11.4 Arenes

Set B Exam practice

Name	Time 1 hour	Total 20 marks	Score ____ / 20

A Data Booklet may be used.

Marks by notes section For the marker: total each row. A score below the target means that section of the notes needs revising.

Notes section	Questions	Marks	Target	Score
1 Structure of Benzene	8(a)(iii)	2	2	
2 Evidence for Delocalisation	8(a)(i), 8(a)(ii), 8(b)	3	2	
4 Electrophilic Substitution	1, 2, 7(a)	3	2	
5 Effect of Substituents	3, 4, 5, 7(b)	9	6	
6 Methylbenzene: Ring vs Side Chain	6	3	2	

A Multiple choice

4 MARKS

(1) COMMON What is the correct set of conditions for the conversion of benzene into nitrobenzene?

	acid	temperature
A	dilute HNO_3	100 °C
B	concentrated HNO_3	0 °C
C	concentrated HNO_3 and concentrated H_2SO_4	10 °C
D	concentrated HNO_3 and concentrated H_2SO_4	120 °C

Answer ☐ [1]

/1

Source: A Level 1999 P3 Q23 (November), via EJC Arenes Topical Quiz, Q6

(2) What is the reason for adding concentrated sulfuric acid to concentrated nitric acid in the preparation of nitrobenzene? $C_6H_6(l) + HNO_3(l) \rightarrow C_6H_5NO_2(l) + H_2O(l)$

A It acts as an inert solvent for the benzene and nitric acid.

B It removes protons from nitric acid, thus forming NO_3^- ions.

C It donates protons to the nitric acid, thus forming NO_2^+ ions.

D It removes the water, thus preventing equilibrium being established.

Answer ☐ [1]

/1

Source: A Level 1999 P3 Q23 (June), via EJC Arenes Topical Quiz, Q7

3 3-chlorobenzoic acid can be synthesised from benzene in three steps. Which of the following is the best method for this synthesis?

	step 1	step 2	step 3
A	Cl_2, $AlCl_3$	CH_3Cl, $AlCl_3$	$KMnO_4$, H_2SO_4
B	Cl_2, $AlCl_3$	$KMnO_4$, H_2SO_4	CH_3Cl, $AlCl_3$
C	CH_3Cl, $AlCl_3$	$KMnO_4$, H_2SO_4	Cl_2, $AlCl_3$
D	CH_3Cl, $AlCl_3$	Cl_2, $AlCl_3$	$KMnO_4$, H_2SO_4

Answer [ ] [1]

/1

Source: CJC 2018 Prelim P1 Q18, via EJC Arenes Topical Revision, Q5

4 1-(chloromethyl)-4-nitrobenzene, $ClCH_2C_6H_4NO_2$, can be synthesised from benzene via a 3-step synthetic method. Which of the following sequences of reactions, when carried out, gives the best yield of 1-(chloromethyl)-4-nitrobenzene?

	step 1	step 2	step 3
A	alkylation	free radical substitution	nitration
B	nitration	alkylation	free radical substitution
C	alkylation	nitration	free radical substitution
D	free radical substitution	nitration	alkylation

Answer [ ] [1]

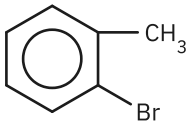
/1

Source: RI 2019 Prelim P1 Q17, via EJC Arenes Topical Revision, Q8

B Structured questions

16 MARKS

5 COMMON Methylbenzene can be used as an additive in unleaded petrol. Methylbenzene, $C_6H_5CH_3$, is converted into $C_6H_5CO_2H$ by reaction I, into $C_6H_5CH_2Br$ by reaction II, and into A by reaction III. A:



(a) Suggest reagents and conditions for each of the reactions I, II and III, and describe as fully as you can the type of reaction undergone in each case.

.....

.....

.....

.....

.....

..... [3]

(b) There are two other positional isomers of A. Draw their structural formulae, and suggest which one is more likely to be formed along with A in reaction III.

[2]

/5

Source: A Level 1998 P1 Q6(c), via EJC Arenes Topical Quiz, Q3(a) and (b)

6 B, C_8H_{10}, can react with Cl_2 in the absence of uv light and using a suitable catalyst to give dense white fumes. B can be oxidised by hot acidified $KMnO_4$ to form C. One mole of C is exactly neutralised by one mole of NaOH. Deduce the structures of B and C and write a balanced equation to show the oxidation of B by hot acidified $KMnO_4$.

.....

.....

.....

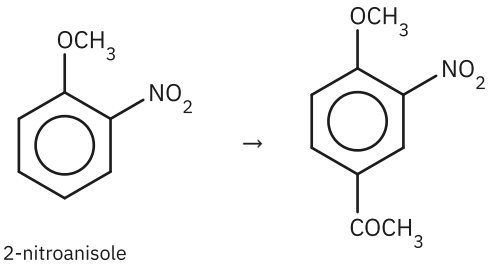
.....

..... **[3]**

/3

Source: EJC 2022 JC1 Arenes Tutorial, Section B Q6

7 In Friedel–Crafts acylation, $FeCl_3$ is employed to attach an acyl group to an aromatic ring via electrophilic substitution. For example, compound A can be prepared by the reaction of 2-nitroanisole with ethanoyl chloride, CH_3COCl, in the presence of $FeCl_3$.



2-nitroanisole → compound A

(a) Write an equation to show how the electrophile is generated.

..... **[1]**

(b) The Friedel–Crafts acylation of nitrobenzene by ethanoyl chloride does not take place under any conditions. Explain why nitrobenzene does not undergo acylation, but the presence of the $-OCH_3$ group in 2-nitroanisole permits acylation.

.....

.....

.....

..... **[2]**

/3

Source: DHS 2017 Prelim P2 Q5(a)(i) and (iii) (adapted), via EJC Arenes Topical Revision, Section B Q1

8 CHALLENGE The table below contains information about cyclohexene and naphthalene. Cyclohexene contains one carbon–carbon double bond and shows chemical properties common to the other alkenes. Naphthalene, $C_{10}H_8$, shows chemical properties common to aromatic compounds.

	conditions for reaction with hydrogen	product	enthalpy change of hydrogenation / kJ mol^{-1}
cyclohexene	room temperature, nickel catalyst	cyclohexane	−118
naphthalene	–	decalin	–

(a)(i) Calculate the enthalpy change of complete hydrogenation of naphthalene, assuming each molecule contains five C=C bonds. Use relevant enthalpy change of hydrogenation data from the table.

[1]

(ii) The actual value for the enthalpy change of complete hydrogenation of naphthalene is −335 kJ mol^{-1}. Compare the value calculated in (a)(i) with this, and suggest what this indicates about the stability of the molecule.

.....

..... **[1]**

(iii) Describe the hybridisation of the orbitals in, and the bonds between, the carbon atoms within a naphthalene molecule, suggested by your answers in (a)(i) and (a)(ii).

.....

.....

.....

..... **[2]**

(b) Suggest the reagents and conditions needed to ensure that complete hydrogenation of naphthalene occurs.

.....

..... **[1]**

/5

Source: A Level 2017 P3 Q7 (modified), via EJC 2022 JC1 Arenes Tutorial, Section B Q1