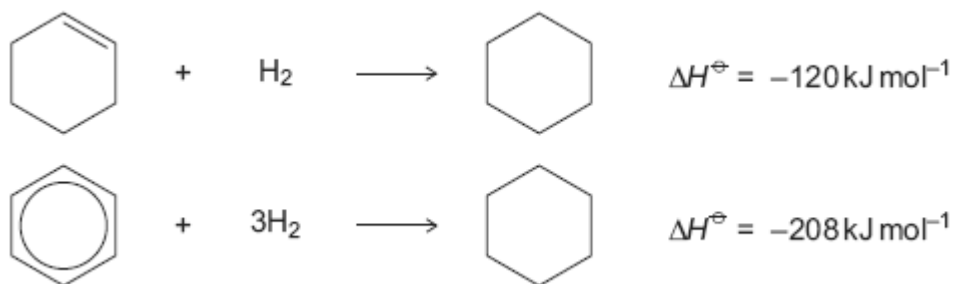


Q1. The hydrocarbons benzene and cyclohexene are both unsaturated compounds. Benzene normally undergoes substitution reactions, but cyclohexene normally undergoes addition reactions.

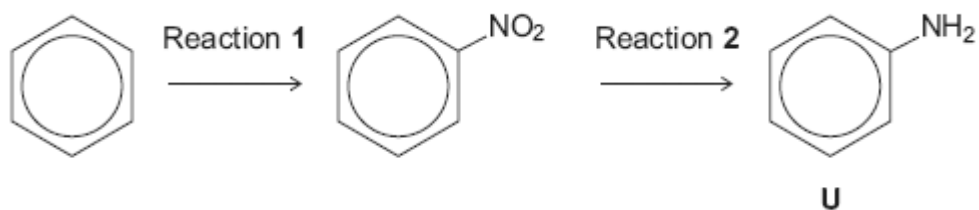
(a) The molecule cyclohexatriene does not exist and is described as hypothetical. Use the following data to state and explain the stability of benzene compared with the hypothetical cyclohexatriene.



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(4)

(b) Benzene can be converted into amine **U** by the two-step synthesis shown below.



The mechanism of Reaction 1 involves attack by an electrophile.

Give the reagents used to produce the electrophile needed in Reaction 1.

Write an equation showing the formation of this electrophile.

Outline a mechanism for the reaction of this electrophile with benzene.

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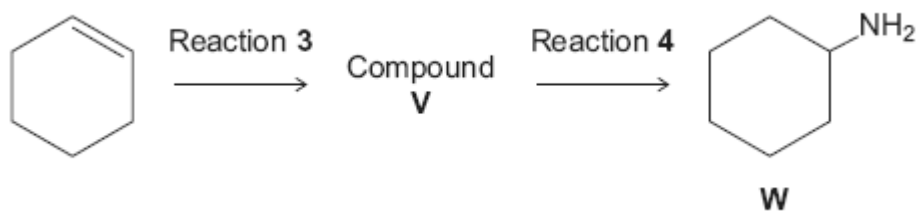
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(6)

- (c) Cyclohexene can be converted into amine **W** by the two-step synthesis shown below.



Suggest an identity for compound **V**.

For Reaction **3**, give the reagent used and name the mechanism.

For Reaction **4**, give the reagent and condition used and name the mechanism.

Equations and mechanisms with curly arrows are **not** required.

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(6)

(d) Explain why amine **U** is a weaker base than amine **W**.

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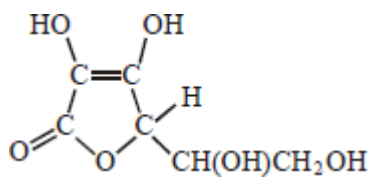
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(3)
(Total 19 marks)

Q2. Which one of the following is **not** a correct statement about vitamin C, shown below?



- A It is a cyclic ester.
- B It can form a carboxylic acid on oxidation.
- C It decolourises a solution of bromine in water.
- D It is a planar molecule.

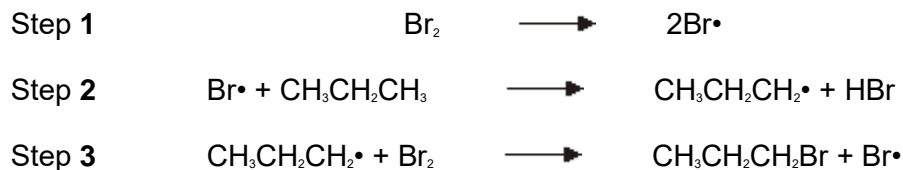
(Total 1 mark)

Q3. Which one of the following reactions will produce an organic compound that has optical isomers?

- A dehydration of butan-2-ol by heating with concentrated sulphuric acid
- B reduction of pentan-3-one by warming with NaBH₄
- C addition of Br₂ to 3-bromopropene
- D reduction of 2,3-dimethylpent-2-ene with H₂ in the presence of a nickel catalyst

(Total 1 mark)

- Q4.** (a) The reaction of bromine with propane is similar to that of chlorine with methane. Three steps in the mechanism for the bromination of propane to form 1-bromopropane are shown below.



- (i) Name the type of mechanism in this reaction.

..... (1)

- (ii) Give an essential condition for Step 1 to occur.

..... (1)

- (iii) Name the type of step illustrated by Steps 2 and 3.

..... (1)

- (iv) In this mechanism, a different type of step occurs in which free radicals combine. Name this type of step.
Write an equation to show how hexane could be formed from two free radicals in the mechanism of this reaction.

Type of step

Equation

(2)

- (v) Write an overall equation for the reaction between bromine and propane by the same mechanism to produce octabromopropane (C_3Br_8).

..... (1)

(b) Bromine reacts with alkenes, even though bromine is a non-polar molecule.

(i) Explain why bromine molecules react with the double bonds in alkenes.

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(2)

(ii) Name the type of mechanism involved in this reaction.

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(1)

(iii) Draw the structure of the compound with $M_r = 387.6$ formed when penta-1,4-diene ($\text{H}_2\text{C}=\text{CHCH}_2\text{CH}=\text{CH}_2$) reacts with an excess of bromine.

(1)

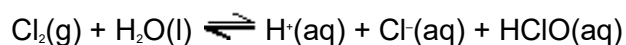
(c) Two products are formed when propene reacts with hydrogen bromide. Draw the structure of the intermediate that leads to the formation of the major product in the reaction of propene with hydrogen bromide. Give the name of this type of intermediate.

Structure of intermediate

Type of intermediate

(2)

- Q5.** (a) When chlorine gas dissolves in cold water, a pale green solution is formed. In this solution, the following equilibrium is established.



Give the formula of the species responsible for the pale green colour in the solution of chlorine in water.

Use Le Chatelier's principle to explain why the green colour disappears when sodium hydroxide solution is added to this solution.

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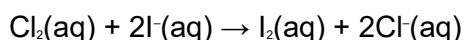
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(3)

- (b) Consider the following reaction in which iodide ions behave as reducing agents.



In terms of electrons, state the meaning of the term *reducing agent*.

Deduce the half-equation for the conversion of chlorine into chloride ions.

Explain why iodide ions are stronger reducing agents than chloride ions.

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(4)

- (c) When chlorine reacts with water in bright sunlight, only two products are formed. One of these products is a colourless, odourless gas and the other is an acidic solution that reacts with silver nitrate solution to give a white precipitate.

Write an equation for the reaction of chlorine with water in bright sunlight.

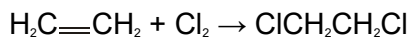
Name the white precipitate and state what you would observe when an excess of aqueous ammonia is added to it.

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(3)

- (d) The reaction of chlorine with ethene is similar to that of bromine with ethene.

Name and outline a mechanism for the reaction of chlorine with ethene to form 1,2-dichloroethane, as shown by the following equation.



(5)
(Total 15 marks)

Q6. The reaction of bromine with an alkene is used in a test to show that the alkene is unsaturated.

(a) State what is meant by the term *unsaturated* as applied to an alkene.

.....

(1)

(b) Name and outline a mechanism for the reaction of bromine with but-2-ene.

Name of mechanism

Mechanism

(5)

(c) But-2-ene can exist as a pair of stereoisomers.

(i) State what is meant by the term *stereoisomers*.

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(2)

(ii) Draw the structure of (*E*)-but-2-ene.

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(1)
(Total 9 marks)