29.2 Characteristic organic reactions

Name: _____ Class: _____ Date: _____ **Total: 21 marks**

KEY WORDS electrophilic substitution • addition–elimination • characteristic organic reactions • free radicals • electrophiles

Objective

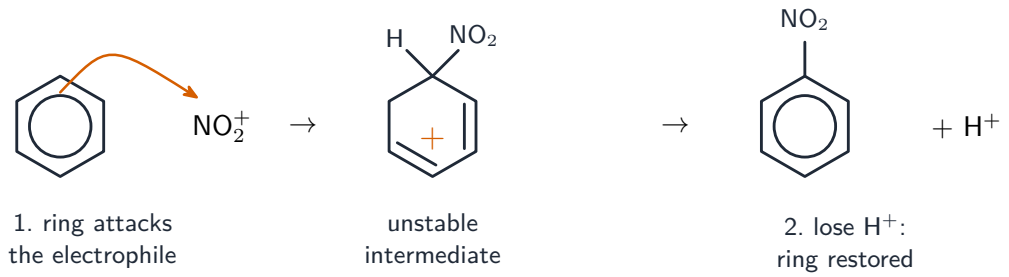
Build the skills to answer exam questions on **characteristic organic reactions** – classifying a reaction by its type and the kind of reagent involved.

You must be able to:

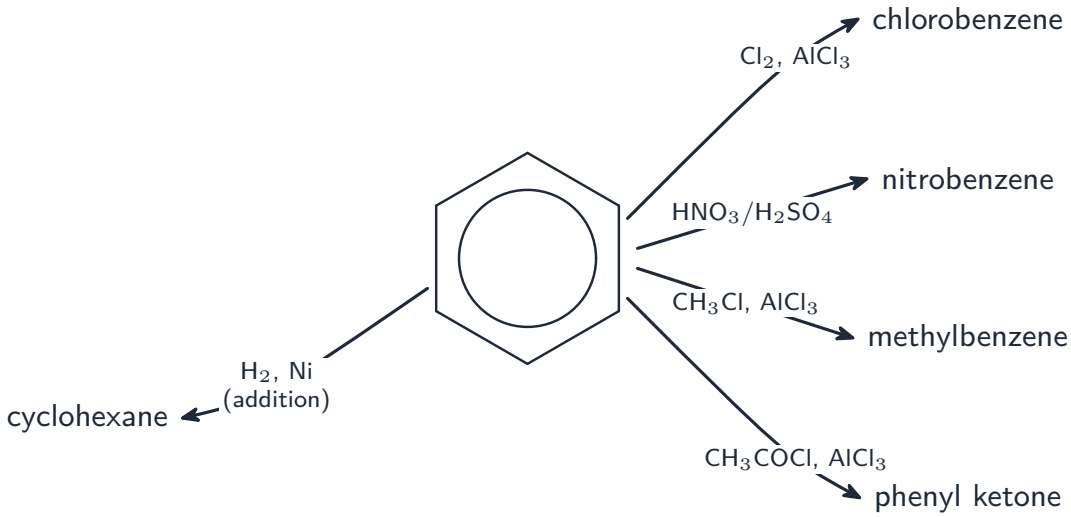
- classify reactions as addition, substitution, elimination, hydrolysis, condensation, oxidation, reduction or polymerisation
- classify reagents as **electrophiles**, **nucleophiles** or **free radicals**
- describe the two new mechanism types: **electrophilic substitution** and **addition–elimination**

1 Key knowledge and worked examples

Naming the reaction type



Electrophilic substitution: an electrophile replaces a ring hydrogen – the characteristic reaction of benzene



Characteristic reactions of the benzene ring

- **electrophilic substitution** – an electrophile replaces an H on a benzene ring (e.g. nitration).
- **nucleophilic substitution** – a nucleophile replaces a leaving group (e.g. OH^- + halogenoalkane).
- **addition** – a π bond opens and two groups add on (e.g. Br_2 + alkene).
- **addition–elimination** – a group adds, then a small molecule leaves (e.g. 2,4-DNPH, acyl chlorides).

Reagent types: electrophile = electron-pair **acceptor**; nucleophile = electron-pair **donor**; radical = species with an unpaired electron.

2 Practice

2.1 State what is meant by an **electrophile**. [1]

2.2 Classify the reaction of bromine with ethene (an alkene). [1]

3 Exam-style questions

3.1 The reaction of OH^- with bromoethane is best classified as: [1]

- ☐ **A** electrophilic addition
- **B** nucleophilic substitution
- **C** electrophilic substitution
- **D** free-radical substitution

3.2 Which species is a nucleophile? [1]

- ☐ **A** NO_2^+
- **B** H^+
- **C** $:NH_3$
- **D** $Cl^\bullet$

3.3 For each reaction, name the **type** and the **reagent class**: [3]

(a) benzene + NO_2^+ → nitrobenzene + H^+

(b) ethene + Br_2 → 1,2-dibromoethane

(c) an ester + water → a carboxylic acid + an alcohol

3.4 Explain why benzene undergoes **substitution** rather than **addition**, unlike an alkene. [2]

3.5 Four reactions of propene and its derivatives are shown.

- **I** $CH_3CH = CH_2 + Br_2 \rightarrow CH_3CHBrCH_2Br$
- **II** $CH_3CHBrCH_3 + KOH(aq) \rightarrow CH_3CH(OH)CH_3 + KBr$
- **III** $CH_3CHBrCH_3 + KOH$ in ethanol $\rightarrow CH_3CH = CH_2 + KBr + H_2O$
- **IV** $CH_3CH(OH)CH_3 + [O] \rightarrow CH_3COCH_3 + H_2O$

(a) Classify each reaction by type. [4]

(b) For **I**, name the attacking species and explain how a non-polar bromine molecule comes to attack an alkene. [3]

(c) Reactions **II** and **III** use the same reagent on the same compound but give different products. Explain what decides which happens. [2]

(d) Name a suitable oxidising agent for **IV**, and state what you would see. Explain why the product cannot be oxidised further. [3]