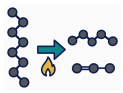
Alkanes Summary Map

Cambridge International AS & A Level Chemistry · 14.1 Alkanes

1 Cracking

14.1.1(b), 14.1.4

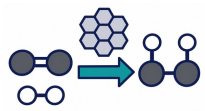
- Long chains → shorter alkanes + alkenes
- **Heat** with an **Al_2O_3** catalyst
- More demand for petrol and alkenes (polymers)
- e.g. $C_{10}H_{22} \rightarrow C_8H_{18} + C_2H_4$
- Balance C and H: the alkene is C_nH_{2n}



2 Hydrogenation

14.1.1(a)

- Alkene + H_2 → alkane
- **H_2(g)**, a **Pt or Ni** catalyst, **heat**
- Addition (and reduction)
- e.g. $CH_2{=}CHCH_3 + H_2 \rightarrow CH_3CH_2CH_3$
- One H_2 for each C=C

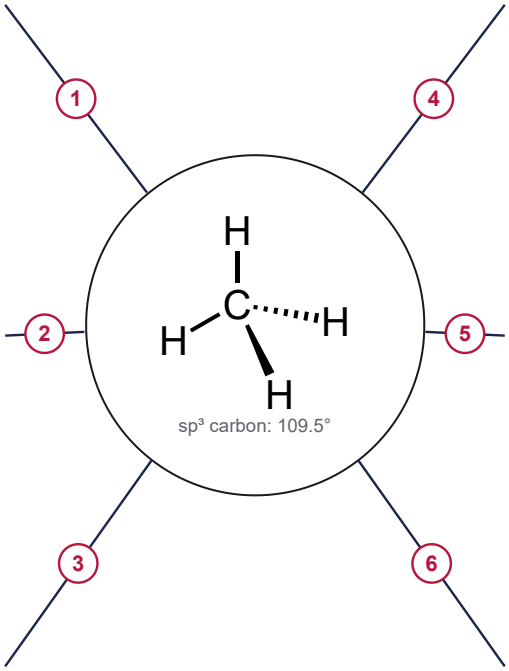


3 Unreactivity

14.1.5

- Alkanes react with few reagents, even polar ones
- **Strong** C–H (and C–C) bonds
- C–H bonds have very little **polarity**
- No δ+ or δ− site to attack
- They burn, and react with halogens in UV light





4 Combustion

14.1.2(a)

- **Complete** (plenty of O_2): $CO_2 + H_2O$
- **Incomplete** (limited O_2): CO or C + H_2O
- Very exothermic: alkanes are fuels
- Balance C, then H, then O last (halves allowed)
- Incomplete burning releases less energy



5 Engine pollutants

14.1.6

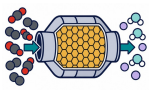
- **CO**: toxic, binds to haemoglobin
- **NO_x**: $N_2 + O_2$ from the air at high engine temperatures
- NO_2 dissolves in rain: acid rain; also smog
- **Unburnt hydrocarbons**: photochemical smog
- CO_2: a greenhouse gas, not removed



6 Catalytic converter

14.1.6

- Pt and Rh on a ceramic honeycomb
- $2CO + 2NO \rightarrow 2CO_2 + N_2$
- Unburnt hydrocarbons + $O_2 \rightarrow CO_2 + H_2O$
- Works only when hot
- Removes CO, NO_x and hydrocarbons, not CO_2



Free-radical substitution: ethane and chlorine

UV light; a dot marks the unpaired electron (Cl•, •C_2H_5); bromine reacts in the same way

Stage	What happens	Equation
initiation	UV light breaks Cl–Cl (homolytic fission)	$Cl_2 \rightarrow 2Cl•$
propagation 1	Cl• takes an H atom	$Cl• + C_2H_6 \rightarrow HCl + •C_2H_5$
propagation 2	•C_2H_5 takes a Cl atom; Cl• is remade	$•C_2H_5 + Cl_2 \rightarrow C_2H_5Cl + Cl•$
termination	two radicals pair their electrons	$Cl• + Cl• \rightarrow Cl_2$; $•C_2H_5 + Cl• \rightarrow C_2H_5Cl$; $2•C_2H_5 \rightarrow C_4H_{10}$
overall	Cl replaces H: substitution	$C_2H_6 + Cl_2 \rightarrow C_2H_5Cl + HCl$
a chain reaction	Cl• made in step 2 starts step 1 again	one Cl• makes many C_2H_5Cl

Worked examples

Balancing: a worked example

- Octane, complete: $C_8H_{18} + O_2 \rightarrow 8CO_2 + 9H_2O$
- O atoms: 16 + 9 = 25
- → **$C_8H_{18} + 12½O_2 \rightarrow 8CO_2 + 9H_2O$**
- To CO: $C_8H_{18} + 8½O_2 \rightarrow 8CO + 9H_2O$

Two ways to make alkanes

- Cracking: $C_{14}H_{30} \rightarrow C_{10}H_{22} + C_4H_8$ (heat, Al_2O_3)
- Hydrogenation: $C_4H_8 + H_2 \rightarrow C_4H_{10}$ (Ni, heat)
- Cracking makes alkenes; hydrogenation uses them

Why the mixture?

- C_2H_5Cl still has C–H bonds for Cl• to attack
- Excess ethane favours C_2H_5Cl
- Butane ($2•C_2H_5$) shows ethyl radicals form

Butane among the products of chlorinating ethane is evidence for ethyl radicals ($2•C_2H_5 \rightarrow C_4H_{10}$).

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