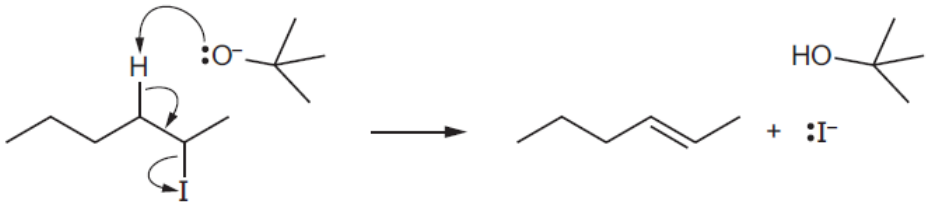
Hydrocarbons – 2021 AS

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 $(CH_3)_3CO^-$ is behaving as a Brønsted-Lowry base.

B $(CH_3)_3CO^-$ is behaving as an oxidising agent.

C The C–I bond breaks via homolytic fission.

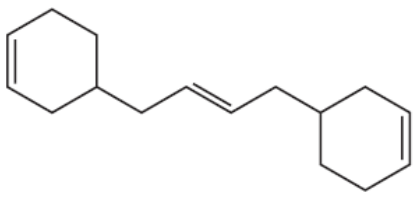
D This is a hydrolysis reaction.

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?

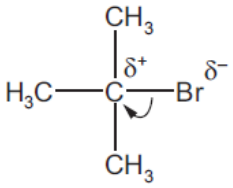
A 3 **B** 4 **C** 6 **D** 8

3. Nov/2021/Paper_11/No.23

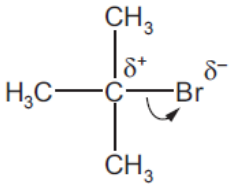
When 2-bromo-2-methylpropane reacts with aqueous sodium hydroxide, an alcohol is formed.

Which diagram describes the first step in the reaction mechanism?

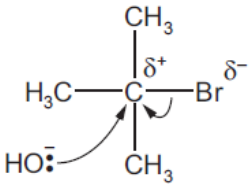
A



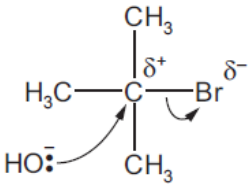
B



C



D



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–C*l* 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

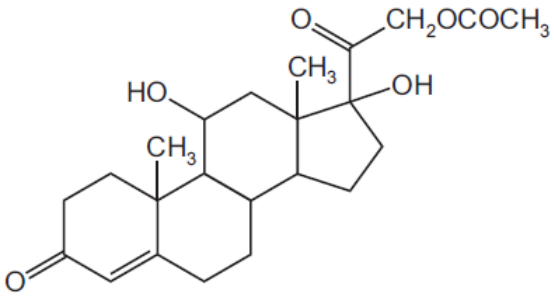
2 mixing propan-1-ol with warm ethanoic acid and a few drops of concentrated sulfuric acid

3 warming propan-1-ol with HBr

7. Nov/2021/Paper_12/No.20

The formula of hydrocortisone acetate is shown.

hydrocortisone acetate



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?

A $C_2H_5Cl + Cl\bullet \rightarrow C_2H_4Cl\bullet + HCl$

B $C_2H_6 + Cl\bullet \rightarrow C_2H_5Cl + H\bullet$

C $C_2H_5Cl + H\bullet \rightarrow C_2H_5\bullet + HCl$

D $C_2H_5\bullet + Cl\bullet \rightarrow C_2H_5Cl$

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 C_2H_3Cl

3 C_3H_6O

12. Nov/2021/Paper_12/No.39

Which of the reactions give products containing a chiral centre?

1 $CH_2(OH)COCO_2H$ + an excess of HCN

2 $CH_2(OH)COCO_2H$ + an excess of $NaBH_4$

3 $CH_2(OH)COCO_2H$ + 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?

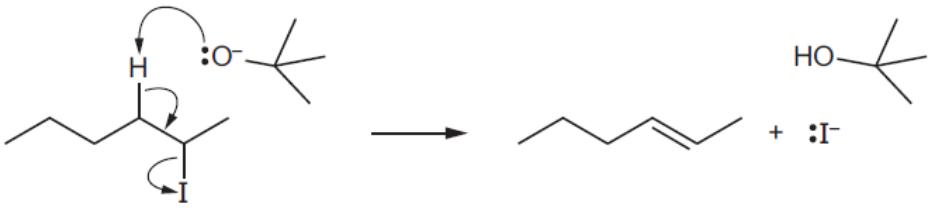
1 sodium butanoate

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?

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B $(CH_3)_3CO^-$ is behaving as an oxidising agent.

C The C–I bond breaks via homolytic fission.

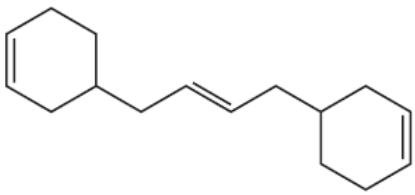
D This is a hydrolysis reaction.

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 $CH_3CH_2CCl(CH_3)_2$

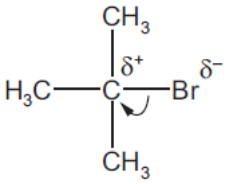
D $(CH_3)_2CHCHClCH_3$

17. Nov/2021/Paper_13/No.23

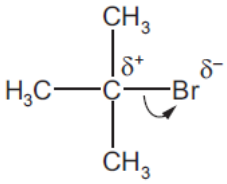
When 2-bromo-2-methylpropane reacts with aqueous sodium hydroxide, an alcohol is formed.

Which diagram describes the first step in the reaction mechanism?

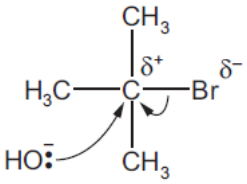
A



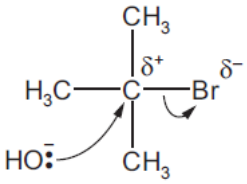
B



C



D



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 $CH_3CH(OH)CH_3$

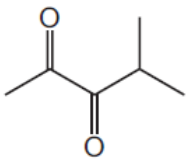
D $(CH_3)_3COH$

19. Nov/2021/Paper_13/No.29

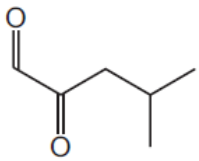
Reduction of compound R with $LiAlH_4$ gives the compound 4-methylpentane-2,3-diol.

What could be the identity of compound R?

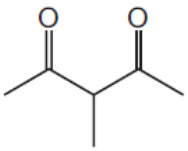
A



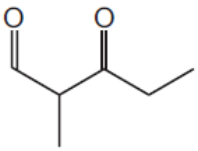
B



C



D



20. Nov/2021/Paper_13/No.38

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

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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.

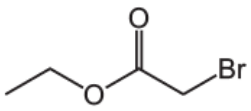
2 If X is butane, then Y and Z could both show *cis-trans* isomerism.

3 X could be octane.

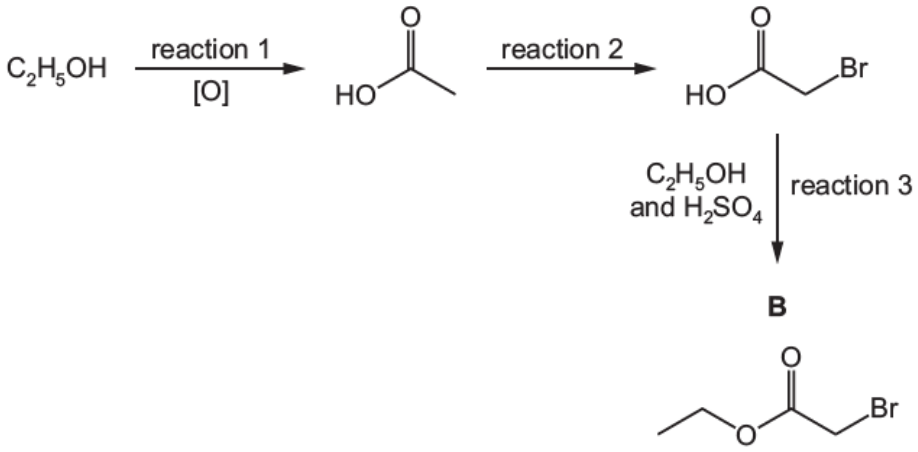
21. Nov/2021/Paper_21/No.4

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

B



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.

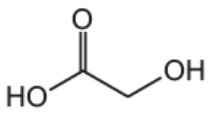
Explain why H_2SO_4 is described as *homogeneous*.

.....

..... [1]

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

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 1100 cm^{-1} and 1720 cm^{-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.

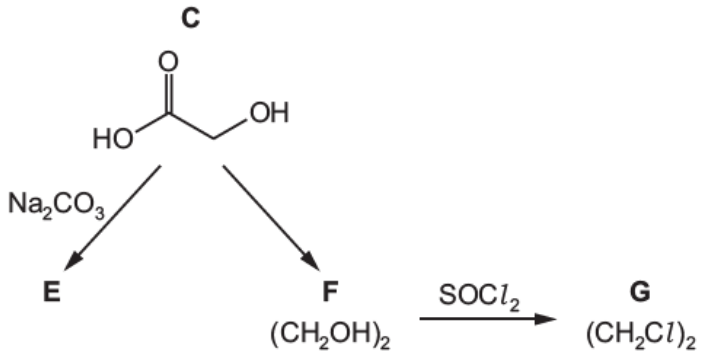
.....

.....

.....

..... [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**, $(CH_2OH)_2$, from **C**.
Explain your answer.

.....

..... [1]

(iii) Construct an equation for the reaction of $(CH_2OH)_2$ with $SOCl_2$ to form **G**, $(CH_2Cl)_2$.

..... [1]

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

.....

.....

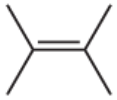
..... [1]

[Total: 12]

22. Nov/2021/Paper_22/No.3

Compound **T** is an isomer of C_6H_{12}.

T



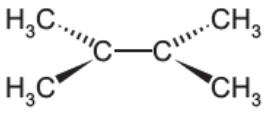
(a) Name **T**.

..... [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.

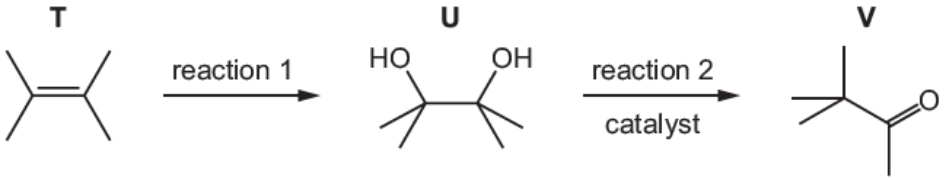


(i) On the diagram, draw the orbitals that represent the pi (π) bond that is also present in **T**. [1]

(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 .....

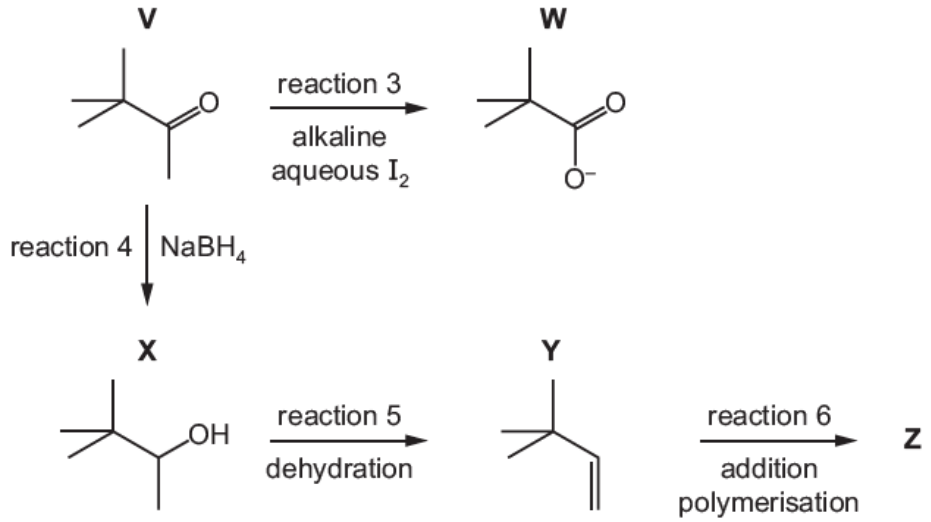
.....

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 $NaBH_4$.

$C_6H_{12}O$ + ... [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.

$$CH_3NH_2 + HCl \rightarrow CH_3NH_3^+Cl^-$$

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

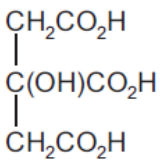
C methylamine, hydrogen chloride and water

D methylamine, sodium chloride and water

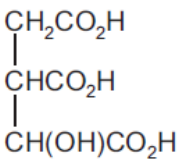
24. March/2021/Paper_12/No.20

The structures of citric acid and isocitric acid are shown.

citric acid



isocitric acid



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.

$$2NaOH + C_5H_{10}Br_2 \rightarrow C_5H_8 + 2NaBr + 2H_2O$$

Which isomer produces only one hydrocarbon product?

A 1,5-dibromopentane

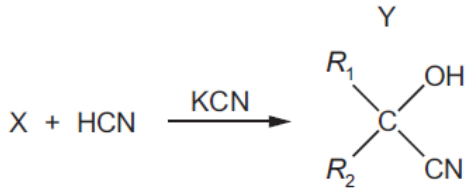
B 1,4-dibromopentane

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

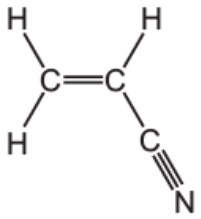
28. March/2021/Paper_22/No.3

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

P

Q

R



(a) The equation for the complete combustion of **P**, $C_4N_2(l)$, is shown.

$$C_4N_2(l) + 4O_2(g) \rightarrow 4CO_2(g) + N_2(g) \qquad \Delta H = -2036\,kJ\,mol^{-1}$$

(i) The enthalpy change of formation, ΔH_f, of $CO_2(g)$ 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, $N_2(g)$.

Explain the lack of reactivity of nitrogen.

..... [1]

https://solvedpapers.co.uk

(b) **Q** forms when HCN reacts with ethyne, H—C≡C—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 .....

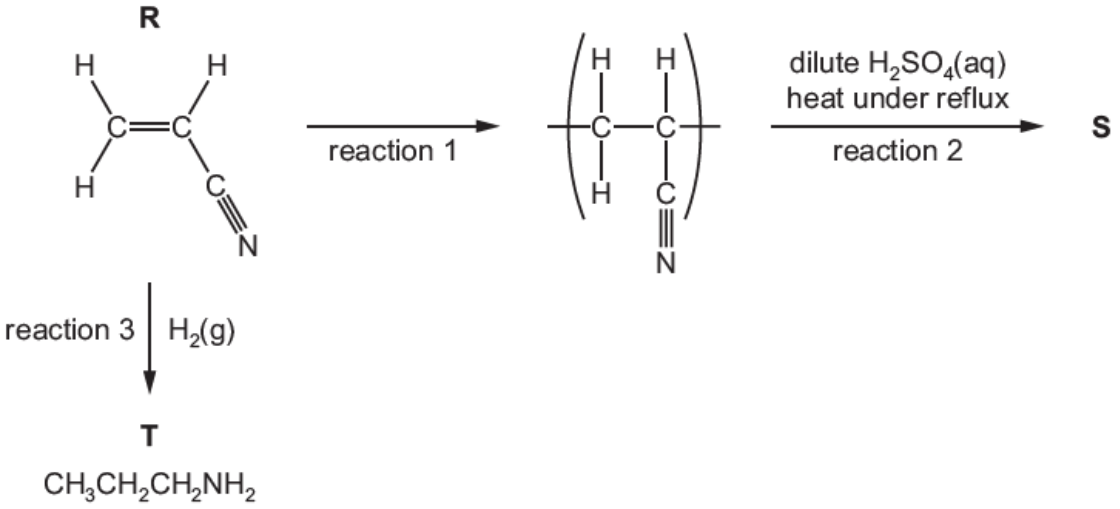
.....

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 $CH_3CH_2CH_2Br$ 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.

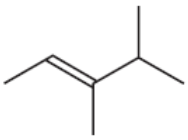
C The lone pair of electrons on N of CN^- attacks the carbon atom of the C–Br bond.

D The lone pair of electrons on N of CN^- attacks the carbocation formed when the C–Br bond breaks.

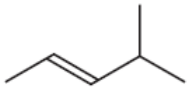
30. June/2021/Paper_11/No.21

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

A

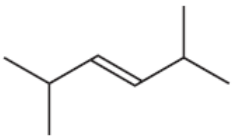


B



C

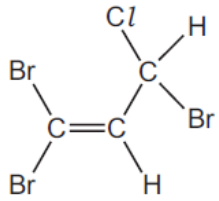
D



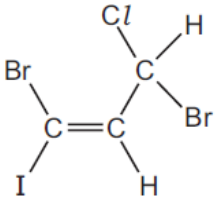
31. June/2021/Paper_11/No.22

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

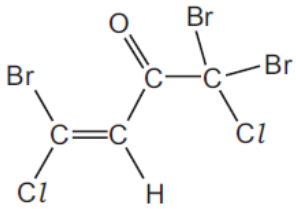
A



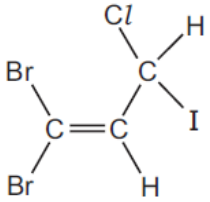
B



C



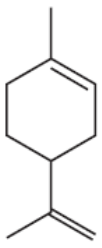
D



32. June/2021/Paper_11/No.23

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

limonene

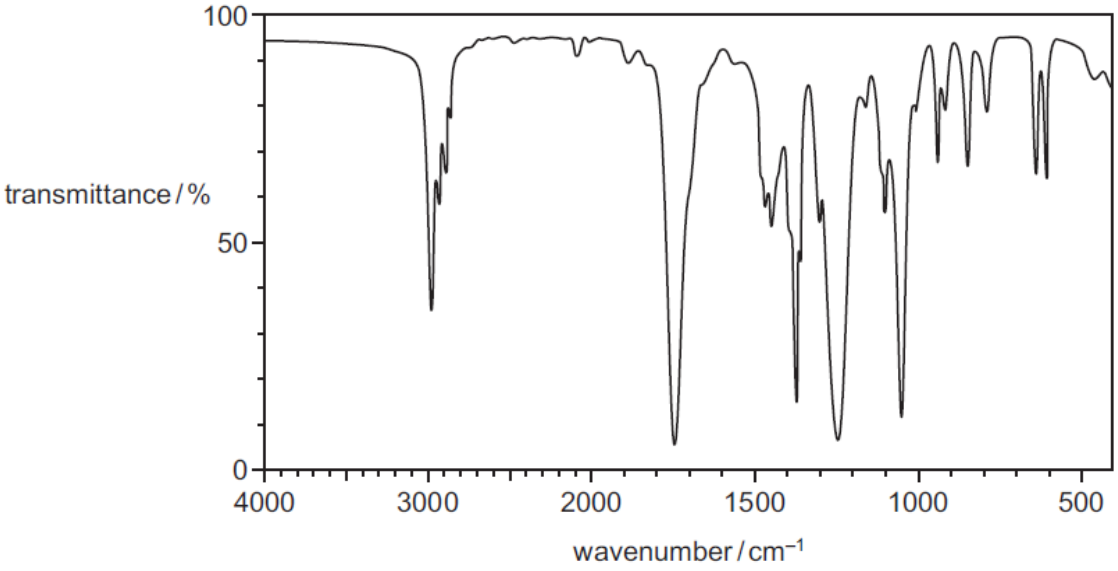


What is the molecular formula of limonene?

A $C_{10}H_{12}$ **B** $C_{10}H_{14}$ **C** $C_{10}H_{16}$ **D** $C_{10}H_{18}$

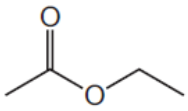
33. June/2021/Paper_11/No.26

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

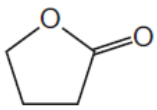


What could be the skeletal formula of compound X?

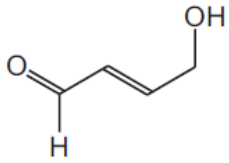
A



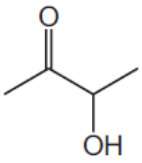
B



C



D



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

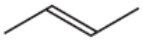
35. June/2021/Paper_11/No.33

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

What could be the skeletal formula of this hydrocarbon?

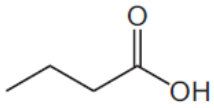
1

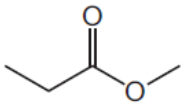
2

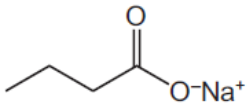
3 

36. June/2021/Paper_12/No.3

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

X 

Y 

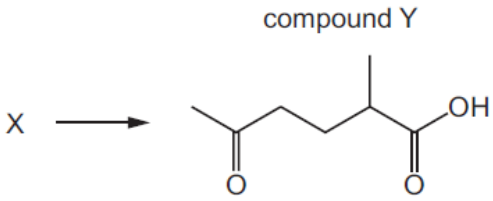
Z 

Which row is correct?

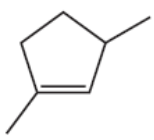
	lowest boiling point	→	highest boiling point
A	X	Y	Z
B	Y	X	Z
C	Z	X	Y
D	Z	Y	X

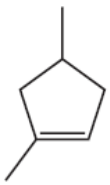
37. June/2021/Paper_12/No.22

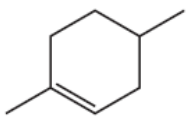
Compound X can be converted into compound Y in a single step.

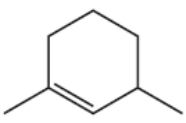


What could be the identity of X?

A 

B 

C 

D 

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 CH_3 **C** Br and C_2H_6 **D** CH_3 and CH_3Br

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.

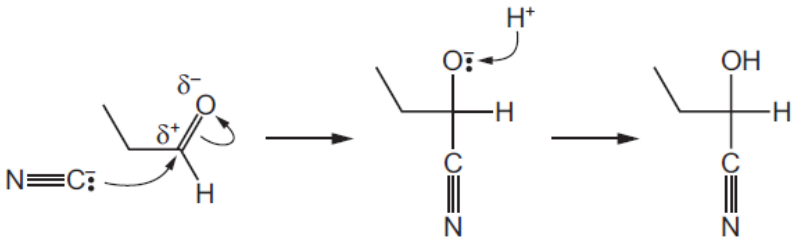
Which row is correct?

	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 + $AgNO_3(aq)$

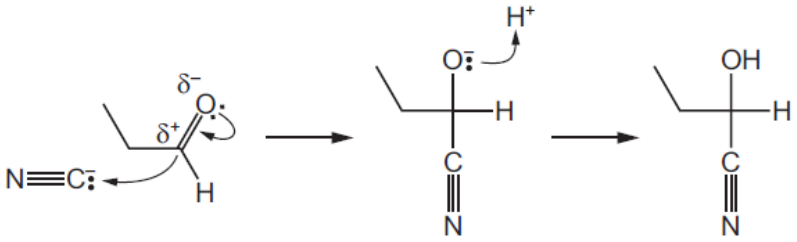
40. June/2021/Paper_12/No.28

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

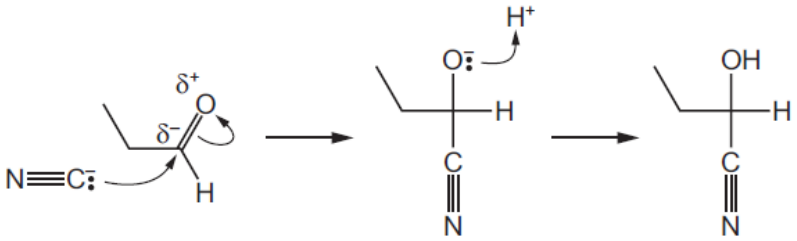
A



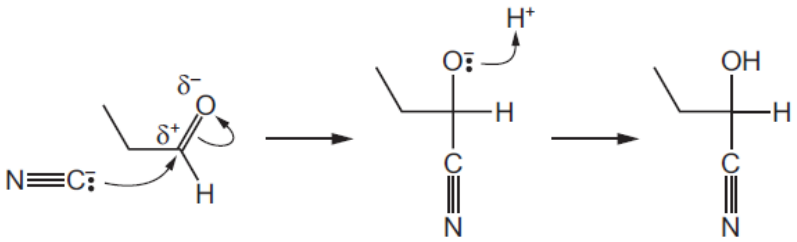
B



C



D



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

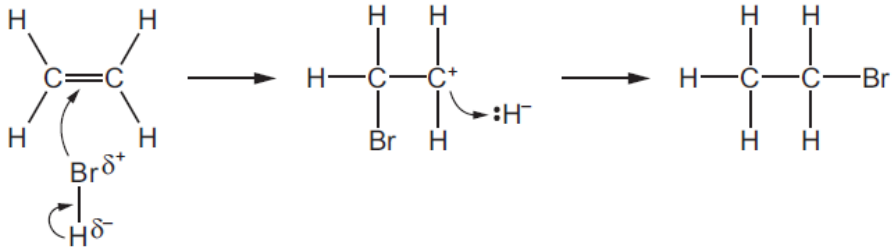
C difluorochlorobromomethane

D pent-1-ene

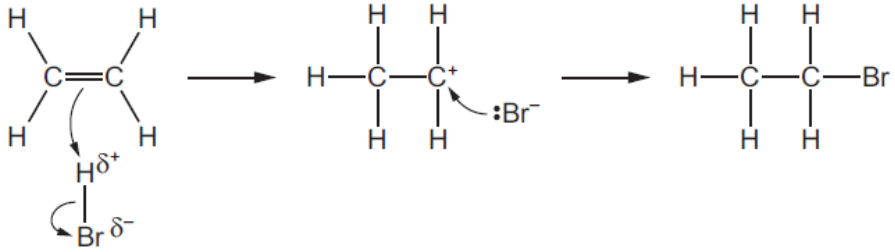
43. June/2021/Paper_13/No.22

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

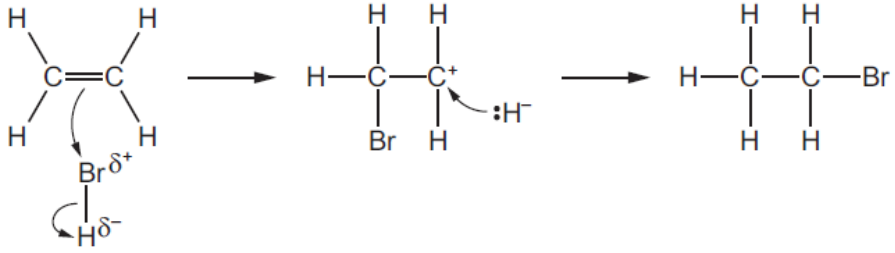
A



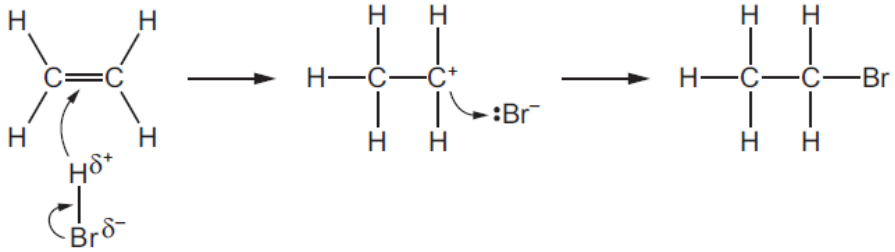
B



C



D



44. June/2021/Paper_21/No.5

(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.

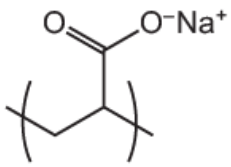
.....

..... [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]

45. June/2021/Paper_21/No.6

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 .....

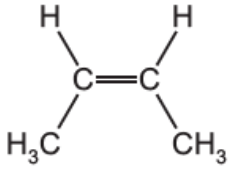
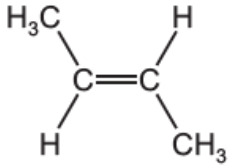
[2]

[Total: 12]

46. June/2021/Paper_22/No.4

(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 $Cr_2O_7^{2-}$ 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]