**Q1.**          Hydrogen and carbon monoxide were mixed in a 2:1 mole ratio. The mixture was allowed to reach equilibrium according to the following equation at a fixed temperature and a total pressure of 1.75 × 104 kPa.

2H2(g)   +   CO(g)      CH3OH(g)

(a)     The equilibrium mixture contained 0.430 mol of carbon monoxide and 0.0850 mol of methanol.

(i)      Calculate the number of moles of hydrogen present in the equilibrium mixture.

.............................................................................................................

(ii)     Hence calculate the mole fraction of hydrogen in the equilibrium mixture.

.............................................................................................................

.............................................................................................................

.............................................................................................................

(iii)     Calculate the partial pressure of hydrogen in the equilibrium mixture.

.............................................................................................................

.............................................................................................................

.............................................................................................................

**(5)**

(b)     In a different mixture of the three gases at equilibrium, the partial pressure of carbon monoxide was 7550 kPa, the partial pressure of hydrogen was 12300 kPa and the partial pressure of methanol was 2710 kPa.

(i)      Write an expression for the equilibrium constant, *K*p, for this reaction.

.............................................................................................................

(ii)     Calculate the value of the equilibrium constant, *K*p, for the reaction under these conditions and state its units.

*K*p ........................................................................................................

.............................................................................................................

*Units* ....................................................................................................

**(3)**

(c)     Two isomeric esters **E** and **F** formed from methanol have the molecular formula C6H12O2

Isomer **E** has only 2 singlet peaks in its proton n.m.r. spectrum.

Isomer **F** is optically active.

Draw the structures of these two isomers.

*Isomer* ***E***

*Isomer* ***F***

**(2)**

**(Total 10 marks)**

**Q2.**          (a)     **P**, **Q** and **R** have the molecular formula C6H12

All three are branched-chain molecules and none is cyclic.  
**P** can represent a pair of optical isomers.  
**Q** can represent a pair of geometrical isomers.  
**R** can represent another pair of geometrical isomers different from **Q**.

Draw one possible structure for one of the isomers of each of **P**, **Q** and **R**.

*Structure of* ***P***

*Structure of* ***Q***

*Structure of* ***R***

**(3)**

(b)     Butanone reacts with reagent **S** to form compound **T** which exists as a racemic mixture. Dehydration of **T** forms **U**, C5H7N, which can represent a pair of geometrical isomers.

(i)      State the meaning of the term *racemic mixture* and suggest why such a mixture is formed in this reaction.

*Racemic mixture* .................................................................................

.............................................................................................................

*Explanation*..........................................................................................

.............................................................................................................

.............................................................................................................

(ii)     Identify reagent **S**, and draw a structural formula for each of **T** and **U**.

*Reagent* ***S*** ...........................................................................................

*Compound* ***T***

*Compound* ***U***

**(6)**

**(Total 9 marks)**

**Q3.**          (a)     Name and outline a mechanism for the formation of butylamine, CH3CH2CH2CH2NH2, by the reaction of ammonia with 1-bromobutane, CH3CH2CH2CH2Br.

*Name of mechanism* ....................................................................................

*Mechanism*

**(5)**

(b)     Butylamine can also be prepared in a two-step synthesis starting from 1-bromopropane, CH3CH2CH2Br. Write an equation for each of the two steps in this synthesis.

*Step 1*

......................................................................................................................

*Step 2*

......................................................................................................................

**(3)**

(c)     (i)      Explain why butylamine is a stronger base than ammonia.

.............................................................................................................

.............................................................................................................

.............................................................................................................

(ii)     Identify a substance that could be added to aqueous butylamine to produce a basic buffer solution.

.............................................................................................................

**(3)**

(d)     Draw the structure of a tertiary amine which is an isomer of butylamine.

**(1)**

**(Total 12 marks)**

**Q4.**          Each of the parts (a) to (e) below concerns a different pair of isomers.

Draw one possible structure for each of the species **A** to **J**, using Table 2 on the Data Sheet where appropriate.

(a)     Compounds **A** and **B** have the molecular formula C5H10**A** decolourises bromine water but **B** does not.

**A**       **B**

**(2)**

(b)     Compounds **C** and **D** have the molecular formula C2H4O2

Each has an absorption in its infra-red spectrum at about 1700 cm–1 but only **D** has a broad absorption at 3350 cm–1

**C**       **D**

**(2)**

(c)     Compounds **E** and **F** are esters with the molecular formula C5 H10O2

The proton n.m.r. spectrum of **E** consists of two singlets only whereas that of **F** consists of two quartets and two triplets.

**E**       **F**

**(2)**

(d)     Compounds **G** and **H** have the molecular formula C3H6Cl2 **G** shows optical activity but **H** does not.

**G**      **H**

**(2)**

(e)     Compounds **I** and **J** have the molecular formula C6H12

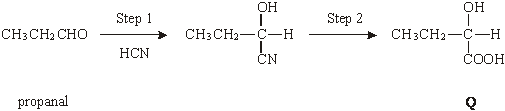
Each has an absorption in its infra-red spectrum at about 1650 cm–1 and neither shows geometrical isomerism. The proton n.m.r. spectrum of **I** consists of a singlet only whereas that of **J** consists of a singlet, a triplet and a quartet.

**I**        **J**

**(2)**

**(Total 10 marks)**

**Q5.**          Consider the reaction sequence shown below.



(a)     Name and outline a mechanism for the reaction in Step 1.

*Name of mechanism ....................................................................................*

Mechanism

**(5)**

(b)     (i)      Name compound **Q** formed in Step 2.

.............................................................................................................

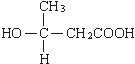
(ii)     Two stereoisomers are formed by the dehydration of **Q**. Give the structures of these two isomers and name the type of stereoisomerism shown.

*Structures of isomers*

*Type of stereoisomerism .*.............................................................................

**(4)**

(c)     An isomer of **Q** which has the structure shown below is polymerised to form the biodegradeable polymer known as PHB.



(i)      Draw the repeating unit of the polymer PHB.

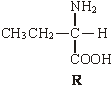
(ii)     Suggest a reason why the polymer is biodegradeable.

.............................................................................................................

.............................................................................................................

**(2)**

(d)     The amino acid **R** is shown below.



(i)      Draw the structure of the zwitterion formed by **R**.

(ii)     Draw the structure of the major organic product formed when an excess of **R** is reacted with bromomethane.

(iii)     Name the mechanism of the reaction which results in the formation of the product given in part (ii).

.............................................................................................................

**(3)**

**(Total 14 marks)**

**Q6.**          (a)     The reaction of but-1-ene with chlorine produces 1,2-dichlorobutane, C4H8Cl2

(i)      Given that chlorine exists as a mixture of two isotopes, 35Cl and 37Cl, predict the number of molecular ion peaks and their *m/z* values in the mass spectrum of C4H8Cl2

(ii)     The mass spectrum of 1,2-dichlorobutane contains peaks at *m/z* = 77 and 79. Draw the structure of the fragment ion which produces the peak at *m/z*= 77 and write an equation showing its formation from the molecular ion.

**(6)**

(b)     The reaction of but-2-ene with hydrogen chloride forms a racemic mixture of the stereoisomers of 2-chlorobutane.

(i)      Name the type of stereoisomerism shown by 2-chlorobutane and give the meaning of the term *racemic mixture*. State how separate samples of the stereoisomers could be distinguished.

(ii)     By considering the shape of the reactive intermediate involved in the mechanism of this reaction, explain how a racemic mixture of the two stereoisomers of 2-chlorobutane is formed.

**(7)**

(c)     The reaction of but-2-ene with chlorine produces 2,3-dichlorobutane, C4H8Cl2

(i)      State the number of peaks, their integration ratio and any splitting of peaks in the proton n.m.r. spectrum of 2,3-dichlorobutane.

(ii)     Compound **S**, an isomer of C4H8Cl2, produces a proton n.m.r. spectrum which consists only of a singlet, a triplet and a quartet with an integration ratio of 3:3:2 respectively.

Compound **T**, also an isomer of C4H8Cl2, produces a proton n.m.r. spectrum which consists only of two singlets with an integration ratio of 3:1

Draw the structures of **S** and of **T**.

**(6)**

**(Total 19 marks)**

**Q7.**          (a)     Name the compound (CH3)2NH

......................................................................................................................

**(1)**

(b)     (CH3)2NH can be formed by the reaction of an excess of CH3NH2 with CH3Br. Name and outline a mechanism for this reaction.

*Name of mechanism* ....................................................................................

*Mechanism*

**(5)**

(c)     Name the type of compound produced when a large excess of CH3Br reacts with CH3NH2 Give a use for this type of compound.

*Type of compound* ......................................................................................

*Use ..*............................................................................................................

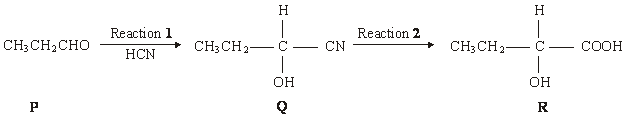
**(2)**

(d)     Draw the structures of the two compounds formed in the reaction of CH3NH2 with ethanoic anhydride.

**(2)**

**(Total 10 marks)**

**Q8.**          Consider the sequence of reactions below.



(a)     Name and outline a mechanism for Reaction **1**.

*Name of mechanism* ....................................................................................................

*Mechanism*

**(5)**

(b)     (i)      Name compound **Q**

.............................................................................................................

(ii)     The molecular formula of **Q** is C4H7NO. Draw the structure of the isomer of **Q** which shows geometrical isomerism and is formed by the reaction of ammonia with an acyl chloride.

**(3)**

(c)     Draw the structure of the main organic product formed in each case when **R** reacts separately with the following substances:

(i)      methanol in the presence of a few drops of concentrated sulphuric acid;

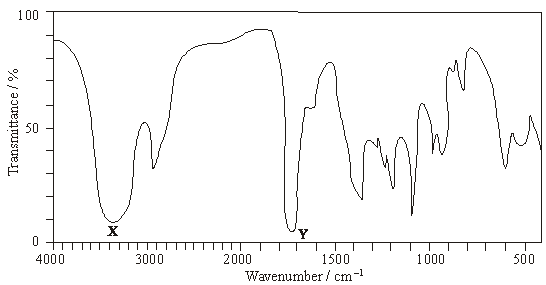
(ii)     acidified potassium dichromate(VI);

(iii)     concentrated sulphuric acid in an elimination reaction.

**(3)**

**(Total 11 marks)**

**Q9.**          (a)     The infra-red spectrum of compound **A**, C3H6O2, is shown below.



Identify the functional groups which cause the absorptions labelled **X** and **Y**.

Using this information draw the structures of the three possible structural isomers for **A**.

Label as **A** the structure which represents a pair of optical isomers.

**(6)**

(b)     Draw the structures of the three **branched**-**chain** alkenes with molecular formula C5H10

Draw the structures of the three dibromoalkanes, C5H10Br2, formed when these three alkenes react with bromine.

One of these dibromoalkanes has only three peaks in its proton n.m.r. spectrum. Deduce the integration ratio and the splitting patterns of these three peaks.

**(10)**

**(Total 16 marks)**

**Q10.**          (a)     Write an equation for the formation of methyl propanoate, CH3CH2COOCH3, from methanol and propanoic acid.

......................................................................................................................

**(1)**

(b)     Name and outline a mechanism for the reaction between methanol and propanoyl chloride to form methyl propanoate.

*Name of mechanism .*...................................................................................

*Mechanism*

**(5)**

(c)     Propanoic anhydride could be used instead of propanoyl chloride in the preparation of methyl propanoate from methanol. Draw the structure of propanoic anhydride.

**(1)**

(d)     (i)      Give **one** advantage of the use of propanoyl chloride instead of propanoic acid in the laboratory preparation of methyl propanoate from methanol.

.............................................................................................................

.............................................................................................................

(ii)     Give **one** advantage of the use of propanoic anhydride instead of propanoyl chloride in the industrial manufacture of methyl propanoate from methanol.

.............................................................................................................

.............................................................................................................

**(2)**

(e)     An ester contains a benzene ring. The mass spectrum of this ester shows a molecular ion peak at *m/z* = 136.

(i)      Deduce the molecular formula of this ester.

.............................................................................................................

.............................................................................................................

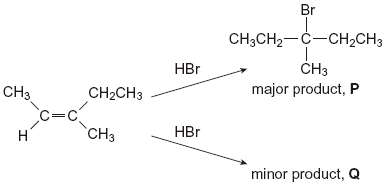
.............................................................................................................

(ii)     Draw **two** possible structures for this ester.

**(3)**

**(Total 12 marks)**

**Q11.**          The alkene (Z)-3-methylpent-2-ene reacts with hydrogen bromide as shown below.



(a)     (i)      Name the major product **P**.

.............................................................................................................

**(1)**

(ii)     Name the mechanism for these reactions.

.............................................................................................................

**(1)**

(iii)     Draw the displayed formula for the minor product **Q** and state the type of structural isomerism shown by **P** and **Q**.

Displayed formula for **Q**

Type of structural isomerism ..............................................................

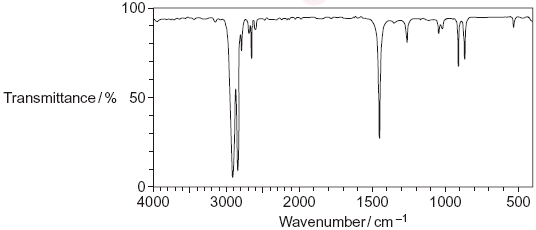
**(2)**

(iv)    Draw the structure of the (E)-stereoisomer of 3-methylpent-2-ene.

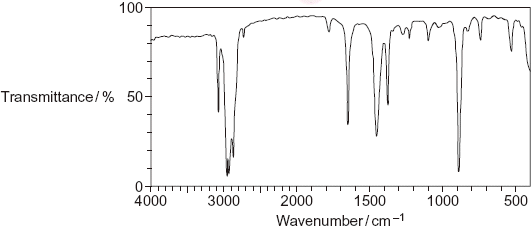
**(1)**

(b)     The infrared spectra of two compounds **R** and **S** are shown below. **R** and **S** have the molecular formula C6H12 and are structural isomers of 3-methylpent-2-ene. **R** is an unsaturated hydrocarbon and **S** is a saturated hydrocarbon.

Spectrum **1**

****

Spectrum **2**

****

(i)      Identify the infrared Spectrum **1** or **2** that represents compound **R**.  
Use information from the infrared spectra to give **one** reason for your answer.  
You may find it helpful to refer to **Table 1** on the Data Sheet.

**R** is represented by Spectrum ................

Reason ...............................................................................................

.............................................................................................................

**(2)**

(ii)     State the type of structural isomerism shown by **R** and **S**.

.............................................................................................................

**(1)**

(iii)     Name **one** possible compound which could be **S**.

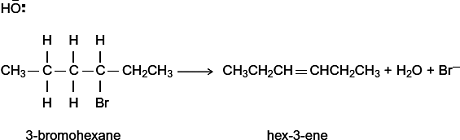
.............................................................................................................

**(1)**

**(Total 9 marks)**

**Q12.**Alkenes are useful intermediates in the synthesis of organic compounds.

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



**(3)**

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

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

**(2)**

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

...............................................................................................................

...............................................................................................................

...............................................................................................................

...............................................................................................................

...............................................................................................................

*(Extra space)* ........................................................................................

...............................................................................................................

**(2)**

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

CH3CH2CH=CHCH2CH3   +   H2SO4      CH3CH2CH2CH(OSO2OH)CH2CH3

Outline a mechanism for this reaction.

**(4)**

**(Total 11 marks)**

**M1.**          (a)     (i)      0.86 **(1)**

(ii)     total moles = 0.86 + 0.43 +0.085 = 1.375 **(1)  
** mole fraction of H2 =  = 0.625 **(1)**

(0.62 ‑ 0.63)

*Conseq on (i)*

(iii)     pp = mole fractn × total P **(1)**     = 0.625 × 1.75 × 104     = 1.09 × 104 (kPa) **(1)**

*or 1.1(0)  
Ignore units  
Conseq on (ii)*

**5**

(b)     (i)      Kp =  **(1)**

*Penalise [  ]*

(ii)     *K*p =  = 2.37 (2.4) × 10–9  **(1)**

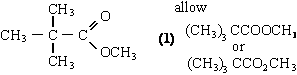
*OR 2.37 × 10–15*

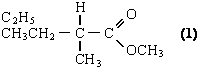
*Units*: kPa–2 **(1)**

*or Pa–2*

*not conseq to wrong Kp expression*

**3**

(c)     *Isomer* ***E****:* 

*Isomer* ***F****: *

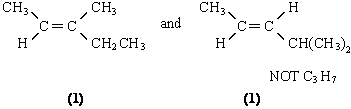
**2**

**[10]**

**M2.**          (a)     *Structure of* **P**:

 (1)

Structures of **Q** and **R**:



*Q and R in any order*

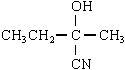
**3**

(b)     (i)      *Racemic mixture*: equal mixture of optical isomers / enantiomers

*OR in explanation*

*Explanation*: planar (>C=O) **(1)**                    attack from either side is equally likely **(1)**

(ii)     *Reagent* ***S***: HCN or (KCN / HCl **or** H2SO4) **(1)**

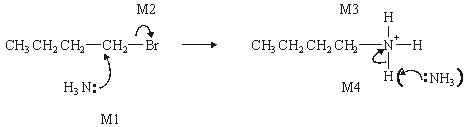
*Compound* ***T***: **(1)**

*Compound* ***U***:  **(1)**

**6**

**[9]**

**M3.**          (a)     Nucleophilic substitution



**1**

          M1, M2 and M4 for arrows, M3 for structure of cation

*(Allow M2 alone first, i.e. SN1 formation of carbocation)*

*(Penalise M4 if Br– used to remove H+)*

**4**

(b)     Step 1        CH3CH2CH2CN   1

CH3CH2CH2Br + KCN → CH3CH2CH2CN + KBr balanced

**1**

                            (or CN–) (or Br–)  
                   (*not HCN*)

**1**

Step 2        CH3CH2CH2CN + 2H2 → CH3CH2CH2CH2NH2                     (or 4[H])

**1**

(c)     (i)      Lone pair (on N) (in correct context)

**1**

R group increases electron density / donates electrons /pushes  
electrons / has positive inductive effect

**1**

(ii)     Any strong acid (but not concentrated)  
or any amine salt or ammonium salt of a strong acid

**1**

(d)     CH3CH2N(CH3)2

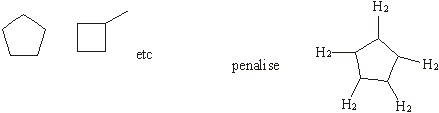
**1**

**[12]**

**M4.**         (a)     **A**       any C5 alkene

**1**

**B**

****

**1**

(b)     **C**

****

         or CH3COOH    or      HCOOCH3

**1**

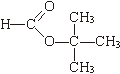
**D**

****

         or HOCH2CHO

**1**

(c)     **E**

****

**1**

**F**

****

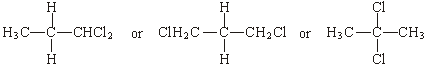
**1**

(d)     **G**

****

**1**

**H**

****

**1**

(e)     **I**

****

**1**

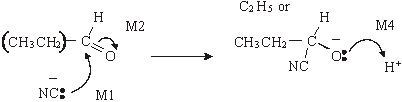
**J**

****   **NOT** hex-3-ene

**1**

**[10]**

**M5.**          (a)     necleophilic addition;



**1**

M3 structure;

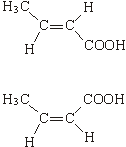
*(be lenient on position of charge on CN– )  
(M2 not allowed independent of M1,   
but allow M1 for correct attack on C+  
if M2 show as independent first.)  
(+on C of C=O loses M2 but ignore δ+ if correct)  
(M4 for arrow and lone pair (only allow for correct M3 or close))*

**4**

(b)     (i)      2-hydroxybutanoic acid

**1**

(ii)

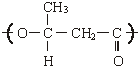


**1**

geometric(al) or cis-trans

**1**

(c)     (i)



*(one unit only) (ignore brackets or n) (trailing bonds are needed)*

**1**

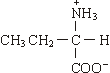
(ii)     can be hydrolysed

         OR

         can be reacted with/attacked by acid/base/nucleophiles/H2O/OH–;

**1**

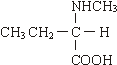
(d)     (i)



*(allow –NH3+)*

**1**

(ii)



*(or zwitterions product)*

**1**

(iii)     nucleophilic substitution;

**1**

**[14]**

**M6.**          (a)     (i)      3 peaks or shown in a list

**1**

*m/z* = 126, 128 and 130 (56 +70/72/74)

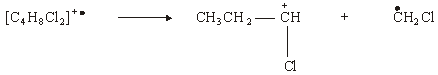
*(all 3 scores 2)*

*(if 56 wrong allow (x + 70/72/74) for 1(x cannot be zero)*

*(any two scores 1)*

**2**

(ii)

  
(1)                                           (1)                                 (1)

allow wrong structure                    for structure                  dot can be  
                                                                                   anywhere

**3**

(b)     (i)      optical

**1**

equal mixture of enantiomers

**1**

(optically) inactive or effects cancel

**1**

plane polarised light                    use stereospecific reagent (QoL)

**1**

rotated in opposite/different

directions (QoL)                          reacts with one isomer only

**1**

(ii)     carbocation

**1**

planar

*(must refer to carbocation or intermediate)*

**1**

attack from either side equally likely

*(must refer to carbocation /intermediate)*

**1**

**7 max**

(c)     (i)      2 peaks

*(if 4 peaks allow splitting only)*

**1**

ratio 6:2 or 3:1

**1**

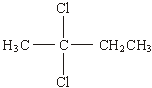
doublet (6 or 3)

**1**

quartet (2 or 1)

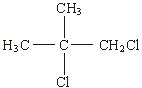
**1**

(ii)     **S**



**1**

**T**



**1**

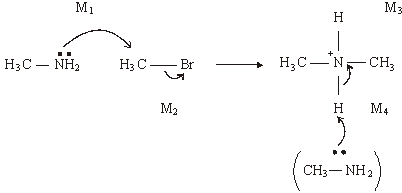
**[19]**

**M7.**          (a)     dimethylamine

**1**

(b)     nucleophilic substitution

**1**

****

**4**

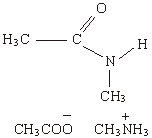
(c)     quaternary ammonium salt

**1**

(cationic) surfactant / bactericide / detergent / fabric softener or  
conditioner/hair conditioner

**1**

(d)



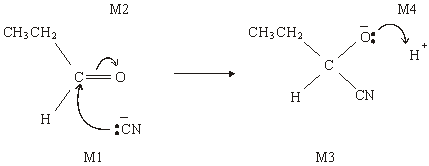
*(allow CH3COOH or CH3COO– NH4+)*

**2**

**[10]**

**M8.**          (a)     nucleophilic addition

**1**

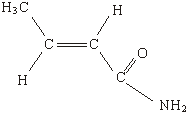
****

**4**

(b)     (i)      2-hydroxybutanenitrile

**1**

(ii)

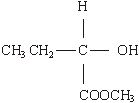


*(allow 1 for amide even if not C4H7NO, i.e. RCONH2)*

*(if not amide, allow one for any isomer of C4H7NO which shows  
geometric isomerism)*

**2**

(c)     (i)



**1**

(ii)



**1**

(iii)     CH3CH=CHCOOH

**1**

**[11]**

**M9.**          (a)     **X** (O–H) (alcohols)

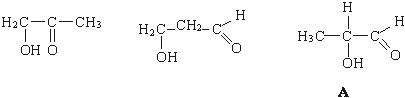
*penalise acid or missing “alcohol”*

**1**

**Y** C=O

*allow carbonyl*

**1**

****

*NOT acid*

**4**

(b)

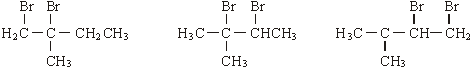


*Allow conseq dibromocompounds following incorrect unbranched alkenes*

*NOT allow dibromocompound consequent on a duplicate alkene*

*NOT allow monobromocompounds if HBr added*

**3**

****

**3**

6:3:1 either next to correct structure or to none

**1**

Allow a mark for identifying correct dibromocompound with three peaks  
even if integration ratio is wrong

**1**

if 6:3:1 missing or wrong, no marks for splitting

Only award a mark for splitting if it is clear which integration number it  
refers to

6 singlet or drawn

**1**

3 doublet or drawn

**1**

1 quartet/quadruplet or drawn

**1**

**(max 10 marks)**

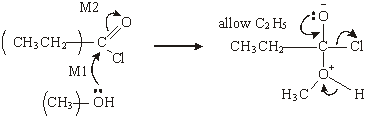
**[16]**

**M10.**          (a)     CH3OH + CH3CH2COOH → CH3CH2COOCH3 + H2O

**1**

(b)     (nucleophilic) addition–elimination NOT acylation

**1**

****

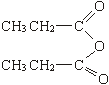
*ignore use of Cl– to remove H+*

*M3 for structure*

*M4 for 3 arrows and lone pair*

**4**

(c)



*allow C2H5 and –CO2–*

*allow CH3CH2COOCOCH2CH3*

***or*** *(CH3CH2CO)2O*

**1**

(d)     (i)      faster/not reversible/bigger yield/purer product/no(acid) (catalyst)  
required

**1**

(ii)     anhydride less easily hydrolysed or reaction less violent/exothermic  
no (corrosive) (HCl) fumes formed or safer or less toxic/dangerous  
expense of acid chloride or anhydride cheaper

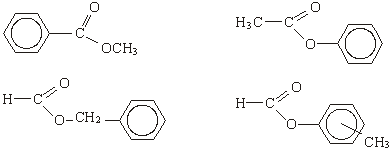
*any one*

**1**

(e)     (i)      C8H8O2

**1**

(ii)     **any** two **from**

****

*Allow –CO2–      allow C6H5*

**2**

**[12]**

**M11.**          (a)     (i)      **3**-bromo-**3**-methylpentane ONLY

*Must be correct spelling but ignore hyphens and commas*

**1**

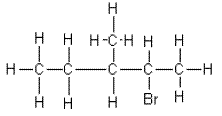
(ii)     Electrophilic addition (reaction)

*Both words needed*

*Accept phonetic spelling*

**1**

(iii)     **M1**    Displayed formula of 2-bromo-3-methylpentane



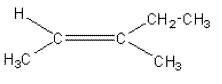
*All the bonds must be drawn out but ignore bond angles*

**M2** Position(al) (isomerism)

***Do not forget to award this mark***

**2**

(iv)    Structure of (E)-3-methylpent-2-ene



*The arrangement of groups around the double bond must be clear with the ethyl group attached in the correct order. Ignore bond angles.*

*Accept C2H5 for ethyl*

*Be lenient on C ─ C bonds. The main issue here is whether they have drawn an (E) isomer.*

*Accept “sticks” for C ─ H bonds and correct skeletal formula*

**1**

(b)     (i)      **M1** R is represented by **Spectrum 2**

**M2** Spectrum 2 shows an infrared absorption/spike/dip/  
trough/peak with any value(s)/range within the range 1620 to  
1680 (cm–1) OR this range quoted/identified and this  
is due to C=C   
OR this information could be a correctly labelled absorption  
on the spectrum

OR Spectrum 1 does not have an infrared absorption in range  
1620 to 1680 (cm–1) and does not contain C=C.

*Award M1 if it is obvious that they are referring to the second spectrum (or the bottom one)*

*M2 depends on a correct M1*

*Ignore other correctly labelled peaks*

*Ignore reference to “double bond” or “alkene”*

**2**

(ii)     Functional group (isomerism)

**1**

(iii)     Cyclohexane

***OR***

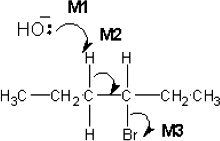
Methylcyclopentane etc.

*Named correctly*

*Ignore structures and ignore numbers on the methyl group of methylcyclopentane*

**1**

**[9]**

**M12.**         (a)      (i)

*Penalise one mark from their total if half-headed arrows are used*

*Penalise* ***M3*** *for formal charge on C of the C-Br or incorrect partial charges on C-Br*

*Ignore other partial charges*

**M1** must show an arrow from the lone pair on oxygen of a negatively charged hydroxide ion to the correct H atom

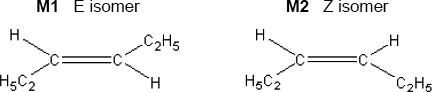
*Penalise once only in any part of the mechanism for a line and two dots to show a bond.*

**M2** must show an arrow from the correct C–H bond to the correct C–C bond.  
Only award if an arrow is shown attacking the H atom of the correct C–H  
bond in **M1**

**M3** is independent but **CE=0 if nucleophilic substitution**

**N.B these are double-headed arrows**

**3**

(ii)

*Award 1 mark if both correct stereoisomers but in the wrong places*

*Accept no other alkenes.*

*Be reasonably lenient on the bonds to ethyl (or to CH2CH3) since the question is about E and Z positions but penalise once only if connection is clearly to the CH3 of CH2CH3*

*Accept linear structures*

**2**

(iii)     **M1**   (Compounds / molecules with) the same structural formula

*Penalise* ***M1*** *if “same structure”*

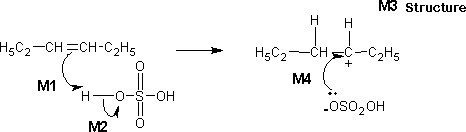
**M2**    with atoms/bonds/groups arranged differently in space

*Ignore references to “same molecular formula” or “same empirical formula” or any reference to “displayed formula”*

***OR***atoms/bonds/groups that have different spatial arrangements / different orientation.

*Mark independently*

**2**

(b)     

**M1**must show an arrow from the double bond towards the H atom of the H – O bond   
OR HO on a compound with molecular formula for H2SO4

M1 could be to an H+ ion and M2 an independent O – H bond break on a compound with molecular formula for H2SO4

***M1*** *Ignore partial negative charge on the double bond.*

**M2** must show the breaking of the O – H bond.

***M2*** *Penalise partial charges on O – H bond if wrong way and penalise formal charges*

*In M2 do not penalise incorrect structures for H2SO4*

**M3** is for the structure of the carbocation.

**M4** must show an arrow from the lone pair of electrons on the correct oxygen of the negatively charged ion towards a correct (positively charged) carbon atom.

***M4*** *NOT HSO4–*

*For* ***M4****, credit as shown or –:OSO3H ONLY with the negative charge anywhere on this ion*

*OR correctly drawn out with the negative charge placed correctly on oxygen*

*Penalise once only in any part of the mechanism for a line and two dots to show a bond*

**NB The arrows here are double-headed**

*Max 3 of any 4 marks for wrong organic reactant or wrong organic product (if shown)*

*Accept the correct use of “sticks”*

**4**

**[11]**