Q1 (a) Describe and explain how the acidities of ethanol and phenol compare to that of water.

.....

.....

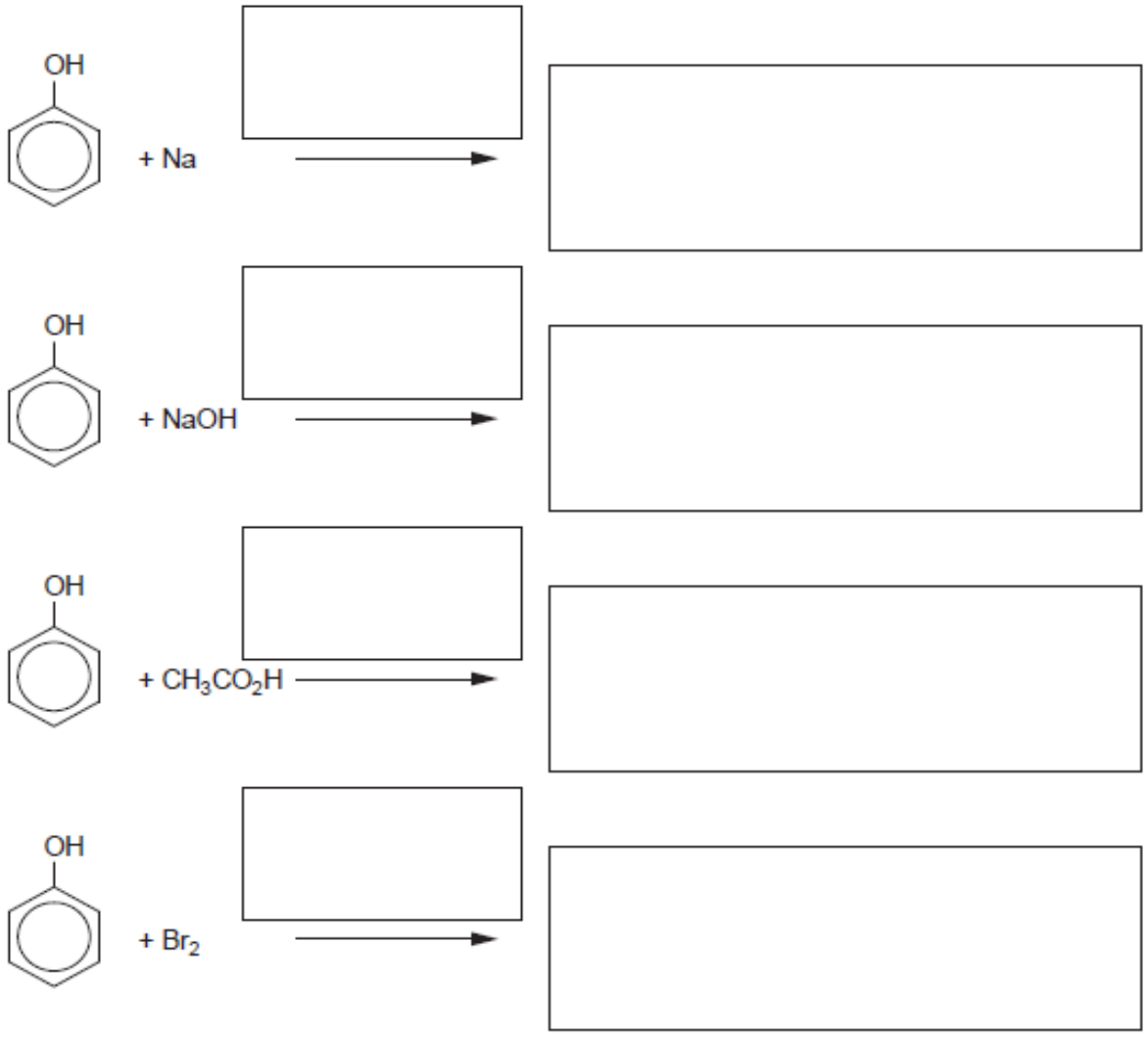
.....

.....

.....

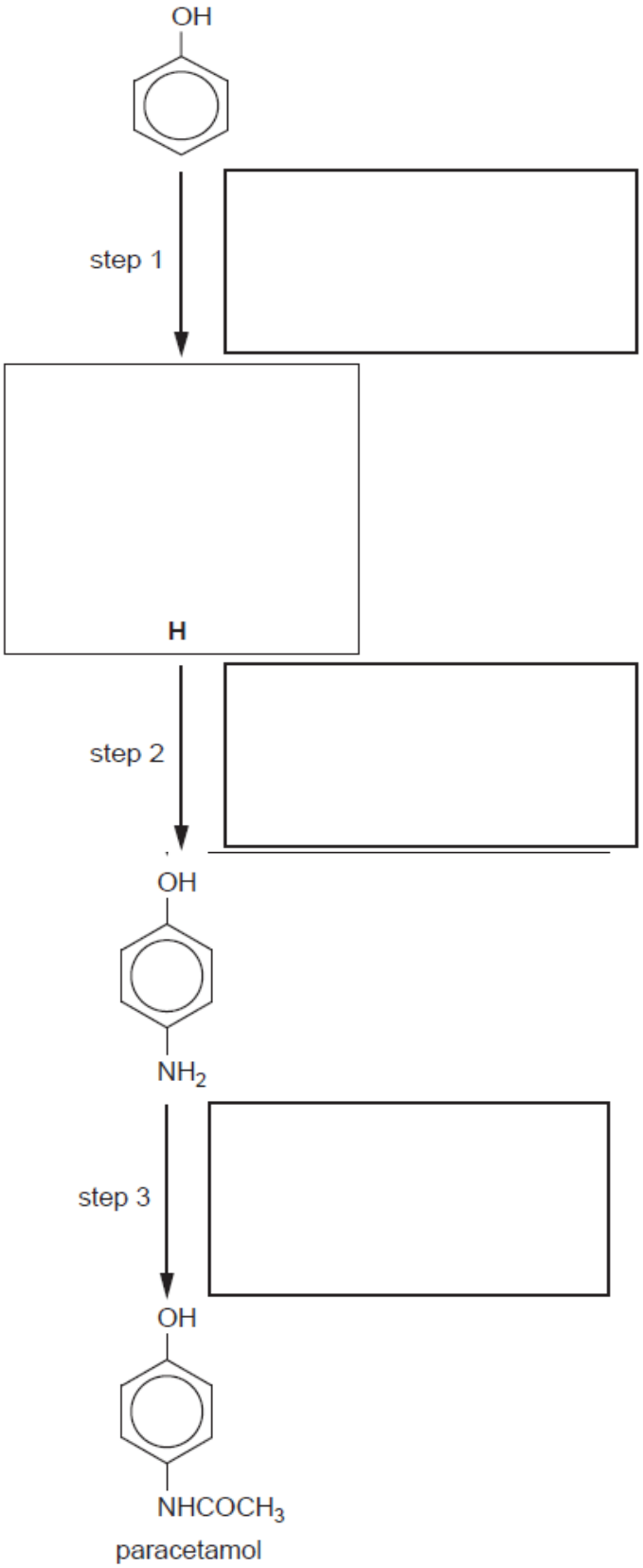
..... [4]

(b) Complete the following equations showing **all** the products of each of these reactions of phenol. Include reaction conditions where appropriate in the boxes over the arrows. If no reaction occurs write ***no reaction*** in the products box.



[5]

(c) The analgesic drug paracetamol can be synthesised from phenol by the following route. Suggest reagents and conditions for the each of three steps, and suggest the structure of the intermediate **H**. Write your answers in the boxes provided.

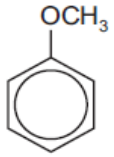


[4]

[Total: 13]

(June 2011 P42 Q5)

Q2 (a) Methoxybenzene reacts with $Br_2(aq)$ in a similar manner to phenol.



methoxybenzene

(i) Draw the structural formula of the product of the reaction between methoxybenzene and an excess of bromine.

(ii) Suggest a chemical reaction you could use to distinguish between methoxybenzene and phenol. State the reagent, describe the observations you would make, and give an equation for the reaction.

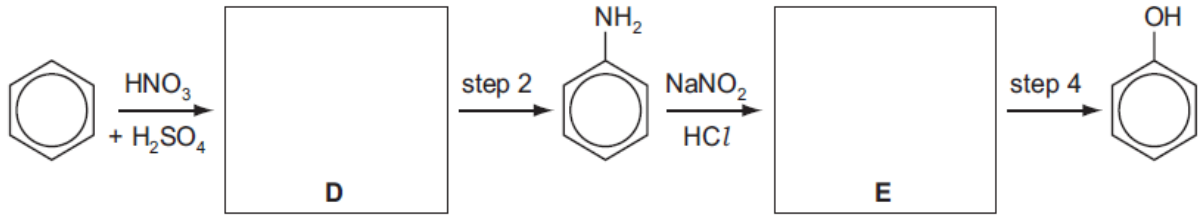
reagent .....

observation .....

equation.....

[4]

(b) Phenol can be synthesised from benzene by the following route.

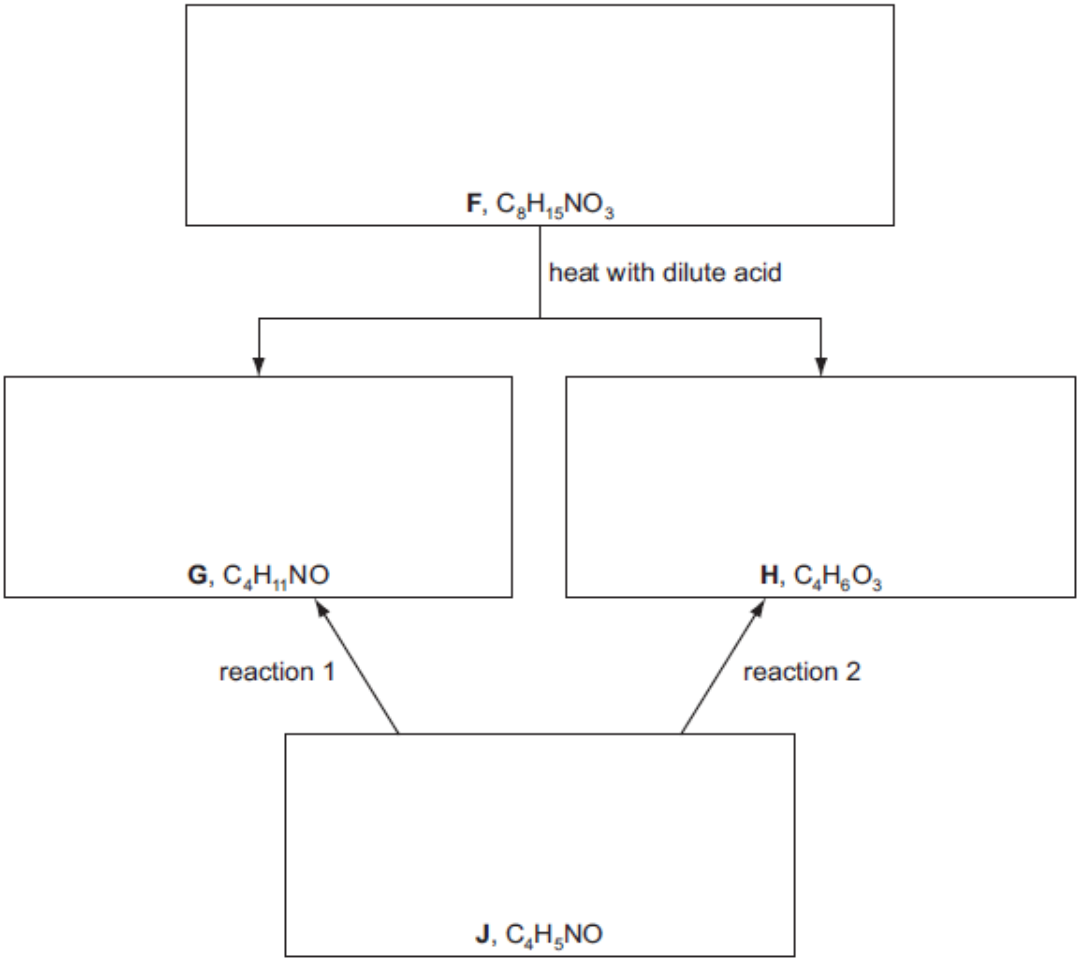


(i) Suggest structures for compounds **D** and **E** and draw them in the boxes above.
(ii) Suggest reagents and conditions for

step 2, ...

step 4. .....[4]

(c) The following chart shows some reactions of compound **F** which is a neutral compound.
G forms a salt with dilute H_2SO_4, whereas **H** forms a salt with NaOH(aq).
Both **G** and **H** can be obtained from compound **J** by separate one-step reactions (reaction1 and reaction 2 below).
All four compounds **F**, **G**, **H** and **J** form a yellow precipitate with alkaline aqueous iodine.

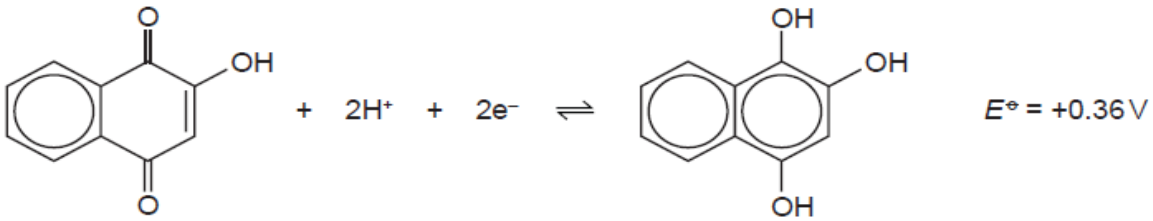


(i) Suggest structures for **F**, **G**, **H** and **J**, and draw them in the boxes above.
(ii) Suggest reactants and conditions for

reaction 1, ...

reaction 2. .....[6]
(June 2012 41 Q5)

Q3 Lawsone is the dye that is extracted from the henna plant, *Lawsonia inermis*. Although its natural colour is yellow, lawsone reacts with the proteins in hair and skin to produce the characteristic brown henna colour.
Lawsone can readily be reduced to 1,2,4-trihydroxynaphthalene, compound **A**.



lawsone 1,2,4-trihydroxynaphthalene, **A**

(a) (i) Name **three** functional groups in lawsone.

.....

(ii) Describe a reaction (reagent with conditions) that you could use to distinguish lawsone from compound **A**. Describe the observations you would make with **both** compounds.

.....

.....

.....

.....

(iii) Suggest a reagent that could be used to convert lawsone into compound **A** in the laboratory.

.....

.....

(iv) Draw the structural formula of the compound formed when lawsone is reacted with $Br_2(aq)$.

[6]

(b) Compound **A** can be oxidised to lawsone by acidified $K_2Cr_2O_7$.

(i) Use the *Data Booklet* to calculate the E_{cell} for this reaction.

.....

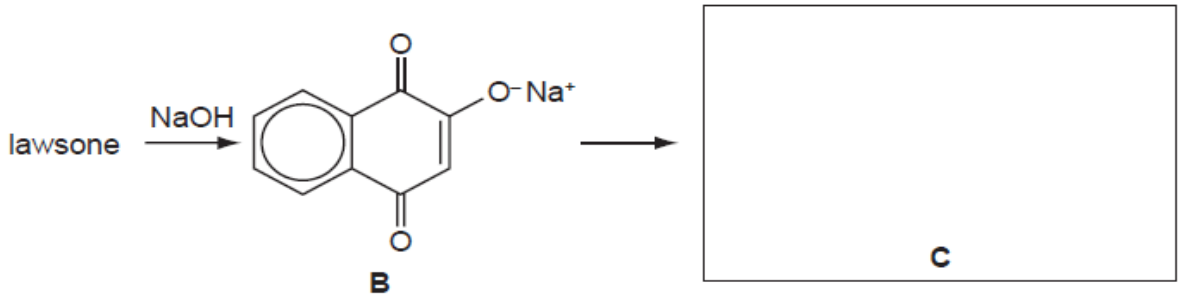
(ii) Construct an equation for this reaction. Use the molecular formulae of lawsone, $C_{10}H_6O_3$, and compound **A**, $C_{10}H_8O_3$, in your equation.

.....

(iii) When 20.0 cm^3 of a solution of compound **A** was acidified and titrated with 0.0500 $moldm^{-3}$ $K_2Cr_2O_7$, 7.50cm^3 of the $K_2Cr_2O_7$ solution was needed to reach the end-point. Calculate [**A**] in the solution.

[**A**] = ... $moldm^{-3}$ [5]

(c) When lawsone is reacted with NaOH(aq), compound **B** is produced.

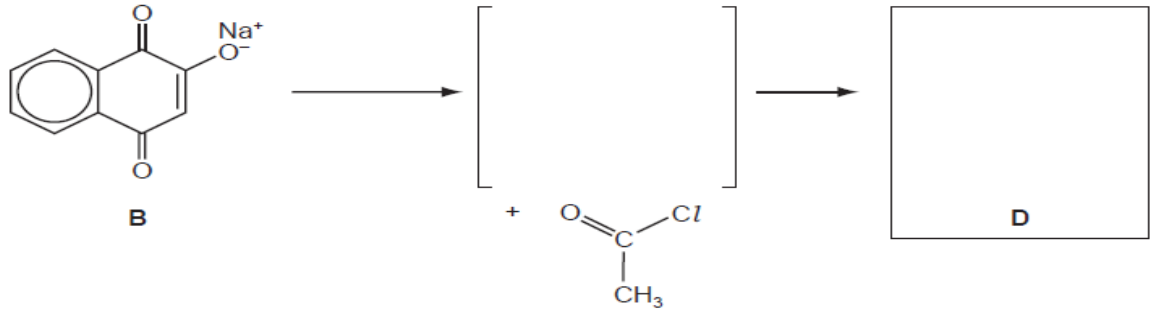


Reacting **B** with ethanoyl chloride, CH_3COCl, produces compound **C**, with the molecular formula $C_{12}H_8O_4$.
(i) Suggest the identity of compound **C**, and draw its structure in the box above.

Another compound, **D**, in addition to **C**, is produced in the above reaction. **D** is an isomer of **C** which contains the same functional groups as **C**, but in different positions.
(ii) Suggest a possible structure for **D**.

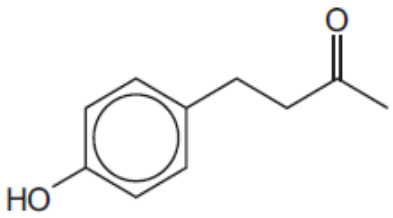
D

(iii) Suggest a mechanism for the formation of **D** from **B** and ethanoyl chloride by drawing relevant structures and curly arrows in the following scheme.



(June 2012 P42 Q3)

Q4 Compound **G** is a naturally occurring aromatic compound that is present in raspberries.



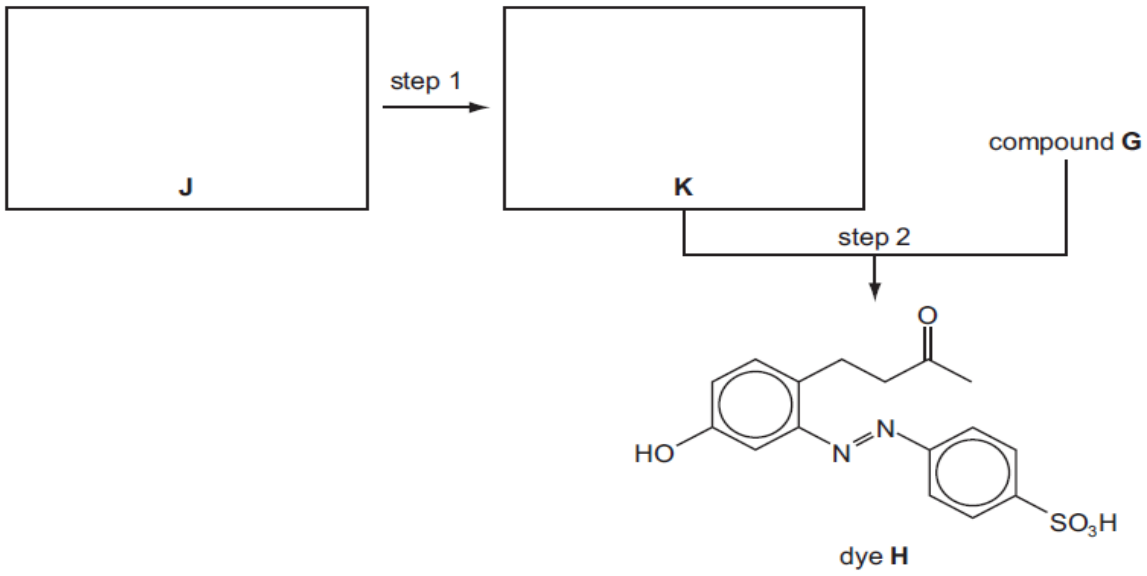
compound **G**

(a) Identify the functional groups present in compound **G**.

..... [2]
(b) Complete the following table with information about the reactions of the three stated reagents with compound **G**.

reagent	observation	structure of organic product	type of reaction
sodium metal			
aqueous bromine			
aqueous alkaline iodine			

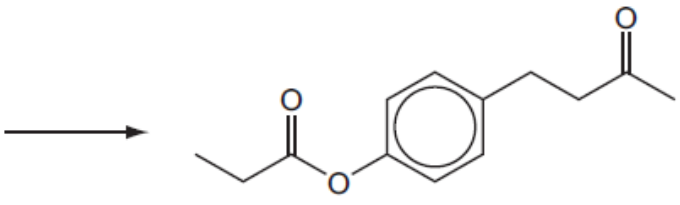
(c) The dye **H** can be made from compound **G** by the route shown below.



(i) Draw the structures of the amine **J** and the intermediate **K** in the boxes above.
(ii) Suggest reagents and conditions for

step 1, ...

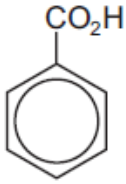
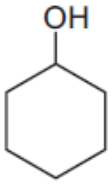
step 2. .....[5]
(d) Suggest a reaction scheme by which compound **G** and propanoic acid could be converted into compound **L**.



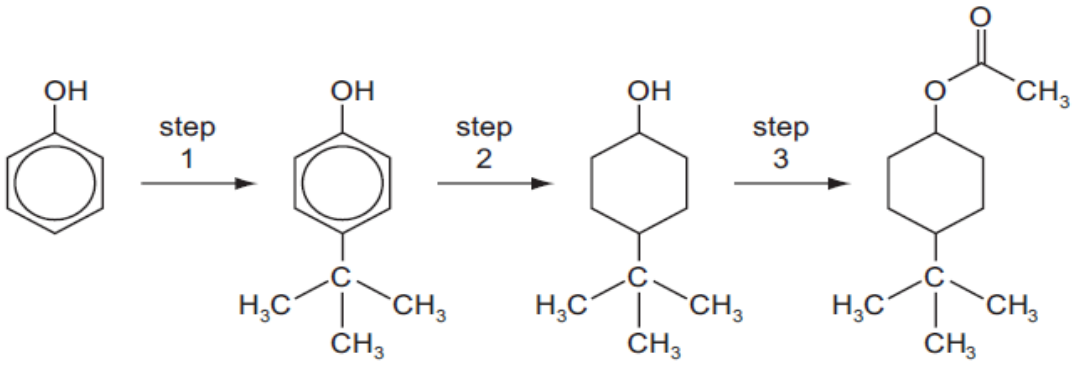
compound **L**

(Nov 2012 P41 Q5)

Q5 (a) A series of experiments is carried out in which the reagent shown at the top of the column of the table is mixed, in turn, with each of the reagents at the side.
Complete the following table by writing in each box the formula of any gas produced.
Write **x** in the box if no gas is produced.
The first column has been completed as an illustration.

	H_2O			
Na	H_2			
KOH(aq)	**x**			
Na_2CO_3(aq)	**x**			

(b) Compound **C** is responsible for the pleasant aroma of apples. It can be prepared from phenol by the following 3-step synthesis.



A **B** **C**

(i) The only by-product of step 1 is HC*l*. Suggest the reagent that was used to react with phenol to produce compound **A**.

.....

(ii) What *type of reaction* is occurring in step 2?

.....

(iii) What reagents and conditions are required for step 3?

.....

(iv) State the reagent and conditions needed to convert **C** back to **B**, the reverse of step 3.

.....[5]

(c) (i) Either compound **A** or compound **B**, or both, react with the following reagents.
For each reagent draw the structure of the organic product formed with **A**, and with **B**. If no reaction occurs, write 'no reaction' in the relevant box.

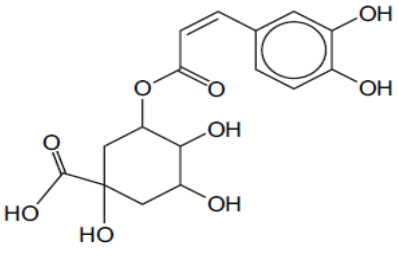
reagent and conditions	product with **A**	product with **B**
an excess of $Br_2(aq)$		
heat with HBr		
pass vapour over heated Al_2O_3		
heat with acidified $K_2Cr_2O_7$		

(ii) Choose **one** of the above reactions to enable you to distinguish between **A** and **B**.
State below the observations you would make with each compound.

reagent	observation with **A**	observation with **B**

(June 2013 P41 Q5)

Q6 Coffee beans contain chlorogenic acid.



chlorogenic acid

(a) (i) Draw circles around any chiral centres in the above structure.
(ii) Write down the molecular formula of chlorogenic acid.

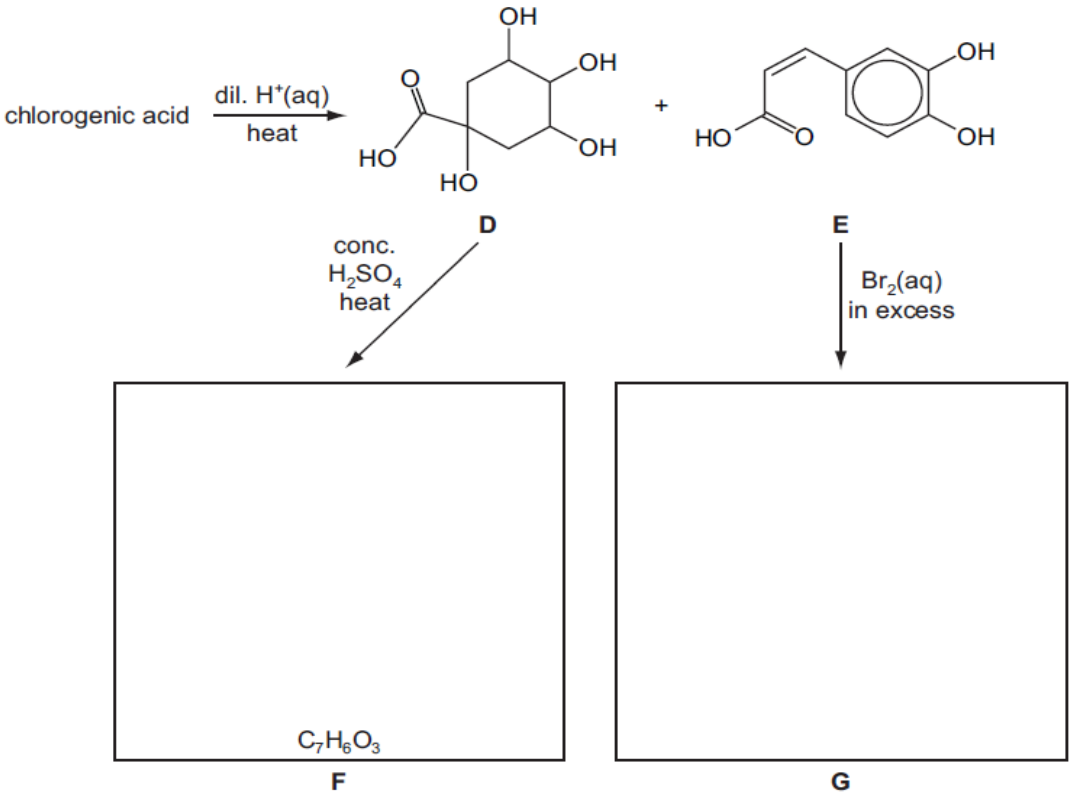
.....

(iii) How many moles of $H_2(g)$ will be evolved when 1 mol of chlorogenic acid reacts with an excess of sodium metal?

(iv) How many moles of NaOH(aq) will react with 1 mol of chlorogenic acid under each of the following conditions?

in the cold .....on heating .....[6]

(b) On heating with dilute aqueous acid, chlorogenic acid produces two compounds, **D** and **E**.



(i) What *type of reaction* is chlorogenic acid undergoing when **D** and **E** are formed?

.....

When compound **D** is heated with concentrated H_2SO_4, compound **F**, $C_7H_6O_3$, is formed. Compound **F** evolves $CO_2(g)$ when treated with $Na_2CO_3(aq)$, and decolourises $Br_2(aq)$, giving a white precipitate. It does not, however, decolourise cold dilute acidified $KMnO_4$. When compound **E** is treated with an excess of $Br_2(aq)$, compound **G** is produced.

(ii) If the test with cold dilute acidified $KMnO_4$ had been positive, which functional group would this have shown to be present in **F**?

.....

(iii) Name the functional groups in compound **F** that would react with the following.

Na_2CO_3(aq) ..... Br_2(aq) .....

(iv) Suggest structures for compounds **F** and **G** and draw them in the relevant boxes above.
(v) Compound **E** is one of a pair of stereoisomers.

What type of stereoisomerism is shown by compound **E**?

.....
(vi) Draw the structure of the other stereoisomer in the box below.

(c) Calculate the volume of 0.1 mol dm^{-3} NaOH that is needed to react completely with 0.1 g of compound **E**.

volume = ... cm^3 [3]
(June 2013 P42 Q5)