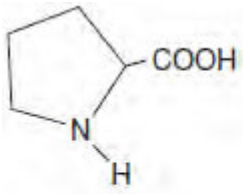
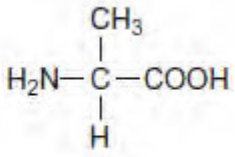
Q1.(a) The structures and common names of two amino acids are shown.



proline



alanine

(i) Draw the structure of the zwitterion of proline.

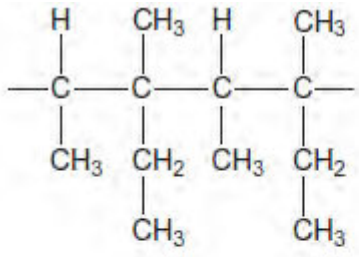
(1)

(ii) Draw the structure of the tripeptide formed when a proline molecule bonds to two alanine molecules, one on each side.

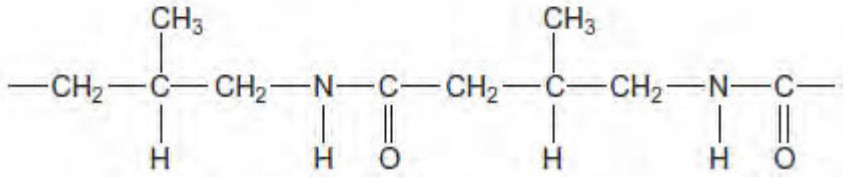
(2)

(b) Sections of two polymers, **L** and **M**, are shown.

L



M



(i) Give the IUPAC name of a monomer that forms polymer **L**.

.....

(1)

(ii) Give the IUPAC name of the monomer that forms polymer **M**.

.....

(1)

(iii) Draw the section of a polymer made from a dicarboxylic acid and a diamine that is isomeric with the section of polymer **M** shown.

(1)

(vi) Explain why polymer **L** is non-biodegradable.

.....

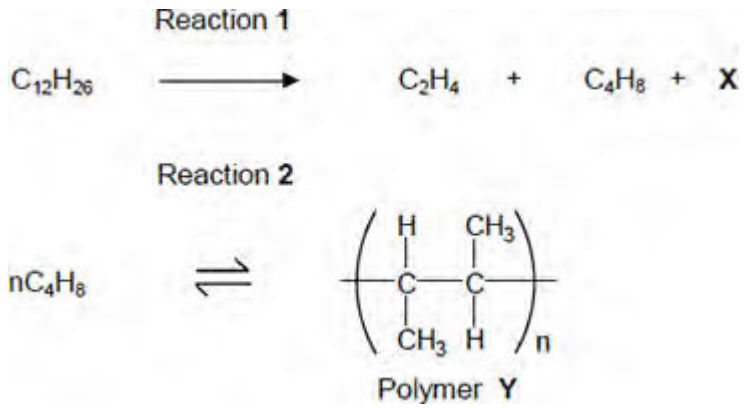
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(1)

(Total 7 marks)

Q2. Dodecane ($C_{12}H_{26}$) is a hydrocarbon found in the naphtha fraction of crude oil. Dodecane can be used as a starting material to produce a wide variety of useful products. The scheme below shows how one such product, polymer **Y**, can be produced from dodecane.



(a) Name the homologous series that both C_2H_4 and C_4H_8 belong to.
Draw a functional group isomer of C_4H_8 that does **not** belong to this homologous series.

Name .....

Functional group isomer

(2)

(b) Identify compound **X**.

.....

(1)

(c) Name polymer **Y**.

.....

(1)

(d) Reaction **1** is an example of thermal cracking and is carried out at a temperature of 750 °C.

State **one other** reaction condition needed.

.....

(1)

(e) Reaction **2** is exothermic. A typical compromise temperature of 200 °C is used industrially for this reaction.

Explain the effect of a change of temperature on both the position of equilibrium and the rate of reaction, and justify why a compromise temperature is used industrially.

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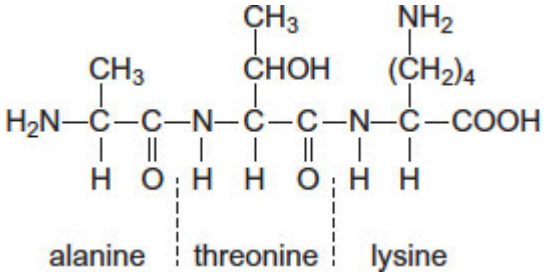
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(6)
(Total 11 marks)

Q3.(a) The tripeptide shown is formed from the amino acids alanine, threonine and lysine.



(i) Draw a separate circle around **each** of the asymmetric carbon atoms in the tripeptide.

(1)

(ii) Draw the zwitterion of alanine.

(1)

(iii) Give the IUPAC name of threonine.

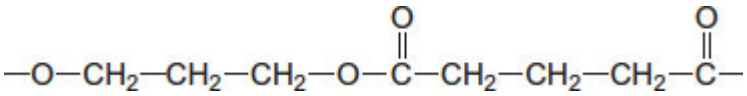
.....

(1)

(iv) Draw the species formed by lysine at low pH.

(1)

(b) The repeating unit shown represents a polyester.



(i) Name this type of polymer.

.....

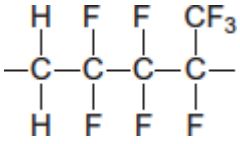
(1)

(ii) Give the IUPAC name for the alcohol used to prepare this polyester.

.....

(1)

(c) The repeating unit shown represents a polyalkene co-polymer. This co-polymer is made from two different alkene monomers.



(i) Name the type of polymerisation occurring in the formation of this co-polymer.

.....

(1)

(ii) Draw the structure of each alkene monomer.

Alkene monomer 1 Alkene monomer 2

(2)

(d) One of the three compounds shown in parts (a), (b) and (c) cannot be broken down by hydrolysis.

Write the letter **(a)**, **(b)** or **(c)** to identify this compound and explain why hydrolysis of this compound does **not** occur.

Compound .....

Explanation .....

.....

.....

(2)

(Total 11 marks)

Q4. The carbonyl compound CH_3CH_2CHO reacts very slowly with HCN

(a) Name and outline a mechanism for the reaction of CH_3CH_2CHO with HCN

Name of mechanism .....

Mechanism

(5)

(b) The reaction in part (a) produces a pair of enantiomers.

(i) Draw the structure of each enantiomer to show how they are related to each other.

(2)

(ii) State and explain how you could distinguish between the two enantiomers.

.....

.....

.....

.....

(2)

(c) Give the IUPAC name of the product of the reaction in part (a).

.....

(1)

(d) In practice, KCN rather than HCN is added to the carbonyl compound.

Given that K_a for HCN = 4.0×10^{-10} mol dm^{-3}, suggest why the reaction with HCN is very slow.

.....

.....

.....

.....

(2)

(e) Acrylic fibres are used as a substitute for wool. Acrylics are copolymers of acrylonitrile with other compounds.

Acrylonitrile is the common name for the following compound.

$$H_2C = CH - C \equiv N$$

(i) Acrylonitrile can be formed from propene.

Write an equation for the reaction of propene with ammonia and oxygen to form acrylonitrile and one other product.

.....

(1)

(ii) The term copolymer is used to describe the product obtained when two or more different monomers form a polymer.

Draw the repeating unit of the acrylic copolymer that contains 75% acrylonitrile monomer and 25% chloroethene monomer.

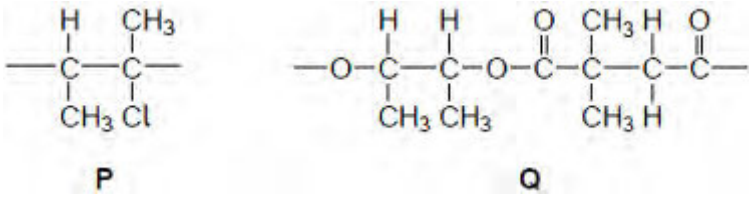
(1)

(iii) Name the type of polymerisation involved in part (ii)

.....

(1)
(Total 15 marks)

Q5. Repeating units of two polymers, **P** and **Q**, are shown in the figure below.



P **Q**

(a) Draw the structure of the monomer used to form polymer **P**.
Name the type of polymerisation involved.

Monomer

Type of polymerisation .....

(2)

(b) Draw the structures of **two** compounds that react together to form polymer **Q**.

Structure of compound 1

Structure of compound 2

(2)

(c) Suggest an environmental advantage of polymer **Q** over polymer **P**.
Justify your answer.

Advantage .....

Justification .....

.....

.....

.....

.....

(3)
(Total 7 marks)

Q1. The following pairs of compounds can be distinguished by simple test−tube reactions.

For each pair of compounds, give a reagent (or combination of reagents) that, when added separately to each compound, could be used to distinguish between them. State what is observed in each case.

(a) Butan−2−ol and 2−methylpropan−2−ol

Reagent .....

Observation with butan−2−ol

.....

.....

Observation with 2−methylpropan−2−ol

.....

.....

(3)

(b) Propane and propene

Reagent .....

Observation with propane

.....

.....

Observation with propene

.....

.....

(3)

(c) Aqueous silver nitrate and aqueous sodium nitrate

Reagent .....

Observation with aqueous silver nitrate

.....

.....

Observation with aqueous sodium nitrate

.....

.....

(3)

(d) Aqueous magnesium chloride and aqueous barium chloride

Reagent .....

Observation with aqueous magnesium chloride

.....

.....

Observation with aqueous barium chloride

.....

.....

(3)
(Total 12 marks)

Q2. In each of the following questions, you should draw the structure of the compound in the space provided.

(a) Draw the structure of the alkene that would form 1,2-dibromo-3-methylbutane when reacted with bromine.

(1)

(b) Draw the structure of the alcohol with molecular formula $C_4H_{10}O$ that is resistant to oxidation by acidified potassium dichromate(VI).

(1)

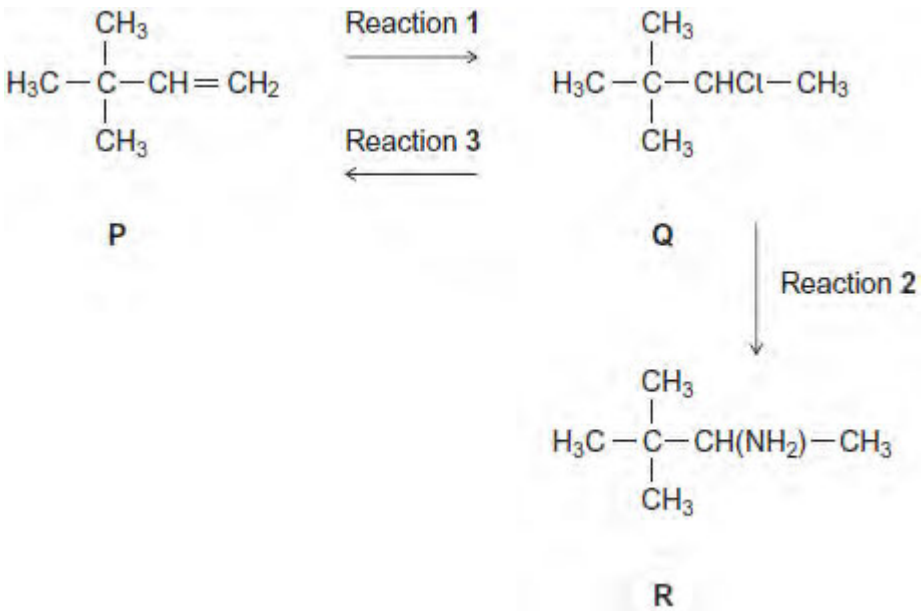
(c) Draw the structure of the alkene that has a peak, due to its molecular ion, at *m/z* = 42 in its mass spectrum.

(1)

(d) Draw the structure of the organic product with M_r = 73, made from the reaction between 2-bromobutane and ammonia.

(1)
(Total 4 marks)

Q3. Consider the following scheme of reactions.



(a) Give the IUPAC name for compound **P** and that for compound **Q**.

P .....

Q .....

(2)

(b) The conversion of **P** into **Q** in Reaction **1** uses HCl

Name and outline a mechanism for this reaction.

.....

(5)

(c) The conversion of **Q** into **R** in Reaction **2** uses NH_3

Name and outline a mechanism for this reaction.

.....

(5)

(d) State the type of reaction shown by Reaction **3**.

Identify a reagent for this reaction.

Give **one** condition necessary for a high yield of product when **Q** is converted into **P**.

.....

.....

.....

.....

.....

(3)

(e) Hydrogen bromide (HBr) could be used in the overall conversion of **P** into **R**, instead of using HCl
Hydrogen bromide is made by the reaction of NaBr with concentrated phosphoric acid.
Concentrated sulfuric acid is **not** used to make HBr from NaBr

Write an equation for the reaction of NaBr with H_3PO_4 to produce HBr and Na_3PO_4 only.

Identify **two** toxic gases that are formed, together with HBr, when NaBr reacts with concentrated H_2SO_4

State the role of H_2SO_4 in the formation of these two toxic gases.

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(4)
(Total 19 marks)

Q4. What is the major product of the reaction between but-1-ene and DBr?
(D is deuterium and represents ^2H)

A $CH_2DCH_2CH_2CH_2Br$ ⬭

B $CH_2DCH_2CHBrCH_3$ ⬭

C $CH_3CH_2CHBrCH_2D$ ⬭

C $CH_3CH_2CHDCH_2Br$ ⬭

(Total 1 mark)

Q5. But-1-ene reacts with a reagent of the form HY to form a saturated compound.

(a) Suggest a reagent of the form HY which reacts with but-1-ene.

.....

(1)

(b) Name and draw a mechanism for the reaction in part **(a)**.

Name of mechanism .....

Mechanism

(5)

(c) Explain how three isomeric products are formed when HY reacts with but-1-ene.

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(3)
(Total 9 marks)

Q6. Consider the reaction between propene and hydrogen bromide to form the major product.

Which species is formed in the mechanism of this reaction?

A $CH_3–C^+H–CH_2Br$ ○

B $CH_3–CHBr–C^+H_2$ ○

C $CH_3–C^+H–CH_3$ ○

D $CH_3–CH_2–C^+H_2$ ○

(Total 1 mark)

Q7. A student carried out an experiment to determine the number of C=C double bonds in a

molecule of a cooking oil by measuring the volume of bromine water decolourised.

The student followed these instructions:

- Use a dropping pipette to add 5 drops of oil to 5.0 cm^3 of inert organic solvent in a conical flask.
- Use a funnel to fill a burette with bromine water.
- Add bromine water from a burette to the solution in the conical flask and swirl the flask after each addition to measure the volume of bromine water that is decolourised.

The student's results are shown in the table below.

Experiment	Volume of bromine water / cm^3
1	39.40
2	43.50
3	41.20

(a) In a trial experiment, the student failed to fill the burette correctly so that the gap between the tap and the tip of the burette still contained air.

Suggest what effect this would have on the measured volume of bromine water in this trial. Explain your answer.

.....

.....

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.....

.....

(2)

(b) Other than incorrect use of the burette, suggest a reason for the inconsistency in the student's results.

.....

(1)

(c) Outline how the student could improve this practical procedure to determine the number of C=C double bonds in a molecule of the oil so that more consistent results are obtained.

.....

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(4)

(d) The oil has a density of 0.92 g cm^{-3} and each of the 5 drops of oil has a volume of 5.0×10^{-2} cm^3.
The approximate M_r of the oil is 885.
The concentration of bromine water used was 2.0×10^{-2} mol dm^{-3}.

Use these data and the results from experiment **1** to deduce the number of C=C double bonds in a molecule of the oil.
Show your working.

(5)
(Total 12 marks)

Q1. Consider the reaction between propene and hydrogen bromide to form the major product.

Which species is formed in the mechanism of this reaction?

A $CH_3–C^+H–CH_2Br$ ⬭

B $CH_3–CHBr–C^+H_2$ ⬭

C $CH_3–C^+H–CH_3$ ⬭

D $CH_3–CH_2–C^+H_2$ ⬭

(Total 1 mark)

Q2. Which statement about *E*-1,2-dichloroethene is correct?

A It has the same boiling point as *Z*-1,2-dichloroethene. ⬭

B It forms a polymer with the same repeating unit as *Z*-1,2-dichloroethene. ⬭

C It has the same IR spectrum as *Z*-1,2-dichloroethene in the range 400–1500 cm^{-1}. ⬭

D It has a molecular ion peak different from that of *Z*-1,2-dichloroethene in its mass spectrum. ⬭

(Total 1 mark)

Q3. Which statement about ethene is correct?

A It has no geometric isomers because there is free rotation around the C=C bond. ⬭

B It reacts with HBr in a nucleophilic addition reaction. ⬭

C It burns in excess oxygen to produce carbon dioxide and water. ⬭

D The C=C bond is twice as strong as the C–C bond in ethane. ⬭

(Total 1 mark)

Q4. What is the major product of the reaction between but-1-ene and DBr?
(D is deuterium and represents ^{2}H)

A $CH_2DCH_2CH_2CH_2Br$ ⬭

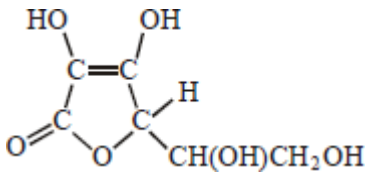
B $CH_2DCH_2CHBrCH_3$ ⬭

C $CH_3CH_2CHBrCH_2D$ ⬭

C $CH_3CH_2CHDCH_2Br$ ⬭

(Total 1 mark)

Q5. Which one of the following is **not** a correct statement about vitamin C, shown below?



A It is a cyclic ester.

B It can form a carboxylic acid on oxidation.

C It decolourises a solution of bromine in water.

D It is a planar molecule.

(Total 1 mark)

Q6. Which one of the following reactions will produce an organic compound that has optical isomers?

A dehydration of butan-2-ol by heating with concentrated sulphuric acid

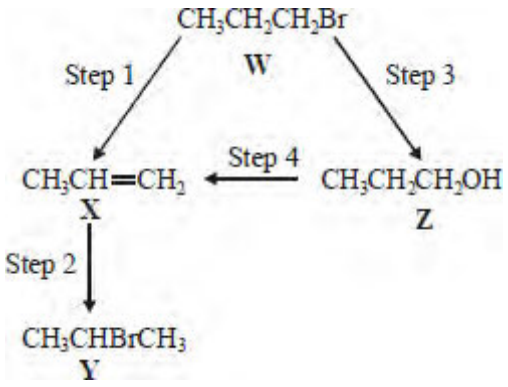
B reduction of pentan-3-one by warming with $NaBH_4$

C addition of Br_2 to 3-bromopropene

D reduction of 2,3-dimethylpent-2-ene with H_2 in the presence of a nickel catalyst

(Total 1 mark)

Q7. For this question refer to the reaction scheme below.



Which one of the following statements is **not** correct?

A Reaction of **W** with sodium cyanide followed by hydrolysis of the resulting product gives propanoic acid.

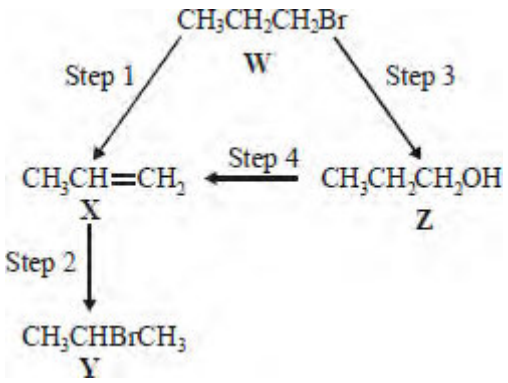
B Mild oxidation of **Z** produces a compound that reacts with Tollens' reagent, forming a silver mirror.

C **Z** reacts with ethanoic acid to produce the ester propyl ethanoate.

C **W** undergoes addition polymerisation to form poly(propene).

(Total 1 mark)

Q8. For this question refer to the reaction scheme below.



Which one of the following reagents would **not** bring about the reaction indicated?

A Step 1 : alcoholic KOH

B Step 2 : aqueous Br_2

C Step 3 : aqueous NaOH

C Step 4 : concentrated H_2SO_4

(Total 1 mark)

Q9. Propene reacts with hydrogen bromide to form a mixture of saturated organic products. The proton n.m.r. spectrum of the major organic product has

A 3 peaks with relative intensities 3 : 2 : 2

B 2 peaks with relative intensities 3 : 4

C 3 peaks with relative intensities 3 : 1 : 3

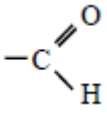
D 2 peaks with relative intensities 6 : 1

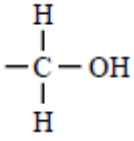
(Total 1 mark)

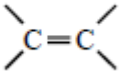
Q10. Certain chemical tests were performed on the pain-relief drug ibuprofen. The results of these tests are given in the table below.

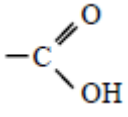
Test	**Result**
Aqueous sodium carbonate	Effervescence
Bromine water	Remained orange
Acidified potassium dichromate(VI) and heat	Remained orange
Fehling's solution and heat	Remained blue

Which one of the following functional groups do these results suggest that ibuprofen contains?

A 

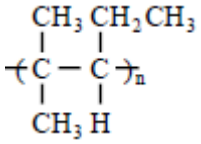
B 

C 

D 

(Total 1 mark)

Q11. The correct name for the alkene monomer which forms the polymer shown below is



A 2-methyl-3-ethylpropene

B 2-methylpent-2-ene

C 2-methylpent-3-ene

D 4-methylpent-2-ene

(Total 1 mark)

Q12. Which one of the following mechanisms is **not** involved in the reaction sequence below?

$CH_3CH_3 \rightarrow CH_3CH_2Cl \rightarrow CH_3CH_2OH \rightarrow CH_2{=}CH_2 \rightarrow CH_3CH_2Br$

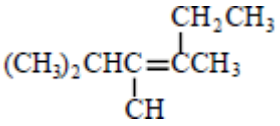
A electrophilic addition

B electrophilic substitution

C nucleophilic substitution

D free-radical substitution

(Total 1 mark)

Q13. The correct systematic name for  is

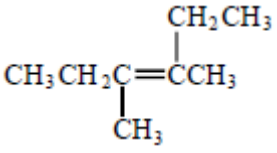
A 2-ethyl-3,4-dimethylpent-2-ene

B 4-ethyl-2,3-dimethylpent-3-ene

C 2,3,4-trirnethylhex-3-ene

D 3,4,5-trimethylhex-3-ene

(Total 1 mark)

Q14. The correct systematic name for  is

A 2,3-diethylbut-2-ene

B 2-ethyl-3-methylpent-2-ene

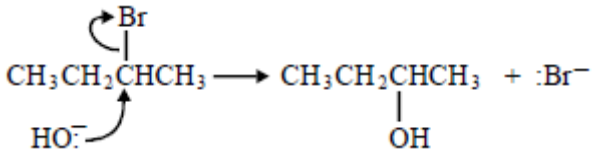
C 4-ethyl-3-methylpent-3-ene

D 3,4-dimethylhex-3-ene

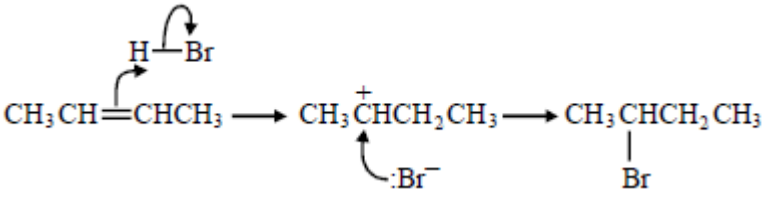
(Total 1 mark)

Q15. In which of the following is a curly arrow used incorrectly?

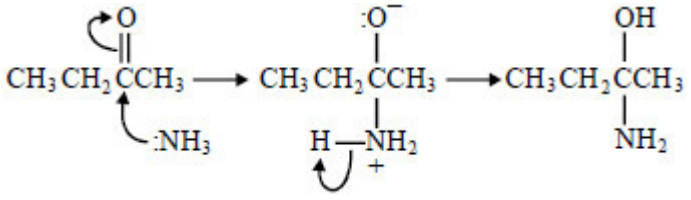
A



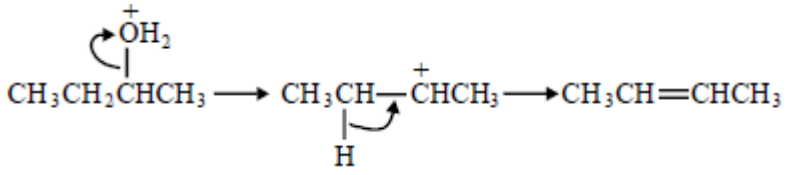
B



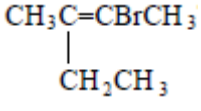
C



D



(Total 1 mark)

Q16. Which one of the following is the correct name for  ?

A 2-bromo-3-methylpent-2-ene

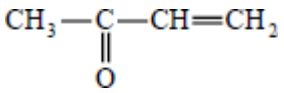
B 2-bromo-3-ethylbut-2-ene

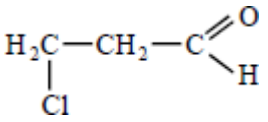
C 3-bromo-2-ethylbut-2-ene

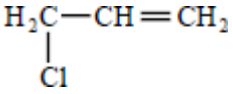
D 4-bromo-3-methylpent-3-ene

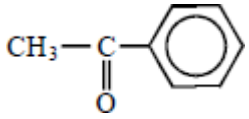
(Total 1 mark)

Q17. Which one of the following can react both by nucleophilic addition and by nucleophilic substitution?

A 

B 

C 

D 

(Total 1 mark)

Q18. Which one of the following does **not** contain any delocalised electrons?

A poly(propene)

B benzene

C graphite

D sodium

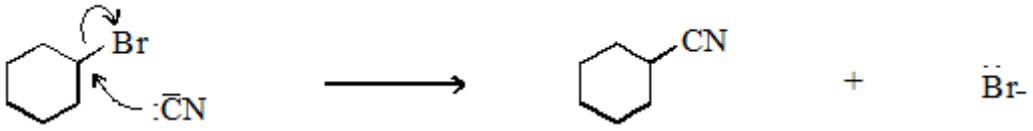
(Total 1 mark)

Q19. In which one of the following are the curly arrows **not** used correctly?

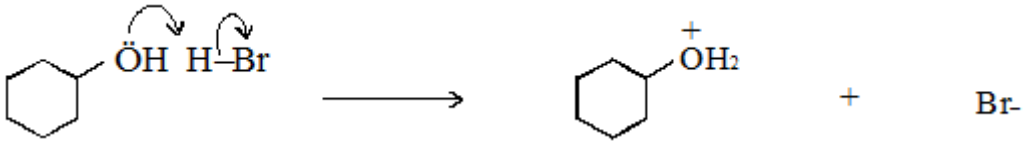
A



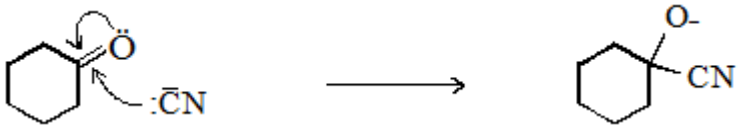
B



C



D



(Total 1 mark)

Q20. Which one of the following does **not** represent an oxidation?

A propene → propane

B propan-l-ol → propanal

C propan-l-ol → propanoic acid

D propanal → propanoic acid

(Total 1 mark)

Q21. Which one of the following is **not** a suitable method for the preparation of ethanol?

A oxidation of ethane

B hydration of ethene

C reduction of ethanal

D hydrolysis of bromoethane

(Total 1 mark)

Q22. Which one of the following reactions involves nucleophilic addition?

A $CH_3CH = CH_2 + HBr \rightarrow CH_3CHBrCH_3$

B $CH_3CH_2CH_3 + Cl_2 \rightarrow CH_3CHClCH_3 + HCl$

C $CH_3CH_2CH_2Br + NaOH \rightarrow CH_3CH_2CH_2OH + NaBr$

D $CH_3CH_2CHO + HCN \rightarrow CH_3CH_2CH(OH)CN$

(Total 1 mark)

Q23. Which one of the following conversions does **not** represent a reduction?

A propene → propane

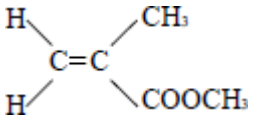
B propanal → propan-l-ol

C propanal → propanoic acid

D propanone → propane

(Total 1 mark)

Q24. The structure of the molecule of methyl 2-methylpropenoate is shown below.



Which one of the following statements concerning this compound is **not** true?

A It displays geometrical isomerism.

B It forms an addition polymer.

C It undergoes reduction.

D It decolourises bromine.

(Total 1 mark)

Q1. Which statement about *E*-1,2-dichloroethene is correct?

A It has the same boiling point as *Z*-1,2-dichloroethene. ⬭

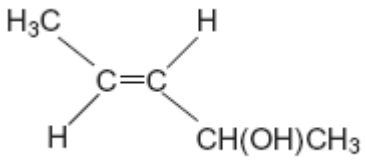
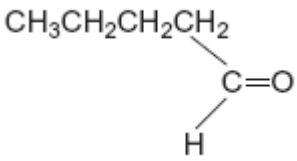
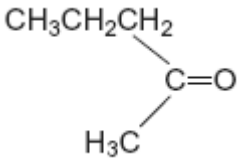
B It forms a polymer with the same repeating unit as *Z*-1,2-dichloroethene. ⬭

C It has the same IR spectrum as *Z*-1,2-dichloroethene in the range 400–1500 cm^{-1}. ⬭

D It has a molecular ion peak different from that of *Z*-1,2-dichloroethene in its mass spectrum. ⬭

(Total 1 mark)

Q2. The table below shows the structures of three isomers with the molecular formula $C_5H_{10}O$

Isomer **1** 	(*E*)-pent-3-en-2-ol
Isomer **2** 	pentanal
Isomer **3** 	

(a) Complete the table by naming Isomer **3**.

(1)

(b) State the type of structural isomerism shown by these three isomers.

.....

(1)

(c) The compound (*Z*)-pent-3-en-2-ol is a stereoisomer of (*E*)-pent-3-en-2-ol.

(i) Draw the structure of (*Z*)-pent-3-en-2-ol.

(1)

(ii) Identify the feature of the double bond in (*E*)-pent-3-en-2-ol and that in (*Z*)-pent-3-en-2-ol that causes these two compounds to be stereoisomers.

.....

(1)

(d) A chemical test can be used to distinguish between separate samples of Isomer **2** and Isomer **3**.
Identify a suitable reagent for the test.
State what you would observe with Isomer **2** and with Isomer **3**.

Test reagent .....

Observation with Isomer **2**.....

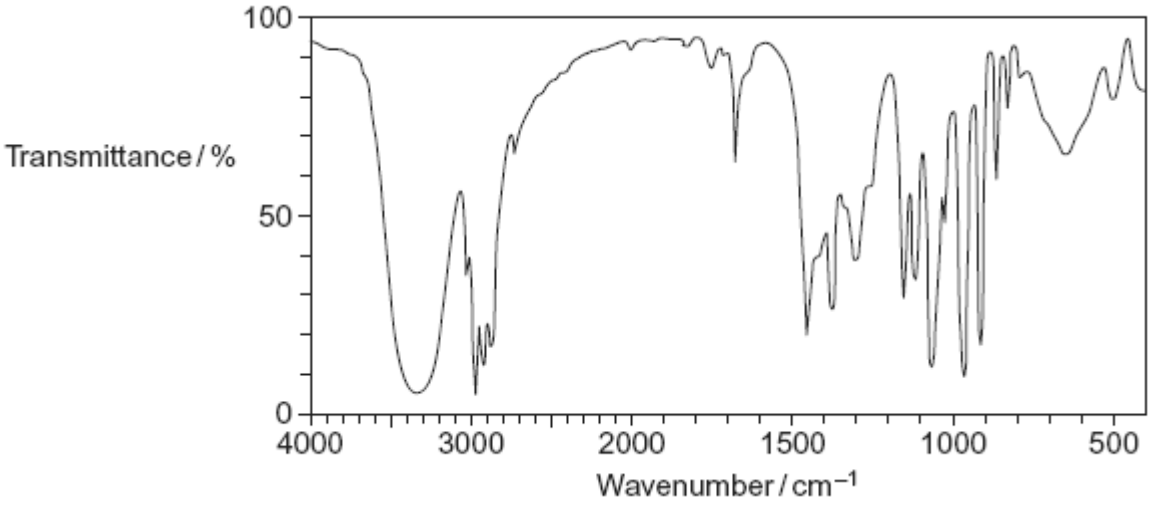
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Observation with Isomer **3**.....

.....

(3)

(e) The following is the infrared spectrum of one of the isomers **1**, **2** or **3**.



(i) Deduce which of the isomers (**1**, **2** or **3**) would give this infrared spectrum. You may find it helpful to refer to **Table 1** on the Data Sheet.

.....

(1)

(ii) Identify two features of the infrared spectrum that support your deduction. In each case, identify the functional group responsible.

Feature 1 and functional group .....

.....

.....

.....

Feature 2 and functional group .....

.....

.....

.....

(2)
(Total 10 marks)

Q3. (a) Give the **formula** of a Group 2 metal hydroxide used in agriculture.

.....

(1)

(b) Identify a sodium halide that does **not** undergo a redox reaction when added as a solid to concentrated sulfuric acid.

.....

(1)

(c) Chlorine gas reacts with cold dilute sodium hydroxide solution to form sodium chloride and another chlorine-containing compound, **X**.

Give the **formula** of **X**.

.....

(1)

(d) Give the **formula** of the substance responsible for the orange colour when chlorine gas is bubbled through an aqueous solution of sodium bromide.

.....

(1)

(e) Solid sodium iodide undergoes a redox reaction with concentrated sulfuric acid.

Give the **formula** for each of the following in this reaction.

Formula of the solid reduction product .....

Formula of the oxidation product .....

(2)

(f) Draw the structure of each of the following organic compounds.

(i) The hydrocarbon that is a chain isomer of methylpropene, but does **not** exhibit E–Z stereoisomerism.

(1)

(ii) The alcohol that is a position isomer of butan-2-ol.

(1)

(iii) The hydrocarbon that has a peak, due to its molecular ion, at *m/z* = 44 in its mass spectrum.

(1)

(iv) The bromoalkane that reacts with sodium cyanide to produce propanenitrile.

(1)
(Total 10 marks)

Q4. Which statement about ethene is correct?

A It has no geometric isomers because there is free rotation around the C=C bond. ⬭

B It reacts with HBr in a nucleophilic addition reaction. ⬭

C It burns in excess oxygen to produce carbon dioxide and water. ⬭

D The C=C bond is twice as strong as the C–C bond in ethane. ⬭

(Total 1 mark)

Q5. It is possible to convert but-1-ene into its structural isomer but-2-ene.

(a) State the type of structural isomerism shown by but-1-ene and but-2-ene.

.....

(1)

(b) The first stage in this conversion involves the reaction of hydrogen bromide with but-1-ene.

$$CH_3CH_2CH=CH_2 + HBr \longrightarrow CH_3CH_2CHBrCH_3$$

Outline a mechanism for this reaction.

(4)

(c) The second stage is to convert 2-bromobutane into but-2-ene.

$$CH_3CH_2CHBrCH_3 + KOH \longrightarrow CH_3CH=CHCH_3 + KBr + H_2O$$

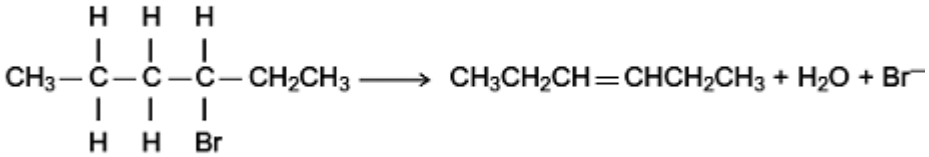
Outline a mechanism for this reaction.

(3)
(Total 8 marks)

Q6. Alkenes are useful intermediates in the synthesis of organic compounds.

(a) (i) Complete the elimination mechanism by drawing appropriate curly arrows.

HO^{-}:



3-bromohexane hex-3-ene

(3)

(ii) Draw structures for the E and Z stereoisomers of hex-3-ene.

E isomer of hex-3-ene Z isomer of hex-3-ene

(2)

(iii) State the meaning of the term *stereoisomers*.

.....

.....

.....

.....

.....

(Extra space) .....

.....

(2)

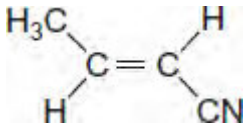
(b) The equation for the first reaction in the conversion of hex-3-ene into hexan-3-ol is shown below.

$$CH_3CH_2CH{=}CHCH_2CH_3 + H_2SO_4 \longrightarrow CH_3CH_2CH_2CH(OSO_2OH)CH_2CH_3$$

Outline a mechanism for this reaction.

(4)
(Total 11 marks)

Q7. The alkene *(E)*-but-2-enenitrile is used to make acrylic plastics.
The structure of *(E)*-but-2-enenitrile is



(a) (i) Draw the structure of *(Z)*-but-2-enenitrile.

(1)

(ii) Identify the feature of the double bond in the E and Z isomers that causes them to be stereoisomers.

.....

.....

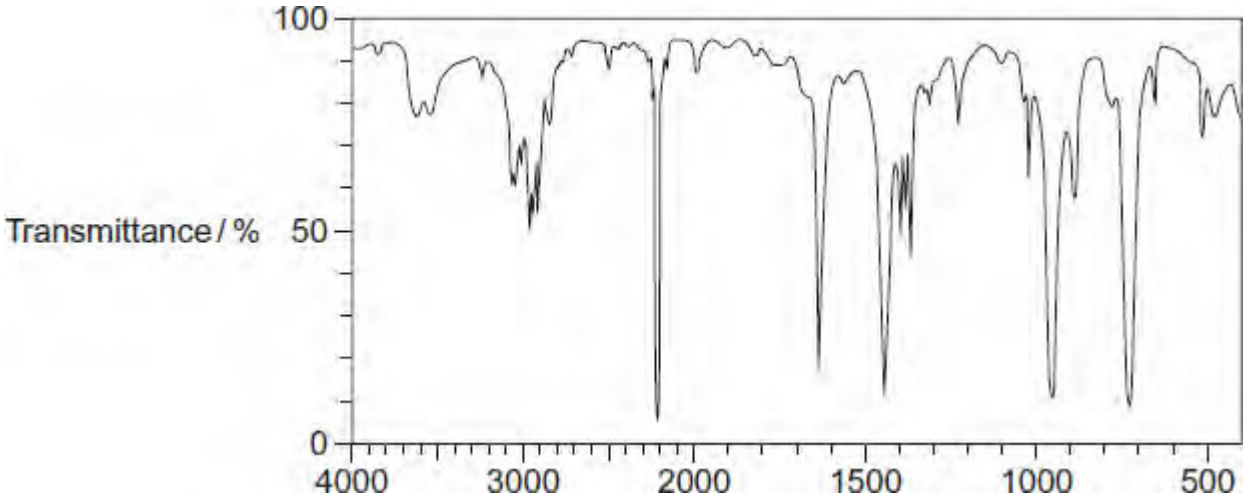
.....

(1)

(b) Draw the repeating unit of the polyalkene formed by addition polymerisation of *(E)*-but-2-enenitrile.

(1)

(c) Consider the infrared spectrum of *(E)*-but-2-enenitrile.



Identify **two** features of the infrared spectrum that support the fact that this is the infrared spectrum for but-2-enenitrile.
You may find it helpful to refer to **Table 1** on the Data Sheet.

Feature 1 .....

.....

.....

Feature 2 .....

.....

.....

(2)
(Total 5 marks)