5.3.1 Use benzene evidence and select substitution conditions

Name: _____ Class: _____ Date: _____ **Total: 18 marks**

KEY WORDS evidence • conditions

Objective

Use benzene evidence and select substitution conditions. All questions and marking guidance are original.

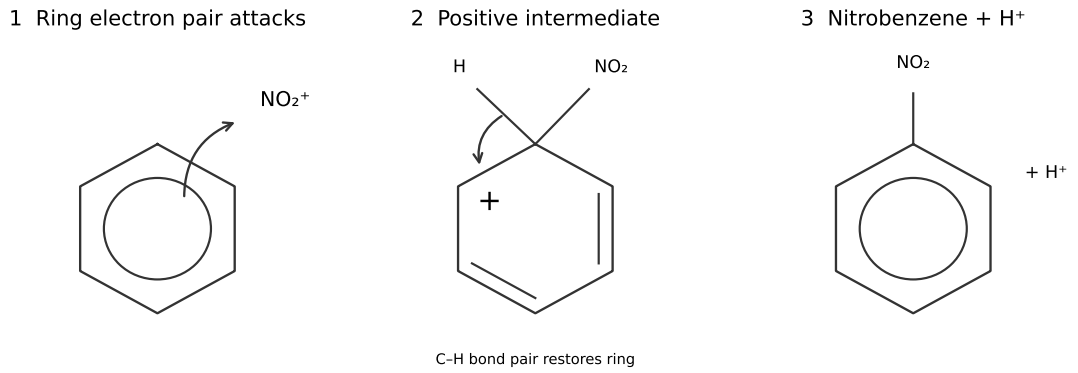
1 Key knowledge and worked examples

Benzene has equal C–C lengths and a delocalised ring. Addition would destroy that system. Electrophilic substitution replaces H then restores delocalisation. Phenol reacts with bromine water more readily because oxygen's lone pair increases ring electron density.

■ Worked method

If three isolated C=C bonds predict hydrogenation −360 kJ mol^{-1} but benzene gives −208, benzene is 152 kJ mol^{-1} more stable than that hypothetical localised model. Nitration uses concentrated HNO_3/H_2SO_4. $HNO_3 + H_2SO_4 \rightarrow NO_2^+ + HSO_4^- + H_2O$ generates the electrophile. A ring electron pair attacks NO_2^+; loss of H^+ restores the ring.

Nitration mechanism after NO_2^+ generation; curly arrows show electron pairs



2 Practice

2.1 Give two pieces of evidence against three separate ordinary C=C bonds in benzene. [2]

2.2 Calculate stabilisation relative to the hypothetical model if one C=C hydrogenation is -118 kJ mol^{-1} and benzene is -206 kJ mol^{-1}. [3]

2.3 State benzene bromination conditions and compare phenol with bromine water. [3]

3 Exam-style questions

3.1 Write the nitrating-electrophile generation equation and name the electrophile. Explain how substitution retains the aromatic system overall. [4]

3.2 Give reagents for making ethylbenzene and phenylethanone from benzene. Identify which is Friedel–Crafts acylation. [3]

3.3 A student predicts benzene will rapidly decolourise bromine water because it has six π electrons. Explain the error, and state sulfonation conditions. [3]