

17 CARBONYL COMPOUNDS

Learning outcomes

Candidates should be able to:

- recall the reactions (reagents and conditions) by which aldehydes and ketones can be produced:
 - the oxidation of primary alcohols using acidified $\text{K}_2\text{Cr}_2\text{O}_7$ or acidified KMnO_4 and distillation to produce aldehydes
 - the oxidation of secondary alcohols using acidified $\text{K}_2\text{Cr}_2\text{O}_7$ or acidified KMnO_4 and distillation to produce ketones
- describe:
 - the reduction of aldehydes and ketones, using NaBH_4 or LiAlH_4 to produce alcohols
 - the reaction of aldehydes and ketones with HCN , KCN as catalyst, and heat to produce hydroxynitriles exemplified by ethanal and Propanone
- describe the mechanism of the nucleophilic addition reactions of hydrogen cyanide with aldehydes and ketones in 17.1.2(b)
- describe the use of 2,4-dinitrophenylhydrazine (2,4-DNPH reagent) to detect the presence of carbonyl compounds
- deduce the nature (aldehyde or ketone) of an unknown carbonyl compound from the results of simple tests (Fehling's and Tollens' reagents; ease of oxidation)
- deduce the presence of a $\text{CH}_3\text{CO}-$ group in an aldehyde or ketone, $\text{CH}_3\text{CO}-\text{R}$, from its reaction with alkaline $\text{I}_2(\text{aq})$ to form a yellow precipitate of tri-iodomethane and an ion, RCO_2^-

Initial assessment

- Which equation below describes what happens when a ketone is reduced?
 - $\text{CH}_3\text{COCH}_3 + 2[\text{H}] \rightarrow \text{CH}_3\text{CH}(\text{OH})\text{CH}_3$
 - $\text{CH}_3\text{CHO} + 2[\text{H}] \rightarrow \text{CH}_3\text{CH}_2\text{OH}$
 - $\text{CH}_3\text{COCH}_3 + \text{H}_2 \rightarrow \text{CH}_3\text{CH}(\text{OH})\text{CH}_3$
 - $\text{CH}_3\text{COCH}_3 + \text{H}_2\text{O} \rightarrow \text{CH}_3\text{CH}(\text{OH})\text{CH}_3 + [\text{O}]$
- Describe the first step in the reaction mechanism when $\text{OH}^-(\text{aq})$ is mixed with $\text{CH}_3\text{CH}_2\text{Cl}$.
- Draw the displayed formula of your choice to represent:
 - a primary alcohol
 - a secondary alcohol
 - a tertiary alcohol.

4. Discuss what happens in these addition reactions:
- bromine reacts with ethene
 - ethene forms poly(ethene).

Preparation

1. **By oxidation of alcohols** (revise from properties of alcohols)

Properties

Reduction (revise in preparation of alcohol)

Reaction with HCN

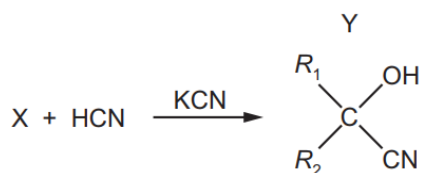
1. Which mechanism describes the reaction of aldehydes and ketones with HCN + NaCN?

- A electrophilic addition
B electrophilic substitution
C nucleophilic addition
D nucleophilic substitution

2. Ethanal, CH₃CHO, undergoes an addition reaction with HCN in the presence of CN⁻ ions. Which row identifies the type of reaction and the name of the product formed?

	type of reaction	name of product
A	electrophilic addition	2-hydroxypropanenitrile
B	electrophilic addition	2-hydroxyethanenitrile
C	nucleophilic addition	2-hydroxypropanenitrile
D	nucleophilic addition	2-hydroxyethanenitrile

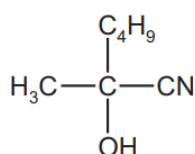
3. The diagram shows the formation of compound Y from compound X in a chemical reaction. R₁ and R₂ are alkyl groups.



Which row about this reaction is correct?

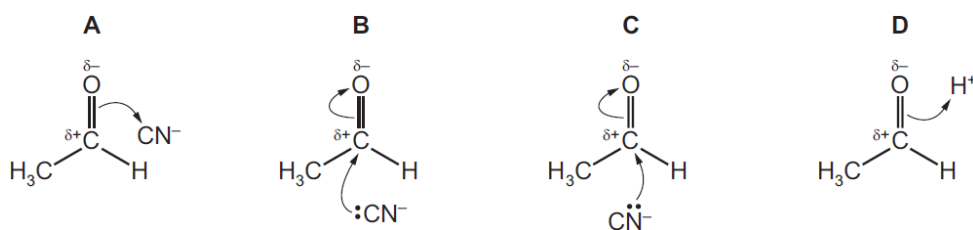
	mechanism	compound X
A	electrophilic addition	aldehyde
B	electrophilic addition	ketone
C	nucleophilic addition	ketone
D	nucleophilic addition	aldehyde

4. The diagram shows the structure of a compound formed by the reaction of HCN with a carbonyl compound, X.

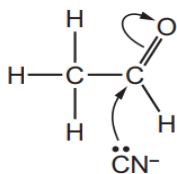


	mechanism of reaction	functional group in X
A	electrophilic addition	aldehyde
B	electrophilic addition	ketone
C	nucleophilic addition	aldehyde
D	nucleophilic addition	ketone

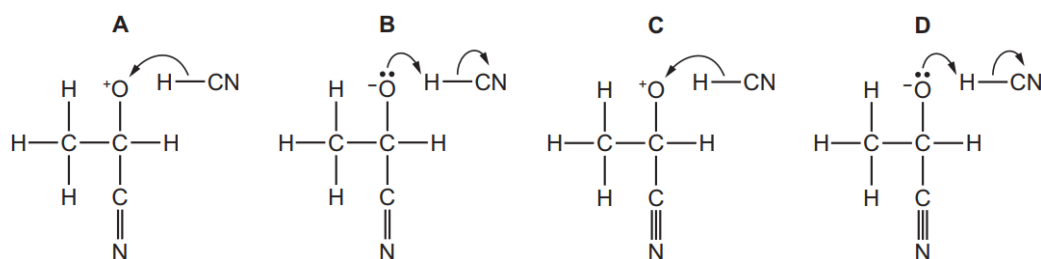
5. Ethanal reacts with hydrogen cyanide in the presence of KCN to produce a hydroxynitrile. What is the first step in the mechanism of this reaction?



6. The mechanism for the reaction between ethanal and hydrogen cyanide starts with the step shown.



What is the correct structure of the intermediate ion formed, and what is the next step in this mechanism?



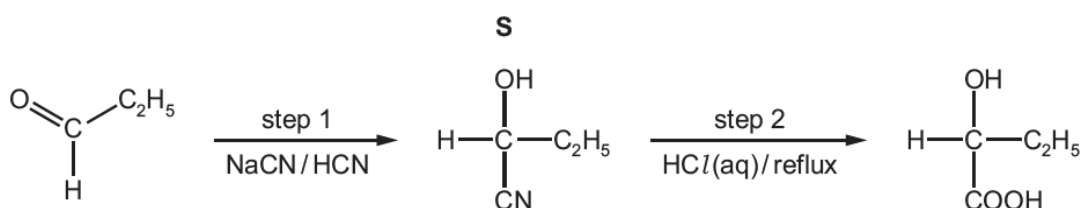
7. $\text{CH}_3\text{CH}_2\text{COCH}_2\text{CH}_3$ reacts with hydrogen cyanide to form an organic product called a cyanohydrin. Which statement is correct?

- A** The cyanohydrin product has one chiral centre.
B The cyanohydrin product is formed by electrophilic addition.
C The cyanohydrin product is formed via an intermediate which contains a C–OH group.
D The formation of the cyanohydrin product requires the use of cyanide ions as a catalyst.

2. Draw the structure of the organic products formed in the following reaction. [1]



3. A student prepares 2-hydroxybutanoic acid using propanal as the starting material. In step 1 the student reacts propanal with a mixture of NaCN and HCN.



Draw the mechanism for the reaction of propanal with the mixture of NaCN and HCN to form S.

- Identify the ion that reacts with propanal.
- Draw the structure of the intermediate of the reaction.
- Include all charges, partial charges, lone pairs and curly arrows.

[4]



4. Complete Fig. 4.2 to show the mechanism for the formation of A from propanone. Include charges, dipoles, lone pairs of electrons and curly arrows as appropriate.

propanone

A



8. Compound Y is heated with a mild oxidising agent. One of the products of the reaction reacts with hydrogen cyanide forming 2-hydroxybutanenitrile.
What is compound Y?

A butan-1-ol

B butan-2-ol

C propan-1-ol

D propan-2-ol

9. Which reaction has a nucleophilic addition mechanism and gives a good yield of product under the stated conditions?

A 1-bromopropane reacting with hot ethanolic sodium hydroxide

B 2-iodopropane reacting with hot aqueous sodium hydroxide

C propanal reacting with hydrogen cyanide under alkaline conditions

D propanal reacting with hydrogen cyanide under acidic conditions

5. CH_3CHO is used in a two-step synthetic route to form **W**, as shown in the following figure.
In step 1, CH_3CHO is heated with HCN in the presence of KCN .



- (i) Name the mechanism for the reaction in step 1 in Fig. 6.1.

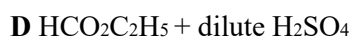
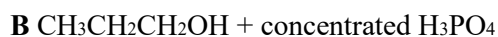
[1]

- (ii) Complete the following figure to show the mechanism for the reaction in step 1.
Include all products, charges, dipoles, lone pairs of electrons and curly arrows, as appropriate.



- (iii) Suggest a suitable reagent and conditions for step 2 in above figure.

10. Which pair of reagents react together in a redox reaction?



11. Which reaction takes place by a nucleophilic addition mechanism?

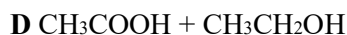
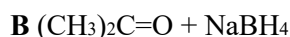
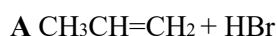
A propene reacting with hydrogen bromide

B 2-bromopropane reacting with sodium hydroxide in ethanol

C propanone reacting with hydrogen cyanide

D methane reacting with chlorine

12. Which pair of reagents reacts to form a product with a chiral carbon atom?



13. Which statement is correct for the reaction of carbonyl compounds with HCN?

A The reaction is catalysed by concentrated H_2SO_4 .

B Pentan-2-one and HCN react to give a chiral product.

C The reaction is a condensation reaction.

D The reaction is nucleophilic substitution.

14. Butanone, $\text{CH}_3\text{CH}_2\text{COCH}_3$, and HCN mixed with a little KCN react together in a nucleophilic addition reaction. Which description of the mechanism of this nucleophilic addition reaction is correct?

A The π bond pair of $\text{C}=\text{O}$ accepts H^+ from HCN and then CN^- acts as a nucleophile.

B A π bond pair from CN^- attacks the δ^+ C and HCN then donates H^+ to O.

C The lone pair on O accepts H^+ from HCN and then CN^- acts as a nucleophile.

D A lone pair from CN^- attacks the δ^+ C and then O^- accepts H^+ from HCN.

6. Name an organic functional group which reacts with a nucleophile in an addition reaction.

..... [1]

15. Which compound, on reaction with hydrogen cyanide, produces a compound with a chiral centre?

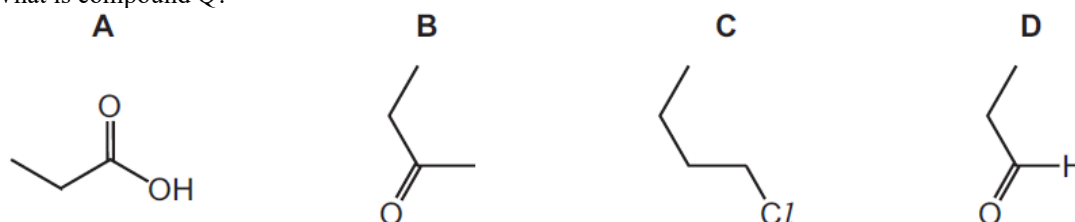
A CH_3CHO

B $\text{CH}_3\text{CH}_2\text{COCH}_2\text{CH}_3$

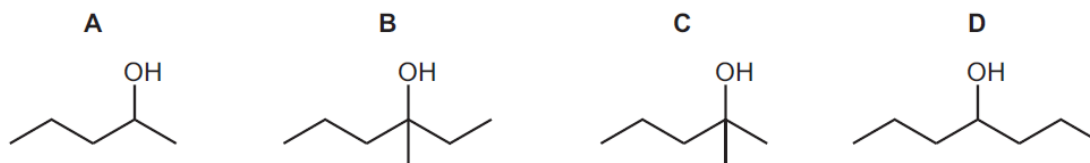
C $\text{CH}_3\text{CO}_2\text{CH}_3$

D HCHO

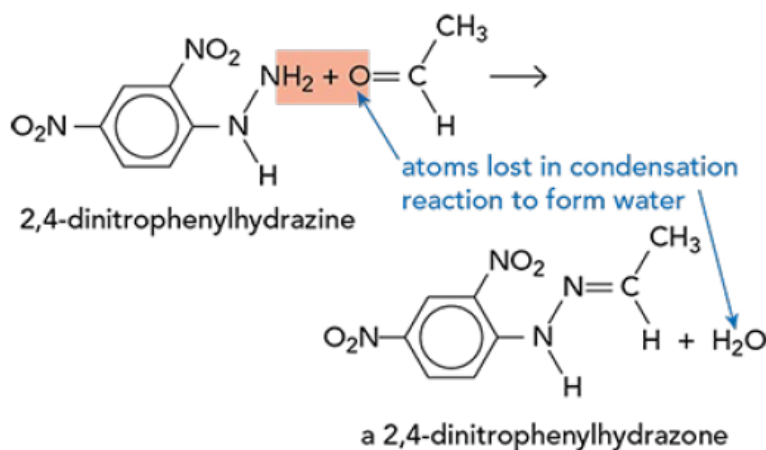
16. Compound Q reacts when heated with HCN in the presence of a catalyst to produce compound R. Molecules of compound R each contain four carbon atoms. What is compound Q?

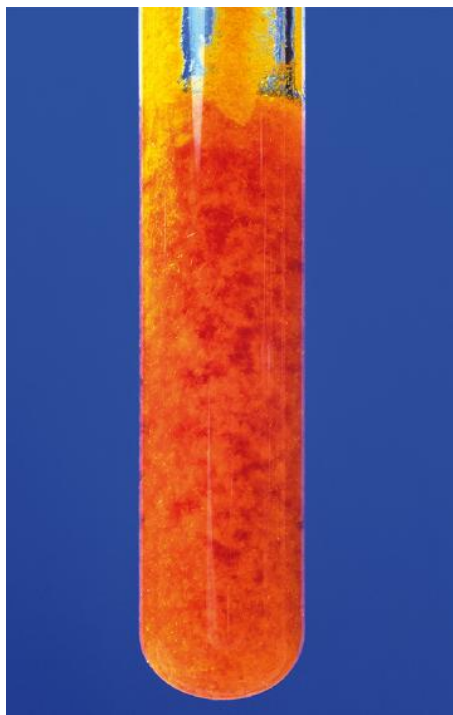


17. An organometallic lithium compound, RLi , contains the nucleophile R^- . $\text{CH}_3\text{CH}_2\text{Li}$ reacts with pentan-2-one. The mechanism is nucleophilic addition. The first step produces an anion which is then protonated to form the final product. Which organic product is formed?

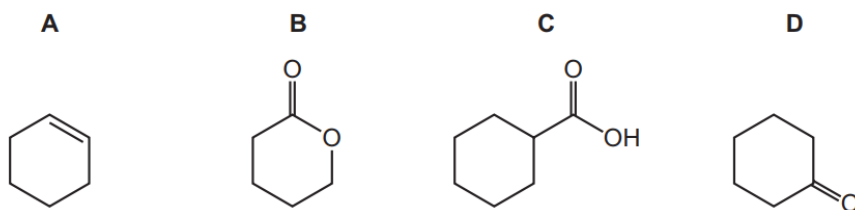


2,4-DNPH test

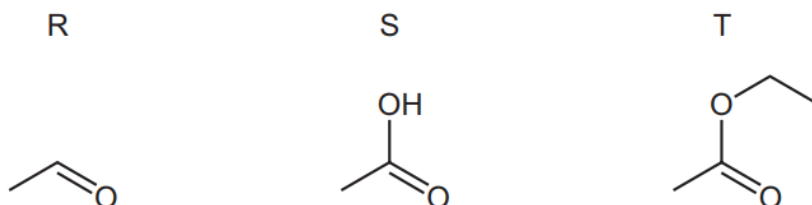




18. Which compound will produce a yellow-orange precipitate when added to 2,4-dinitrophenylhydrazine?



19. The skeletal formulae of three compounds are shown.



Which compounds will give a positive test with 2,4-dinitrophenylhydrazine reagent?

A R only **B** R and S only **C** S and T only **D** R, S and T

20. Two carbon-containing products result from the reaction of alkene Z with a hot, concentrated, acidified solution of potassium manganate(VII).

One product forms an orange precipitate with 2,4-dinitrophenylhydrazine reagent. The other product is a gas which gives a white precipitate with aqueous calcium hydroxide.

Which alkene could be alkene Z?

A but-2-ene
B 2-methylpropene
C 2-methylbut-2-ene
D propene

21. Structural and stereoisomerism should be considered when answering this question.
 P has molecular formula $C_5H_{10}O$.
 P produces an orange precipitate with 2,4-dinitrophenylhydrazine (2,4-DNPH reagent).
 How many isomeric structures does P have?

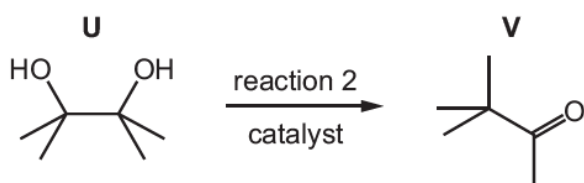
A 5

B 6

C 7

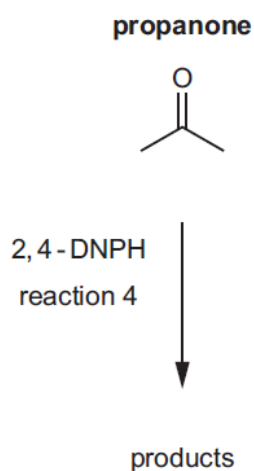
D 8

7. Reaction 2 occurs in the presence of a catalyst; knowledge of the mechanism for this reaction is not required.



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]

8. State what is observed in reaction 4.



22. 1.0 mol of an organic compound, J, requires 6.0 mol of oxygen for complete combustion.
 1.0 mol of J reacts with sodium, producing 0.50 mol of a gas that gives a 'pop' with a lighted splint.
 J reacts with an excess of hot acidified potassium manganate(VII) to produce an organic compound which gives an orange-red precipitate with 2,4-DNPH reagent.
 Which compound is J?

- A but-1-ene
 B butan-2-ol
 C propan-2-ol
 D 2-methylpropan-2-ol

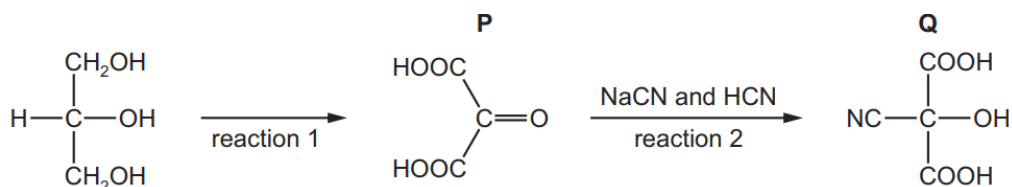
23. But-2-ene reacts with cold dilute acidified KMnO_4 to give product X.
 But-2-ene reacts with hot concentrated acidified KMnO_4 to give product Y.
 Which statement about product X and product Y is correct?

- A Both product X and product Y will react with 2,4-dinitrophenylhydrazine.
 B Neither product X nor product Y will react with 2,4-dinitrophenylhydrazine.
 C Product X will react with 2,4-dinitrophenylhydrazine, product Y will not.
 D Product Y will react with 2,4-dinitrophenylhydrazine, product X will not.

24. Two carbon-containing products result from the reaction of alkene Z with a hot, concentrated, acidified solution of potassium manganate(VII).
 One product forms an orange precipitate with 2,4-dinitrophenylhydrazine reagent. The other product is a gas which gives a white precipitate with aqueous calcium hydroxide.
 Which alkene could be alkene Z?

- A but-2-ene
 B 2-methylpropene
 C 2-methylbut-2-ene
 D propene

9. Glycerol, $\text{CH}_2(\text{OH})\text{CH}(\text{OH})\text{CH}_2\text{OH}$, is widely used in the food industry and in pharmaceuticals.
 A series of reactions starting from glycerol is shown.



- (i) Suggest the reagent(s) and conditions for reaction 1. [1]
- (j) Name the reaction mechanism for reaction 2. [1]
- (k) Give the observation you would make when 2,4-dinitrophenylhydrazine is added to P. [1]

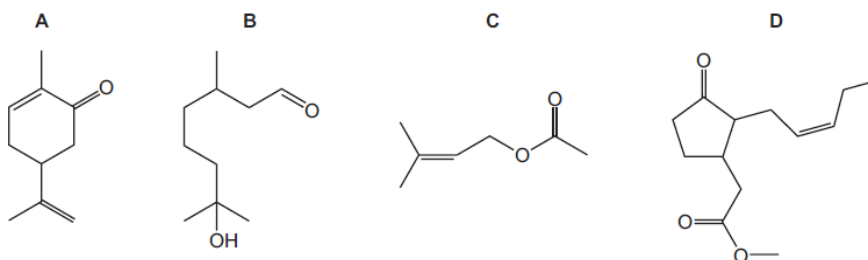
25. Which compound can undergo nucleophilic addition?

- A bromoethane, $\text{C}_2\text{H}_5\text{Br}$
- B ethanal, CH_3CHO
- C ethane, C_2H_6
- D ethene, C_2H_4

Fehling's test



26. Which compound forms a precipitate when mixed with 2,4-DNPH reagent and also forms a precipitate when mixed with Fehling's reagent?

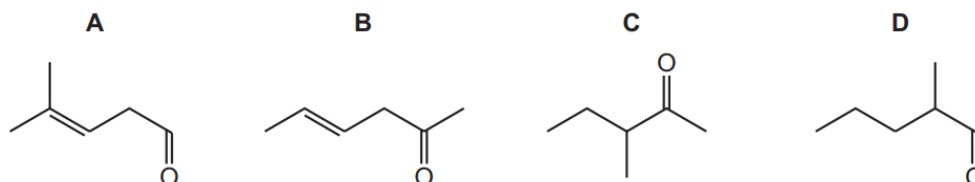


27. A carbonyl compound has the structural formula CH_3COCHO .

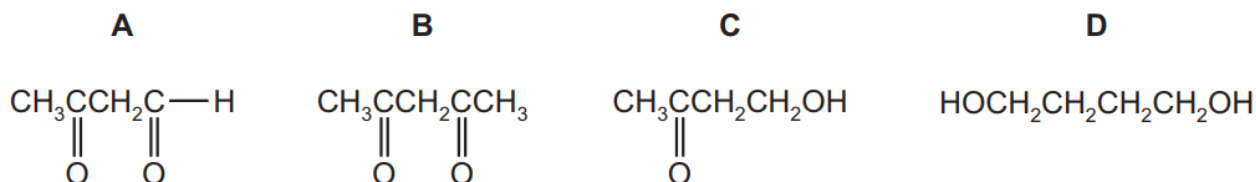
Which row is correct for the observations made when this compound is treated with the given reagents?

	2,4-DNPH reagent	Fehling's reagent
A	silver mirror	red precipitate
B	silver mirror	orange precipitate
C	orange precipitate	silver mirror
D	orange precipitate	red precipitate

28. A carbonyl compound, X, reacts with HCN in the presence of NaCN to make a compound with Mr 85. Compound X does not react with Fehling's reagent.
What is compound X?
- A butanal
B butanone
C propanal
D Propanone
29. Alcohol Y gives a yellow precipitate with alkaline aqueous iodine. It can be oxidised to give a mixture of products including substance Z. Substance Z gives a red-brown precipitate with Fehling's solution.
Which alcohol could be Y?
- A $\text{CH}_3\text{CH}(\text{OH})\text{CH}(\text{CH}_3)\text{CH}_2\text{OH}$
B $\text{CH}_3\text{C}(\text{OH})(\text{CH}_3)\text{CH}_2\text{CH}_2\text{OH}$
C $\text{CH}_3\text{CH}(\text{OH})\text{CH}_2\text{CH}(\text{OH})\text{CH}_3$
D $\text{CH}_2(\text{OH})\text{CH}_2\text{CH}(\text{OH})\text{CH}_2\text{CH}_3$
30. Compound X has stereoisomers and forms a precipitate when warmed with Fehling's reagent.
What could be the structure of compound X?



31. Compound Y:
- changes the colour of acidified $\text{K}_2\text{Cr}_2\text{O}_7$ from orange to green
 - has no effect on Fehling's reagent
 - produces an orange precipitate with 2,4-dinitrophenylhydrazine reagent.
- What is compound Y?



32. Which reaction will distinguish between propan-1-ol and propan-2-ol?
- A warming with acidified KMnO_4
B warming with acidified $\text{K}_2\text{Cr}_2\text{O}_7$
C dehydration, followed by reaction with $\text{Br}_2(\text{aq})$
D mild oxidation, followed by reaction with Fehling's reagent

33. Butanedione, $\text{CH}_3\text{COCOCH}_3$, is a yellow liquid.

How does butanedione react with 2,4-dinitrophenylhydrazine reagent and Fehling's reagent?

	2,4-dinitrophenylhydrazine	Fehling's
A	positive	positive
B	positive	negative
C	negative	positive
D	negative	negative

34. Diols in which both hydroxy groups are bonded to the same carbon atom spontaneously eliminate a molecule of water to produce a carbonyl compound.

Which compound is hydrolysed to form a product that gives a positive reaction with 2,4-dinitrophenylhydrazine but not with Fehling's reagent?

- A** 1,1-dibromopropane
- B** 1,2-dibromopropane
- C** 1,3-dibromopropane
- D** 2,2-dibromopropane

Tollens' test



35. Which reagent:
- can confirm the presence of a carbonyl group in an organic compound
 - does not distinguish between aldehydes and ketones?

A acidified $\text{K}_2\text{Cr}_2\text{O}_7$
 B 2,4-DNPH reagent
 C Fehling's reagent
 D LiAlH_4

10. **K** has molecular formula $\text{C}_3\text{H}_6\text{O}$.

When **K** is added to 2,4-dinitrophenylhydrazine, an orange precipitate forms.

When **K** is warmed with Tollens' reagent, a silver mirror forms.

Draw the displayed formula of **K**.

[2]

11. Hydroxyethanal reacts separately with 2,4-dinitrophenylhydrazine (2,4-DNPH) and with Tollens' reagent. State what you would observe in each reaction.

[2]

12. Explain why Fehling's reagent does not react with propanone.

36. Which compound reacts with 2,4-dinitrophenylhydrazine reagent but does **not** react with Tollens' reagent?

A $\text{CH}_3\text{COCO}_2\text{H}$
 B $\text{CH}_3\text{CH}(\text{OH})\text{CHO}$
 C CH_3COCHO
 D $\text{CH}_3\text{CH}(\text{OH})\text{CH}_3$

37. The formulae of three compounds are shown.

$\text{C}_3\text{H}_7\text{CHO}$ $\text{C}_2\text{H}_5\text{COCH}_3$ $\text{CH}_2\text{CHCH}_2\text{CH}_2\text{OH}$

Only one of these compounds will decolourise bromine water. Only one of these compounds will produce a silver mirror with Tollens' reagent.

Which row shows the correct results?

	decolourises bromine water	forms a silver mirror with Tollens' reagent
A	$\text{C}_2\text{H}_5\text{COCH}_3$	$\text{C}_3\text{H}_7\text{CHO}$
B	$\text{C}_3\text{H}_7\text{CHO}$	$\text{C}_2\text{H}_5\text{COCH}_3$
C	$\text{C}_2\text{H}_5\text{COCH}_3$	$\text{CH}_2\text{CHCH}_2\text{CH}_2\text{OH}$
D	$\text{C}_3\text{H}_7\text{CHO}$	$\text{CH}_2\text{CHCH}_2\text{CH}_2\text{OH}$

38. For which mixture is the observation described correctly?

	reagents	Observation
A	pentanal + Fehling's reagent	blue solution changes to orange/red precipitate
B	pentanal + hot, acidified potassium dichromate(VI)	green solution changes to orange solution
C	pentan-2-one + warm Tollens' reagent	colourless solution changes to silver mirror
D	C ₆ H ₁₄ + acidified potassium manganate(VII)	purple solution changes to colourless solution

13. Alcohol **Y** reacts completely when warmed with acidified Cr₂O₇²⁻ 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 (3) the functional group(s) present in **Z**.

[1]

functional group	present in Z
Aldehyde	
Ketone	
carboxylic acid	

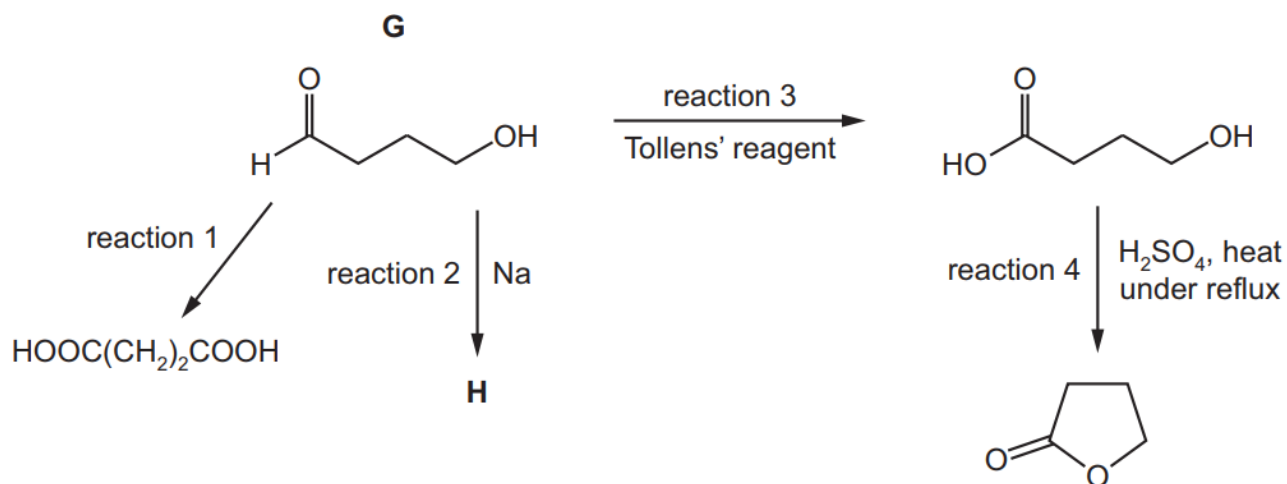
39. Which statement about butanone is correct?

- A** Butanone can be dehydrated by concentrated sulfuric acid to give CH₂=CHCH=CH₂.
B Butanone gives a positive result with Tollens' reagent.
C Butanone reacts with HCN by an electrophilic addition mechanism.
D Butanone reacts with NaBH₄ to give a chiral product.

40. In which reaction is the organic compound oxidised?

- A** CH₃CH₂CH₂CHO + Tollens' reagent
B CH₃CH₂CH₂CHO + LiAlH₄
C CH₃CH₂CH₂OH + concentrated H₃PO₄
D CH₃CO₂C₂H₅ + dilute H₂SO₄

14. Some reactions of compound **G** are shown.



- (i) State the type of reaction that occurs in reaction 1. [1]
- (ii) Suggest the reagent(s) and conditions required for reaction 1. [2]
- (iii) Draw the structure of the organic product, **H**, from reaction 2. [1]
- (iv) State what you would observe in reaction 3. [1]
- (v) Give the type of reaction shown by reaction 4. [1]
41. Which pair of test results would prove that a substance, X, is a ketone?
- A** X has no reaction with Tollens' reagent. X reacts with alkaline aqueous iodine.
- B** X is reduced by lithium aluminium hydride. X is oxidised by acidified dichromate(VI).
- C** X reacts with 2,4-DNPH reagent. X has no reaction with Fehling's reagent.
- D** X reacts with hydrogen cyanide. X is reduced by lithium aluminium hydride.

Iodoform test

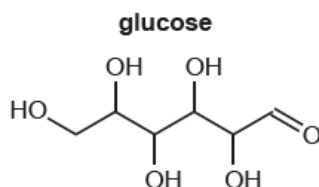


42. Which compound gives both:
- an orange precipitate with 2,4-DNPH reagent
 - **and** a yellow precipitate with alkaline $I_2(aq)$?
- A ethanol
B methanal
C propanal
D propanone
43. Which reagent gives a positive result with propanone?
- A alkaline $I_2(aq)$
B aqueous bromine
C Fehling's reagent
D Tollens' reagent
44. Compound R gives a positive test with alkaline aqueous iodine. Compound R does **not** display stereoisomerism. What could be compound R?
- A $CH_3COCH_2CH_2OH$
B $CH_3CH_2CH(OH)CHO$
C $CH_3COCH(OH)CH_3$
D $(CH_3)_2C(OH)CHO$
45. Which compound produces a precipitate with 2,4-dinitrophenylhydrazine reagent **and** also with alkaline aqueous iodine?
- A butan-2-ol
B butanal
C butanone
D pentan-3-one
46. Which compound gives a positive test with alkaline aqueous iodine and does **not** show optical isomerism?
- A $CH_3COCH_2CH_2OH$
B $CH_3CH_2CH(OH)CHO$
C $CH_3COCH(OH)CH_3$
D $(CH_3)_2C(OH)CHO$

47. In which pair will each compound give a different visible result with alkaline $I_2(aq)$?

- A CH_3CH_2OH and CH_3CHO
 B CH_3CHO and CH_3COCH_3
 C CH_3COOH and $C_2H_5COC_2H_5$
 D CH_3CH_2OH and C_2H_5CHO

15. The structure of glucose, $C_6H_{12}O_6$, is shown in figure below



Separate samples of aqueous glucose are tested with the reagents shown in the following table.

Complete the table with the observation for each reaction.

Write “no reaction” if applicable.

[3]

reagent and conditions	observation with glucose
acidified $KMnO_4(aq)$ and warm	
Fehling's reagent and warm	
alkaline $I_2(aq)$ and warm	

48. W reacts with alkaline $I_2(aq)$ to form a yellow precipitate and $CH_3CH_2CO_2^-$ ions.
 Which row identifies W and the yellow precipitate?

	identity of W	identity of yellow precipitate
A	butanone	CHI_3
B	Butanone	CH_3I
C	Propanone	CHI_3
D	Propanone	CH_3I

49. Which reaction has a product that gives a yellow precipitate when treated with alkaline $I_2(aq)$?

- A** 2-chloropropane is warmed with a dilute aqueous solution of sodium hydroxide.
B Ethanal is heated under reflux with acidified potassium dichromate(VI).
C Methyl ethanoate is heated under reflux with dilute sulfuric acid.
D Propanal is reacted with $NaBH_4$, followed by dilute sulfuric acid.

50. Seven aldehydes and ketones

- contain only one oxygen atom per molecule
- have four or fewer carbon atoms in their structures.

Alkaline $I_2(aq)$ is added to each of these carbonyl compounds separately.

How many of these carbonyl compounds produce a yellow precipitate with alkaline $I_2(aq)$?

- A 1 B 2 C 3 D 4

51. Structural isomerism only should be considered when answering this question.
 Several compounds with molecular formula $C_4H_8O_2$ have **one** carbonyl group and **one** OH group.
 How many of these compounds produce yellow crystals with alkaline $I_2(aq)$ at room temperature?

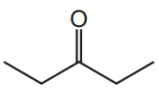
A 2

B 3

C 4

D 5

52. The table shows a student's predictions for the reactions of three compounds.

	compound	alkaline $I_2(aq)$	Fehling's reagent	Tollens' reagent
1		✓	✓	✓
2		✓	x	x
3		x	x	x

Which rows show the correct predictions?

A 1, 2 and 3

B 1 and 2 only

C 1 and 3 only

D 2 and 3 only

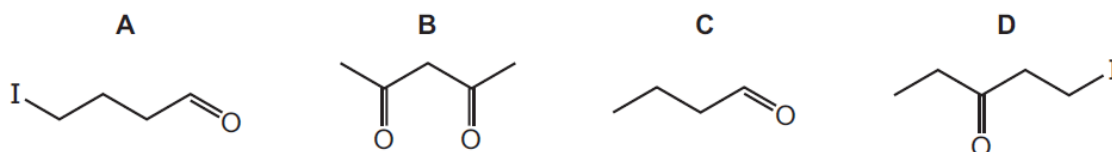
16. Compound X can be oxidised to compound Y.
 Compound Y gives a yellow precipitate with alkaline $I_2(aq)$.
 What is compound X?

- A butan-1-ol
 B butan-2-ol
 C methylpropan-1-ol
 D methylpropan-2-ol

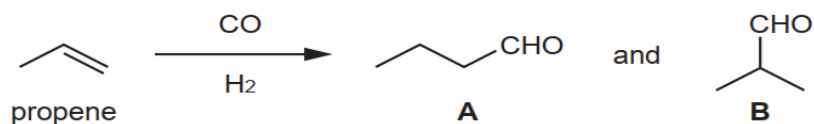
53. Three tests were performed on an unknown organic compound.

test reagent	test result
2,4-DNPH reagent	orange ppt
Tollens' reagent	no change
alkaline $I_2(aq)$	yellow ppt

What is the organic compound tested?



17. Alkenes undergo an addition reaction with a 1:1 mixture of CO and H₂ to form aldehydes. Fig. 3.1 shows the reaction of propene with a 1:1 mixture of CO and H₂.



Aldehydes **A** and **B** are structural isomers. **A** and **B** show reactions typical of aliphatic aldehydes.

- (a) (i) **A** undergoes a nucleophilic addition reaction with a mixture of HCN and KCN, forming compound **C**. Complete the diagram to show the mechanism for this reaction. Include charges, dipoles, lone pairs of electrons and curly arrows, as appropriate. Draw the structure of the organic intermediate.



18. (ii) Table 3.1 shows information about three experiments involving **B**.

Complete the following table

[3]

experiment	reagents	observation with B
1		solution turns from orange to green
2		a silver mirror forms on the sides of the reaction vessel
3	Br ₂ (aq)	

- (iii) **B**, C₄H₈O, is oxidised by acidified potassium manganate(VII).

Complete the equation for this reaction. Use [O] to represent one atom of oxygen from the oxidising agent. [1]

- (b) When propene reacts with CO and an excess of H₂, an alkane and a mixture of alcohols are formed instead. The alcohols are isomers of each other.

Suggest the molecular formulae of the alkane and the alcohols that are formed under these conditions. [2]

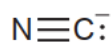
19. CH₃CHO is used in a two-step synthetic route to form **W**, as shown in the following figure.

In step 1, CH₃CHO is heated with HCN in the presence of KCN.



- (i) Name the mechanism for the reaction in step 1 in Fig. 6.1. [1]

(ii) Complete the following figure to show the mechanism for the reaction in step 1. Include all products, charges, dipoles, lone pairs of electrons and curly arrows, as appropriate.



(iii) Suggest a suitable reagent and conditions for step 2 in above figure.

20. A and B are structural isomers with molecular formula C₅H₁₀O.

They are both straight-chained molecules with only one functional group.

Table 5.1 describes observations when separate samples of A and B are added to different reagents.

reagent	A	B
2,4-dinitrophenylhydrazine (2,4-DNPH reagent)	orange precipitate appears	orange precipitate appears
Tollens' reagent	silver mirror appears	no reaction
alkaline I ₂ (aq)	no reaction	no reaction

(i) Name the functional group present in both A and B. [1]

(ii) Draw the structures of A and B in the boxes. [2]

(iii) C is a structural isomer of A and B.

C is straight chained and has two functional groups.

C shows only one type of stereoisomerism.

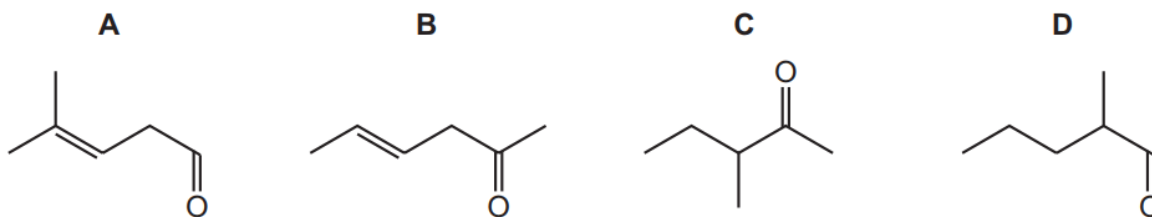
The following table describes observations when separate samples of C are added to different reagents.

reagent	C
2,4-dinitrophenylhydrazine (2,4-DNPH reagent)	no reaction
Br ₂ (aq)	orange to colourless
alkaline I ₂ (aq)	yellow precipitate appears

a) Draw the structure of C. [2]

b) Name the type of stereoisomerism shown by molecules of C. [1]

54. Compound X has stereoisomers and forms a precipitate when warmed with Fehling's reagent. What could be the structure of compound X?



55. T is an organic compound which contains 66.7% by mass of carbon. T also contains one atom of oxygen per molecule. T reacts with alkaline $I_2(aq)$ to produce a yellow precipitate. What is T?

- A methylpropan-2-ol
 B butan-2-ol
 C butanal
 D butanone

56. Two isomeric alcohols, W and X, have molecular formula C_4H_9OH . W is oxidised to carbonyl compound Y which gives a red precipitate with Fehling's solution. X is oxidised to carbonyl compound Z which does **not** give a red precipitate with Fehling's solution. Which of W and X gives a yellow precipitate with alkaline $I_2(aq)$?

- A insufficient data is given to answer this question
 B W only
 C X only
 D neither W nor X

21. W, X and Y have the same molecular formula, $C_5H_{10}O$.

W, X and Y are added separately to different reagents. Observations for these reactions are described in the following table.

	+ 2,4-nitrophenylhydrazine	+ alkaline $I_2(aq)$	+ Fehling's reagent and warm
W	orange precipitate seen	no change	orange-red precipitate seen
X	orange precipitate seen	yellow precipitate seen	no change
Y	orange precipitate seen		

- (i) W, X and Y each contain a common functional group. Name the functional group that is present in all three compounds. [1]
- (ii) State the formula of the yellow precipitate produced when X is added to alkaline $I_2(aq)$. [1]
- (iii) W could be one of four structural isomers.
 • Draw the skeletal formulae for two possible structural isomers of W.

- Describe the type of structural isomerism shown.

[3]

57. The skeletal formulae of two organic compounds are shown.

Which reagents can be used to distinguish these two compounds?

1 alkaline $I_2(aq)$

2 acidified $K_2Cr_2O_7$

3 2,4-dinitrophenylhydrazine (2,4-DNPH reagent)

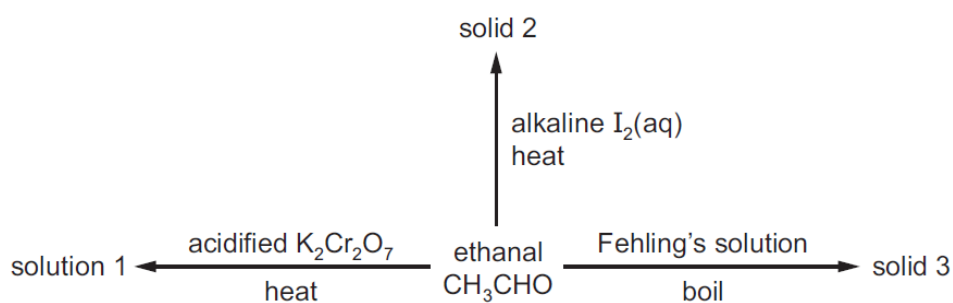
A 1, 2 and 3

B 1 and 3 only

C 2 and 3 only

D 2 only

58. The diagram shows three reactions of ethanal. In each case, an excess of ethanal is used.

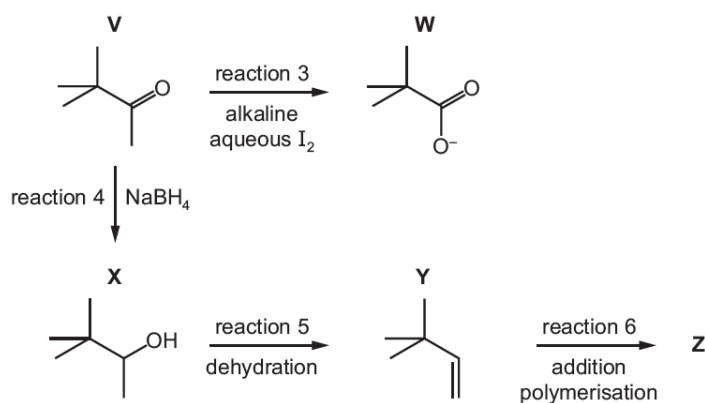


Observations are made after each of the three reactions.

What are the colours of solution 1 and solids 2 and 3?

	solution 1	solid 2	solid 3
A	green	yellow	silver mirror
B	green	yellow	red
C	orange	red	silver mirror
D	orange	red	red

22. **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 $NaBH_4$.



[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]

- 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]

59. Compound X:

- does **not** react with Tollens' reagent
- forms a yellow precipitate with alkaline $I_2(aq)$
- does **not** react with sodium.

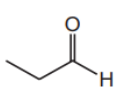
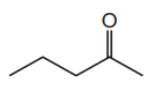
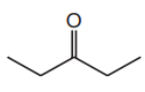
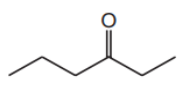
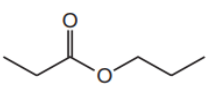
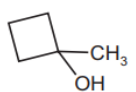
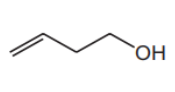
What could be the identity of X?

- A** CH_3CHO
B $C_2H_5COCH_3$
C $CH_3COOC_2H_5$
D $CH_3CHOHCH_3$

23. Organic compounds can be distinguished using chemical tests and analytical techniques.

(a) Table 3.1 shows four pairs of organic compounds.

Table 3.1

organic compounds		reagent	positive result of chemical test on identified compound
A1 	A2 		
B1 	B2 		
C1 	C2 		
D1 	D2 		

Complete Table 3.1 to:

- identify a reagent which can distinguish between the compounds in each pair
 - give the **positive** result of the chemical test **and** identify which compound shows this result.
- Use a different reagent for each test. [8]

(ii) **A1** and **A2** are structural isomers.

Define structural isomers.

[1]

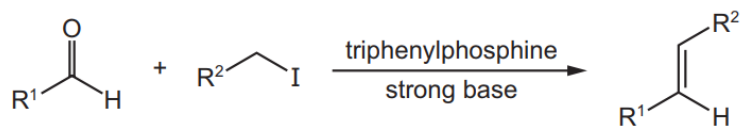
(iii) Give the systematic name of **B2**.

[1]

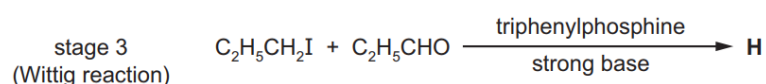
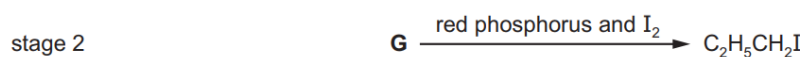
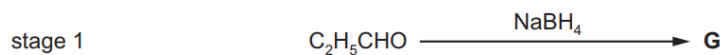
(iv) Deduce the molecular formula **D1**.

[1]

24. In a Wittig reaction, an aldehyde reacts with a halogenoalkane to form an alkene. The conversion is shown in the following unbalanced equation.



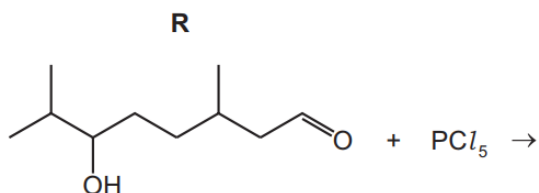
Compound **H** can be made from propanal, $\text{C}_2\text{H}_5\text{CHO}$. Stage 3 in the reaction scheme is a Wittig reaction.



State the types of reaction that occur in stages 1 and 2. [2]

Draw the structures of **G** and **H**. [2]

25. Complete the equation shown in Fig. 3.4 to describe the reaction that occurs when **R** reacts with $\text{PCl}_5(\text{s})$. [2]



Suggest why samples of **Q** and **R** must be dried before PCl_5 is added. Include a relevant equation to support your answer.

60. Two carbonyl compounds have the molecular formula $\text{C}_3\text{H}_6\text{O}$.
Which reagents give **different** observations with these two compounds?
1 acidified aqueous potassium manganate(VII)
2 Fehling's reagent
3 alkaline aqueous iodine

A 1, 2 and 3

B 1 and 2 only

C 2 and 3 only

D 1 only

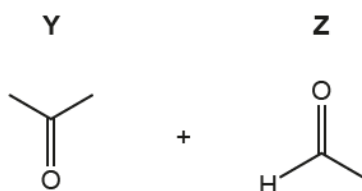
61. X is a non-cyclic ketone with a single carbonyl group and no other functional groups. Ketone X has the following properties.
- When ketone X is treated with NaBH_4 , the organic product has a Mr 2.3256% greater than the Mr of ketone X.
 - Ketone X gives a yellow precipitate with alkaline $\text{I}_2(\text{aq})$.
- How many isomeric ketones could be ketone X?

A 1 B 2 C 3 D 4

62. 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 $\text{CH}_3\text{CH}_2\text{CHO}$
 B $\text{CH}_3\text{CH}_2\text{CO}_2\text{H}$
 C $\text{CH}_3\text{CH}(\text{OH})\text{CH}_3$
 D $(\text{CH}_3)_3\text{COH}$

26. Complete Table 1.1 to show what is observed when compounds **Y** and **Z** react separately with the named reagents.



reagent	observation with Y	observation with Z
$\text{Na}_2\text{CO}_3(\text{aq})$	no reaction	
alkaline $\text{I}_2(\text{aq})$		
2,4-dinitrophenylhydrazine (2,4-DNPH)		
Tollens' reagent		

63. Compound Q reacts separately with HCN and NaBH_4 under suitable conditions. Both reactions produce an organic product with a chiral centre. What is compound Q?

A butanone
 B ethanal
 C propanal
 D Propanone

64. Compound X has the following properties.

- When 0.20 mol of X undergoes complete combustion, 14.4 dm³ of carbon dioxide is produced, measured under room conditions.
- X reacts with 2,4-dinitrophenylhydrazine reagent to give an orange crystalline product.
- X does **not** give a yellow precipitate with alkaline I₂(aq).

What could be X?

A hexan-3-one

B propanal

C propan-1-ol

D Propanone

1. Organic compounds can be distinguished using chemical tests.
Table 4.1 shows four pairs of compounds.

organic compounds		reagent	positive result of chemical test on identified compound
A1 	A2 		
B1 	B2 		
C1 	C2 		
D1 	D2 		

(a) Complete Table 4.1 to:

- identify a reagent that could distinguish between the compounds in each pair
- give the **positive** result of the chemical test **and** identify which compound shows this result.

Use a different reagent for each test.

[8]

(b) **C1** has melting point -94°C and boiling point $+49^{\circ}\text{C}$.

Explain these properties by referring to the type of van der Waals' forces between molecules.

[1]

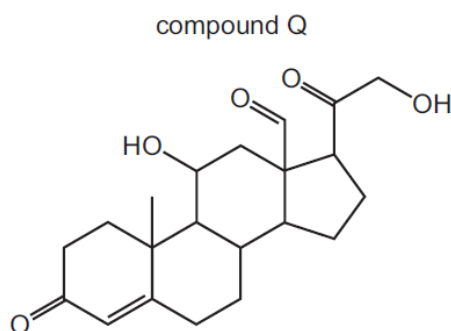
(c) Draw the structure of the cis isomer of **C2**.

[1]

65. Which statement about $\text{H}_2\text{C}=\text{C}(\text{CH}_3)\text{CH}_2\text{CO}_2\text{CH}_3$ is correct?

- A It can be hydrolysed to a secondary alcohol.
- B It can be made using ethanoic acid and a suitable alcohol.
- C It gives a positive test with alkaline $\text{I}_2(\text{aq})$.
- D When treated with hot concentrated acidified KMnO_4 , it gives $\text{CH}_3\text{COCH}_2\text{COOH}$ as one product.

66. The structure of a naturally occurring compound, Q, is shown.



Compound Q is heated under reflux with an excess of acidified KMnO_4 .

Organic product R is formed.

Which row is correct?

	results of tests with compound Q	results of tests with organic product R
A	orange precipitate with 2,4-DNPH and no reaction with alkaline $\text{I}_2(\text{aq})$	yellow precipitate with alkaline $\text{I}_2(\text{aq})$ and no reaction with fehling's reagent
B	red precipitate with Fehling's reagent and no reaction with alkaline $\text{I}_2(\text{aq})$	orange precipitate with 2,4-DNPH and no reaction with alkaline $\text{I}_2(\text{aq})$
C	yellow precipitate with alkaline $\text{I}_2(\text{aq})$ and orange precipitate with 2,4-DNPH	no reaction with alkaline $\text{I}_2(\text{aq})$ and no reaction with Fehling's reagent
D	yellow precipitate with alkaline $\text{I}_2(\text{aq})$ and red precipitate with Fehling's reagent	yellow precipitate with alkaline $\text{I}_2(\text{aq})$ and orange precipitate with 2,4-DNPH

***This is not a complete note. It is to guide you. It is recommended to study the prescribed textbooks along with this material. ***