohexatriene:** Not planar, lacks complete conjugation due to sp^3 hybridized carbons

(iii) **Cyclooctatetraene (C_8H_8):** Contains 8π electrons, follows 4n rule (n=2), making it antiaromatic

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9.13

How will you convert benzene into:

(i) p-nitrobromobenzene
(ii) m-nitrochlorobenzene
(iii) p-nitrotoluene
(iv) acetophenone

Answer:

(i) **C_6H_6 --$Br_2/FeBr_3$--> C_6H_5Br --HNO_3/H_2SO_4--> p-$BrC_6H_4NO_2$**

(ii) **C_6H_6 --HNO_3/H_2SO_4--> $C_6H_5NO_2$ --$Cl_2/FeCl_3$--> m-$ClC_6H_4NO_2$**

(iii) **C_6H_6 --$CH_3Cl/AlCl_3$--> $C_6H_5CH_3$ --HNO_3/H_2SO_4--> p-$CH_3C_6H_4NO_2$**

(iv) **C_6H_6 --$CH_3COCl/AlCl_3$--> $C_6H_5COCH_3$**

9.14

In the alkane $H_3C–CH_2–C(CH_3)_2–CH_2–CH(CH_3)_2$, identify 1°, 2°, 3° carbon atoms and give the number of H atoms bonded to each one of these.

Answer:

Structure analysis:

- **1° carbons:** 4 (all terminal CH_3 groups) - Each has 3H atoms
- **2° carbons:** 2 (CH_2 groups) - Each has 2H atoms
- **3° carbons:** 2 (C with 3 other carbons attached) - Each has 1H atom
- **4° carbons:** 1 (central C with 4 other carbons) - Has 0H atoms

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9.15

What effect does branching of an alkane chain have on its boiling point?

Answer:

Branching decreases the boiling point because:

1. **Surface area decreases:** Branched molecules are more spherical
2. **Weaker van der Waals forces:** Less surface contact between molecules
3. **Reduced intermolecular attractions:** Easier to separate molecules
4. **Lower energy required:** Less heat needed for vaporization

Example: n-Butane (b.p. 273K) > Isobutane (b.p. 261K)

9.16

Addition of HBr to propene yields 2-bromopropane, while in the presence of benzoyl peroxide, the same reaction yields 1-bromopropane. Explain and give mechanism.

Answer:

Normal Addition (Markovnikov's Rule): $CH_3–CH=CH_2 + HBr \rightarrow CH_3–CHBr–CH_3$ (2-bromopropane)

Mechanism (Ionic):

1. H^+ attacks double bond forming more stable 2° carbocation
2. Br^- attacks carbocation

Peroxide Effect (Anti-Markovnikov): $CH_3–CH=CH_2$ + HBr --peroxide--> $CH_3–CH_2–CH_2Br$ (1-bromopropane)

Mechanism (Free Radical):

1. **Initiation:** $(C_6H_5CO)_2O_2 \rightarrow 2C_6H_5COO\bullet \rightarrow 2C_6H_5\bullet + 2CO_2$
2. **Propagation:**
   - $C_6H_5\bullet$ + HBr → C_6H_5H + Br•
   - Br• + $CH_3–CH=CH_2$ → $CH_3–CH\bullet–CH_2Br$ (more stable 2° radical)
   - $CH_3–CH\bullet–CH_2Br$ + HBr → $CH_3–CH_2–CH_2Br$ + Br•

9.17

Write down the products of ozonolysis of 1,2-dimethylbenzene (o-xylene). How does the result support Kekulé structure for benzene?

Answer:

Ozonolysis products:

- **Glyoxal (CHOCHO)**
- **Methylglyoxal (CH_3COCHO)**
- **Biacetyl ($CH_3COCOCH_3$)**

Support for Kekulé structure: The multiple products indicate that benzene doesn't have fixed double bonds as in Kekulé structure. If it had fixed positions, only one product would form. The

multiple products support the resonance hybrid structure with delocalized electrons.

9.18

Arrange benzene, n-hexane and ethyne in decreasing order of acidic behaviour. Also give reason for this behaviour.

Answer:

Acidic order: Ethyne > Benzene > n-Hexane

Reasons:

- **Ethyne:** sp hybridized C-H bonds (50% s-character), most electronegative
- **Benzene:** sp^2 hybridized C-H bonds (33% s-character), moderately acidic
- **n-Hexane:** sp^3 hybridized C-H bonds (25% s-character), least acidic

Higher s-character = Higher electronegativity = More acidic

9.19

Why does benzene undergo electrophilic substitution reactions easily and nucleophilic substitutions with difficulty?

Answer:

Electrophilic substitution (Easy):

- Benzene has high electron density due to delocalized π electrons
- π electrons act as nucleophile, attracting electrophiles
- Substitution maintains aromaticity after proton loss

Nucleophilic substitution (Difficult):

- Benzene ring is electron-rich, repels nucleophiles
- No good leaving groups in benzene
- Would require breaking aromaticity (energetically unfavorable)
- Lacks electron-withdrawing groups to activate the ring

9.20

How would you convert the following compounds into benzene?

(i) Ethyne
(ii) Ethene
(iii) Hexane

Answer:

(i) **$3HC{\equiv}CH \xrightarrow{Fe/873K} C_6H_6$**

(ii) **$3CH_2{=}CH_2 \xrightarrow{1773K} 3HC{\equiv}CH \xrightarrow{Fe/873K} C_6H_6$**

(iii) **$C_6H_{14} \xrightarrow{Cr_2O_3/Al_2O_3/773K} C_6H_6 + 4H_2$** (Aromatization)

9.21

Write structures of all the alkenes which on hydrogenation give 2-methylbutane.

Answer:

2-methylbutane structure: $CH_3–CH(CH_3)–CH_2–CH_3$

Possible alkenes:

1. **$CH_3–C(CH_3)=CH–CH_3$** (2-Methylbut-2-ene)
2. **$CH_3–CH(CH_3)–CH=CH_2$** (3-Methylbut-1-ene)
3. **$CH_2=C(CH_3)–CH_2–CH_3$** (2-Methylbut-1-ene)

9.22

Arrange the following set of compounds in order of their decreasing relative reactivity with an electrophile, E^+

(a) Chlorobenzene, 2,4-dinitrochlorobenzene, p-nitrochlorobenzene
(b) Toluene, p-$H_3C–C_6H_4–NO_2$, p-$O_2N–C_6H_4–NO_2$

Answer:

(a) **Chlorobenzene > p-nitrochlorobenzene > 2,4-dinitrochlorobenzene**

(b) **Toluene > p-$H_3C–C_6H_4–NO_2$ > p-$O_2N–C_6H_4–NO_2$**

Reason: Electron-donating groups activate benzene ring, while electron-withdrawing groups deactivate it.

9.23

Out of benzene, m-dinitrobenzene and toluene which will undergo nitration most easily and why?

Answer:

Toluene will undergo nitration most easily.

Reason:

- **Toluene:** -CH_3 group is electron-donating (activating), increases electron density
- **Benzene:** Neutral reactivity
- **m-dinitrobenzene:** Two -NO_2 groups are strongly electron-withdrawing (deactivating), decreases electron density

Order: Toluene > Benzene > m-dinitrobenzene

9.24

Suggest the name of a Lewis acid other than anhydrous aluminium chloride which can be used during ethylation of benzene.

Answer:

$FeCl_3$ (Ferric chloride) or **$ZnCl_2$ (Zinc chloride)** can be used as Lewis acids.

Reaction: $C_6H_6 + C_2H_5Cl \xrightarrow{FeCl_3} C_6H_5C_2H_5 + HCl$

9.25

Why is Wurtz reaction not preferred for the preparation of alkanes containing odd number of carbon atoms? Illustrate your answer by taking one example.

Answer:

Wurtz reaction is not preferred for odd-carbon alkanes because:

1. **Requires different alkyl halides**
2. **Gives mixture of products**
3. **Side reactions occur**

Example - Preparation of pentane (C_5):

$CH_3CH_2Br + CH_3CH_2CH_2Br + 2Na \rightarrow$ **Mixture of:**

- $CH_3CH_2–CH_2CH_2CH_3$ (Pentane - desired)
- $CH_3CH_2–CH_2CH_3$ (Butane - side product)
- $CH_3CH_2CH_2–CH_2CH_2CH_3$ (Hexane - side product)

Better method: Decarboxylation of hexanoic acid gives pure pentane.

ADDITIONAL PRACTICE QUESTIONS

Short Answer Questions:

Q1. Why do alkenes show geometrical isomerism but alkanes do not?

Q2. Explain why terminal alkynes are acidic in nature.

Q3. What is the difference between σ and π bonds in alkenes?

Q4. Why does benzene give substitution reactions rather than addition reactions?

Q5. Write the mechanism of bromination of benzene.

Long Answer Questions:

Q1. Explain the conformations of ethane with energy profile diagram.

Q2. Discuss the mechanism of addition of HBr to alkenes in presence and absence of peroxides.

Q3. Explain the structure of benzene on the basis of resonance and molecular orbital theory.

Q4. Write detailed mechanism of electrophilic substitution in benzene with suitable example.

Q5. Compare and contrast the chemical properties of alkenes and alkynes.

Note: This compilation includes all in-text problems and back exercise questions from NCERT Class 11 Chemistry Chapter 9: Hydrocarbons. Practice these questions thoroughly for better understanding and exam preparation.