

## Question

### Benzene Properties

**Subject & topics:** Chemistry | Organic | Aromaticity    **Stage & difficulty:** A Level P1

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#### Part A

#### Benzene

Which property of benzene may be directly attributed to the stability associated with its delocalised electrons?

- ☐ It tends to undergo substitution rather than addition reactions.
- ☐ It does not conduct electricity.
- ☐ It has a low boiling point.
- ☐ It is susceptible to attack by nucleophilic reagents.
- ☐ Its enthalpy change of formation is negative.

**Part B**  
**Reactions**

The most characteristic type of reaction undergone by benzene and its derivatives is:

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

Part A adapted with permission from UCLES, A-Level Chemistry, June 1992, Paper 4, Question 23;

Part B adapted with permission from OCSEB, A-Level Chemistry, June 1995, Paper 1, Question 24.

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## Question

### Nitration of Methylbenzene

**Subject & topics:** Chemistry | Organic | Reactions (aromatics)    **Stage & difficulty:** A Level P2

When methylbenzene reacts with a mixture of concentrated nitric and sulfuric acids the product consists largely of two isomers of formula  $C_7H_7NO_2$ .

#### Part A

##### Reaction type

What type of reaction is this?

#### Part B

##### Major products

While the nitro group could replace any of the hydrogens on the ring, giving  potential isomers, not all of them are equally likely. Due to the directing effect of the methyl group, the main products will be 1-methyl--nitrobenzene and 1-methyl--nitrobenzene.

Items:

1  2  3  4  5

Adapted with permission from UCLES, A-Level Science, November 1996, Chains and Rings, Question 2

Question deck:

**STEM SMART Chemistry Week 41**

## Question

### Nitration of Benzene Mechanism

**Subject & topics:** Chemistry | Organic | Reactions (aromatics)    **Stage & difficulty:** A Level P3

The mechanism of the nitration of benzene by concentrated nitric and sulfuric acids is thought to proceed *via* the following pathway.

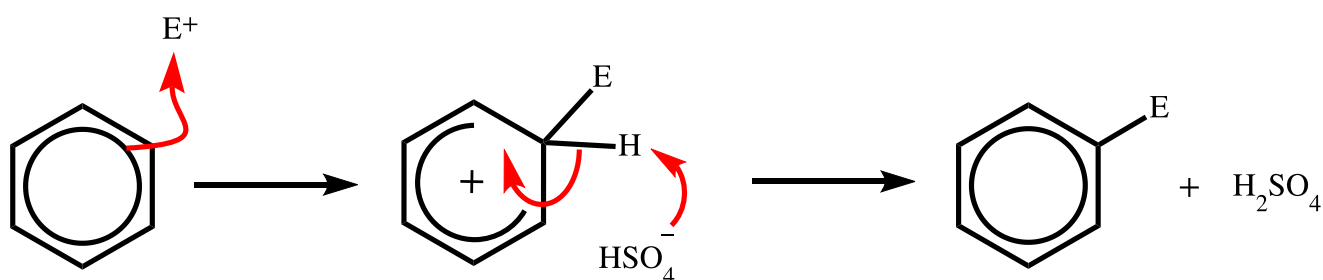


Figure 1: Benzene nitration mechanism

#### Part A

##### Electrophile

What is the formula and charge of the electrophile in this reaction?

#### Part B

##### Formation of electrophile

Write a balanced equation for the formation of this electrophile (state symbols are not required).

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## Question

### Aromatic Chemistry with Side Chains

**Subject & topics:** Chemistry | Organic | Aromaticity    **Stage & difficulty:** A Level P1

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Part A

Reaction with cyanide ion

A compound **Q** has the following structure:

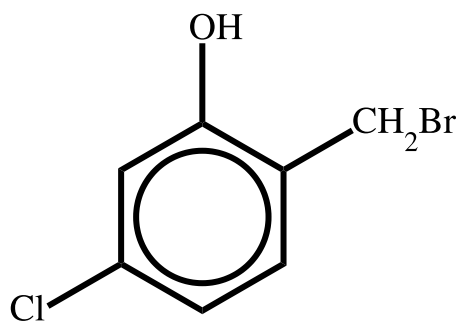
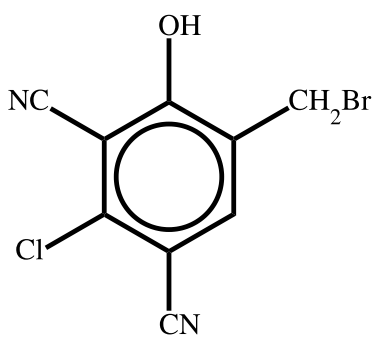
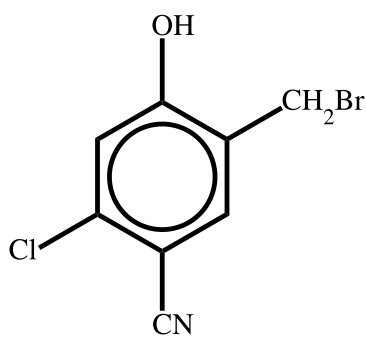


Figure 1: Structure of compound **Q**

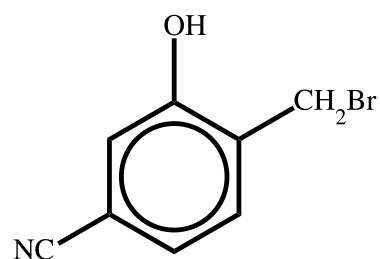
Which compound is obtained by nucleophilic substitution when a cyanide ion reacts with compound **Q**?



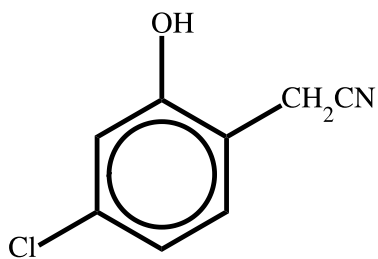
A



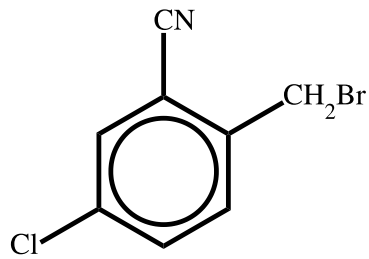
B



C



D



E

Figure 2: Possible reaction products of **Q** with cyanide ion.

☐ A

☐ B

☐ C

☐ D

☐ E

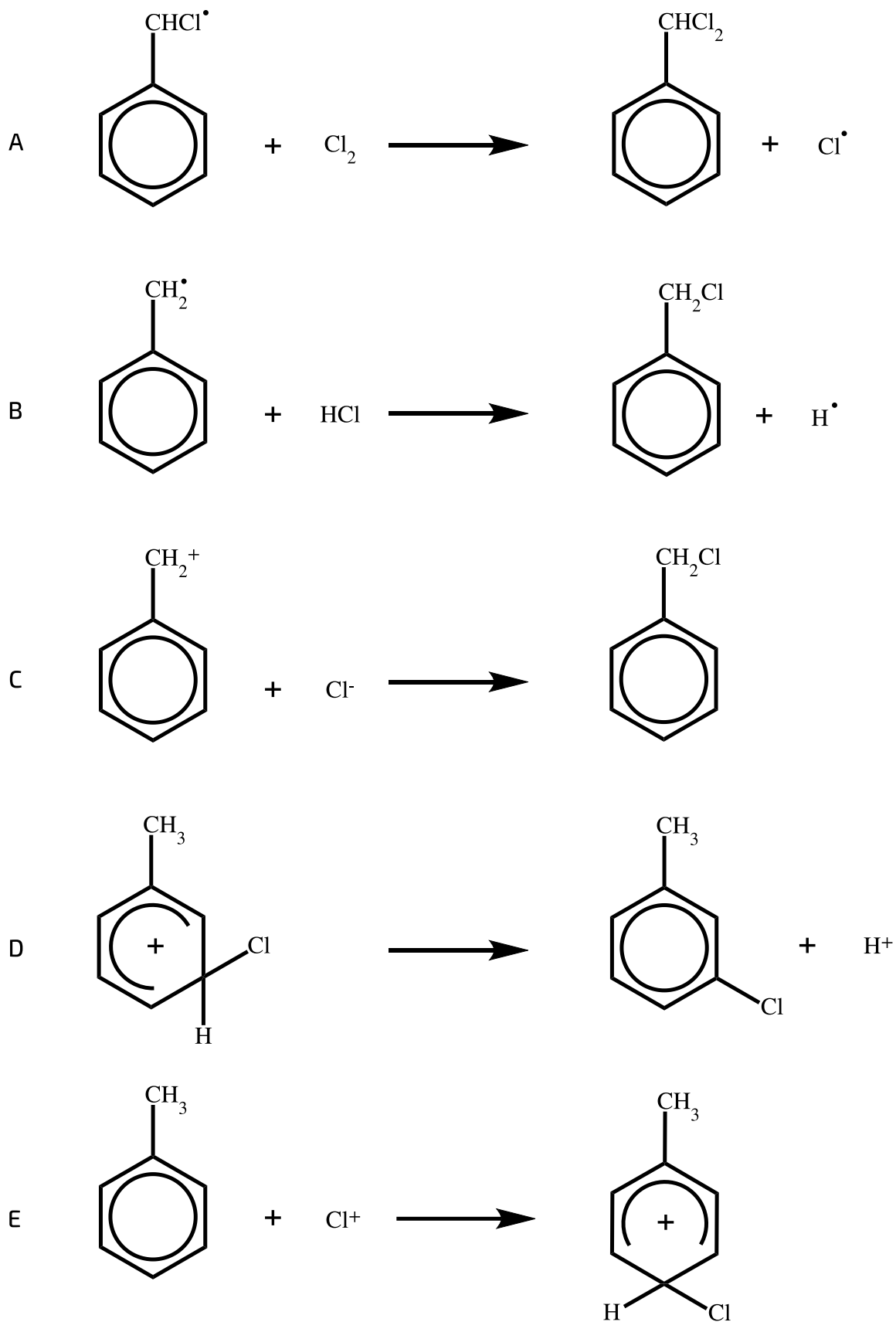


**Part B**

**Methylbenzene with chlorine**

The reaction between boiling methylbenzene and chlorine takes place in a number of steps to give several products.

Which of the following could be one of the steps?



**Figure 3:** Possible reaction steps of methylbenzene with chlorine.

- ☐ A
- ☐ B
- ☐ C

☐ D

☐ E

Part A adapted with permission from UCLES, A-Level Chemistry, June 1991, Paper 1, Question 26;

Part B adapted with permission from UCLES, A-Level Chemistry, November 1992, Paper 4, Question 22

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**STEM SMART Chemistry Week 41**

## Question

### Phenols

**Subject & topics:** Chemistry | Organic | Aromaticity    **Stage & difficulty:** A Level P1

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#### Part A

#### Phenol with aqueous bromine

An account in a student's notebook read:

*"An excess of aqueous bromine was added to aqueous phenol in a test-tube. 2,4,6-Tribromophenol was produced as a creamy-white precipitate suspended in a yellow alkaline solution."*

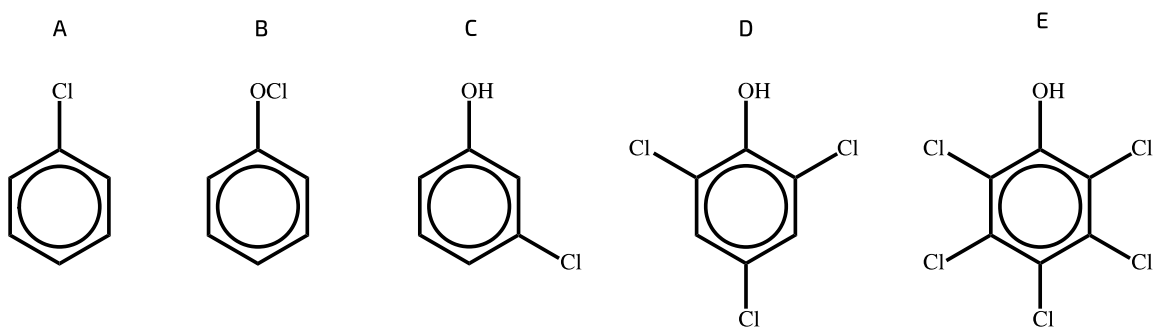
Which statement in this account must have been incorrect?

- ☐ The resultant solution is not alkaline, but acidic.
- ☐ The precipitate is not 2,4,6-tribromophenol, but a mixture of 2- and 4-bromophenol
- ☐ The resultant solution is not yellow, but purple.
- ☐ The precipitate obtained is not creamy-white but yellow

**Part B**  
**Germicide**

Phenol was one of earliest antiseptics used; however, it causes painful blisters on the skin. A safer and more effective germicide can be produced by reacting phenol with aqueous chlorine.

What is the formula of this safer germicide?



**Figure 1:** Possible products of reaction between phenol and chlorine

- ☐ A
- ☐ B
- ☐ C
- ☐ D
- ☐ E

Part A adapted with permission from UCLES, A-Level Chemistry, June 1995, Paper 4, Question 25;

Part B adapted with permission from UCLES, A-Level Chemistry, November 1992, Paper 4, Question 25.

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## Question

### Aromatics with Nitrogen Groups

**Subject & topics:** Chemistry | Organic | Aromaticity    **Stage & difficulty:** A Level P1

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Part A

Phenylamine and benzoyl chloride

What is the most likely product of the reaction between phenylamine and benzoyl chloride ( $\text{C}_6\text{H}_5\text{COCl}$ )?

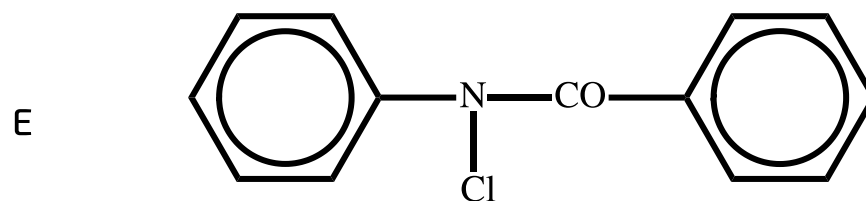
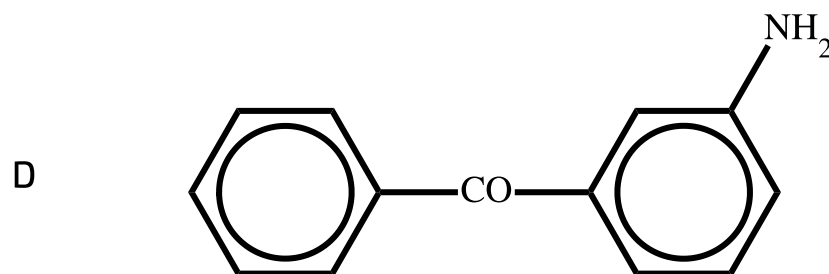
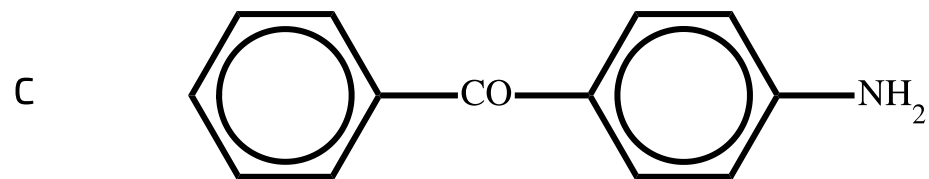
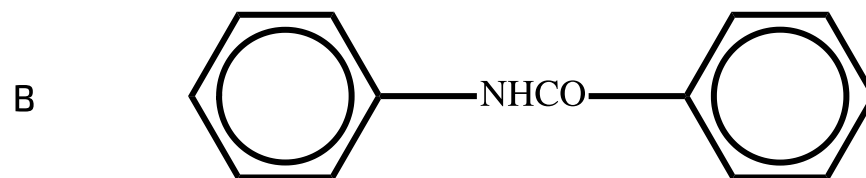
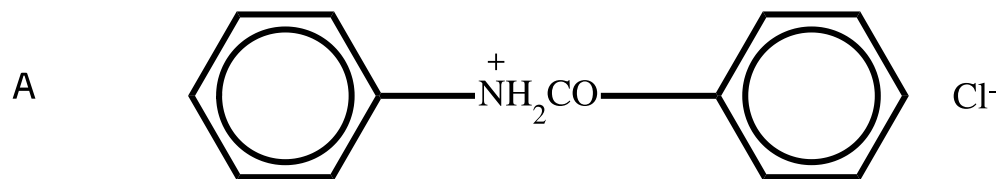


Figure 1: Possible products of reaction between phenylamine and benzoyl chloride.

☐ B

☐ C

☐ D

☐ E



Part B  
Hydrolysis

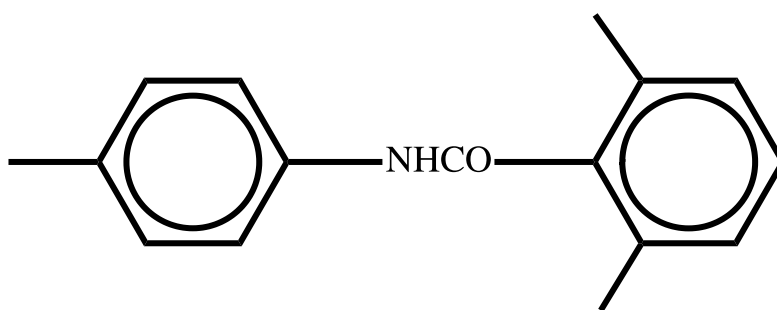
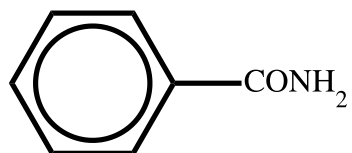


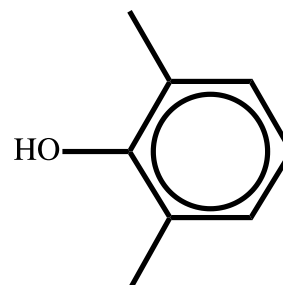
Figure 2: Compound Y

Which of the following are formed by the hydrolysis of compound Y?

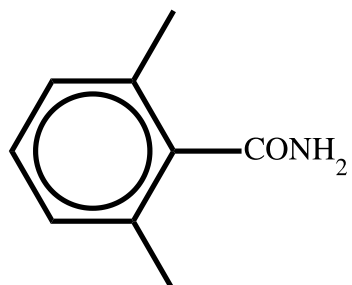
A



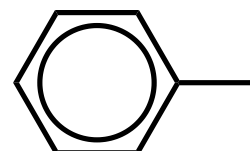
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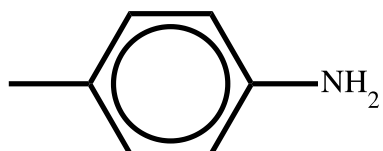
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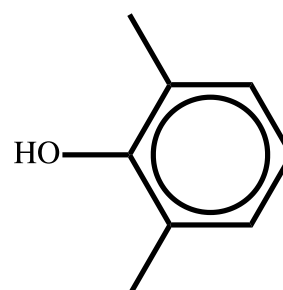
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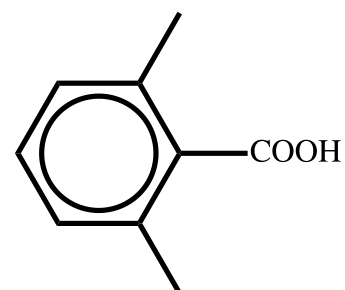
C



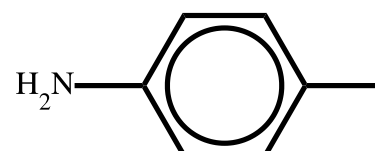
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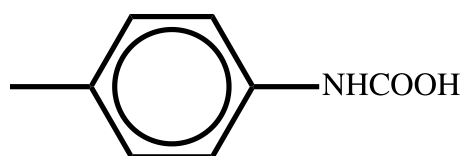
D



and



E



and

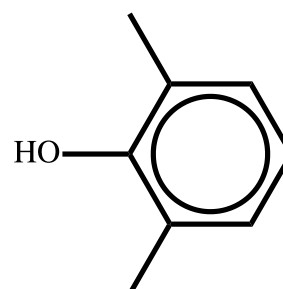


Figure 3: Possible products of hydrolysis of compound Y

☐ A

☐ B

☐ C

☐ D

☐ E

Part A adapted with permission from UCLES, A-Level Chemistry, June 1991, Paper 1, Question 30;

Part B adapted with permission from UCLES, A-Level Chemistry, June 1988, Paper 3, Question 29.

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## Question

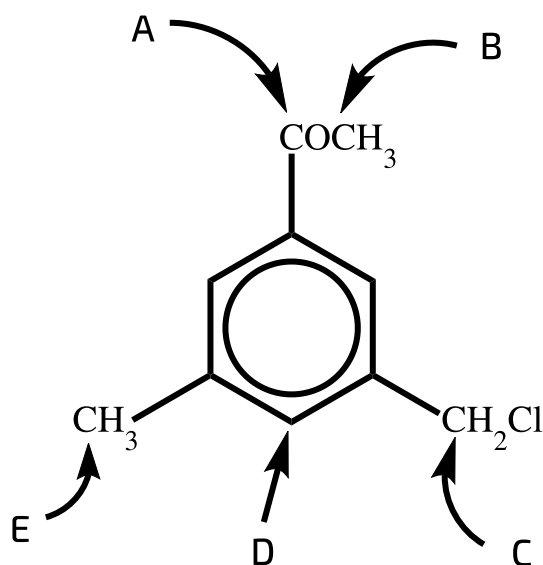
### Electrophilic Attack

**Subject & topics:** Chemistry | Organic | Aromaticity    **Stage & difficulty:** A Level C1

#### Part A

#### Site of attack

At which of the carbon atoms in the molecule below is electrophilic attack most likely?



**Figure 1:** Potential sites of electrophilic attack

- ☐ A
- ☐ B
- ☐ C
- ☐ D
- ☐ E

Part B  
Cumene process

The first stage of the cumene process for the industrial production of phenol is as follows.

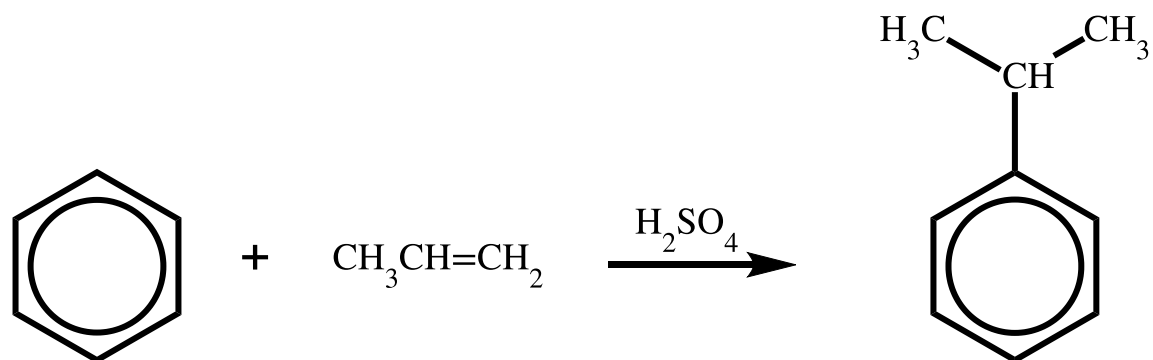
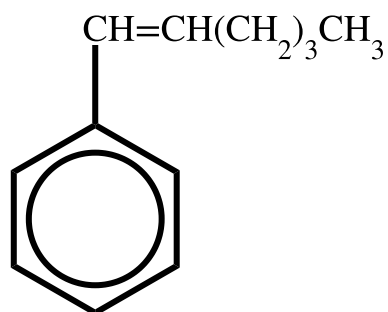
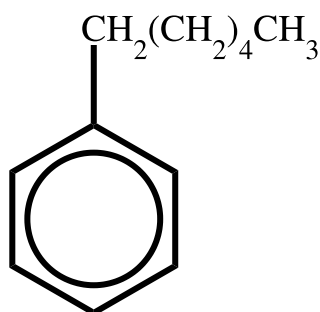
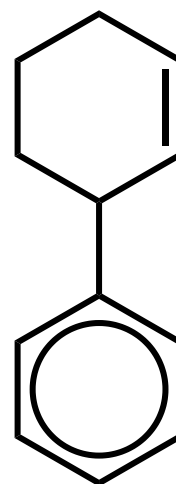
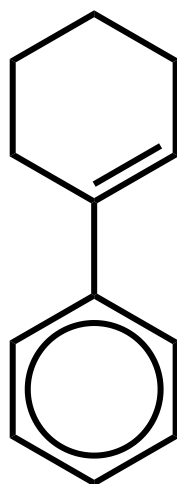
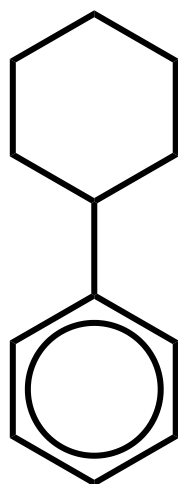


Figure 2: First stage of the cumene process

Which of the following would be the product of the reaction, under similar conditions, between benzene and cyclohexene?



**Figure 3:** Possible products of the reaction between benzene and cyclohexene

- ☐ A
- ☐ B
- ☐ C
- ☐ D
- ☐ E

Part A adapted with permission from UCLES, A-Level Chemistry, 1988, Paper 3, Question 24;

Part B adapted with permission from UCLES, A-Level Chemistry, 1988, Paper 3, Question 27.

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**STEM SMART Chemistry Week 41**

## Question

### Reactions of Aromatics

**Subject & topics:** Chemistry | Organic | Reactions (aromatics)    **Stage & difficulty:** A Level P2

Draw the the structures of the products of the following reactions. If there is no reaction, give the structure of the starting material.

Use the [structure editor](#) to generate SMILES strings.

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 A

#### Benzene + Br<sub>2</sub>

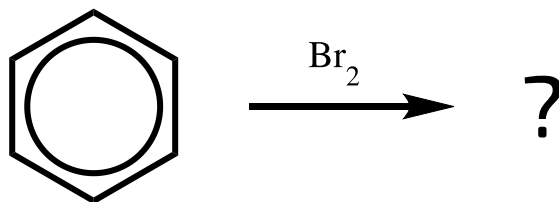


Figure 1: Benzene + Br<sub>2</sub>

Part B

Benzene + Br<sub>2</sub> / FeBr<sub>3</sub>

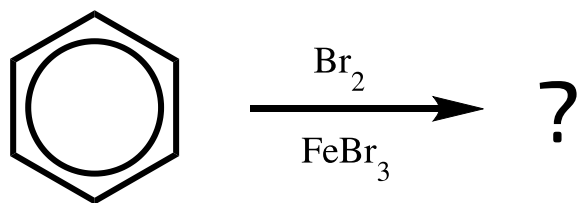


Figure 2: Benzene + Br<sub>2</sub> / FeBr<sub>3</sub>

Part C

Phenol + Br<sub>2</sub>

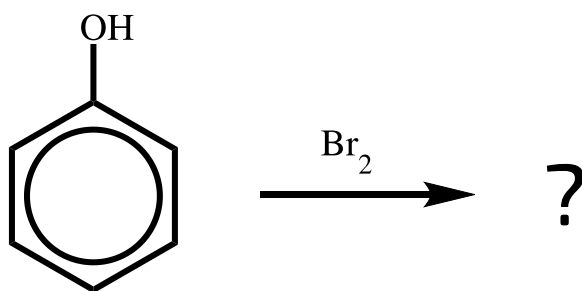


Figure 3: Phenol + Br<sub>2</sub>



Part D

Benzene +  $\text{CH}_3\text{COCl}$  /  $\text{AlCl}_3$

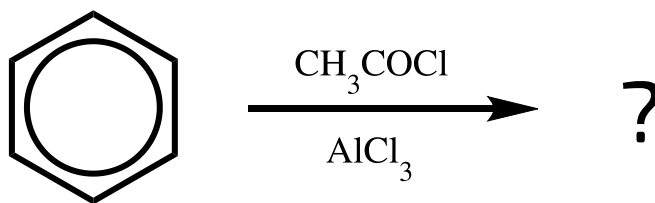


Figure 4: Benzene +  $\text{CH}_3\text{COCl}$  /  $\text{AlCl}_3$

Part E

Phenol +  $\text{CH}_3\text{COCl}$

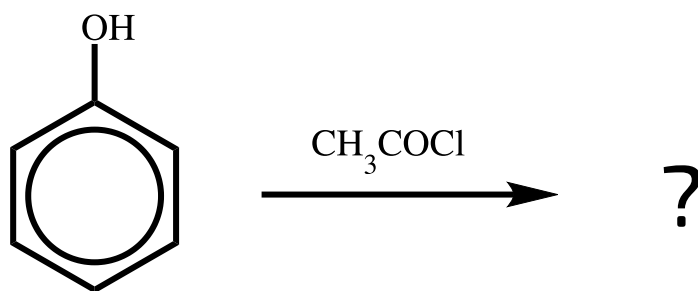


Figure 5: Phenol +  $\text{CH}_3\text{COCl}$

Part F

Nitrobenzene + Sn / HCl

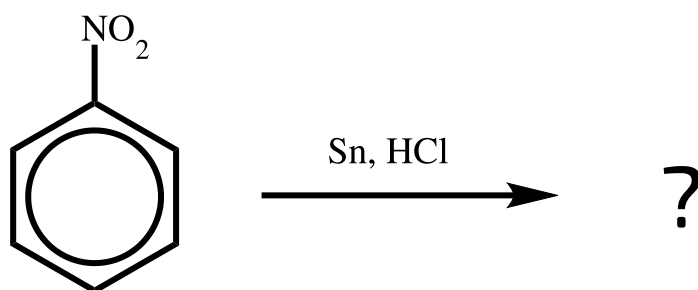


Figure 6: Nitrobenzene + Sn / HCl

Part G

Benzene +  $\text{C}_2\text{H}_5\text{Cl}$  /  $\text{AlCl}_3$

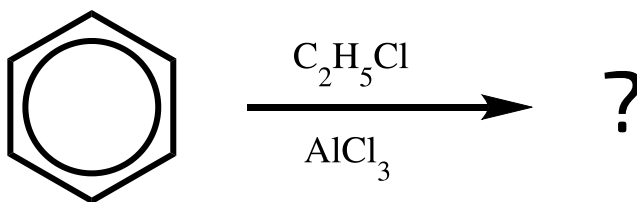


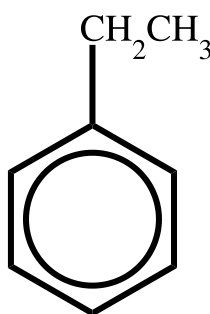
Figure 7: Benzene +  $\text{C}_2\text{H}_5\text{Cl}$  /  $\text{AlCl}_3$

## Question

### Ethylbenzene

**Subject & topics:** Chemistry | Organic | Aromaticity    **Stage & difficulty:** A Level C1

Ethylbenzene, is an important intermediate in the manufacture of poly(phenylethene), commonly known as polystyrene.



**Figure 1:** Structure of ethylbenzene.

When ethylbenzene is treated with chlorine under certain conditions, a mixture of two isomeric chlorides, **A** and **B**, are formed.

**A** and **B** both react with hot concentrated alcoholic potassium hydroxide to give phenylethene, but with aqueous sodium hydroxide, form two isomeric compounds **C** and **D**, respectively, of formula C<sub>8</sub>H<sub>10</sub>O.

**C** reacts with acidified potassium dichromate(VI) to give **E** which does not give a silver mirror in the presence of Tollens' reagent.

**D** also reacts with acidified potassium dichromate(VI) to give **F** as a final product. **F** gives effervescence of CO<sub>2</sub> on addition of aqueous sodium carbonate solution.

Give the structures of compounds **A** - **F**. Use the [structure editor](#) to generate a SMILES string as your answer.

#### Part A

#### Compound A

Give the structure of compound **A**. Use the [structure editor](#) to generate a SMILES string as your answer.

**Part B**

**Compound B**

Give the structure of compound **B**. Use the [structure editor](#) to generate a SMILES string as your answer.

**Part C**

**Compound C**

Give the structure of compound **C**. Use the [structure editor](#) to generate a SMILES string as your answer.

**Part D**

**Compound D**

Give the structure of compound **D**. Use the [structure editor](#) to generate a SMILES string as your answer.

**Part E**

**Compound E**

Give the structure of compound **E**. Use the [structure editor](#) to generate a SMILES string as your answer.

Part F

Compound F

Give the structure of compound F. Use the [structure editor](#) to generate a SMILES string as your answer.

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

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## Question

### Aromatic Acids and Bases

**Subject & topics:** Chemistry | Organic | Aromaticity    **Stage & difficulty:** A Level C2

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The benzene ring has a strong effect on the acidity and basicity of groups directly bonded to the ring. **Negative charges** and **lone pairs** of electrons are **delocalised** into the aromatic ring.

OH groups become more acidic and N lone pairs become less basic as a result of this delocalisation.

Part A

Aromatic acids

Match the aromatic compound with its correct  $pK_a$  value.

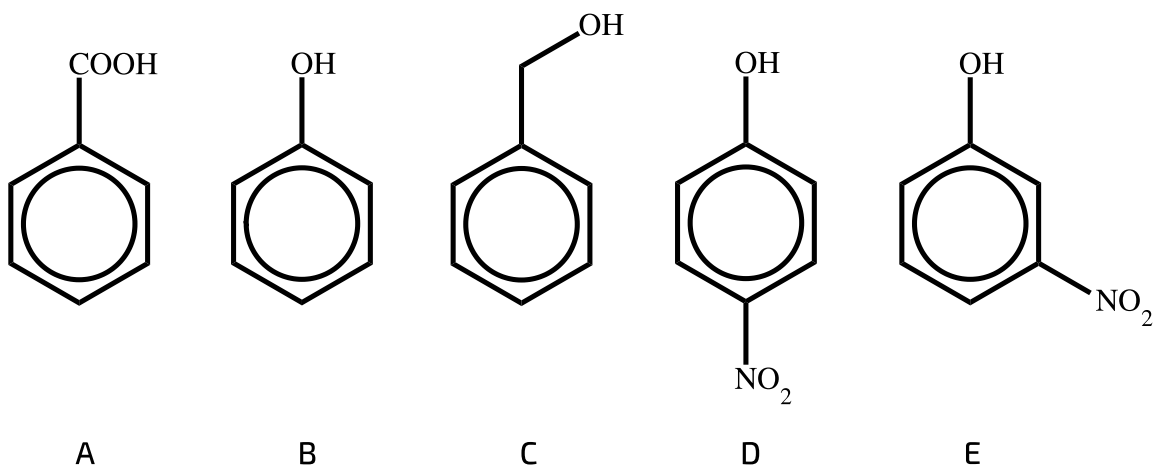


Figure 1: Aromatic compounds A - E with acidic hydrogen atoms.

Compound	$pK_a$
A	<input type="text"/>
B	<input type="text"/>
C	<input type="text"/>
D	<input type="text"/>
E	<input type="text"/>

Items:

Part B

Phenylamine with aqueous sulfuric acid

Which of the following products is formed when phenylamine (aniline) dissolves in dilute aqueous sulfuric acid?

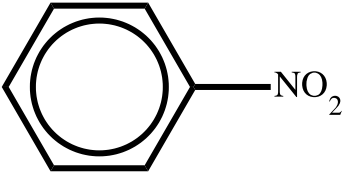
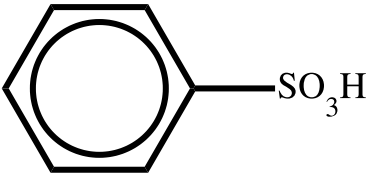
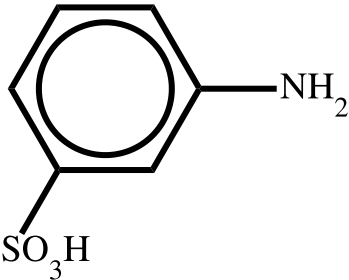
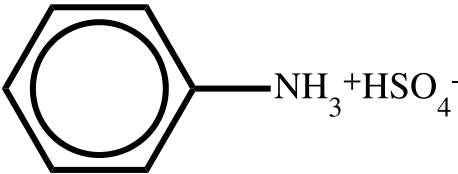
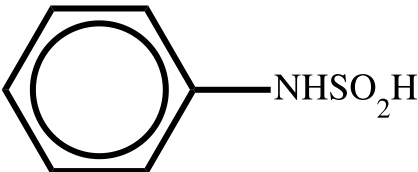
- A 
- B 
- C 
- D 
- E 

Figure 2: Possible products of phenylamine with dilute aqueous sulfuric acid.

- ☐ A
- ☐ B
- ☐ C
- ☐ D
- ☐ E



Part C

Basicity of amines

Rank the following compounds in order of increasing basicity:

**Most basic**

**Least basic**

Items:

Phenylamine

Diphenylamine

Ammonia

Ethylamine

Diethylamine

Parts A and C created for isaacphysics.org by R. Less;

Part B adapted with permission from OCSEB, A-Level Chemistry, June 1994, Paper 1, Question 28