Chlorinated Aromatics

A Level

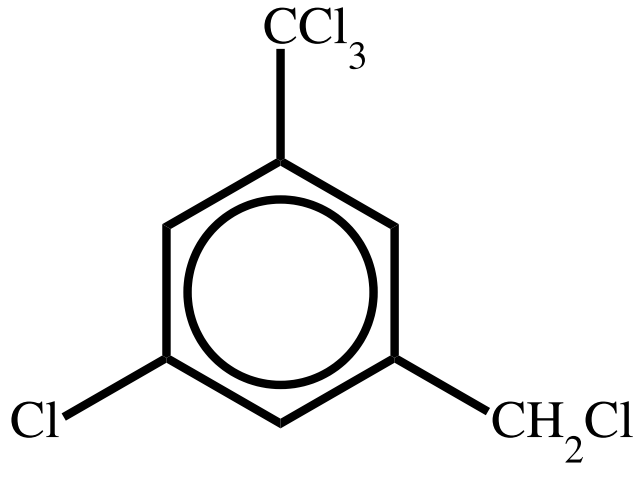
Part A Chlorobenzene

When chlorobenzene is warmed with dilute sodium hydroxide

- 3-chlorophenol is obtained.
- no reaction occurs.
- a mixture of chlorophenols is obtained.
- phenol is obtained.
- 4-chlorophenol is obtained.

Part B With dilute sodium hydroxide

If compound **X** was heated to reflux with dilute aqueous sodium hydroxide, how many chlorine atoms per molecule of **X** would be replaced?



Compound X

Figure 1: Structure of compound **X**.

- 1
- 2
- 3
- 4
- 5

Part A adapted with permission from OCSEB, A-Level Chemistry, June 1995, Paper 1, Question 27;
Part B adapted with permission from UCLES, A-Level Chemistry, June 1994, Paper 1 Question 25.

Alizarin Yellow

A Level

A class of compounds known as *azo dyes* which contain the $-\mathrm{N}=\mathrm{N}-$ functional group can be prepared by a coupling reaction between a *diazonium salt* (which has the functional group $-\mathrm{N}\equiv\mathrm{N}^{+}\mathrm{Cl}^{-}$) and a *phenol* as shown:

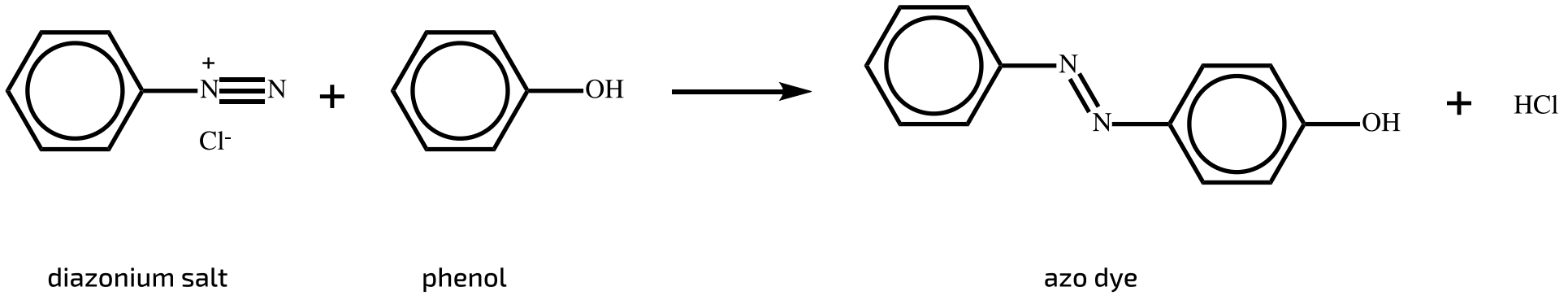


Figure 1: Synthesis of azo dyes.

The dyestuff *Alizarin Yellow* can be prepared by using the reaction scheme below:

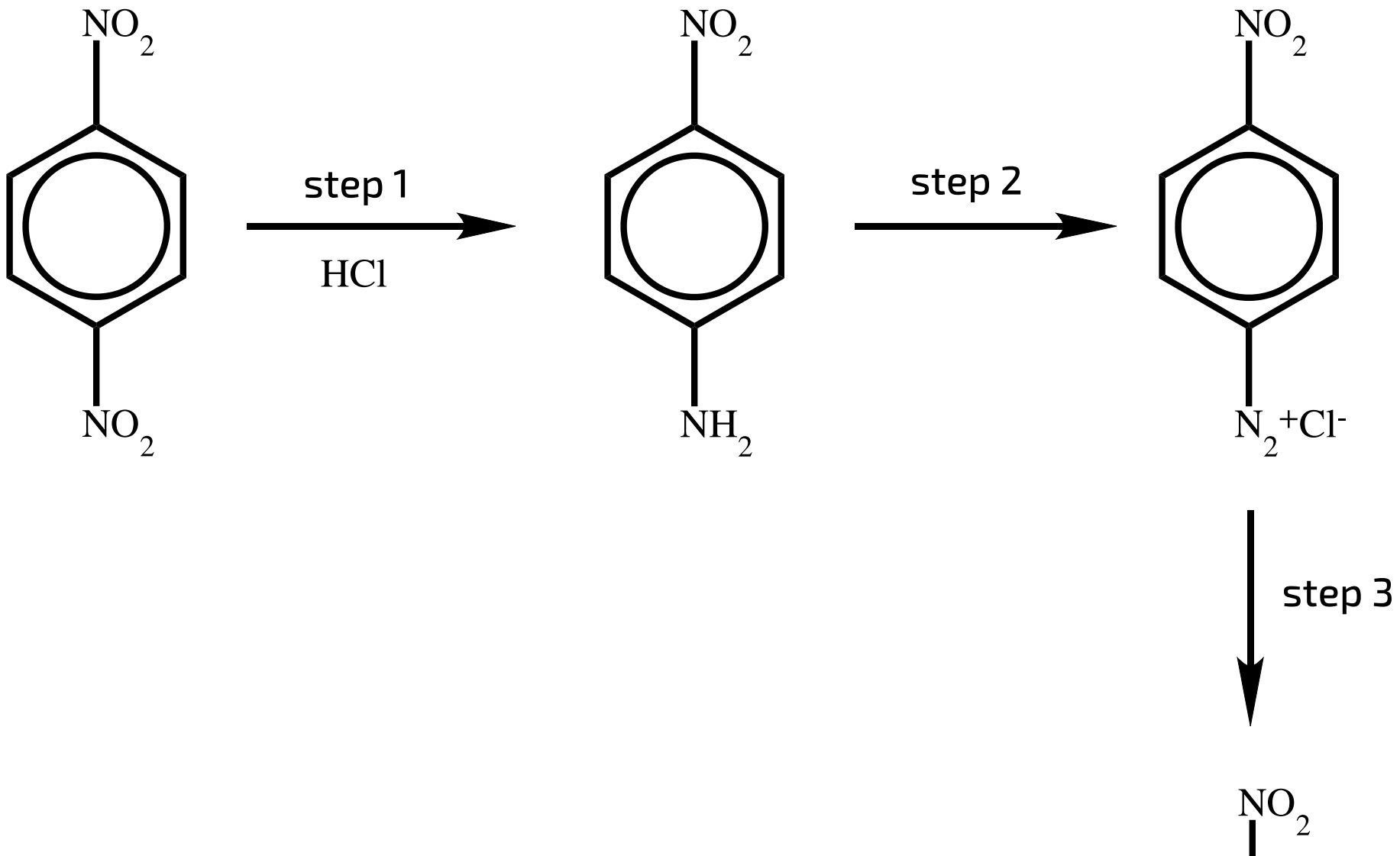


Figure 2: Synthesis of *Alizarin Yellow*.

Part A Step 1

In addition to HCl what reagent must be added at step 1 to achieve this transformation?

Part B Step 3

Using the structure editor, draw the structural formula of the compound which would be added in step 3 to make Alizarin Yellow.

Enter your answer as a SMILES string.

Adapted with permission from UCLES, A-Level Chemistry, November 1993, Paper 3, Question 5.

Gameboard:

STEM SMART Chemistry Week 46

Agrochemicals

A Level

Part A Binapacryl

Binapacryl was used as a fungicide.

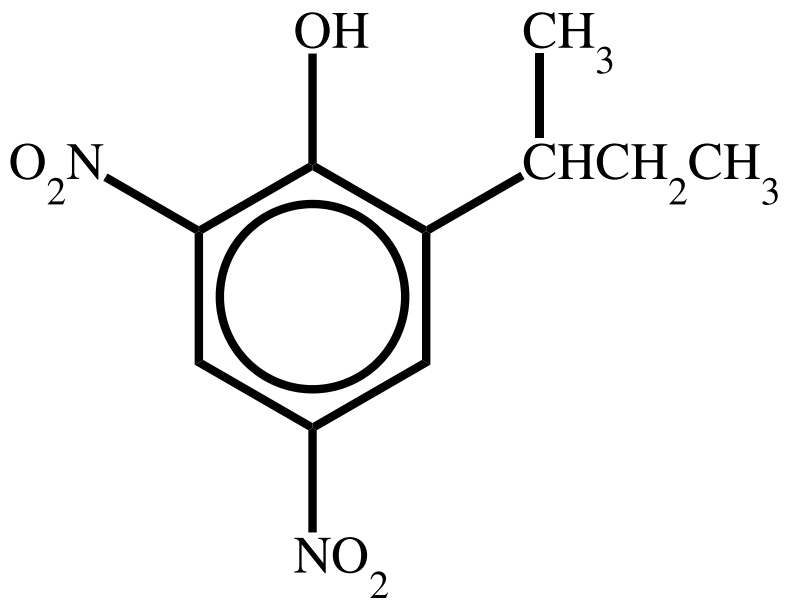


Figure 1: Structure of *Binapacryl*

Which of the following statements about *Binapacryl* are correct?

1. Its aqueous solution is acidic.
2. It can exist in optically active forms.
3. It reacts with ethanol in the presence of concentrated sulfuric acid to give an ester.

- **3** only is correct
- **1** and **2** only are correct
- **1** only is correct
- **2** and **3** only are correct
- **1** and **3** only are correct
- **1**, **2** and **3** are correct
- **2** only is correct

Part B 2,4-D

The compound *2,4-D* is used as a weedkiller.

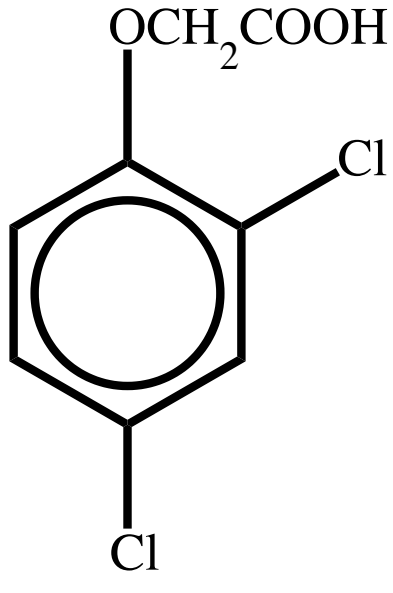


Figure 2: Structure of *2,4-D*.

Which of the following statements about this compound are correct?

1. It can be esterified by ethanol in the presence of H^+ ions.

2. It can exist as a zwitterion.

3. It is readily attacked by aqueous alkali to form the structure in Figure 3.

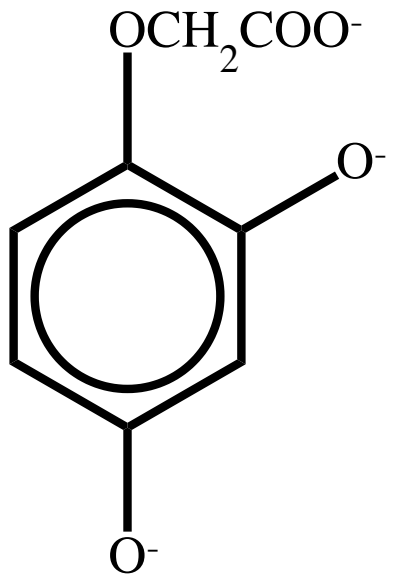


Figure 3: Possible structure of 2,4-D after being attacked by aqueous alkali.

- **1**, **2** and **3** are correct
- **1** only is correct
- **1** and **3** only are correct
- **1** and **2** only are correct
- **2** and **3** only are correct
- **3** only is correct
- **2** only is correct

Phenols and Anilines

A Level

Part A Similar reactivity

With which of the following reagents do phenylamine and phenol have similar reactions?

- $\mathrm{Br_2\,(aq)}$
- $\mathrm{HNO_2\,(aq)}$
- $\mathrm{NaOH\,(aq)}$
- $\mathrm{HCl\,(aq)}$

Part B 2-aminophenol

The compound 2-aminophenol contains both OH and $\mathrm{NH_2}$ functional groups on a benzene ring. It reacts with oxalyl chloride ($\mathrm{ClOCCOCl}$) to give HCl and compound **Q** which has formula $\mathrm{C_8H_5NO_3}$.

What is the structure of compound **Q**?

Use the structure editor to draw the structure of compound **Q**.

Enter your answer as a SMILES string.

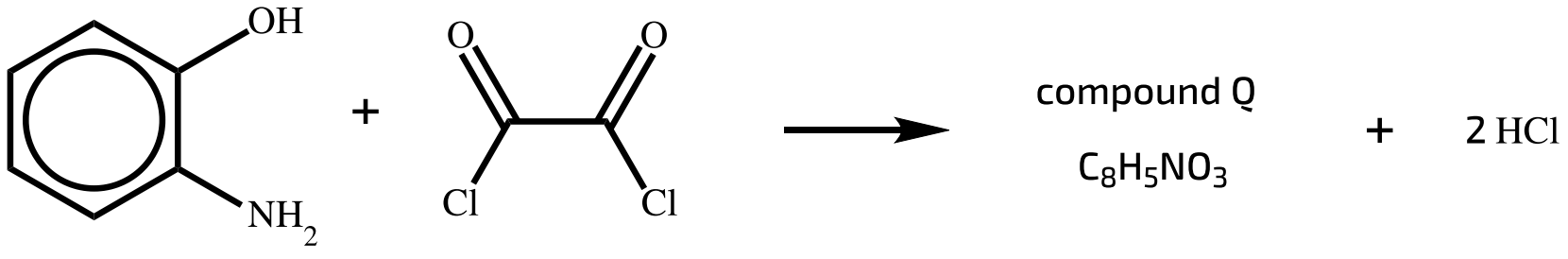


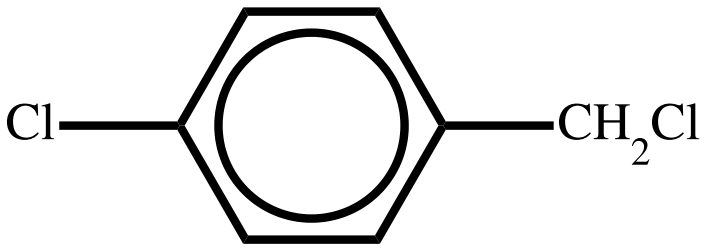
Figure 1: Reaction of 2-aminophenol with oxalyl chloride.

Aromatic Halogenation

A Level

Part A Methylbenzene and chlorine

Chlorine was passed into methylbenzene under reflux in the presence of aluminium chloride. Compound **M** was found to be in the product.



M

Figure 1: Structure of compound **M**.

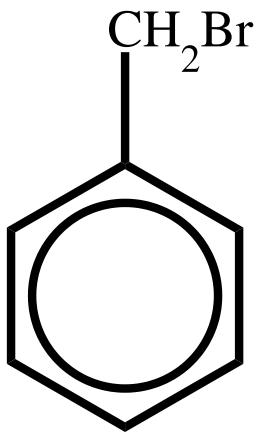
How is the mechanism for the formation of this product best described?

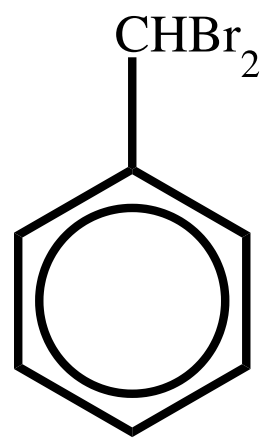
- Electrophilic and free-radical substitution.
- Nucleophilic and free-radical substitution.
- Electrophilic and nucleophilic substitution.
- Nucleophilic substitution only.

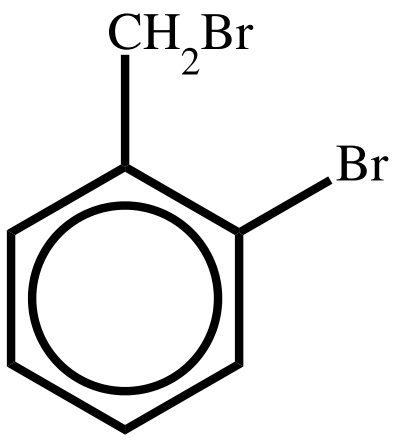
Part B Methylbenzene and bromine

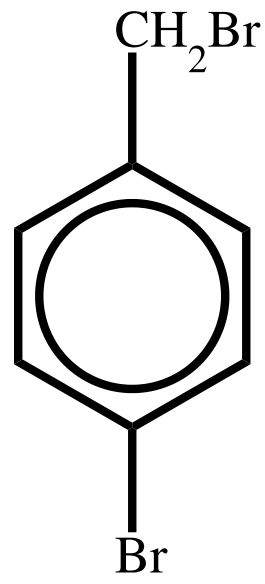
Iron filings were added to a solution containing equimolar quantities of methylbenzene and bromine. The mixture was immediately placed in the dark until no further change took place.

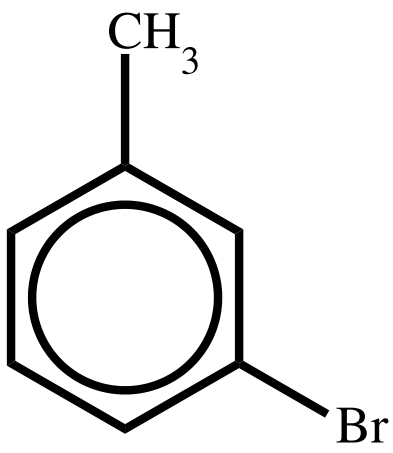
Which of the following are likely to have been the main products?

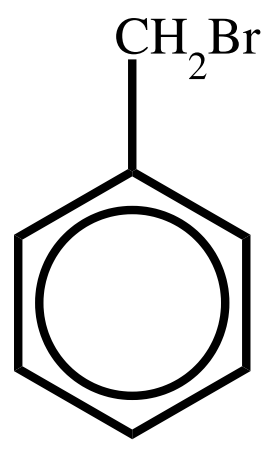
A 

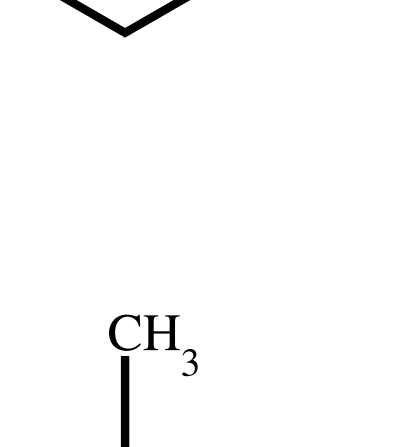
and 

B 

and 

C 

and 

D 

and

Figure 2: Possible products of the reaction between methylbenzene and bromine in the presence of iron filings.

- **A**
- **B**
- **C**

D

Part A adapted with permission from UCLES, A-Level Chemistry, December 1994, Paper 4, Question 19;
Part B adapted with permission from UCLES, A-Level Chemistry, June 1994, Paper 4, Question 21.

Gameboard:
STEM SMART Chemistry Week 46

Mixed Aromatics

A Level

Part A With excess ethanoyl chloride

The compound below reacts with ethanoyl chloride.

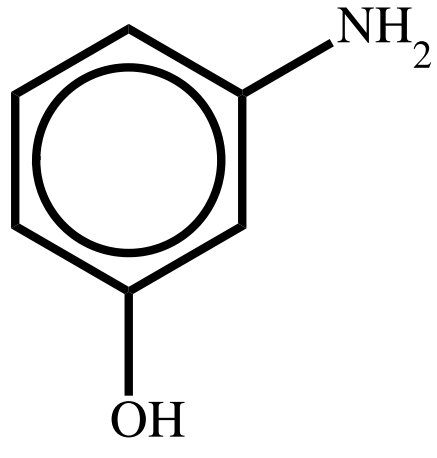
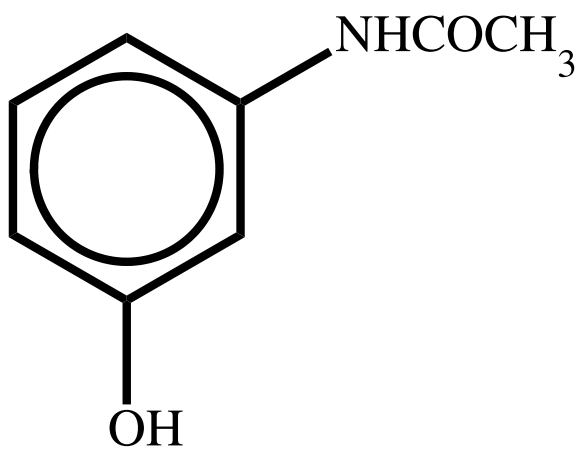


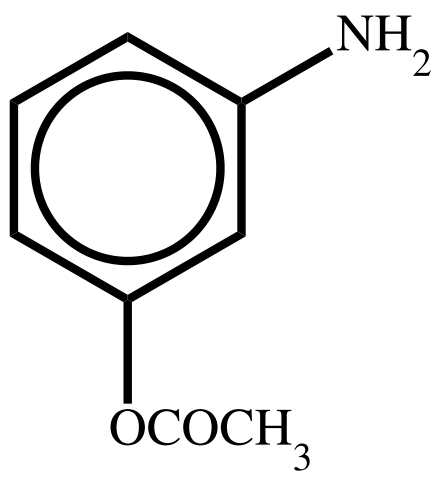
Figure 1: Compound reacting with ethanoyl chloride.

What is the formula of the product when the ethanoyl chloride is in excess?

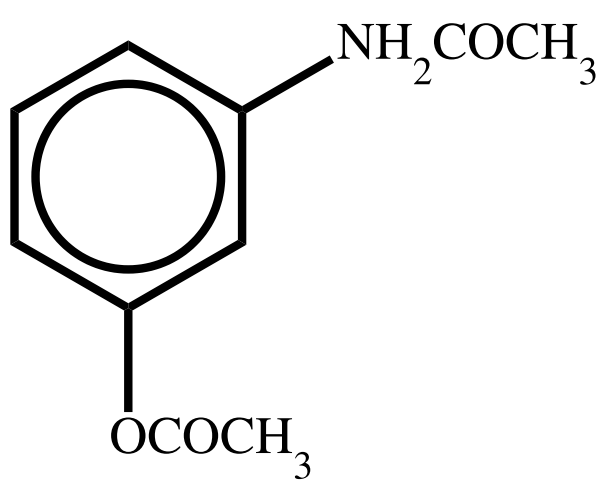
A



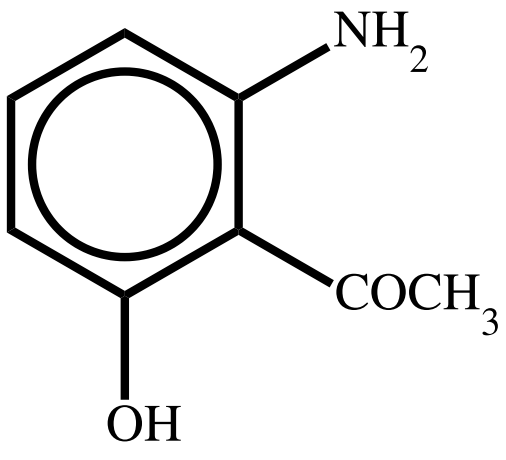
B



C



D



E

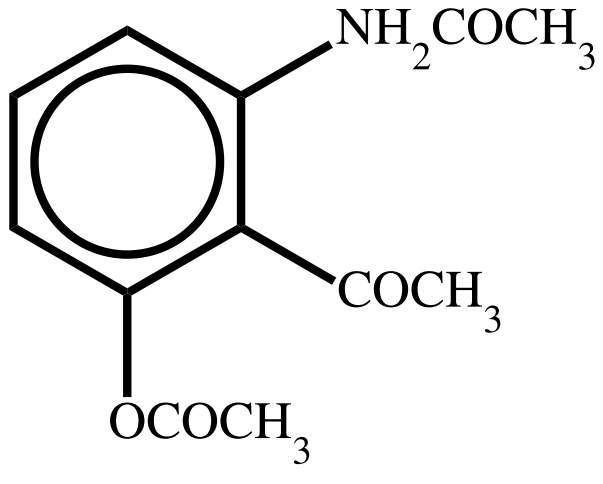


Figure 2: Possible products with excess ethanoyl chloride.

- **A**
- **B**
- **C**
- **D**
- **E**

Part B Reaction sequence

A reaction sequence is shown below.

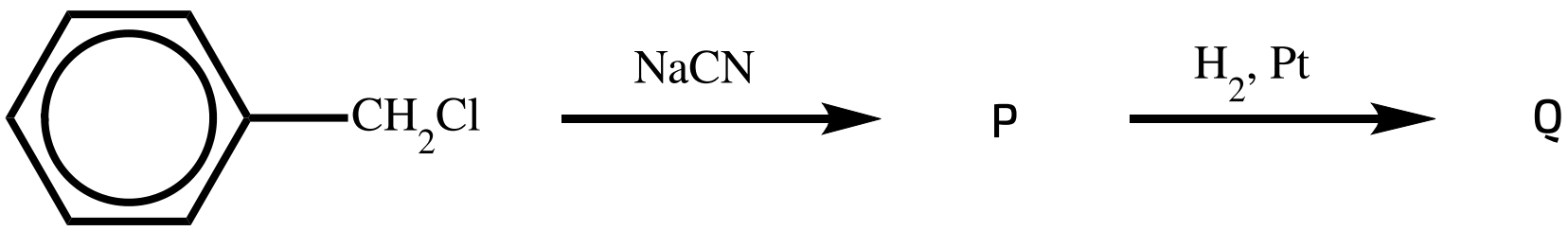
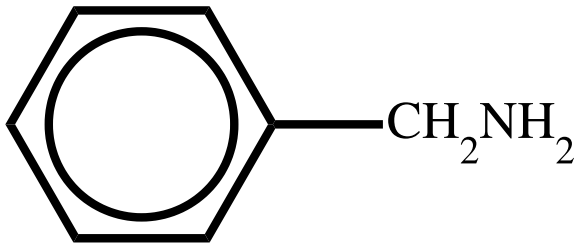
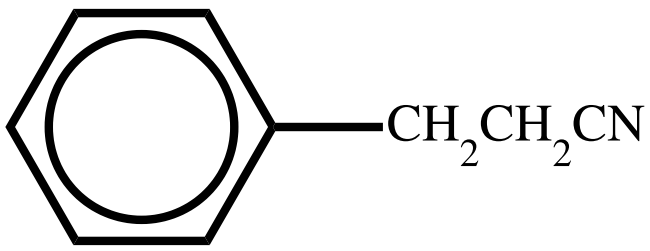
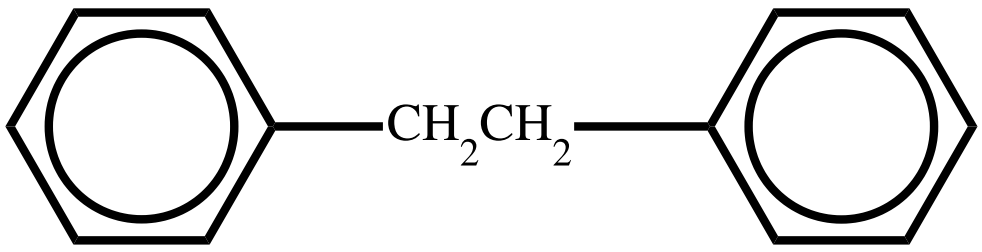


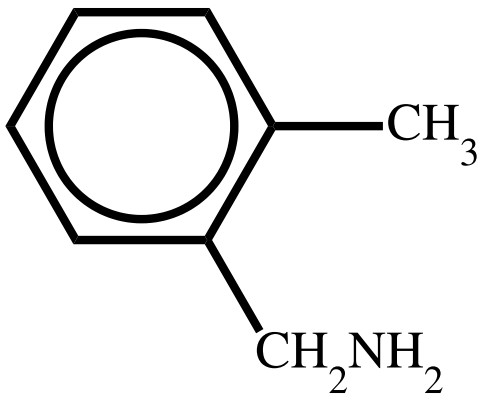
Figure 3: Two step reaction sequence forming **P** then **Q**.

What would be the product **Q**?

A 

B 

C 

D 

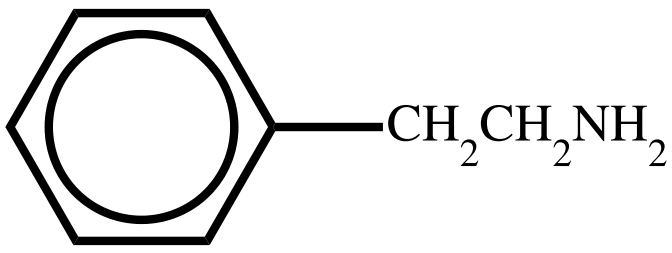
E 

Figure 4: Possible structures of compound **Q**.

- A

- **B**
- **C**
- **D**
- **E**

Part A adapted with permission from UCLES, A-Level Chemistry, November 1992, Paper 4, Question 29;
Part B adapted with permission from UCLES, A-Level Chemistry, 1989, Paper 3, Question 30.

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Dyestuff

A Level

Compound **C** is required for the manufacture of a dyestuff.

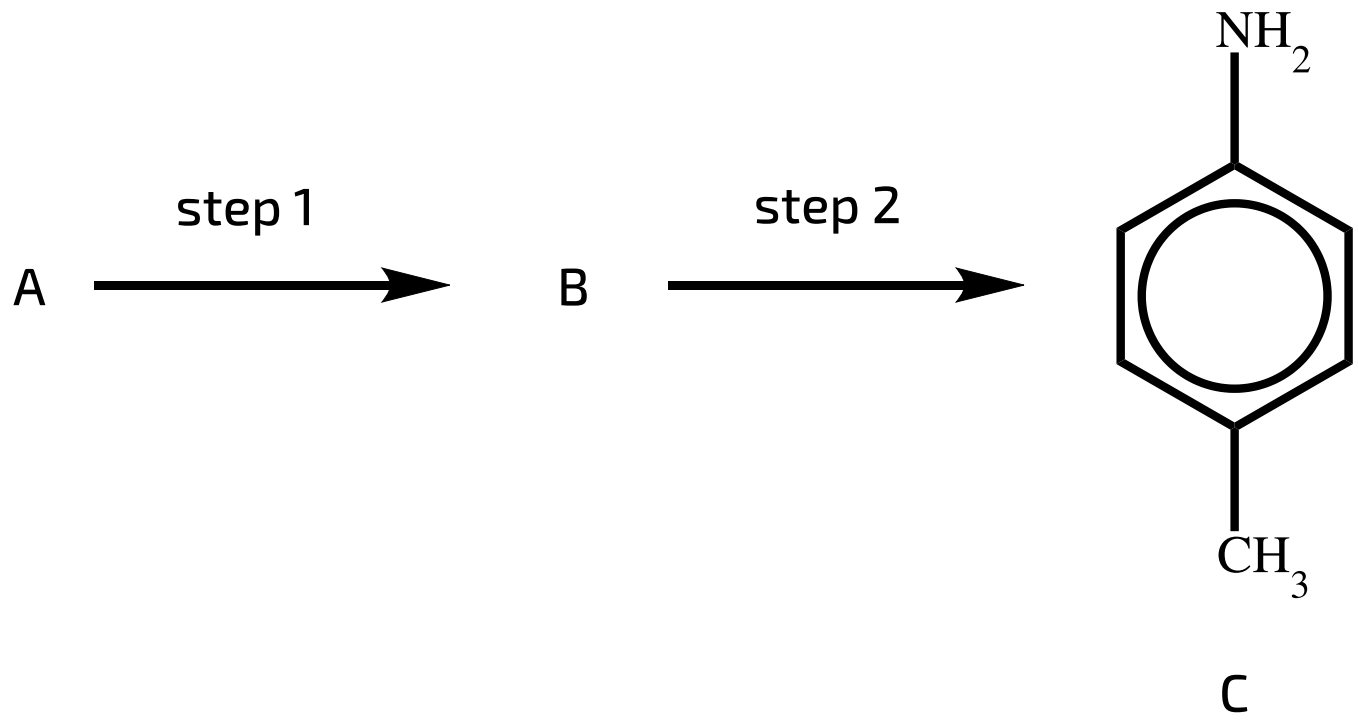

Figure 1: Synthesis of compound **C**.

It can be synthesised in two steps from hydrocarbon **A** and an intermediate compound **B**.

Part A Compound A

Use the structure editor to draw the structure of the hydrocarbon **A**.

Enter your answer as a SMILES string.

Part B Step 1

What type of reaction is occurring in step 1?

Part C Step 2

What type of reaction is occurring in step 2?

Adapted with permission from UCLES, A-Level Chemistry, November 1995, Paper 1, Question 10.

Gameboard:

STEM SMART Chemistry Week 46

Saccharin

A Level

The artificial sweetener saccharin can be made from methylbenzene by the synthetic pathway outlined below.

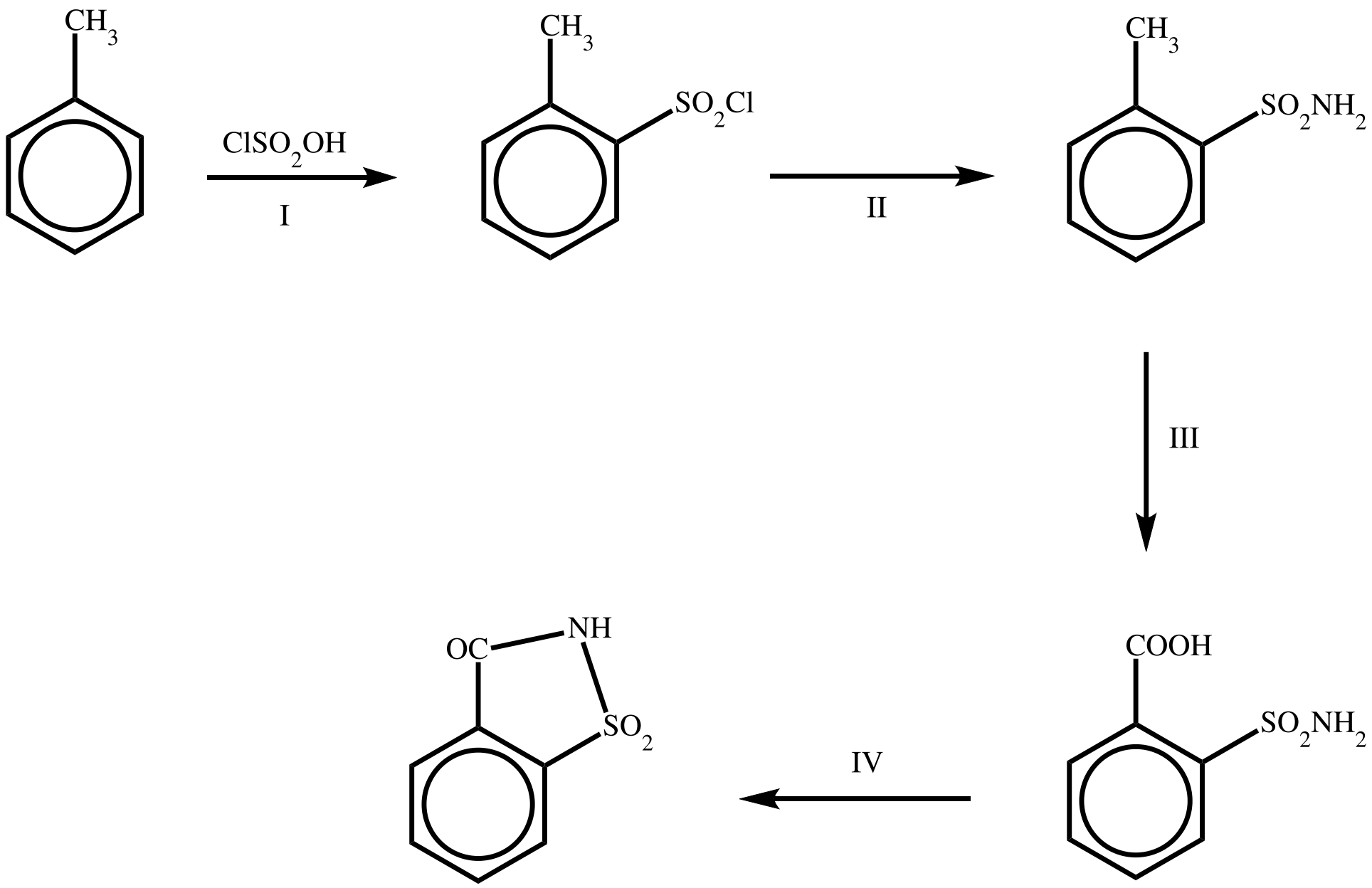

Figure 1: Synthesis of saccharin.

Part A Step I mechanism

Suggest what type of reaction mechanism is taking place in step I.

Part B Step II mechanism

Suggest what type of reaction mechanism is taking place in step II.

Part C Step III reaction

Suggest what type of reaction is taking place in step III.

Part D Step IV functional group

What type of functional group is formed in saccharin during step IV?

Adapted with permission from UCLES, A-Level Chemistry, November 1992, Paper 3, Question 5.

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Adrenaline

A Level

Adrenaline is a hormone which, when secreted directly into the bloodstream, acts as a stimulant. It has the structure:

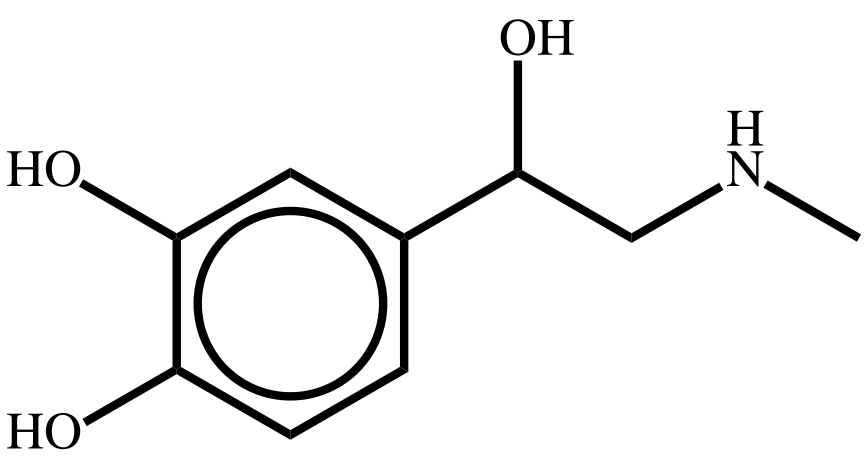

Figure 1: Structure of adrenaline.

The synthesis of adrenaline includes the following stages:

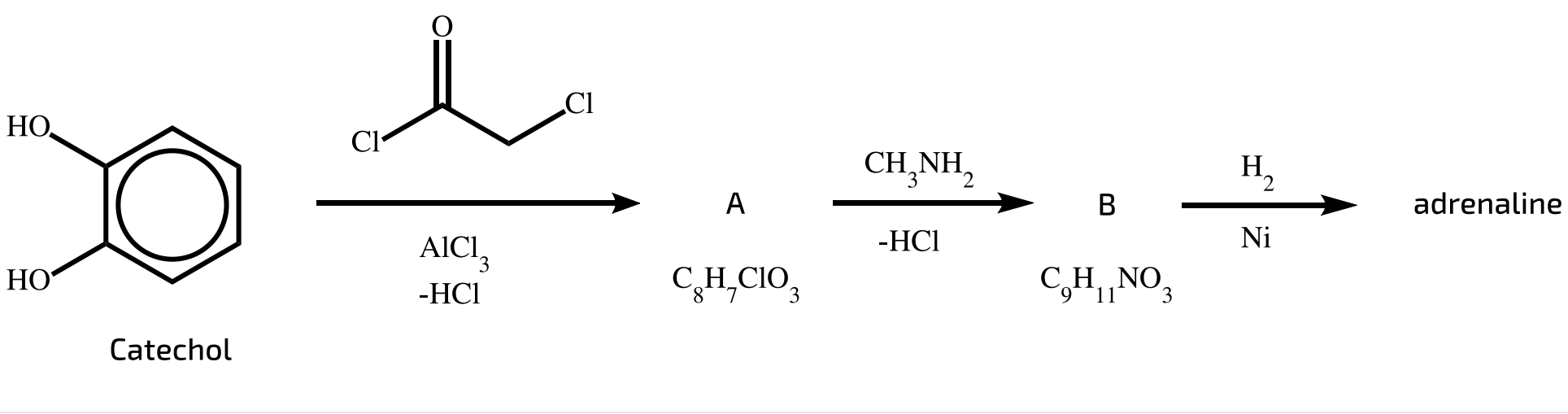

Figure 2: Synthesis of adrenaline.

Part A Molecule A

Use the structure editor to draw the structural formula of molecule **A**.

Enter your answer as a SMILES string.

In the editor, after drawing your structure, click on the round, yellow smiley face to generate a SMILES string. Copy the SMILES string and paste it in the answer box.

Using the structure editor

Part B Catechol ⟶ A reaction

What type of reaction mechanism is occurring to catechol to form **A**?

- Electrophilic substitution
- Free-radical substitution
- Electrophilic addition
- Nucleophilic addition
- Nucleophilic substitution

Part C Molecule B

Use the structure editor to draw the structural formula of molecule **B**.

Enter your answer as a SMILES string.

In the editor, after drawing your structure, click on the round, yellow smiley face to generate a SMILES string. Copy the SMILES string and paste it in the answer box.

Using the structure editor

Part D A ⟶ B reaction

What type of reaction mechanism is occurring to **A** to form **B**?

- ○ Electrophilic addition
- ○ Electrophilic substitution
- ○ Free-radical substitution
- ○ Nucleophilic substitution
- ○ Nucleophilic addition

Part E B ⟶ adrenaline reaction

What type of reaction is occurring to **B** to form adrenaline?

- ○ Oxidation
- ○ Hydrolysis
- ○ Addition
- ○ Reduction
- ○ Substitution
- ○ Elimination

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Gameboard:

STEM SMART Chemistry Week 46

Benzaldehyde

A Level

C C C

Suggest the structures of the products when benzaldehyde reacts with the following. The structure of benzaldehyde is given below.

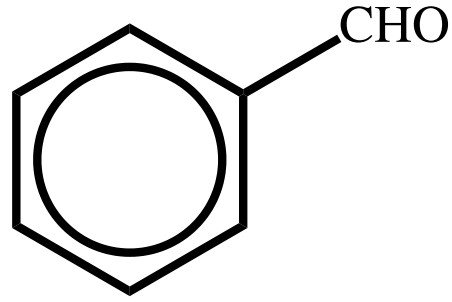

Figure 1: Structure of benzaldehyde.

Part A Acidified $K_2Cr_2O_7$

Acidified $K_2Cr_2O_7$.

Use the structure editor to generate a SMILES string as your answer.

Part B HCN

HCN (catalysed by base).

Use the structure editor to generate a SMILES string as your answer.

Part C $NaBH_4$

$NaBH_4$.

Use the structure editor to generate a SMILES string as your answer.

Part D KOH conc. (F)

When benzaldehyde is treated with very concentrated aqueous potassium hydroxide, followed by acidification, two compounds, **F**(C_7H_8O) and **G**($C_7H_6O_2$), are formed in equimolar amounts.

F and **G** both evolve hydrogen gas when treated with sodium metal. **G** dissolves in aqueous sodium hydroxide but **F** does not. **G** can be obtained from **F** by treatment with acidified potassium dichromate(VI).

Suggest a structure for **F**.

Use the structure editor to generate a SMILES string as your answer.

Part E KOH conc. (G)

When benzaldehyde is treated with very concentrated aqueous potassium hydroxide, followed by acidification, two compounds, **F**(C_7H_8O) and **G**($C_7H_6O_2$), are formed in equimolar amounts.

F and **G** both evolve hydrogen gas when treated with sodium metal. **G** dissolves in aqueous sodium hydroxide but **F** does not. **G** can be obtained from **F** by treatment with acidified potassium dichromate(VI).

Suggest a structure for **G**.

Use the structure editor to generate a SMILES string as your answer.

Adapted with permission from UCLES, A-Level Chemistry, November 1992, Paper 1, Question 11.