Q20.

Which alkene reacts with hydrogen bromide to give 2-bromo-3-methylbutane as the major product?

A $(CH_3)_2C=CHCH_3$ ⬭

B $CH_3CH_2CH=CHCH_3$ ⬭

C $CH_3CH_2C(CH_3)=CH_2$ ⬭

D $(CH_3)_2CHCH=CH_2$ ⬭

(Total 1 mark)

Q21.

A hydrocarbon contains 87.8% by mass of carbon and has a relative molecular mass (M_r) of 82.0
The hydrocarbon decolourises bromine water.

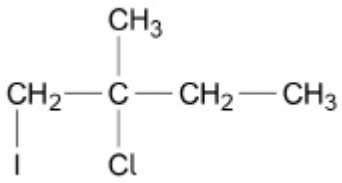
Determine the empirical and molecular formulae of the hydrocarbon.
Suggest **two** possible structures for the hydrocarbon.
Name the type of reaction taking place when bromine water reacts with the hydrocarbon.

(Total 6 marks)

Q22.

Which is the major product of the reaction between 2-methylbut-2-ene and iodine monochloride (ICl)?

A



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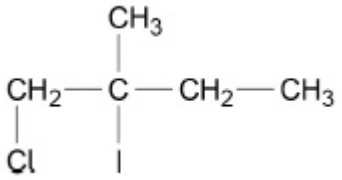
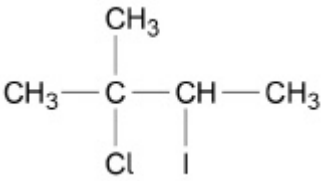
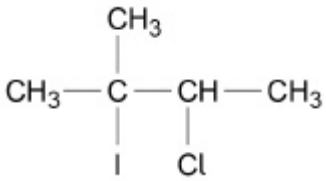


C



D



(Total 1 mark)

Q23.

Concentrated sulfuric acid reacts with alkenes, alcohols and sodium halides.

(a) Name the mechanism for the reaction of concentrated sulfuric acid with an alkene.

_____

(1)

(b) Outline the mechanism for the reaction of concentrated sulfuric acid with propene to show the formation of the major product.

(4)

(c) Draw the structure of the minor product of the reaction between concentrated sulfuric acid and propene.

(1)

(d) Explain why the product shown in your answer to part (b) is the major product.

_____

_____

_____

_____

_____

_____

(2)

(e) Butan-2-ol reacts with concentrated sulfuric acid to form a mixture of three isomeric alkenes. Two of the alkenes are stereoisomers.

Draw the skeletal formula of each of the three isomeric alkenes formed by the reaction of butan-2-ol with concentrated sulfuric acid.

Give the full IUPAC name of each isomer.

Skeletal formula	Name

(3)

(f) A by-product of the reaction of butan-2-ol with concentrated sulfuric acid has the molecular formula C_4H_8O

Name this by-product, identify the role of the sulfuric acid in its formation and suggest the name of a method that could be used to separate the products of this reaction.

By-product _____

_____

Role of sulfuric acid _____

_____

Name of separation method

_____

(3)

(g) Concentrated sulfuric acid reacts with solid sodium chloride.

Give the observation you would make in this reaction.

State the role of the sulfuric acid.

Observation with sodium chloride _____

_____

Role of sulfuric acid _____

_____

(2)

(h) Concentrated sulfuric acid reacts with solid sodium iodide, to produce several products.

Observations made during this reaction include the formation of a black solid, a yellow solid and a gas with the smell of bad eggs.

Identify the product responsible for each observation.

Black solid _____

Yellow solid _____

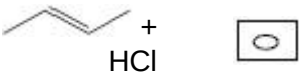
Gas _____

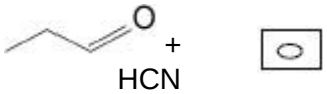
(3)

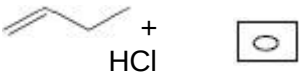
(Total 19 marks)

Q24.

Which pair of compounds does **not** form a racemic mixture when the compounds react?

A  + HCl

B  + HCN

C  + HCl

D  + HCN

(Total 1 mark)

Q25.

2-Methyl but-2-ene reacts with concentrated sulfuric acid to form two different products.

(a) Outline a mechanism for this reaction to show the formation of the major product.

(4)

(b) Draw the structure of the minor product of this reaction.

(1)

(c) Explain why the two products are formed in different amounts.

_____

_____

_____

_____

_____

(2)

(Total 7 marks)

Q26.

A student carried out an experiment to determine the number of C=C double bonds in a molecule of a cooking oil by measuring the volume of bromine water decolourised.

The student followed these instructions:

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

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

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

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

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

_____

_____

_____

_____

_____

(2)

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

_____

(1)

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

(4)

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

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

(5)
(Total 12 marks)

Q27.

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

Which species is formed in the mechanism of this reaction?

A $CH_3–C^+H–CH_2Br$ ⬭

B $CH_3–CHBr–C^+H_2$ ⬭

C $CH_3–C^+H–CH_3$ ⬭

D $CH_3–CH_2–C^+H_2$ ⬭

(Total 1 mark)

Mark Scheme

Q20.

D

[1]

Q21.

M1 C:H = 7.3 : 12.2 seen

*Extended response: **M1** is for working of some sort leading to the formulae.*

*If C_3H_5 and C_6H_{10} are both shown but it is not indicated which formula is which; or the formulas are stated the wrong way round, then allow 1 mark for **M2** and **M3** combined; if both correct formulas are given with only one stated correctly to be the empirical/molecular formula, then allow **M2** and **M3**.*

1

M2 (converting C:H 7.3 : 12.2 to 3:5)
to give empirical formula = C_3H_5

1

M3 molecular formula = C_6H_{10}

1

M4, 5 two possible structures of C_6H_{10} (in any structural form)
cyclic compounds with 6/5/4/3-membered C ring with one double bond, e.g.

or any dienes with 6 C atoms,

or a molecule with a triple bond

***M4** and M5 ignore names given in addition to structures*

*Credit **M4** and M5 for correct names if no structures drawn*

*Apply list principle to structures in **M4** and **M5***

2

M6 (electrophilic) addition

1

Alternative route to C_6H_{10} that could gain credit
***M1** 82/12 gives/suggests 6 C atoms*
***M2** molecular formula = C_6H_{10}*
***M3** empirical formula = C_3H_5*

Alternative route to C_6H_{10} that could gain credit
***M1** 82 × 0.878 = 72, (72/12) = 6 C atoms*
***M2** molecular formula = C_6H_{10}*
***M3** empirical formula = C_3H_5*

***M6** penalise nucleophilic addition; ignore bromination*

[6]

Q22.

C

[1]

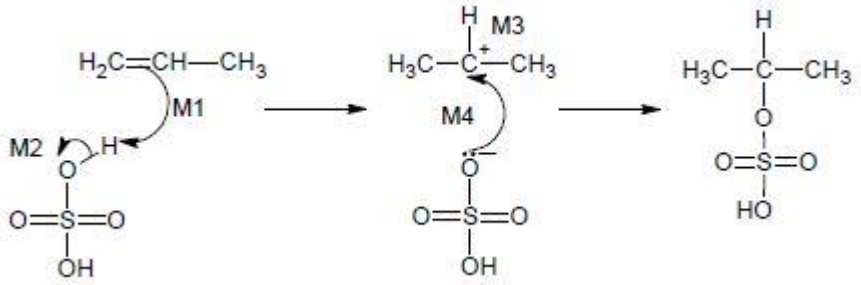
Q23.

(a) electrophilic addition

ALLOW phonetic e.g. electrophylic, electrophillic

1

(b)



M1: must show an arrow from = of C=C towards the H atom of the H–O bond or HO that is part of H–O–S–… on a compound with molecular formula H_2SO_4
M1 could have arrow to H^+ in which case **M2** would be for an independent H–O bond break on a compoundwith formula H_2SO_4

ALLOW CH_3–C^+ etc for carbocation

No need for hydrogensulfate to be displayed

*If H_2O used as electrophile – max **M3** ONLY*

M2: must use an arrow to show the breaking of the H–O bond

***M2** ignore partial charges unless wrong*

M3: is for the correct carbocation structure

*NOT **M3** if primary carbocation shown.*

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

***M4** NOT HSO_4*

credit as shown (or $^-$:OSO_2OH)

or as :OSO_3H – in which case negative charge can be shown anywhere

*ecf from H_2SO_3 in **M1***

NB: The arrows are double-headed

***IGNORE** subsequent use of water to hydrolyse hydrogensulfate*

4

(c) minor product = $CH_3CH_2CH_2OSO_3H$

ecf from 1° in (b) for $CH_3CH(OSO_3H)CH_3$

ecf from alcohol as product in (b)

ecf from side chain such as –$OHSO_3$ or –HSO_4 in (b)

1

(d) (major) product formed via more stable carbocation OR secondary carbocation more stable (than primary)

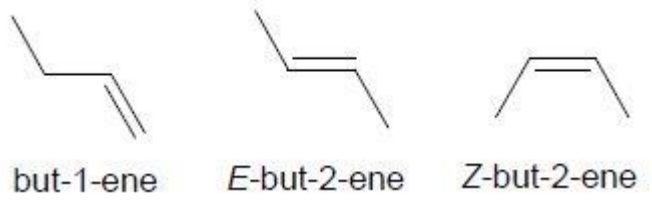
1

Due to electron-releasing character / (positive) inductive effect of two alkyl / methyl groups (as opposed to one)

1

ALLOW 'more' alkyl groups in place of 'two' alkyl groups

(e)



*matching name **and** formula for each mark*

One 'salvage' mark available for 3 correct structures or 3 correct names if no other mark awarded

*use of trans **and** cis can score 1/2 for the two but-2-ene structures*

3

(f) butanone

ALLOW butan-2-one

1

oxidising agent

ALLOW electron acceptor but NOT electron pair acceptor

1

(fractional) distillation

ALLOW gas chromatography

1

(g) white / misty / steamy fumes

NOT gas evolved / effervescence

1

acid/proton donor

1

(h) iodine / I_2

IGNORE state symbols

1

sulfur / S / S_8

*If name **and** formula given they must both be right*

1

hydrogen sulfide / H_2S

1

[19]

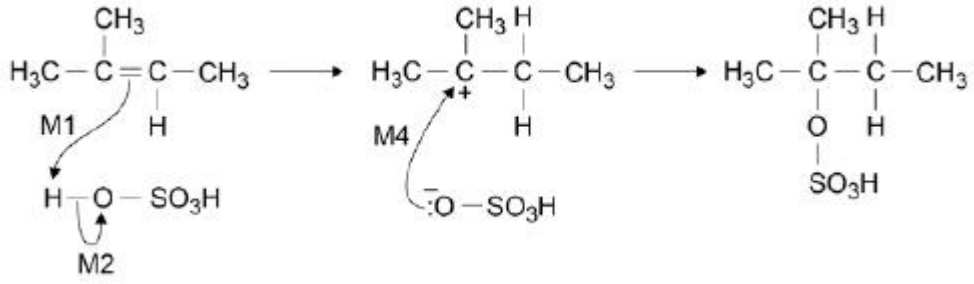
Q24.

D

[1]

Q25.

(a)

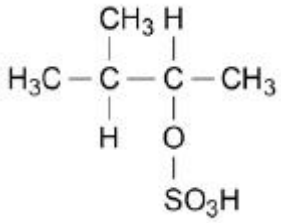


M1, M2 and M4 are awarded for the three curly arrows shown on the mechanism (1 mark for each correct)

M3 is for the structure of the carbocation intermediate

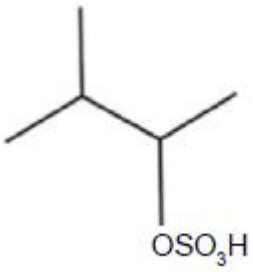
4

(b)



Correct answers include:

- *the displayed formula*
- *structural formulae such as $CH_3CH(CH_3)CH(OSO_3H)CH_3$*
- *skeletal formulae such as*



1

(c) The major product is formed via a tertiary carbocation intermediate and the minor product is formed via a secondary carbocation intermediate

1

The tertiary carbocation is more stable than the secondary carbocation

1

[7]

Q26.

(a) Measured volume would be greater

1

Level in burette falls as tap is filled before any liquid is delivered

1

(b) Drop sizes vary

Allow percentage error for amount of oil will be large as the amount used is so small

1

(c) Use a larger single volume of oil

1

Dissolve this oil in the organic solvent

1

Transfer to a conical flask and make up to 250 cm^3 with more solvent

1

Titrate (25 cm^3) samples from the flask

1

(d) Stage 1

Mass of oil = $0.92 \times (5.0 \times 10^{-2} \times 5) = 0.23$ (g)

1

Mol of oil = $0.23 / 885 = 2.6 \times 10^{-4}$

1

Extended response calculation

To gain 4 or 5 marks, students must show a logical progression from stage 1 and stage 2 (in either order) to stage 3

Stage 2

Mol bromine = $2.0 \times 10^{-2} \times 39.4 / 1000 = 7.9 \times 10^{-4}$

1

Stage 3

Ratio oil : bromine

2.6×10^{-4} : 7.9×10^{-4}

Simplest ratio = $2.6 \times 10^{-4} / 2.6 \times 10^{-4} : 7.9 \times 10^{-4} / 2.6 \times 10^{-4}$

= 1 : 3

1

Hence, 3 C=C bonds

M5 cannot be awarded unless working for M4 is shown

1

[12]

Q27.

C

[1]