ANSWERS	

Level 3 Chemistry

91391 Demonstrate understanding of the properties of organic compounds

Credits: Five

Achievement	Achievement with Merit	Achievement with Excellence
Demonstrate understanding of the properties of organic compounds.	Demonstrate in-depth understanding of the properties of organic compounds.	Demonstrate comprehensive understanding of the properties of organic compounds.

You should attempt ALL the questions in this booklet.

A periodic table is provided in the Resource Sheet.

If you need more room for any answer, use the extra space provided at the back of this booklet and clearly number the question.

Check that this booklet has pages 2 – 13 in the correct order and that none of these pages is blank.

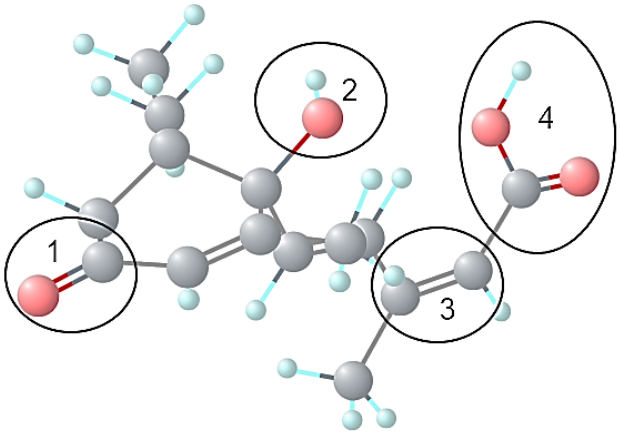
YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.

TOTAL

ASSESSOR'S USE ONLY

QUESTION ONE

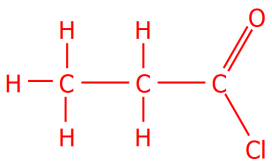
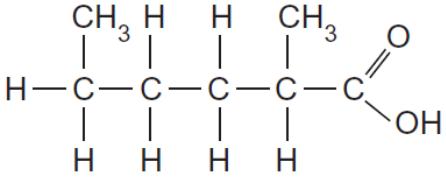
(a) The structure of a plant hormone, ABA, is given below.

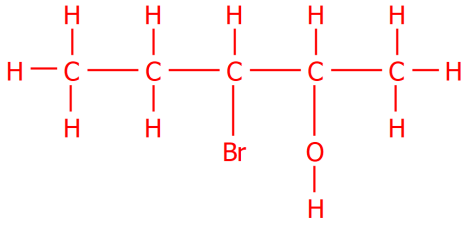


Identify the FOUR different functional groups within the molecule that are circled and numbered above:

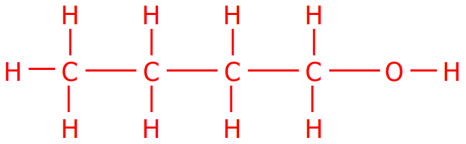
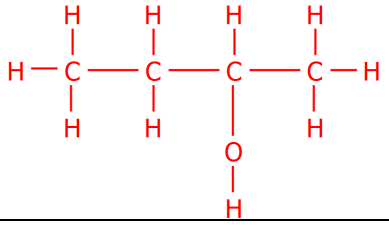
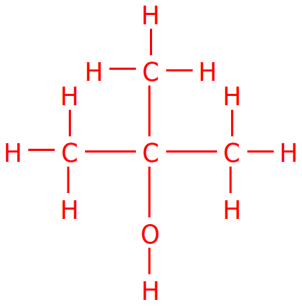
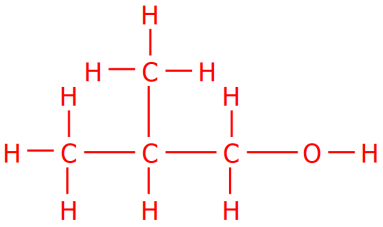
1 ketone	2 alcohol
3 alkene	4 carboxylic acid

(b) Complete the table below by drawing the structural formula for the named compounds or naming the drawn compound using its IUPAC systematic name.

IUPAC systematic name.	Structural formula
Propanoyl chloride	
2-methylhexanoic acid (a bit of a trick Q – check for longest C chain!)	

3-bromopentan-2-ol	

(c) (i) C_4H_9OH has four isomers that are all alcohols.
They are butan-1-ol, butan-2-ol and two others, A and B. Draw them in the box below.

Butan-1-ol 	Butan-2-ol 
Alcohol A 	Alcohol B 

A or B could be either way round

(ii) Describe a chemical test you could do to distinguish between butan-1-ol and butan-2-ol. Include the name of the reagent, any conditions and the expected observations.

Lucas test: Warm samples with anhydrous $ZnCl_2$ and conc HCl.

The one with butan-2-ol will go cloudy after about 10 minutes and the one with butan-1-ol will not change (in this time).

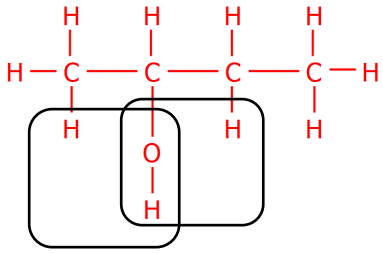
(iii) Using a different reagent, describe how you could distinguish between the isomers A and B you have drawn. Include the observations that would occur.

Warm samples of alcohols A and B with acidified dictomate ($Cr_2O_7^{2-}$ /H^+); Alcohol B (above) will reduce the orange dichromate to green Cr^{3+} while there will be no colour change from orange with the tertiary alcohol (A here).

(d) Elaborate on the reactions when butan-2-ol reacts with concentrated sulfuric acid. In your answer you should include:

- the identification of all organic products formed
- an explanation of the type of reaction taking place
- reasons for the formation of any major and minor products.

Butan-2-ol will undergo an elimination reaction when heated with concentrated sulfuric acid (also known as a dehydration reaction). A H atom and OH group will be removed from adjacent carbon atoms. Since the OH group is on C atom #2 then the H atom could be lost from C atom #1 or C atom #3 giving rise to 2 different products, but-1-ene and but-2-ene respectively.



In elimination reactions the H atom is lost from the C atom that already had least H atoms ("the poor get poorer" / Saytzeff's rule / Zaitsev's rule). The more substituted alkene product is the major product.

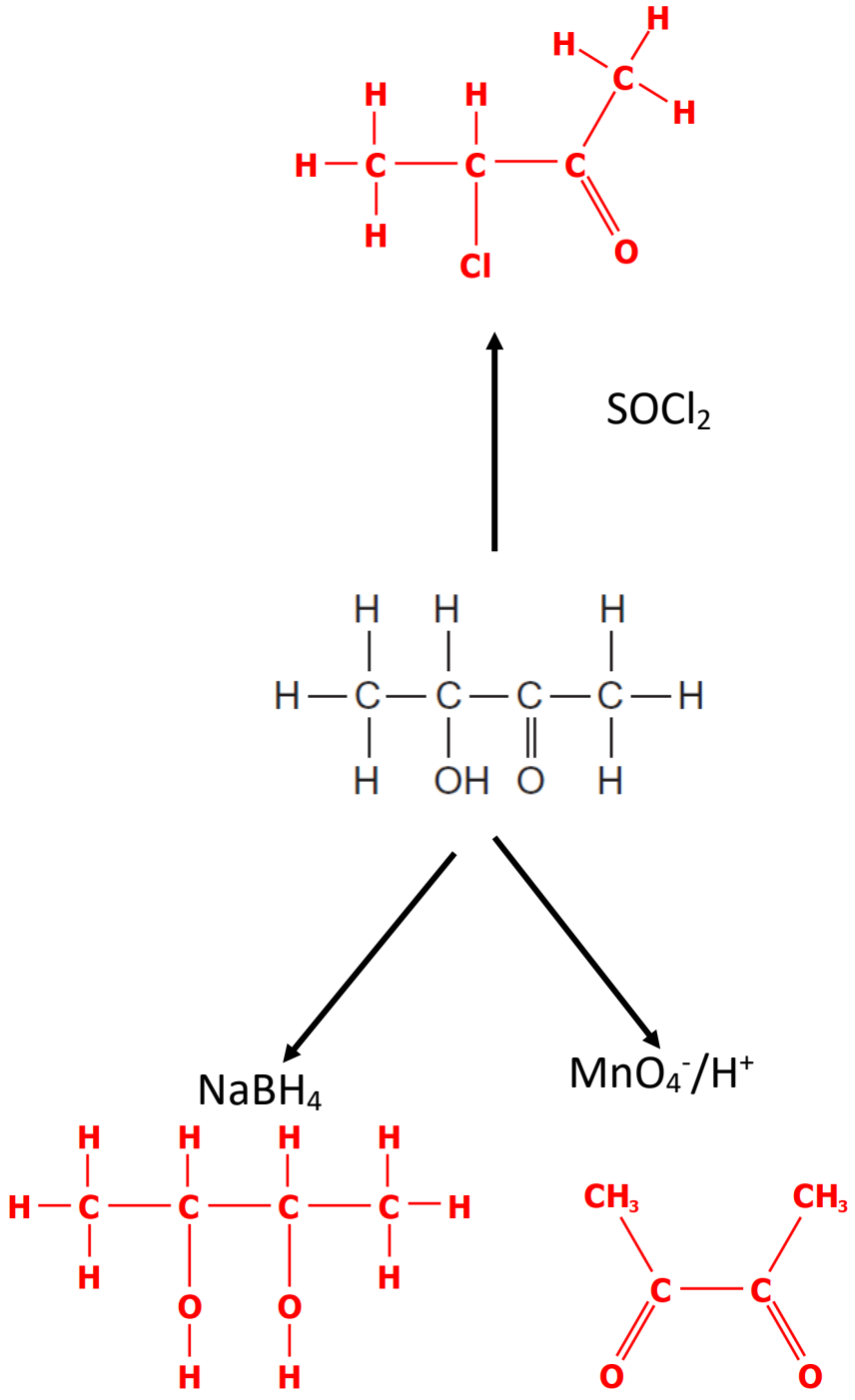
This means the major product is but-2-ene and the minor produce is but-1-ene.

In addition, the but-2-ene formed could be cis or trans-but-2-ene.

Question Two

Acetoin (3-hydroxybutanone) is a colourless or pale yellow to green yellow liquid with a pleasant buttery odour. It is used as a food flavoring and a fragrance.

(a) Complete the scheme that shows some of the reactions of acetoin.



(b) Acetoin is optically active.

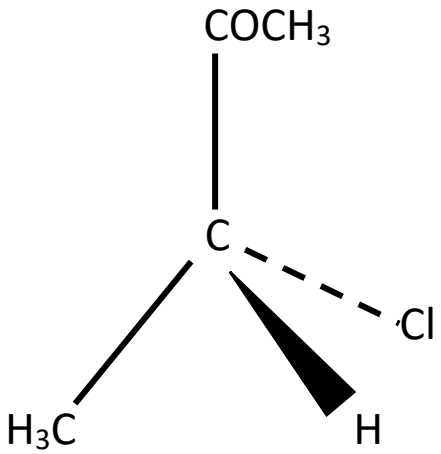
(i) Explain what is meant by the term optically active.

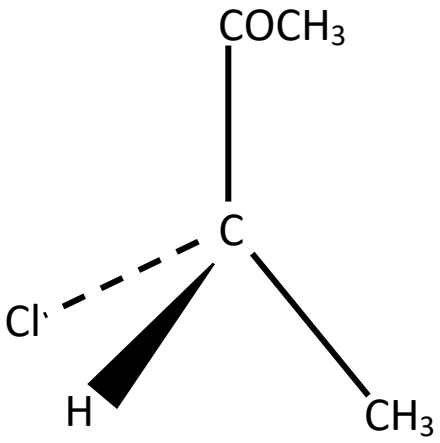
An optically active substance will rotate the plane of plane polarized light as it passes through it.

(ii) Describe the structural feature necessary for acetoin to be optically active.

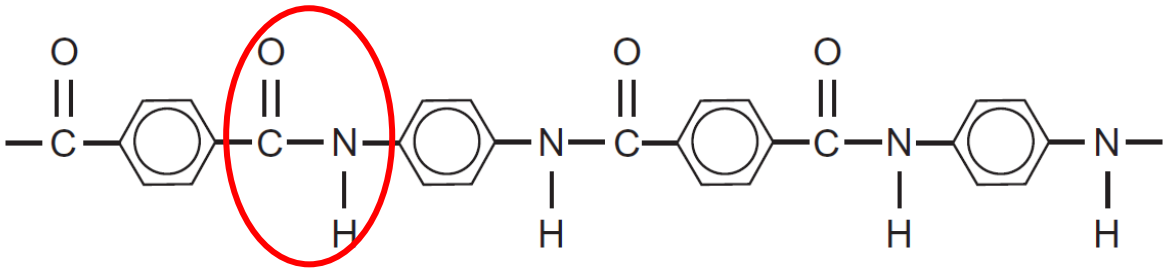
It needs to have a chiral / asymmetric carbon atom, that is, a C atom bonded to 4 different atoms and/or groups, so that the 2 forms (enantiomers) are non-superimposable mirror images of each other.

(iii) Draw the two optical isomers of acetoin below, as 3-D structures.



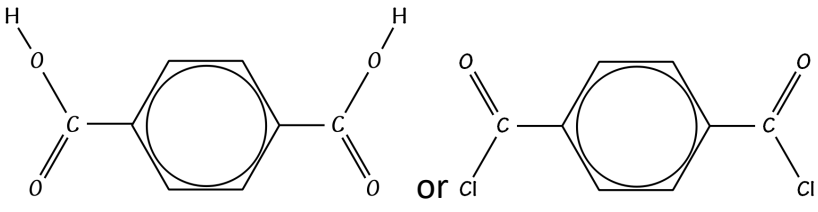


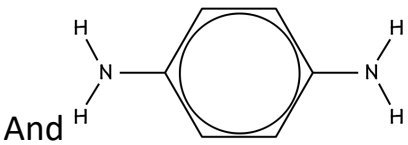
(c) Kevlar is a polyamide. It is used in bulletproof jackets. A section of the polymer chain is drawn below.



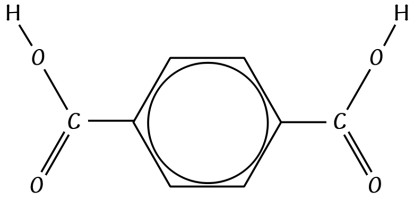
- circle an amide link in the diagram above
- explain the term condensation polymer
- draw the structures of the two monomers which can be used to produce Kevlar.

A condensation polymer is a polymer made from many monomers that react and join in such a way that a small molecule is eliminated as a by product. This molecule is often water or HCl. The monomers have different functional groups.



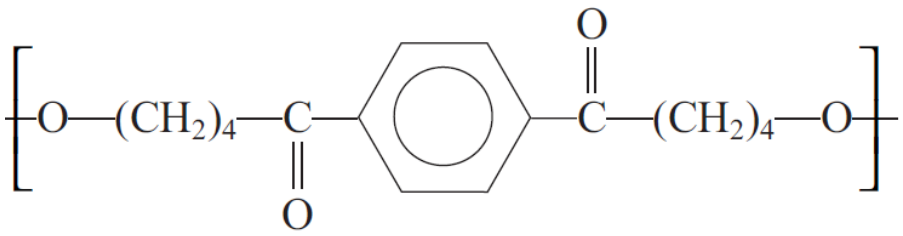


(d) (i) Butane-1,4-diol and benzene-1,4-dicarboxylic acid react to form a polyester.

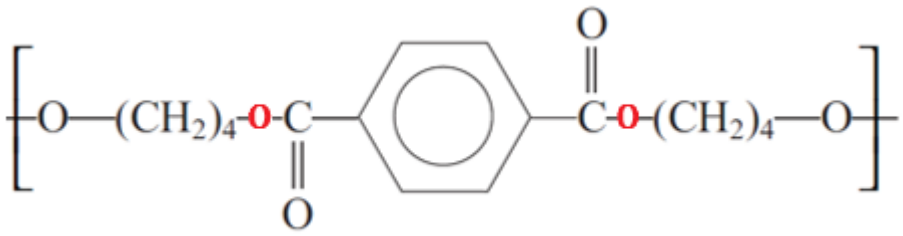


benzene-1,4-dicarboxylic acid

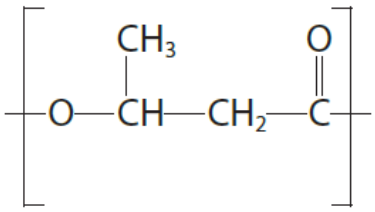
A student was asked to draw the repeat unit of the polyester but made error(s).



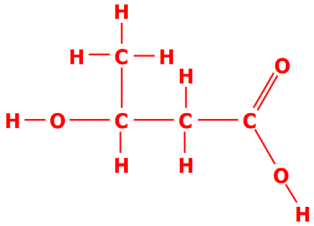
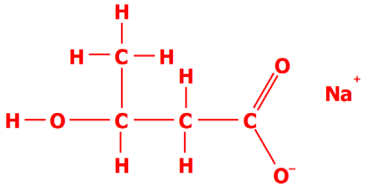
Draw a correct version in the space provided.



(ii) PHB is a biodegradable polymer. The repeat unit is shown below.



It can be hydrolysed by either hydrochloric acid or sodium hydroxide to form different organic products. State the formula of the organic product in each case.

Hydrolysis with HCl	Hydrolysis with NaOH
	

Question Three

(a) Identify the reagents, conditions required, and observations linked to species, to enable the following pairs of chemicals to be distinguished from each other.

(i) 1-chlorobutane and butanoyl chloride

Add water to a sample of each. 1-chlorobutane and water will make a cloudy liquid when shaken. Butanoyl chloride will react vigorously with water to form butanoic acids and 'clouds' of hydrogen chloride gas, i.e. it will fume.

(ii) propanal and propanone

Do a Tollen's or Fehlings test – either answer is correct.

With Tollen's test (Ag^{+}/NH_3) a silver mirror will form with propanal but not with propene.
With Fehlings (Cu^{2+}) there will be a colour change from blue solution to red-orange precipitate with propanal but not with propene.

(iii) aqueous solutions of propanamide and propan-1-amine

Test both with moist red litmus paper / moist green UI paper. There will be a colour change from red to blue (or green to blue) with the amine which is basic but the amide will not change the colour of the indicator paper.

2-chloro-2-methylbutane may be prepared by reacting 2-methylbutan-2-ol with concentrated hydrochloric acid:

$$(CH_3)_2C(OH)CH_2CH_3 + HCl \rightarrow (CH_3)_2C(Cl)CH_2CH_3 + H_2O$$

The method is as follows.

1. *Carefully place 5.00 mL of 2-methylbutan-2-ol and about 25 mL of concentrated hydrochloric acid into a separating funnel.*
2. *Gently shake the mixture for 10 minutes.*
3. *Discard the lower aqueous layer.*
4. *Slowly add about 10 mL of dilute sodium hydrogen carbonate solution to the separating funnel, shaking the mixture gently, inverting the separating funnel and opening the tap at regular intervals.*
5. *Remove the aqueous layer and discard it as before.*
6. *Transfer the organic layer to a conical flask.*
7. *Add a few pieces of anhydrous calcium chloride to the conical flask and shake the mixture.*
8. *Decant the liquid into a distillation flask and distil it to collect the pure 2-chloro-2-methylbutane.*

Organic compound	2-methylbutan-2-ol	2-chloro-2-methylbutane
Boiling point / °C	102	85.5

(b) Why is it necessary to continuously shake the 2-methylbutan-2-ol and the concentrated hydrochloric acid for the reaction to occur (step 2)?

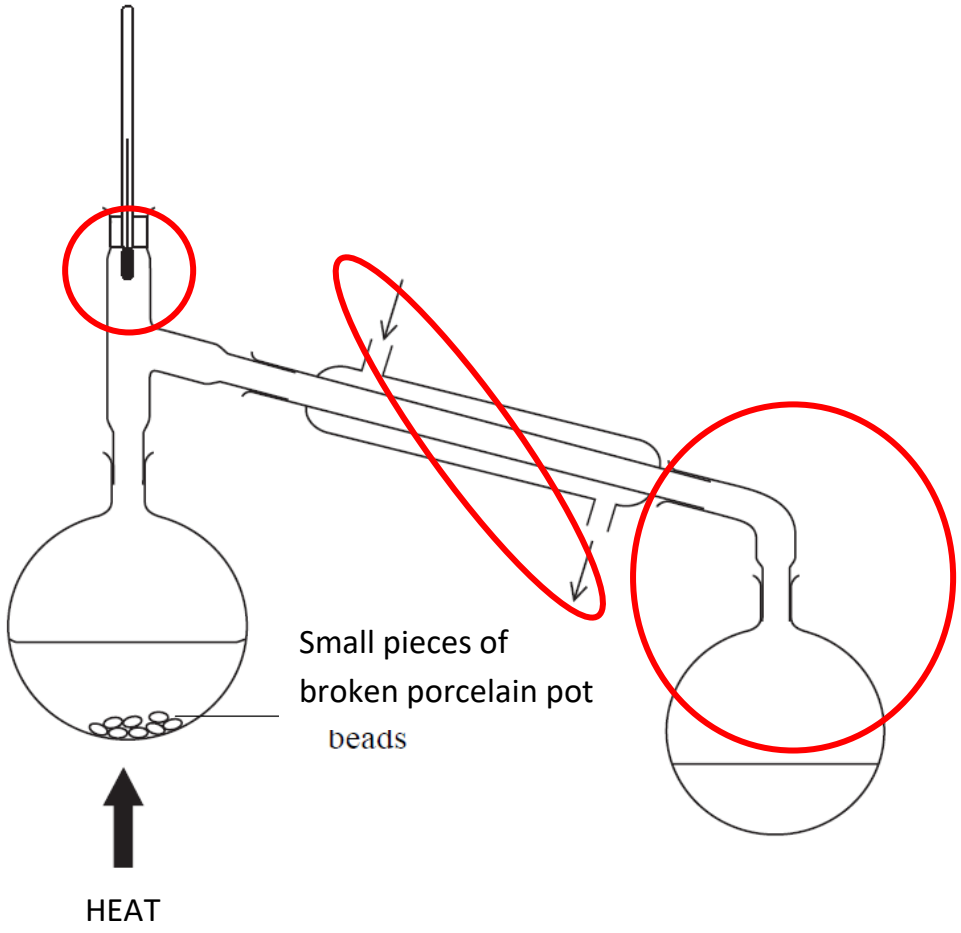
To mix them / bring the 2 chemicals into contact with each other since the Organic & aqueous layers are immiscible

(c) Sodium hydrogen carbonate solution is added in step 4. Explain:

- the purpose of adding the sodium hydrogen carbonate
- the reason for opening the tap of the separating funnel at regular intervals

Neutralise (excess) acid / H^+ / remove acid / H^+ / React with acid
Carbon dioxide / CO_2 /gas is formed so need to release pressure / pressure builds up

(d) An incorrect diagram of the distillation apparatus is shown below.
The clamps are NOT shown but the equipment is adequately held in place.



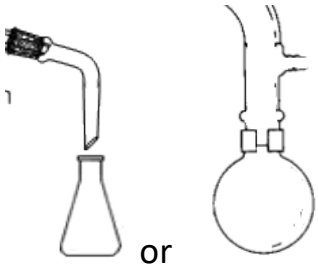
(i) Circle **three mistakes** with the experimental set-up.

(ii) Describe what effects these mistakes would have if the student tried to distil the pure 2-chloro-2-methylbutane.

Thermometer bulb should be opposite the side arm/condenser so that the temperature of the vapour distilling over is measured otherwise a fraction with a wrong boiling point could be collected.

Cold water enters the condenser at the bottom so that the whole condenser is filled with cold water and so the water meeting the hot vapour is always at its coldest so that condensation is the most effective.

The whole assembly is “sealed’ and so would pop apart when pressure built up on heating. Needs to be open e.g.



or

Extra paper if required.

Write the question number(s) if applicable