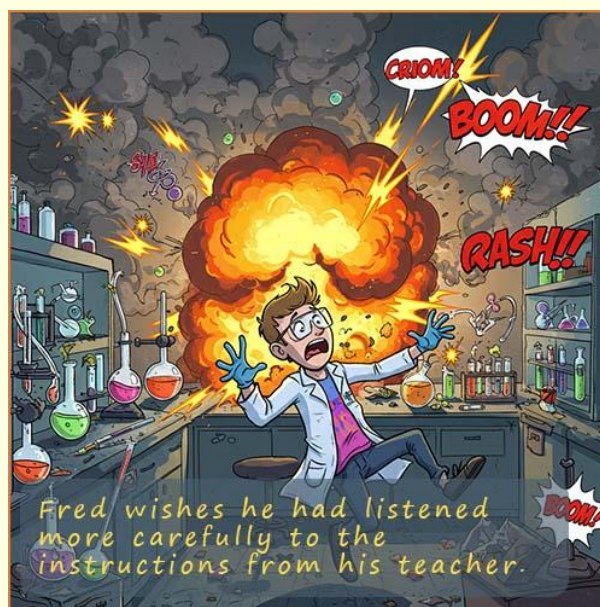




Answer all the questions below as fully as you can then check your answers

1. What type of reaction is the nitration of benzene?
2. Identify the electrophile in the nitration of benzene.
3. What are the two reactants required to generate the nitronium ion?



4. What is the role of sulfuric acid in the nitration of benzene?
5. Write the overall equation for the formation of the nitronium ion from nitric and sulfuric acids.

6. What is the main organic product formed when benzene is reacted with a mixture of concentrated nitric and sulfuric acids at 50–55°C?

7. Why is it important to control the temperature during the nitration of benzene?

8. Explain, using reaction mechanisms how the nitronium ion forms from concentrated nitric and sulfuric acids.

b. Outline the mechanism for the nitration of benzene. Include the structure of the intermediate arenium ion and explain why it is resonance stabilised.

9. Why is the nitration of benzene considered an electrophilic substitution reaction?

Explain why the nitration of benzene is slower than the nitration of methylbenzene (toluene).

10. TNT (trinitrotoluene) is a powerful explosive. Explain why it is so much more powerful than nitrobenzene.

Answers:

1. What type of reaction is the nitration of benzene?

Answer: Electrophilic Substitution

2. Identify the electrophile in the nitration of benzene.

Answer: Nitronium ion, NO_2^+

3. What are the two reactants required to generate the nitronium ion?

Answer: Concentrated nitric acid and concentrated sulfuric acid

4. What is the role of sulfuric acid in the nitration of benzene?

Answer: Catalyst

5. Write the overall equation for the formation of the nitronium ion from nitric and sulfuric acids.

Answer: $2\text{H}_2\text{SO}_4 + \text{HNO}_3 \rightarrow \text{NO}_2^+ + 2\text{HSO}_4^- + \text{H}_3\text{O}^+$

6. What is the main organic product formed when benzene is reacted with a mixture of concentrated nitric and sulfuric acids at $50-55^\circ\text{C}$?

Answer: Nitrobenzene

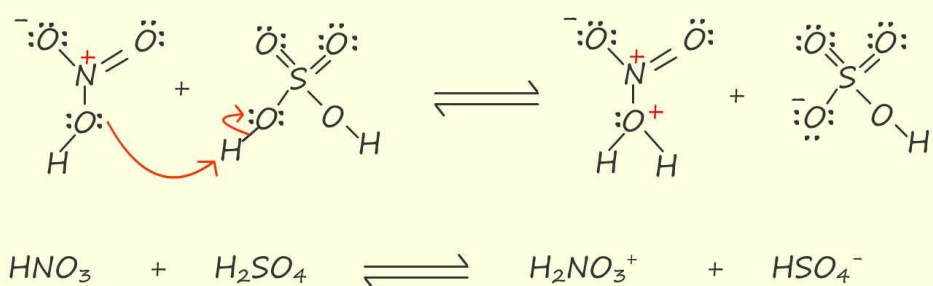
7. Why is it important to control the temperature during the nitration of benzene?

Answer: To prevent multiple nitrations, which can lead to the formation of polynitrated compounds. Higher temperatures favour the formation of di- and tri-nitrobenzene).

8. Explain, using reaction mechanisms how the nitronium ion forms from concentrated nitric and sulfuric acids.

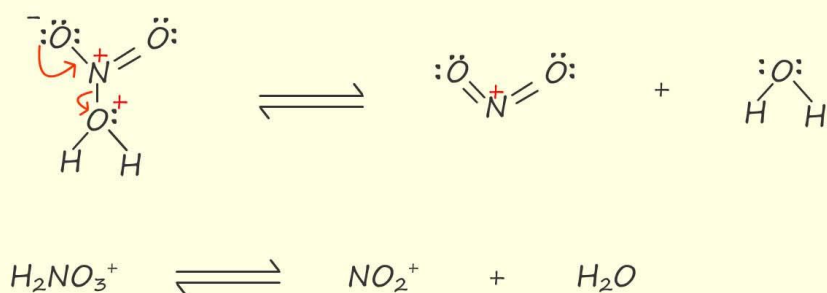
Answer: In step 1 the sulfuric acid protonates the nitric acid in an acid-base reaction.

Step 1:



In step 2 the unstable intermediate breaks down to form the nitronium ion.

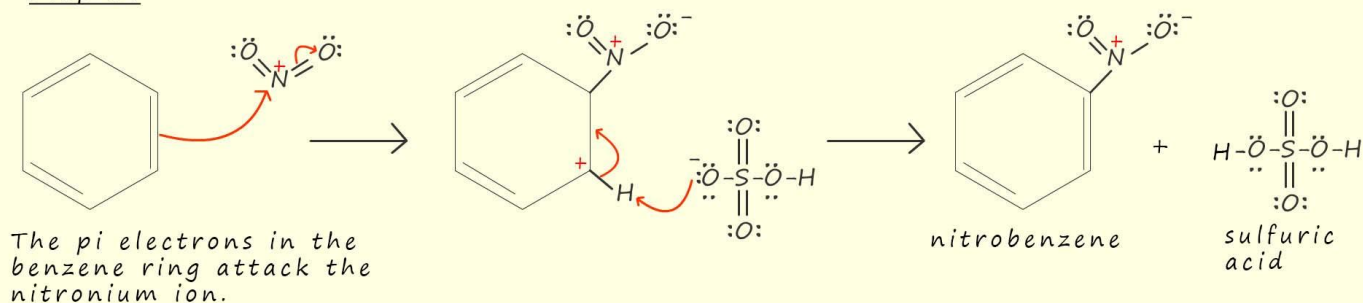
Step 2:



b. Outline the mechanism for the nitration of benzene. Include the structure of the intermediate arenium ion and explain why it is resonance stabilised.

Answer: Step 3 in the image below shows the attack of the benzene ring on the nitronium ion and the formation of the arenium carbocation followed by loss of a proton (hydrogen ion, H^+) to form nitrobenzene. The intermediate arenium ion is unstable and resonance helps to stabilise it.

Step 3:



9. Why is the nitration of benzene considered an electrophilic substitution reaction?

Answer: The electrophile, NO_2^+ , substitutes for a hydrogen atom on the benzene ring.

Explain why the nitration of benzene is slower than the nitration of methylbenzene (toluene).

Answer: Methyl group is an activating group which increases the electron density of the benzene ring making it more susceptible to electrophilic attack. The methyl group donates electron density through the positive inductive effect. Nitration of benzene requires more forcing conditions such as a higher temperature.

10. TNT (trinitrotoluene) is a powerful explosive. Explain why it is so much more powerful than nitrobenzene.

Answer: The presence of three nitro groups in TNT significantly increases the energy released upon detonation. The rapid formation of gaseous products (N_2 , CO_2 , H_2O) and the large enthalpy change of the reaction contribute to its explosive power.