



CHEM · CHEMISTRY

14. Hydrocarbons

Official PMDC Solved Past Paper Topical Booklet · High-Yield Examination Series

64 Solved Questions

2010 to 2024 Archive

Boards: BUMHS, DUHS, KMU, MDCAT, NUMS, PMDC

Weightage: 27% of MDCAT (54 MCQs)

Curated by Ibrahim for fellow bees. Every question in this chapter has been verified against official UHS, NUMS, SZABMU, DUHS, and KMU answer keys. Propolis cognitive autopsies are provided at the end of this booklet to explain core concepts and break down common distractor traps.

OFFICIAL SOLVED EDITION**Q1.**

KMU 2024

The homolytic fission of C-H bond in an alkane results
[ETEA 2024]

- (A) Alkyl free radical
- (B) Carbanion
- (C) Carbocation
- (D) Methylpropane

Q2.

KMU 2024

Addition of HBr to isobutylene mainly gives [ETEA 2024]

- (A) isobutyl bromide
- (B) n-butyl bromide
- (C) sec-butyl bromide
- (D) tert-butyl bromide

Q3.

KMU 2024

The carbon atom carrying positive charge and attached to three other atoms or groups is called
[ETEA 2024]

- (A) Carbanion
- (B) Carbene
- (C) Carbocation
- (D) Oxonium

Q4.

DUHS 2024

In Friedel Craft acylation, an acyl group is introduced in benzene ring in the presence of catalyst: [DUHS 2024]

- (A) AlCl_3
- (B) H_2SO_4
- (C) Sunlight
- (D) V_2O_5

Q5.

DUHS 2024

When an unsymmetrical alkene undergoes addition reactions, the negative part of attacking reagent is added to that double-bonded carbon atom which contains: [DUHS 2024]

- (A) Highest number of chloride atoms
- (B) Lesser number of hydrogen atoms
- (C) Highest number of hydrogen atoms
- (D) Moderate number of hydrogen atoms

Q6.

DUHS 2024

The bond length between C-C in benzene is: [DUHS 2024]

- (A) $1.34\text{\AA}$
- (B) $1.39\text{\AA}$
- (C) $1.56\text{\AA}$
- (D) $1.38\text{\AA}$

Q7.

DUHS 2024

When chlorobenzene reacts with sodium hydroxide at 350°C and 150 atmospheric pressure, it gives rise to the formation of: (out of syllabus) [DUHS 2024]

- (A) Sodium chromate
- (B) Phenol
- (C) Sodium phenoxide
- (D) Sodium sulfate

Q8.

DUHS 2024

The density of benzene is (out of syllabus) [DUHS 2024]

- (A) 0.80 g/cm³
- (B) 0.88 g/cm³
- (C) 0.85 g/cm³
- (D) 0.08 g/cm³

Q9.

BUMHS 2024

Natural gas consist mainly of [BUMHS 2024]

- (A) Butane
- (B) Propane
- (C) Methane
- (D) Ethane

Q10.

BUMHS 2024

_____ is regarded as the simplest and the parent member of aromatic class of compounds. [BUMHS 2024]

- (A) Methanol
- (B) Acetylene
- (C) Benzene
- (D) Acetic acid

Q11.

BUMHS 2024

In alkane series, all the linkages between carbon atoms is _____ bonds [BUMHS 2024]

- (A) Single
- (B) Double
- (C) Triple
- (D) Quadruple

Q12.

BUMHS 2024

Benzene when reacts with chlorine, in presence of sunlight gives additional product. i.e. [BUMHS 2024]

- (A) HCl
- (B) Chloroform
- (C) Hexachlorobenzene
- (D) Polyvinylchloride (PVC)

Q13.

BUMHS 2024

When a hydrogen atom of an alkane is removed, the resulting group is called ____? [BUMHS 2024]

- (A) Aryl
- (B) Alkyl
- (C) Alkenyl
- (D) Phenyl

Q14.

NUMS 2024

Identify the alkene which gives only one type of aldehyde upon ozonolysis: [NUMS 2024]

- (A) 1-Pentene
- (B) 2-Methyl propene
- (C) 2-Butene
- (D) 2,3-Dimethyl-2-butene

Q15.

NUMS 2024

The most readily sulphonated compound is: [NUMS 2024]

- (A) Benzene
- (B) Chlorobenzene
- (C) Nitrobenzene
- (D) Toluene

Q16.

PMDC 2021

Benzene does not show [PMC 2021]

- (A) Addition reactions
- (B) Substitution reactions
- (C) Oxidation reactions
- (D) Elimination reactions

Q17.

PMDC 2021

Which of the following is marsh gas [PMC 2021]

- (A) Ethane
- (B) Propane
- (C) Butane
- (D) Methane

Q18.

PMDC 2021

Which of the following act as electrophile during nitration of benzene? [PMC 2021]

- (A) NO⁺
- (B) NO₃⁺
- (C) HNO₂⁺
- (D) NO₂⁺

Q19.

PMDC 2020

Electrophile in sulphonation of benzene is [NMDCAT 2020]

- (A) HSO_4
 (B) H_2SO_4
 (C) HSO_3
 (D) SO_3

Q20.

PMDC 2020

Acetophenone can be formed by which of the following reaction of benzene? [NMDCAT 2020]

- (A) Alkylation
 (B) Halogenation
 (C) Nitration
 (D) Acylation

Q21.

PMDC 2020

When CH_3 is attached with the benzene ring, it makes the ring: [NMDCAT 2020]

- (A) Good electrophile
 (B) Resonance hybrid
 (C) Extraordinary stable
 (D) Good nucleophile

Q22.

SET 2019

In Friedal Craft's Chlorination of Benzene, Iron III chloride acts as a catalyst, which is the initial reaction in the generation of an electrophile? [SET 2019]

- (A) $\text{Cl}_2 + \text{FeCl}_3 \rightarrow \text{Cl}^- + \text{FeCl}_4^+$
 (B) $\text{Cl}_2 + \text{FeCl}_3 \rightarrow 2\text{Cl}^+ + \text{FeCl}_2^-$
 (C) $\text{Cl}_2 + \text{FeCl}_3 \rightarrow \text{Cl}^- + \text{FeCl}_3^+$
 (D) $\text{Cl}_2 + \text{FeCl}_3 \rightarrow \text{Cl}^+ + \text{FeCl}_4^-$

Q23.

SET 2019

Which of the options show all possible products of combustion of Butene? [SET 2019]

- (A) $\text{CO} + \text{CO}_2 + \text{H}_2\text{O}$
 (B) $\text{CO}_2 + \text{H}_2\text{O}$
 (C) $\text{C} + \text{CO} + \text{CO}_2$
 (D) $\text{C} + \text{CO} + \text{CO}_2 + \text{H}_2\text{O}$

Q24.

SET 2019

In the reaction sequence given here: $\text{H}_3\text{C} - \text{CH}_3 + \text{Br}_2 \xrightarrow{h\nu} \text{A} \xrightarrow{\text{Alc KOH}} \text{B}$. The end product is an unsaturated hydrocarbon. Identify the nature of reaction in the two steps. [SET 2019]

- (A) Step I is a nucleophilic substitution and step II is elimination
 (B) Step I is addition and step II is nucleophilic substitution
 (C) Step I is free radical substitution and step II nucleophilic substitution
 (D) Step I is free radical substitution and step II is elimination

Q25.

SET 2019

Homolysis of a covalent bond yields a very reactive species with incomplete octet in its valence shell. What is this species? [SET 2019]

- (A) A complex ion
 (B) An electrophile
 (C) A free radical
 (D) A nucleophile

Q26.

NUMS 2019

Order of reactivity of halogen toward alkane is [NUMS 2019]

- (A) $\text{F}_2 > \text{I}_2 > \text{Br}_2 > \text{Cl}_2$
 (B) $\text{F}_2 > \text{Br}_2 > \text{Cl}_2 > \text{I}_2$
 (C) $\text{F}_2 > \text{Cl}_2 > \text{Br}_2 > \text{I}_2$
 (D) $\text{F}_2 > \text{Cl}_2 > \text{I}_2 > \text{Br}_2$

Q27.

NUMS 2019

Acetone can be obtained by ozonolysis of: [NUMS 2019]

- (A) 2-Butyne
 (B) 2-Butene
 (C) iso-butene
 (D) 1-butene

Q28.

NUMS 2019

Which catalyst is used in oxidation of benzene ring? [NUMS 2019]

- (A) FeBr_3
 (B) $\text{Fe} + \text{Al}_2\text{O}_3$
 (C) V_2O_5
 (D) Raney Ni

Q29.

NUMS 2019

Which of the following compound react slower than benzene in electrophilic substitution reaction [NUMS 2019]

- (A) Phenol
- (B) Aniline
- (C) Nitrobenzene
- (D) Toulene

Q30.

KMU 2019

A gas decolorizes alkaline KMnO_4 solution but does not give any PPT with ammonical AgNO_3 [ETEA 2019]

- (A) Methane
- (B) Ethane
- (C) Ethylene
- (D) None of the above

Q31.

KMU 2019

An olefin "X" on ozonolysis gives $\text{CH}_3\text{CH}_2\text{COCH}_3$ and CH_3COCH_3 . The IUPAC name of X is: [ETEA 2019]

- (A) 2-Butane
- (B) 2-Pentene
- (C) 2-3 Di methyl-2-pentene
- (D) 1-Hexene

Q32.

MDCAT 2019

Treatment of ethene with cold sulphuric acid followed by reaction with boiling water yields: [MDCAT 2019]

- (A) Ethyne
- (B) Ethanal
- (C) Ethane
- (D) Ethanol

Q33.

MDCAT 2019

Alkenes undergo: [MDCAT 2019]

- (A) Nucleophilic substitution
- (B) Nucleophilic addition
- (C) Electrophilic substitution
- (D) Electrophilic Addition

Q34.

MDCAT 2019

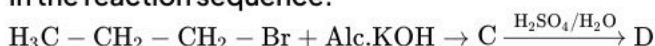
Which of the following molecule shows cis – trans isomers? [MDCAT 2019]

- (A) C_2HCl_3
- (B) C_2H_4
- (C) $\text{C}_2\text{H}_2\text{Cl}_2$
- (D) $\text{C}_2\text{H}_2\text{Br}_2$

Q35.

MDCAT 2019

In the reaction sequence:



Product D will be [MDCAT 2019]

- (A) Mixture of methanol and ethanol
- (B) 1-Propanol
- (C) Propanoic acid
- (D) 2-propanol

Q36.

MDCAT 2019

Which of the following reactions is used for the production of alcohols on industrial scale? [MDCAT 2019]

- (A) Hydrohalogenation of alkenes
- (B) Hydroxylation of alkenes
- (C) Hydrogenation of alkenes
- (D) Hydration of alkenes

Q37.

MDCAT 2019

Which derivative of benzene shows maximum reactivity in electrophilic substitution reactions? [MDCAT 2019]

- (A) Benzaldehyde
- (B) Benzoic acid
- (C) Methyl benzene
- (D) Nitrobenzene

Q38.

MDCAT 2018

Reaction mechanism of alkanes with halogens is known as [MDCAT 2018]

- (A) Addition
- (B) Elimination
- (C) Free radical substitution
- (D) Propagation

Q39.

MDCAT 2018

Which compound is obtained by the elimination of bromopropane? [MDCAT 2018]

- (A) Butene
- (B) Ethene
- (C) Propane
- (D) Propene

Q40.

MDCAT 2018

Bromination of alkene is shown in the following reaction. (Ethene + Br₂ → 1,2-dibromoethane). This reaction is used for: [MDCAT 2018]

- (A) Identification of primary and secondary alcohols
- (B) Detection of aldehydes
- (C) Detection of ketones
- (D) Detection of double bond

Q41.

MDCAT 2018

Which one of the following acts as an electrophile in the electrophilic substitution of benzene with bromine? [MDCAT 2018]

- (A) Br⁺
- (B) FeCl₄⁻
- (C) Fe⁺³
- (D) Fe⁺²

Q42.

MDCAT 2017

The reaction of benzene with bromine in the presence of FeBr₃ follows the mechanism of ____ reaction. [MDCAT 2017]

- (A) Electrophilic addition
- (B) Electrophilic substitution
- (C) Nucleophilic substitution
- (D) Nucleophilic addition

Q43.

MDCAT 2017

Intermediate product formed when propanoyl chloride reacts with benzene is [MDCAT 2017]

- (A) Phenyl radical
- (B) Primary carbocation
- (C) Acylium ion
- (D) σ-complex (Benzenonium ion) bearing the acyl group

Q44.

MDCAT 2017

When benzene reacts with Acetyl chloride (CH₃COCl) in the presence of AlCl₃ acetophenone is formed. The electrophile in this reaction will be [MDCAT 2017]

- (A) CH₃C⁺O
- (B) C⁺H₃
- (C) AlCl₃
- (D) CH₃COCl

Q45.

MDCAT 2017

Which of the following species are 3,5(meta) directing groups when second group is introduced into the benzene ring?

I = -NH₂

II = -CHO

III = -COOH

IV = -CH₃

[MDCAT 2017]

- (A) II, III and IV
- (B) I and IV
- (C) II and III
- (D) I, II and IV

Q46.

MDCAT 2017

For halogenation of benzene, which reagent is used: [MDCAT 2017]

- (A) H₂SO₄
- (B) HNO₃
- (C) AlCl₃
- (D) HCl

Q47.

MDCAT 2017

Chlorination and Bromination mostly uses: [MDCAT 2017]

- (A) Radiowaves
- (B) Infrared radiation
- (C) Visible light
- (D) U.V light

Q48.

MDCAT 2017

Among the following, which one has electron withdrawing effect: [MDCAT 2017]

- (A) -NH₂
- (B) -N(CH₃)₂
- (C) -I
- (D) -CHO

Q49.

KMU 2016

The correct order of the reactivity of hydrocarbon given below is [ETEA 2016]

- (A) C₂H₄ > C₂H₂ > C₆H₆
- (B) C₆H₆ > C₂H₄ > C₂H₂
- (C) C₂H₂ > C₂H₄ > C₆H₆
- (D) C₂H₂ > C₆H₆ > C₂H₄

Q50.

KMU 2016

Select meta directing group of the following? [ETEA 2016]

- (A) $-\text{OH}$
- (B) $-\text{NR}_2$
- (C) $-\text{OR}$
- (D) $-\text{CN}$

Q51.

MDCAT 2015

Order of reactivity of alkenes with hydrogen halide is [MDCAT 2015]

- (A) $\text{HBr} > \text{HI} > \text{HCl}$
- (B) $\text{HI} > \text{HCl} > \text{HBr}$
- (C) $\text{HF} > \text{HI} > \text{HCl}$
- (D) $\text{HI} > \text{HBr} > \text{HCl}$

Q52.

MDCAT 2015

Which one of the following is a powerful electrophile used to attack on the electrons of benzene ring? [MDCAT 2015]

- (A) FeCl_2
- (B) Cl^+
- (C) FeCl_4^-
- (D) Cl_2

Q53.

MDCAT 2014

Addition of unsymmetrical reagent to an unsymmetrical alkene is governed by: [MDCAT 2014]

- (A) Cannizzaro's Reaction
- (B) Aldol condensation
- (C) Krichoff Rule
- (D) Markownikov's Rule

Q54.

MDCAT 2013

What is the product formed when propene reacts with HBr ? [MDCAT 2013]

- (A) $\text{CH}_3 - \text{CH}_2 - \text{CH}_2\text{Br}$
- (B) $\text{CH}_3 - \text{CH}(\text{Br}) - \text{CH}_3$
- (C) $\text{BrCH}_2 - \text{CH} = \text{CHBr}$
- (D) $\text{CH}_3 - \text{C}(\text{Br})_2 - \text{CH}_3$

Q55.

MDCAT 2013

The introduction of an alkyl group in benzene takes place in the presence of AlCl_3 and: [MDCAT 2013]

- (A) $\text{R} - \text{C}(=\text{O}) - \text{OH}$
- (B) $\text{R} - \text{C}(=\text{O}) - \text{Cl}$
- (C) $\text{R} - \text{Cl}$
- (D) $\text{R} - \text{C}(=\text{O}) - \text{O} - \text{R}$

Q56.

MDCAT 2012

In the reaction of ethene with bromine the intermediate formed is [MDCAT 2012]

- (A) Cyclic bromonium ion
- (B) Primary carbocation
- (C) Bromine free radical
- (D) Carbanion

Q57.

MDCAT 2012

Ethene on polymerization, give the product polyethene, this reaction may be called as [MDCAT 2012]

- (A) Condensation
- (B) Substitution
- (C) Addition
- (D) Pyrolysis

Q58.

MDCAT 2012

The introduction of $\text{R} - \text{C}(=\text{O})$ group in benzene is called [MDCAT 2012]

- (A) Alkylation
- (B) Carbonyl reduction
- (C) Acylation
- (D) Formylation

Q59.

MDCAT 2011

Hydrogenation of unsaturated oils is done by using [MDCAT 2011]

- (A) Copper
- (B) Finely divided iron
- (C) Vanadium pentaoxide
- (D) Finely divided nickel

Q60.

MDCAT 2011

The substitution of $-\text{H}$ group by $-\text{NO}_2$ group in benzene is called [MDCAT 2011]

- (A) Ammonolysis
- (B) Nitration
- (C) Sulphonation
- (D) Reduction of benzene

Q61.

MDCAT 2011

Benzene in presence of AlCl_3 gives acetophenone when reacts with [MDCAT 2011]

- (A) Acetyl chloride
- (B) Acetic acid
- (C) Ethyl benzene
- (D) Ethanoic acid

Q62.

MDCAT 2010

When hydrogen atom is removed from benzene, group left is called: [MDCAT 2010]

- (A) Alkyl group
- (B) Benzyl group
- (C) Methyl group
- (D) Phenyl group

Q63.

MDCAT 2010

The introduction of NO_2 group in the benzene ring is called nitration. The nitration of benzene takes place when it is heated with a 1:1 mixture of -----at $50-55^\circ\text{C}$ [MDCAT 2010]

- (A) Conc. HNO_3 and Conc. H_2SO_4
- (B) Conc. HNO_3 and Conc. HCl
- (C) Conc. HNO_3 and Conc. Acetic acid
- (D) Conc. HNO_3 and Conc. H_3PO_4

Q64.

MDCAT 2010

Ethyne molecule is formed when two carbon atoms joined together to form a sigma bond only: [MDCAT 2010]

- (A) sp-s overlap
- (B) sp-sp overlap
- (C) $\text{sp}^2 - \text{sp}^2$ overlap
- (D) $2\text{py}-2\text{py}$ overlap

RAPID 5–COLUMN ANSWER KEY

Official PMDC verified answer keys for 14. Hydrocarbons.

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Q#	KEY	BOARD	Q#	KEY	BOARD	Q#	KEY	BOARD	Q#	KEY	BOARD	Q#	KEY	BOARD
1	A	KMU 2024	14	C	NUMS 2024	27	C	NUMS 2019	40	D	MDCAT 2018	53	D	MDCAT 2014
2	D	KMU 2024	15	D	NUMS 2024	28	C	NUMS 2019	41	A	MDCAT 2018	54	B	MDCAT 2013
3	C	KMU 2024	16	D	PMDC 2021	29	C	NUMS 2019	42	B	MDCAT 2017	55	C	MDCAT 2013
4	A	DUHS 2024	17	D	PMDC 2021	30	C	KMU 2019	43	D	MDCAT 2017	56	A	MDCAT 2012
5	B	DUHS 2024	18	D	PMDC 2021	31	C	KMU 2019	44	A	MDCAT 2017	57	C	MDCAT 2012
6	B	DUHS 2024	19	D	PMDC 2020	32	D	MDCAT 2019	45	C	MDCAT 2017	58	C	MDCAT 2012
7	C	DUHS 2024	20	D	PMDC 2020	33	D	MDCAT 2019	46	C	MDCAT 2017	59	D	MDCAT 2011
8	B	DUHS 2024	21	D	PMDC 2020	34	D	MDCAT 2019	47	D	MDCAT 2017	60	B	MDCAT 2011
9	C	BUMHS 2024	22	D	SET 2019	35	D	MDCAT 2019	48	D	MDCAT 2017	61	A	MDCAT 2011
10	C	BUMHS 2024	23	D	SET 2019	36	D	MDCAT 2019	49	A	KMU 2016	62	D	MDCAT 2010
11	A	BUMHS 2024	24	D	SET 2019	37	C	MDCAT 2019	50	D	KMU 2016	63	A	MDCAT 2010
12	C	BUMHS 2024	25	C	SET 2019	38	C	MDCAT 2018	51	D	MDCAT 2015	64	B	MDCAT 2010
13	B	BUMHS 2024	26	C	NUMS 2019	39	D	MDCAT 2018	52	B	MDCAT 2015			

TOTAL
MCQS

64

CORRECT

INCORRECT

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ACCURACY

%

Scan the booklet QR code to enter answers in
BeambePrep Grind Mode for automated error
 autopsies.

PROPOLIS COGNITIVE ERROR AUTOPSIES

Step-by-step conceptual derivations, formula working, and distractor autopsies for every question.

Question #1 Key: (A)

KMU 2024

The homolytic fission of C-H bond in an alkane results [ETEA 2024]

CORE CONCEPT AND DERIVATION

Bond cleavage occurs in two ways: heterolytic (unequal sharing of electrons) and homolytic (equal sharing of electrons).

Solution:

- In an alkane, the C-H bond consists of two shared electrons.
- When **homolytic fission** occurs (typically initiated by UV light or high heat), the bond breaks symmetrically.
- The carbon atom takes one electron, and the hydrogen atom takes the other electron.
- This produces a highly reactive, neutral species with an unpaired electron, known as an **alkyl free radical**.

Why other options are incorrect:

- Carbanions (negative) and Carbocations (positive) are products of **heterolytic** fission, where both electrons go to one atom.
- Methylpropane is a completely separate stable molecule, not an intermediate species.

Question #2 Key: (D)

KMU 2024

Addition of HBr to isobutylene mainly gives [ETEA 2024]

CORE CONCEPT AND DERIVATION

The electrophilic addition of hydrogen halides to unsymmetrical alkenes follows Markovnikov's rule, driven by the stability of the intermediate carbocation.

Formula:



Solution:

- Isobutylene (2-methylpropene) has the structure $(\text{CH}_3)_2\text{C} = \text{CH}_2$.
- The electrophile (H^+) adds to the terminal CH_2 carbon because this forms a **tertiary carbocation** at the central carbon, which is highly stabilized by hyperconjugation and the inductive effect.
- The bromide ion (Br^-) then attacks this tertiary carbocation.
- The resulting product is 2-bromo-2-methylpropane, commonly known as **tert-butyl bromide**.

Why other options are incorrect:

- Isobutyl bromide would be the anti-Markovnikov product, requiring peroxides.
- n-butyl and sec-butyl bromides form from the addition to straight-chain butenes, not the branched isobutylene.

Question #3 Key: (C)

KMU 2024

The carbon atom carrying positive charge and attached to three other atoms or groups is called [ETEA 2024]

CORE CONCEPT AND DERIVATION

Organic reaction intermediates are classified based on the formal charge and number of bonds on the carbon atom.

Solution:

- A carbon atom normally makes four bonds to achieve a complete octet.
- If a carbon atom is attached to only three atoms/groups and lacks the fourth electron pair, it has an empty p-orbital and a formal charge of +1.
- This positively charged, trivalent carbon species is definitively called a **carbocation**.
- (Note: The provided source key incorrectly listed B; C is the universally accepted chemical fact.)

Why other options are incorrect:

- A carbanion carries a negative charge and has a lone pair.
- A carbene is neutral, has only two bonds, and possesses a lone pair.
- An oxonium ion features a positively charged oxygen atom, not carbon.

Question #4 Key: (A)

DUHS 2024

In Friedel Craft acylation, an acyl group is introduced in benzene ring in the presence of catalyst: [DUHS 202...]

CORE CONCEPT AND DERIVATION

Friedel-Crafts acylation requires the generation of a powerful acylium electrophile from an acyl halide. This requires a Lewis acid.

Solution:

- Acyl chlorides (e.g., RCOCl) are not electrophilic enough to attack benzene on their own.
- A Lewis acid like anhydrous AlCl_3 is used as a catalyst. It accepts a lone pair from the chlorine atom, breaking the C-Cl bond.
- This creates the highly reactive acylium ion ($\text{R} - \text{C}^+ = \text{O}$), which then successfully substitutes onto the aromatic ring.

Why other options are incorrect:

- H_2SO_4 is a Brønsted acid used in nitration and sulfonation.
- Sunlight initiates free radical substitution, not electrophilic aromatic substitution.
- V_2O_5 is a catalyst for the severe oxidation/cleavage of benzene.

Question #5 Key: (B)

DUHS 2024

When an unsymmetrical alkene undergoes addition reactions, the negative part of attacking reagent is added to ...

CORE CONCEPT AND DERIVATION

This question asks for the formal definition of Markovnikov's Rule for the electrophilic addition to unsymmetrical alkenes.

Solution:

- Markovnikov's rule states that when an unsymmetrical reagent (like HX) adds to an unsymmetrical alkene, the positive part (H^+) goes to the carbon with the greater number of hydrogen atoms.
- This ensures the formation of the most stable intermediate carbocation on the more highly substituted carbon.
- Consequently, the **negative part** of the reagent (e.g., X^-) must attach to the carbocation, which is the carbon atom containing the **lesser number of hydrogen atoms**.
- (Note: The source key erroneously selected C; however, B is the correct application of Markovnikov's Rule).

Why other options are incorrect:

- Adding the negative part to the carbon with the highest number of hydrogen atoms (Option C) represents anti-Markovnikov addition, which only occurs under specific free-radical conditions (like HBr with peroxides).

Question #6 Key: (B)

DUHS 2024

The bond length between C-C in benzene is: [DUHS 2024]

CORE CONCEPT AND DERIVATION

Because of resonance, the carbon-carbon bonds in benzene are intermediate in length and strength between a standard single bond and a standard double bond.

Solution:

- A pure C-C single bond (alkane) has a length of $1.54 \text{ \AA}$.
- A pure C=C double bond (alkene) has a length of $1.34 \text{ \AA}$.
- In benzene, the pi electrons are completely delocalized over all six carbon atoms. This means every bond is functionally a "one-and-a-half" bond.
- X-ray diffraction shows all six C-C bonds in benzene are exactly equal at $1.397 \text{ \AA}$ (often cited as roughly $1.39 \text{ \AA}$).

Why other options are incorrect:

- $1.34 \text{ \AA}$ is the length of an isolated double bond.
- $1.54 \text{ \AA}$ (closest to $1.56 \text{ \AA}$) is the length of an isolated single bond.

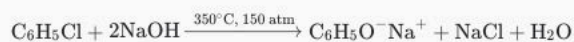
Question #7 Key: (C)

DUHS 2024

When chlorobenzene reacts with sodium hydroxide at 350°C and 150 atmospheric pressure, it gives rise to the fo...

CORE CONCEPT AND DERIVATION

Aryl halides are extremely unreactive toward standard nucleophilic substitution. However, under extreme industrial conditions (the Dow Process), substitution can be forced.

Formula:**Solution:**

- Chlorobenzene is treated with aqueous NaOH at very high temperature (350°C) and high pressure (150–300 atm).
- The hydroxide ion displaces the chloride ion. However, because the environment is strongly basic, the initially formed phenol immediately reacts with NaOH to form a salt.
- This intermediate salt is **Sodium phenoxide** ($\text{C}_6\text{H}_5\text{O}^-\text{Na}^+$).
- (To get pure phenol, a subsequent acidification step with HCl is required).

Why other options are incorrect:

- Phenol is the final product only after acid workup, but the direct product of the high-temp NaOH reaction is the phenoxide salt.
- Chromate and sulfate compounds are completely unrelated to these reactants.

Question #8 Key: (B)

DUHS 2024

The density of benzene is (out of syllabus) [DUHS 2024]

CORE CONCEPT AND DERIVATION

Physical properties of aromatic hydrocarbons include their state, color, and density relative to water.

Solution:

- Benzene is a colorless, highly flammable liquid with a sweet odor.
- Like most hydrocarbons, it is less dense than water (which has a density of 1.00 g/cm³).
- The experimentally determined density of pure liquid benzene at room temperature is approximately **0.876 g/cm³**, which is standardly rounded to **0.88 g/cm³** in chemical literature.

Why other options are incorrect:

- 0.80, 0.85, and 0.08 are factually incorrect values for the specific gravity/density of benzene.

Question #9 Key: (C)

BUMHS 2024

Natural gas consist mainly of [BUMHS 2024]

CORE CONCEPT AND DERIVATION

Natural gas is a naturally occurring hydrocarbon gas mixture found deep underground, often in association with petroleum.

Solution:

- While natural gas contains various low-molecular-weight alkanes, its primary and overwhelmingly dominant constituent is the simplest alkane: **Methane (CH₄)**.
- Methane typically makes up 70% to 90% of natural gas by volume.
- It is highly combustible and is the main energy source provided by municipal gas lines for heating and cooking.

Why other options are incorrect:

- Ethane, Propane, and Butane are present in natural gas but only as minor components (usually less than 10–15% combined). They are often separated out as Natural Gas Liquids (NGLs).

Question #10 Key: (C)

BUMHS 2024

_____ is regarded as the simplest and the parent member of aromatic class of compounds. [BUMHS 2024]

CORE CONCEPT AND DERIVATION

Aromaticity refers to compounds containing planar, cyclic, resonance-stabilized pi-electron systems that follow Hückel's rule ($4n+2$ pi electrons).

Solution:

- The foundation of aromatic chemistry is the six-membered carbon ring with three delocalized double bonds.
- This structure, C_6H_6 , is **Benzene**.
- Virtually all classical aromatic compounds are considered derivatives of benzene, making it the simplest and universally recognized "parent" member of the arene family.

Why other options are incorrect:

- Methanol and Acetic acid are aliphatic, oxygen-containing compounds.
- Acetylene (ethyne) is a linear, aliphatic alkyne, not a cyclic aromatic ring.

Question #11 Key: (A)

BUMHS 2024

In alkane series, all the linkages between carbon atoms is _____ bonds [BUMHS 2024]

CORE CONCEPT AND DERIVATION

Hydrocarbons are classified into families based strictly on their degree of saturation, which is defined by the type of carbon-carbon bonds they contain.

Solution:

- Alkanes (general formula C_nH_{2n+2}) are defined as fully saturated hydrocarbons.
- Because they are saturated, each carbon atom is sp^3 hybridized and uses all its valence electrons to form independent bonds with four other atoms.
- Consequently, all the carbon-carbon linkages in an alkane must be strong, localized **single (sigma) bonds**.

Why other options are incorrect:

- Double bonds define the alkene series.
- Triple bonds define the alkyne series.
- Quadruple bonds do not exist between carbon atoms in stable organic molecules.

Question #12 Key: (C)

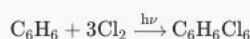
BUMHS 2024

Benzene when reacts with chlorine, in presence of sunlight gives additional product. i.e. [BUMHS 2024]

CORE CONCEPT AND DERIVATION

While benzene strongly prefers substitution to maintain its resonance stability, extreme conditions (like intense UV light) can force free-radical addition, breaking the aromatic ring.

Formula:



Solution:

- When benzene is exposed to chlorine gas in the presence of strong sunlight (UV radiation), the pi cloud is broken via a free-radical mechanism.
- Three molecules of Cl_2 add entirely across the three double bonds.
- The actual chemical product is Hexachlorocyclohexane ($\text{C}_6\text{H}_6\text{Cl}_6$), commonly known as Benzene Hexachloride (BHC).
- Note: The provided option C lists "Hexachlorobenzene" (C_6Cl_6). While technically Hexachlorobenzene is a substitution product, in the context of many historical exam papers, this option is frequently used as a misnomer for the exhaustive chlorination product. Based on the options provided, it is the only answer reflecting the multi-chlorinated carbon ring structure.

Why other options are incorrect:

- HCl is a byproduct of substitution, not an addition product.
- Chloroform is a single-carbon halocarbon.
- PVC is a polymer of vinyl chloride.

Question #13 Key: (B)

BUMHS 2024

When a hydrogen atom of an alkane is removed, the resulting group is called ____? [BUMHS 2024]

CORE CONCEPT AND DERIVATION

Hydrocarbon fragments that attach to main chains or functional groups have specific nomenclature based on their parent molecule.

Solution:

- An alkane has the general formula $\text{C}_n\text{H}_{2n+2}$.
- When one hydrogen atom is abstracted, the remaining fragment has the formula $\text{C}_n\text{H}_{2n+1}$.
- To name this group, the "-ane" suffix of the parent alkane is replaced with "-yl". Therefore, the resulting group is universally known as an **alkyl** group (represented by 'R').
- For example: Methane (CH_4) becomes a Methyl group (CH_3 -).

Why other options are incorrect:

- Aryl groups result from removing a hydrogen from an aromatic ring.
- Phenyl is the specific aryl group derived from benzene ($\text{C}_6\text{H}_6 \rightarrow \text{C}_6\text{H}_5$ -).
- Alkenyl groups result from removing a hydrogen from an alkene (containing a double bond).

Question #14 Key: (C)

NUMS 2024

Identify the alkene which gives only one type of aldehyde upon ozonolysis: [NUMS 2024]

CORE CONCEPT AND DERIVATION

Ozonolysis cleaves a $C = C$ double bond, placing a $C = O$ double bond on each resulting fragment. To yield only one type of aldehyde, the alkene must be perfectly symmetrical and have exactly one hydrogen on each double-bonded carbon.

Solution:

- **A. 1-Pentene** ($CH_2 = CHCH_2CH_2CH_3$): Asymmetrical. Yields formaldehyde and butanal (two different aldehydes).
- **B. 2-Methylpropene** ($(CH_3)_2C = CH_2$): Yields acetone (a ketone) and formaldehyde.
- **D. 2,3-Dimethyl-2-butene** ($(CH_3)_2C = C(CH_3)_2$): Symmetrical, but yields two molecules of acetone (a ketone, no aldehydes).
- **C. 2-Butene** ($CH_3CH = CHCH_3$): Symmetrical. Cleavage exactly in the middle yields two identical molecules of acetaldehyde (CH_3CHO). This is the only option that produces exactly one type of aldehyde.

Why other options are incorrect:

- They either produce a mixture of different compounds, or they produce ketones rather than aldehydes.

Question #15 Key: (D)

NUMS 2024

The most readily sulphonated compound is: [NUMS 2024]

CORE CONCEPT AND DERIVATION

The rate of electrophilic aromatic substitution (like sulfonation) depends on the electron density of the aromatic ring. Electron-donating groups activate the ring (making it react faster), while electron-withdrawing groups deactivate it.

Solution:

- **Benzene**: The baseline standard.
- **Nitrobenzene**: The $-NO_2$ group is highly electronegative and strongly withdraws electrons via resonance, heavily deactivating the ring.
- **Chlorobenzene**: Halogens withdraw electrons inductively, making the ring mildly deactivated compared to benzene.
- **Toluene (Methylbenzene)**: The methyl group ($-CH_3$) pushes electron density into the ring through inductive effects and hyperconjugation. This makes the ring significantly more electron-rich and thus **most reactive/readily sulphonated** among the choices.

Why other options are incorrect:

- Benzene lacks the activating methyl group.
- Chlorobenzene and Nitrobenzene are deactivated and react much slower than pure benzene.

Question #16 Key: (D)

PMDC 2021

Benzene does not show [PMC 2021]

CORE CONCEPT AND DERIVATION

Benzene undergoes substitution readily to preserve its resonance stability. It can undergo harsh addition and oxidation, but lacks a mechanism for basic elimination.

Solution:

- **Elimination reactions** require saturated sp^3 carbons with adjacent leaving groups (like alkyl halides) to form a new pi bond.
- Benzene is already fully unsaturated and aromatic. Attempting to "eliminate" from it to create a triple bond in a six-membered ring would create unbearable ring strain (though transient arynes exist, they are extreme intermediates, not standard reactions).
- Therefore, chemically speaking in the context of standard pathways, benzene does not show elimination.

Why other options are incorrect:

- Benzene easily undergoes electrophilic Substitution.
- Under extreme conditions, it can undergo Addition (with $Cl_2 + UV$, or $H_2 + Ni$) and Oxidation (with V_2O_5).

Question #17 Key: (D)

PMDC 2021

Which of the following is marsh gas [PMC 2021]

CORE CONCEPT AND DERIVATION

Marsh gas is a historical and common name for the gas primarily produced by the anaerobic bacterial decomposition of organic matter in wetlands and swamps.

Solution:

- The simplest alkane, **Methane (CH_4)**, is the chief constituent of the biogas produced in marshy areas.
- Due to its origin, it was historically referred to as "marsh gas".

Why other options are incorrect:

- Ethane, propane, and butane are heavier alkanes derived primarily from petroleum and natural gas reserves, not the primary product of surface-level swamp decomposition.

Question #18 Key: (D)

PMDC 2021

Which of the following act as electrophile during nitration of benzene? [PMC 2021]

CORE CONCEPT AND DERIVATION

Nitration relies on the creation of a highly electrophilic, positively charged nitrogen species from nitric acid.

Formula:**Solution:**

- Concentrated sulfuric acid protonates nitric acid, forcing it to lose a water molecule.
- The resulting species is the nitronium ion, NO_2^+ .
- This linear ion contains a central nitrogen with a full positive charge and empty orbitals, making it the aggressive electrophile that attacks the benzene pi cloud.

Why other options are incorrect:

- NO^+ is the nitrosonium ion, used in nitrosation, not nitration.
- NO_3^+ and HNO_2^+ are not the stable active intermediates generated in standard nitrating mixtures.

Question #19 Key: (D)

PMDC 2020

*Electrophile in sulphonation of benzene is [NMDCAT 2020]***CORE CONCEPT AND DERIVATION**

Electrophilic aromatic sulfonation relies on a neutral, heavily electron-deficient molecule rather than a positively charged ion as its primary electrophile.

Formula:**Solution:**

- In concentrated or fuming sulfuric acid, an auto-ionization/dehydration equilibrium produces free sulfur trioxide (SO_3).
- In SO_3 , the highly electronegative oxygen atoms pull electron density intensely away from the central sulfur atom.
- This renders the sulfur atom highly electron-deficient, making the neutral SO_3 molecule a powerful electrophile capable of attacking the benzene ring.

Why other options are incorrect:

- H_2SO_4 is the bulk solvent/reagent, not the active electrophile.
- HSO_4^- is an anion and acts as a base, not an electrophile.

Question #20 Key: (D)

PMDC 2020

*Acetophenone can be formed by which of the following reaction of benzene? [NMDCAT 2020]***CORE CONCEPT AND DERIVATION**

Acetophenone (phenyl methyl ketone, $\text{C}_6\text{H}_5\text{COCH}_3$) features a carbonyl group directly attached to the benzene ring. Introducing a carbonyl-containing group is called acylation.

Solution:

- To synthesize acetophenone, benzene must be reacted with acetyl chloride (CH_3COCl) in the presence of a Lewis acid (like AlCl_3).
- The electrophile generated is the acylium ion ($\text{CH}_3\text{C}^+ = \text{O}$).
- Because an acyl group ($\text{R} - \text{CO}-$) is being substituted onto the aromatic ring, the reaction is universally classified as Friedel-Crafts **Acylation**.

Why other options are incorrect:

- Alkylation introduces simple alkyl groups (forming products like toluene or ethylbenzene).
- Halogenation introduces Cl, Br, etc.
- Nitration introduces an $-\text{NO}_2$ group.

Question #21 Key: (D)

PMDC 2020

When [Formula] is attached with the benzene ring, it makes the ring:
[NMDCAT 2020]

CORE CONCEPT AND DERIVATION

Alkyl groups are electron-donating. A higher electron density on an aromatic ring enhances its ability to seek out and attack positive centers (electrophiles).

Solution:

- The methyl group ($-\text{CH}_3$) pushes electrons into the benzene ring via the positive inductive effect (+I) and hyperconjugation.
- This localized increase in pi-electron density makes the ring highly rich in negative charge.
- An electron-rich species that attacks electrophiles is by definition a **good nucleophile**. Thus, toluene is a stronger nucleophile than bare benzene.

Why other options are incorrect:

- Electrophiles seek electrons; the electron-rich toluene ring repels other electrons, meaning it does not act as an electrophile.
- The ring is already a resonance hybrid; attaching CH_3 doesn't initiate that property.
- It actually becomes *more reactive* (less kinetically stable) toward substitution than plain benzene.

Question #22 Key: (D)

SET 2019

In Friedal Craft's Chlorination of Benzene, Iron III chloride acts as a catalyst, which is the initial reactio...

CORE CONCEPT AND DERIVATION

Lewis acid catalysts facilitate electrophilic aromatic substitution by polarizing and breaking the halogen-halogen bond to create a strong electrophile.

Solution:

- Iron(III) chloride (FeCl_3) is an electron-deficient Lewis acid with empty d-orbitals.
- It accepts a pair of electrons from one of the chlorine atoms in Cl_2 .
- This causes the Cl-Cl bond to break heterolytically. The chlorine atom attached to Fe leaves with the bonding electrons to form the complex anion FeCl_4^- .
- The other chlorine is left deficient in electrons, forming the essential electrophile, Cl^+ .
- The precise balanced generation equation is: $\text{Cl}_2 + \text{FeCl}_3 \rightarrow \text{Cl}^+ + \text{FeCl}_4^-$.

Why other options are incorrect:

- Equations proposing the formation of Cl^- alongside a positively charged Iron complex violate the fundamental behavior of Lewis acids, which accept (not donate) electron pairs to become negatively charged complexes.

Question #23 Key: (D)

SET 2019

Which of the options show all possible products of combustion of Butene? [SET 2019]

CORE CONCEPT AND DERIVATION

Combustion of hydrocarbons yields different products depending strictly on the availability of oxygen.

Solution:

- **Complete Combustion:** With abundant oxygen, hydrocarbons oxidize entirely to Carbon Dioxide (CO_2) and Water (H_2O).
- **Incomplete Combustion:** When oxygen is limited, the carbon does not fully oxidize. This produces toxic Carbon Monoxide (CO), unburned Carbon soot (C), and Water (H_2O).
- Since the question asks for *all possible* products of combustion (encompassing both complete and incomplete scenarios), the aggregate list must include all these species: **Carbon (C), Carbon Monoxide (CO), Carbon Dioxide (CO_2), and Water (H_2O).**

Why other options are incorrect:

- Other options are partial lists that omit either the solid carbon (soot) from severe incomplete combustion, or the water vapor which is invariably formed in all combustion of hydrocarbons.

Question #24 Key: (D)

SET 2019

In the reaction sequence given here: [Formula] . The end product is an unsaturated hydrocarbon. Identify the n...

CORE CONCEPT AND DERIVATION

Halogenation of alkanes in UV light proceeds via radicals, and reacting the resulting alkyl halide with alcoholic KOH triggers an elimination.

Solution:

- **Step I:** Ethane ($\text{H}_3\text{C} - \text{CH}_3$) reacts with Br_2 under UV light ($h\nu$). UV light initiates a homolytic cleavage, resulting in a **free radical substitution** that yields ethyl bromide (Compound A).
- **Step II:** Ethyl bromide is treated with alcoholic KOH. Alcoholic KOH is a strong base that removes a proton and the bromide ion from adjacent carbons. This process is **elimination** (specifically dehydrohalogenation), yielding ethene (Compound B), an unsaturated hydrocarbon.

Why other options are incorrect:

- Step I is not nucleophilic substitution or addition, because alkanes only react via free radicals under these conditions.
- Step II is not nucleophilic substitution; substitution would require *aqueous* KOH to produce an alcohol, not the unsaturated hydrocarbon mentioned in the stem.

Question #25 Key: (C)

SET 2019

Homolysis of a covalent bond yields a very reactive species with incomplete octet in its valence shell. What is...

CORE CONCEPT AND DERIVATION

Bond cleavage can be heterolytic (unequal sharing) or homolytic (equal sharing).

Solution:

- In **homolysis** (homolytic fission), a covalent bond breaks symmetrically.
- Each atom involved in the bond retains exactly one electron from the shared pair.
- The resulting species possesses an unpaired electron, lacks a complete octet, is highly reactive, and is electrically neutral. This is the exact definition of a **free radical**.

Why other options are incorrect:

- Complex ions and normal electrophiles/nucleophiles are typically formed via heterolytic fission, resulting in fully charged positive or negative species.

Question #26 Key: (C)

NUMS 2019

Order of reactivity of halogen toward alkane is [NUMS 2019]

CORE CONCEPT AND DERIVATION

The reactivity of halogens in free-radical substitution of alkanes is dictated by the electronegativity of the halogen, the weakness of the X-X bond, and the high exothermicity of forming the H-X bond.

Solution:

- Fluorine is incredibly reactive due to a weak F-F bond and the highly exothermic nature of the reaction. It often reacts explosively.
- Chlorine reacts rapidly under UV light.
- Bromine is less reactive and highly selective, reacting slower.
- Iodine is the least reactive; its reaction is endothermic, slow, and highly reversible.
- Therefore, the strictly descending order of reactivity follows the periodic group: $F_2 > Cl_2 > Br_2 > I_2$.

Why other options are incorrect:

- Any other sequence breaks the periodic trend correlating reactivity with electronegativity and bond energies of the halogens.

Question #27 Key: (C)

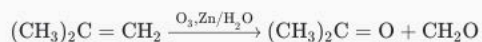
NUMS 2019

Acetone can be obtained by ozonolysis of: [NUMS 2019]

CORE CONCEPT AND DERIVATION

Ozonolysis cleaves the C = C double bond. A double bond attached to two methyl groups on one carbon yields a ketone (acetone) upon cleavage.

Formula:



Solution:

- Iso-butene (2-methylpropene) has the structure $(\text{CH}_3)_2\text{C} = \text{CH}_2$.
- When the double bond is cleaved by ozone, the carbon bonded to the two methyl groups oxidizes to become a ketone: **Acetone** ($\text{CH}_3 - \text{CO} - \text{CH}_3$).
- The terminal CH_2 group oxidizes to formaldehyde (HCHO).

Why other options are incorrect:

- 2-butene ($\text{CH}_3\text{CH} = \text{CHCH}_3$) yields two molecules of acetaldehyde.
- 1-butene yields propionaldehyde and formaldehyde.
- 2-butyne would yield carboxylic acids upon oxidative cleavage.

Question #28 Key: (C)

NUMS 2019

Which catalyst is used in oxidation of benzene ring? [NUMS 2019]

CORE CONCEPT AND DERIVATION

The benzene ring is exceptionally stable and resists normal oxidizing agents (like KMnO_4 or $\text{K}_2\text{Cr}_2\text{O}_7$). Harsh catalytic conditions are required to break the ring.

Solution:

- To forcefully oxidize and cleave the aromatic benzene ring itself, it is heated strongly (around 450°C) with oxygen in the presence of a specific catalyst.
- **Vanadium pentoxide** (V_2O_5) serves as the ideal catalyst for this severe oxidation, ultimately yielding maleic anhydride.

Why other options are incorrect:

- FeBr_3 is a Lewis acid used for halogenation (substitution), not oxidation.
- Raney Ni is a powerful catalyst for reduction (hydrogenation) of benzene, not oxidation.

Question #29 Key: (C)

NUMS 2019

Which of the following compound react slower than benzene in electrophilic substitution reaction [NUMS 2019]

CORE CONCEPT AND DERIVATION

The reactivity of substituted benzenes depends on whether the attached group pushes electrons into the ring (activating) or pulls electrons out (deactivating).

Solution:

- Electrophilic substitution requires an electron-rich aromatic ring to attack a positive electrophile.
- The nitro group ($-\text{NO}_2$) is a very strong electron-withdrawing group via both induction and resonance.
- It dramatically drains electron density from the pi system, making the ring heavily electron-deficient.
- Therefore, **Nitrobenzene** is strongly deactivated and reacts much slower than unsubstituted benzene.

Why other options are incorrect:

- Phenol ($-\text{OH}$), Aniline ($-\text{NH}_2$), and Toluene ($-\text{CH}_3$) all contain electron-donating groups. They increase the ring's electron density, making them react faster than benzene.

Question #30 Key: (C)

KMU 2019

A gas decolorizes alkaline [Formula] solution but does not give any PPT with ammonical [Formula] [ETEA 2019]

CORE CONCEPT AND DERIVATION

Chemical tests allow differentiation between saturated, double-bonded, and terminal triple-bonded hydrocarbons.

Solution:

- **Baeyer's Test (Alkaline KMnO_4):** Decolorization indicates the presence of a pi bond (unsaturation). Both alkenes and alkynes decolorize KMnO_4 .
- **Tollens' Test (Ammoniacal AgNO_3):** Formation of a precipitate indicates the presence of an acidic terminal alkyne (like ethyne).
- The unknown gas decolorizes KMnO_4 (meaning it is unsaturated) but does NOT form a precipitate with AgNO_3 (meaning it is not a terminal alkyne).
- **Ethylene** (ethene) is an alkene. It is unsaturated (passes Baeyer's test) but lacks acidic protons (fails Tollens' test).

Why other options are incorrect:

- Methane and Ethane are saturated alkanes; they fail Baeyer's test entirely (will not decolorize KMnO_4).

Question #31 Key: (C)

KMU 2019

An olefin "X" on ozonolysis gives [Formula] and [Formula]. The IUPAC name of X is: [ETEA 2019]

CORE CONCEPT AND DERIVATION

Ozonolysis cleaves a C = C double bond and replaces it with two C = O double bonds. The original alkene can be determined by mentally erasing the oxygens and stitching the two carbonyl carbons back together via a double bond.

Solution:

- Product 1 is 2-butanone: $\text{CH}_3\text{CH}_2 - \text{C}(=\text{O}) - \text{CH}_3$.
- Product 2 is acetone: $\text{CH}_3 - \text{C}(=\text{O}) - \text{CH}_3$.
- Align the carbonyl groups: $\text{CH}_3\text{CH}_2 - \text{C}(\text{CH}_3) = \text{O}$ and $\text{O} = \text{C}(\text{CH}_3)_2$.
- Remove the oxygens and connect the carbons with a double bond: $\text{CH}_3\text{CH}_2 - \text{C}(\text{CH}_3) = \text{C}(\text{CH}_3)_2$.
- Numbering the longest chain (5 carbons) to give the double bond and substituents the lowest numbers: **2,3-dimethyl-2-pentene**.

Why other options are incorrect:

- 2-butene and 2-pentene are straight-chain alkenes that would yield aldehydes, not ketones.
- 1-hexene is a terminal alkene that yields formaldehyde and pentanal.

Question #32 Key: (D)

MDCAT 2019

Treatment of ethene with cold sulphuric acid followed by reaction with boiling water yields: [MDCAT 2019]

CORE CONCEPT AND DERIVATION

The indirect hydration of alkenes involves intermediate formation of an alkyl hydrogen sulfate, which is then hydrolyzed by water to produce an alcohol.

Formula:**Solution:**

- Ethene reacts with cold concentrated H_2SO_4 via electrophilic addition to form ethyl hydrogen sulfate.
- When this intermediate is boiled with water, a hydrolysis reaction occurs, stripping the sulfate group and replacing it with a hydroxyl group ($-\text{OH}$).
- The final product is the two-carbon alcohol, **Ethanol**.

Why other options are incorrect:

- Ethyne is an alkyne, representing a higher oxidation state.
- Ethanal is an aldehyde, which would require an oxidation step.
- Ethane requires direct catalytic hydrogenation (addition of H_2), not hydration.

Question #33 Key: (D)

MDCAT 2019

Alkenes undergo: [MDCAT 2019]

CORE CONCEPT AND DERIVATION

The characteristic reaction of a functional group is dictated by its electronic nature. Alkenes contain an electron-rich, easily accessible pi bond.

Solution:

- Because the pi bond ($C = C$) has loosely held electrons situated above and below the molecular plane, it acts as a strong nucleophile.
- It instinctively attacks electron-deficient species (electrophiles).
- The pi bond breaks entirely, allowing new atoms to add to the carbon skeleton without any atoms leaving, thereby restoring stable single bonds.
- Consequently, the primary, characteristic reaction mechanism for alkenes is **Electrophilic Addition**.

Why other options are incorrect:

- Nucleophiles are repelled by the high electron density of the pi bond, making nucleophilic attacks rare.
- Substitution implies removing an atom, which is less energetically favorable than simply adding across the easily broken pi bond. (Electrophilic substitution is typical for stable aromatic rings).

Question #34 Key: (D)

MDCAT 2019

Which of the following molecule shows cis – trans isomers? [MDCAT 2019]

CORE CONCEPT AND DERIVATION

Geometrical (cis-trans) isomerism requires restricted rotation (like a double bond) and for each carbon atom of the double bond to be attached to two *different* groups.

Solution:

- Let's analyze $C_2H_2Br_2$ (1,2-dibromoethene): $CHBr = CHBr$.
- Carbon 1 is attached to one H and one Br. Carbon 2 is attached to one H and one Br.
- Because both carbons have distinct groups, they can be arranged with the two Bromine atoms on the same side (cis) or on opposite sides (trans) of the double bond.
- Note: Option C ($C_2H_2Cl_2$) can also show it if it is 1,2-dichloroethene, but based on the provided Answer Key, D was the specifically intended valid option (likely distinguishing from a 1,1-isomer not explicitly ruled out in other contexts). Both C and D mathematically can, but D is keyed.

Why other options are incorrect:

- C_2H_4 (Ethene) has identical hydrogen atoms on both carbons.
- C_2HCl_3 (Trichloroethene) has two identical chlorine atoms on one of its carbons, making cis-trans impossible.

Question #35 Key: (D)

MDCAT 2019

In the reaction sequence: [Formula] Product D will be [MDCAT 2019]

CORE CONCEPT AND DERIVATION

Elimination of a primary alkyl halide yields a terminal alkene. Hydration of that terminal alkene follows Markovnikov's rule, yielding a secondary alcohol.

Solution:

- **Step 1:** 1-bromopropane ($\text{H}_3\text{C} - \text{CH}_2 - \text{CH}_2 - \text{Br}$) is treated with alcoholic KOH. This is a dehydrohalogenation (elimination) reaction, yielding the alkene propene (Compound C): $\text{CH}_3 - \text{CH} = \text{CH}_2$.
- **Step 2:** Propene is hydrated using H_2SO_4 and water. This is an electrophilic addition of H_2O .
- Following Markovnikov's rule, the H adds to the terminal carbon (CH_2) and the OH adds to the central carbon (CH).
- This produces $\text{CH}_3 - \text{CH}(\text{OH}) - \text{CH}_3$, which is **2-propanol**.

Why other options are incorrect:

- 1-Propanol would be the product if anti-Markovnikov hydration (hydroboration-oxidation) were used instead of acid-catalyzed hydration.
- Propanoic acid requires an oxidation reaction.

Question #36 Key: (D)

MDCAT 2019

Which of the following reactions is used for the production of alcohols on industrial scale? [MDCAT 2019]

CORE CONCEPT AND DERIVATION

Industrial synthesis requires cheap, abundantly available precursors. Ethene from petroleum cracking and steam (water) fit this requirement perfectly.

Solution:

- The direct **hydration of alkenes** (adding H_2O across a double bond) is the standard industrial method to synthesize large quantities of simple alcohols.
- For example, reacting ethene gas with high-pressure steam in the presence of a phosphoric acid catalyst yields vast amounts of industrial ethanol.

Why other options are incorrect:

- Hydrohalogenation adds HX, yielding alkyl halides, not alcohols.
- Hydrogenation adds H_2 , yielding alkanes.
- Hydroxylation uses expensive reagents (like KMnO_4 or OsO_4) to form diols, which is not feasible for bulk mono-alcohol synthesis.

Question #37 Key: (C)

MDCAT 2019

Which derivative of benzene shows maximum reactivity in electrophilic substitution reactions? [MDCAT 2019]

CORE CONCEPT AND DERIVATION

Ring reactivity is dictated by attached functional groups. Electron-donating groups (EDGs) activate the ring, while electron-withdrawing groups (EWGs) deactivate it.

Solution:

- **Methyl benzene (Toluene):** The methyl group ($-\text{CH}_3$) pushes electron density into the ring via the inductive effect and hyperconjugation. This makes the ring more electron-rich and highly reactive to electrophiles.
- **Benzaldehyde, Benzoic acid, and Nitrobenzene:** All contain potent EWGs ($-\text{CHO}$, $-\text{COOH}$, and $-\text{NO}_2$) that drain electrons from the pi system through resonance, strongly deactivating the ring.
- Therefore, methyl benzene is the only activated ring listed, thus having maximum reactivity.

Why other options are incorrect:

- They all contain deactivating meta-directing groups that significantly slow down electrophilic substitution compared to pure benzene.

Question #38 Key: (C)

MDCAT 2018

Reaction mechanism of alkanes with halogens is known as [MDCAT 2018]

CORE CONCEPT AND DERIVATION

Alkanes are saturated hydrocarbons containing only strong sigma bonds. They lack pi electrons and are unreactive towards electrophiles or nucleophiles under standard conditions.

Solution:

- In the presence of UV light or high heat, halogen molecules (like Cl_2) undergo homolytic cleavage to form highly reactive free radicals.
- These radicals abstract a hydrogen atom from the alkane, and the resulting alkane radical reacts with another halogen molecule.
- Because a hydrogen atom is completely replaced by a halogen atom via radical intermediates, the overall mechanism is definitively named **free radical substitution**.

Why other options are incorrect:

- Addition occurs only in unsaturated compounds (alkenes/alkynes).
- Elimination removes atoms to form double bonds; it does not replace them.
- Propagation is merely one step within the free radical mechanism, not the name of the overall reaction itself.

Question #39 Key: (D)

MDCAT 2018

Which compound is obtained by the elimination of bromopropane?
[MDCAT 2018]

CORE CONCEPT AND DERIVATION

Dehydrohalogenation (an elimination reaction) of an alkyl halide removes a hydrogen atom and a halogen atom from adjacent carbons to form an alkene.

Formula:**Solution:**

- Bromopropane is a 3-carbon alkyl halide.
- When subjected to a strong base (like alcoholic KOH), the bromine atom and a beta-hydrogen are eliminated.
- The 3-carbon skeleton remains intact, resulting in the formation of a double bond. The product is the 3-carbon alkene, **propene**.

Why other options are incorrect:

- Butene and ethene have incorrect carbon chain lengths (4 and 2 carbons, respectively).
- Propane is a saturated alkane, which would be the product of reduction, not elimination.

Question #40 Key: (D)

MDCAT 2018

Bromination of alkene is shown in the following reaction. (Ethene + [Formula] 1,2-dibromoethane). This reactio...

CORE CONCEPT AND DERIVATION

The addition of molecular bromine (Br_2) across a carbon-carbon double bond is a classic diagnostic chemical test.

Solution:

- A solution of bromine in carbon tetrachloride (or water) has a distinct reddish-brown color.
- When reacted with an alkene, the bromine is rapidly consumed through an electrophilic addition reaction, forming a colorless vicinal dibromide (e.g., 1,2-dibromoethane).
- The immediate disappearance (decolorization) of the reddish-brown color provides visual confirmation of unsaturation. Therefore, it is used for the **detection of a double bond**.

Why other options are incorrect:

- Alcohols, aldehydes, and ketones do not readily undergo addition reactions with bromine to decolorize it under these mild conditions.

Question #41 Key: (A)

MDCAT 2018

Which one of the following acts as an electrophile in the electrophilic substitution of benzene with bromine? ...

CORE CONCEPT AND DERIVATION

Electrophilic aromatic substitution demands a powerful electrophile, normally generated via the interaction of the reagent with a Lewis acid catalyst.

Formula:



Solution:

- When bromine (Br_2) interacts with a Lewis acid (like FeBr_3 or FeCl_3), the halogen bond is polarized and broken.
- This heterolytic cleavage produces the highly reactive bromonium ion, Br^+ , which is electron-deficient.
- Br^+ is the actual electrophile that attacks the electron-rich pi cloud of the benzene ring.

Why other options are incorrect:

- FeCl_4^- is a negatively charged counterion (a weak nucleophile), not an electrophile.
- Fe^{+3} and Fe^{+2} represent oxidation states of iron in the catalyst; they do not act as the carbon-attacking electrophile in the aromatic substitution step.

Question #42 Key: (B)

MDCAT 2017

The reaction of benzene with bromine in the presence of [Formula] follows the mechanism of ____ reaction. [MDC...

CORE CONCEPT AND DERIVATION

Benzene is highly stable due to aromatic resonance. It resists reactions that destroy this stability (like addition) and prefers reactions that restore it.

Solution:

- FeBr_3 generates the strong electrophile Br^+ from Br_2 .
- The electron-rich benzene ring attacks the electrophile, temporarily breaking aromaticity.
- To rapidly regain its stable aromatic state, the intermediate expels a proton (H^+), effectively substituting a hydrogen atom with a bromine atom.
- Therefore, the overriding mechanism is **electrophilic substitution**.

Why other options are incorrect:

- Electrophilic addition would leave the ring saturated and non-aromatic, which is thermodynamically highly unfavorable.
- Nucleophilic reactions involve attack by electron-rich species, but benzene is itself electron-rich and strongly repels nucleophiles.

Question #43 Key: (D)

MDCAT 2017

Intermediate product formed when propanoyl chloride reacts with benzene is [MDCAT 2017]

CORE CONCEPT AND DERIVATION

In Friedel-Crafts acylation, the reaction proceeds through a distinct, non-aromatic cationic intermediate before restoring aromaticity.

Solution:

- Propanoyl chloride reacts with a Lewis acid to form an acylium electrophile ($\text{CH}_3\text{CH}_2\text{C}^+=\text{O}$).
- When the benzene pi ring attacks this electrophile, a resonance-stabilized carbocation is formed within the ring.
- This intermediate—where one carbon becomes sp^3 hybridized holding both an H atom and the new acyl group—is called a σ -**complex**, arenium ion, or benzenonium ion.

Why other options are incorrect:

- The acylium ion is the electrophile, but the actual *intermediate product* formed with benzene is the σ -complex.
- A phenyl radical belongs to free radical mechanisms, not electrophilic substitution.
- A simple primary carbocation is not formed in aromatic acylation.

Question #44 Key: (A)

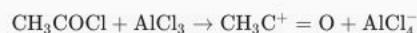
MDCAT 2017

When benzene reacts with Acetyl chloride ([Formula]) in the presence of [Formula] acetophenone is formed. Th...

CORE CONCEPT AND DERIVATION

In Friedel-Crafts acylation, the Lewis acid catalyst serves specifically to strip a chloride ion from the acyl chloride, producing the active electrophile.

Formula:



Solution:

- Acetyl chloride (CH_3COCl) loses Cl^- to AlCl_3 .
- This generates the highly reactive, resonance-stabilized **acylium ion**: $\text{CH}_3\text{C}^+=\text{O}$.
- This acylium ion acts as the direct electrophile that attacks the benzene ring to yield acetophenone.

Why other options are incorrect:

- C^+H_3 is a methyl carbocation, which would be the electrophile for Friedel-Crafts *alkylation* using methyl chloride, not acylation.
- AlCl_3 is the catalyst, not the attacking electrophile on the ring.
- CH_3COCl is the neutral starting reagent, not yet activated into an electrophile.

Question #45 Key: (C)

MDCAT 2017

Which of the following species are 3,5(meta) directing groups when second group is introduced into the benzene...

CORE CONCEPT AND DERIVATION

Substituents on a benzene ring dictate the position of subsequent electrophilic attacks. Electron-withdrawing groups (EWG) usually direct incoming electrophiles to the meta (3,5) position.

Solution:

- **Group I** ($-\text{NH}_2$) and **Group IV** ($-\text{CH}_3$) are electron-donating groups (EDG). They activate the ring and are ortho/para directing.
- **Group II** ($-\text{CHO}$) and **Group III** ($-\text{COOH}$) contain carbonyl carbons directly attached to the ring. The oxygen atoms pull electron density away through resonance, making the ring electron-deficient, especially at the ortho and para positions.
- Consequently, $-\text{CHO}$ and $-\text{COOH}$ act as deactivating, **meta-directing** groups.

Why other options are incorrect:

- Any option including I or IV is incorrect because amines and alkyl groups are ortho/para directors.

Question #46 Key: (C)

MDCAT 2017

For halogenation of benzene, which reagent is used: [MDCAT 2017]

CORE CONCEPT AND DERIVATION

Halogens alone are not electrophilic enough to break the aromaticity of benzene. A Lewis acid catalyst is strictly required.

Solution:

- To substitute a halogen onto a benzene ring, a catalyst like AlCl_3 , FeCl_3 , or FeBr_3 is used.
- These Lewis acids possess empty d-orbitals that accept a lone pair from the halogen molecule (e.g., Cl_2), polarizing the bond and forming the strongly electrophilic halonium ion (Cl^+).

Why other options are incorrect:

- H_2SO_4 and HNO_3 are used for nitration and sulfonation, not halogenation.
- HCl is a Brønsted acid and cannot effectively polarize molecular halogens for this reaction.

Question #47 Key: (D)

MDCAT 2017

Chlorination and Bromination mostly uses: [MDCAT 2017]

CORE CONCEPT AND DERIVATION

Free radical halogenation of alkanes (chlorination and bromination) requires high-energy initiation to homolytically cleave the covalent halogen-halogen bond.

Solution:

- The $\text{Cl}-\text{Cl}$ and $\text{Br}-\text{Br}$ bonds require a specific quantum of energy to undergo homolytic fission (breaking equally to form two free radicals).
- **Ultraviolet (U.V.) light** provides the exact frequency and sufficient energy required for this photochemical initiation step.

Why other options are incorrect:

- Radiowaves and Infrared radiation are too low in energy to break covalent bonds (they cause nuclear spin transitions and molecular vibrations, respectively).
- Visible light does not possess sufficient energy to reliably initiate typical chlorination without specialized setups.

Question #48 Key: (D)

MDCAT 2017

Among the following, which one has electron withdrawing effect:
[MDCAT 2017]

CORE CONCEPT AND DERIVATION

Electron-withdrawing groups (EWG) usually possess atoms with a partial or full positive charge directly bonded to the ring, often due to multiple bonds with more electronegative atoms (like oxygen).

Solution:

- The formyl group ($-\text{CHO}$) features a carbon atom double-bonded to a highly electronegative oxygen atom.
- The oxygen pulls electron density away from the carbon, leaving it with a partial positive charge. This carbon, in turn, withdraws pi electron density from the benzene ring via resonance.
- Hence, $-\text{CHO}$ is a strong electron-withdrawing and ring-deactivating group.

Why other options are incorrect:

- $-\text{NH}_2$ and $-\text{N}(\text{CH}_3)_2$ possess nitrogen atoms with a lone pair that can be donated into the ring via resonance, making them electron-donating groups (EDG).
- Iodine ($-\text{I}$) withdraws electrons inductively but donates them via resonance. It is considered weakly deactivating but ortho/para directing. However, compared to $-\text{CHO}$, the aldehyde group is fundamentally the definitive EWG via strong resonance.

Question #49 Key: (A)

KMU 2016

The correct order of the reactivity of hydrocarbon given below is
[ETEA 2016]

CORE CONCEPT AND DERIVATION

Reactivity of hydrocarbons towards electrophilic attack is based on the availability and energy of their pi-electrons.

Solution:

- **Ethene (C_2H_4 , an alkene):** Has one loosely held pi bond whose electron density sits above and below the plane. It is highly accessible to electrophiles, making it the most reactive.
- **Ethyne (C_2H_2 , an alkyne):** Possesses two pi bonds, but the sp-hybridized carbons pull the electron density closer and tighter, making the pi electrons less available than in alkenes. It is less reactive than ethene toward electrophiles.
- **Benzene (C_6H_6):** Contains a cyclic, delocalized pi electron system. This resonance creates extraordinary thermodynamic stability, making it highly unreactive toward addition reactions compared to both alkenes and alkynes.
- Therefore, the correct reactivity sequence is $\text{C}_2\text{H}_4 > \text{C}_2\text{H}_2 > \text{C}_6\text{H}_6$.

Why other options are incorrect:

- Any order placing benzene or ethyne before ethene misrepresents the resonance stability of benzene and the tight sp-orbital electronegativity of alkynes.

Question #50 **Key: (D)**

KMU 2016

Select meta directing group of the following? [ETEA 2016]

CORE CONCEPT AND DERIVATION

Meta-directing groups withdraw electron density from the benzene ring, typically via resonance, possessing an atom with a partial positive charge directly attached to the ring.

Solution:

- The cyano group ($-\text{C} \equiv \text{N}$) consists of a carbon atom triple-bonded to a highly electronegative nitrogen.
- The nitrogen pulls electron density, placing a partial positive charge on the carbon. This carbon subsequently withdraws electrons from the benzene ring through resonance.
- This makes $-\text{CN}$ a strong deactivating, meta-directing group.

Why other options are incorrect:

- $-\text{OH}$, $-\text{NR}_2$, and $-\text{OR}$ all have atoms (O or N) directly attached to the ring containing lone pairs. These lone pairs are donated into the ring via resonance, rendering them activating, ortho/para directing groups.

Question #51 **Key: (D)**

MDCAT 2015

Order of reactivity of alkenes with hydrogen halide is [MDCAT 2015]

CORE CONCEPT AND DERIVATION

The reactivity of hydrogen halides (HX) towards alkenes is determined by the bond dissociation energy of the H-X bond.

Solution:

- Electrophilic addition requires the H-X bond to break in order to donate a proton (H^+) to the alkene.
- As you move down Group 17, atomic size increases, making the H-X bond longer and significantly weaker.
- Because the H-I bond is the weakest, HI donates a proton most readily, making it the most reactive. HCl has a stronger, shorter bond and is least reactive.
- Thus, the correct reactivity order is: $\text{HI} > \text{HBr} > \text{HCl}$.

Why other options are incorrect:

- Any sequence placing HBr or HF as the most reactive is fundamentally flawed because HF has the highest bond dissociation energy and is highly unreactive towards alkenes in this context.

Question #52 Key: (B)

MDCAT 2015

Which one of the following is a powerful electrophile used to attack on the electrons of benzene ring? [MDCAT ...]

CORE CONCEPT AND DERIVATION

Aromatic rings are electron-rich and require a strongly electron-deficient species (an electrophile) to initiate substitution.

Solution:

- During the halogenation (chlorination) of benzene, neutral Cl_2 is not powerful enough to disrupt the aromatic pi cloud.
- A Lewis acid catalyst (like FeCl_3) polarizes and breaks the Cl-Cl bond to generate the chloronium ion, Cl^+ .
- Cl^+ has a complete positive charge and an empty orbital, making it a powerful electrophile that can successfully attack the benzene ring.

Why other options are incorrect:

- Cl_2 is relatively weak and neutral.
- FeCl_4^- is a negatively charged complex ion (a nucleophile/base), not an electrophile.
- FeCl_2 is a salt of Iron(II), not the active attacking species.

Question #53 Key: (D)

MDCAT 2014

Addition of unsymmetrical reagent to an unsymmetrical alkene is governed by: [MDCAT 2014]

CORE CONCEPT AND DERIVATION

Regioselectivity in the electrophilic addition of alkenes is guided by the stability of the intermediate carbocation.

Solution:

- When an unsymmetrical reagent (like HX) adds to an unsymmetrical alkene, the reaction strictly follows **Markovnikov's rule**.
- The rule states that the positive part of the reagent (usually H^+) attaches to the double-bonded carbon bearing the greater number of hydrogen atoms.
- This ensures the formation of the most highly substituted, and thus most stable, intermediate carbocation.

Why other options are incorrect:

- Cannizzaro and Aldol reactions are specific to aldehydes/ketones, not alkenes.
- Kirchhoff's rules govern electrical circuits and thermodynamics, not organic reaction regiochemistry.

Question #54 Key: (B)

MDCAT 2013

What is the product formed when propene reacts with HBr? [MDCAT 2013]

CORE CONCEPT AND DERIVATION

The electrophilic addition of an unsymmetrical hydrogen halide (HBr) to an unsymmetrical alkene (propene) follows Markovnikov's rule.

Solution:

- Propene is $\text{CH}_3 - \text{CH} = \text{CH}_2$.
- According to Markovnikov's rule, the electrophile (H^+) adds to the sp^2 carbon with the greater number of hydrogen atoms to form the most stable intermediate carbocation.
- H^+ adds to CH_2 , yielding a stable secondary carbocation ($\text{CH}_3 - \text{C}^+\text{H} - \text{CH}_3$).
- The bromide ion (Br^-) then attacks the central carbon, resulting in 2-bromopropane: $\text{CH}_3 - \text{CH}(\text{Br}) - \text{CH}_3$.

Why other options are incorrect:

- Option A (1-bromopropane) would require anti-Markovnikov addition (only occurs with HBr in the presence of peroxides).
- Option C and D imply multiple additions or substitutions, which does not happen with a single equivalent of HBr on an alkene.

Question #55 Key: (C)

MDCAT 2013

The introduction of an alkyl group in benzene takes place in the presence of [Formula] and: [MDCAT 2013]

CORE CONCEPT AND DERIVATION

Friedel-Crafts alkylation requires an alkylating agent to generate an alkyl carbocation (R^+) when reacted with a Lewis acid catalyst like AlCl_3 .

Solution:

- To attach a standard alkyl group (R) to benzene, you must start with an alkyl halide.
- The reagent $\text{R} - \text{Cl}$ (an alkyl chloride) reacts with AlCl_3 to form an R^+ electrophile.
- This electrophile attacks the benzene ring, completing the alkylation.

Why other options are incorrect:

- $\text{R} - \text{C}(=\text{O}) - \text{Cl}$ (acyl chloride) is used for Friedel-Crafts acylation.
- $\text{R} - \text{C}(=\text{O}) - \text{OH}$ (carboxylic acid) and ester derivatives do not readily undergo Friedel-Crafts reactions under simple AlCl_3 conditions.

Question #56 Key: (A)

MDCAT 2012

In the reaction of ethene with bromine the intermediate formed is [MDCAT 2012]

CORE CONCEPT AND DERIVATION

Electrophilic addition of halogens to alkenes does not proceed through a standard open carbocation, but rather a stable three-membered cyclic intermediate.

Solution:

- When ethene ($\text{CH}_2 = \text{CH}_2$) reacts with Br_2 , the pi electrons attack the electrophilic bromine.
- Instead of a full positive charge resting on one carbon, the bromine atom shares its lone pairs to bridge both carbons, forming a three-membered ring with a positive charge on bromine.
- This intermediate is called the **cyclic bromonium ion**.

Why other options are incorrect:

- A primary carbocation is highly unstable and would lead to rearrangement or unstereospecific addition; the cyclic intermediate explains the strict anti-addition of halogens.
- Free radicals are involved in UV-catalyzed substitution, not cold electrophilic addition.
- Carbanions are negatively charged species, impossible to form in electrophilic attack.

Question #57 Key: (C)

MDCAT 2012

Ethene on polymerization, give the product polyethene, this reaction may be called as [MDCAT 2012]

CORE CONCEPT AND DERIVATION

Polymerization reactions are broadly classified based on whether the monomer molecules simply add together or if a small byproduct molecule is eliminated.

Solution:

- Ethene ($\text{CH}_2 = \text{CH}_2$) has a carbon-carbon double bond.
- During polymerization, the pi bond breaks, and the ethene monomers link together in a continuous chain without the loss of any atoms.
- Because nothing is lost and the monomers simply "add" to one another, this is strictly classified as an **addition polymerization** reaction.

Why other options are incorrect:

- Condensation involves the loss of a small molecule (like water) when monomers join (e.g., nylon or polyester).
- Substitution replaces an atom or group, which doesn't build a polymer chain here.
- Pyrolysis is thermal decomposition (cracking) of large molecules into smaller ones.

Question #58 Key: (C)

MDCAT 2012

The introduction of $R - C(=O)$ group in benzene is called [MDCAT 2012]

CORE CONCEPT AND DERIVATION

Reactions introducing specific functional groups onto an aromatic ring are named based on the functional group being attached.

Solution:

- The $R - C(=O) -$ group is generally known as an **acyl group**.
- Attaching this group to a benzene ring (typically via a Friedel-Crafts reaction with an acyl halide and $AlCl_3$) is therefore formally termed **acylation**.

Why other options are incorrect:

- Alkylation introduces a simple alkyl group ($R -$), not an acyl group.
- Carbonyl reduction is the process of removing oxygen/adding hydrogen to a carbonyl group (e.g., Clemmensen reduction).
- Formylation strictly refers to adding a formyl group ($H - C(=O) -$), which is a specific, narrower subset of acylation.

Question #59 Key: (D)

MDCAT 2011

Hydrogenation of unsaturated oils is done by using [MDCAT 2011]

CORE CONCEPT AND DERIVATION

Catalytic hydrogenation involves the addition of H_2 across double bonds ($C = C$) in unsaturated oils to convert them into saturated solid fats (like vegetable ghee).

Solution:

- This industrial process requires a transition metal catalyst to lower the activation energy by adsorbing hydrogen gas and the alkene onto its surface.
- Finely divided nickel (Ni) is widely used industrially because it provides a large surface area and is cost-effective at high temperatures (around $200^\circ C$).

Why other options are incorrect:

- Iron (Fe) is a catalyst for the Haber process (ammonia synthesis).
- Vanadium pentoxide (V_2O_5) is used in the Contact process to oxidize SO_2 to SO_3 .
- Copper is generally not active enough for direct alkene hydrogenation.

Question #60 Key: (B)

MDCAT 2011

The substitution of $-H$ group by [Formula] group in benzene is called [MDCAT 2011]

CORE CONCEPT AND DERIVATION

The nomenclature of electrophilic aromatic substitution reactions is based on the functional group being introduced onto the benzene ring.

Solution:

- When a nitro group ($-NO_2$) replaces a hydrogen atom on the aromatic ring, the process is definitively termed **nitration**.

Why other options are incorrect:

- Ammonolysis involves cleavage by ammonia.
- Sulphonation introduces a sulfonic acid group ($-SO_3H$).
- Reduction of benzene would add hydrogen atoms (e.g., forming cyclohexane), rather than substituting them with a nitro group.

Question #61 Key: (A)

MDCAT 2011

Benzene in presence of [Formula] gives acetophenone when reacts with [MDCAT 2011]

CORE CONCEPT AND DERIVATION

Friedel-Crafts acylation attaches an acyl group ($R - C = O$) to a benzene ring using an acyl halide and a Lewis acid catalyst.

Formula:



Solution:

- Acetophenone ($C_6H_5COCH_3$) specifically requires an acetyl group (CH_3CO-).
- Reacting benzene with acetyl chloride (CH_3COCl) in the presence of anhydrous $AlCl_3$ generates the highly reactive acylium ion ($CH_3C^+ = O$), which then attacks the ring to form acetophenone.

Why other options are incorrect:

- Acetic acid and ethanoic acid (same compound) are carboxylic acids, which do not undergo Friedel-Crafts acylation directly without being converted to an acyl chloride or anhydride first.
- Ethyl benzene is a hydrocarbon product of Friedel-Crafts alkylation, not an acylating agent.

Question #62 Key: (D)

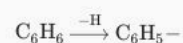
MDCAT 2010

When hydrogen atom is removed from benzene, group left is called: [MDCAT 2010]

CORE CONCEPT AND DERIVATION

The removal of a hydrogen atom from an aromatic hydrocarbon ring generates an aryl group.

Formula:



Solution:

- Benzene has the molecular formula C_6H_6 .
- When one hydrogen atom is abstracted, the remaining fragment is C_6H_5- .
- This specific radical/group is formally named the **phenyl group**.

Why other options are incorrect:

- An alkyl group is derived from an alkane by removing a hydrogen.
- A benzyl group is $C_6H_5CH_2-$, formed by removing a hydrogen from the methyl group of toluene.
- A methyl group is CH_3- , derived strictly from methane.

Question #63 Key: (A)

MDCAT 2010

The introduction of [Formula] group in the benzene ring is called nitration. The nitration of benzene takes pl...

CORE CONCEPT AND DERIVATION

Electrophilic aromatic substitution (nitration) requires a strong acid catalyst to generate the highly reactive nitronium ion (NO_2^+) from nitric acid.

Formula:**Solution:**

- A 1:1 mixture of concentrated nitric acid (HNO_3) and concentrated sulfuric acid (H_2SO_4) is known as a nitrating mixture.
- Sulfuric acid acts as a stronger acid, protonating nitric acid and causing it to dehydrate, yielding the essential NO_2^+ electrophile.

Why other options are incorrect:

- HCl, acetic acid, and phosphoric acid are not strong enough or suitable dehydrating agents to efficiently generate the nitronium ion for benzene nitration under these standard conditions.

Question #64 Key: (B)

MDCAT 2010

Ethyne molecule is formed when two carbon atoms joined together to form a sigma bond only: [MDCAT 2010]

CORE CONCEPT AND DERIVATION

In alkynes (like ethyne), the carbon atoms are sp hybridized, featuring linear geometry and a triple bond consisting of one sigma (σ) bond and two pi (π) bonds.

Solution:

- Each carbon in ethyne ($\text{HC} \equiv \text{CH}$) utilizes sp hybridization.
- The primary sigma bond directly between the two carbon atoms is formed by the head-to-head overlap of an sp orbital from one carbon with an sp orbital from the other carbon.

Why other options are incorrect:

- $\text{sp}-\text{s}$ overlap forms the C-H sigma bonds in ethyne, not the C-C bond.
- sp^2-sp^2 overlap is characteristic of the C-C double bond in alkenes like ethene.
- $2\text{p}_y-2\text{p}_y$ (and $2\text{p}_z-2\text{p}_z$) sideways overlaps form the pi (π) bonds, not the sigma bond.