

Alcohol

(Past Year Topical Questions 2010-2015)

Oct/Nov 2010 (23)/Q3

Two derivatives of ethene which have been detected in dust clouds in Space are acrylonitrile (2-propenenitrile), $\text{CH}_2=\text{CHCN}$, and vinyl alcohol (ethenol), $\text{CH}_2=\text{CHOH}$.

Vinyl alcohol cannot be polymerised in the same way as acrylonitrile because it will readily isomerise into another common organic compound, **Z**.

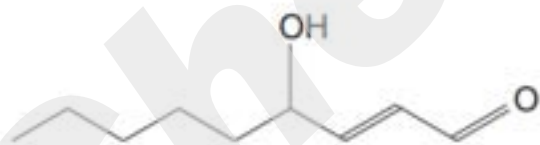
(c) (i) Suggest the structural formula of the organic compound **Z**.

(ii) Suggest the structural formula of another isomer of vinyl alcohol which has a cyclic (ring) structure.

[2]

May/June 2011 (23)

4 The compound *trans*-4-hydroxy-2-nonenal (HNE) is thought to lead to infections of the lung when cigarettes are smoked.



trans-4-hydroxy-2-nonenal

HNE is a reactive compound.

(c) Give the structural formulae of all of the carbon-containing compounds formed in each case when HNE is reacted separately with the following reagents.

(i) hot concentrated manganate(VII) ions in acid solution

(ii) hot phosphorus trichloride, PCl_3

(iii) sodium tetrahydridoborate(III), NaBH_4

[4]

A sample of 2-ethyl-3-methylbutanoic acid may be prepared in a school or college laboratory by the oxidation of 2-ethyl-3-methylbutan-1-ol, $(\text{CH}_3)_2\text{CHCH}(\text{C}_2\text{H}_5)\text{CH}_2\text{OH}$.

- (b) (i) State the reagent(s) that would be used for this oxidation.
Describe what colour change would be seen.

reagent(s)

colour change from to

This reaction is carried out by heating the reacting chemicals together.

- (ii) What could be the main organic impurity present in the sample of the acid?

Explain your answer.

.....
.....
.....

- (iii) State whether a distillation apparatus or a reflux apparatus should be used.

Explain your answer.

.....
.....
.....

[6]

- (c) A structural isomer of 2-ethyl-3-methylbutan-1-ol is 2-ethyl-3-methylbutan-2-ol, $(\text{CH}_3)_2\text{CHC}(\text{OH})(\text{C}_2\text{H}_5)\text{CH}_3$.

What colour change would be seen if this were heated with the reagents you have given in (b)(i)?

Explain your answer as clearly as you can.

.....
.....
..... [3]

Oct/Nov 2011 (21)

- 5 Astronomers using modern telescopes of various types have found many molecules in the dust clouds in space. Many of these molecules are those of organic compounds and astronomers constantly look for evidence that amino acids such as aminoethanoic acid, $\text{H}_2\text{NCH}_2\text{CO}_2\text{H}$, are present.

One molecule that has been found in the dust clouds is hydroxyethanal, HOCH_2CHO .

- (b) Give the **skeletal** formulae of the organic compounds formed when hydroxyethanal is reacted separately with the following.



[2]

In a school or college laboratory, it is possible to convert a sample of hydroxyethanal into aminoethanoic acid in a three-step process.



By considering the possible reactions of the functional groups present in hydroxyethanal, you are to deduce a possible route for this conversion.

- (c) (i) In the boxes below, draw the structural formulae of your suggested intermediates **X** and **Y**.

X	Y
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- (ii) State the reagents for each of the three steps you have chosen.

step 1.....

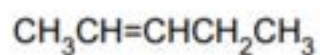
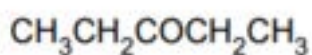
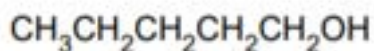
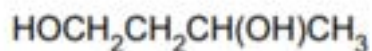
step 2.....

step 3.....

[5]

Oct/Nov 2011 (23)

4 The structural formulae of six different compounds, **P – U**, are given below.

**P****Q****R****S****T****U**

(c) Compound **S** can be converted into compound **R**.

(i) What type of reaction is this?

.....

(ii) What reagent would you use for this reaction?

.....

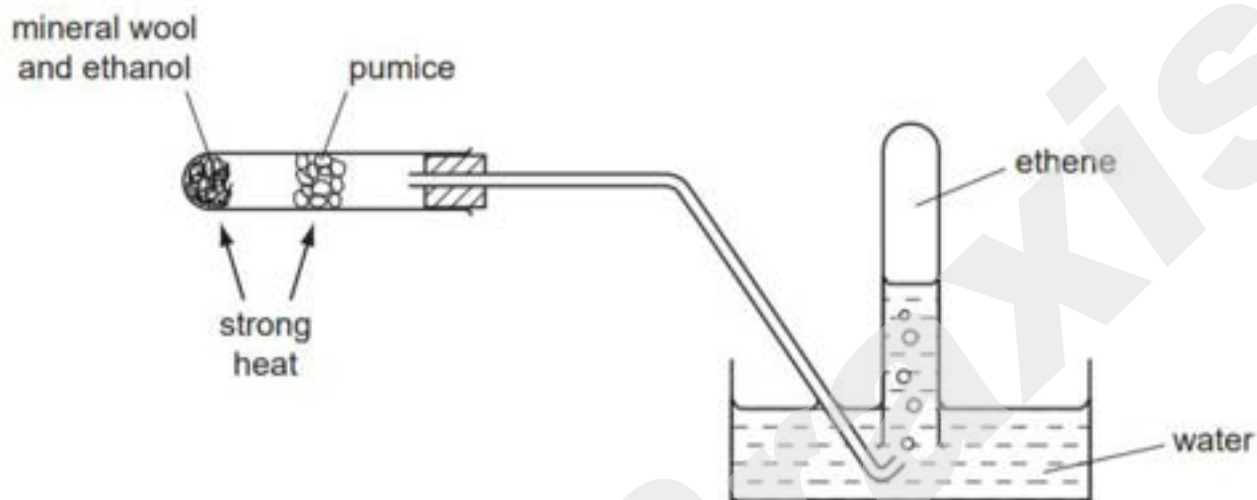
(iii) Write the structural formula of the compound formed when **T** undergoes the same reaction using an excess of the reagent you have used in (c)(ii).

.....

[3]

May/June 2012 (21)

- 4 One method of preparing ethene in a school or college laboratory is from ethanol by using the apparatus shown below.



- (a) (i) Write a balanced equation for this reaction.

.....

- (ii) What *type of reaction* is this?

.....

- (iii) Give the chemical name of a reagent other than pumice that could be used to carry out this reaction. It is not necessary to use the same apparatus.

.....

[3]

- 5 Organic compounds which contain oxygen may contain alcohol, aldehyde, carboxylic acid, ester or ketone functional groups. The functional groups may be identified by their reactions with specific reagents.

Compound **X** has the empirical formula CH_2O and M_r of 90.

- (a) There is no reaction when **X** is treated with NaHCO_3 .

What functional group does this test show to be **not** present in **X**?

.....

[1]

- (b) When 0.600 g of **X** is reacted with an excess of Na, 160 cm^3 of H_2 , measured at room temperature and pressure, is produced.

- (i) What functional group does this reaction show to be present in **X**?

.....

- (ii) Use the data to calculate the amount, in moles, of hydrogen **atoms** produced from 0.600 g of **X**.

- (iii) Hence, show that each molecule of **X** contains **two** of the functional groups you have given in (i).

[4]

- (c) When **X** is warmed with Fehling's reagent, a brick red precipitate is formed.
Treatment of **X** with 2,4-dinitrophenylhydrazine reagent produces an orange solid.
- (i) What functional group do these reactions show to be present in **X**?
Draw the displayed formula of this functional group.
- (ii) Use your answers to (b)(i), (b)(ii) and (c)(i) to deduce the structural formula of **X**.
- (iii) What is the structural formula of the organic product of the reaction of **X** with Fehling's reagent?

[3]

(d) Compound X can be both oxidised and reduced.

(i) Give the structural formula of the compound formed when X is reacted with NaBH_4 under suitable conditions.

(ii) Give the structural formula of the compound formed when X is heated under reflux with acidified $\text{K}_2\text{Cr}_2\text{O}_7$.

[2]

May/June 2012 (22)

4 Oxygen-containing organic compounds may contain a number of different functional groups including alcohol, aldehyde, carboxylic acid, ester or ketone functional groups. These functional groups may be identified by their reactions with specific reagents.

(a) On treating compounds containing each of these functional groups with the reagents below, only five reactions occur. Complete the table by placing a tick (\checkmark) in each box where you believe a reaction will occur. You should place **no more** than five ticks in the table.

reagent	alcohol R_2CHOH	aldehyde RCHO	carboxylic acid RCO_2H	ester $\text{RCO}_2\text{R}'$	ketone RCOR'
NaHCO_3					
Na					
$\text{Cr}_2\text{O}_7^{2-}/\text{H}^+$					

[5]

Compound **G** has the empirical formula CH_2O and M_r of 90.

An aqueous solution of **G** is neutral. There is no reaction when **G** is treated with NaHCO_3 .

When 0.30 g of pure **G** is reacted with an excess of Na, 80 cm^3 of H_2 , measured at room temperature and pressure, is produced.

(b) (i) What functional group do these two reactions show to be present in **G**?

.....

(ii) Use the data to calculate the amount, in moles, of hydrogen atoms produced from 0.30 g of **G**.

(iii) Hence, show that each molecule of **G** contains **two** of the functional groups you have given in (i).

[4]

(d) Compound **G** can be both oxidised and reduced.

(i) When **G** is heated under reflux with acidified $K_2Cr_2O_7$, compound **H** is formed.
Give the structural formula of compound **H**.

(ii) When **G** is reacted with $NaBH_4$ under suitable conditions, compound **J** is formed.
Give the structural formula of compound **J**.

[2]

May/June 2012 (23)

- 5 Many naturally occurring organic compounds contain oxygen. Such compounds may contain alcohol, aldehyde, carboxylic acid, ester or ketone functional groups. These functional groups may be identified by their reactions with specific reagents.

Compound **F** is a white solid which has the molecular formula $C_3H_6O_3$.

Compound **F** is soluble in water. Addition of $NaHCO_3$ to this solution produces a colourless gas, **G**, which turns lime water milky.

- (a) (i) What is the identity of the gas **G**?

.....

- (ii) What functional group does this test show to be present in **F**?

.....

[2]

- (b) When **F** is heated with concentrated sulfuric acid, a colourless liquid **H** is produced. When cold dilute acidified $KMnO_4$ is shaken with **H**, the solution becomes colourless.

- (i) What *type of reaction* occurs when **H** is formed from **F**?

.....

- (ii) Use your answers to (a)(ii) and (b)(i) to deduce the structural formula of the colourless liquid **H**.

[4]

(c) Compound **F** will react with sodium.

Calculate the volume of H_2 , measured at room temperature and pressure, which will be produced when 0.600 g of **F** is reacted with an excess of Na.

[4]

(d) There are two structural isomers of **F** that give the reactions described in (a) and (b).

(i) Suggest two structural formulae for these isomers.

J	K
----------	----------

(ii) Isomers **J** and **K** can both be oxidised.
What will be produced when **each** of the isomers **J** and **K** is heated under reflux with acidified $K_2Cr_2O_7$?

product from J	product from K
-----------------------	-----------------------

[2]

Oct/Nov 2012 (21)

4 Many organic compounds, including alcohols, carbonyl compounds, carboxylic acids and esters, contain oxygen.

(a) The table below lists some oxygen-containing organic compounds and some common laboratory reagents.

(i) Complete the table as fully as you can.

If you think no reaction occurs, write 'no reaction' in the box for the structural formula(e).

reaction	organic compound	reagent	structural formula(e) of organic product(s)
A	$(\text{CH}_3)_3\text{COH}$	$\text{Cr}_2\text{O}_7^{2-}/\text{H}^+$ heat under reflux	
B	$\text{CH}_3\text{CH}_2\text{CHO}$	Fehling's reagent warm	
C	$\text{HCO}_2\text{CH}(\text{CH}_3)_2$	$\text{NaOH}(\text{aq})$ warm	
D	$\text{CH}_2=\text{CHCHO}$	NaBH_4	
E	$(\text{CH}_3)_3\text{COH}$	NaBH_4	
F	$\text{CH}_3\text{CH}_2\text{COCH}_3$	$\text{MnO}_4^-/\text{H}^+$ heat under reflux	

- (ii) During some of the reactions in (i) a colour change occurs. Complete the table below for any such reactions, stating the letter of the reaction and what the colour change is.

reaction	colour at the beginning of the reaction	colour at the end of the reaction

[10]

Oct/Nov 2012 (23)

4 Many organic compounds, including alcohols, carbonyl compounds, carboxylic acids and esters, contain oxygen.

(a) The table below lists some oxygen-containing organic compounds and some common laboratory reagents.

(i) Complete the table as fully as you can.
If you think no reaction occurs, write 'no reaction' in the box for the structural formula(e).

reaction	organic compound	reagent	structural formula(e) of organic product(s)
A	$\text{CH}_3\text{CH}(\text{OH})\text{CH}_3$	NaBH_4	
B	CH_3COCH_3	Tollens' reagent warm	
C	$\text{CH}_3\text{CO}_2\text{CH}(\text{CH}_3)_2$	$\text{KOH}(\text{aq})$ warm	
D	$(\text{CH}_3)_3\text{COH}$	$\text{Cr}_2\text{O}_7^{2-}/\text{H}^+$ heat under reflux	
E	CH_3COCH_3	NaBH_4	
F	$(\text{CH}_3)_3\text{COH}$	PCl_5	
G	$\text{CH}_3\text{CH}=\text{CHCH}_2\text{OH}$	$\text{MnO}_4^-/\text{H}^+$ heat under reflux	

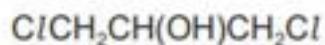
- (ii) During some of the reactions in (i) a colour change occurs. Complete the table below for any such reactions, stating the letter of the reaction and what the colour change is.

reaction	colour at the beginning of the reaction	colour at the end of the reaction

[12]

May/June 2013 (22)

(c) Chloropropanols such as 1,3-dichloropropan-2-ol (1,3-DCP) are present in some foods.



1,3-DCP

- (i) What will be produced when 1,3-DCP is reacted separately with the following reagents under suitable conditions?
In each case give the **structural** formula.

concentrated sulfuric acid

an excess of ammonia

- (ii) Describe as fully as you can what type of reaction occurs with ammonia.

.....
[4]

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

- (a) In the boxes below, write the **structural formula** of the organic compound formed when crotyl alcohol is reacted separately with each reagent under suitable conditions. If you think no reaction occurs, write 'NO REACTION' in the box.

A	Br_2 in an inert organic solvent	
B	PCl_5	
C	H_2 and Ni catalyst	
D	NaBH_4	
E	$\text{K}_2\text{Cr}_2\text{O}_7/\text{H}^+$ heat under reflux	

[5]

(b) Draw the **displayed formula** of the organic compound formed when crotyl alcohol is reacted with cold, dilute acidified potassium manganate(VII).

[1]

(c) Draw the **skeletal formula** of the compound formed in reaction E.

[2]

May/June 2013 (23)

- 5** Compounds containing the allyl group, $\text{CH}_2=\text{CHCH}_2-$, have pungent smells and are found in onions and garlic.

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

- (a)** Allyl alcohol behaves as a primary alcohol and as an alkene.

Give the structural formula of the organic compound formed when allyl alcohol is reacted separately with each of the following reagents.

- (i)** acidified potassium dichromate(VI), heating under reflux

- (ii)** bromine in an inert organic solvent

- (iii)** cold, dilute, acidified potassium manganate(VII)

- (iv)** hot, concentrated, acidified potassium manganate(VII)

[5]

(b) Allyl alcohol undergoes the following reactions.

(i) When reacted with concentrated HCl at 100°C , $\text{CH}_2=\text{CHCH}_2\text{Cl}$ is formed.

State as fully as you can what *type of reaction* this is.

.....

(ii) When reacted with MnO_2 at room temperature, $\text{CH}_2=\text{CHCHO}$ is formed.

What *type of reaction* is this?

.....

[2]

(c) Allyl alcohol can be converted into propanal in two steps.



(i) What reagents and conditions would be used for **each** step?

step I

reagent(s)

condition(s)

step II

reagent(s)

condition(s)

(ii) Allyl alcohol and propanal are isomers.

What form of isomerism do they display?

.....
[5]**(d)** Allyl alcohol may also be converted into propanal by using a ruthenium(IV) catalyst in water.

Suggest what is unusual about this single step reaction.

.....
..... [1]

Oct/Nov 2013 (23)

5 The molecular formula C_4H_9OH represents four different alcohols, W, X, Y and Z.

W	X	Y	Z
$CH_3CH_2CH_2CH_2OH$	$CH_3CH_2CH(OH)CH_3$	$(CH_3)_2CHCH_2OH$	$(CH_3)_3COH$

(a) Draw the skeletal formula of Z.

[1]

(b) Acidified potassium dichromate(VI) is used as an oxidising agent in organic chemistry.

Give the **structural formula** of the organic product formed when **each** of the four alcohols above is heated under reflux with acidified potassium dichromate(VI).
If you believe that no reaction occurs, write 'no reaction' in the box.

W	
X	
Y	
Z	

[4]

- (c) One of the alcohols, W, X, Y or Z, can be dehydrated to give more than one organic product.

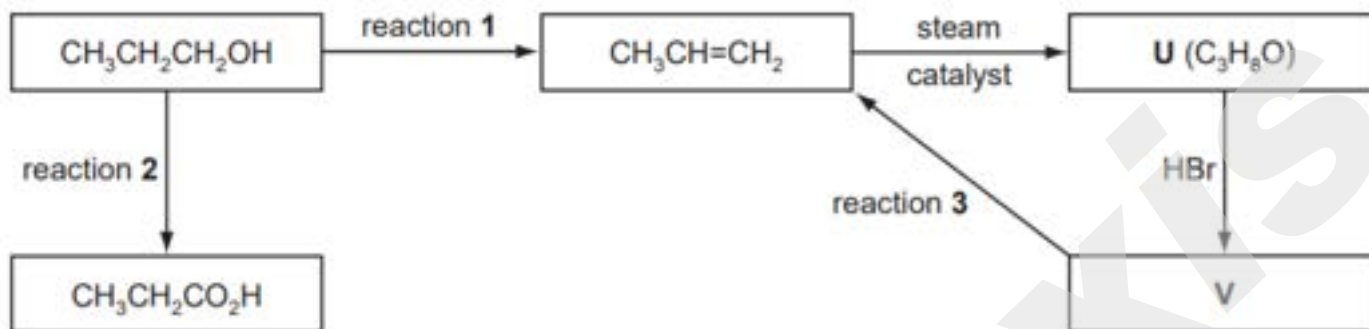
Identify this alcohol and give the structural formulae of **two** of the products.

alcohol	
product 1	
product 2	

[2]

Oct/Nov 2014 (23)

4 A series of reactions based on propan-1-ol is shown.



(a) Suggest a suitable reagent and conditions for reaction 1.

..... [2]

(b) (i) Write an equation for reaction 2, using [O] to represent the oxidising agent.

..... [1]

(ii) Suggest a suitable reagent and conditions for reaction 2.

..... [2]

(c) Give the structural formulae of U and V.

U

V [2]

(d) Suggest a suitable reagent and conditions for reaction 3.

..... [2]

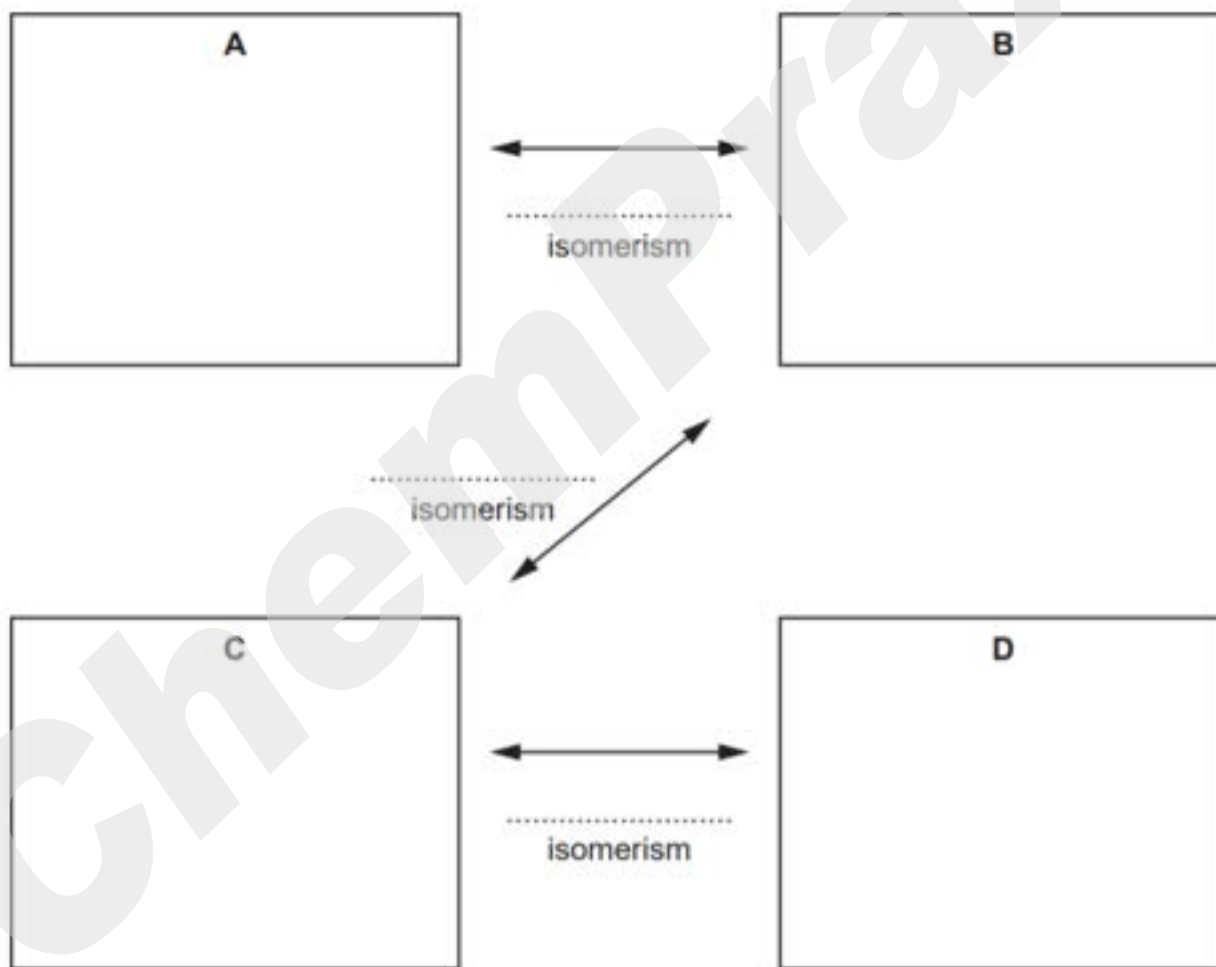
May/June 2015 (21)

- 4 There are four alcohols, **A**, **B**, **C** and **D**, which are structural isomers with the molecular formula $C_4H_{10}O$.

Alcohol **A** does not react with acidified potassium dichromate(VI) solution but **B**, **C** and **D** do.

All four alcohols react with hot, concentrated sulfuric acid to form products with the molecular formula C_4H_8 . **A**, **C** and **D** each give a single product in this reaction. **B** gives a mixture of two structural isomers, one of which shows stereoisomerism.

- (a) Give the **skeletal** formula for each of the four alcohols and complete the diagram with the names of the types of structural isomerism shown by each linked pair of compounds.



[7]

- (b) (i) Give the names of the two structural isomers produced by the reaction of **B** with hot, concentrated sulfuric acid

..... [2]

- (ii) State which of these two isomers shows stereoisomerism. Explain why this molecule is capable of showing stereoisomerism.

.....

.....

.....

..... [2]

- (iii) Draw **displayed** formulae to show the two stereoisomers.



[2]

May/June 2015 (23)/Q3

(b) **D**, **E** and **F** all decolourise bromine and effervesce slowly with sodium metal.

E shows geometrical isomerism. Only **D** has a branched chain.

None of these isomers contains an oxygen atom bonded to a carbon atom involved in π bonding.

None of these isomers contains a chiral centre.

(i) Give the structures of **D**, **E** and **F**. Show the two stereoisomers of **E** and label the stereoisomerism shown.

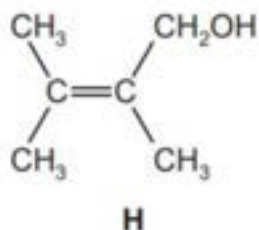
D		
E	E	
F		

[5]

(ii) Identify the gas produced during the reaction of each of these isomers with sodium metal.

..... [1]

4 The structure of **H** is shown.



(a) **H** reacts with both cold, dilute, acidified potassium manganate(VII) and with hot, concentrated, acidified potassium manganate(VII).

(i) Give the structure of the organic product of the reaction of **H** with cold, dilute, acidified potassium manganate(VII).

[1]

(ii) Give the structures of the organic products of the reaction of **H** with hot, concentrated, acidified potassium manganate(VII).

[2]

- (b) (i) Complete the reaction scheme to show the mechanism of the reaction of H with bromine to form J.

Include all necessary curly arrows, lone pairs and charges.



[3]