1(a). This question is about the analysis of organic compounds.

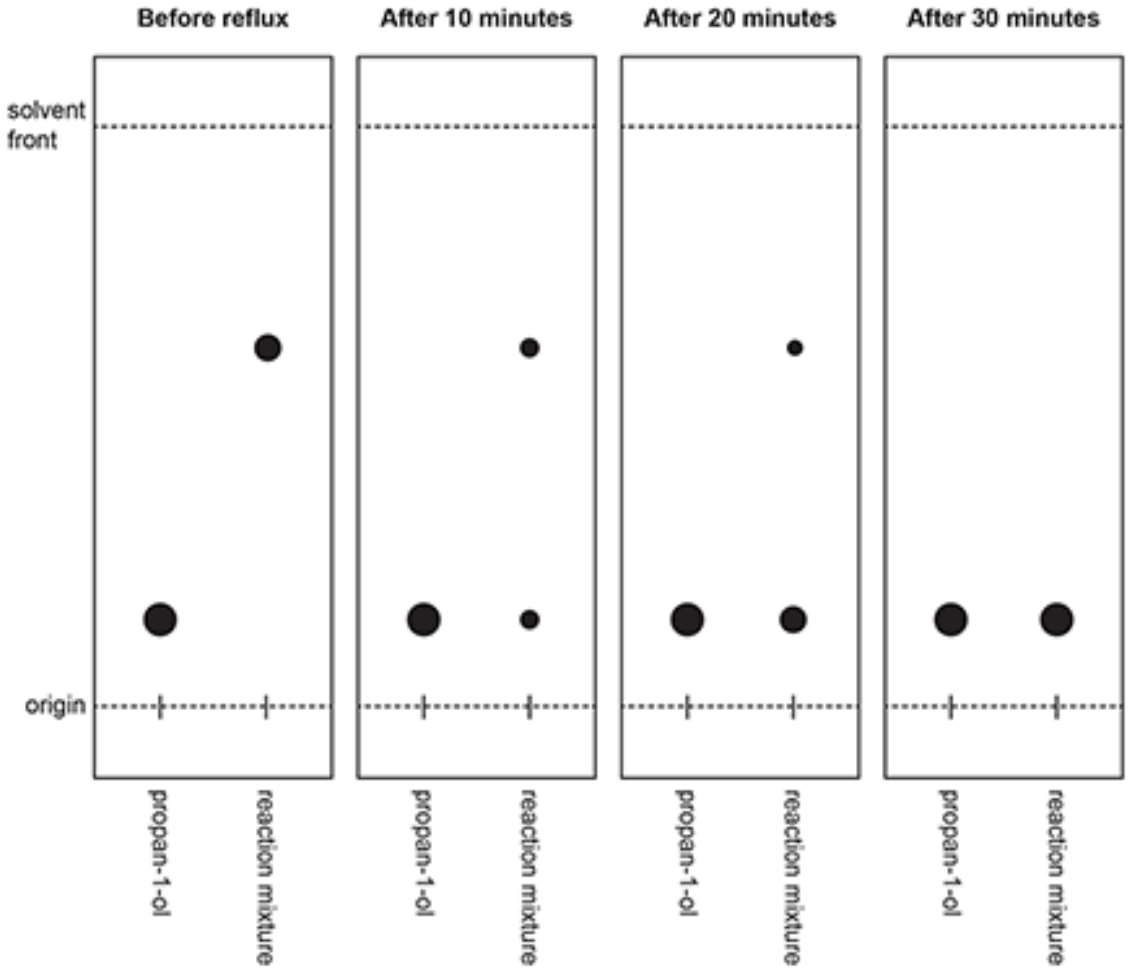
A student investigates the alkaline hydrolysis of 1-bromopropane as outlined below.

Step 1 The student adds 1-bromopropane to an excess of aqueous potassium hydroxide, KOH(aq), in a pear-shaped flask.

Step 2 A TLC chromatogram is run using propan-1-ol and the reaction mixture.

Step 3 The reaction mixture is refluxed.
A TLC chromatogram of the reaction mixture is run every 10 minutes.

The TLC chromatograms are shown below



i. Determine the R_f value of propan−1−ol.

Show your working.

R_f = ... **[1]**

ii. Write an equation for the alkaline hydrolysis of 1−bromopropane.

Show structures of organic compounds.

[1]

iii. A student investigates the alkaline hydrolysis of 1−chloropropane using the same method as for 1−bromopropane.

Predict, with reasons, how the appearance of the reaction mixture in the chromatogram produced after 20 minutes would be different when 1−chloropropane is used instead of 1−bromopropane.

Suggest why propan−1−ol is run alongside the reaction mixture.

[3]

(b). Compounds **F, G, H** and **I** are structural isomers.

A student carries out test-tube tests on the compounds.
The student records the observations after carrying out each test.
These are shown in **Table 5.1**.

In **Table 5.1**, 2,4-dintrophenylhydrazine has been abbreviated to 2,4−DNP.

Table 5.1

Compound	Test			
	2,4-DNP	**Acidified dichromate(VI) reflux**	**Bromine water**	**Tollens' reagent**
F	Orange solution	Green solution	Colourless solution	Colourless solution
G	Orange solution	Green solution	Orange solution	Colourless solution
H	Orange precipitate	Orange solution	Orange solution	Colourless solution
I	Orange precipitate	Green solution	Orange solution	Silver mirror

i. Write the formula of the species causing the colours after refluxing with acidified dichromate(VI).

Green solution _____

Orange solution _____ **[2]**

ii. The student is provided with further information about compounds **F–I**.

- They all have the molecular formula $C_5H_{10}O$.
- One of the compounds is alicyclic.
- The other compounds are unbranched.

Use this further information and the student's observations in **Table 5.1** to answer the following.

- How do the observations provide evidence for the possible functional groups in compounds **F–I**?
- Suggest a possible structure for each of the compounds **F–I**.

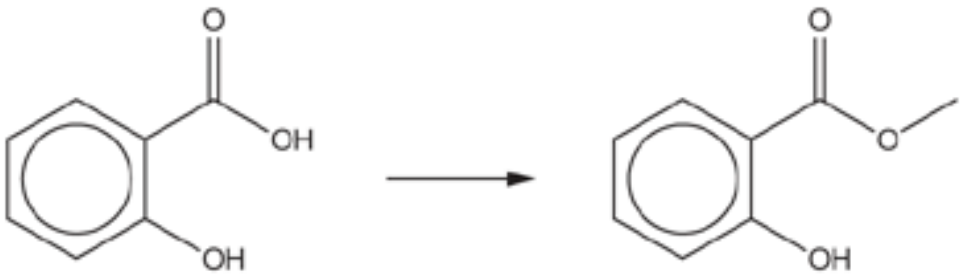
Show your reasoning.

Extra answer space if required.

[6]

2. Oil of wintergreen is a liquid used in medicine to relieve muscle pain.

Compound **H** is a component in oil of wintergreen and can be synthesised from compound **G**, as shown below. The boiling point and density of compound **H** are stated.



Compound G **Compound H**

boiling point = 222 °C
density = 1.174 g cm^{-3}

A student prepares a sample of compound **H** by the method below.

Step 1	Reflux 8.97 g of compound **G** for 30 minutes with an excess of methanol in the presence of a small amount of sulfuric acid as a catalyst.
Step 2	Add an excess of aqueous sodium carbonate, Na_2CO_3(aq). Two layers are obtained.
Step 3	Purify the impure compound **H** that forms from the resulting mixture.

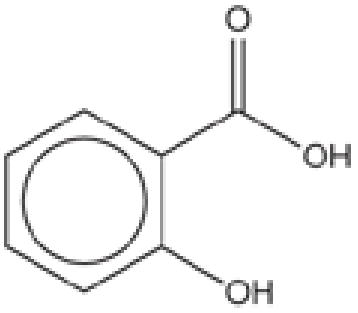
The student follows this method and obtains 5.32 g of pure compound **H**.

i. **In Step 2**, Na_2CO_3(aq) removes the sulfuric acid catalyst **and** any unreacted compound **G** from the mixture.

Write equations for this removal.

Removal of sulfuric acid

Removal of unreacted compound **G**



Compound G

[3]

ii. Another student suggests that adding aqueous sodium hydroxide would be more effective in removing the sulfuric acid catalyst than $Na_2CO_3(aq)$.

Comment on whether the student's suggestion is an improvement for the preparation of compound **H**.

[1]

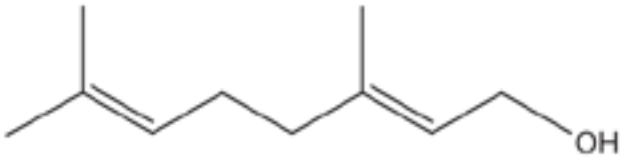
3. A student investigates the rate of hydrolysis of different iodoalkanes using aqueous silver nitrate in ethanol.

What colour of precipitate is seen?

A Brown
B Cream
C White
D Yellow

Your answer ☐ **[1]**

4. Geraniol, shown below, is a component in many natural oils.



Geraniol

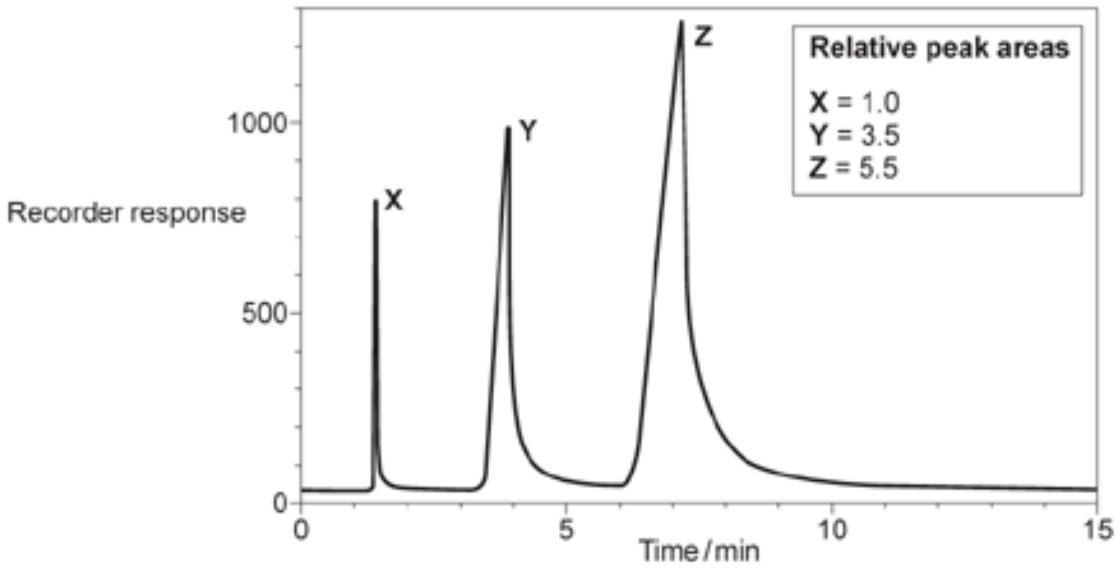
Which pair of reagents identifies both functional groups in geraniol?

A Acidified dichromate(VI) and 2,4-dinitrophenylhydrazine.
B Bromine water and 2,4-dinitrophenylhydrazine.
C Bromine water and acidified dichromate(VI).
D Tollens' reagent and aqueous silver nitrate in ethanol.

Your answer ☐ **[1]**

5. A sample containing a mixture of 3 components, **X**, **Y** and **Z**, is analysed using gas chromatography.

The gas chromatogram below is obtained.
The relative peak areas of **X**, **Y** and **Z** are included.



Which statement(s) is/are true?

1 The peak for component **X** shows the mass of one mole.
2 Component **Y** stays in the column for longer than component **X**.
3 Component **Z** consists of more than half of the sample.

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

Your answer ☐ **[1]**

6. An unknown organic compound is analysed.

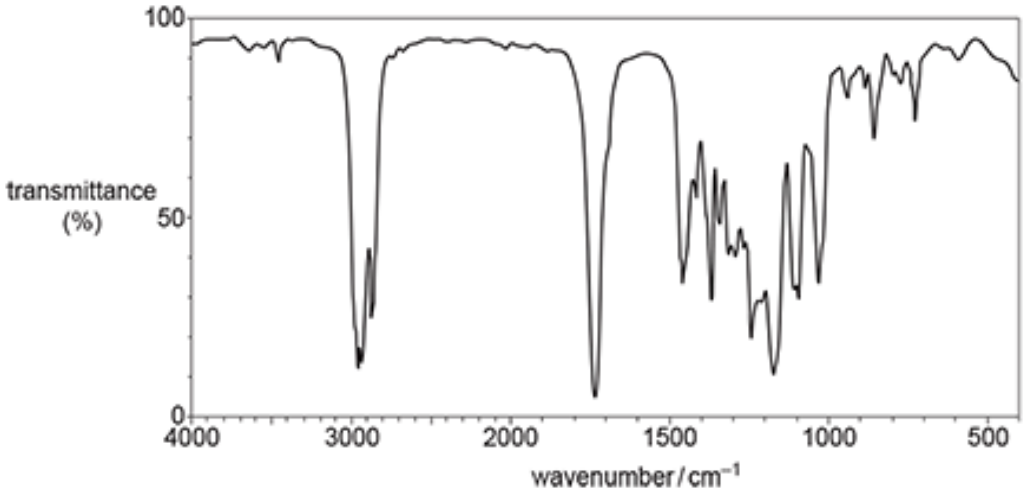
The results are shown below.

Addition of 2,4-DNP
No visible change

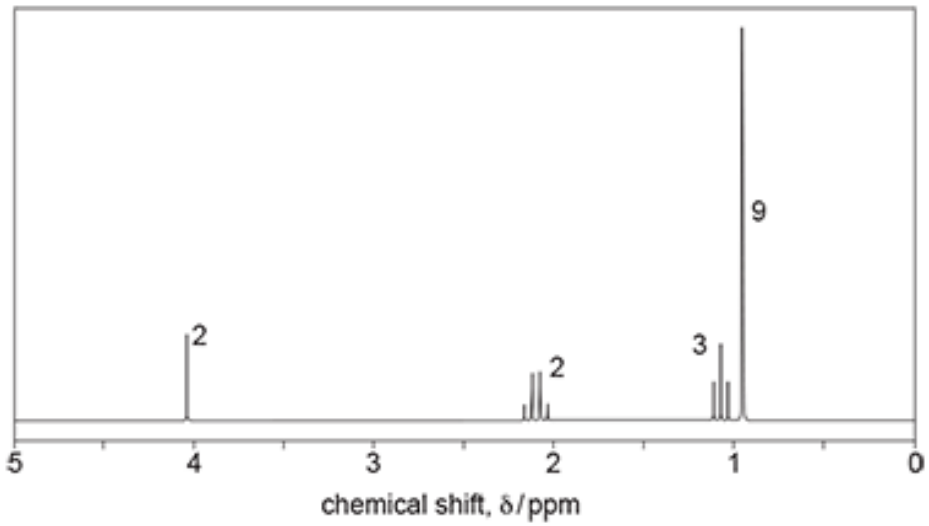
Elemental analysis by mass
C, 66.63%; H, 11.18%; O, 22.19%

Mass spectrum
Molecular ion peak at $m / z = 144.0$

IR spectrum



Proton NMR spectrum
The numbers by each peak are the relative peak areas.



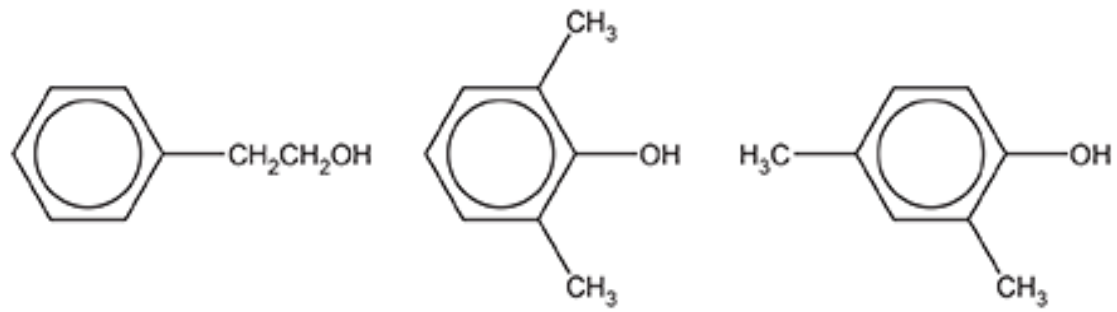
Use the information to identify the organic compound.

Show **all** your reasoning.

[6]

7. 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**

i. What chemical test(s) could be used to confirm the presence of the phenol group in compounds **K** and **L**?

[1]

ii. A student thought that ^{13}C NMR spectroscopy could be used to distinguish between compounds **J**, **K** and **L**.

Explain, with reasoning, whether the student is correct.

[3]

iii. Compound **J** is substituted at the 2- and 4- positions by chlorine in the presence of a catalyst.

Outline the mechanism for the 4 substitution of compound **J** by chlorine in the presence of a catalyst.

Show the role of the catalyst.

[4]

END OF QUESTION PAPER