

Exercise walk-through

5.3.2

Draw aromatic substitution and regenerate the catalyst

Pearson Edexcel · International A-Level · Chemistry

Choose a cell voltage

Your turn

Reduction potentials are $+0.80\text{ V}$ and $+0.34\text{ V}$. What is spontaneous E°_{cell} ?

- A. $+1.14\text{ V}$
- B. $+0.46\text{ V}$
- C. -0.46 V

Find oxidation state and coordination

Your turn

$[\text{Cr}(\text{H}_2\text{O})_4\text{Cl}_2]^+$ has which chromium state and coordination number?

- A. +1 and 4
- B. +3 and 6
- C. +3 and 2

Aspirin transfer calculation

Your turn

2.76 g salicylic acid, $M=138$, gives aspirin $M=180$ in 1:1 ratio. Dry mass is 2.52 g. What is yield?

- ☐ A. 50.0%
- ☐ B. 70.0%
- ☐ C. 91.3%

Exercise 2.1

2.1 Draw the ring attack, positive intermediate and ring-restoration electron-pair arrows for benzene nitration after NO_2^+ is generated. [4]

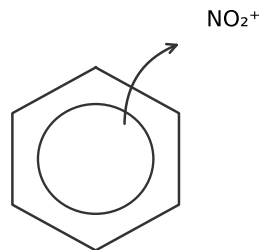
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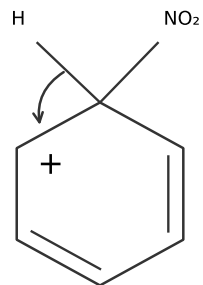
2.1

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

1 Ring electron pair attacks

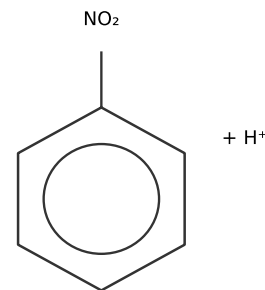


2 Positive intermediate



C-H bond pair restores ring

3 Nitrobenzene + H^+



B1 ring attack arrow; B1 intermediate with H and NO_2 on the same carbon and positive charge; B1 C-H pair returning to ring; B1 nitrobenzene and H^+ .

Exercises 2.2·3.1

2.2 State which reagent generates the nitrating electrophile with nitric acid, and which species accepts H^+ to regenerate that reagent. [2]

2.3 Write the equations for ethyl-electrophile generation using $\text{C}_2\text{H}_5\text{Cl}/\text{AlCl}_3$ and catalyst regeneration using $\text{AlCl}_4^-/\text{H}^+$, using the simple free-electrophile model. [2]

3.1 Write ethanoyl-electrophile generation and the overall benzene acylation equation with ethanoyl chloride. Identify the organic product. [3]

Exercises 2.2·3.1

2.2 State which reagent generates the nitrating electrophile with nitric acid, and which species accepts H^+ to regenerate that reagent. [2]

2.2 Concentrated sulfuric acid; HSO_4^- accepts H^+ to regenerate H_2SO_4 .

2.3 Write the equations for ethyl-electrophile generation using $\text{C}_2\text{H}_5\text{Cl}/\text{AlCl}_3$ and catalyst regeneration using $\text{AlCl}_4^-/\text{H}^+$, using the simple free-electrophile model. [2]

2.3 $\text{C}_2\text{H}_5\text{Cl} + \text{AlCl}_3 \rightarrow \text{C}_2\text{H}_5^+ + \text{AlCl}_4^-$; $\text{AlCl}_4^- + \text{H}^+ \rightarrow \text{AlCl}_3 + \text{HCl}$.

3.1 Write ethanoyl-electrophile generation and the overall benzene acylation equation with ethanoyl chloride. Identify the organic product. [3]

3.1 $\text{CH}_3\text{COCl} + \text{AlCl}_3 \rightarrow \text{CH}_3\text{CO}^+ + \text{AlCl}_4^-$. $\text{C}_6\text{H}_6 + \text{CH}_3\text{COCl} \rightarrow \text{C}_6\text{H}_5\text{COCH}_3 +$

Exercises 3.2·3.3

3.2 Explain why phenol bromination is faster than benzene under bromine-water conditions and give the balanced overall equation. [3]

3.3 A proposed arrow starts at NO_2^+ and ends inside benzene, followed by an arrow from

Exercises 3.2·3.3

3.2 Explain why phenol bromination is faster than benzene under bromine-water conditions and give the balanced overall equation. [3]

3.2 Oxygen lone-pair interaction increases ring electron density, easing electrophile attack. $\text{C}_6\text{H}_5\text{OH} + 3\text{Br}_2 \rightarrow \text{C}_6\text{H}_2\text{Br}_3\text{OH} + 3\text{HBr}$.

3.3 A proposed arrow starts at NO_2^+ and ends inside benzene, followed by an arrow from

3.3 The first arrow must start at the ring electron pair and end at the electrophile. The second must start at the C–H bond pair and end at the ring bond as H^+ leaves.

Exercise 3.4

3.4 Draw ring attack, the positive intermediate and ring-restoration electron-pair arrows for benzene bromination using $\text{Br}_2/\text{FeBr}_3$. Include electrophile generation and catalyst regeneration in the simple electrophile model. [6]

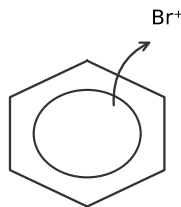
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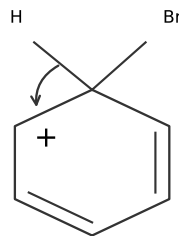
3.4

Bromination: simple electrophile model

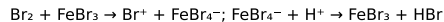
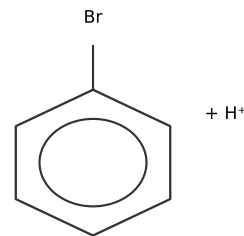
1 Ring pair attacks E^+



2 C-H pair restores ring



3 Bromobenzene



B1 electrophile generation; B1 ring electron-pair attack; B1 positive intermediate with H and incoming group on one carbon; B1 C-H bond arrow restoring ring; B1 correct aromatic product; B1 catalyst regeneration.

Exercise 3.5

3.5 Draw ring attack, the positive intermediate and ring-restoration electron-pair arrows for benzene alkylation using $\text{C}_2\text{H}_5\text{Cl}/\text{AlCl}_3$. Include electrophile generation and catalyst regeneration in the simple electrophile model. [6]

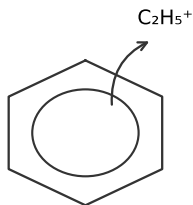
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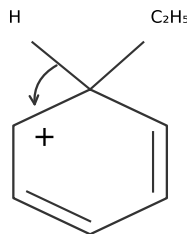
3.5

Alkylation: simple electrophile model

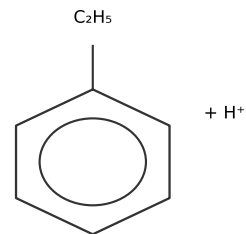
1 Ring pair attacks E^+



2 C-H pair restores ring



3 Ethylbenzene



B1 electrophile generation; B1 ring electron-pair attack; B1 positive intermediate with H and incoming group on one carbon; B1 C-H bond arrow restoring ring; B1 correct aromatic product; B1 catalyst regeneration.

Exercise 3.6

3.6 Draw ring attack, the positive intermediate and ring-restoration electron-pair arrows for benzene acylation using $\text{CH}_3\text{COCl}/\text{AlCl}_3$. Include electrophile generation and catalyst regeneration in the simple electrophile model. [6]

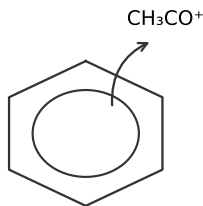
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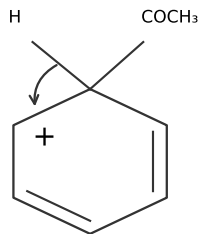
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Acylation: simple electrophile model

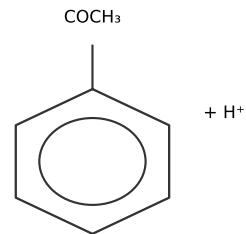
1 Ring pair attacks E^+



2 C-H pair restores ring



3 Phenylethanone



B1 electrophile generation; B1 ring electron-pair attack; B1 positive intermediate with H and incoming group on one carbon; B1 C-H bond arrow restoring ring; B1 correct aromatic product; B1 catalyst regeneration.