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CHEMISTRY

ORGANIC CHEMISTRY II

Level & Board	AQA (A-LEVEL)
TOPIC:	AROMATIC CHEMISTRY
PAPER TYPE:	SOLUTION - 3
TOTAL QUESTIONS	10
TOTAL MARKS	56

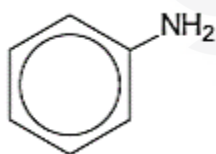
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Aromatic Chemistry - 3

1.

Reagents:

The reagents used to produce the electrophile for the nitration of benzene are concentrated nitric acid (conc. HNO_3) and concentrated sulfuric acid (conc. H_2SO_4).

Equation:**Mechanism:****Product:**

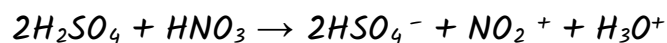
(6)

2.

(a)

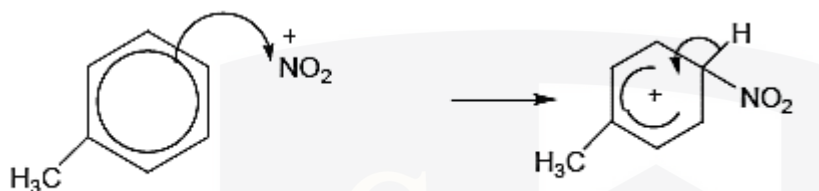
Reagents:

Concentrated nitric acid (conc. HNO_3) and concentrated sulfuric acid (conc. H_2SO_4).

Equation:

(3)

(b)

Mechanism:*Product:*

(3)

(c)

There are 2 number of peaks in the ¹H n.m.r. spectrum of TNT.

(1)

(d)

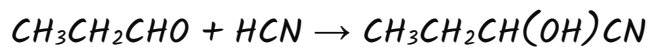


(1)

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3.

(a)

*Equation:**Reaction of propanal with HCN**Name the product:**2-hydroxybutanenitrile*

(2)

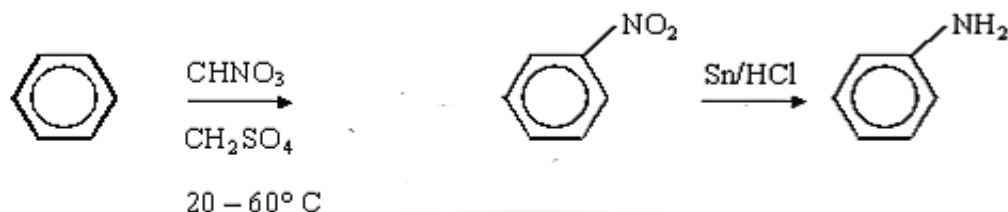
(b)

*Name of the mechanism: Nucleophilic addition**Mechanism:**Product: CH₃CH₂CH(OH)CN*

(5)

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4.



Nitration of Benzene:

- **Reagents:** Concentrated HNO₃ and concentrated H₂SO₄.
- **Conditions:** Heat to 50–60°C.
- **Product:** Nitrobenzene (C₆H₅NO₂).

Reduction of Nitrobenzene:

- **Reagents:** Sn/HCl or Fe/HCl, or H₂/Ni.
- **Conditions:** Room temperature to reflux for Sn/HCl or Fe/HCl; elevated temperature and pressure for H₂/Ni.
- **Product:** Phenylamine (aniline, C₆H₅NH₂).

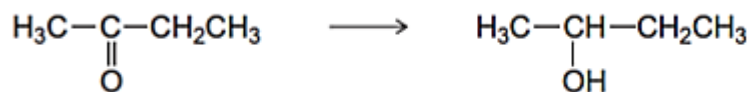
Why Phenylamine Cannot Be Prepared from Bromobenzene

- **C-Br Bond:**
The C-Br bond is stronger and less polar, making it less reactive.
- **Nucleophilicity:**
NH₃ is a nucleophile, but benzene is typically attacked by electrophiles, not nucleophiles.
- **Br Lone Pair Delocalization:**
The lone pair on Br can be delocalized into the ring, reducing reactivity.

(5)

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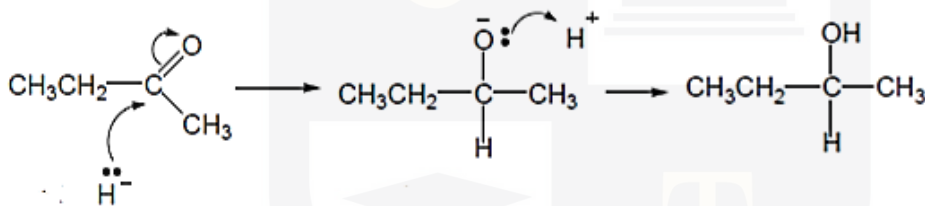
5. The reducing agent in the following conversion is NaBH_4



Name of the mechanism:

Nucleophilic addition

Mechanism:



(5)

6. (a)

The enthalpy of hydrogenation of cyclohexene is typically -120 kJ/mol . Cyclohexa-1,4-diene has two isolated double bonds, each similar to cyclohexene.

Therefore, the enthalpy of hydrogenation for cyclohexa-1,4-diene is:

$$2 \times (-120 \text{ kJ/mol}) = -240 \text{ kJ/mol}$$

So, the enthalpy of hydrogenation of cyclohexa-1,4-diene is -240 kJ/mol .

(1)

(b)

The predicted enthalpy of hydrogenation for cyclohexa-1,3-diene is around -220 kJ/mol ,

(1)

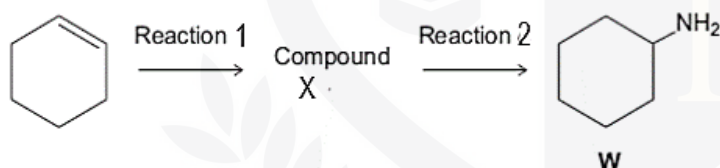
(c)

For cyclohexa-1,3-diene, the enthalpy of hydrogenation is less negative compared to cyclohexa-1,4-diene due to the close proximity of the double bonds, which increases repulsion between electron clouds.

There is some delocalization of pi electrons in cyclohexa-1,3-diene, providing extra stability.

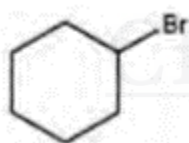
(3)

7.



Compound X:

Chlorocyclohexane or Bromocyclohexane



For Reaction 1

Reagent: HBr

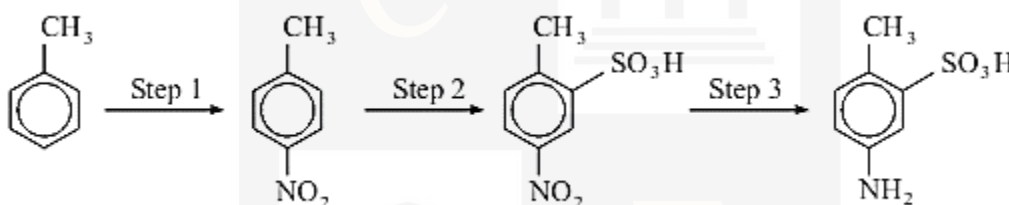
Name of the mechanism: Electrophilic addition

Reaction 2**Reagent:** Ammonia**Condition:** Excess ammonia or sealed in a tube**Name of the mechanism:** Nucleophilic substitution

(5)

8.

(a)

**Step 1:****Nitration of methylbenzene to form nitromethylbenzene.**

- **Type of Reaction:** Electrophilic substitution (nitration)
- **Reagent(s):** HNO_3 (nitric acid) + H_2SO_4 (sulfuric acid)

Step 2:**Reduction of Nitromethylbenzene to 2-Methylaniline**

- **Type of Reaction:** Reduction
- **Reagent(s):** Hydrogen gas (H_2) with a metal catalyst such as palladium on carbon (Pd/C) or Raney nickel (Ni)

Step 3:

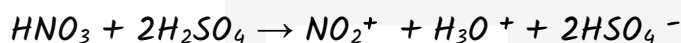
Sulfonation of 2-methylaniline to form 5-amino-2-methylbenzenesulfonic acid.

- **Type of Reaction:** Electrophilic substitution (sulfonation)
- **Reagent(s):** Concentrated sulfuric acid (H_2SO_4)
- Nitration of methylbenzene to form nitromethylbenzene.
- Reduction of nitromethylbenzene to form 2-methylaniline.
- Sulfonation of 2-methylaniline to form 5-amino-2-methylbenzenesulfonic acid.

(4)

(b)

Following is the equation for the formation of the reactive inorganic species involved in the mechanism in Step 1.

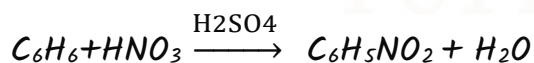


(2)

9.

Nitration of Benzene:

- **Reagents:** Concentrated HNO_3 (nitric acid) + Concentrated H_2SO_4 (sulfuric acid)
- **Name of Mechanism:** Electrophilic substitution
- **Overall Equation:**



(4)

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10.

Benzene's structure and bonding can be described as the π -bonding:

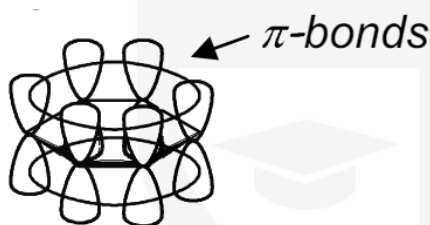
- **π -Bonding:**

- ***p*-Orbitals Overlap:**

The delocalized π -bonds in benzene are formed by the overlap of *p*-orbitals on adjacent carbon atoms.

- **Above and Below the Ring:**

These *p*-orbitals overlap both above and below the plane of the carbon atoms, resulting in a delocalized π -electron cloud.



- **Delocalized π -Bonds:**

The π -electrons in benzene are delocalized over the entire ring, providing stability to the molecule.

- **Planar Structure:**

Benzene's ring is planar, with all carbon atoms lying in the same plane.

- **Equal Bond Lengths:**

The carbon-carbon bonds in benzene have equal lengths, which are intermediate between a single bond and a double bond, reflecting the delocalization of π -electrons.

- **Bond Angles:**

The bond angles between carbon-carbon bonds in benzene are approximately 120° , consistent with a trigonal planar geometry.

(5)



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