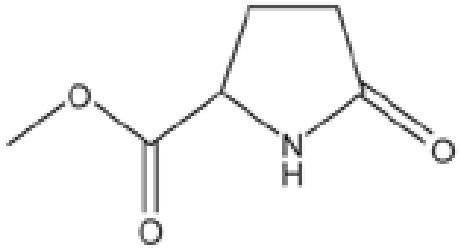
1. The compound below contains an ester and an amide group.



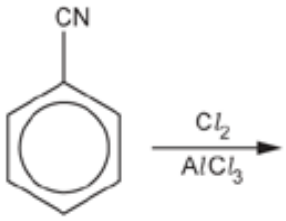
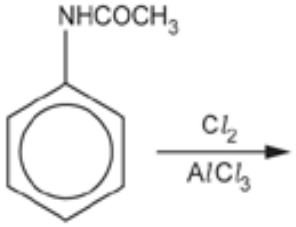
Draw the structures of the organic products formed by the complete **alkaline** hydrolysis of this compound using NaOH(aq).

[4]

2. The table shows directing effects for different groups in the electrophilic substitution of aromatic compounds.

Directing effect	**2- and 4- directing**	**3-directing**
Group	−OH	$-NO_2$
	$-NH_2$	$-COCH_3$
	$-NHCOCH_3$	−CN

i. Draw all organic products formed from monosubstitution reactions of the substituted benzene compounds shown below.

Reaction	**Monosubstituted Product(s)**
	
	

[3]

ii. The reactions of $C_6H_5NH_2$ are similar to the reactions of phenol.

Write an equation for the tri-substitution of $C_6H_5NH_2$ with chlorine.

[2]

iii. Explain why chlorine reacts much more readily with $C_6H_5NH_2$ than with benzene.

[3]

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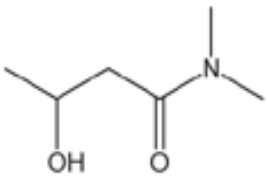
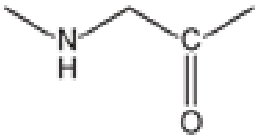
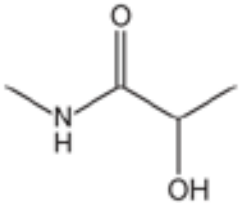
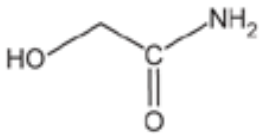
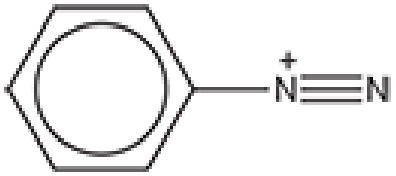
3. Which compound is a secondary amide?

A	
B	
C	
D	

Your answer ☐ **[1]**

4. The benzenediazonium ion, shown below, is stable at temperatures below 10 °C.



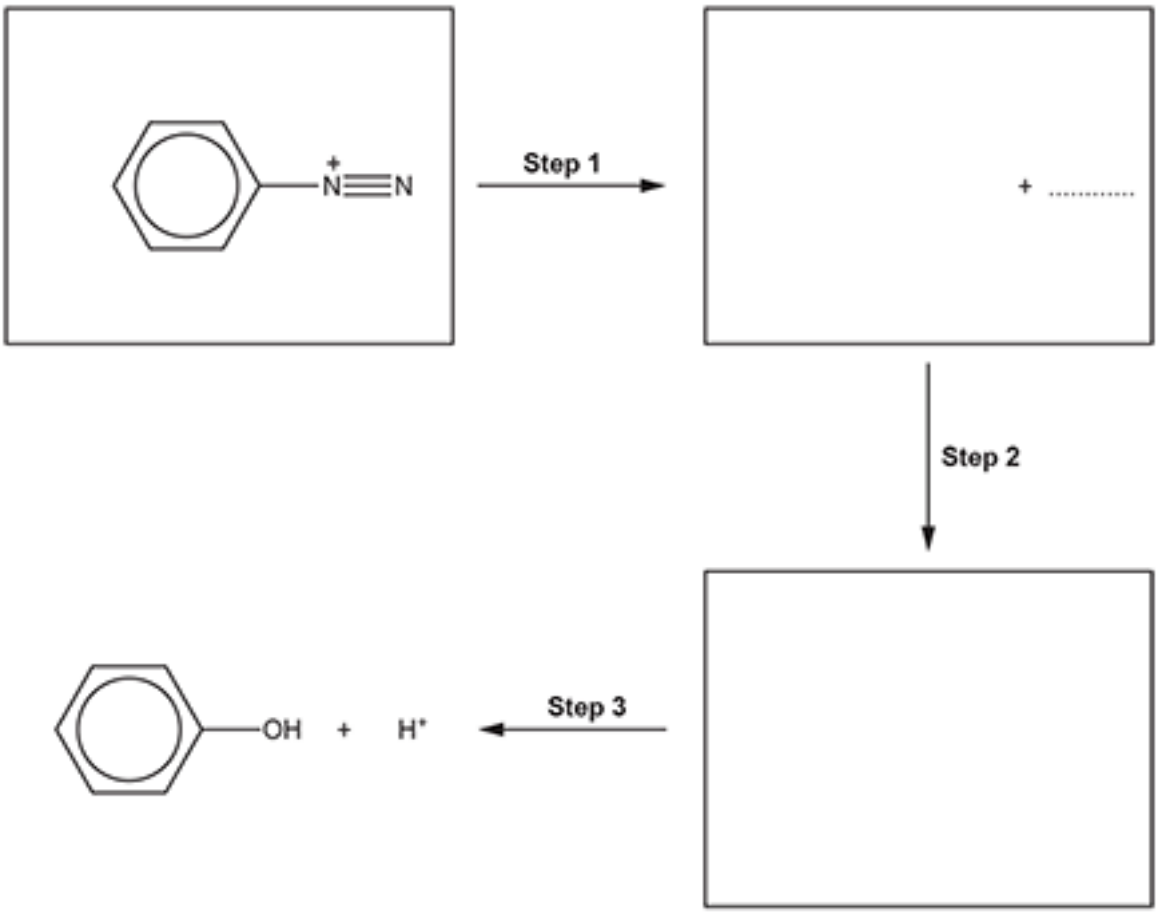
Benzenediazonium

Above 10 °C, the benzenediazonium ion reacts with water to form phenol.

The reaction proceeds in a three-step mechanism.

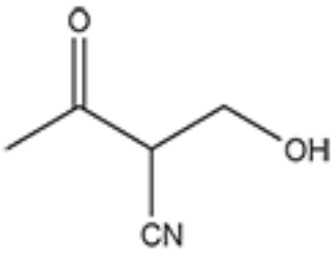
Step 1 Elimination of nitrogen gas to form a carbocation.
Step 2 Nucleophilic attack by water.
Step 3 Proton loss to form the organic product.

Complete the boxes below with intermediates and curly arrows to show the mechanism for this reaction.



[4]

5. A chemist is investigating compound **A**, shown below, as a potential organic intermediate.



Compound A

Describe the type of stereoisomerism shown by compound **A** and suggest three reactions of compound **A**, one for each of the **three** functional groups using reagents of your choice.

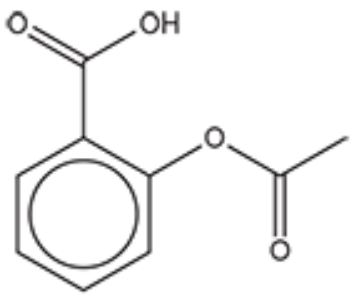
In your answer, show stereoisomers of compound **A**, your chosen reactants and conditions, and the structures for the organic products produced.

Mechanisms and equations are **not** required.

[6]

6. Aspirin tablets are used for pain relief.

The structure of aspirin is shown below.



Aspirin

Aspirin reacts with hot NaOH(aq), under reflux.

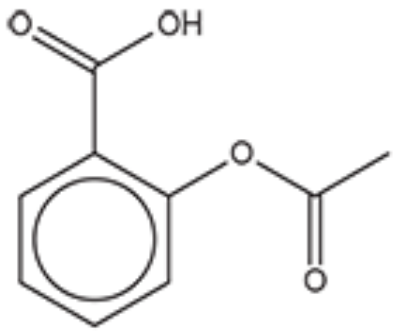
i. Draw a labelled diagram of suitable apparatus for reflux.

[2]

ii. In this reaction, 1 mol of aspirin reacts with 3 mol of hot NaOH(aq).

Complete the equation for the reaction of aspirin with an excess of hot NaOH(aq).

Show structures for organic compounds.



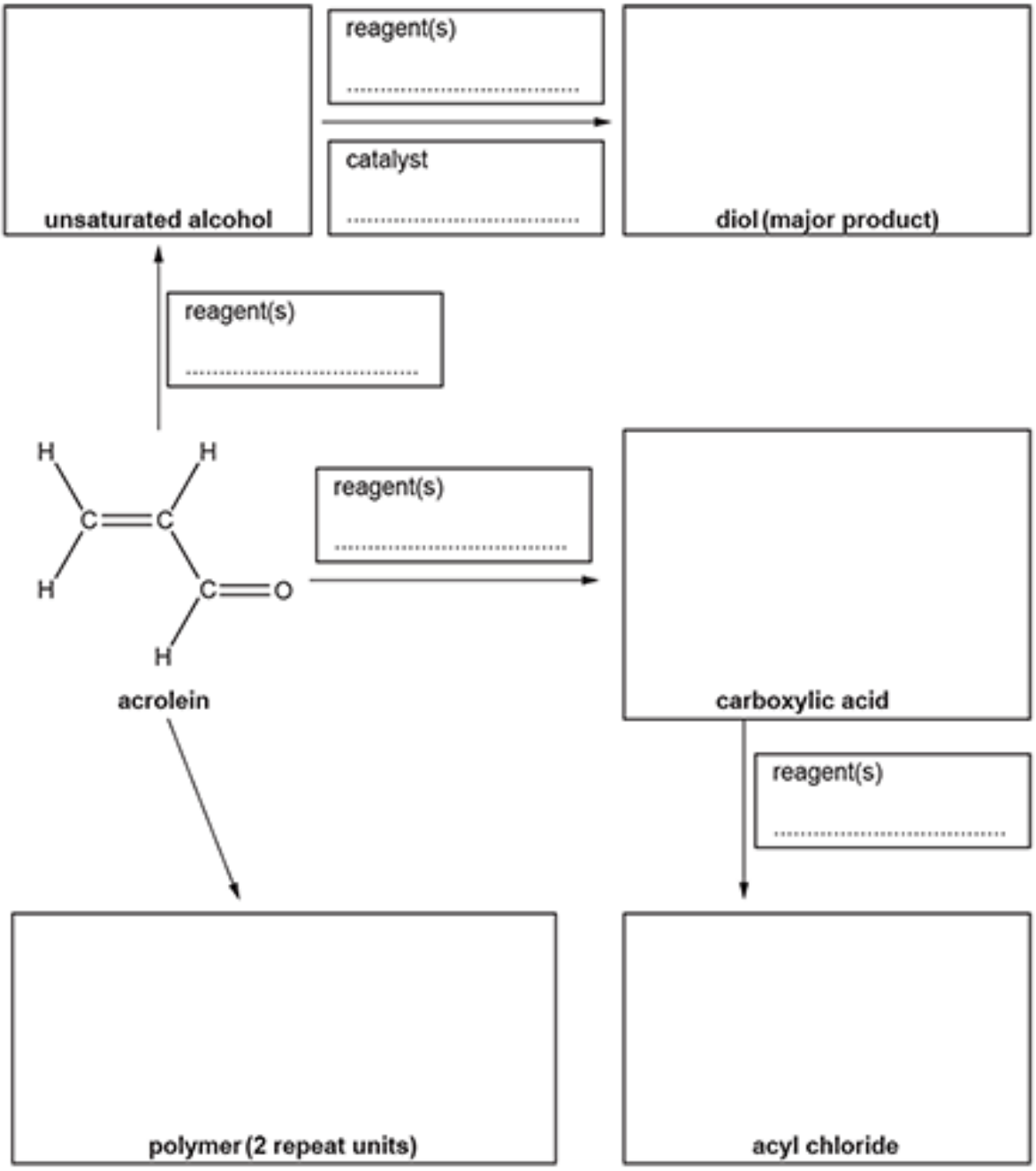
+ .....

↓

[3]

7. This question is about reactions of acrolein, $H_2C=CHCHO$.

Complete the flowchart by filling in each box.



[9]

8. 1,3-dinitrobenzene is a solid at room temperature.

A chemist prepares 1,3-dinitrobenzene as outlined below.

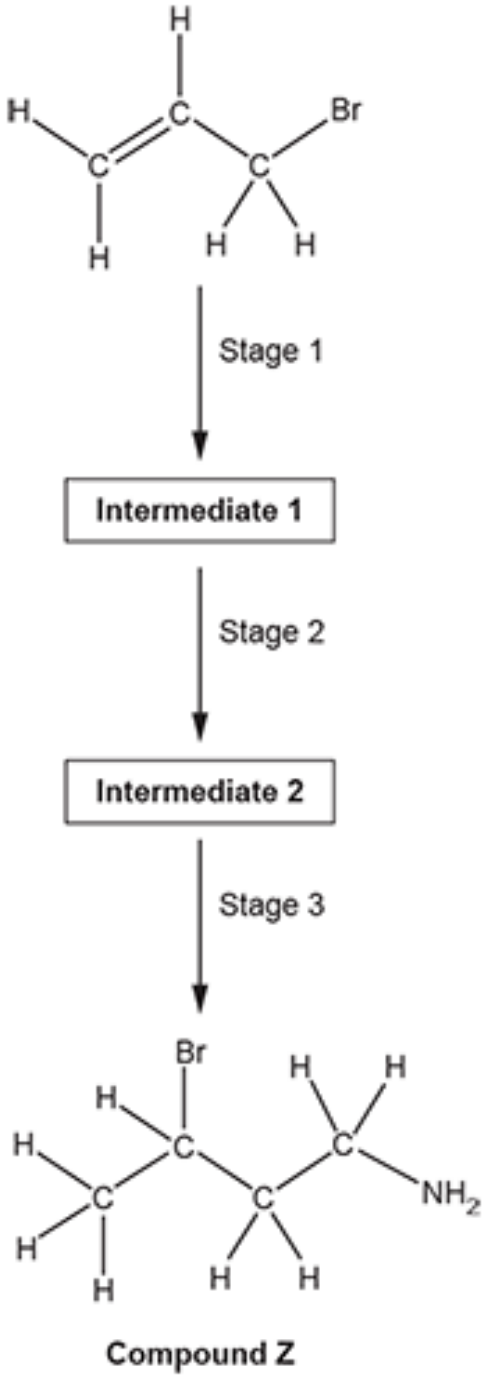
Step 1	12.5 cm^3 of nitrobenzene (density = 1.20 g cm^{-3}) is refluxed with concentrated nitric acid in the presence of concentrated sulfuric acid as a catalyst.
Step 2	The mixture is cooled. Impure crystals of 1,3-dinitrobenzene appear.
Step 3	The impure crystals are purified to obtain pure 1,3-dinitrobenzene.

The chemist obtains 15.0 g of pure 1,3-dinitrobenzene.

Describe how to purify the impure crystals in **Step 3**.

[3]

9. A student intends to synthesise compound **Z**, as shown in the flowchart below.

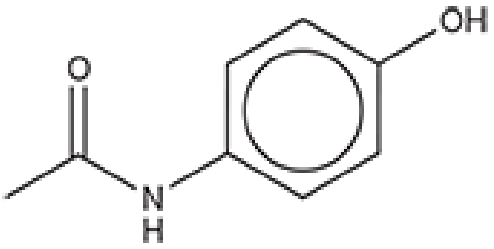


Compound Z

Plan this synthesis showing reagents, the structures of **intermediate 1** and **intermediate 2**, and equations.

[6]

10. The structure of the painkiller paracetamol is shown below.



Paracetamol

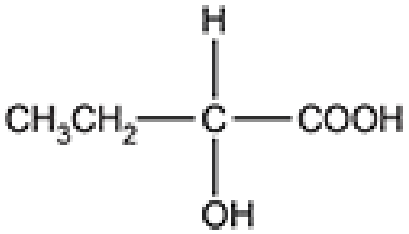
Which functional groups are present in paracetamol?

A alcohol, amide
B alcohol, arene, ketone, amine
C phenol, amide
D phenol, ketone, amine

Your answer ☐ **[1]**

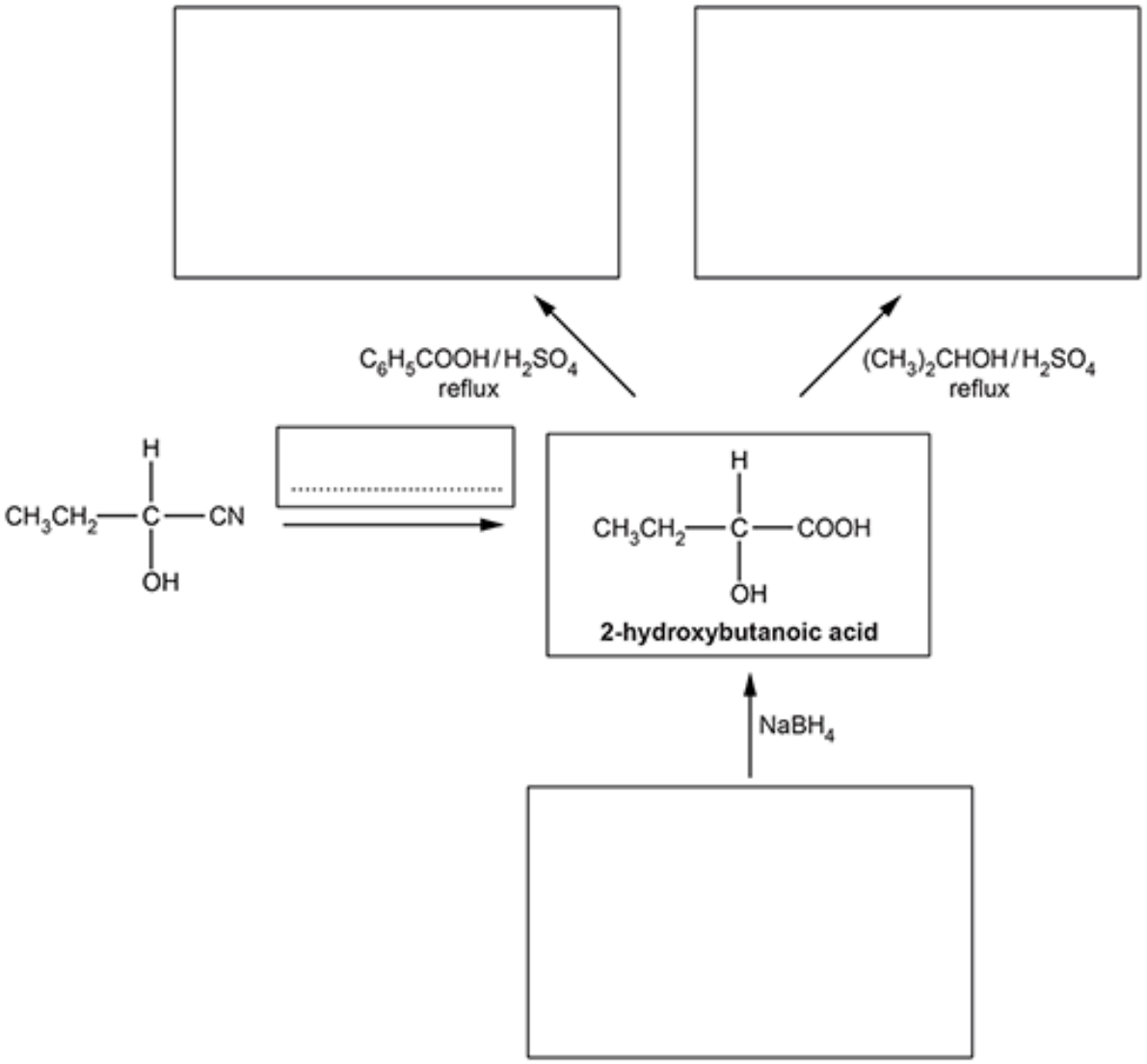
11(a). This question is about compounds that contain the carboxylic acid functional group.

The structure of 2-hydroxybutanoic acid is shown below.



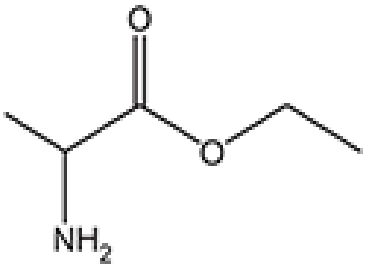
2-hydroxybutanoic acid

Fill in the flowchart for reactions involving 2-hydroxybutanoic acid.



[4]

(b). *A student intends to synthesise compound **I**.



Compound I

Plan a synthesis to prepare 9.36 g of compound **I** starting from 2-chloropropanoic acid, $CH_3CHClCOOH$. The overall percentage yield of compound **I** from 2-chloropropanoic acid is 64%.

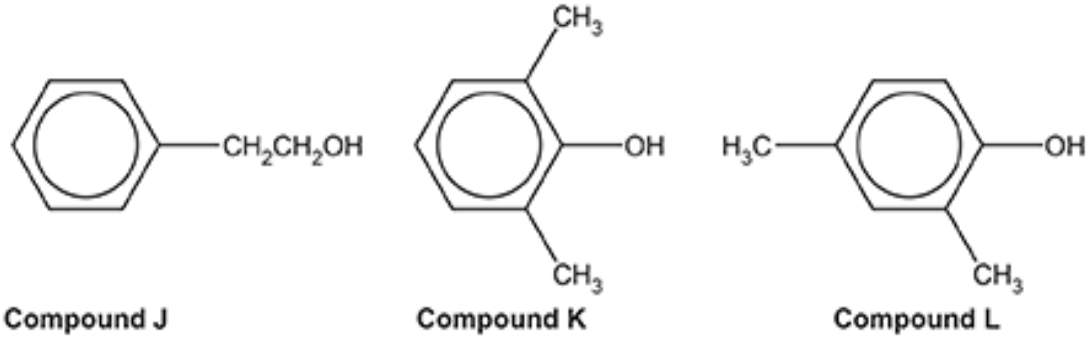
In your answer, include starting mass of 2-chloropropanoic acid, reagents, conditions and equations where appropriate.

Additional answer space if required.

[6]

12. This question is about the chemistry of aromatic compounds.

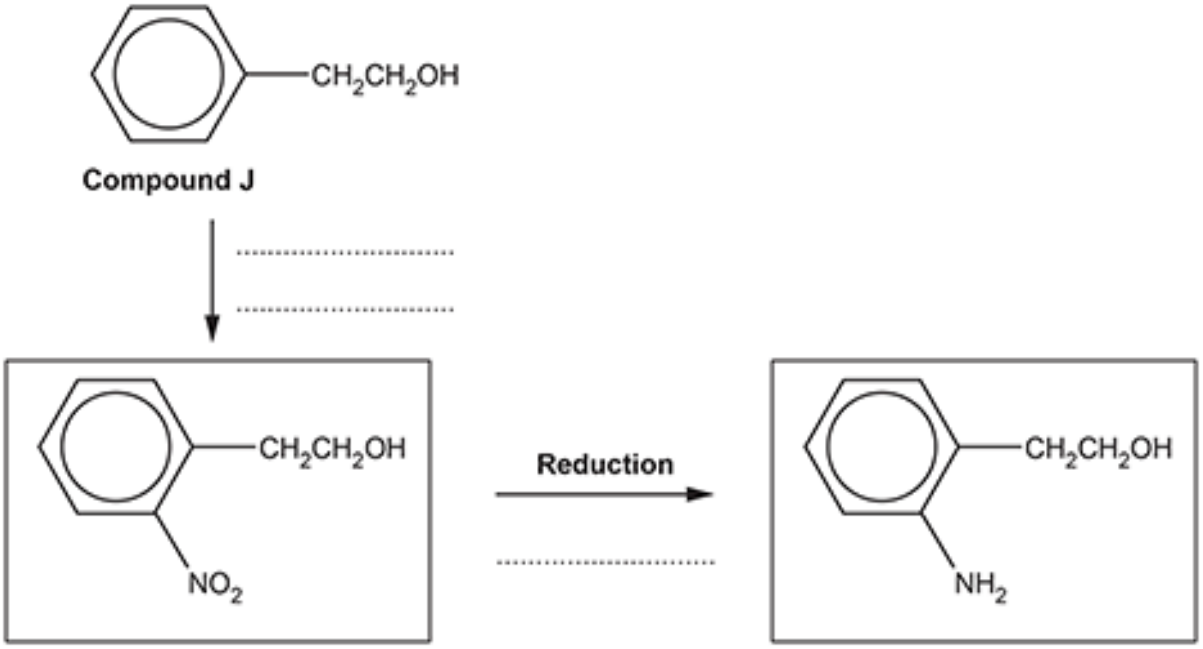
Compounds **J**, **K** and **L**, shown below, are structural isomers.



Compound J **Compound K** **Compound L**

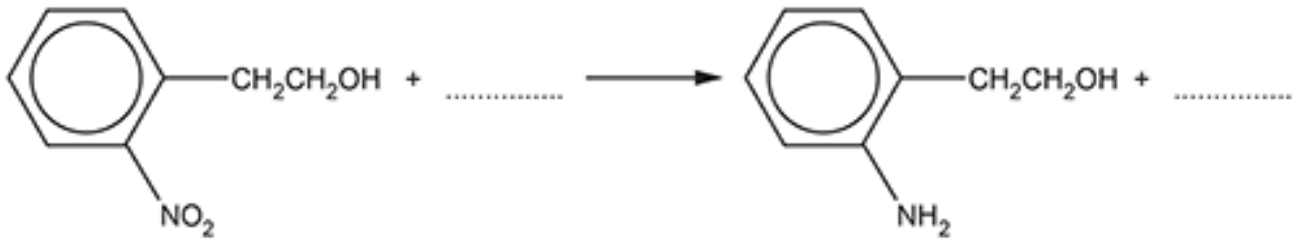
A two-stage synthesis of an amine from compound **J** is shown below.

i. Add the reagents for each stage of this synthesis.



[2]

ii. Fill in the equation for the reduction stage of this synthesis.



[1]

13. Which species could react as a nucleophile?

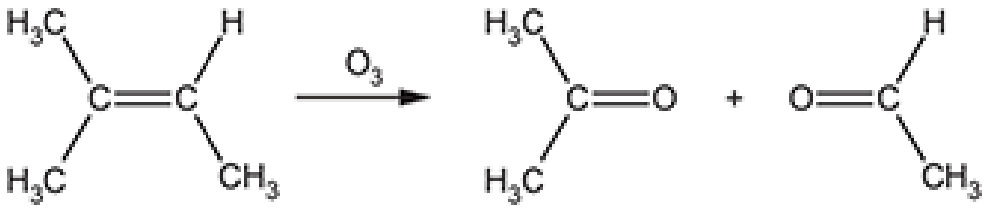
1 NH_3
2 OH^-
3 CH_3NH_2

A 1, 2 and 3
B Only 1 and 2
C Only 2 and 3
D Only 1

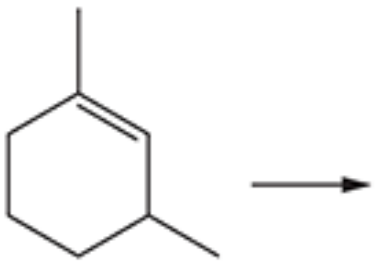
Your answer ☐ **[1]**

14. 'Ozonolysis' is used in organic synthesis. Ozone breaks C=C bonds to form carbonyl compounds.

For example, the complete ozonolysis of methylbut-2-ene is shown below.



i. Draw the structures of the products you would expect from the ozonolysis of the **two** compounds below.

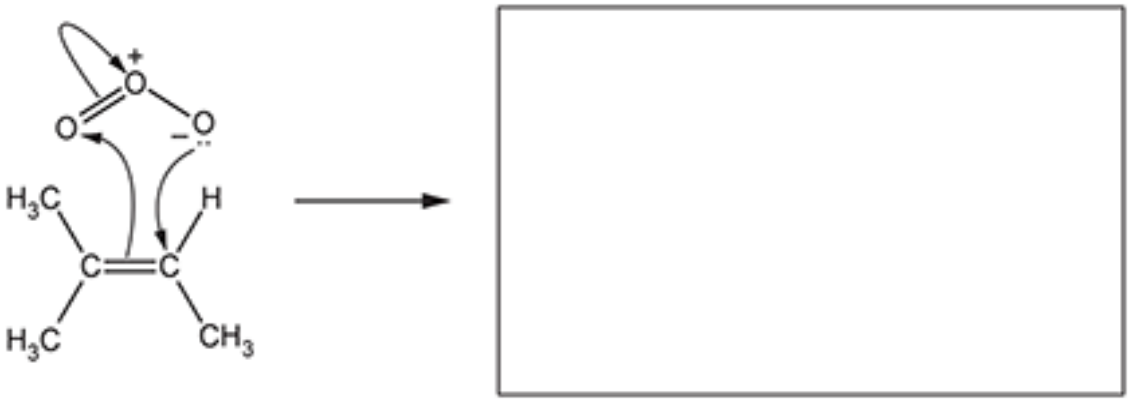


[2]

ii. The mechanism for ozonolysis takes place in several steps.

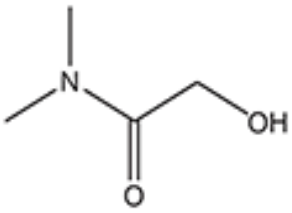
The curly arrows in the first step in the ozonolysis of methylbut-2-ene are shown below.

In the box, draw the structure(s) for the product(s) of this step.



[1]

15. The skeletal formula of an organic compound is shown below.



Which functional groups are present?

A amide and alcohol
B amide and carboxylic acid
C amine and carboxylic acid
D amine, ketone and alcohol

Your answer ☐ **[1]**

END OF QUESTION PAPER