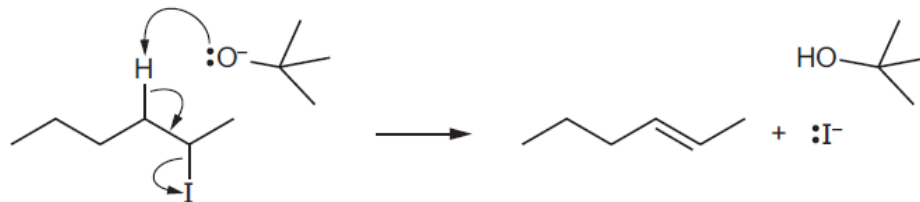


Hydrocarbons – 2021 AS

1. Nov/2021/Paper_11/No.20

Hex-2-ene can be made by the reaction shown.



Which statement about this reaction is correct?

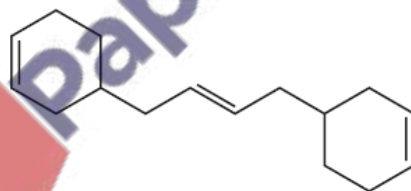
- A $(\text{CH}_3)_3\text{CO}^-$ is behaving as a Brønsted-Lowry base.
- B $(\text{CH}_3)_3\text{CO}^-$ is behaving as an oxidising agent.
- C The C–I bond breaks via homolytic fission.
- D This is a hydrolysis reaction.

2. Nov/2021/Paper_11/No.21

Structural isomerism **only** should be considered when answering this question.

Molecule X contains three C=C double bonds. One mole of X is reacted with three moles of HBr. The carbon skeleton is unchanged.

molecule X



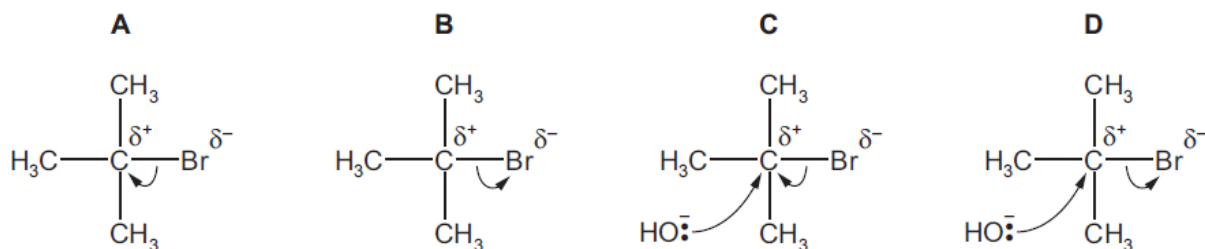
How many different products are formed?

- A 3
- B 4
- C 6
- D 8

3. Nov/2021/Paper_11/No.23

When 2-bromo-2-methylpropane reacts with aqueous sodium hydroxide, an alcohol is formed.

Which diagram describes the first step in the reaction mechanism?



4. Nov/2021/Paper_11/No.38

One molecule of dodecane, $C_{12}H_{26}$, is cracked, producing three product molecules, X, Y and Z.

X is a straight chain alkane. Y and Z are straight chain alkenes with different M_r values.

Which statements about X, Y and Z are correct?

- 1 If Y and Z are but-1-ene and ethene respectively, X will be hexane.
- 2 If X is butane, then Y and Z could both show *cis-trans* isomerism.
- 3 X could be octane.

5. Nov/2021/Paper_11/No.39

Which statements about chlorofluoroalkanes are correct?

- 1 Both the C-Cl and C-F bonds are readily dissociated by ultra-violet light.
- 2 They have caused ozone depletion.
- 3 They are relatively chemically inert.

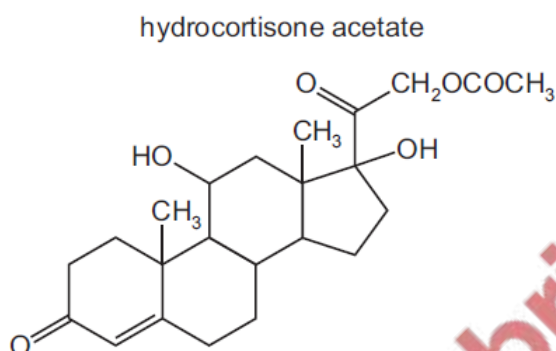
6. Nov/2021/Paper_11/No.40

Which reactions of propan-1-ol have water as one of the products?

- 1 passing propan-1-ol vapour over hot Al_2O_3
- 2 mixing propan-1-ol with warm ethanoic acid and a few drops of concentrated sulfuric acid
- 3 warming propan-1-ol with HBr

7. Nov/2021/Paper_12/No.20

The formula of hydrocortisone acetate is shown.



Which row is correct?

	number of C atoms in one molecule	number of chiral atoms in one molecule
A	22	7
B	22	8
C	23	7
D	23	8

8. Nov/2021/Paper_12/No.22

Structural and stereoisomerism should be taken into account when answering this question.

Y is a gaseous hydrocarbon which decolourises aqueous bromine. It contains no rings.

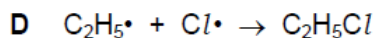
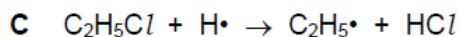
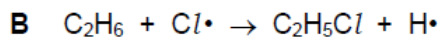
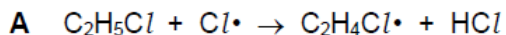
10.0 g of Y occupies a volume of 3.43 dm^3 under room conditions.

How many isomeric structures are possible for Y?

- A 4 B 5 C 6 D 7

9. Nov/2021/Paper_12/No.23

Which equation represents a valid propagation step in the chlorination of ethane?



10. Nov/2021/Paper_12/No.37

What is the same for a pair of optical isomers?

1 their empirical formula

2 their functional groups

3 their structural formula

11. Nov/2021/Paper_12/No.38

Which of the molecular formulae represent at least one compound that can undergo addition polymerisation?

1 C_4H_8

2 $\text{C}_2\text{H}_3\text{Cl}$

3 $\text{C}_3\text{H}_6\text{O}$

12. Nov/2021/Paper_12/No.39

Which of the reactions give products containing a chiral centre?

1 $\text{CH}_2(\text{OH})\text{COCO}_2\text{H} + \text{an excess of HCN}$

2 $\text{CH}_2(\text{OH})\text{COCO}_2\text{H} + \text{an excess of NaBH}_4$

3 $\text{CH}_2(\text{OH})\text{COCO}_2\text{H} + \text{an excess of LiAlH}_4$

13. Nov/2021/Paper_12/No.40

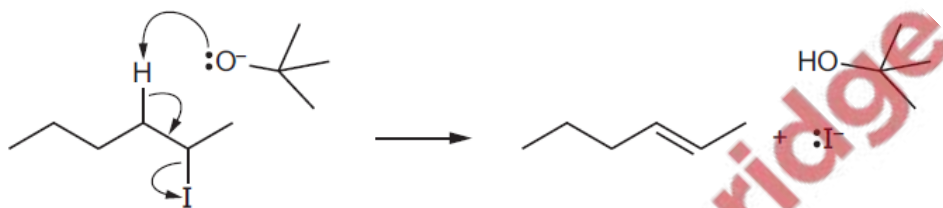
Ethyl butanoate is heated with a dilute aqueous solution of sodium hydroxide.

Which substances are products of this reaction?

- 1 sodium butanoate
- 2 water
- 3 sodium ethanoate

14. Nov/2021/Paper_13/No.20

Hex-2-ene can be made by the reaction shown.



Which statement about this reaction is correct?

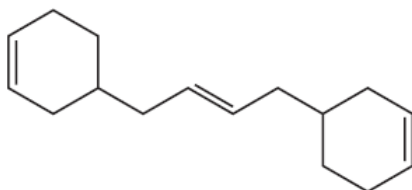
- A $(\text{CH}_3)_3\text{CO}^-$ is behaving as a Brønsted-Lowry base.
- B $(\text{CH}_3)_3\text{CO}^-$ is behaving as an oxidising agent.
- C The C–I bond breaks via homolytic fission.
- D This is a hydrolysis reaction.

15. Nov/2021/Paper_13/No.21

Structural isomerism **only** should be considered when answering this question.

Molecule X contains three C=C double bonds. One mole of X is reacted with three moles of HBr. The carbon skeleton is unchanged.

molecule X



How many different products are formed?

- A 3
- B 4
- C 6
- D 8

16. Nov/2021/Paper_13/No.22

Structural isomerism **and** stereoisomerism should be considered when answering this question.

A colourless liquid, $C_5H_{11}Cl$, exists as a mixture of two optical isomers.

When heated with sodium hydroxide in ethanol, a mixture of **only two** alkenes is formed.

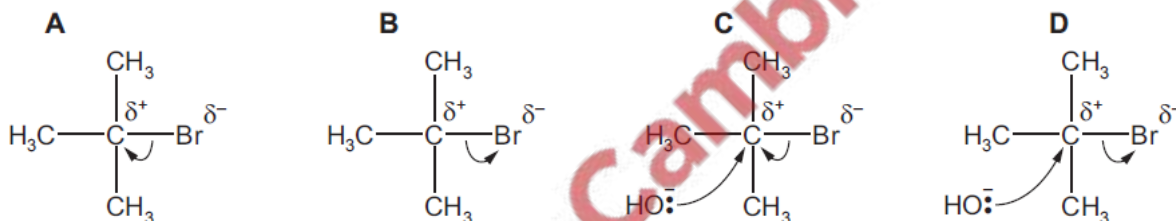
What could the colourless liquid be?

- A $(CH_3CH_2)_2CHCl$
- B $CH_3CH_2CH_2CHClCH_3$
- C $CH_3CH_2CCl(CH_3)_2$
- D $(CH_3)_2CHCHClCH_3$

17. Nov/2021/Paper_13/No.23

When 2-bromo-2-methylpropane reacts with aqueous sodium hydroxide, an alcohol is formed.

Which diagram describes the first step in the reaction mechanism?



18. Nov/2021/Paper_13/No.24

When an organic compound, Q, is treated with phosphorus pentachloride, fumes of hydrogen chloride are evolved. When Q is warmed with acidified aqueous potassium dichromate(VI), the solution turns green.

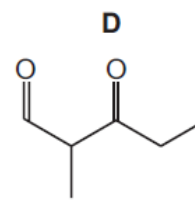
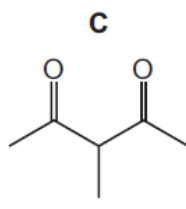
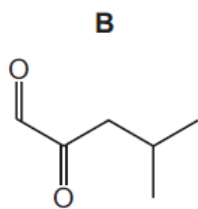
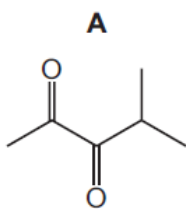
What is Q?

- A CH_3CH_2CHO
- B $CH_3CH_2CO_2H$
- C $CH_3CH(OH)CH_3$
- D $(CH_3)_3COH$

19. Nov/2021/Paper_13/No.29

Reduction of compound R with LiAlH_4 gives the compound 4-methylpentane-2,3-diol.

What could be the identity of compound R?



20. Nov/2021/Paper_13/No.38

One molecule of dodecane, $\text{C}_{12}\text{H}_{26}$, is cracked, producing three product molecules, X, Y and Z.

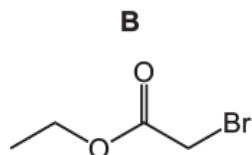
X is a straight chain alkane. Y and Z are straight chain alkenes with different M_r values.

Which statements about X, Y and Z are correct?

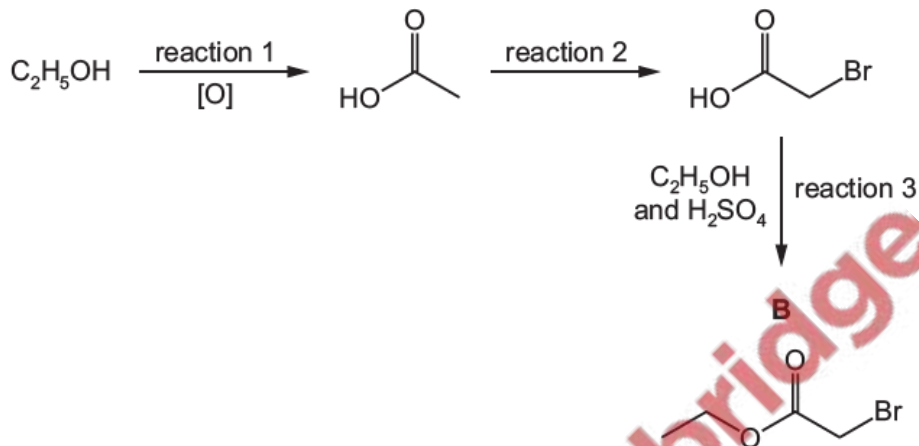
- 1 If Y and Z are but-1-ene and ethene respectively, X will be hexane.
- 2 If X is butane, then Y and Z could both show *cis-trans* isomerism.
- 3 X could be octane.



Compound **B** is a liquid with a fruity smell.



The reaction scheme shows how **B** can be made from ethanol, C_2H_5OH .



(a) (i) Reaction 1 is an oxidation reaction.

Give the reagent(s) and conditions required for reaction 1.

reagent(s)

conditions

[2]

(ii) Construct an equation to represent reaction 1.

Use [O] to represent an oxygen atom from the oxidising agent in this reaction.

..... [1]

(iii) Suggest the type of reaction that occurs in reaction 2.

..... [1]

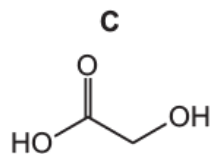
(iv) H_2SO_4 acts as a homogeneous catalyst in reaction 3.

Explain why H_2SO_4 is described as *homogeneous*.

.....

..... [1]

(b) Reaction 2 needs to take place in the absence of water to prevent formation of compound **C**.



If **C** is present in the reaction mixture of reaction 3, a different compound, compound **D**, will also form. Compound **D** has two identical functional groups.

The infrared spectrum of **D** shows strong absorptions at 1100cm^{-1} and 1720cm^{-1} , but no absorption due to O–H bonds.

Use the *Data Booklet* to identify the functional group present in **D**.

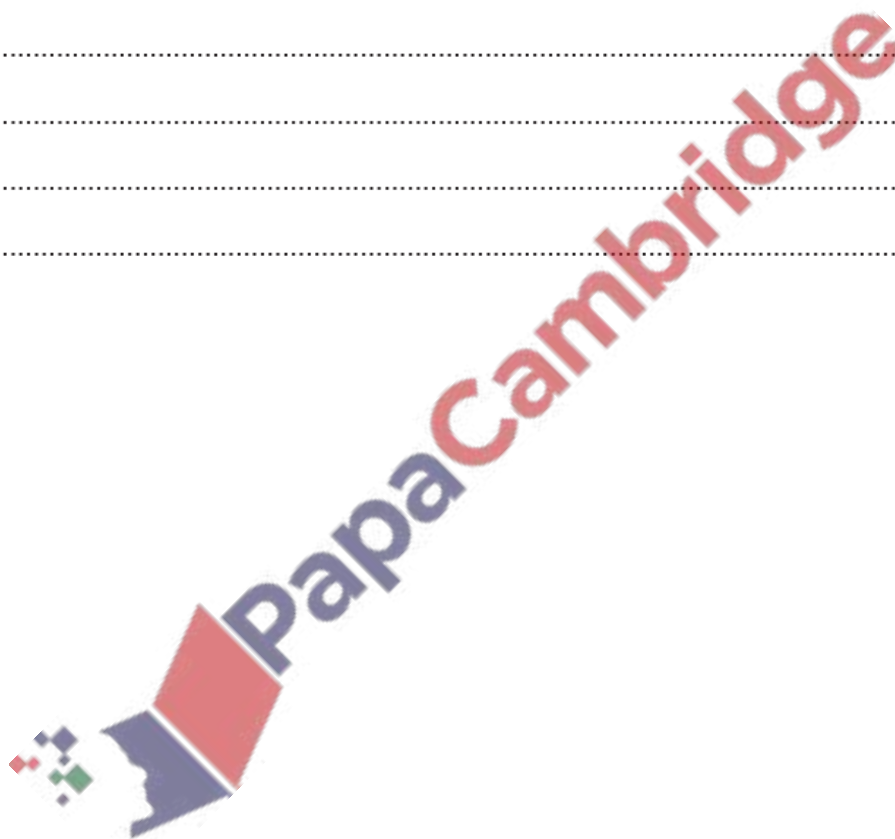
Explain your answer as fully as you can.

.....

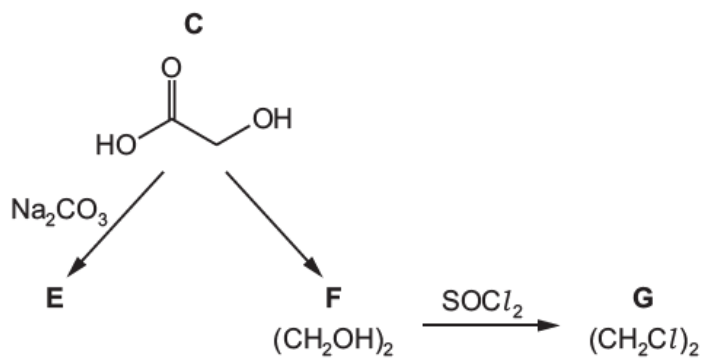
.....

.....

..... [3]



(c) Some other reactions of **C** are shown.



(i) Draw the structure of **E**.

[1]

(ii) Suggest why NaBH_4 is not a suitable reagent to make **F**, $(\text{CH}_2\text{OH})_2$, from **C**. Explain your answer.

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

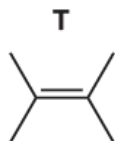
(iii) Construct an equation for the reaction of $(\text{CH}_2\text{OH})_2$ with SOCl_2 to form **G**, $(\text{CH}_2\text{Cl})_2$.

..... [1]

(d) Explain why **C** is very soluble in water.

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

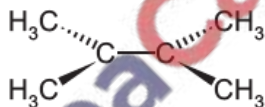
[Total: 12]

Compound **T** is an isomer of C_6H_{12} .(a) Name **T**.

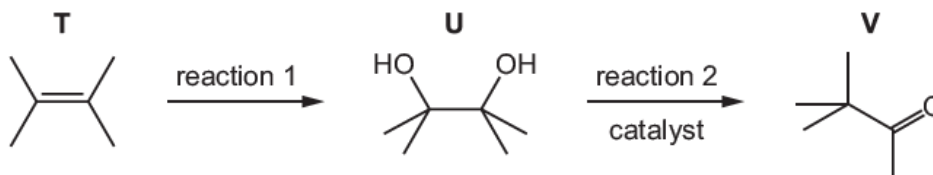
..... [1]

(b) Draw the skeletal formula of a structural isomer of **T** that shows *cis-trans* (geometrical) isomerism.

[1]

(c) Each carbon atom in **T** forms a sigma (σ) bond to at least one other carbon atom, as shown.(i) On the diagram, draw the orbitals that represent the pi (π) bond that is also present in **T**. [1](ii) State the hybridisation of the two carbon atoms between which the pi (π) bond forms.

..... [1]

(d) A reaction scheme starting with **T** is shown. Reaction 2 occurs in the presence of a catalyst; knowledge of the mechanism for this reaction is not required.

(i) Give the reagent(s) and conditions for reaction 1.

..... [1]

- (ii) State and explain how 2,4-dinitrophenylhydrazine (2,4-DNPH) can be used to detect the presence of **V** as a product of reaction 2.

.....

 [2]

- (iii) The progress of reaction 2 can be monitored by infrared spectroscopy.

The absorption caused by O–H bonds is always present because water is used as a solvent.

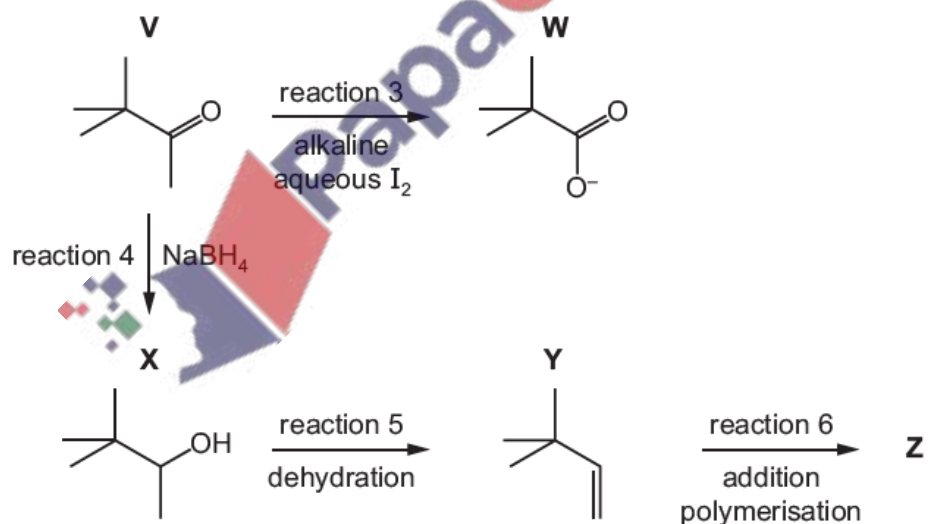
Identify two absorptions, and the bonds responsible for these absorptions, whose appearance will change significantly during the reaction.

1

 2
 [2]

- (e) **V** is used in a wide range of organic reactions.

Some reactions of **V** are shown.



- (i) **V** and **W** are colourless and soluble in water.

State what you would observe in reaction 3.

..... [1]

(ii) Reaction 3 is a redox reaction.

Identify which of the **reactants** is reduced in this reaction.

..... [1]

(iii) Construct an equation for reaction 4.

Use [H] in the equation to represent an atom of hydrogen from NaBH₄.

C₆H₁₂O + [1]

(iv) **X** is a mixture of two optical isomers.

Draw the two optical isomers in the boxes provided.

[2]

(v) Both optical isomers of **X** can be dehydrated to form a single product, **Y**.
Give the reagent(s) and conditions required for reaction 5.

..... [1]

(vi) **Y** can form an addition polymer **Z**.

Draw one repeat unit of **Z**.



[1]

(vii) Reaction 6 does not proceed quickly at room temperature.

Suggest why this is the case.

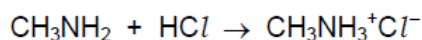
.....

..... [1]

[Total: 17]

23. March/2021/Paper_12/No.19

Methylamine, CH_3NH_2 , has similar chemical properties to ammonia, NH_3 . Methylamine reacts with hydrogen chloride to form a white crystalline salt, methylammonium chloride.



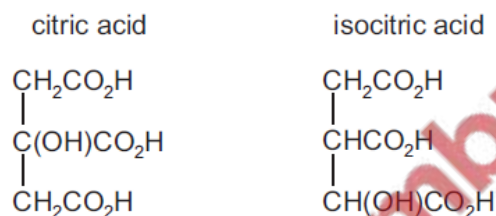
A sample of methylammonium chloride is heated with aqueous sodium hydroxide.

What are the products?

- A ammonia, sodium chloride and water
- B ammonia, sodium hydrogencarbonate and sodium chloride
- C methylamine, hydrogen chloride and water
- D methylamine, sodium chloride and water

24. March/2021/Paper_12/No.20

The structures of citric acid and isocitric acid are shown.

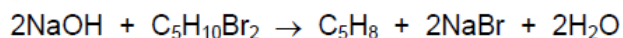


How many chiral centres does each acid possess?

	citric acid	isocitric acid
A	1	1
B	1	2
C	0	1
D	0	2

25. March/2021/Paper_12/No.25

Dibromopentanes can undergo 'double elimination' reactions to produce hydrocarbons.

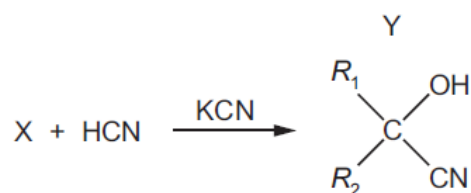


Which isomer produces only one hydrocarbon product?

- A 1,5-dibromopentane
- B 1,4-dibromopentane
- C 2,3-dibromopentane
- D 2,4-dibromopentane

26. March/2021/Paper_12/No.26

The diagram shows the formation of compound Y from compound X in a chemical reaction. R_1 and R_2 are alkyl groups.



Which row about this reaction is correct?

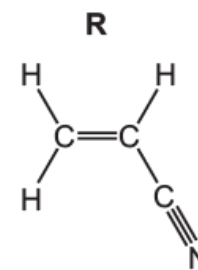
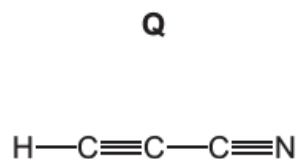
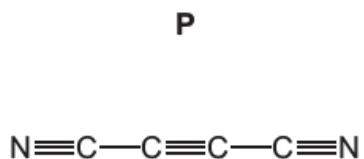
	mechanism	compound X
A	electrophilic addition	aldehyde
B	electrophilic addition	ketone
C	nucleophilic addition	ketone
D	nucleophilic addition	aldehyde

27. March/2021/Paper_12/No.37

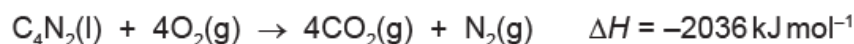
In which reactions is the major product formed by a nucleophilic substitution reaction?

- 1 bromoethane + potassium cyanide in ethanol
- 2 bromoethane + ammonia in ethanol under pressure
- 3 bromoethane + hot concentrated sodium hydroxide in ethanol

Compounds **P**, **Q** and **R** have all been found in the atmosphere of one of Saturn's moons.



(a) The equation for the complete combustion of **P**, $\text{C}_4\text{N}_2(\text{l})$, is shown.



(i) The enthalpy change of formation, ΔH_f , of $\text{CO}_2(\text{g})$ is -384 kJ mol^{-1} .

Calculate the enthalpy change of formation, ΔH_f , of **P**, in kJ mol^{-1} .

ΔH_f of **P** = kJ mol^{-1} [2]

(ii) One of the products of the complete combustion of **P** is nitrogen gas, $\text{N}_2(\text{g})$.

Explain the lack of reactivity of nitrogen.

..... [1]

(b) **Q** forms when HCN reacts with ethyne, $\text{H}-\text{C}\equiv\text{C}-\text{H}$.

(i) Ethyne, HCN and **Q** are all weak Brønsted–Lowry acids.

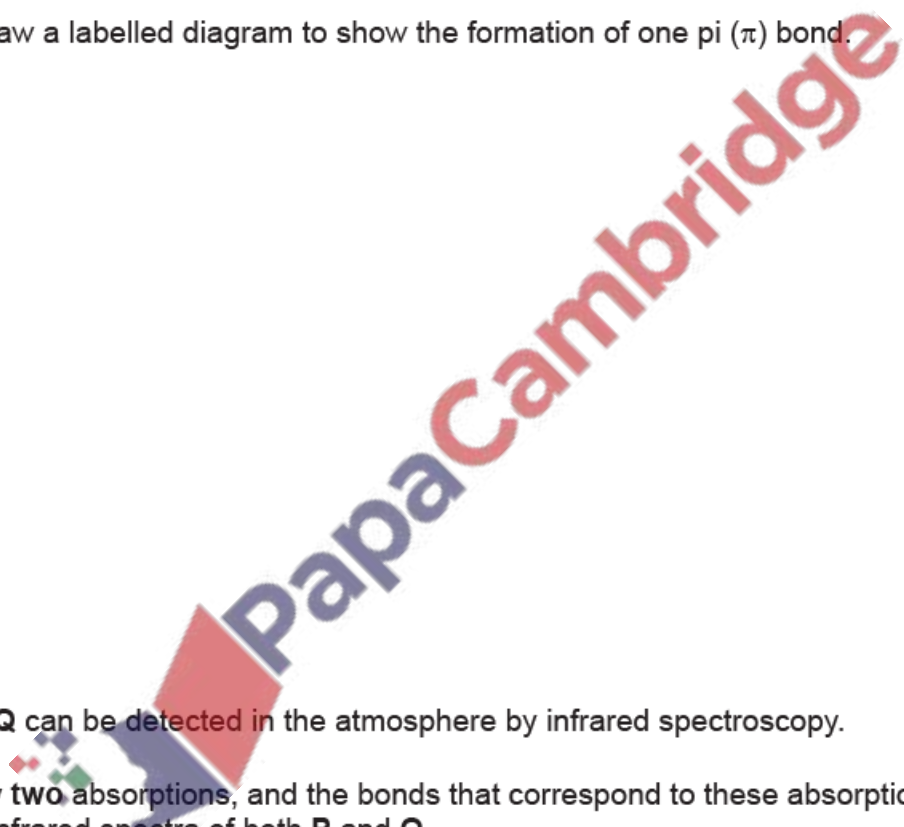
Explain what is meant by the term *weak Brønsted–Lowry acid*.

.....
.....
..... [2]

(ii) Ethyne, HCN and **Q** all contain triple bonds between two atoms.

A triple bond consists of one sigma (σ) and two pi (π) bonds.

Draw a labelled diagram to show the formation of one pi (π) bond.



[2]

(c) **P** and **Q** can be detected in the atmosphere by infrared spectroscopy.

Identify **two** absorptions, and the bonds that correspond to these absorptions, that will appear in the infrared spectra of both **P** and **Q**.

1

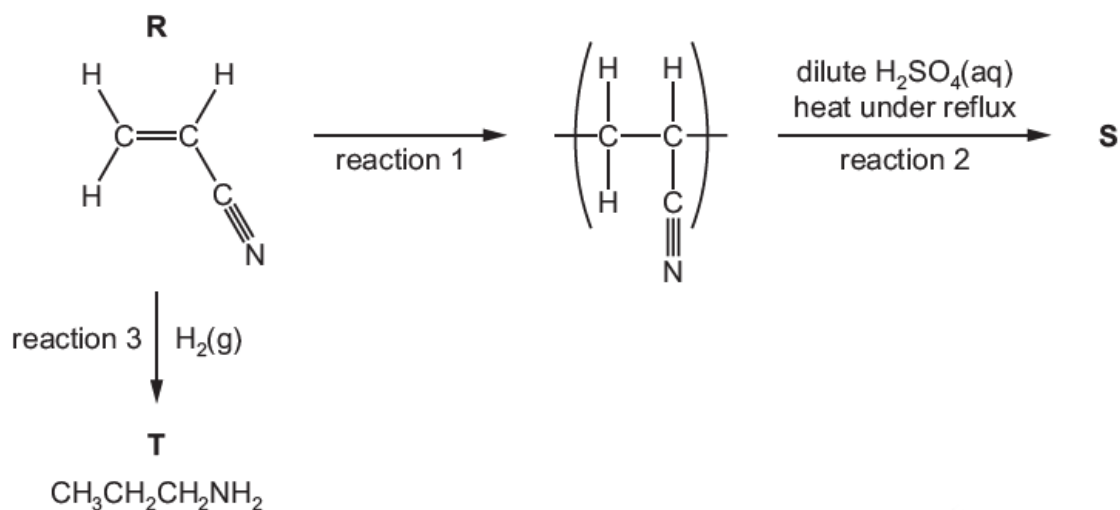
.....

2

.....

[2]

(d) The flow chart shows some reactions of **R**.



(i) Name the type of reaction shown in reaction 1.

..... [1]

(ii) Draw the structure of **S**, the organic product of reaction 2.

[1]

(iii) Name **T**.

..... [1]

(iv) **T** can also be formed by the reaction of $\text{CH}_3\text{CH}_2\text{CH}_2\text{Br}$ with ammonia.

State the necessary conditions of this reaction.

..... [1]

[Total: 13]

29. June/2021/Paper_11/No.20

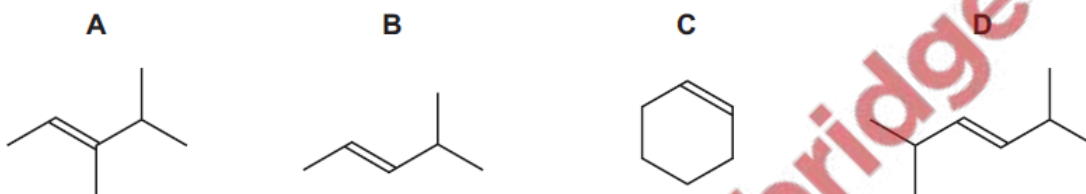
Bromoethane reacts with cyanide ions, producing propanenitrile.

Which statement about the S_N2 mechanism of this reaction is correct?

- A The lone pair of electrons on C of CN⁻ attacks the carbon atom of the C–Br bond.
- B The lone pair of electrons on C of CN⁻ attacks the carbocation formed when the C–Br bond breaks.
- C The lone pair of electrons on N of CN⁻ attacks the carbon atom of the C–Br bond.
- D The lone pair of electrons on N of CN⁻ attacks the carbocation formed when the C–Br bond breaks.

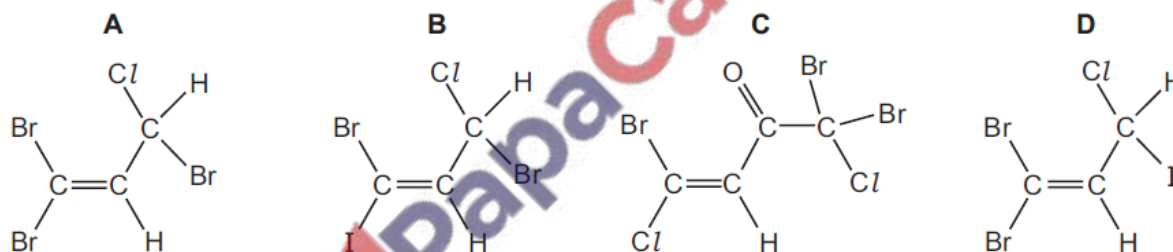
30. June/2021/Paper_11/No.21

Which compound would produce two different carboxylic acids when treated with hot, concentrated, acidified manganate(VII) ions?



31. June/2021/Paper_11/No.22

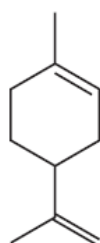
Which compound could show **both** *cis-trans* isomerism and optical isomerism?



32. June/2021/Paper_11/No.23

Limonene is a hydrocarbon found in the rind of citrus fruits.

limonene

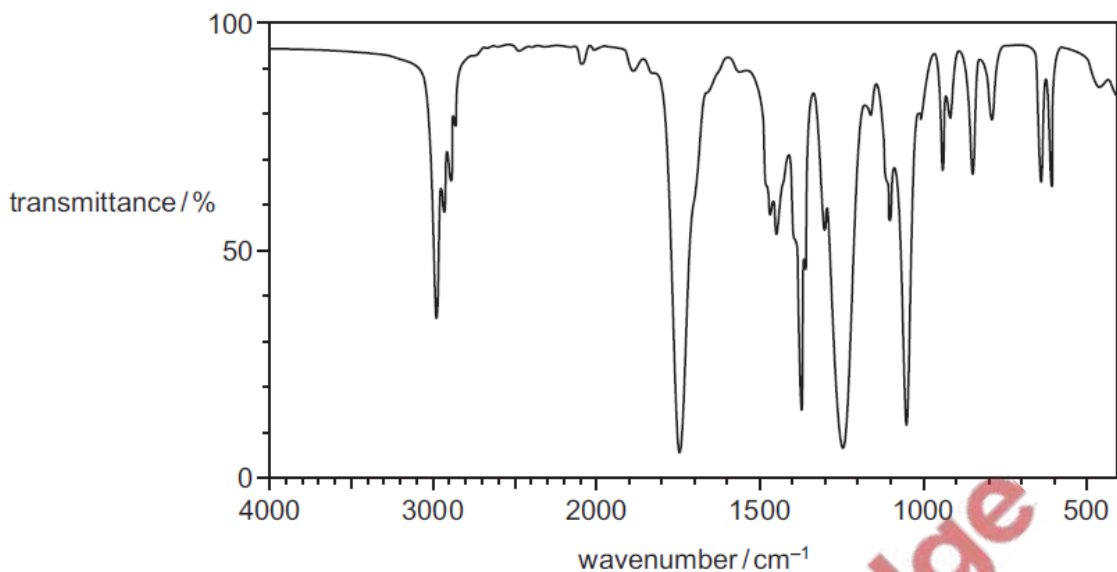


What is the molecular formula of limonene?

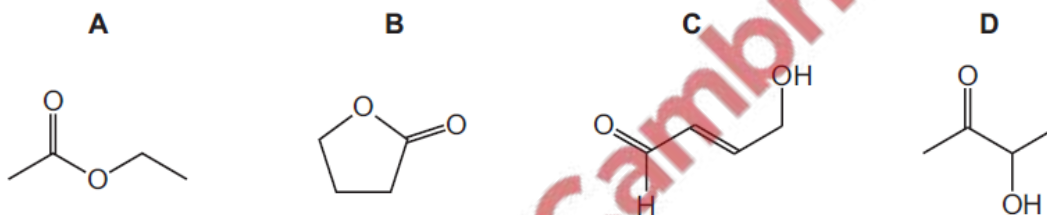
- A C₁₀H₁₂ B C₁₀H₁₄ C C₁₀H₁₆ D C₁₀H₁₈

33. June/2021/Paper_11/No.26

Compound X has the empirical formula C_2H_4O . Its infra-red spectrum is shown.



What could be the skeletal formula of compound X?



34. June/2021/Paper_11/No.29

The table describes four reactions of propene.

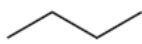


Which row is correct?

	reagent used	name of main organic product
A	aqueous bromine	2-bromopropane
B	cold acidified aqueous potassium manganate(VII)	propane-1,3-diol
C	hydrogen chloride	2-chloropropane
D	steam	propan-1-ol

35. June/2021/Paper_11/No.33

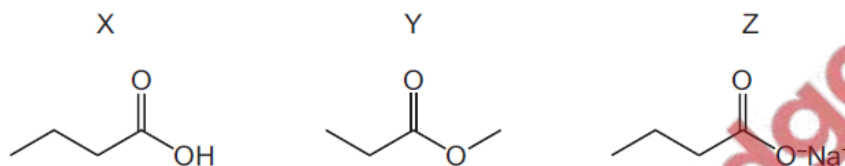
A gaseous hydrocarbon has a density of 2.42 g dm^{-3} under room conditions.

What could be the skeletal formula of this hydrocarbon?

- 1 
- 2 
- 3 

36. June/2021/Paper_12/No.3

The structures represent three compounds, each with four carbon atoms per molecule.

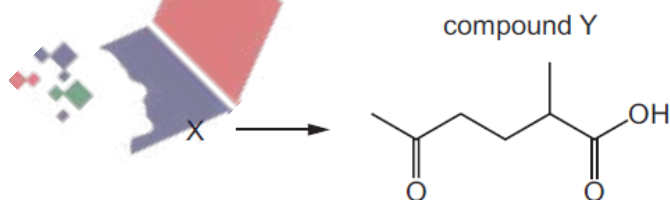


Which row is correct?

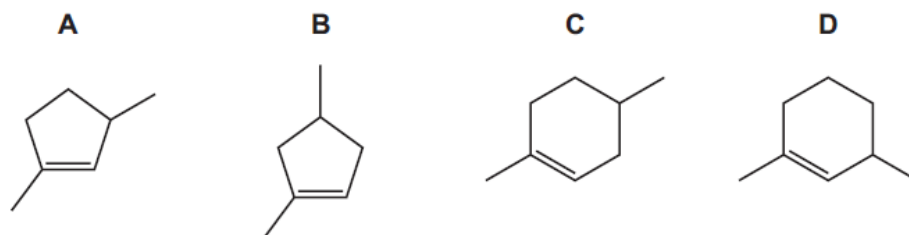
	lowest boiling point	→	highest boiling point
A	X	Y	Z
B	Y	X	Z
C	Z	X	Y
D	Z	Y	X

37. June/2021/Paper_12/No.22

Compound X can be converted into compound Y in a single step.



What could be the identity of X?



38. June/2021/Paper_12/No.23

Methane and bromine react by free radical substitution.

P and Q are involved in the reaction mechanism.

P and Q:

- are **both** involved in propagation steps as reactants
- are **both** involved in termination steps as reactants.

What could be P and Q?

- A Br and H B Br and CH₃ C Br and C₂H₆ D CH₃ and CH₃Br

39. June/2021/Paper_12/No.24

A few drops of 2-bromopropane were placed in a test-tube. An equal volume of aqueous silver nitrate was added. A precipitate was formed.

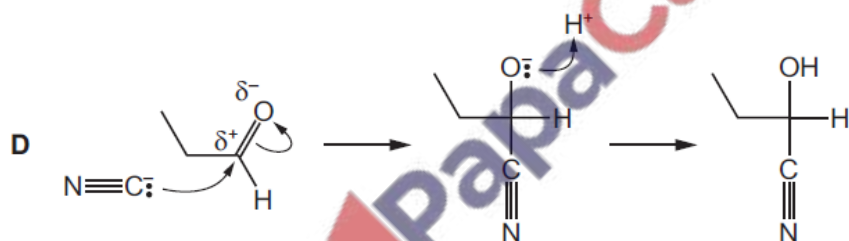
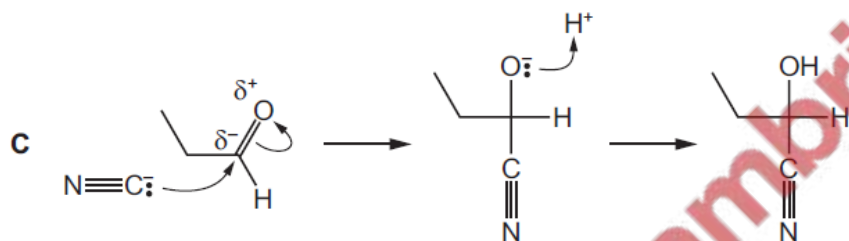
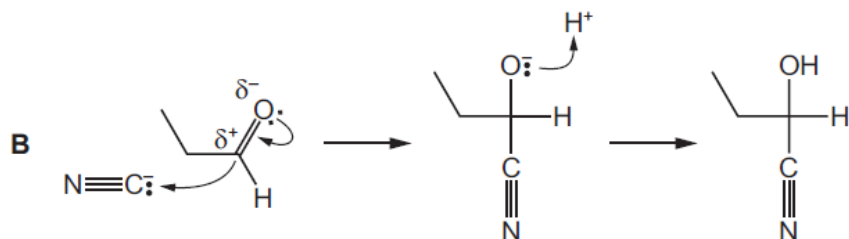
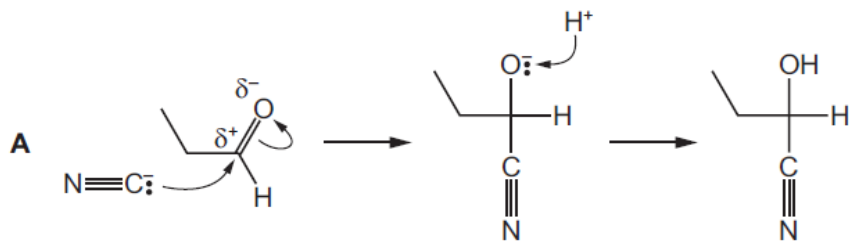
The experiment was repeated with 2-iodopropane.

Which row is correct?

	colour of precipitate from 2-bromopropane + AgNO ₃ (aq)	faster rate of reaction
A	cream	2-bromopropane + AgNO ₃ (aq)
B	yellow	2-bromopropane + AgNO ₃ (aq)
C	cream	2-iodopropane + AgNO ₃ (aq)
D	yellow	2-iodopropane + AgNO ₃ (aq)

40. June/2021/Paper_12/No.28

Which reaction mechanism for the formation of $C_2H_5CH(OH)(CN)$ is correct?



41. June/2021/Paper_12/No.32

Compound X is a straight chain hydrocarbon with an M_r of 84.

What can be determined about X?

- 1 empirical formula
- 2 molecular formula
- 3 whether X contains a C=C bond or not

The responses **A** to **D** should be selected on the basis of

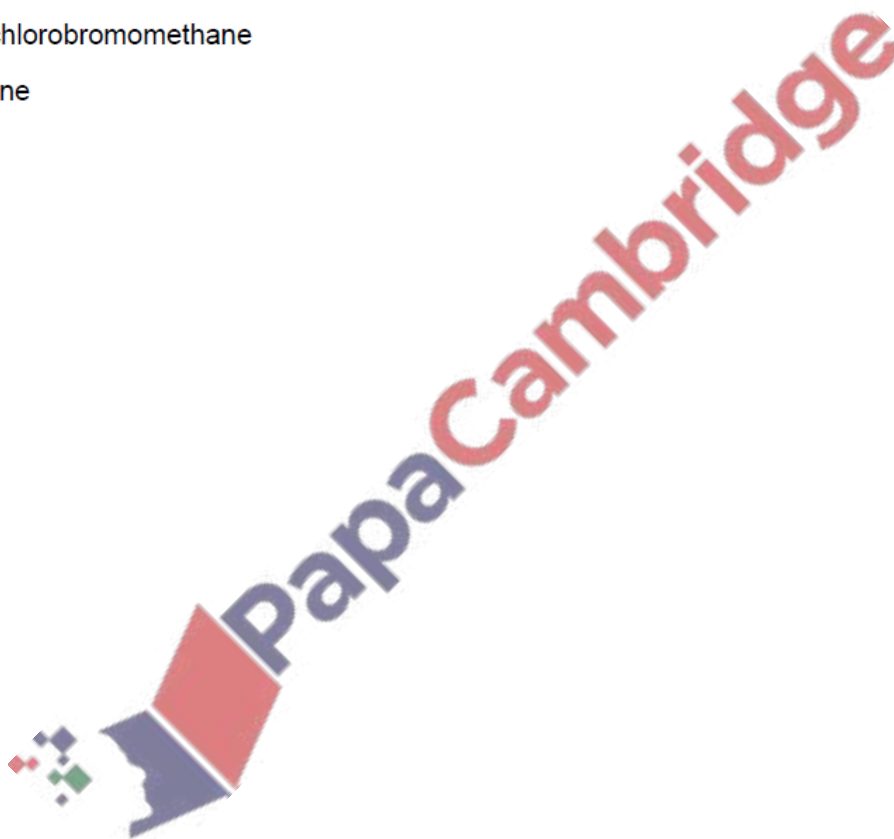
A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

No other combination of statements is used as a correct response.

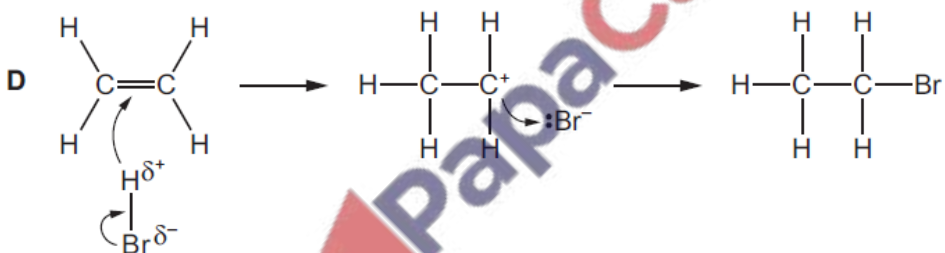
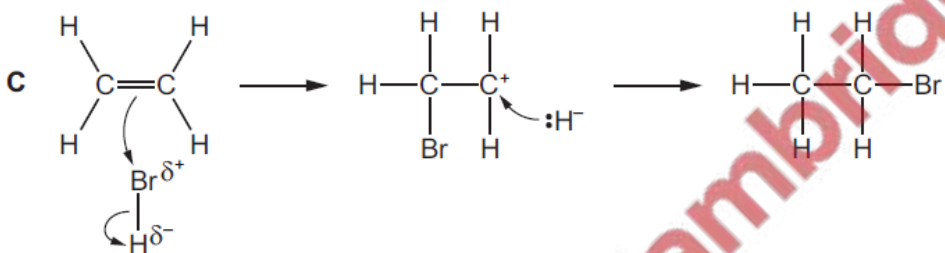
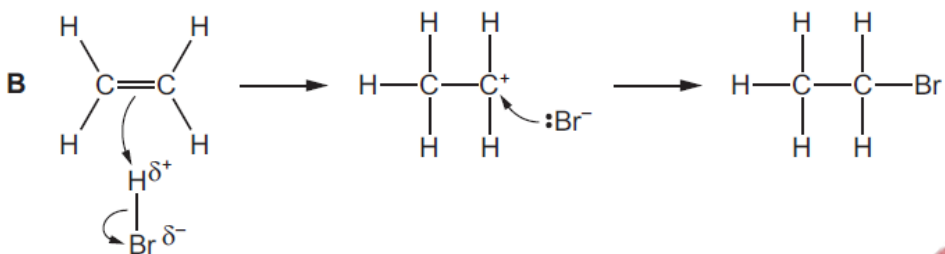
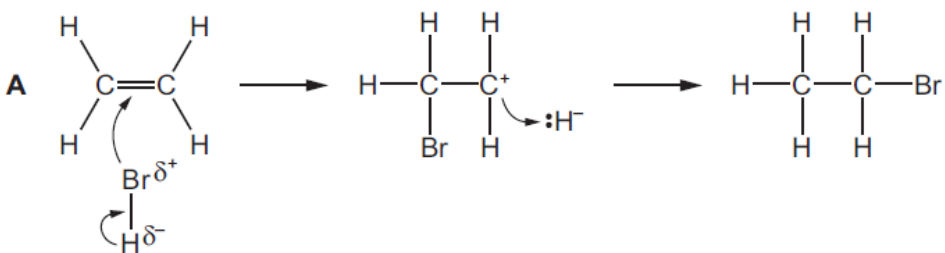
42. *June/2021/Paper_13/No.20*

Which compound shows stereoisomerism?

- A 2-methylbut-2-ene
- B 2-chloropropan-1-ol
- C difluorochlorobromomethane
- D pent-1-ene



What is the correct mechanism for the addition of hydrogen bromide to ethene?



PapaCambridge

(a) Naphtha is a mixture which contains only hydrocarbon molecules.

(i) What is meant by the term *hydrocarbon*?

.....
 [1]

(ii) Name the raw material that is used to produce a sample of naphtha.

..... [1]

(b) Compound **V** is found in naphtha. It has a molecular formula $C_{10}H_{22}$.

When **V** is heated at high pressure in the absence of air, an equal number of moles of ethene, propene and **W** are made. **W** is a compound made of straight chain, saturated molecules.

(i) Name the process that describes this reaction.

..... [1]

(ii) Deduce the structure of **W**. Draw its structure below.

[1]

(c) Propene is separated from the mixture and heated in air in the presence of a catalyst. Propene is oxidised to **X**, which contains two functional groups.

(i) Effervescence is seen when $Na_2CO_3(aq)$ is added to **X**.

Identify the functional group present in **X** which is responsible for this observation.

..... [1]

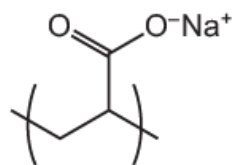
(ii) Identify a reagent which could be used to show that **X** contains a $C=C$. Include relevant observations.

.....
 [2]

(d) X reacts with another reagent to form Y.

Molecules of Y react together to form addition polymer Z. The diagram shows the repeat unit of polymer Z.

repeat unit of polymer Z



Draw the structural formula of monomer Y.

[1]

(e) Polymer Z is useful because it absorbs large amounts of water. However, there are problems associated with the disposal of products containing polymer Z.

Combustion is not an appropriate method to dispose of pure Z because the process releases harmful gases. Some of these gases contribute to the enhanced greenhouse effect.

(i) Identify a gas released during the combustion of Z which contributes to the enhanced greenhouse effect.

..... [1]

(ii) Identify another gas which could be produced during the combustion of pure Z. Describe a consequence, other than the enhanced greenhouse effect, of its release into the atmosphere.

gas

consequence

[1]

[Total: 10]

Propene, C_3H_6 , reacts with H_2O in the presence of an acid catalyst to form an alcohol with molecular formula C_3H_8O .

(a) Name this type of reaction.

..... [1]

(b) Name the catalyst used and state the conditions needed for this reaction to occur.

catalyst

conditions

[2]

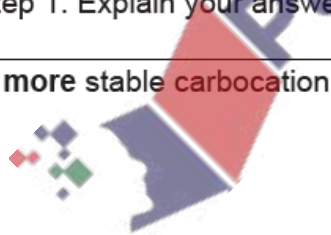
(c) Complete the table to show the numbers of sigma (σ) bonds and pi (π) bonds present in propene, C_3H_6 , and C_3H_8O .

	σ	π
C_3H_6		
C_3H_8O		

[2]

(d) The reaction of propene, C_3H_6 , with H_2O occurs in a two-step mechanism. In step 1 C_3H_6 reacts with the catalyst, H^+ , to form a carbocation.

(i) Draw structures to identify the more stable and less stable carbocations which can form in step 1. Explain your answer.

more stable carbocation	less stable carbocation
	

explanation

.....

.....

.....

.....

[3]

(ii) Name the major organic product formed from the reaction of propene, C_3H_6 , with H_2O .

..... [1]

(e) 2-bromopropane reacts to form propene, hydrogen bromide and water under certain conditions.

(i) Name this type of reaction.

..... [1]

(ii) Describe the reagents and conditions needed to favour this reaction.

reagents

conditions

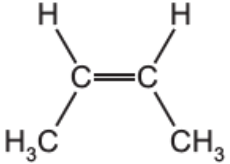
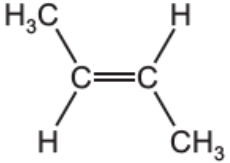
[2]

[Total: 12]



(a) The table shows the structural formulae of four compounds, **A**, **B**, **C** and **D**, with molecular formula C_4H_8 .

(i) Complete the table by giving the systematic name of **A**, **B**, **C** and **D**.

	structural formula	name
A	$CH_3CH_2CH=CH_2$	
B		
C		
D	$CH_2=C(CH_3)_2$	

[4]

(ii) Explain what is meant by *stereoisomerism*.

.....
 [1]

(b) **W** is an alkene with formula C_4H_8 . It reacts with HBr to form two possible carbocations, $CH_3C^+(H)(CH_2CH_3)$ and $H_2C^+CH_2CH_2CH_3$.

(i) Identify **W** as compound **A**, **B**, **C** or **D**.

..... [1]

- (ii) Draw the skeletal formula of the major organic product formed when HBr reacts with **W**. Explain why this is the major organic product.

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

[3]

- (c) A sample of propan-1-ol reacts with concentrated sulfuric acid to form propene.
Identify the role of concentrated sulfuric acid in this reaction.

..... [1]

- (d) Alcohol **Y** reacts completely when warmed with acidified $\text{Cr}_2\text{O}_7^{2-}$ to form **Z**.

Z is distilled from the reaction mixture as soon as it is made.

Tollens' reagent is added to a sample of **Z** and warmed. A silver mirror forms.

- (i) Name the type of reaction that occurs when **Y** reacts to form **Z**.

..... [1]

- (ii) Identify with a tick (✓) the functional group(s) present in **Z**.

functional group	present in Z
aldehyde	
ketone	
carboxylic acid	

[1]

[Total: 12]