

Benzene structure and electrophilic substitution

Chemistry grades 11-12 (A Level · IB · Class 11-12) · Test

Name: _____ Date: _____ Class: _____ Mark: ____ / 20

This test lasts 45 minutes and is worth 20 points. Show all working, write balanced equations and give units. Use A_r values: H 1.0, C 12.0, N 14.0, O 16.0.

Level: Chemistry grades 11-12 (A Level · IB · Class 11-12) · **Curriculum:** A Level 3.3.10

Time: 45 minutes · 8 questions · Total: 20 marks · Calculator allowed

Question 1 Bond lengths (2 marks)

Benzene has six identical carbon-carbon bonds of length 0.140 nm. Typical C-C and C=C lengths are 0.154 nm and 0.134 nm. Explain what this shows about the Kekulé structure. (2 marks)

Question 2 Enthalpy of hydrogenation (3 marks)

ΔH (hydrogenation) of cyclohexene is -120 kJ/mol and of benzene is -208 kJ/mol .

- Calculate the value predicted for Kekulé benzene. (1 mark)
- Calculate the stabilisation energy and explain its meaning. (2 marks)

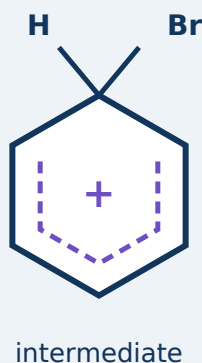
Question 3 Nitration of benzene (4 marks)

- State the reagents and the temperature limit. (2 marks)
- Write the equation for nitration. (1 mark)
- Explain why the limit is needed. (1 mark)

Question 4 The intermediate (3 marks)

The figure shows the intermediate in the bromination of benzene.

- State what the dashed arc and the + sign show. (1 mark)
- Describe the step that follows to form bromobenzene. (1 mark)
- State the role of the halogen carrier. (1 mark)



Intermediate in an electrophilic substitution of benzene.

Question 5 Substitution, not addition (2 marks)

Explain why benzene undergoes substitution with bromine rather than addition. (2 marks)

Question 6 Friedel-Crafts alkylation (2 marks)

Write the equation for the formation of methylbenzene from benzene and chloromethane, and state the catalyst. (2 marks)

Question 7 Percentage yield (3 marks)

3.90 g of benzene ($M = 78.0 \text{ g/mol}$) gives 5.18 g of bromobenzene ($M = 157.0 \text{ g/mol}$). Calculate the percentage yield. (3 marks)

Question 8 Using methylbenzene in schools (1 mark)

Suggest why schools use methylbenzene or esters instead of benzene in practicals. (1 mark)