CLASS 11 CHEMISTRY — FORMULA SHEET

Chapter 9 : Hydrocarbons (NCERT)

9.1 Classification & General Formulae

Class	General Formula	Example	DoU	Bond
Alkane	C_nH_{2n+2}	Methane CH_4	0	C−C (sp^3)
Alkene	C_nH_{2n}	Ethene C_2H_4	1	C=C (sp^2)
Alkyne	C_nH_{2n-2}	Ethyne C_2H_2	2	C≡C (sp)
Cycloalkane	C_nH_{2n}	Cyclopentane C_5H_{10}	1	C−C ring
Arene (benzene)	C_nH_{2n-6}	Benzene C_6H_6	4	Delocalised

9.2 Combustion (General Equations)

Compound	Combustion Equation
Alkane	$C_nH_{2n+2} + (3n+1)/2\ O_2 \rightarrow n\ CO_2 + (n+1)\ H_2O$
General hydrocarbon	$C_xH_y + (x + y/4)\ O_2 \rightarrow x\ CO_2 + (y/2)\ H_2O$
Methane	$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$
Ethene	$C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O$
Ethyne	$2C_2H_2 + 5O_2 \rightarrow 4CO_2 + 2H_2O$

9.3 Alkanes — Preparation & Reactions

Reaction	Equation / Condition
Wurtz reaction	2R−X + 2Na → R−R + 2NaX (dry ether)
Hydrogenation (Sabatier)	Alkene/alkyne + H_2 → alkane (Ni/Pt/Pd, Δ)
Decarboxylation	RCOONa + NaOH → R−H + Na_2CO_3 (CaO, Δ)
Kolbe electrolysis	2RCOONa + $2H_2O$ → R−R + $2CO_2$ + H_2 + 2NaOH
Frankland reaction	2R−X + Zn → R−R + ZnX_2
Halogenation (free radical)	$CH_4 + Cl_2 \rightarrow CH_3Cl + HCl$ (UV light); reactivity 3°H > 2°H > 1°H
Free-radical steps	Initiation: $Cl_2 \rightarrow 2Cl\bullet$; Propagation & Termination
Isomerisation / Pyrolysis	n-alkane → branched ($AlCl_3$, HCl) ; cracking → smaller alkane + alkene (high T)

9.4 Alkenes — Reactions & Markovnikov's Rule

Reaction	Equation / Rule
Markovnikov's rule	H^+ adds to C with MORE H atoms (forms more stable carbocation)
Anti-Markovnikov (peroxide / Kharasch)	Only with HBr + peroxide: Br adds to C with MORE H (free-radical)

Reaction	Equation / Rule
Hydrogenation	$CH_2=CH_2 + H_2 \rightarrow CH_3-CH_3$ (Ni/Pt/Pd)
Halogenation	$CH_2=CH_2 + Br_2 \rightarrow BrCH_2-CH_2Br$ (decolourises Br_2 water)
Hydration	$CH_2=CH_2 + H_2O \rightarrow CH_3CH_2OH$ (dil. H_2SO_4)
Ozonolysis (reductive)	Alkene + O_3 → ozonide → (Zn/H_2O) → aldehydes/ketones
Baeyer's test (oxidation)	Cold dilute alkaline $KMnO_4$ → vicinal diol (pink decolourised)
Polymerisation	n $CH_2=CH_2$ → polythene (high P, catalyst)

9.5 Alkynes — Reactions

Reaction	Equation / Condition
Hydrogenation → alkene	$RC\equiv CR + H_2 \rightarrow$ cis-alkene (Lindlar's catalyst: $Pd/BaSO_4$ + quinoline)
Hydrogenation → alkane	$RC\equiv CR + 2H_2 \rightarrow$ alkane (Ni/Pt)
Hydration (Markovnikov)	$HC\equiv CH + H_2O \rightarrow CH_3CHO$ ($HgSO_4$, dil. H_2SO_4)
Acidity of terminal alkyne	$HC\equiv CH + Na \rightarrow HC\equiv C^-Na^+ + \frac{1}{2}H_2$; reacts with $NaNH_2$
Silver acetylide test	Terminal alkyne + ammoniacal $AgNO_3$ → white precipitate
Cuprous acetylide test	Terminal alkyne + ammoniacal Cu_2Cl_2 → red precipitate
Acidity order	$HC\equiv CH > H_2C=CH_2 > CH_3-CH_3$ ($sp > sp^2 > sp^3$; more s-character)
Cyclic polymerisation	3 $HC\equiv CH \rightarrow$ benzene (red-hot Fe tube, 873 K)

9.6 Aromatic Hydrocarbons — Benzene

Concept	Detail
Aromaticity (Huckel's rule)	Planar, cyclic, fully conjugated, with $(4n + 2)$ π electrons (n = 0,1,2…)
Benzene	6 π electrons (n = 1) → aromatic; all C−C bonds equal (resonance hybrid)
Electrophilic substitution (EAS)	Halogenation, nitration, sulphonation, Friedel–Crafts alkylation & acylation
Nitration	C_6H_6 + conc. HNO_3/conc. H_2SO_4 → nitrobenzene ($E^+ = NO_2^+$)
Halogenation	$C_6H_6 + Cl_2 \rightarrow$ chlorobenzene (anhyd. $FeCl_3/AlCl_3$)
Friedel–Crafts alkylation	$C_6H_6 + RCl \rightarrow C_6H_5R$ (anhyd. $AlCl_3$)
Friedel–Crafts acylation	$C_6H_6 + RCOCl \rightarrow C_6H_5COR$ (anhyd. $AlCl_3$)

9.7 Directing Effects in Benzene (EAS)

Director Type	Groups
Ortho/para directing (activating)	−OH, −OR, $-NH_2$, −NHR, $-NR_2$, −NHCOR, $-CH_3$ (−R) → increase reactivity
Ortho/para directing (deactivating)	−F, −Cl, −Br, −I (halogens: deactivate but direct o/p)
Meta directing (deactivating)	$-NO_2$, −CN, −CHO, −COR, −COOH, $-SO_3H$ → decrease reactivity
Reactivity order	Activated ring > benzene > deactivated ring

9.8 Important Name Reactions

Name Reaction	Equation / Condition
Wurtz	$2R-X + 2Na \rightarrow R-R + 2NaX$ (dry ether)
Kolbe electrolysis	$2RCOONa + 2H_2O \rightarrow R-R + 2CO_2 + H_2 + 2NaOH$
Frankland	$2R-X + Zn \rightarrow R-R + ZnX_2$
Ozonolysis	Alkene + $O_3 \rightarrow (Zn/H_2O) \rightarrow$ aldehydes/ketones
Friedel–Crafts	Benzene + RCl/RCOCl $\rightarrow$ alkyl/acyl benzene (anhyd. $AlCl_3$)

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General formulae	Alkane 2n+2, Alkene 2n, Alkyne 2n−2, Arene 2n−6 (each π/ring drops 2 H).
Markovnikov	'Rich get richer' — H adds to the C that already has more H atoms.
Peroxide effect	ONLY HBr + peroxide gives anti-Markovnikov (HCl & HI don't).
Both tests decolourise	Br_2 water AND Baeyer's ($KMnO_4$) decolourise with C=C and C≡C.
Acidity of C−H	$sp > sp^2 > sp^3 \rightarrow$ terminal alkynes are acidic (give metal acetylides).
Huckel's rule	Aromatic if (4n+2) π electrons → 2, 6, 10… (benzene = 6).
o/p vs m directors	Activating groups → o/p ; deactivating (except halogens) → meta.
Lindlar's catalyst	$Pd/BaSO_4$ + quinoline → stops at cis-alkene (poisoned catalyst).