- Alcohols and Carboxylic Acids

1st Reaction

Alcohols ~~reaction~~ react with Na or K metal at n.t.p. to form metal alkoxide and $H_2$ gas

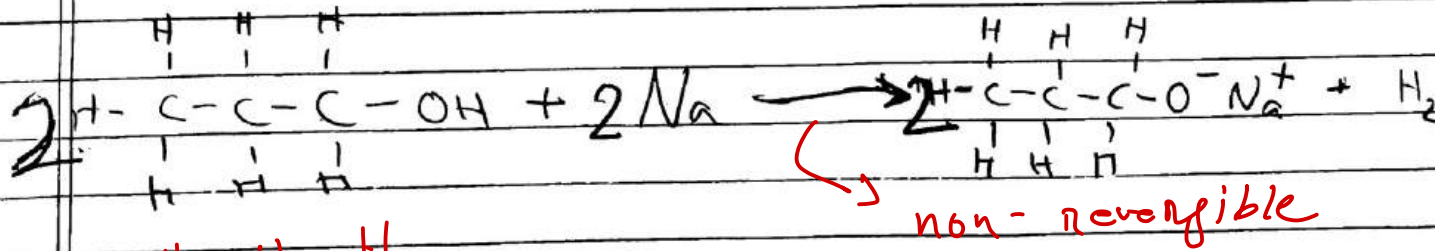
Type of Reaction: Redox Reaction (Acid-Metal Reaction)
Type

# $pH = -\log_{10}[H^+]$ : for water the conc. of $H^+$ ions in ~~to~~ $1 \times 10^{-7}$

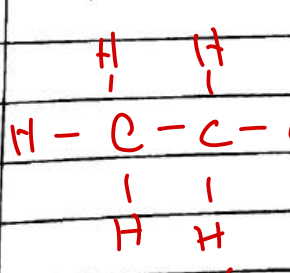
$= -\log_{10}[1 \times 10^{-7}]$

$= 7$

# Alcohols do not react with alkali as it has a lower $H^+$ ion ~~conc~~ conc$^n$ than water and even water cannot react with ~~the~~ alkali.




non-reversible



acts as an organic base

(All alkoxide ions)

# In all of the reactions under 2nd Reaction, Carboxylic Acid will also react in place of Alcohols. Eg. $R-COOH + PCl_5 \rightarrow R-COCl + POCl_3 + HCl$

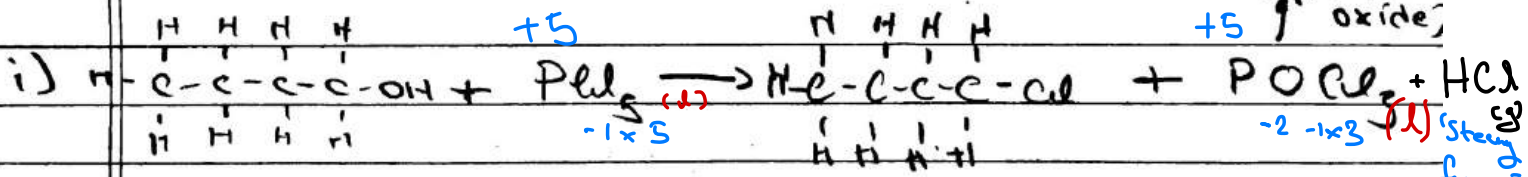
## 2nd Reaction

a) Alcohols react with $PCl_5$ or $SOCl_2$ (Sulphur dichloride oxide) at r.t.p. to form Chloroalkane and $HCl_{(g)}$ (steamy fumes) and other by-products.

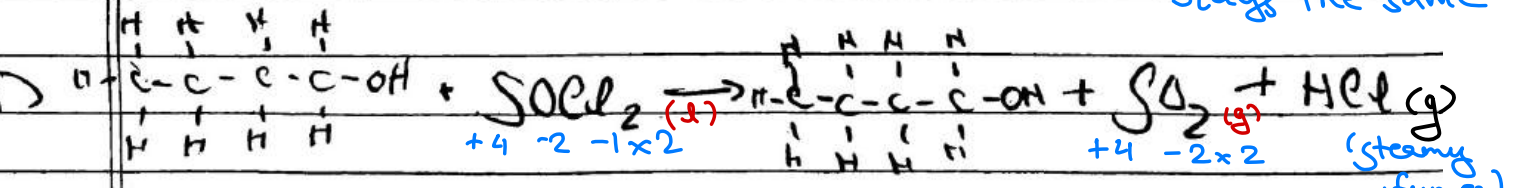
Alcohols also react with $PCl_3$ to form chloroalkane and Phosphorous acid ($H_3PO_3$) (Phosphonic acid III) ONLY! on heating under reflux.

# Phosphonic Acid ($H_3PO_4$) is also called phosphoric acid (V)

Type of Reaction: Nucleophelic Substitution

i) 

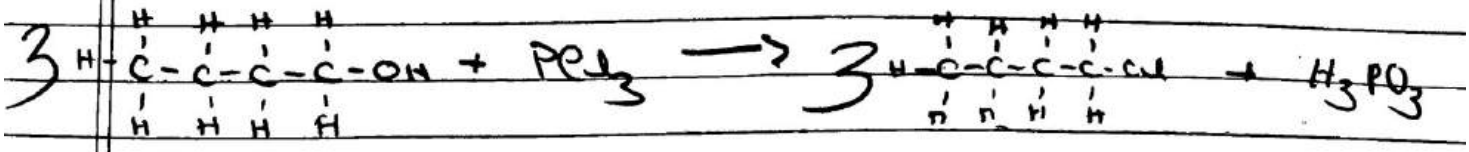

# Since its substitution reac$^n$, its not redox reac$^n$, thus oxidation no. stays the same

ii) 


# 1 mol of $PCl_5$ / $PCl_3$ / $SOCl_2$ will only react with 1 mol of (-OH) functional group

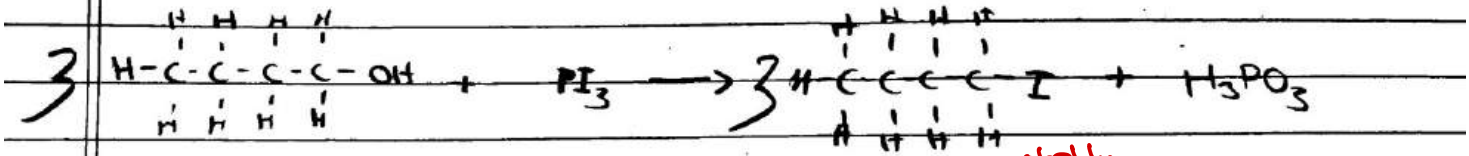
# P has 2 oxidation states, +3 and +5

iii)



b) Alcohol reacts with red Phosphorous and $I_2$ or $Br_2$ to form Iodoalkane or Bromoalkane on heating under reflux, in ~~fitted~~ 'situ vessel'

$$P_4 + I_2 \rightarrow PI_3$$

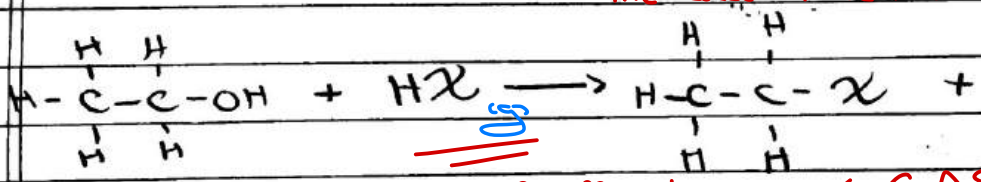


# " same for Br.

Most probably
# Not heating under reflux because HX is gas.

c) Alcohol reacts with hydrogen halide on heating under reflux to form Halogenoalkane

# ↳ In a P1 Question, the alcohol reacted with $HX_{(g)}$ on being "warmed"



# must mention HX GAS.

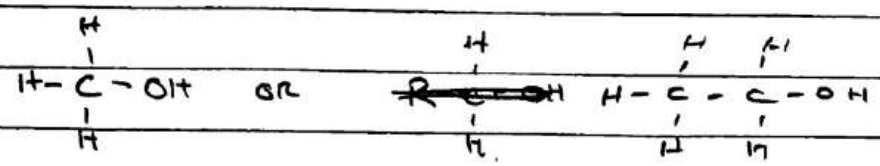
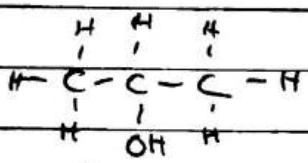
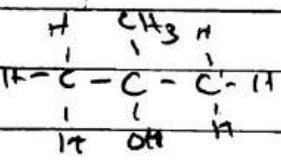
$NaX + H_2SO_4 \rightarrow NaHSO_4 + HX$ (do not need to show)

↳ This reaction is covered in the Group VII chapter, under, reducing abilities of Halide ions. This reaction is common to all Na hallides.

Reaction: 3

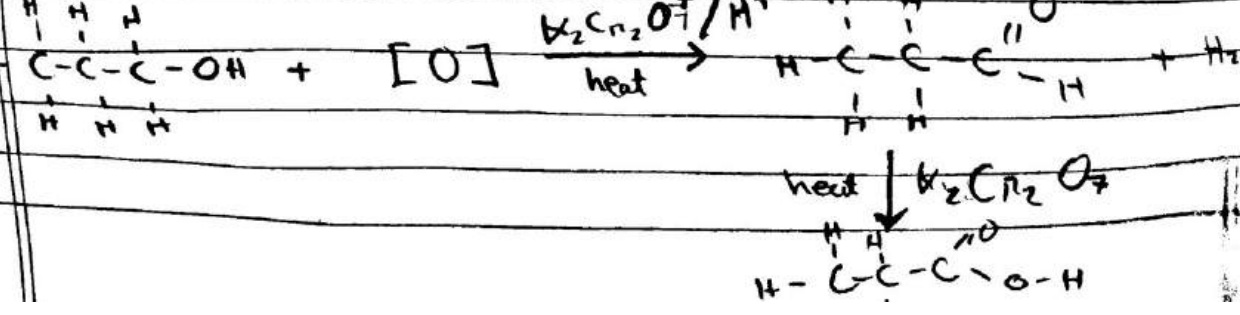
↳ Oxidation of Alcohols

There are 3 types of alcohols : i) Primary
ii) Secondary
iii) Tertiary

- Primary Alcohol : 
- Secondary Alcohol : 
- Tertiary Alcohol : 

i) Oxidation of Primary Alcohol

↳ They are oxidized by reacting with acidified ~~$K_2Cr_2O_7$~~ $K_2Cr_2O_7$ (potassium dichromate) to form aldehyde initially with will be further oxidized to form carboxylic acid on heating under reflux.



# To obtain aldehyde from primary alcohols

↳ Conditions: WARM (heat) and distill off (fractional distillation) with acidified $K_2Cr_2O_7$

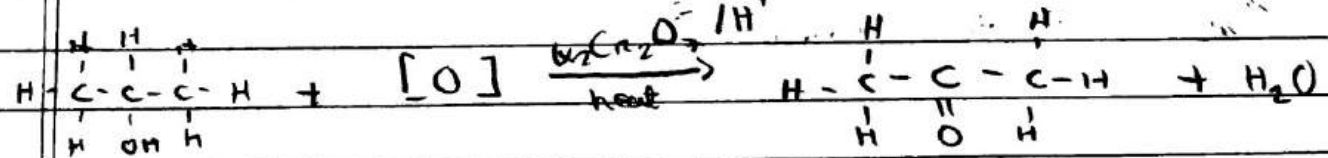
↳ One ms says warm instead of heat, to be safe, write both

# To obtain carboxylic acid from primary alcohols

↳ Conditions: heat under reflux with acidified $K_2Cr_2O_7$

↳ Oxidation of secondary alcohols

They are oxidised by reacting with acidified $K_2Cr_2O_7$ on heating under reflux to form ~~ketone~~




# Tertiary Alcohols cannot be oxidised under any conditions

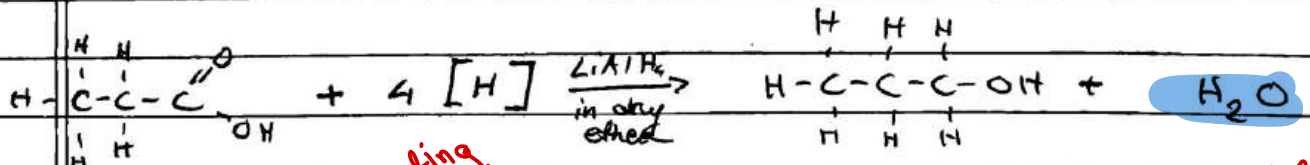
# Oxidation of Carboxylic Acids

↳ Only methanoic acid and ethandioic acid can be further oxidised into $CO_2$.

↳ To become further oxidised into $CO_2$, methanoic acid needs weak oxidising agent but ethandioic acid needs strong oxidising agent → Only upon refluxing with $KMnO_4$, NOT even with $Cr_2O_7^{2-}$

# Reduction of Carboxylic Acids

↳ Carboxylic Acids are reduced by reacting with $LiAlH_4$ only to form primary alcohol.



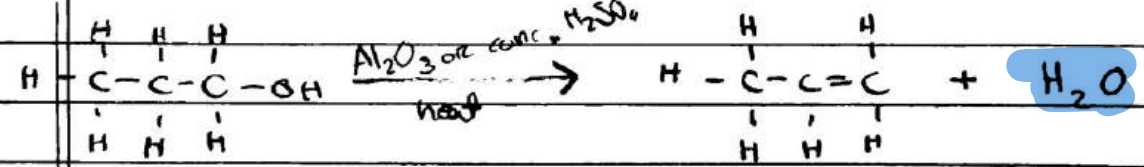

↳ Alcohols are dehydrated by heating in presence $Al_2O_3$ or conc. $H_2SO_4$ as dehydrating agent, on strong heating to form Alkene and steam

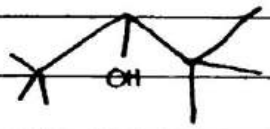
↑ role is dehydrating agent

hot → ACTS as a catalyst

↳ Maybe also acts as catalyst (Not sure)

Type of Reaction: Elimination



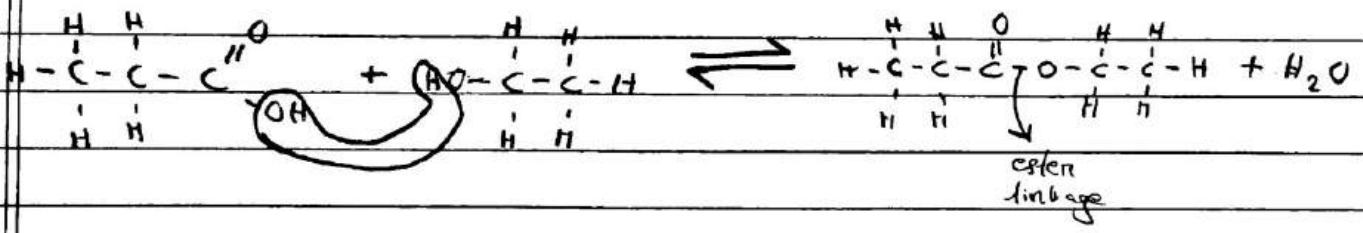

→ no reaction

Condensation Reaction: A reaction where 2 or more reactants react together to form a large product by the elimination of a small molecule like water ($H_2O$) or HCl.

Condensation = Addition + Elimination

↳ Alcohols react with carboxylic acid in the presence of small amount of conc $H_2SO_4$ as catalyst, on heating under reflux to form Ester and Water.

↳ Type: Condensation Reaction

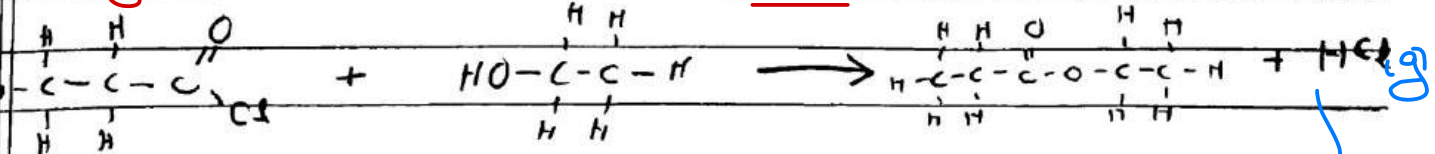



# Acyl Chloride and Carboxylic acids are alternative reactants; Acyl Chlorides are more reactive and more efficient than carboxylic acids

↳ NO Heating under Reflux

Acyl Chlorides react with Alcohols readily at rtp. to form Ester however unlike Carboxylic Acid the reaction goes to full completion

↳ Vigorous reaction even at RTP

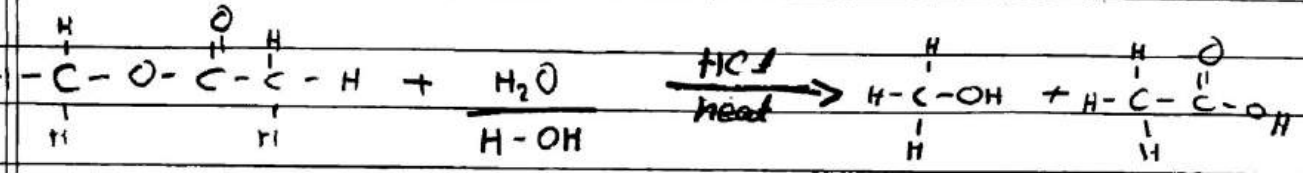


↳ Steamy fumes

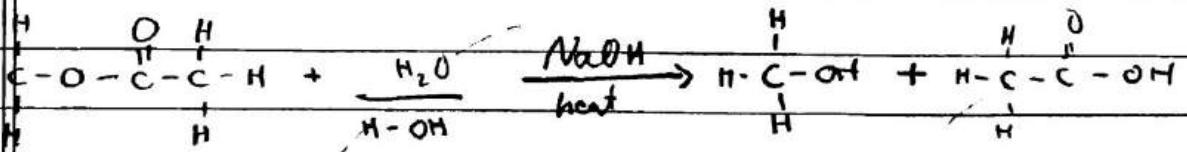
## Hydrolysis of Ester

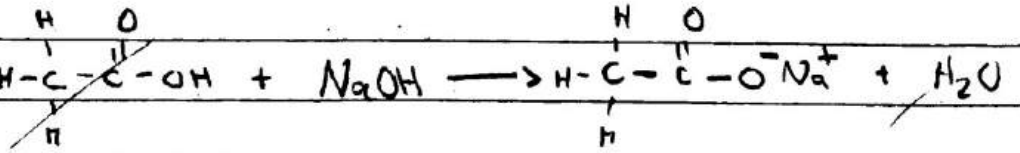
↳ Esters are hydrolysed by reacting with dilute mineral acid (HCl) or alkali (NaOH) on heating under reflux to form alcohol and carboxylic acid.

→ Acid Hydrolysis

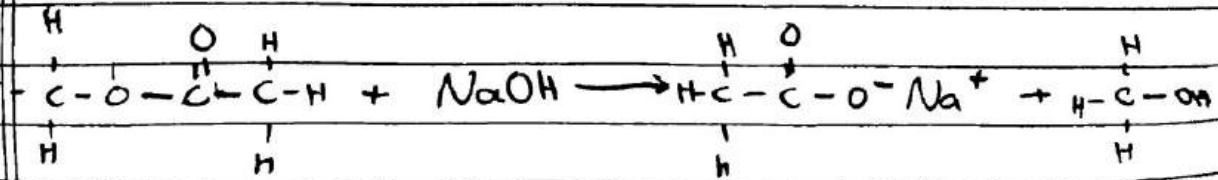


→ Alkali Hydrolysis





overall reaction:



# Whether HCN and NaCN are (aq), ethanolic or otherwise, mentioned in the qns.

ONLY HCN and NaCN is given for this particular reaction and its conditions

# Aldehyde and Ketones (Carbonyl Group)

↳ Formation of Aldehydes and Ketones : Oxidation of Primary and Secondary Alcohols

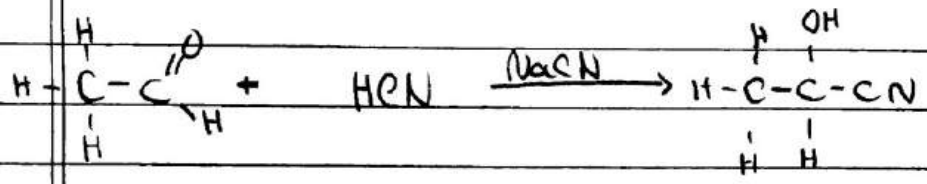
↳ Common Reactions of Aldehydes and Ketones

i) Aldehydes and Ketones both react with ~~heat~~ HCN in presence of NaCN (ethanolic) eg ~~cat~~ catalyst on heating under reflux to form hydroxyl alkane nitrile compound only.

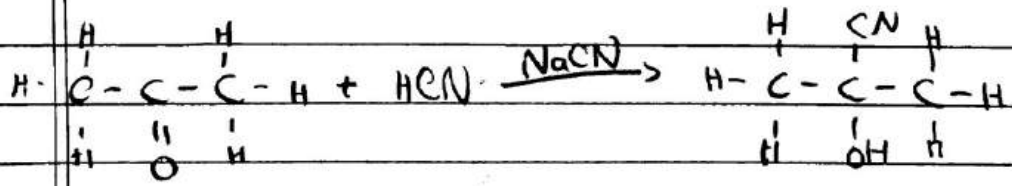
only NaCN NOT KCN for P2

Type of Reaction : Nucleophilic Addition Reaction

KCN is acceptable catalyst in P1

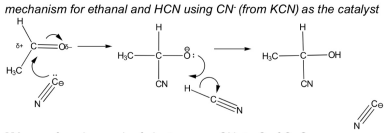


2-hydroxyl propane nitrile



2-hydroxy-2-methyl propanenitrile

*mechanism for ethanal and HCN using $CN^-$ (from KCN) as the catalyst*



**M1** arrow from lone pair of electrons on $:CN^-$ to C of C=O
**M2** correct dipole on $C^{\delta+}=O^{\delta-}$ AND arrow from the double bond to or beyond the O of C=O
**M3** arrow from lone pair of electrons on O of intermediate to H of HCN AND arrow from H-C bond to C of H-C≡N

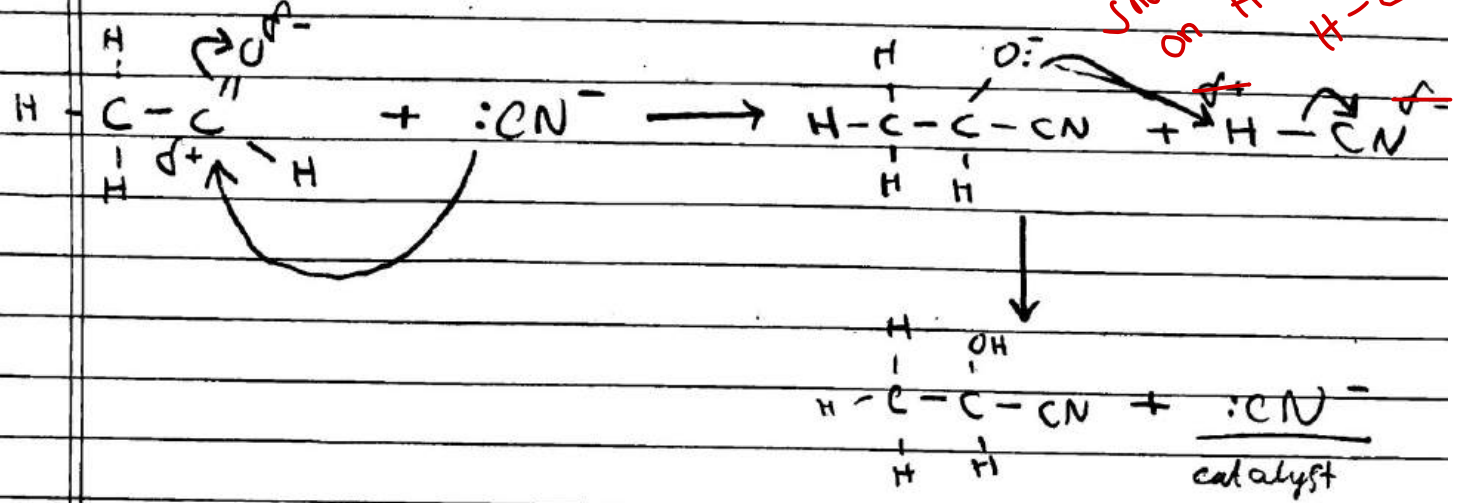
# Reaction Mechanism of Nucleophilic Addition

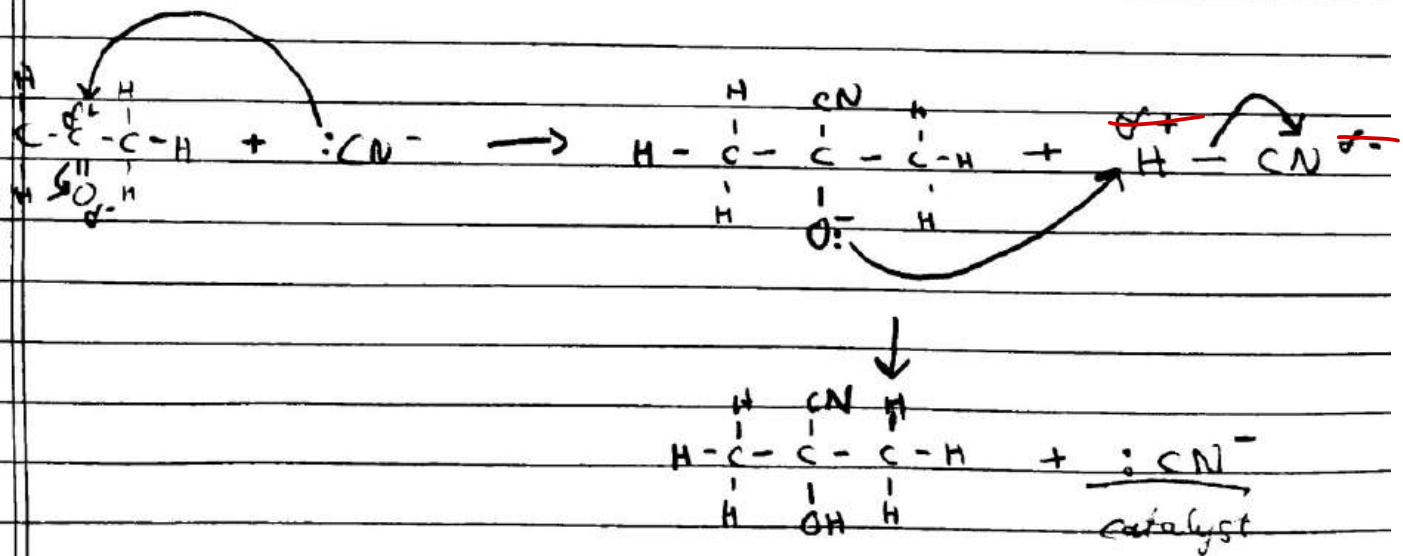
$HCN \rightleftharpoons H^+ + :CN^-$

$NaCN \longrightarrow Na^+ + CN^-$

## Mechanism

# recent ms do not show partial charges on H and C in H−C≡N





# Must show $:CN^-$ is regenerated at the end

→ mention heat under reflux for P2. MCQs can vary. #physicsandmathtutor.com also does not mention 'heating under reflux'

↳ Aldehyde and Ketone both react with 2,4-dinitrophenylhydrazine (2,4-DNPH) (on heating under reflux) to form hydrazone compound (Orange ppt.) and $H_2O$

↳ Stable due to benzene rings and C=N coupling

refer to Misc Notes →

# probably does not require heating under reflux

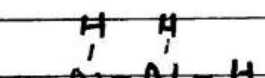
This reaction is used as a test for carbonyl compounds

Positive Result for Carbonyl: Orange ppt.

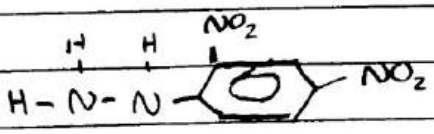
Type of Reaction: Condensation

# Benzene:  , $C_6H_6$

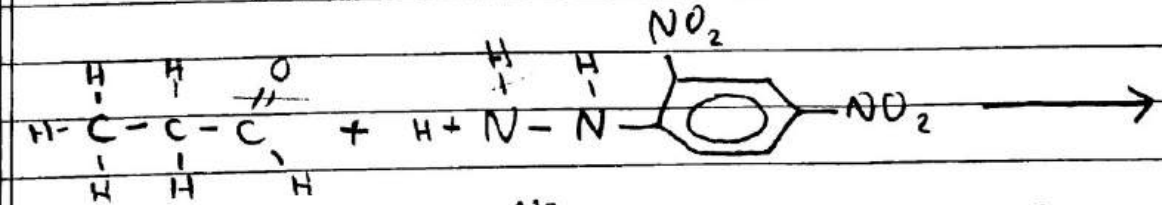
↳ when a H is removed from Benzene, it is called phenyl

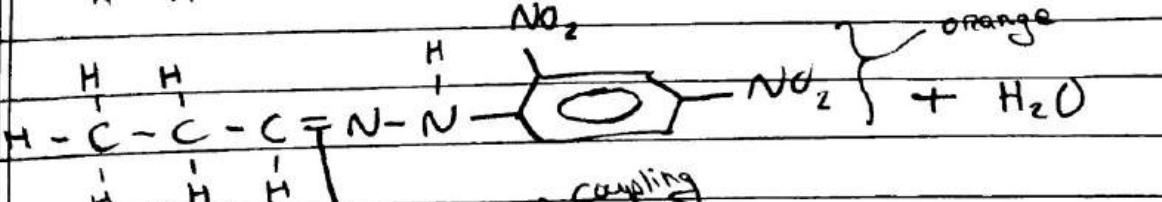
hydrazine: 

2,4 dinitrophenylhydrazine (2,4-DNPH)

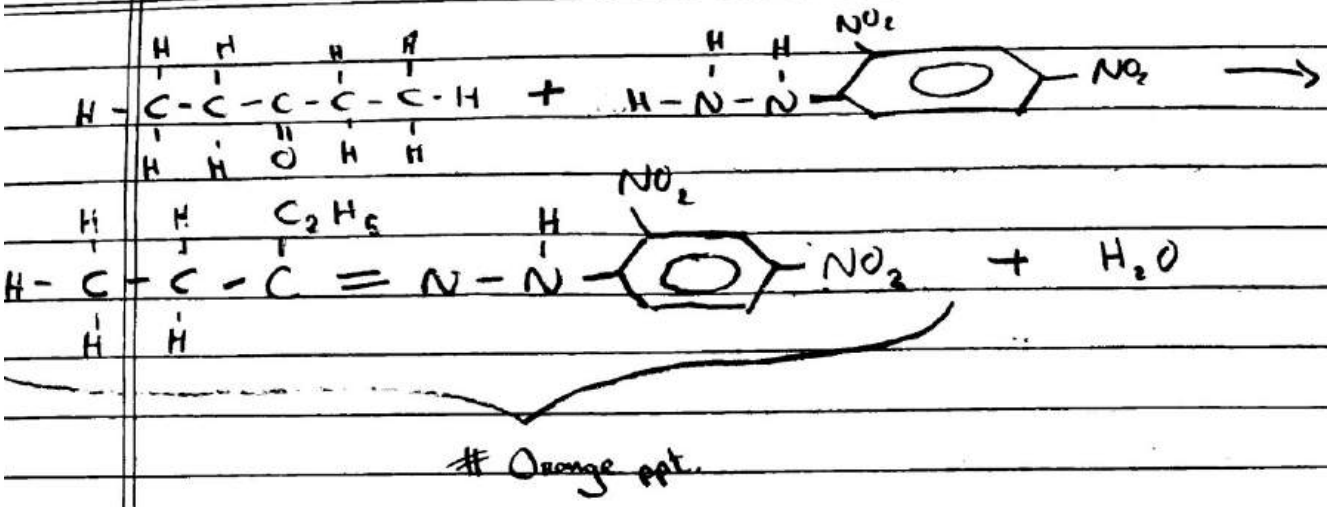


↳






# This is used eg methyl orange dye



# Orange ppt.

NO HEATING UNDER REFLUX

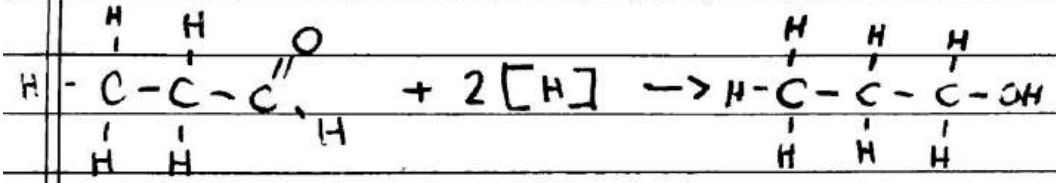
Reduction of Aldehydes and Ketones

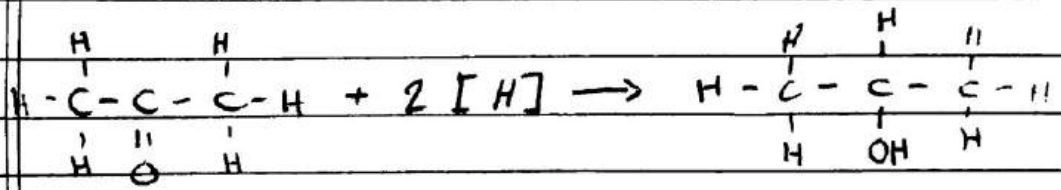
↳ Aldehydes are reduced by reacting with $LiAlH_4$ in dry ether or $NaBH_4$ in alkaline conditions to form primary alcohol

only for $NaBH_4$

↳ Ketones are reduced by reacting with $LiAlH_4$ (in dry ether) ~~only~~. AND $NaBH_4$ in alkaline conditions to form secondary alcohol

Type of Reaction: Reduction





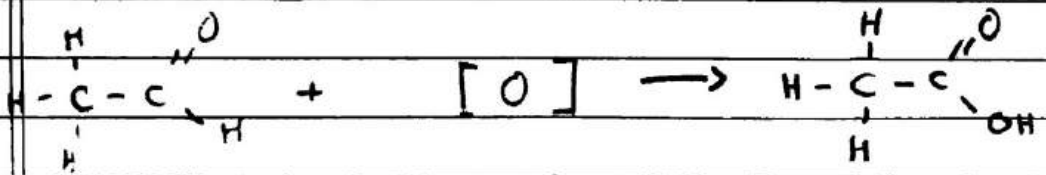
# Distinguishing between Aldehydes and Ketones

1) Tollen's Reagent : It is an ammoniacal sol$^n$ of Silver Nitrate (silver nitrate dissolved in aqueous ammonia) It acts as a mild oxidising agent.

* # $NH_3$ molecules form dative covalent bonds with the central $Ag^+$ cation

$$AgNO_3 + 2NH_3 \longrightarrow \underbrace{[Ag(NH_3)_2]^+}_{\text{diamine silver ion}} + NO_3^-$$

# Tollen's reagent can only oxidise aldehydes to form carboxylic acid on warming



# $[Ag(NH_3)_2]^+ + e^- \longrightarrow Ag_{(s)} + 2NH_3$

$Ag_{(s)}$ → deposited on the walls of the test-tube forming silver mirror

Observation: Silver Mirror

* No reaction with Ketone

# Sometimes black ppt. is observed because the test-tube is heated too much and $Ag_{(s)}$ oxidises into black $Ag_2O$

2. Fehling's Reagent : It is an ~~alkaline~~ alkanine sol$^n$ of $CuSO_4$.

: It is also a mild oxidising agent with gentle heating

↳ When reacted with Aldehyde, it forms salt of Carboxylic Acid. ~~is~~ reduced

In addition, $Cu^{2+}$ ions are ~~oxidised~~ to form red or orange ppt. of Copper(I) Oxide

↳ 2012 ms says Brick-red

↳ It also does not react with ketones.

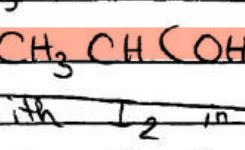
Book says it forms CARBOXYLATE ($R-COO^-$) ion and NOT salt

2012 ms says $R-COO^-$ or $R-COOH$

# Neither Fehling's nor Tollen's reagent can oxidise alcohols because alcohol require strong oxidising agent AND heating under reflux to be oxidised.

Must be primary OR Secondary Alcohol
CANNOT be TERTIARY Alcohol

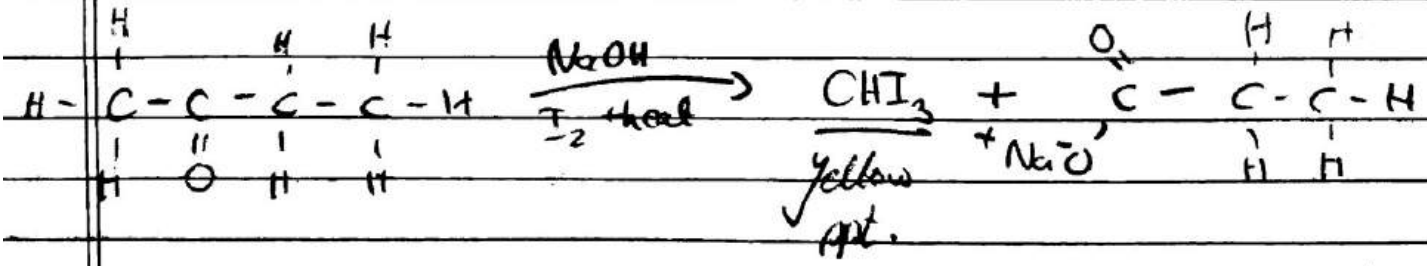
# Iodoform Reaction (Formation of $CHI_3$)

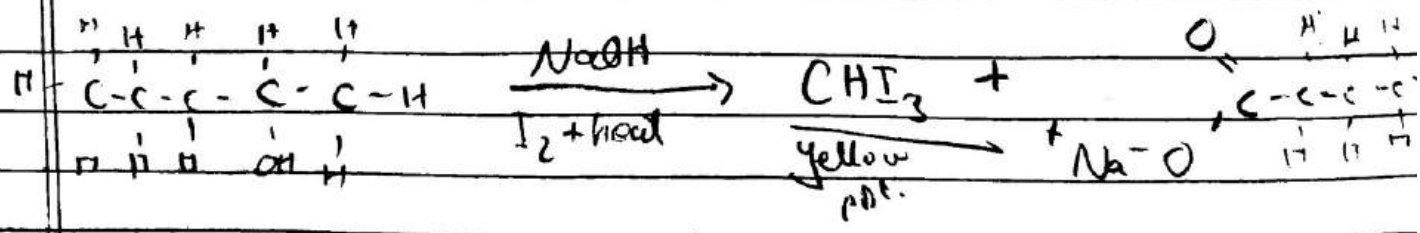
Methyl Ketone, Ethanal and any alcohol molecule containing $CH_3CH(OH)-$  can be H or R (carbon chain)
~~will react with $I_2$ in the~~ will react react with $I_2$ in the presence of NaOH (aq) → Alkali
on heating under reflux to form $CHI_3$ and salt of carboxylic acid

aqueous alkaline $I_2$

Type of Reaction: Hydrolysis

Observation: Yellow ppt. ($CHI_3$) (always write this)
: Antiseptic smell (only write this when asked for 2 observations)



# Misc. Notes

**Reaction Kinetics** 13

$H_2NNHC_6H_3(NO_2)_2$ is the structural formula of 2,4-DNPH.

Many, but not all, organic reactions need to be heated before reaction occurs.

Which reaction occurs at a good rate at room temperature (20 °C)?

**A** $C_{10}H_{22} \rightarrow C_8H_{18} + C_2H_4$

**B** $CH_3CH_2CH_2Br + NH_3 \rightarrow CH_3CH_2CH_2NH_2 + HBr$

**C** $CH_3CH_2OH + KBr \rightarrow CH_3CH_2Br + KOH$

**D** $(CH_3)_2CO + H_2NNHC_6H_3(NO_2)_2 \rightarrow (CH_3)_2C{=}NNHC_6H_3(NO_2)_2 + H_2O$

**Paper 1 Variant 2 Summer 2017 I Q27**

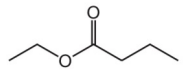
**Answer:**

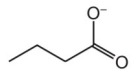
D

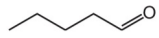
2,4-DNPH

# Alkanoate ion will react with acids to form alkanoic (carboxylic) acid.

**40** Which mixtures form a carboxylic acid as one of the products?

1  + $H_2SO_4(aq)$ →

2  + $H_2SO_4(aq)$ →

3  + $H_2SO_4(aq)$ →

3

# When a STRONG acid is added to the soln of a weak acid, the weak acid deionizes and reverts back to its compound form.

$$HCl + CH_3COO^+ \longrightarrow CH_3COOH + Cl^-$$

↳ # NOT sure if it is reversible or not

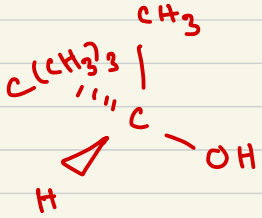
↳ The weak-acid acts as a BL-B

↳ Aldehydes and Ketones have the same general formula

# Addition Reactions (Both electrophilic and nucleophilic) always form intermediates.

# Reduction reactions occur at rtp. except for reduction of alcohols which require strong heating (NOT heating under reflux)

# (ONLY) When drawing Optical isomers, DRAW 3-d shapes



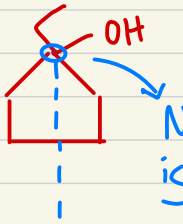

Otherwise just draw regular bonds.

# When showing the repeat unit, use structural formula

# When a question asks why a reacn does not proceed readily at rtp., the answer is usually - high Ea

Optical isomer: molecule with a non super-(im)posable mirror image
-ms

# There will be no chiral Carbon (*) if the ring is symetrical




Not a chiral Carbon because the ring is symmetrical.

# Why primary halogens alkanes use Sn2 mechanism instead of Sn1:

M1 primary/ 1 o (carbo)cation formed is not very stable M2 EITHER (as) only one alkyl group exerting an inductive effect OR only one alkyl group so the charge is (more) localised on the C+ -ms

↓

# Mention the exact no. of alkyl groups

# Alkenes react with $H_2$ in the presence of palladium catalyst to form alkanes.

# A lot of times in MCQs, On warming on warm will be used instead of Heating under reflux

# Acidified $K_2Cr_2O_7$ (aq) does NOT react with alkenes

→ ONLY Acidified $KMnO_4$ (aq) reacts with alkenes

30 Which reaction produces an organic anion with a good yield?

A heating ethanenitrile under reflux with dilute sodium hydroxide

B heating ethanenitrile under reflux with dilute sulfuric acid

C heating ethane with sodium metal

D heating ethanol under reflux with dilute sodium hydroxide

Since $H_2SO_4$ is a strong acid, it will deionize the acid and thus there wont be any alkanoate anions left. However with NaOH the $CH_3COO^-Na^+$ salt fully dissociates in aq to give alkanoate anions

# Termination reac$^n$ is probably different from Addition Reaction

# When naming organic compounds ALWAYS add the position of the functional group even if it is 1 (wherever applicable)

e.g. propanol ✗ propan-1-ol ✓

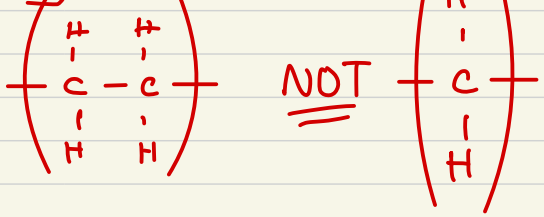
aminopropane ✗ 1-aminopropane ✓

# When it comes to halogenoalkanes, their reactivity depends on the C-X bond strength. For example $CCl_4$ is more reactive than $CF_4$ because the C-Cl bond is easier to break.

# When a question asks for the mechanism of a reac$^n$, include both the Mechanism and Type of reaction

# Dehydration reactions are Elimination Reactions

# Repeat unit of poly(ethene) is



NOT

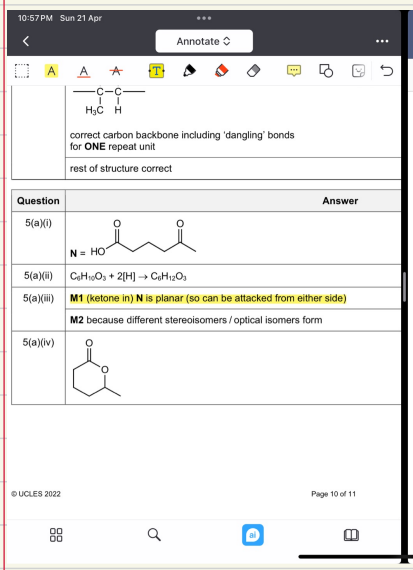
(ii) Construct an equation to show the homolytic fission of halothane, $CF_3CHBrCl$.

$CF_3CHBrCl \longrightarrow Br\bullet + CF_3C\bullet HCl$ [1]

$+ CF_3CHCl\bullet$

How to write homolytic bond fission Equation

# When the Question says Suggest the Structure, ALWAYS use SKELETAL formula unless another representation is used earlier in the Question



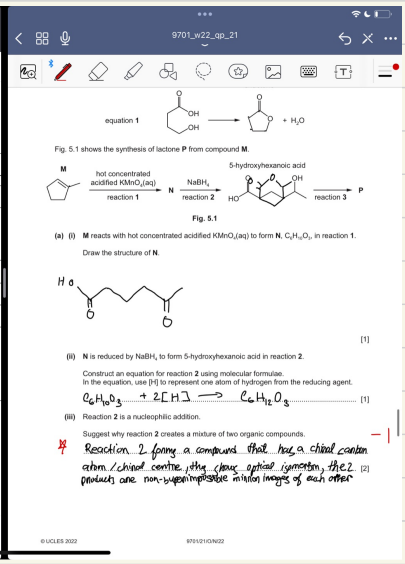
correct carbon backbone including 'dangling' bonds for **ONE** repeat unit

rest of structure correct

| Question | Answer |
|---|---|
| 5(a)(i) | N =  |
| 5(a)(ii) | $C_6H_{10}O_3 + 2[H] \rightarrow C_6H_{12}O_3$ |
| 5(a)(iii) | **M1** (ketone in) **N** is planar (so can be attacked from either side) |
| | **M2** because different stereoisomers / optical isomers form |
| 5(a)(iv) |  |







equation 1 

Fig. 5.1 shows the synthesis of lactone **P** from compound **M**.




Fig. 5.1

(a) (i) **M** reacts with hot concentrated acidified $KMnO_4$(aq) to form **N**, $C_6H_{10}O_3$, in reaction 1.

Draw the structure of **N**.



[1]

(ii) **N** is reduced by $NaBH_4$ to form 5-hydroxyhexanoic acid in reaction 2.

Construct an equation for reaction 2 using molecular formulae.
In the equation, use [H] to represent one atom of hydrogen from the reducing agent.

$C_6H_{10}O_3 + 2[H] \longrightarrow C_6H_{12}O_3$ [1]

(iii) Reaction 2 is a nucleophilic addition.

Suggest why reaction 2 creates a mixture of two organic compounds.

4 Reaction 2 forming a compound that has a chiral carbon atom / chiral centre / the shows optical isomerism, the 2 products are non-superimposable mirror images of each other [2]

# In electrophilic addition, both electrophiles and nucleophiles get added. It just that the electrophile gets added before the nucleophile. The reverse is also true for nucleophilic addition where the nucleophile gets added first and electrophile second.

# conc$^n$ $H_2SO_4$ (aq) acts as a catalyst in Esterification PLUS Esterification using carboxylic acids and alcohols is a reversible reac$^n$ that produces $H_2O$. $H_2SO_4$ (aq) is a dehydrating agent which continuously removes the $H_2O$ as it is formed thus equilibrium tilts well to the right causing high yield of ester.

**20** The unsaturated hydrocarbon octa-1,3,5,7-tetraene, $C_8H_{10}$, can display geometric isomerism.

octa-1,3,5,7-tetraene

$CH_2=CHCH=CHCH=CHCH=CH_2$

How many isomers exist?

A 2 B 3 C 4 D 8

$2^n - 1$

cis-cis
cis-trans
trans-cis
trans-trans

both are same because molecule is symmetric

c = c − c = c − c = c − c = c

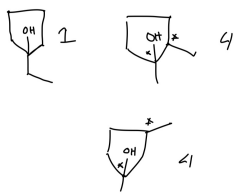
**21** Structural isomerism and stereoisomerism should be considered when answering this question.

If a molecule contains two non-identical chiral carbon atoms, four optical isomers exist.

How many isomers are there with

- molecular formula $C_7H_{14}O$ **and**
- a five-membered ring **and**
- a tertiary alcohol group?

A 4 B 5 C 9 D 13




**22** A polymer has the following repeat unit. It is made from two different monomers.

$$\left\{CH_2-CHCl-CH_2-CH=CH-CH_2\right\}$$

Which pair of monomers could be used to make this polymer?

A $CH_2=CHCl$ and $CH_2=CH_2$

B $CH_2=CHCl$ and $CH_2=CH-CH=CH_2$

C $CH_3-CH_2Cl$ and $CH_3-CH=CH-CH_3$

D $CH_3-CH=CH-CH_3$ and $CH_2=CHCl$

A) $C=C(Cl) + C=C \rightarrow \{C-C(Cl)-C-C\}$

B) $C=C(Cl) + C=C-C=C \rightarrow \{C-C(Cl)-C-C=C-C\}$

$C_5H_{10}$





**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.

$n = \frac{3.43}{24} \Rightarrow 0.143$ moles

$M_r = \frac{m}{n} = \frac{10}{0.143} = 70$

How many isomeric structures are possible for Y?

A 4 B 5 C 6 D 7

1) $C-C-C-C=C(H)-H$

2) $C-C(C)-C=C(H)-H$

3) $C-C-C(C)=C(H)-H$

4) $H_3C-CH_2-C(H)=C(H)-CH_3$ (cis, trans)

5) $CH_3-C(CH_3)=CH-CH_3$


For finding isomers, do branching first and then do positional isomers ( move functional group )

**7** When aqueous bromine is shaken with cyclohexane and allowed to stand, two layers form. The top cyclohexane layer is coloured and the bottom aqueous layer is almost colourless.

What is the most likely explanation for this observation?

**A** Bromine is reduced to bromide ions in the bottom layer.

**B** Bromine molecules are non-polar.

**C** Bromine reacts with water but cannot react with cyclohexane.

**D** The product of the reaction between bromine and cyclohexane is coloured.

---

**8**

**20** The structures of citric acid and isocitric acid are shown.

| citric acid | isocitric acid |
|---|---|
| $CH_2CO_2H$<br>$C(OH)CO_2H$<br>$CH_2CO_2H$ | $CH_2CO_2H$<br>$CHCO_2H$<br>$CH(OH)CO_2H$ |

How many chiral centres does each acid possess?

| | citric acid | isocitric acid |
|---|---|---|
| **A** | 1 | 1 |
| **B** | 1 | 2 |
| **C** | 0 | 1 |
| **D** | 0 | 2 |

**21** How many tertiary alcohols have the molecular formula $C_6H_{14}O$?

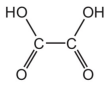
**A** 1 **B** 2 **C** 3 **D** 4

---

**27** How many isomeric esters have the molecular formula $C_4H_8O_2$?

**A** 2 **B** 3 **C** 4 **D** 5

---



Ethanedioic acid reacts with ethanol in the presence of a few drops of concentrated sulfuric acid to form a diester. The molecular formula of the diester is $C_6H_{10}O_4$.

What is the structural formula of the diester?

**A** $CH_3CH_2CO_2CO_2CH_2CH_3$

**B** $CH_3CH_2OCOCO_2CH_2CH_3$

**C** $CH_3CH_2O_2CO_2CCH_2CH_3$

**D** $CH_3CO_2CH_2CH_2OCOCH_3$

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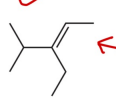
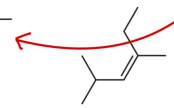
**24** A section of a polymer chain is shown.

What is the correct monomer?

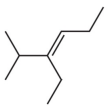
**A**



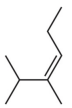
**B**



**C**

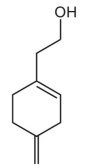


**D**



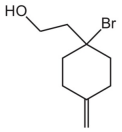
**26** An excess of dry HBr is warmed with compound Y.

Y

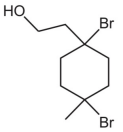



What is the major product of the reaction?

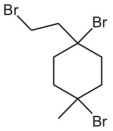
A



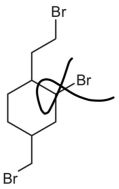

B




C



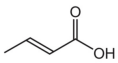

D




**29** What is the skeletal formula of the compound formed when $CH_3CH{=}CHCH_2OH$ is heated, under reflux, with $K_2Cr_2O_7/H^+$?

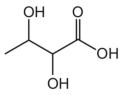
A


B




C


D




**40** Which statements comparing ethene and ethane are correct?

1 The bond angles in ethene are larger than the bond angles in ethane.

2 Ethene reacts much more quickly with bromine in the dark than ethane does.

3 Complete combustion of 0.01 mol of ethene or ethane produces the same volume of gas measured at room temperature and pressure.

A

$C_2H_4 \rightarrow 2CO_2 + 2H_2O_{(l)}$

$C_2H_6 \nearrow 2CO_2 + 3H_2O_{(l)}$

# $H_2O$ NOT gas at n.t.p.

# When the question says measured at n.t.p., use the state of the product at n.t.p.





**22** The compound 'leaf alcohol' is partly responsible for the smell of new-mown grass.

$CH_3CH_2CH{=}CHCH_2CH_2OH$

leaf alcohol

What will be formed when 'leaf alcohol' is oxidised using an excess of hot, acidified $K_2Cr_2O_7(aq)$?

A $CH_3CH_2CH(OH)CH(OH)CH_2CO_2H$

B $CH_3CH_2COCOCH_2CO_2H$

C $CH_3CH_2CH{=}CHCH_2CO_2H$

D $CH_3CH_2CO_2H$ and $HO_2CCH_2CO_2H$

cold dilute, acidified $KMnO_4$ gives diol.

Does hot acidified $K_2Cr_2O_7$ give diol? NO

**20** A new industrial preparation of ethyl ethanoate has been developed using cheap sources of ethanol.

$$CH_3CH_2OH \xrightarrow[-2[H]]{\text{Cu catalyst}} CH_3CHO \xrightarrow[+\,CH_3CH_2OH]{\text{Cu catalyst}} CH_3CH(OH)OCH_2CH_3$$

$$CH_3CH(OH)OCH_2CH_3 \xrightarrow[-2[H]]{\text{Cu catalyst}} CH_3CO_2CH_2CH_3$$

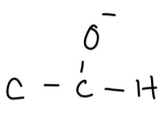
Which process is involved at some stage in this reaction sequence?

A electrophilic addition

B nucleophilic addition

C nucleophilic substitution

D reduction




HCN

H $OCH_2CH_3$

**24** Oct-1-ene, $CH_3(CH_2)_5CH=CH_2$, is subjected to thermal cracking.

Which combination of compounds W, X, Y and Z can be obtained?

| $CH_2=CH_2$ | $CH_3CH=CH_2$ | $CH_3CH_2CH_3$ | $CH_2=CHCH=CH_2$ |
|---|---|---|---|
| W | X | Y | Z |

**A** W, X, Y and Z

**B** W, X and Y only

**C** W, X and Z only

**D** W and X only

$2C_8H_{16} = C_2H_4 + C_3H_6 + C_3H_8 + 2C_4H_6 + H_2$

---

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

Compounds X, Y and Z are shown.

X

Y

Z

How many other isomers of $C_3H_7ClO$ are there that are alcohols?

**A** 2 **B** 3 **C** 4 **D** 5

**21** Two students each make a statement about 2-methylbut-1-ene.

Student 1 states that 2-methylbut-1-ene has geometrical isomers.

Student 2 states that 2-methylbut-1-ene reacts with HBr in an addition reaction to give 1-bromo-2-methylbutane as the main product.

1-chloropropan-2-ol + optical

3-chloropropan-1-ol

2-chloropropan-1-ol + optical

---

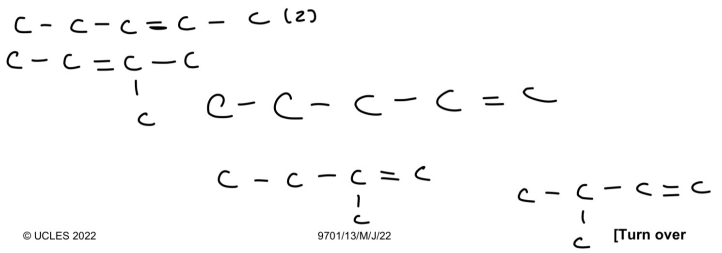
**29** Structural isomerism and stereoisomerism should be considered when answering this question.

Y is a gaseous hydrocarbon which decolourises aqueous bromine.

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







[Turn over

---

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

A set of isomeric hydrocarbons:

- all contain 14.3% by mass of hydrogen
- all react with bromine by addition, 0.280 g of each hydrocarbon reacting with 0.799 g of bromine

What is the maximum number of isomeric compounds in the set?

**A** **B** 3 **C** 4 **D** 5

butene