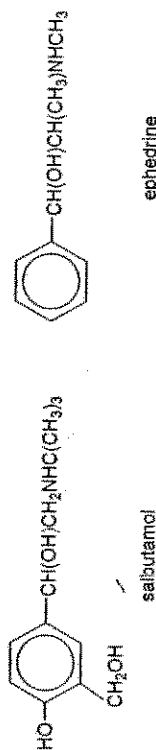


HYDROXY COMPOUNDS

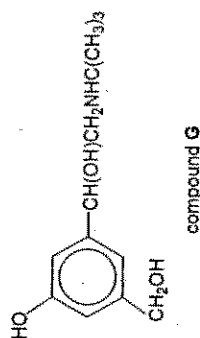
Structured / Free Response Questions

- 1 [JJC 2011/III/3(c)(i)&(iii)]

Pharmaceutical companies produce and market the drugs, salbutamol hydrochloride and ephedrine hydrochloride, for the treatment of asthmatic attacks. The active ingredients are salbutamol and ephedrine respectively.



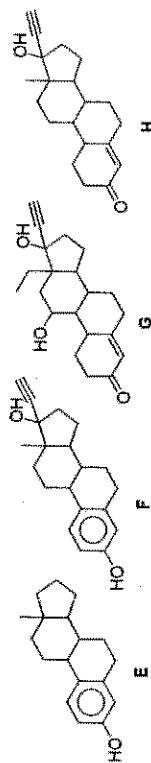
- Suggest a simple chemical test to distinguish between salbutamol and ephedrine.
- An isomer of salbutamol, compound G, has the structure shown.



Predict, with reasoning, whether salbutamol or compound **G** has a lower melting point.

- 2 [DHS 2011/11/3(b)]

Alkynes are also found in many naturally occurring organic molecules, such as the hormone molecules shown below.

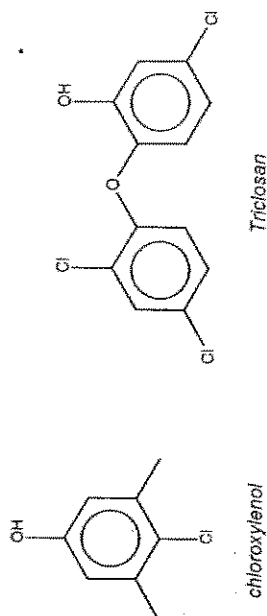


Complete the following sequence of chemical tests by stating suitable reagents, conditions and observations at each step, to identify the stated hormone molecules.

step	reagents, conditions and observations	molecule
1	reagent and conditions: observation:	G
2	reagent and conditions: observation:	H
3	reagent and conditions: observation:	F
4	reagent and conditions: observation:	E

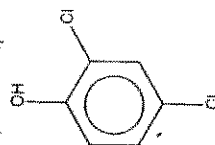
- 3 [MJC 2011/II/5(a) & (c)]

The compound *chloroxylenol* and *Triclosan* are two chlorinated phenol compounds which has been featured for its anti-microbial action, and used in soaps and detergents. While these compounds are relatively safe for humans to handle, they may have a tendency to persist in the environment for a long period of time, where in turn, they can be converted to other more toxic compounds, causing environmental problems.



- (i) By considering their solubility and reaction with water, suggest two reasons why such compounds are likely to persist in the environment.

- (iii) *Triclosan* can be synthesised from 2,4-dichlorophenol.

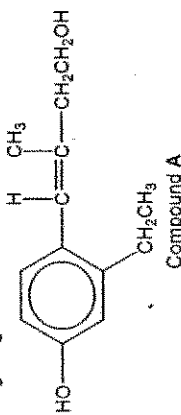


Compare the acidity of 2,4-dichlorophenol with chloroxylenol.

14 Hydroxy Compounds

4 [Modified HCl 2011/III/3(d)]

- (a) Give the structural formulae of the organic products formed when compound **A** reacts with the following reagents.



- (i) hot alkaline KMnO_4
- (ii) dilute HNO_3
- (iii) hot acidified $\text{K}_2\text{Cr}_2\text{O}_7$
- (iv) aqueous bromine
- (v) PCl_5
- (v) $\text{CH}_3\text{CO}_2\text{H}$ and a small amount of concentrated H_2SO_4 , heat

[9]

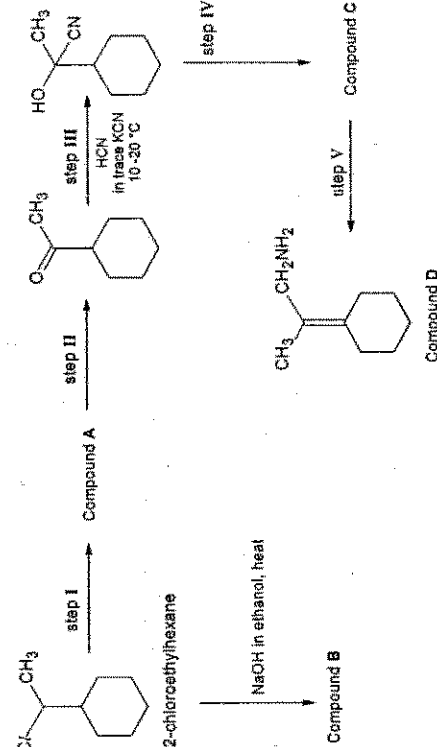
- (b) Explain why compound **A** is more soluble in aqueous sodium hydroxide than in water.

[2]

5 [Modified PJC 2011/III/7(a)]

Amines are commonly found in polymers used in plastics or textiles. Compound **D** is an amine-containing monomer which is used in polymerisation to form plastic materials. The reaction scheme shown below outlines how compound **D** can be formed from 2-chloroethylhexane.

14 Hydroxy Compounds



- (i) Suggest the structural formulae for the compounds **A**, **B** and **C**.
- (ii) Name the type of reactions in steps I to V.
- (iii) Suggest suitable reagents and conditions in steps I, II, IV and V.

[12]

6 [YJC 2011/III/2(c)(iii) & (iv) & RI 2011/III/4(c)(iii) & RI 2009/III/1(c)]

The following table lists the boiling points of some unbranched alkanes and alcohols.

formula	boiling points / °C
C_2H_6	-88
C_3H_8	-42
C_4H_{10}	0
CH_3OH	65
$\text{C}_2\text{H}_5\text{OH}$	78
$\text{C}_3\text{H}_7\text{OH}$	97
$\text{C}_4\text{H}_9\text{OH}$	118
$\text{C}_6\text{H}_{11}\text{OH}$	133

- (a) (i) Explain why the boiling points of the alcohols are much higher than those of the alkanes.

14 Hydroxy Compounds

- (ii) A mixture containing two of the alcohols listed in the table above, is to be separated using fractional distillation. The mixture is placed in the distillation apparatus at room temperature and then gently heated. The first fraction is collected at 97.2 °C.
- Identify one alcohol from the table above that could not be present in the mixture.
 - By specifically referring to this experiment, explain why the alcohol identified in (i) could not be present.
 - Give a reason why the distillation flask should not be heated using a bunsen burner.
- (b) Dehydration occurs when alcohols are heated over Al_2O_3 .
- Compound N is obtained when propan-2-ol is heated over Al_2O_3 . Identify compound N.
 - Suggest reagents and conditions to convert N into 2-hydroxypropanoic acid (commonly known as lactic acid) in no more than 3 steps.
 - When lactic acid is refluxed with a catalytic amount of concentrated sulfuric acid, compound Z with the molecular formula of $C_6H_{10}O_4$ is formed. It does not react with sodium. Deduce the structural formula of Z, giving reasons for your answer.
- 7 [SRJC 2011/III/5(c)]
Organometallic compounds, usually a metal attached to an R group, can be used to convert carbonyl compounds to alcohols. An example is shown below:



2-bromobutane can be converted to 2-methylbutan-2-ol in 3 steps. Write the reagents and conditions required for the conversion, including intermediate compounds.

- 8 [CJC 2011/III/4(c)]
A hydrocarbon A has the molecular formula of $C_{10}H_{14}$. When A is treated with hot aqueous acidified $KMnO_4$, benzoic acid is formed.
- When reacted with bromine in the presence of ultraviolet light, A produced four isomeric monobromo compounds with the formula $C_{10}H_{13}Br$.

5

14 Hydroxy Compounds

Upon heating with alcoholic NaOH, two of the monobromo compounds B and C gave the same compound which can exist as a pair of geometric isomers, D and E.

Heating B with aqueous NaOH produces compound F which does not react with acidified potassium dichromate(VI).

Suggest the structures of A-F, explaining your reasoning.

[9]

9 [PJJC 2011/III/2(c)]

A recently discovered organic compound L possesses a pleasant floral scent and is therefore being used as a component of many essential oils and perfumes. A molecule of L has the molecular formula, $C_{10}H_{18}O$.

A sample of L has the ability to rotate plane-polarised light.

No reaction occurs between L and 2,4-dinitrophenylhydrazine. However, L produces M , $C_{10}H_{12}O$, with hydrogen with nickel catalyst.

No change is observed when L is heated with acidified potassium dichromate(VI).

Heating L with aluminium oxide produces a mixture of two products. N, with molecular formula $C_{10}H_{16}$, is present as the major product.

N reacts with hot concentrated acidified potassium manganate(VII) to produce propanone and P, $C_3H_6O_3$. A colourless gas, which forms a white precipitate in limewater, is liberated.

P can also be produced by the reaction of the following compound with hot concentrated acidified potassium manganate(VII).



Deduce the structures of compounds L, M, N, and P. Explain the chemistry of the reactions described.

[9]

6

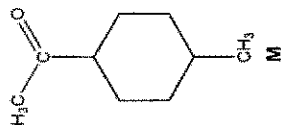
10 [JJC 2011/III/5(d)]

α -Terpineol, $C_{10}H_{18}O$, has a pleasant smell similar to lilac and is a common ingredient in perfumes, cosmetics, and flavours.

α -Terpineol contains a *cyclohexene ring* and an alcohol group which is not readily oxidised.

Heating α -Terpineol with concentrated acidified $KMnO_4$ gives **H**, $C_{10}H_{18}O_4$, which gives a yellow precipitate on warming with alkaline aqueous iodine. On hydrogenation in the presence of palladium catalyst, α -Terpineol gives **J**, $C_{10}H_{20}O$.

J reacts readily in the presence of a few drops of concentrated sulfuric acid to give **K**, $C_{10}H_{18}$. **K** is oxidised by warm acidified $KMnO_4$ to give **M**, $C_9H_{16}O$ along with the evolution of CO_2 gas.



Deduce the structural formulae for **H**, **J**, **K** and α -Terpineol. Explain your reasoning.

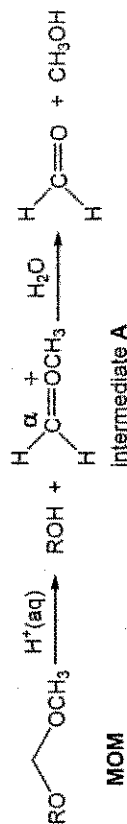
[8]

11 [NYJC 2015/III/1(a)]

Functional groups in a molecule must be protected in order to react in a desired way with reagents used in a synthesis. For instance, alcohols undergo oxidation or nucleophilic substitution reactions readily. To avoid these reactions, the alcohol can be protected by converting it to an unreactive methoxymethyl ether (MOM), $RO-CH_2-OCH_3$, using methylchloromethyl ether (MOMCl), $Cl-CH_2-OCH_3$.

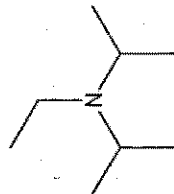
Protection Process

7

Deprotection Process

(a) (i) Suggest why ROH is converted to RO^- in Step I.

(ii) Brønsted-Lowry bases are usually used in Step I of the protection process. Bulky organic bases such as *N,N*-diisopropylethylamine (DIPEA) is one example.



Bulky organic bases such as DIPEA are preferred over

- less bulky organic bases such as primary amine and
- alkalis such as sodium hydroxide.

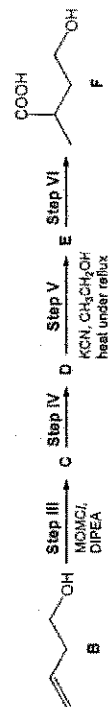
Explain why primary amine is unsuitable to be used as a base in step I of the protection process.

(iii) Explain why Step I does not occur if the base was changed to sodium hydroxide

(iv) Describe the mechanism of Step II for the protection process using MOMCl. (Recall the content learnt in RX)

(v) State the oxidation state of carbon labelled α in intermediate A

(vi) Compound **F** can be made from compound **B** in four steps, where the first step involves the protection of alcohol using MOMCl.

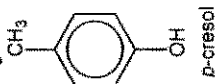


(vii) State the types of reaction for Steps IV, V and VI.

8

12 [CJC 2016/II/5(a)]

The compound *p*-cresol is used in the production of antioxidants. It is also used in the fragrance and dye industries.



Draw the displayed formula of a functional group isomer of *p*-cresol, and describe a laboratory test that will distinguish these two compounds. You should state the reagents used and the observations expected.

(a) Draw the displayed formula of a functional group isomer of *p*-cresol, and describe a laboratory test that will distinguish these two compounds. You should state the reagents used and the observations expected.

13 [DHS 2016/III/5]

The male silk moth secretes 'juvenile hormone', $C_{15}H_{25}O_4$, which contains an unknown number of epoxide rings. Epoxide rings are readily hydrolysed by cold aqueous acid.



The reactions that 'juvenile hormone' and the resulting derivatives undergo are shown in the table below.

Reactant	Reagent	Result
'juvenile hormone'	hydrogen in the presence of a palladium catalyst	S, $C_{16}H_{25}O_4$, formed.
	cold dilute hydrochloric acid	T, $C_{16}H_{25}O_6$, containing four alcoholic groups and three chiral centres is formed.
T	warmed with aqueous sodium hydroxide and then acidified	Methanol and U, $C_{15}H_{23}O_6$, are formed.
U	Mild oxidation	V, $C_{16}H_{23}O_6$, which has two alcoholic groups, is formed.

V	hot concentrated $KMnO_4$	Two moles of carbon dioxide and one mole of W, $C_{15}H_{23}O_6$, are formed.
W	2,4-dinitrophenylhydrazine reagent	orange precipitate formed.
	alkaline aqueous iodine	yellow precipitate formed.

In addition, it is known that 'juvenile hormone' has a continuous 12-carbon long backbone. There are **three methyl substituents** on the skeletal backbone of 'juvenile hormone' and that **each methyl substituent** is five carbon atoms apart from the next methyl substituent.

- Give the products that will be formed when methylethyl ether, $CH_3OCH_2CH_3$, undergoes hydrolysis with aqueous acid.
- State and explain the number of epoxide ring(s) in 'juvenile hormone'.
- State the type of reaction that T has undergone and the functional group that it contains other than the four alcoholic groups.
- Classify the two alcoholic groups in V into either primary, secondary and tertiary alcohols. State the number of each alcohol and explain how you arrive at your conclusion.
- V produced an intermediate upon reacting with hot concentrated acidified $KMnO_4$, which eventually produced carbon dioxide. Draw the displayed formula of this intermediate.
- State the type of reaction between W and 2,4-dinitrophenylhydrazine reagent. State the deduction about W from the result of W reacting with aqueous alkaline iodine.
- Suggest the structures for compounds S to W and for 'juvenile hormone'.

14 [HCl 2016/II/3(b)]

- Under certain conditions, but-2-ene gives alcohol A, $C_4H_{10}O$, which exists as a liquid at room temperature.
 - State the reagents and conditions required in this reaction. Draw the displayed formula of alcohol A formed in this reaction. [2]
 - Explain, in terms of structure and bonding, the difference in the physical state of but-2-ene and alcohol A at room temperature. Draw a diagram to illustrate your answer for alcohol A. [3]

15 [JC 2016/III/4(e)]

- (e) Compound **P**, $C_9H_{12}O_2$, shows optical activity and does not react with aqueous potassium carbonate. However, it is soluble in aqueous potassium hydroxide. When **P** reacts with hot acidified potassium dichromate(VI), the solution turns from orange to green. **P** also decolourises aqueous bromine to form a white precipitate, **Q**, $C_9H_{10}O_2Br_2$.

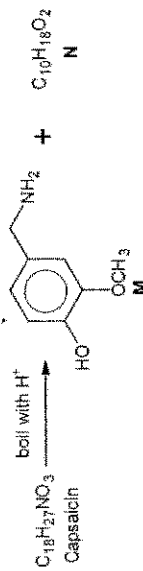
Upon heating with concentrated sulfuric acid, **P** gives only compound **R**, $C_9H_{10}O$, which displays geometric isomerism. **R** gives compound **S** and ethanoic acid on reacting with hot acidified potassium manganate(VII) solution.

Suggest the structures of **P**, **Q**, **R** and **S**, explaining the reactions involved.

[7]

16 [NJC 2016/III/4(b)(i)]

- (b) Capsaicin is a slightly acidic compound responsible for the burning sensation of chilli peppers. Its molecular structure can be deduced by the following reaction scheme. [Assume that $-OCH_3$ group is inert.]



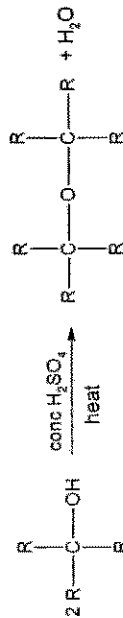
- (i) When **N** is heated with concentrated acidified potassium manganate(VII), **P**, $C_6H_{10}O_4$, and **Q**, C_4H_8O , are formed.
- P** is formed from the reaction of $\text{Br}(\text{CH}_2)_2\text{Br}$ with hot ethanolic KCN followed by hydrolysis. **Q** can be reduced to an alcohol **R**, which is optically active.

Deduce the structures of **N**, **P**, **Q**, **R** and capsaicin.

[5]

17 [NYJC 2016/III/2(e)(i)-(iii)]

- (e) Alcohols react with concentrated sulfuric acid at high temperatures to form alkenes. A common side reaction that can happen is the formation of ethers, which is also catalysed by concentrated sulfuric acid.



11

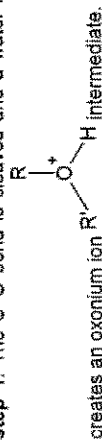
The mechanism occurs via 3 steps:

Step 1:

An acid base reaction in which H^+ from H_2SO_4 protonates the oxygen atom in alcohol. This step is very fast and reversible.

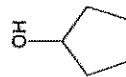
Step 2:

A second alcohol molecule functions as the nucleophile and attacks the product from step 1. The C-O bond is cleaved and a water molecule leaves the molecule. This

**Step 3:**

Another acid base reaction in which the proton in the oxonium ion is removed by a suitable base (in this case a water molecule) to give the ether product. This step is very fast and reversible.

- (i) Draw the ether formed when cyclopentanol undergoes the above reaction.



cyclopentanol

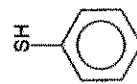
[1]

- (ii) Draw out the full mechanism for the reaction between two cyclopentanol molecules to form an ether. In your answer, show any relevant charges, lone pairs of electrons and movement of electrons.

[3]

18 [SRJC 2016/III/2(a)(i)-(ii)]

- (a) Thiophenol is an organosulfur compound with the formula $\text{C}_6\text{H}_5\text{SH}$. The chemical structure of thiophenol is analogous to phenol, except that the oxygen atom in the hydroxyl group bonded to the aromatic ring is replaced by a sulfur atom.



Thiophenol

12

- (i) Suggest if the C-S-H bond angle in thiophenol will be larger than the C-O-H bond angle in phenol. [1]
- (ii) Explain why thiophenol has a lower pK_a value than phenol. [2]

19 [TPJC 2016/III/2(a)(iv)]

- (a) (iv) $\text{CH}_3\text{CH}_2\text{Cl}$ can be prepared by reacting ethanol with SOCl_2 . Write an equation for this reaction and suggest an advantage of using SOCl_2 as a reagent for halogenation. [2]

20 [VJC 2016/III/2(a)(i)]

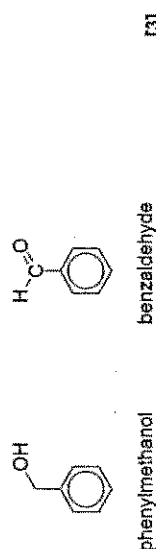
- (a) Styrene (phenylethene) is a useful organic intermediate used for the synthesis of many products. For instance, styrene is able to undergo the reaction shown below:



- (i) State the reagents and conditions required for reactions I, II and III. [3]

22 [VJC 2016/III/5(c)]

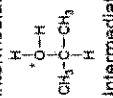
- (c) Draw a labelled diagram to show how benzaldehyde can be synthesised from phenylmethanol in a laboratory.



22 [MI 2016/II/4(b)(i)-(ii)]

- (b) 2-propanol reacts with hot excess concentrated sulfuric acid to form propene. The reaction follows a 3-step mechanism as described below:

Step 1 The oxygen atom on 2-propanol is protonated by H_2SO_4 forming intermediate A and HSO_4^- in an exothermic reaction.



Step 2	The C-O bond in intermediate A breaks, forming a carbocation B and water. This step is endothermic and is the rate determining step.
Step 3	The carbocation is then deprotonated in an exothermic reaction, forming propene. H_2SO_4 is regenerated.

- (i) State the type of reaction undergone when 2-propanol reacts with hot excess concentrated sulfuric acid. [1]
- (ii) Use the information given in the table above to draw out the full mechanism for the reaction between 2-propanol and concentrated sulfuric acid, indicating the movement of electrons using curly arrows and showing clearly the lone pair of electrons involved in the mechanism. You are advised to use structural formulae for all species, so that it is clear which bonds are broken and which are formed. [3]

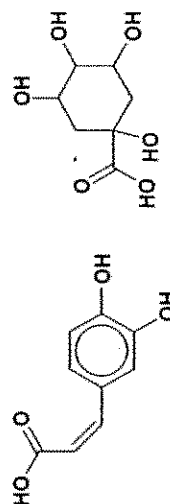
23 [NYJC 2016/III/5]

Compound A ($\text{C}_{12}\text{H}_{16}\text{O}_2$) exhibits optical isomerism. It does not react with hot acidified $\text{K}_2\text{Cr}_2\text{O}_7$. 1 mole of A reacts with 1 mole of PCl_5 to form B. A reacts with cold dilute KMnO_4 to form C ($\text{C}_{12}\text{H}_{16}\text{O}_3$). Upon heating with acidified KMnO_4 , A gives D ($\text{C}_6\text{H}_{10}\text{O}_4$) and E. D produces effervescence when aqueous Na_2CO_3 is added. 1 mole of D reacts with 3 moles of aqueous bromine. E gives F, a yellow precipitate with warm alkaline aqueous iodine.

Draw the structures of A, B, C, D, E and F. [6]

24 [SAJC 2016/III/7(b)]

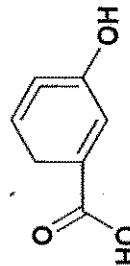
- (b) On heating with dilute acid, chlorogenic acid produces two compounds, X and Y.



Compound X

Compound Y

When compound Y reacts with hot excess concentrated sulfuric acid, a product with a molecular formula of $\text{C}_7\text{H}_6\text{O}_3$ is formed. A student claims that the product formed has the following structural formula but the teacher disagrees.



Draw the correct structure of the product and explain what is wrong with the student's answer. [2]

25 [VJC 2016/II/6(b)(i)-(iii)]

(b) Allyl alcohol, $\text{CH}_2=\text{CHCH}_2\text{OH}$, is a colourless liquid which is soluble in water.

Crotyl alcohol, $\text{CH}_3\text{CH}=\text{CHCH}_2\text{OH}$, is a colourless liquid which is used as a solvent.

(i) Describe how you would distinguish between allyl alcohol and crotyl alcohol. The compounds may be distinguished by a preliminary chemical reaction followed by a subsequent testing of the reaction products. Include clearly the reagents, conditions and observations for each compound. [2]

(ii) Allyl alcohol may be converted into propanal by using a ruthenium(IV) catalyst in water.



State the type of reaction and explain your answer. [1]

Multiple Choice Questions (Section A)

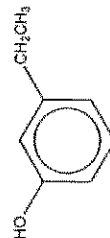
1 [CJC 2011/II/24]

Which of the following reagents may be used to distinguish between 1-bromobutane and 2-bromobutane?

- A alkaline aqueous iodine
- B sodium hydroxide
- C acidified potassium manganate(VII)
- D aqueous silver nitrate

2 [SAJC 2011/II/24]

Which of the following reagent should not be used to distinguish the following two compounds?



and $\text{CH}_3\text{CH}=\text{C}(\text{CH}_3)\text{CH}_2\text{OH}$

- A Hot acidified KMnO_4
- B $\text{Br}_2(\text{aq})$
- C HBr
- D $\text{NaOH}(\text{aq})$

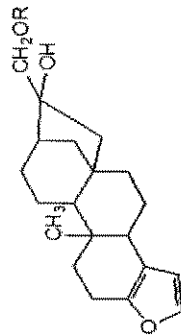
3 [MJC 2011/II/17]

Which of the following alcohols yield only a single product upon heating with concentrated H_2SO_4 ?

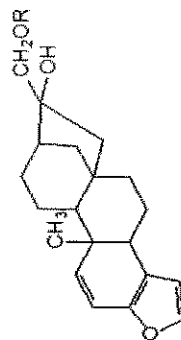
- A $\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{OH}$
- B $\text{CH}_3\text{CH}_2\text{CH}(\text{OH})\text{CH}_3$
- C $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}(\text{OH})\text{CH}_3$
- D $\text{CH}_3\text{CH}_2\text{CH}(\text{OH})\text{CH}_2\text{CH}_3$

4 [AJC 2011/II/22]

Cafestol and Kahweol are fat-soluble compounds known as diterpenes, which are present in the oil derived from coffee beans. Both compounds have liver-protecting properties of caffeine. The structures of Cafestol and Kahweol are given below.



Cafestol



Kahweol

In the following reactions, $-\text{CH}_2\text{OR}$ remains unaltered.

Which of the following statements is true?

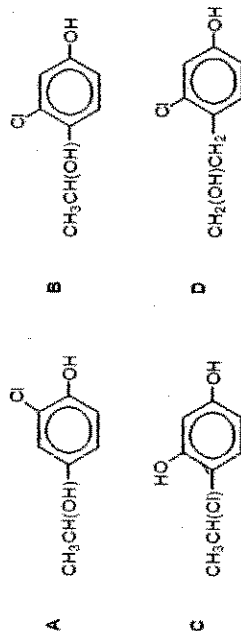
- A Both compounds do not react with acidified $\text{K}_2\text{Cr}_2\text{O}_7$.
- B 1 mol of Cafestol reacts with excess Na to produce 1 mol of H_2 .
- C 1 mol of Kahweol reacts with Br_2 to give a product with 11 chiral centres.
- D When treated with an excess of hot concentrated acidified KMnO_4 , Cafestol will produce a compound with 4 carbonyl groups.

14 Hydroxy Compounds

5 [NYJC 2011/24]

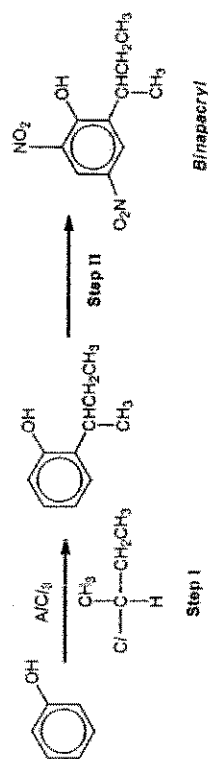
Compound **E**, $\text{C}_8\text{H}_5\text{ClO}_2$, gives compound **F**, $\text{C}_8\text{H}_7\text{ClO}_2$, on mild oxidation. **F** gives a yellow precipitate on warming with alkaline iodine and reacts with 2 moles of aqueous bromine.

Which one of the following is the correct structure for **E**?

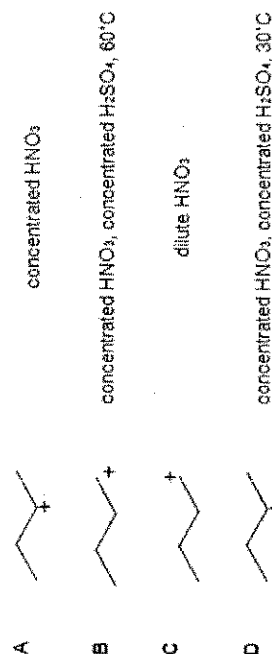


6 [CJC 2011/20]

Binapacryl is used as a fungicide and can be synthesized from phenol via the following synthetic route. Which of the following describes Steps I and II correctly?



Electrophile in Step I Reagents and Conditions for Step II

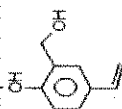


17

14 Hydroxy Compounds

7 [TPJC 2011/29]

A compound has the following structure:

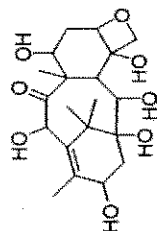



All of the following reagents will react with the above compound, except

- A** aqueous bromine
B phosphorous pentachloride
C hydrogen chloride
D potassium cyanide

8 [RI 2011/20]

Taxol is a drug isolated from the Pacific yew tree and is used in the treatment of lung and ovarian cancers. The tricyclic core of **Taxol** has the following structure.



In the reactions given below, the  ring remains unaltered.

The tricyclic core was first reacted with H_2 and Pt catalyst, followed by hot acidified $\text{K}_2\text{Cr}_2\text{O}_7$.

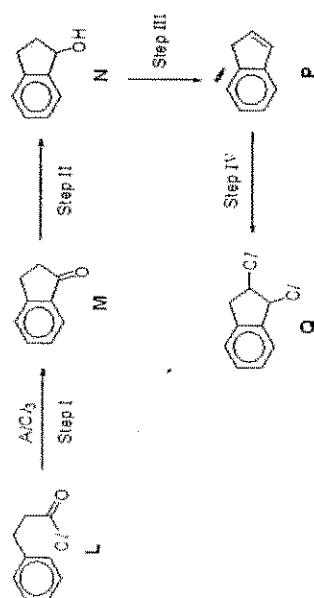
How many chiral centres are present in the product of reaction?

- A** 5 **B** 7
C 9 **D** 11

18

14 Hydroxy Compounds

- 9 [HCl 2011/I/19]
Consider the following reaction scheme.

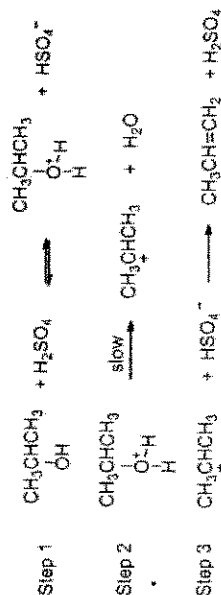


Which of the following statements about the above reaction scheme is **incorrect**?

- A Compound **P** is a planar molecule.
- B Step I is an electrophilic substitution.
- C Compound **Q** can exhibit *cis-trans* isomerism.
- D Step III can be carried out by heating compound **N** over Al_2O_3 .

- 10 [HCl 2011/I/26]

The dehydration of propan-2-ol to form propene is thought to involve the following steps:



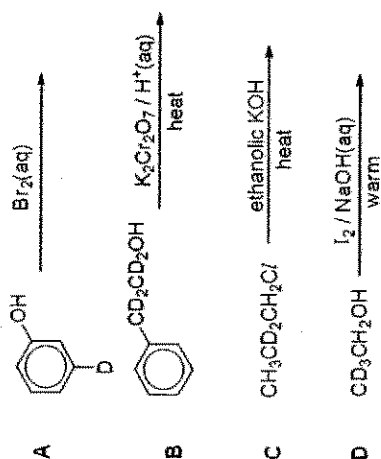
Which of the following statements is **false**? |

- A Propan-2-ol acts as a base in Step 1.
- B HSO_4^- is a catalyst in this reaction.
- C A possible side product of the reaction is $\text{CH}_3\text{CH}(\text{OSO}_3\text{H})\text{CH}_3$.
- D It is more likely for primary alcohols to proceed via this mechanism than tertiary alcohols.

14 Hydroxy Compounds

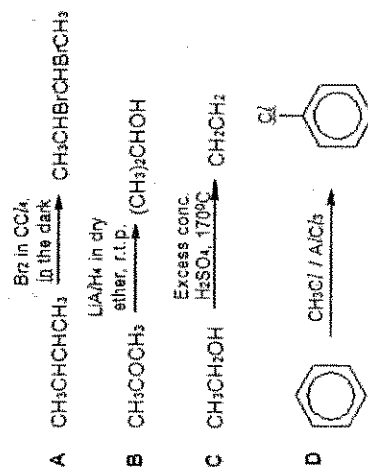
- 11 [RI 2011/I/26]

Which of the following reactions yields an organic compound which has no deuterium incorporated? (Deuterium, $\text{D} = {}^2\text{H}$)



- 12 [SRJC 2011/I/21]

In which of the following reactions is the reactive carbon sp^3 hybridised in the reactant and sp^2 hybridised in the product?



13 [RI 2009/I/27]

One industrial preparation of ethanoic acid is the direct carbonylation of methanol, using a rhodium catalyst.



Which compound could be expected to produce $\text{HO}_2\text{CCH}(\text{CH}_2\text{CO}_2\text{H})_2$ by this method?

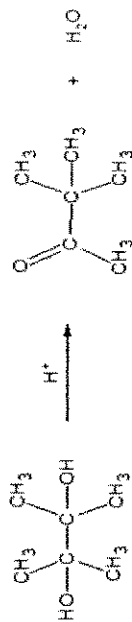
- A $\text{HOCH}_2\text{CH}(\text{OH})\text{CO}_2\text{H}$ B $\text{HOCH}_2\text{CH}(\text{CH}_2\text{CO}_2\text{H})_2$
 C $\text{HO}_2\text{CCH}(\text{OH})\text{CH}_2\text{CO}_2\text{H}$ D $\text{HOCH}_2\text{CH}(\text{OH})\text{CH}_2\text{CO}_2\text{H}$

14 [Modified RI 2009/I/28]

Which of the following shows the given ions arranged in the order of increasing $\text{p}K_a$ values?

- A 2-chloroethoxide ion, ethoxide ion, 4-nitrophenoxide ion, phenoxide ion
 B ethoxide ion, 2-chloroethoxide ion, phenoxide ion, 4-nitrophenoxide ion
 C phenoxide ion, 4-nitrophenoxide ion, ethoxide ion, 2-chloroethoxide ion
 D 4-nitrophenoxide ion, phenoxide ion, 2-chloroethoxide ion, ethoxide ion

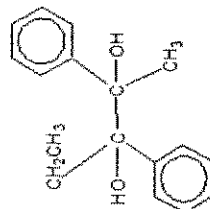
15 The pinacol rearrangement involves the reaction of a diol in acidic conditions to form a carbonyl compound as shown below.



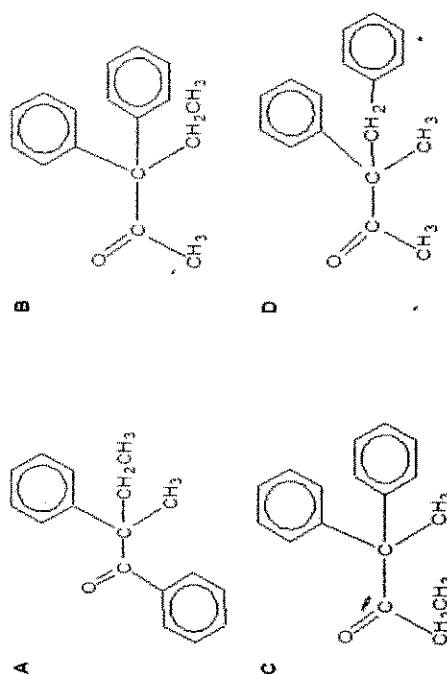
2, 3-dimethylbutane-2,3-diol

3, 3-dimethylbutan-2-one

Which of the following structural formulae is **not** a product of the pinacol rearrangement of 2,3-diphenylpentane-2,3-diol with the structure as shown below?



2,3-diphenylpentane-2,3-diol



14 Hydroxy Compounds

16 [NYJC 2011//39]

Which of the following reagents will have different reactions with the two alcohols, $(\text{CH}_3)_3\text{CCH}_2\text{OH}$ and $(\text{CH}_3)_2\text{CHCH}_2\text{CH}_2\text{OH}$?

- | | |
|--|----------------|
| 1 concentrated sulfuric acid | |
| 2 phosphorus pentachloride | |
| 3 acidified aqueous potassium manganate(VII) | |
| A 1, 2 and 3 only | B 1 and 2 only |
| C 2 and 3 only | D 1 only |

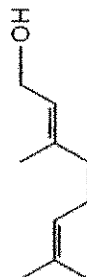
17 [SAJC 2011//38]

Which of the following pairs will give the same organic product when treated with hot acidified KMnO_4 ?

- | | |
|---|----------------|
| 1 $(\text{COOH})_2$ and $\text{CH}_2=\text{CH}_2$ | |
| 2 $\text{CH}_3\text{CH}=\text{CHCH}_3$ and $\text{CH}_3\text{CH}_2\text{OH}$ | |
| 3 $\text{C}_6\text{H}_5\text{CH}_2\text{CH}_2\text{OH}$ and $\text{C}_6\text{H}_5\text{CH}=\text{CH}_2$ | |
| A 1, 2 and 3 only | B 1 and 2 only |
| C 2 and 3 only | D 1 only |

18 [NYJC 2011//36]

Geraniol is one of several compounds produced by the scent glands of honey bees to help them mark nectar-bearing flowers and locate the entrances to their hives.



geraniol

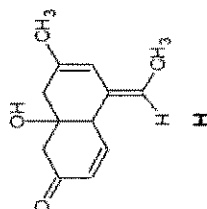
Which statements are true for geraniol?

- | | |
|--|----------------|
| 1 The molecule reacts with hot alkaline KMnO_4 to give 3 organic fragments. | |
| 2 The molecule has 4 sp^2 carbons and 6 sp^3 carbons. | |
| 3 There are 2 pi bonds and 10 sigma bonds in each molecule of geraniol. | |
| A 1, 2 and 3 only | B 1 and 2 only |
| C 2 and 3 only | D 1 only |

14 Hydroxy Compounds

19 [PJC 2011//39]

Which of the following statements are correct about compound H shown below?

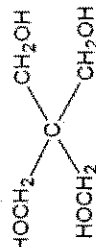


- | | |
|--|--|
| 1. 1 mol of H reacts with 4 mg of hydrogen in presence of platinum catalyst. | |
| 2. 1 mol of H reacts with 1 mol of sodium to form 1 mol of hydrogen gas. | |
| 3. 1 mol of H reacts with 1 mol of sodium hydroxide. | |

- | | |
|-------------------|----------------|
| A 1, 2 and 3 only | B 1 and 2 only |
| C 2 and 3 only | D 1 only |

20 [NYJC 2011//38]

Pentaerythritol is an intermediate in the manufacture of paint.



Which of the following statements about pentaerythritol are correct?

- | | |
|--|----------------|
| 1 It reacts with sodium. | |
| 2 It is dehydrated by concentrated sulfuric acid to an alkene. | |
| 3 Its empirical formula is CH_3O . | |
| A 1, 2 and 3 only | B 1 and 2 only |
| C 2 and 3 only | D 1 only |

21 [DHS 2011//38]

In the presence of concentrated acids, alcohols can act as a base. Which of the following ions can be found in a mixture of ethanol and excess concentrated sulfuric acid?

- | | | |
|--------------------------------------|---|--------------------|
| 1 $\text{CH}_3\text{CH}_2\text{O}^-$ | 2 $\text{CH}_3\text{CH}_2\text{OH}_2^+$ | 3 HSO_4^- |
| A 1, 2 and 3 only | B 1 and 2 only | |
| C 2 and 3 only | D 1 only | |

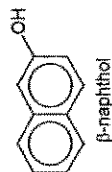
22 [ACJC 2016//24]

The main reason that phenol is a better Brønsted acid than cyclohexanol is

- A that it is a better proton donor.
- B the cyclohexyl group is an electron donating group by induction, which destabilises the anion formed during the dissociation.
- C phenol is able to stabilise the anion formed during the dissociation by resonance, where the electrons are delocalised in the phenyl ring.
- D the phenyl group is an electron withdrawing group by induction, which stabilises the anion formed during the dissociation.

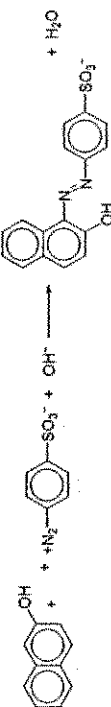
23 [HCl 2016//21]

β -naphthol is a crystalline solid that is widely used in the production of dyes.



Which of the following is likely to be a property of β -naphthol?

- A Its pK_a is lower than that of phenol.
- B It gives white fumes with SOCl₂.
- C It reacts with carboxylic acid to form ester.
- D It undergoes nucleophilic substitution in the reaction below.



24 [JJC 2016//26]

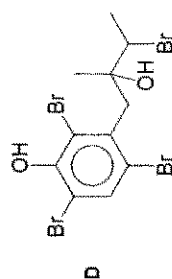
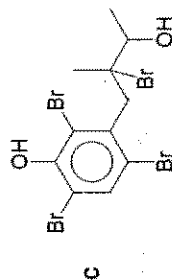
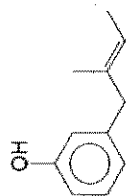
Which of the following reagents is able to convert compound **Q** to compound **R**?



- A PBr₃
- B HBr
- C SOBr₂
- D NaBr

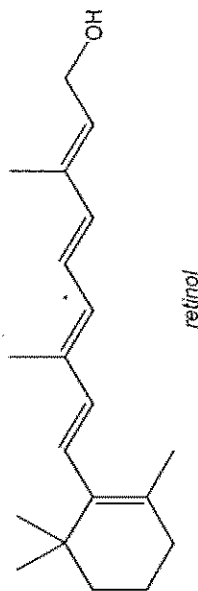
25 [MI 2016//23]

What is the major organic product formed when excess aqueous bromine is added to the following compound?



26 [MJC 2016//29]

The rod cells at the back of the eye contain a primary alcohol called *retinol* which is responsible for their sensitivity to light. *Retinol* is oxidised by an enzyme-catalysed reaction that keeps the double bonds intact, to *retinal*, an aldehyde.



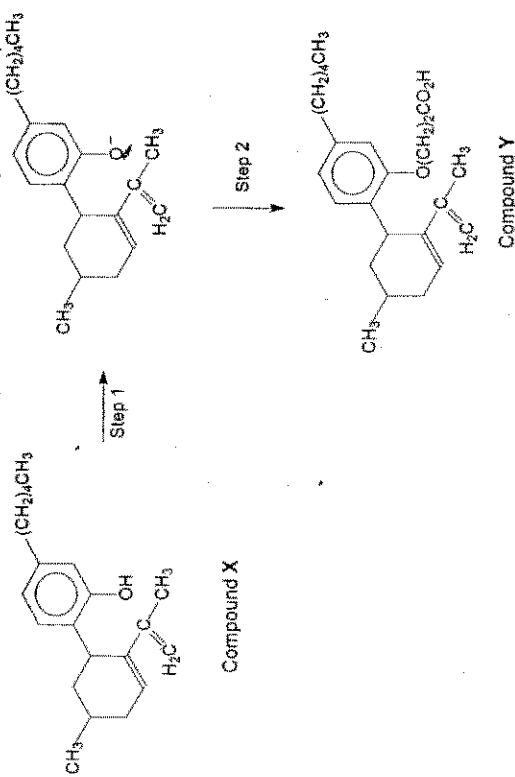
Which of the following is correct?

- A The number of stereoisomers in *retinol* is 32.
- B There are six σ bonds formed by $2sp^2$ - $2sp^3$ overlap in a molecule of *retinol*.
- C In laboratory preparations, *retinol* can be formed from heating *retinal* under reflux with hot potassium dichromate(VI).

- D One mole of *retinol* reacts with 4 moles of hydrogen gas in the presence of palladium catalyst.

27 [NJC 2016//25]

Compound Y can be prepared from compound X in the following reaction sequence.

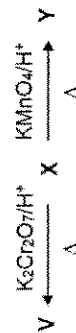


Which reagents can be used to prepare compound Y?

- | | Step I | Step II |
|---|--------------------------|--|
| A | Na | $\text{CH}_2(\text{OH})(\text{CH}_2)_2\text{CO}_2\text{H}$ |
| B | NaOH | $\text{CH}_2\text{Cl}/\text{CH}_2\text{CO}_2\text{H}$ |
| C | NaOH | $\text{CH}_2\text{Cl}/\text{CH}_2\text{CH}_2\text{CO}_2\text{H}$ |
| D | Na_2CO_3 | $\text{CH}_2(\text{OH})\text{CH}_2\text{CO}_2\text{H}$ |

28 [NYJC 2016//24]

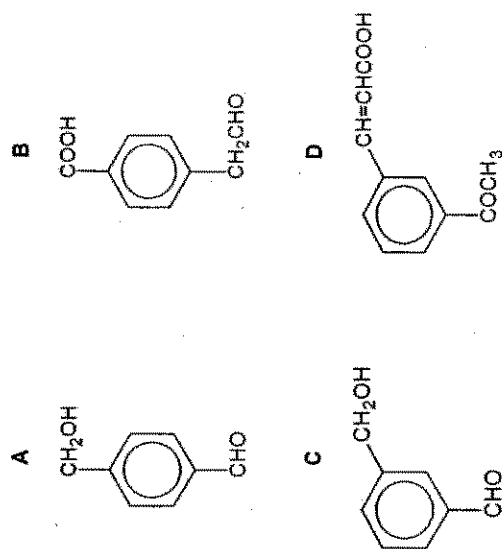
Compound X is used to synthesize DEET, a common active ingredient in mosquito repellent. A brick-red precipitate is observed when it reacts with Fehling's reagent. 1 mol of X undergoes the following reactions.



27

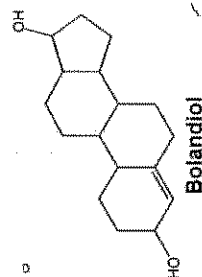
Y reacts with HNO_3 under suitable conditions to produce only 1 possible organic product. V reacts with Na_2CO_3 to produce only 1 mol of $\text{CO}_2(\text{g})$.

What could X be?



29 [SAJC 2016//28]

Bolandiol is a banned synthetic anabolic steroid.



Which of the following statements is not true?

- A Bolandiol has 27 stereoisomers when reacted with liquid bromine.
- B Passing hot aluminium oxide over bolandiol produces a compound with three double bonds.

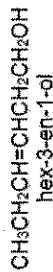
28

- C Orange potassium dichromate (VI) turns green when Bolandiol is heated with it.
- D Bolandiol produces one mole of hydrogen gas when reacted with sodium metal.

30

[TJC 2016//22]

The compound hex-3-en-1-ol has a strong 'leafy' smell of newly cut grass and is used in perfumery.



What are the organic products when hex-3-en-1-ol is treated with hot acidic $\text{K}_2\text{Cr}_2\text{O}_7$, followed by hydrogen gas in the presence of platinum?

- A $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$
- B $\text{CH}_3\text{CH}_2\text{CO}_2\text{H}$ and $\text{HO}_2\text{CCH}_2\text{CO}_2\text{H}$
- C $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$ and $\text{HOCH}_2\text{CH}_2\text{CH}_2\text{OH}$
- D $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CO}_2\text{H}$

31

[TJC 2016//23]

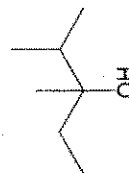
Which of the follow reaction produces an organic species that contains deuterium atom?

- A $\text{CH}_3\text{CH}_2\text{Br} \xrightarrow[\text{heat}]{\text{NaOD(aq)}}$
- B $\text{CH}_3\text{CH}_2\text{OH} \xrightarrow[\text{heat}]{\text{MnO}_4^-, \text{NaOD(aq)}}$
- C $\text{CH}_3\text{CH}_2\text{OH} \xrightarrow[\text{heat}]{\text{conc D}_2\text{SO}_4}$
- D $\text{CH}_3\text{CO}_2\text{H} + \text{CH}_3\text{OH} \xrightarrow[\text{heat}]{\text{conc D}_2\text{SO}_4}$

32.

[YJC 2016//20]

The structure of compound Z is as seen below:



29

Compound Z

It is completely reacted with hot concentrated H_2SO_4 to form compound Y. What is the total number of isomers of Y?

- A 2 B 3 C 4 D 5

51. HYDROXY COMPOUNDS SUGGESTED SOLUTIONS

Multiple Choice Questions (Section A)

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.
A	C	A	A	B	A	D	B	A	D	D	C	D	B	D

16.	17.	18.	19.	20.	21.	22.	23.	24.	25.	26.	27.	28.	29.	30.
D	A	B	D	D	C	C	A	B	D	B	B	B	A	D

31.	32.
A	C

Structured/Free Response Questions

- 1 (i) Test: Add $\text{Br}_2(\text{aq})$ to both samples separately.

Observations:

Salbutamol: Brown Br_2 decolourises.

Ephedrine: Brown Br_2 remains.

OR

Test: Add neutral $\text{FeCl}_3(\text{aq})$ to both samples separately.

Observations:

Salbutamol: Violet colouration observed.

Ephedrine: No violet colouration.

- (ii) Salbutamol has a lower melting point than compound G.

Both compounds have simple molecular structures with hydrogen bonds between their respective molecules.

However, for Salbutamol, it is possible to form intramolecular hydrogen bonds between the phenol group and the primary alcohol group.

Thus, less energy is required to overcome the less extensive intermolecular hydrogen bonds between salbutamol molecules as compared to that in G.

30

Step	reagents, conditions and observations	molecule
1	Reagent and conditions: $K_2Cr_2O_7(aq)$, $H_2SO_4(aq)$, Heat under reflux Observation: Orange solution turns green	G
2	Reagent and conditions: 2,4-dinitrophenylhydrazine, warm Observation: Orange ppt formed	H
3	Reagent and conditions: PCl_5 Observation: White fumes produced.	F
4	Reagent and conditions: Aqueous bromine / bromine in CCl_4 in the dark / Neutral $FeCl_3$ Observation: Decolourisation of brown aqueous bromine and white ppt formed / Decolourisation of brown bromine in CCl_4 and white ppt formed / Formation of purple complex	E

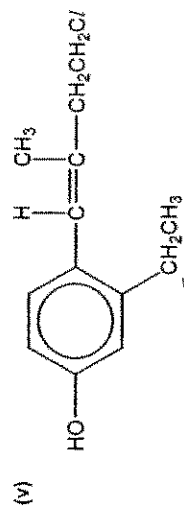
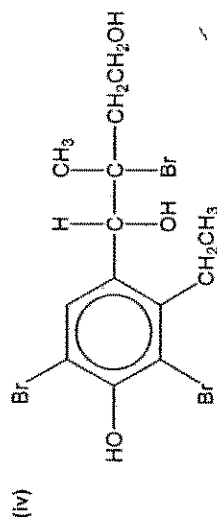
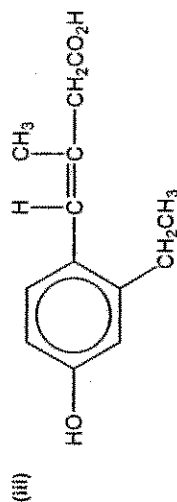
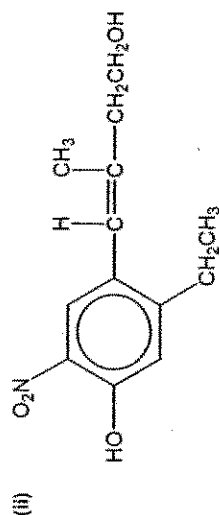
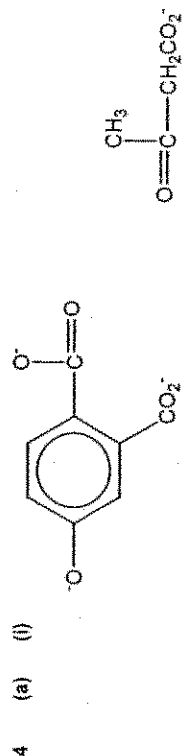
- 3 (i) 1. The presence of the bulky hydrophobic benzene ring interferes with the formation of hydrogen bonding between the compounds and water. Hence the compounds are likely to be insoluble in water.
2. The p orbital of chlorine atom overlaps with the π electron cloud of the benzene ring, giving rise to the partial double bond character of the C-Cl bond. This makes halogenoarenes less susceptible to nucleophilic substitutions. Hence the compounds cannot be easily hydrolysed by water.

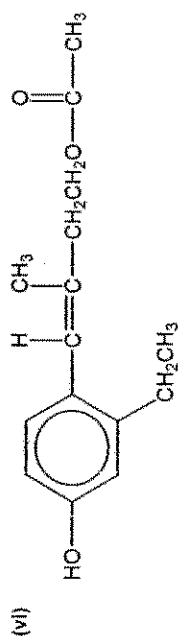
As such they are difficult to remove by natural processes in the environment.

- (ii) There are more electron-withdrawing -Cl groups attached to the benzene ring in 2,4-dichlorophenol.

This disperses the negative charge on the oxygen atom of the phenoxide ion more, thus, further stabilising the phenoxide ion from 2,4-dichlorophenol with respect to that from *chloroxylenol*.

Therefore, 2,4-dichlorophenol is a stronger acid than *chloroxylenol*.

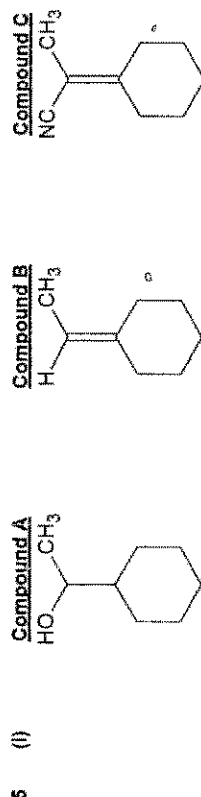




- (b) The presence of the bulky hydrophobic group in compound **A** prevents it from dissolving well in water despite being able to form some hydrogen bonds with water.

(Note: Energy evolved from formation of solute – solvent interactions is insufficient to compensate for the energy required to overcome the solute – solute interactions and solvent – solvent interactions.)

In the presence of sodium hydroxide, compound **A** reacts to form a sodium salt which dissociates completely. Strong ion-dipole interactions between water molecules and the oppositely charged ions allow compound **A** to dissolve in sodium hydroxide.

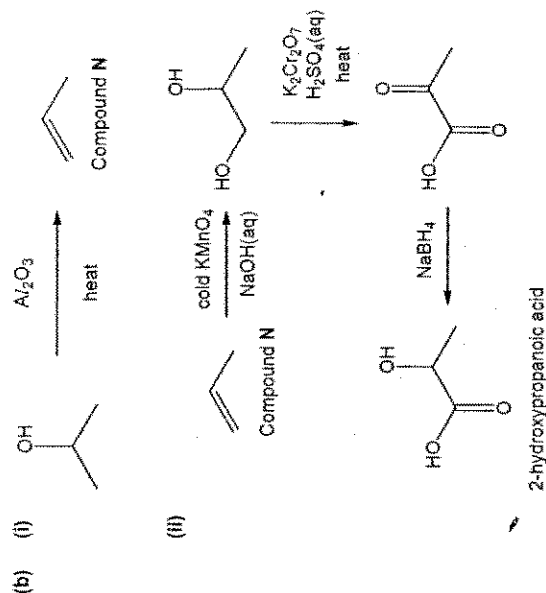


- (ii)
- | | | | | |
|--|-------------------------------------|--|---------------------------------------|------------------------------------|
| <p>Step I
Nucleophilic
Substitution</p> | <p>Step II
Oxidation</p> | <p>Step III
Nucleophilic
Addition</p> | <p>Step IV
Elimination</p> | <p>Step V
Reduction</p> |
|--|-------------------------------------|--|---------------------------------------|------------------------------------|

- (iii)
- | | | | |
|--|--|--|---|
| <p>Step I
NaOH(aq), Heat under reflux</p> | <p>Step II
K₂Cr₂O₇(aq), H₂SO₄(aq), Heat under reflux</p> | <p>Step IV
Excess concentrated H₂SO₄, 170°C</p> | <p>Step V
LiAlH₄ in dry ether</p> |
|--|--|--|---|

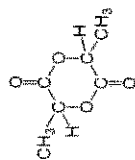
- 6 (a) (i) The intermolecular hydrogen bonding between alcohol molecules is stronger than the instantaneous-dipole induced-dipole forces of attraction between alkane molecules.
Hence greater amount of energy is required to overcome the hydrogen bonds in alcohols.

- (ii) I methanol or ethanol
II if methanol (ethanol) had been present in the mixture it would have condensed as the first fraction at 65 °C (78 °C);
Or
The boiling temperature of methanol (ethanol) is below 97 °C. Hence the methanol (ethanol) could have boiled off before the first fraction is collected.
III Flammability of alcohol vapours or risk of fire or explosion

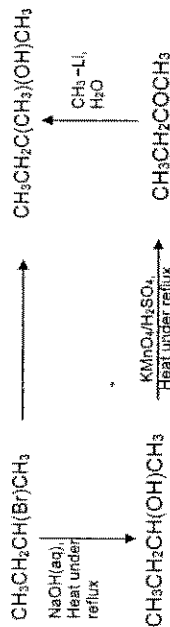


LiAlH₄ not accepted for last step as it will reduce –COOH too.

(c)

Compound **D** is**D** does not contain —OH nor —COOH since it does not react with sodium.It is a diester formed when —OH and —COOH groups of one lactic acid molecule reacts with the —COOH and —OH groups respectively of another lactic acid molecule.

7

1st step: NaOH(aq). Heat under reflux2nd step: H₂SO₄(aq), KMnO₄(aq), Heat under reflux3rd step: CH₃—Li (and H₂O)

8

Evidence	Deduction
When A is treated with hot aqueous acidified KMnO ₄ , benzoic acid is formed.	Side-chain oxidation occurred. A has only 1 <u>alkyl side-chain</u> on the benzene ring.
A reacts with bromine in the presence of uv light, producing 4 isomeric monobromo compounds.	Free radical substitution occurred on the <u>alkyl side-chain</u> in A .
Upon heating with alcoholic NaOH, both B and C gave the same products, D and E , which are geometric isomers.	<u>Elimination</u> occurred. D and E contain <u>C=C</u> .
Heating B with NaOH(aq) gives F which does not react with acidified K ₂ Cr ₂ O ₇ .	<u>Nucleophilic substitution</u> occurred. F is an <u>alcohol</u> .
	F does not undergo oxidation. F is a <u>tertiary alcohol</u> .

A:	B:	C:
D and E		F:

9

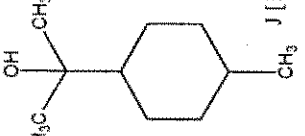
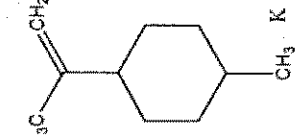
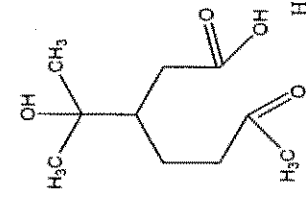
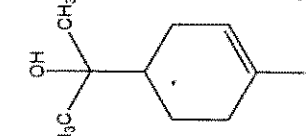
Evidence	Deduction
L rotates plane-polarised light.	L exhibits optical isomerism and contains at least 1 <u>chiral carbon</u> .
No reaction occurs between L and 2,4-dinitrophenylhydrazine.	No <u>condensation</u> reaction occurred. No <u>aldehyde</u> or <u>ketone</u> functional group in L .
L produces M , C ₁₀ H ₂₀ O	<u>Reduction</u> occurred. L is <u>unsaturated</u> . Addition of 4 H atoms indicate presence of 2 <u>C=C</u> bonds.
No change is observed when L is heated with acidified potassium dichromate(VI).	L does not undergo <u>oxidation</u> . L contains a <u>3° alcohol</u> group.
Heating L with aluminium oxide forms N as major product.	L contains <u>alcohol</u> that undergoes <u>elimination</u> . N contains an additional <u>C=C</u> bond upon elimination.
N reacts with hot concentrated acidified KMnO ₄ to produce propanone, P and a gas which gives a white precipitate with limewater.	<u>Oxidative cleavage</u> of all three <u>C=C</u> occurred. Gas evolved is <u>CO₂</u> . The white ppt formed is <u>CaCO₃</u> . Presence of 2 <u>terminal C=C</u> bond due to 2 moles of <u>CO₂</u> produced during oxidative cleavage. (loss of 2 C from N to propanone & P).
P can also be produced by oxidation of the given compound with concentrated acidified KMnO ₄ and heating.	 P is

<p>L:</p> $\begin{array}{c} \text{CH}_3 \\ \\ \text{CH}_3-\text{C}-\text{OH} \\ \\ \text{CH}_2=\text{CH}-\text{CH}_2-\text{CH}_2-\text{CH}=\text{CH}_2 \end{array} \quad \text{or} \quad \begin{array}{c} \text{CH}_3 \\ \\ \text{CH}_3-\text{C}-\text{H} \\ \\ \text{CH}_2=\text{CH}-\text{C}-\text{CH}_2-\text{CH}_2-\text{CH}=\text{CH}_2 \\ \\ \text{OH} \end{array}$ <p>(Note: The 2 structures below are not accepted as they will not lead to formation of the correct structure for N)</p> $\begin{array}{c} \text{CH}_3 \quad \text{CH}_3 \\ \quad \\ \text{C}=\text{CH}-\text{C}-\text{CH}_2-\text{CH}_2-\text{CH}=\text{CH}_2 \\ \quad \\ \text{CH}_3 \quad \text{OH} \end{array} \quad \text{or} \quad \begin{array}{c} \text{CH}_3 \\ \\ \text{C}=\text{CH}-\text{CH}_2-\text{CH}_2-\text{C}-\text{CH}=\text{CH}_2 \\ \quad \\ \text{CH}_3 \quad \text{OH} \end{array}$	
<p>M:</p> $\begin{array}{c} \text{CH}_3 \\ \\ \text{CH}_3-\text{C}-\text{CH} \\ \\ \text{CH}_3-\text{CH}_2-\text{CH}-\text{CH}_2-\text{CH}_2-\text{CH}_3 \end{array} \quad \text{or} \quad \begin{array}{c} \text{CH}_3 \\ \\ \text{CH}_3-\text{C}-\text{H} \\ \\ \text{CH}_3-\text{CH}_2-\text{C}-\text{CH}_2-\text{CH}_2-\text{CH}_3 \\ \\ \text{OH} \end{array}$	
<p>N:</p> $\text{CH}_2=\text{CH}-\text{C}(\text{CH}_3)_2-\text{CH}_2-\text{CH}_2-\text{CH}=\text{CH}_2$	

10

Evidence	Deduction
α -Terpineol has an alcohol group which is not readily oxidised.	α -Terpineol has a <u>tertiary alcohol</u> .
Heating α -Terpineol with concentrated acidified KMnO_4 gives H.	Oxidative cleavage occurred. <u>C=C</u> is broken.
H gives yellow ppt when warmed with alkaline $\text{I}_2(\text{aq})$	H contains $-\text{CH}_2\text{CO}_2$. H undergoes <u>mild oxidation</u> with alkaline aqueous iodine to give CHI_3 , a yellow ppt.
On hydrogenation, α -Terpineol gives J	Reduction occurred. α -Terpineol is unsaturated. Additional of 2 H atoms indicate presence of <u>1 C=C bond</u> . (recall: α -Terpineol has a cyclohexene ring)

37

J reacts with a few drops of conc H_2SO_4 to give K.	J contains <u>alcohol</u> that undergoes elimination. K contains an additional <u>C=C bond</u> upon elimination.
K is oxidised to give M	Oxidative cleavage occurred. <u>C=C</u> is broken. Presence of <u>terminal C=C bond</u> due to one mole of CO_2 produced during oxidative cleavage. (loss of 1 C from K to M).
 <p>J [1]</p>	 <p>K [1]</p>
 <p>H [1]</p>	 <p>α-Terpineol [1]</p>

11 [NYJC 2015/III/1(a)]

- (a) (i) The base added will deprotonate the alcohol to form the alkoxide ion which is a stronger nucleophile. [1] The negatively charged alkoxide ion can better attack the electron-deficient carbon in MOMCl , substituting the halogen atom to form

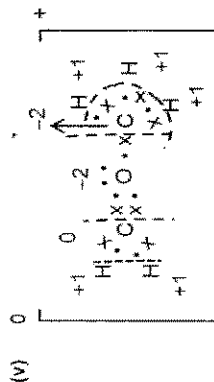
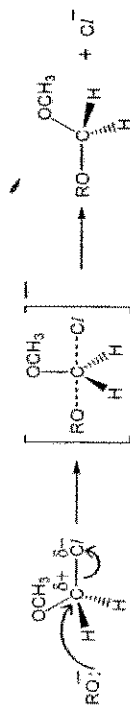
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MOM.

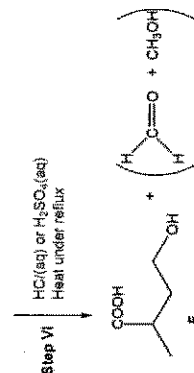
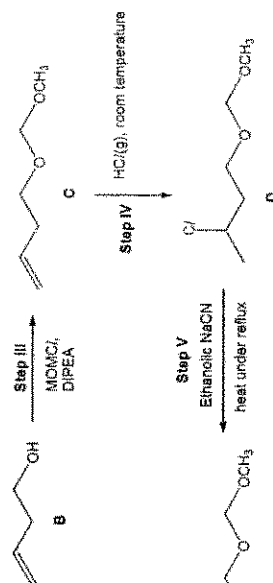
(ii) Less bulky organic bases are not preferred as they may act as nucleophiles and attack MOMCl instead. [1] The lone pair of electrons on primary amines are more accessible as it contains less bulky alkyl groups hence they are stronger nucleophiles.

(iii) Alkalis are not preferred as aliphatic alcohols are not acidic enough to be deprotonated by alkalis. [1] The electron donating alkyl group of ROH will increase the electron density on the O atom of its conjugate base, making it more negative, therefore destabilising it. Hence, ROH is weakly acidic.

(iv) Type of reaction: Nucleophilic Substitution (S_N2) [1]

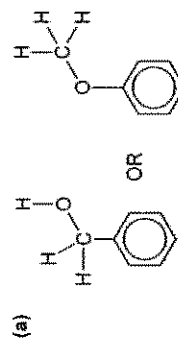


(vi)



(vii) Step IV: Electrophilic addition [1]
Step V: Nucleophilic substitution [1]
Step VI: Acidic hydrolysis [1]

12 [CJC 2016/III/5(a)]



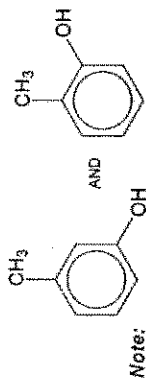
To separate test tube containing each sample, add neutral FeCl_3 . Violet colouration will be formed with *p*-cresol whereas no violet colouration for its isomer. OR

To separate test tube containing each sample, add aqueous Br_2 . Orange bromine solution decolourise and a white precipitate is formed with *p*-cresol whereas no decolourisation of orange bromine solution with its isomer. [3]

NOT ACCEPTED: PCl_5

14 Hydroxy Compounds

Note: Oxidation using $\text{KMnO}_4/\text{H}_2\text{SO}_4$ is not accepted for *p*-cresol and phenylmethanol since both can undergo side-chain oxidation.



Note:

are not accepted because these are positional isomers of *p*-cresol. Positional isomers have the same carbon chain, but different positions of functional groups. Functional group isomers have different functional groups.

13 [DHS 2016/III/5]

(a) CH_3OH and $\text{CH}_3\text{CH}_2\text{OH}$.

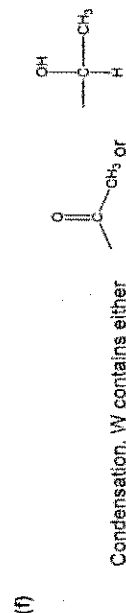
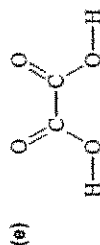
(b) Two epoxide rings.

Two alcoholic groups are produced for every epoxide ring that will be hydrolysed. Since there are four alcoholic groups formed after 'juvenile hormone' undergoes hydrolysis, this implies that there are two epoxide rings in 'juvenile hormone'.

(c) T undergoes basic hydrolysis to give methanol and U. T is likely to contain an ester.

(d) Two tertiary alcohol groups.

T has four alcohol groups which were retained in U even after basic hydrolysis. Since V has only two alcohol groups left after mild oxidation, this implies that the two alcohol group must be tertiary in order to resist oxidation.



Condensation. W contains either

14 Hydroxy Compounds

(g)

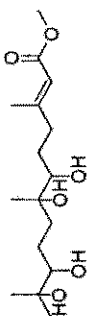


Juvenile hormone

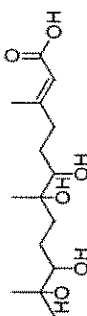
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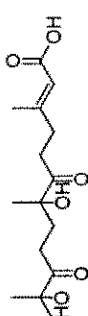
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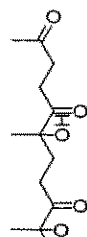
U



V

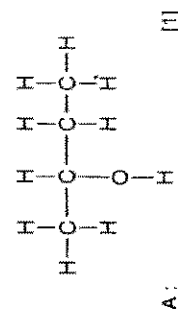


W



14 [HCl 2016/III/3(b)]

(b) (i) Steam, 300°C , 70 atm (or 60 atm), (conc) H_3PO_4 [1]
OR conc H_2SO_4 followed by warming with water.



A: [1]

14 Hydroxy Compounds

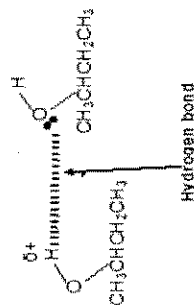
- (ii) Both but-2-ene and alcohol are simple covalent compounds /simple, discrete molecules /have simple molecular structure. [1/2]

For but-2-ene, there are weak dispersion forces between its molecules. For alcohol **A** (butan-2-ol) with polar O-H bond, there are strong intermolecular hydrogen bonding between its molecules. [1/2]

More energy is required to overcome the stronger intermolecular hydrogen bonding in alcohol **A** than the weak dispersion forces in but-2-ene which is therefore in gaseous state. [1/2]

OR
the energy provided by room temperature is insufficient to overcome the strong hydrogen bonds between alcohol **A** molecules,

Hence alcohol **A** exists as a liquid at room temperature and but-2-ene exists as gas. [1/2]

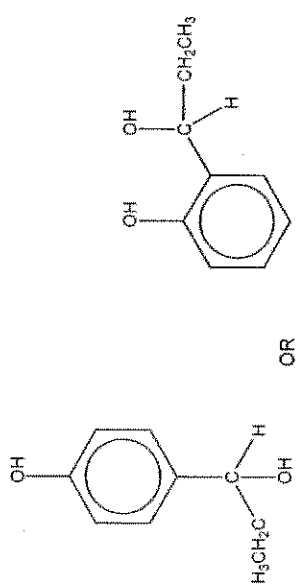


- Diagram [1]
- showing correct hydrogen bond (must be oxygen atom and the H atom from the OH group)
 - labelling hydrogen bond
 - showing lone pair of electrons on oxygen
 - labelling δ^+ and δ^- for the O-H group forming H bond.

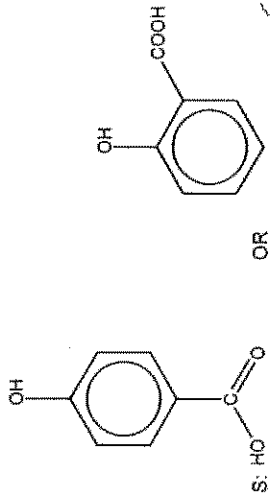
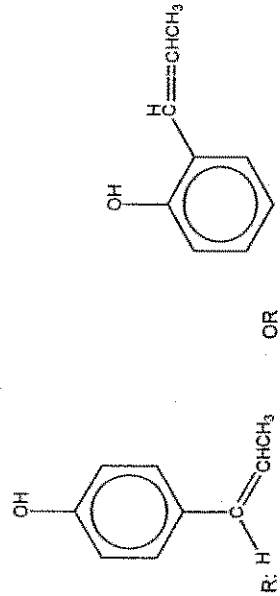
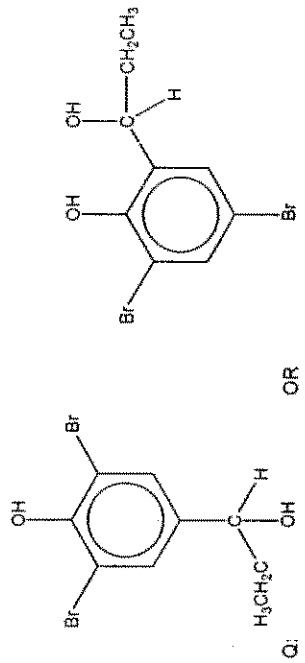
Each mistake minus 1/2 mark

15 [JJC 2016/III/4(e)]

(e)



14 Hydroxy Compounds



1m for each structure

P shows optical activity	P has <u>chiral carbon</u> (N)
P does not react with aqueous potassium carbonate.	No -COOH

- (i) Oxygen is more electronegative than sulfur, thus the electron density around O atom will be greater. The bond-pair electrons will be nearer to the nucleus resulting in more repulsion. Thus the bond angle of C-O-H in phenol will be larger. [1]

- (ii) Thiophenol has a lower pK_a . [1]

The sulfur atom is less electronegative and the lone pair of electrons on the conjugate base is able to delocalise into the benzene ring more readily as compared to phenol, thus stabilising its conjugate base more than the phenoxide ion. [2]

- 19 [TPJC 2016/III/2(a)(iv)]

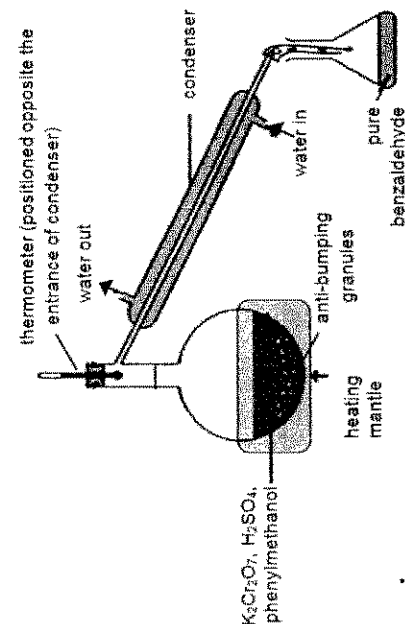


This method has the advantage of forming only gaseous side-products which are easily removed from the system.

- 20 [VJC 2016/III/2(a)(ii)]

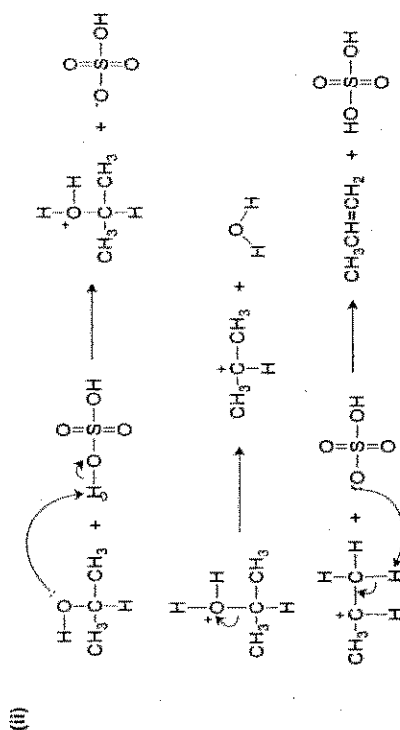
- (a) (i) I: Hl(g) , room temperature (ignore state symbol unless it's given as aqueous state)
 II: NaOH(aq) , heat
 III: $\text{K}_2\text{Cr}_2\text{O}_7(\text{aq})$, $\text{H}_2\text{SO}_4(\text{aq})$, heat

- 21 [VJC 2016/III/5(c)]



- 22 [MI 2016/II/4(b)(i)-(iii)]

- (b) (i) Elimination.



- 23 [NYJC 2016/II/5]

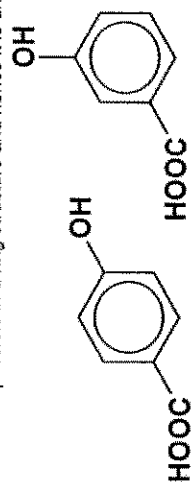
<p>A [1]</p>	<p>B [1]</p>
<p>C [1]</p>	<p>D [1]</p>

14 Hydroxy Compounds

$\begin{array}{c} \text{CH}_3 \\ \\ \text{O}=\text{C}-\text{CH}_3 \end{array} \quad [1]$	$\text{CHI}_3 \quad [1]$
E	F

24 [SAJC 2016/III/7(b)]

- (b) The product formed is unstable as there is ring strain. Or sp hybridized C should have linear shape but this is not possible in a ring structure and hence it is unstable.



[2]

25 [VJC 2016/III/6(b)(i)-(ii)]

- (b) (i) Step I: KMnO_4 , NaOH(aq) , cold

Step II: I_2 , NaOH(aq) , warm

Crotyl alcohol gives yellow ppt.

Allyl alcohol does not give yellow ppt.

- (ii) It is a disproportionation reaction where the $\text{C}=\text{C}$ bond is reduced and the primary alcohol is oxidised.