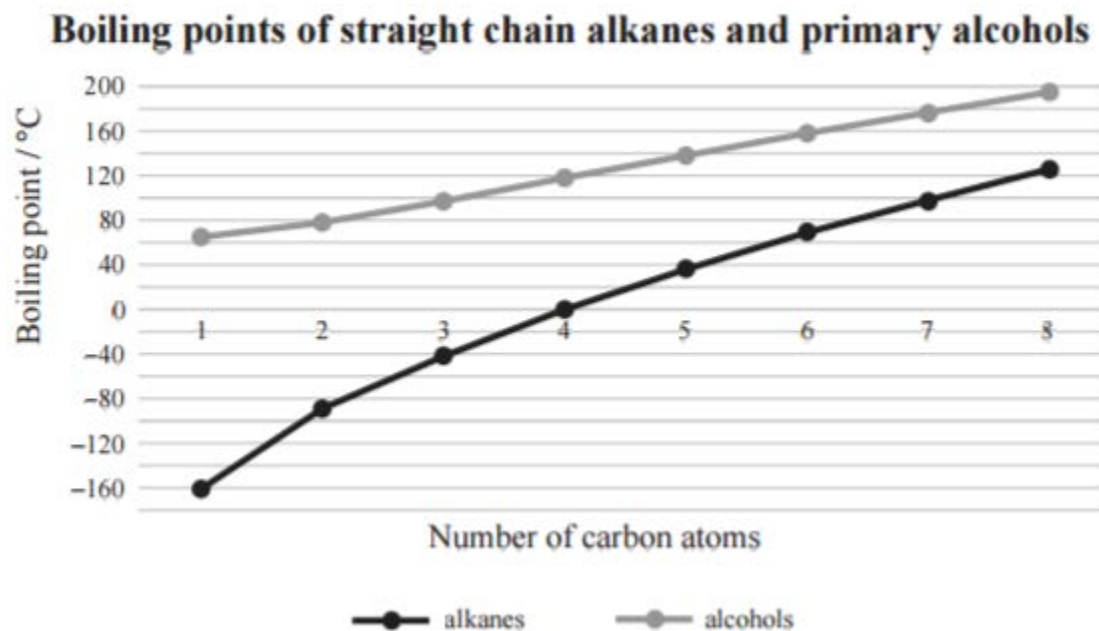


## ALCOHOLS

Modified questions from 2016



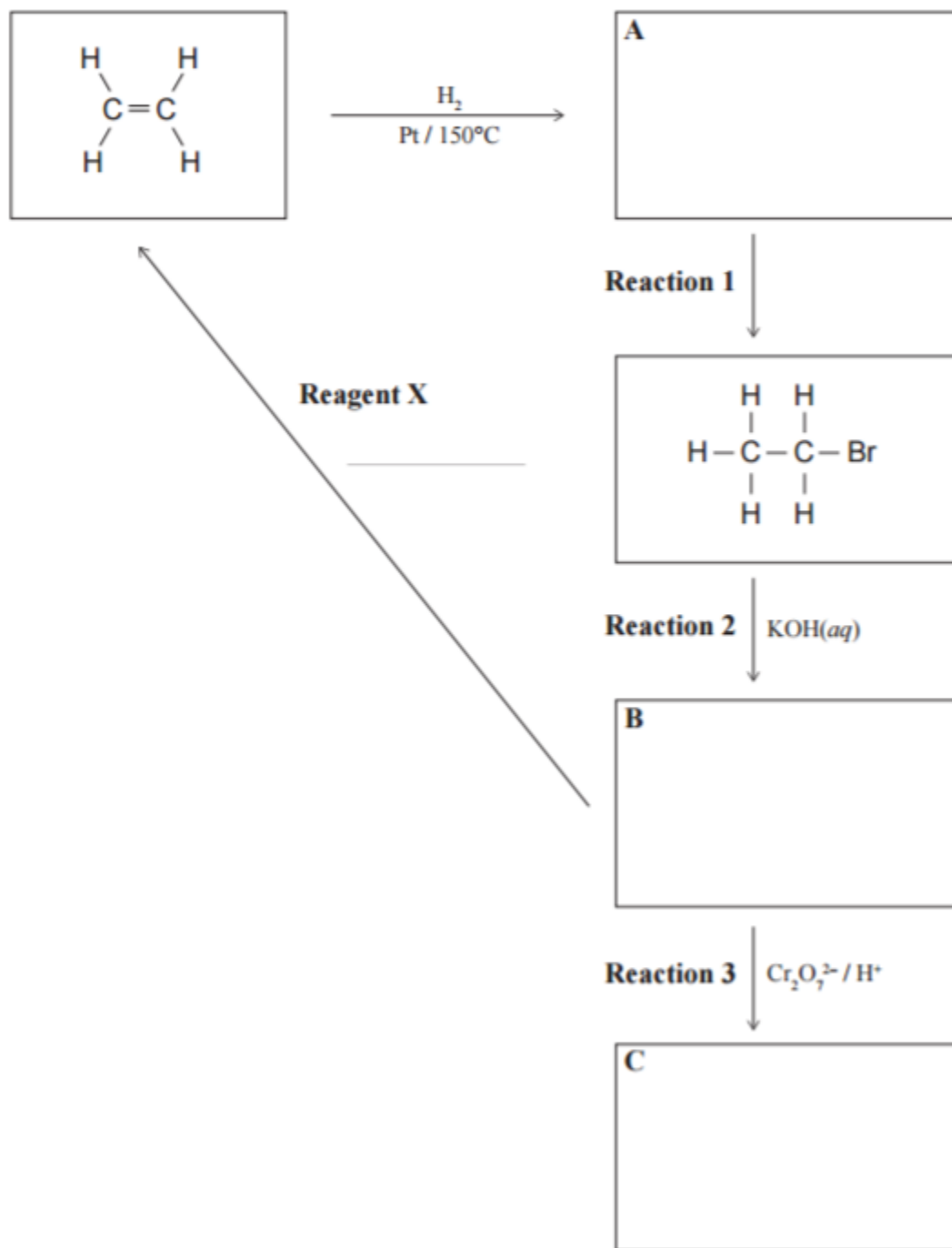
- (a) (i) Identify the trends shown on the graph above.

Modified Question 3, 2016

- (a) (i) Complete the following chart by drawing the structural formulae for the organic compounds B, and C and identifying reagent X.

Organic compound A is ethane,  $C_2H_6$ .

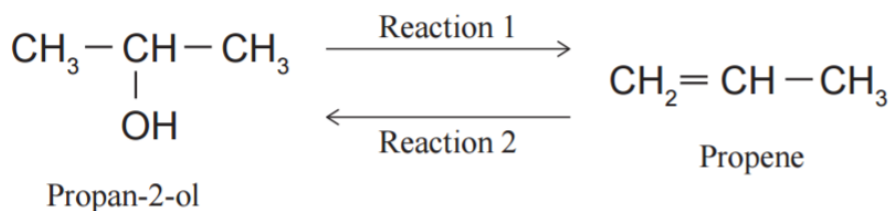
- (i) Identify the type of organic reaction occurring in each of Reactions 2, and 3.



Modified questions from 2015

- (a) Butan-1-ol has the molecular formula  $\text{C}_4\text{H}_{10}\text{O}$ . Its structural formula is:  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$
- Define the term constitutional (structural) isomer
  - Draw THREE other constitutional (structural) isomers of  $\text{C}_4\text{H}_{10}\text{O}$ .
  - Choose a secondary alcohol from the structures above and give a reason for your choice.

(b)

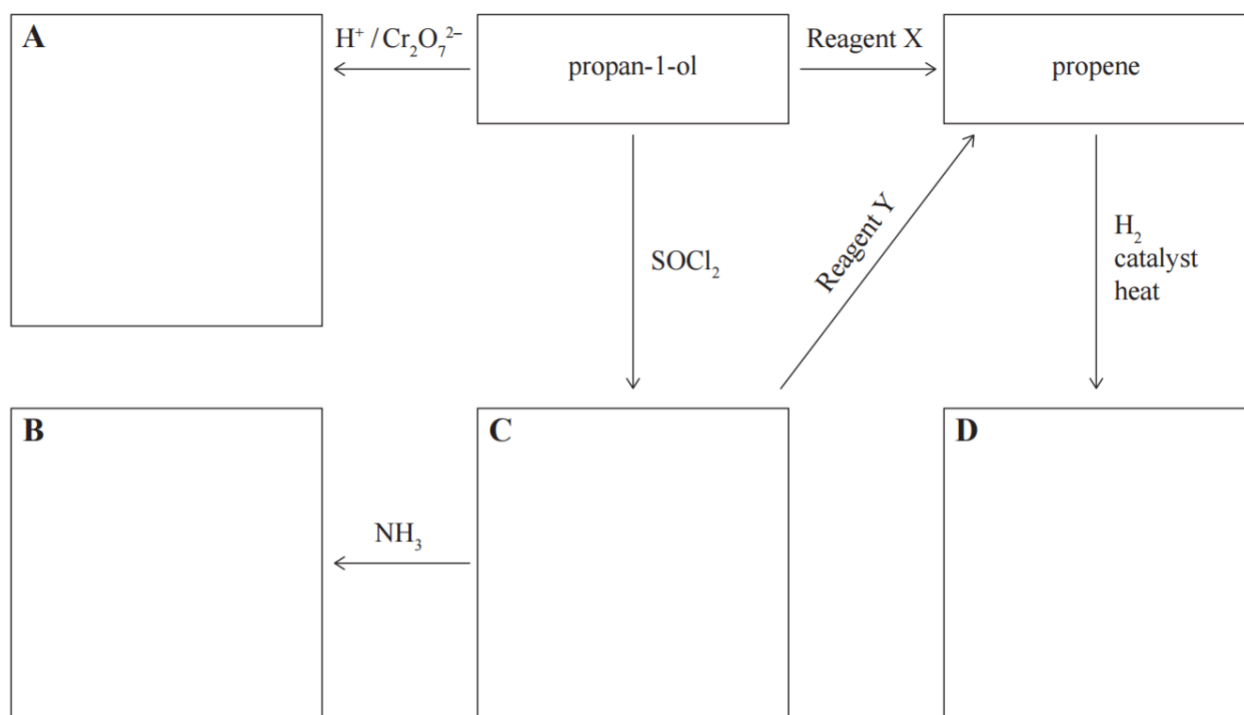


In Reaction 1, propan-2-ol can be converted to propene. In Reaction 2, propene can be converted back to propan-2-ol.

Analyse BOTH of these reactions by:

- describing the reagents and conditions needed for each reaction to occur
- identifying each type of reaction and explaining your choice
- explaining why Reaction 1 forms only a single organic product, but Reaction 2 forms a mixture of organic products.

(c)

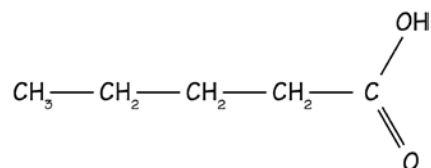


- Complete the scheme above by drawing the structural formulae of the organic compounds A and C.
- Identify reagent X.

#### Modified questions from 2014

- Draw a primary, a secondary, and a tertiary alcohol for the molecule  $\text{C}_5\text{H}_{11}\text{OH}$ .

- (b) When primary alcohols are oxidised by acidified permanganate,  $\text{MnO}_4^- / \text{H}^+$ , they form carboxylic acids. Draw the primary alcohol that was oxidised to form the carboxylic acid shown.



- (c) Hexan-1-ol,  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$ , reacts with  $\text{PCl}_3$ .
- (i) State whether any conditions are required
- (ii) Describe the type of reaction occurring and why this reaction is classified as this type of reaction.
- (d) Draw the structural formula for 2,2-dichloropentan-1-ol.

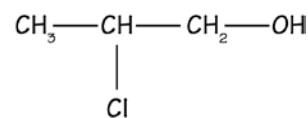
- (e) Sodium carbonate, hydrochloric acid, and sulfuric acid are each added to separate samples of the organic compound.

Reagent	Organic compound $\text{CH}_3\text{-CH}_2\text{-CH}_2\text{-OH}$
$\text{Na}_2\text{CO}_3$	No reaction
$\text{HCl}$	$\text{CH}_3\text{-CH}_2\text{-CH}_2\text{-Cl}$
$\text{H}_2\text{SO}_4$	$\text{CH}_3\text{-CH=CH}_2$

Describe the different types of reactions occurring, and give reasons why they are classified as that type. Identify any specific conditions that are required for the reactions to occur.

### Modified questions from 2013

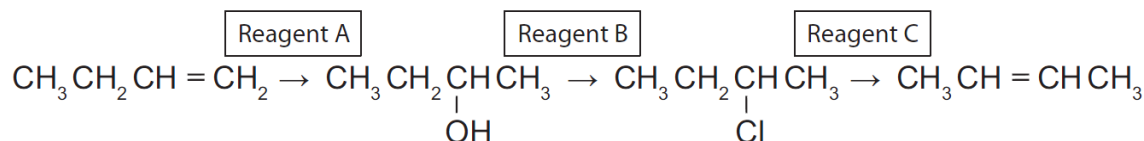
- (a) Give the IUPAC (systematic) name for this compound.
- (b) Two separate colourless organic liquids are known to be:



- pentan-1-ol
- ethanol

Write a valid method to show how these liquids can be identified using only water.

- (c) The flow diagram below shows a reaction scheme for the conversion of but-1-ene into but-2-ene.



Use the reaction scheme above, identify:

- the formula of reagent A and reagent B, including any necessary conditions
  - the type of reaction occurring with reagent A and reagent B.
- (d) Butan-1-ol can react separately with each of  $\text{PCl}_5$ ,  $\text{Cr}_2\text{O}_7^{2-} / \text{H}^+$ , and concentrated  $\text{H}_2\text{SO}_4$ .

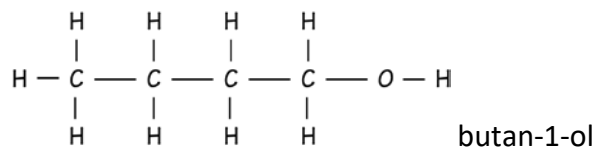
Elaborate on the reactions of butan-1-ol with each of the three reagents.

For each reaction, your answer should include:

- the type of reaction occurring and the reason why it is classified as that type
- the name of the functional group formed in each product
- the structural formula of the **organic** product.

### Modified questions from 2012

- (a) Four of the structural isomers of  $\text{C}_4\text{H}_{10}\text{O}$  are alcohols. One of these isomers has been drawn and named for you below.



- (i) Draw the structural formulae and give the IUPAC (systematic) names of the other three structural isomers.
- (ii) Butan-1-ol can be oxidised to form a carboxylic acid.
- Write the name or formula of a suitable reagent that could be used to carry out the reaction.
  - Include any specific conditions.
  - Describe the colour change that would be observed.

(iii) One of the other alcohol isomers of  $C_4H_{10}O$  can also be oxidised to form a carboxylic acid.

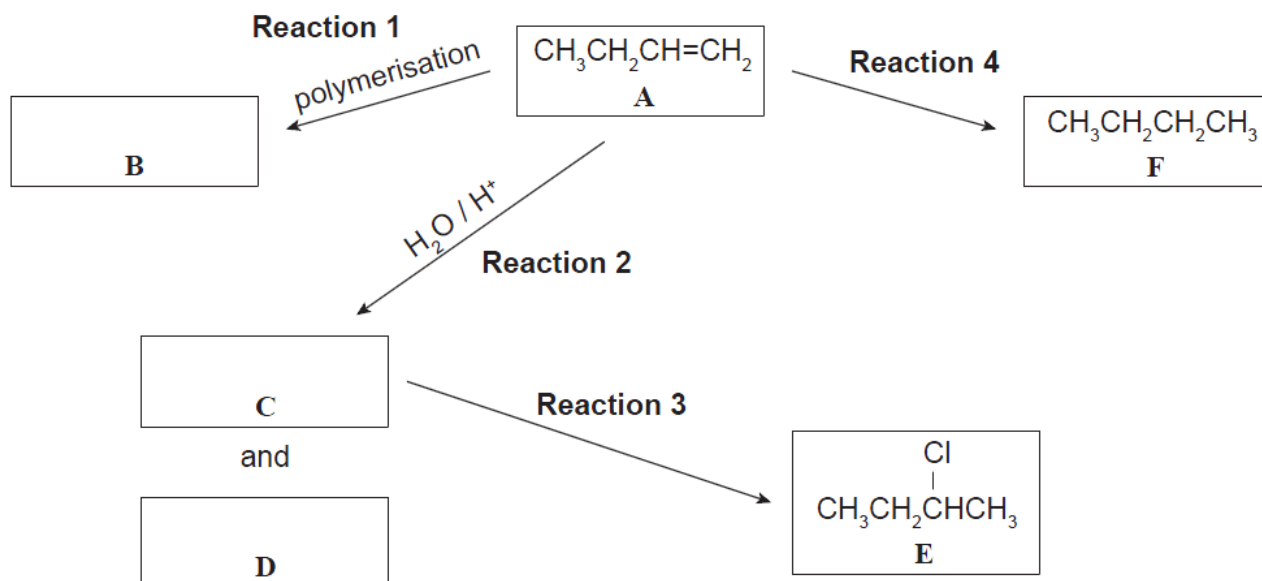
- Identify this isomer by name or structural formula.
- Explain your choice of isomer.

(b) Chloroethane,  $CH_3CH_2Cl$ , reacts with aqueous  $KOH$ . Describe the reaction of chloroethane with this reagent.

In your answer you should include:

- the type of reaction occurring and the reason why it is classified as that type
- the type of functional group formed
- equations showing structural formulae for reaction occurring.

(c) But-1-ene is used in the reaction sequence below.



(i) Give the name or formula of a suitable reagent in **Reaction 3**.

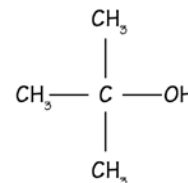
(ii) Draw the structural formulae of the organic molecules **C** and **D**, formed in **Reaction 2**.

(iii) Elaborate on the reaction occurring in **Reaction 2**. In your answer you should include:

- identification of the major and minor products
- an explanation of why there are two possible products
- justification of your placement of the different structures in boxes **C** and **D** with reference to the reaction sequence.

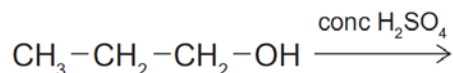
Modified questions from 2011 (expired AS 90309)

- (a) Draw the structural formula for butan-1,2-diol.
- (b) **The molecule** below can be classified as a tertiary alcohol. Describe why this molecule is classified as tertiary.
- (c) Draw a structural isomer of the molecule in (b).



Modified questions from 2010 (expired AS 90309)

- (a) Draw the structural formula for 2-chlorobutan-2-ol.
- (b) For the following reaction:



- (i) Write the structural formula of the organic product formed.
- (ii) State the type of reaction occurring. Choose from the word list below.

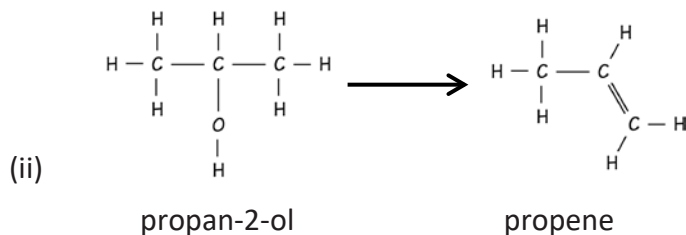
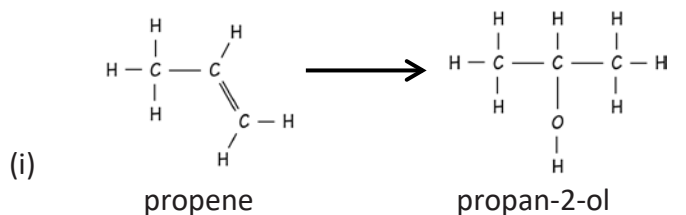
Elimination addition oxidation substitution hydrolysis halogenation acid-base

- (c) Classify each of the following alcohols as **primary**, **secondary** or **tertiary**. Then explain why you chose this answer.
- (i)  $\text{CH}_3\text{CHCH}_3\text{OH}$
- (ii)  $\text{CH}_3\text{CHCH}_3\text{CH}_2\text{OH}$

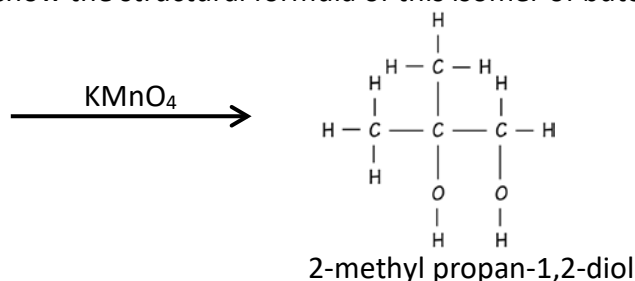
Modified questions from 2009 (expired AS 90309)

- (a) Draw the structural formula for 3-chlorobutan-1-ol.
- (b) For each of the following reactions:
- Write the **name** or **structural formula** of the reagent used to bring about the conversion.
  - State the **type** of reaction occurring. Choose from the list below.

acid-base addition elimination hydrolysis substitution



- (c) Give the **structural formula** of the organic product formed when ethanol,  $\text{C}_2\text{H}_5\text{OH}$ , reacts with acidified potassium dichromate solution.
- (d) An isomer of butene ( $\text{C}_4\text{H}_8$ ) can be oxidised with potassium permanganate,  $\text{KMnO}_4$  to form 2-methyl propan-1,2-diol. Complete the following to show the structural formula of this isomer of butene.



- (e) 2-methyl propan-1,2-diol can be further oxidised with acidified potassium dichromate,  $\text{Cr}_2\text{O}_7^{2-} / \text{H}^+$ , to form a compound with molecular formula  $\text{C}_4\text{H}_8\text{O}_3$ . The compound  $\text{C}_4\text{H}_8\text{O}_3$  reacts with sodium carbonate solution to form bubbles of carbon dioxide gas. [Hint: Tertiary alcohol groups will not be oxidised.]

Draw the **structural formula** of the compound  $\text{C}_4\text{H}_8\text{O}_3$ .

- (f) Two of these substances are orange in colour, the other three are colourless.
- acidified potassium dichromate
  - bromine water
  - methanol
  - hexane
  - hex-1-ene.

Discuss (by only using some of the five substances), how methanol could be identified

Your answer should include:

- (i) a clear description of what you would do
- (ii) observations
- (iii) an equation showing the structural formula of organic substance for the reaction occurring.

Modified questions from 2008 (expired AS 90309)

- (a) Draw the structural formula for pentan-2-ol.
- (b) Ethanol is heated with a catalyst (either concentrated sulfuric acid or aluminium oxide).
- (i) Write the **IUPAC name** or the **structural formula** of the product formed.
  - (ii) State the type of reaction occurring. Choose from: acid-base, addition, elimination, hydrolysis, oxidation or substitution.
- (c) **Compare and contrast** the reactions of ethene and ethanol with acidified potassium permanganate.

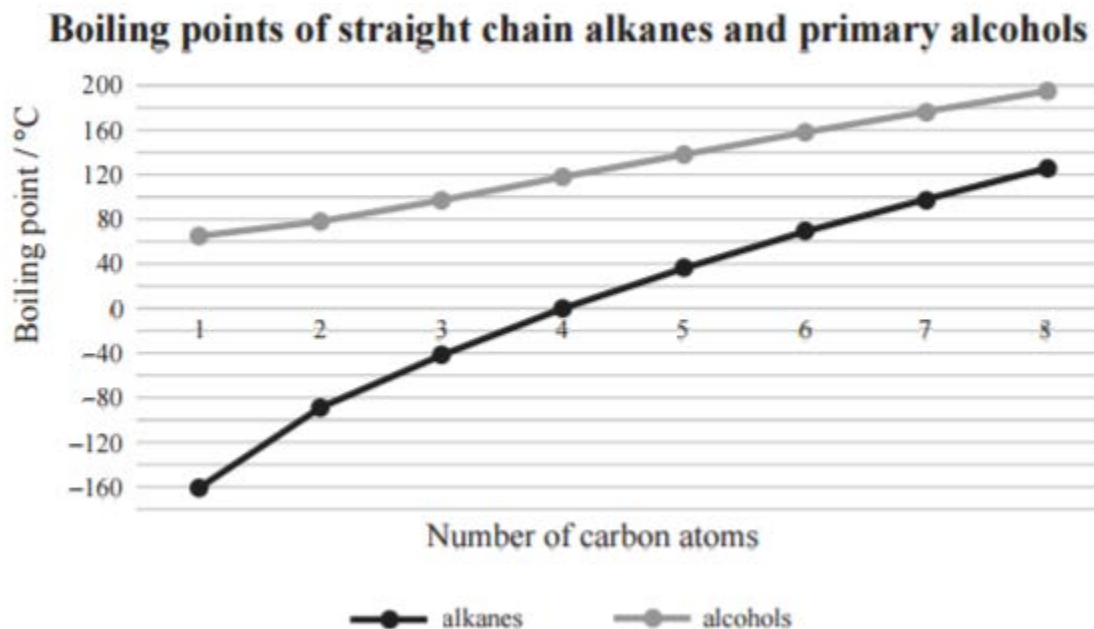
For each reaction you must include:

- observations
- equations showing the structural formulae of the organic reactant and product
- type of reaction occurring.



# ANSWERS

Modified questions from 2016



- (a) (i) Identify the trends shown on the graph above.

The boiling points of both alkanes and alcohols increase as the number of C atoms increases. The boiling points of alcohols are always higher than the alkanes (with the same number of C atoms).

Modified Question 3, 2016

- (b) (i) Complete the following chart by drawing the structural formulae for the organic compounds B, and C and identifying reagent X.

Organic compound A is ethane,  $C_2H_6$ .

B =  $CH_3CH_2OH$

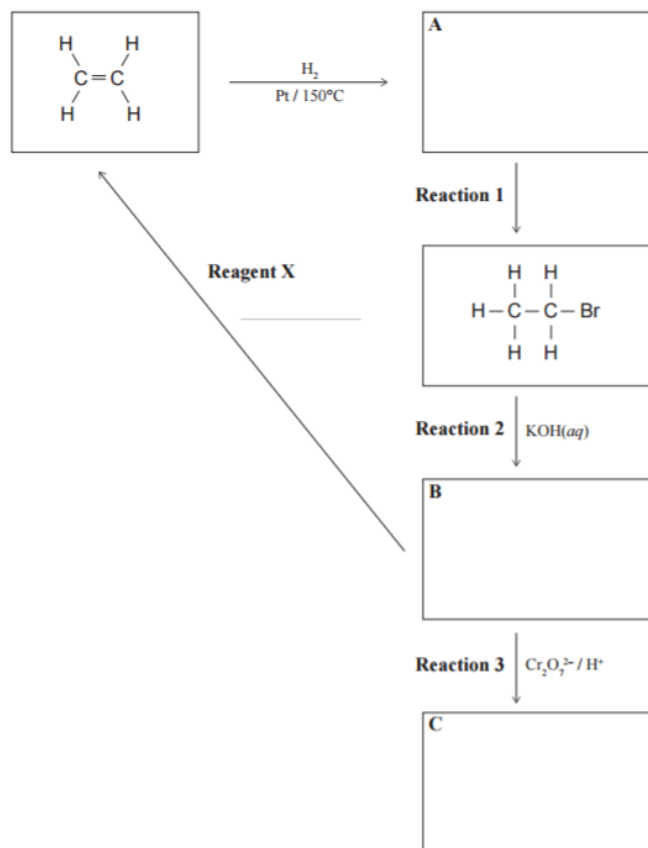
C =  $CH_3COOH$  (or  $CH_3CHO$  aldehyde)

X = concentrated  $H_2SO_4$

- (ii) Identify the type of organic reaction occurring in each of Reactions 2, and 3.

Reaction 2 – substitution

Reaction 3 - oxidation



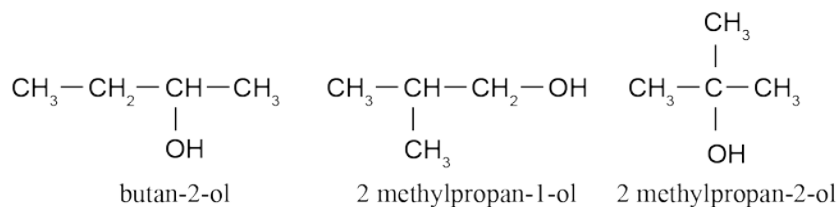
Modified questions from 2015

(a) Butan-1-ol has the molecular formula  $C_4H_{10}O$ . Its structural formula is:  $CH_3CH_2CH_2CH_2OH$

(i) Define the term constitutional (structural) isomer

A constitutional (structural) isomer has the same molecular formula, but a different arrangement of atoms / different structural formula.

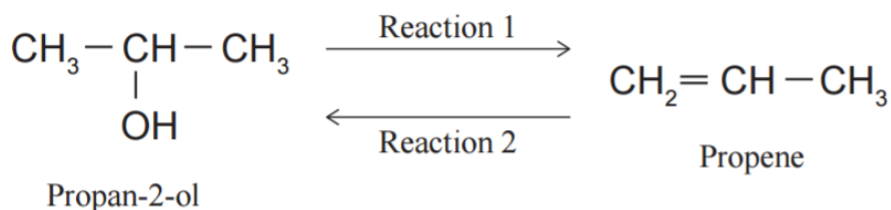
(ii) Draw THREE other constitutional (structural) isomers of  $C_4H_{10}O$ .



(iii) Choose a secondary alcohol from the structures above and give a reason for your choice.

Butan-2-ol is secondary because the carbon atom that is attached to the OH group is bonded to either two other carbon atoms or to only one hydrogen atom.

(b)



In Reaction 1, propan-2-ol can be converted to propene. In Reaction 2, propene can be converted back to propan-2-ol.

Analyse BOTH of these reactions by:

- describing the reagents and conditions needed for each reaction to occur
- identifying each type of reaction and explaining your choice
- explaining why Reaction 1 forms only a single organic product, but Reaction 2 forms a mixture of organic products.

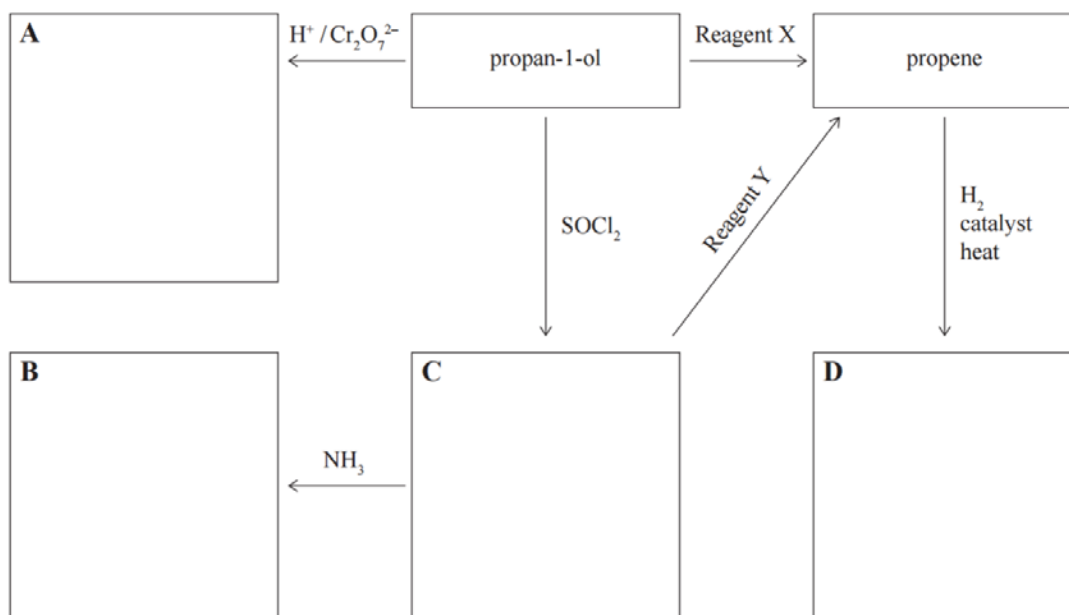
To convert propan-2-ol to propene, add concentrated sulfuric acid (which is a dehydrating agent). It is an elimination reaction because OH and H are removed from adjacent carbon atoms and a double bond is created to form an alkene.

To convert propene to propan-2-ol, add dilute (sulfuric) acid. This is an addition reaction because the double bond is broken forming a C-C (single) bond, allowing H and OH from water to bond to the C atoms that were double bonded together.

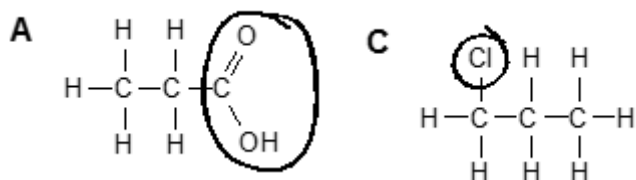
Reaction 1 forms only one product because the carbon atom from which the H is removed (C1 or C3) does not affect the structure of the product as propan-2-ol is symmetrical.

Reaction 2 produces two products because an asymmetric reagent (H-OH) adds onto an asymmetric alkene ( $\text{CH}_3\text{CH}=\text{CH}_2$ ). There are two carbons that the H or OH can bond with (C1 and C2), so there are two possible combinations. We can predict which will be the major product by using Markovnikov's rule, which states that the carbon with the most hydrogens gains more hydrogens. This means that most of the time, C1 will get another hydrogen while C2 will get the OH in this reaction. Propan-2-ol will be the major product and propan-1-ol the minor product.

(c)



- (i) Complete the scheme above by drawing the structural formulae of the organic compounds A and C.



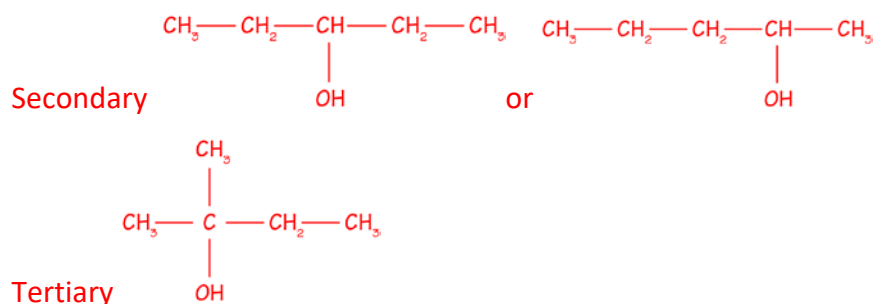
- (ii) Identify reagent X.

Reagent X is concentrated sulfuric acid, conc  $\text{H}_2\text{SO}_4$ , or  $\text{c.H}_2\text{SO}_4$ .

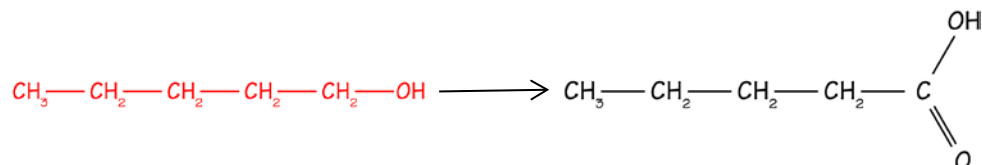
### Modified questions from 2014

- (a) Draw a primary, a secondary, and a tertiary alcohol for the molecule  $\text{C}_5\text{H}_{11}\text{OH}$ .

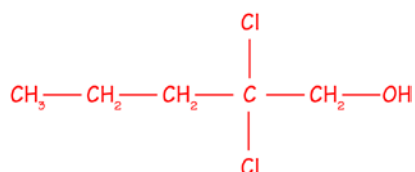
Primary  $\text{CH}_3-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{OH}$



- (b) When primary alcohols are oxidised by acidified permanganate,  $\text{MnO}_4^- / \text{H}^+$ , they form carboxylic acids. Draw the primary alcohol that was oxidised to form the carboxylic acid shown.



- (c) Hexan-1-ol,  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$ , reacts with  $\text{PCl}_3$ .
- (iii) State whether any conditions are required **no**
- (iv) Describe the type of reaction occurring and why this reaction is classified as this type of reaction.  
**It is a substitution reaction. A group of atoms is being replaced with another atom.**
- (d) Draw the structural formula for 2,2-dichloropentan-1-ol.



- (e) Sodium carbonate, hydrochloric acid, and sulfuric acid are each added to separate samples of the organic compound.

Reagent	Organic compound
	$\text{CH}_3-\text{CH}_2-\text{CH}_2-\text{OH}$
$\text{Na}_2\text{CO}_3$	No reaction
$\text{HCl}$	$\text{CH}_3-\text{CH}_2-\text{CH}_2-\text{Cl}$
$\text{H}_2\text{SO}_4$	$\text{CH}_3-\text{CH}=\text{CH}_2$

Describe the different types of reactions occurring, and give reasons why they are classified as that type. Identify any specific conditions that are needed for the reactions to occur.

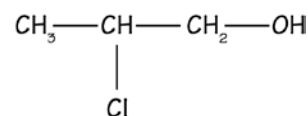
**When propan-1-ol reacts with  $\text{HCl}$ , a substitution reaction occurs; in this reaction the  $\text{Cl}$  from  $\text{HCl}$  replaces the  $-\text{OH}$  group from propan-1-ol, forming a haloalkane.**

**The reaction between conc.  $\text{H}_2\text{SO}_4$  / heat, and propan-1-ol is an elimination reaction because an  $-\text{OH}$  group attached to  $\text{C}_1$ , and a hydrogen atom from  $\text{C}_2$  are both removed from the organic molecule. A double bond forms between  $\text{C}_1$  &  $\text{C}_2$ , with the elimination of water, forming propene.**

Modified questions from 2013

- (a) Give the IUPAC (systematic) name for this compound.

2-chloropropan-1-ol



- (b) Two separate colourless organic liquids are known to be:

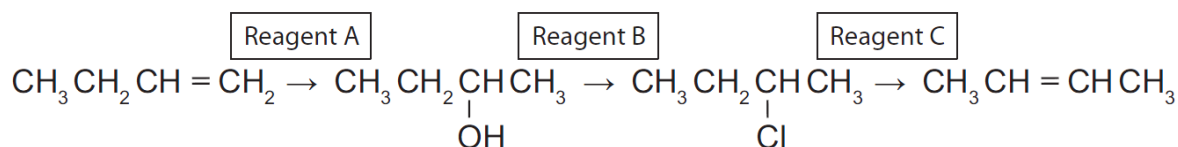
• pentan-1-ol

• ethanol

Write a valid method to show how these liquids can be identified using only water.

Add water to the liquids. One will dissolve in water (ethanol), one will not (pentan-1-ol).

- (c) The flow diagram below shows a reaction scheme for the conversion of but-1-ene into but-2-ene.



Use the reaction scheme above, identify:

- the formula of reagent A and reagent B, including any necessary conditions

A:  $\text{H}^+/\text{H}_2\text{O}$  B:  $\text{PCl}_3 / \text{PCl}_5 / \text{SOCl}_2$

- the type of reaction occurring with reagent A and reagent B.

With A: addition With B: substitution

- (d) Butan-1-ol can react separately with each of  $\text{PCl}_5$ ,  $\text{Cr}_2\text{O}_7^{2-} / \text{H}^+$ , and concentrated  $\text{H}_2\text{SO}_4$ .

Elaborate on the reactions of butan-1-ol with each of the three reagents.

For each reaction, your answer should include:

- the type of reaction occurring and the reason why it is classified as that type
- the name of the functional group formed in each product
- the structural formula of the **organic** product.

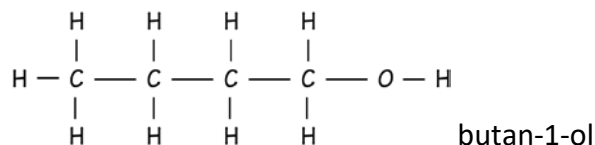
Reaction with  $\text{PCl}_5$  is a substitution reaction. The hydroxyl group ( $-\text{OH}$ ) is replaced by a chloro group ( $-\text{Cl}$ ). The product is  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{Cl}$ . The functional group in the product is a chloro group / chloroalkane (haloalkane).

Reaction with acidified dichromate is oxidation as the alcohol is oxidised to a carboxylic acid. The product is  $\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH}$ . The functional group in the product is carboxylic acid.

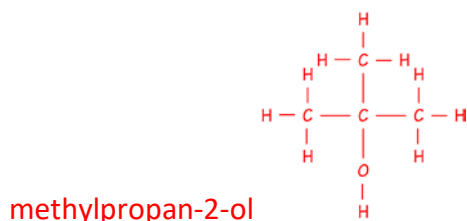
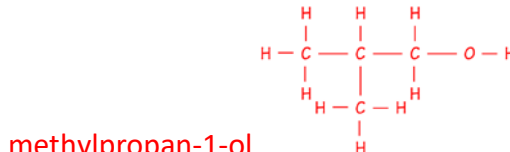
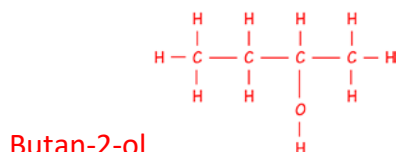
Reaction with concentrated  $\text{H}_2\text{SO}_4$  is an elimination reaction. A hydrogen atom and the  $-\text{OH}$  group on (adjacent) carbon atoms are removed forming a (carbon-to-carbon) double bond. The product is  $\text{CH}_3\text{CH}_2\text{CH}=\text{CH}_2$ . The functional group in the product is a (carbon-to-carbon) double bond / alkene

Modified questions from 2012

- (a) Four of the structural isomers of  $C_4H_{10}O$  are alcohols. One of these isomers has been drawn and named for you below.



- (i) Draw the structural formulae and give the IUPAC (systematic) names of the other three structural isomers.



- (ii) Butan-1-ol can be oxidised to form a carboxylic acid.
- Write the name or formula of a suitable reagent that could be used to carry out the reaction.
  - Include any specific conditions.
  - Describe the colour change that would be observed.  
 $MnO_4^- / H^+$  or  $Cr_2O_7^{2-} / H^+$ . Purple  $\rightarrow$  colourless, or orange  $\rightarrow$  green
- (iv) One of the other alcohol isomers of  $C_4H_{10}O$  can also be oxidised to form a carboxylic acid.
- Identify this isomer by name or structural formula.
  - Explain your choice of isomer.  
 2-methylpropan-1-ol. Since it is a  $1^\circ$  alcohol it can be oxidised to a carboxylic acid / since the others are secondary or tertiary alcohols and can't be oxidised to a carboxylic acid.

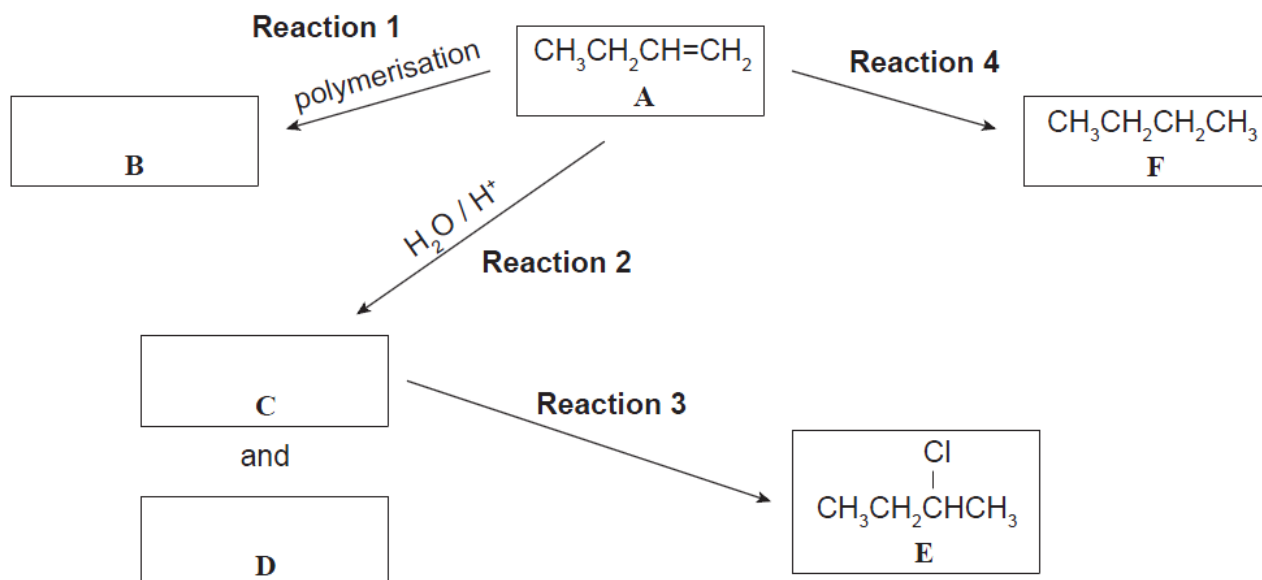
- (b) Chloroethane,  $CH_3CH_2Cl$ , reacts with aqueous KOH. Describe the reaction of chloroethane with this reagent.

In your answer you should include:

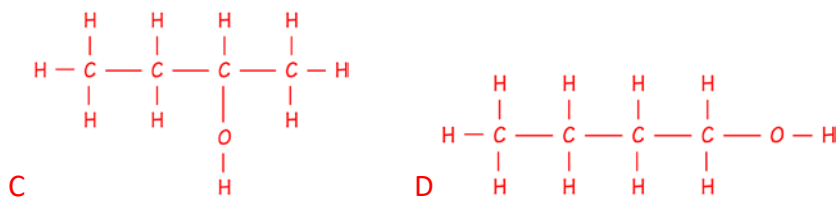
- the type of reaction occurring and the reason why it is classified as that type
- the type of functional group formed
- equations showing structural formulae for reaction occurring.

Chloroethane reacts with  $KOH(aq)$  to form an alcohol in a substitution reaction; The  $-Cl$  is replaced by  $-OH$ .  $CH_3CH_2Cl \rightarrow CH_3CH_2OH$

(c) But-1-ene is used in the reaction sequence below.



- (i) Give the name or formula of a suitable reagent in **Reaction 3**.  $\text{PCl}_3 / \text{PCl}_5 / \text{SOCl}_2$
- (ii) Draw the structural formulae of the organic molecules **C** and **D**, formed in **Reaction 2**.



(iii) Elaborate on the reaction occurring in **Reaction 2**. In your answer you should include:

- identification of the major and minor products
- an explanation of why there are two possible products
- justification of your placement of the different structures in boxes **C** and **D** with reference to the reaction sequence.

**C** is the major product and **D** is the minor product. There are 2 possible products because when the double bond is broken, an H (or  $-\text{OH}$ ) will bond to one C (and a  $-\text{OH}$  group (or H) will bond with the other C). The product will depend on which (C) the H (or the  $-\text{OH}$ ) bond to.

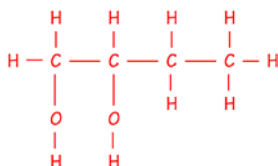


**C** must be  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$  since product **E** is  $\text{CH}_3\text{CH}_2\text{CH}(\text{Cl})\text{CH}_3$  i.e. both functional groups are on the second carbon atom.

If  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$  was **C** then **E** would be  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{Cl}$ .

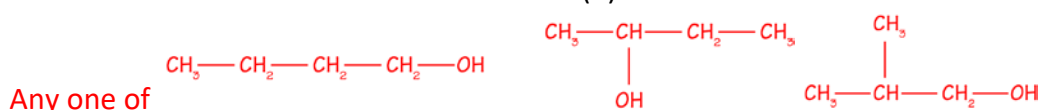
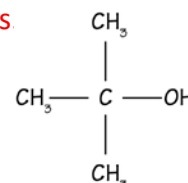
Modified questions from 2011 (expired AS 90309)

- (a) Draw the structural formula for butan-1,2-diol.



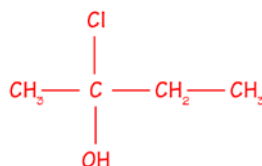
- (b) The molecule below can be classified as a tertiary alcohol. Describe why this molecule is classified as tertiary. **OH group attached to a C atom that is attached directly to 3 other C atoms**

- (c) Draw a structural isomer of the molecule in (b).

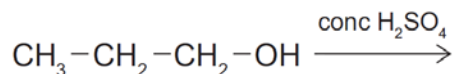


Modified questions from 2010 (expired AS 90309)

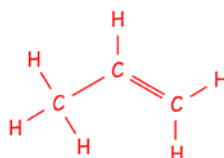
- (a) Draw the structural formula for 2-chlorobutan-2-ol.



- (b) For the following reaction:



- (i) Write the structural formula of the organic product formed.

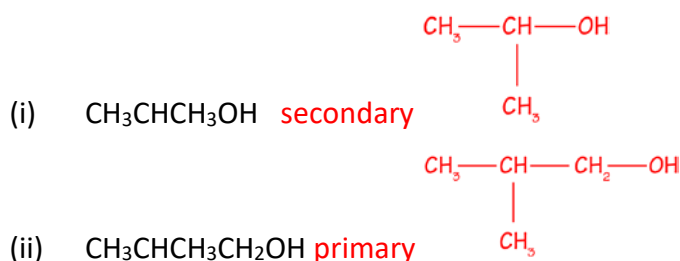


- (ii) State the type of reaction occurring. Choose from the word list below.

Elimination addition oxidation substitution hydrolysis halogenation acid-base

**elimination**

- (c) Classify each of the following alcohols as **primary**, **secondary** or **tertiary**. Then explain why you chose this answer.

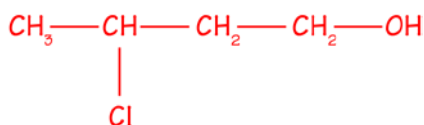


**-OH is attached to a C bonded to (i) 2 carbon atoms (ii) 1 carbon atom**



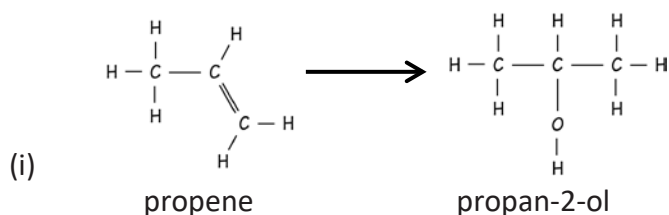
Modified questions from 2009 (expired AS 90309)

(a) Draw the structural formula for 3-chlorobutan-1-ol.

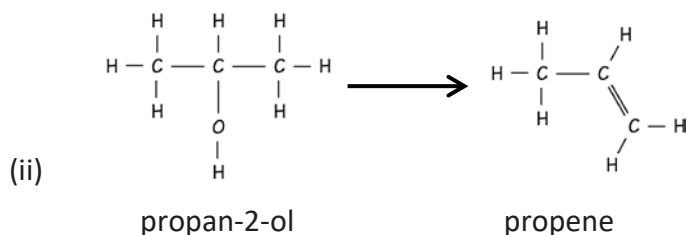


(b) For each of the following reactions:

- Write the **name** or **structural formula** of the reagent used to bring about the conversion.
- State the **type** of reaction occurring. Choose from the list below.  
acid-base addition elimination hydrolysis substitution



$\text{H}_2\text{O}/\text{H}^+$  OR  $\text{H}_2\text{O}/$  acid OR concentrated  $\text{H}_2\text{SO}_4$  then  $\text{H}_2\text{O}$  OR dilute / aq  $\text{H}_2\text{SO}_4$  Type – addition

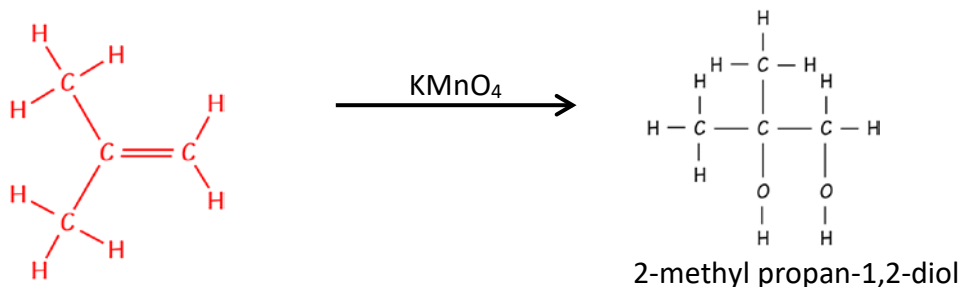


conc / c  $\text{H}_2\text{SO}_4$  OR  $\text{Al}_2\text{O}_3$  / broken pottery Type – elimination

(c) Give the **structural formula** of the organic product formed when ethanol,  $\text{C}_2\text{H}_5\text{OH}$ , reacts with acidified potassium dichromate solution.

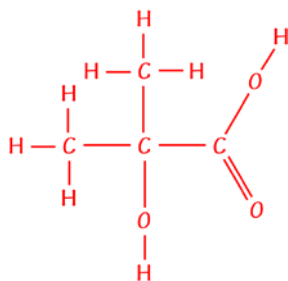


- (d) An isomer of butene ( $C_4H_8$ ) can be oxidised with potassium permanganate,  $KMnO_4$  to form 2-methyl propan-1,2-diol. Complete the following to show the structural formula of this isomer of butene.



- (e) 2-methyl propan-1,2-diol can be further oxidised with acidified potassium dichromate,  $Cr_2O_7^{2-} / H^+$ , to form a compound with molecular formula  $C_4H_8O_3$ . The compound  $C_4H_8O_3$  reacts with sodium carbonate solution to form bubbles of carbon dioxide gas. [Hint: Tertiary alcohol groups will not be oxidised.]

Draw the **structural formula** of the compound  $C_4H_8O_3$ .



- (f) Two of these substances are orange in colour, the other three are colourless.
- acidified potassium dichromate
  - bromine water
  - methanol
  - hexane
  - hex-1-ene.

Discuss (by only using some of the five substances), how methanol could be identified

Your answer should include:

- (i) a clear description of what you would do
- (ii) observations
- (iii) an equation showing the structural formula of organic substance for the reaction occurring.

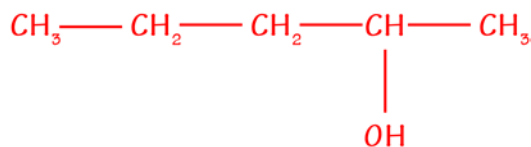
Orange solutions are acidified dichromate and bromine water. Add one of the orange substances to all three colourless substances. If the orange substance decolourised, then it was bromine water. The solution it decolourised was hex-1-ene.  $CH_2CH(CH_2)_3CH_3 + Br_2 \rightarrow CH_2BrCHBr(CH_2)_3CH_3$

If the orange substance turned green, it was acidified potassium dichromate. The solution that made the acidified dichromate turn green was methanol.  $CH_3OH \rightarrow HCOOH$

The substance that did not react with either orange reagent was hexane. (Or accept miscibility argument for methanol versus hexane / hex-1-ene.)

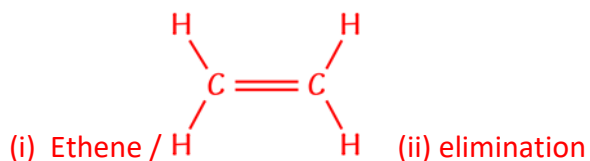
Modified questions from 2008 (expired AS 90309)

(a) Draw the structural formula for pentan-2-ol.



(b) Ethanol is heated with a catalyst (either concentrated sulfuric acid or aluminium oxide).

- Write the **IUPAC name** or the **structural formula** of the product formed.
- State the type of reaction occurring. Choose from: acid-base, addition, elimination, hydrolysis, oxidation or substitution.



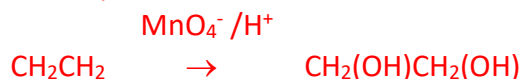
(c) **Compare and contrast** the reactions of ethene and ethanol with acidified potassium permanganate.

For each reaction you must include:

- observations
- equations showing the structural formulae of the organic reactant and product
- type of reaction occurring.

In both reactions, a colour change from purple to colourless will be seen as purple  $\text{MnO}_4^- / \text{H}^+$  is reduced to  $\text{Mn}^{2+}$ . (OR colour change from purple to brown precipitate if non-acidified  $\text{MnO}_4^-$ .)

Ethene will react to form a diol, ethan-1,2-diol:



Ethanol will react to form a carboxylic acid, ethanoic acid:

