2.9 ALKENES EXTRA QUESTIONS MS

1. (a) $C_2H_6 \rightarrow C_2H_4 + H_2$ 1

(b) Addition 1

(ignore self or chain as a preface to "addition ")
(penalise additional)

[2]

2. Electrophilic addition 1

M1: curly arrow <u>from C=C</u> bond towards/alongside the side of H atom on H_1OSO_2OH 1
(penalise M1 if arrow to H_2SO_4 OR to formal charge on H of H_1O bond)
(ignore partial charges on H and O of H_2SO_4, but penalise if these are incorrect on the H atom being attacked)
(credit M1 and M2 if correct curly arrow to H+ provided the anion is present)

M2: curly arrow from <u>H–O bond</u> towards/alongside the side of the O atom on $H–OSO_2OH$ 1
(credit the arrow even if there are partial or formal charges on H and O but the structure of H_2SO_4 is correct)

M3: correct structure of the carbocation 1
(penalise use of 'sticks' in this structure)
M4: curly arrow <u>from lone pair on an individual oxygen atom</u> of (correct formula for) hydrogensulphate ion towards/alongside C atom bearing the positive charge 1
(insist that the an ion has the correct formula with a lone pair of electrons and a negative charge)

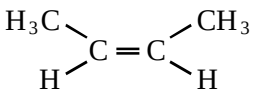
[5]

3. *Type of isomerism* geometrical <u>or</u> E-Z **(1)**

Explanation restricted rotation <u>or</u> double bond rigid **(1)** 2

[2]

4.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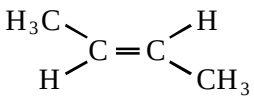
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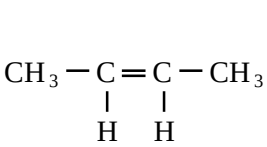
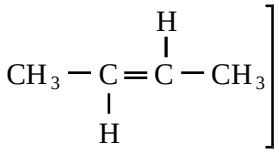
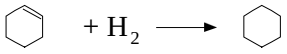
accept  and 

Credit 1 mark for a correct formula for but-2-ene
Credit 1 mark for any pair of cis / trans isomers

Geometric(al)
Or cis-trans
Or diastereoisomerism
NOT stereoisomerism

3

[3]

5. (i) 

or $C_6H_{10} + H_2 \rightarrow C_6H_{12}$

(ii) *Reagent(s)* Br_2 or $KMnO_4$ **(1)**

Observation(s) no charge **(1)**

[3]

6. (i) Electron pair/ lone pair acceptor OR seeking/bonds with an electron pair 1

(insist on reference to a pair of electrons)

(ii) M1 curly arrow from middle of C=C bond of the alkene towards/ alongside the H atom of the H-Br; 1

(penalise arrows which go towards one of the carbon atoms)
(ignore a partial negative charge on the C=C)

M2 curly arrow from H-Br bond to side of Br atom; 1

(penalise M2 if there are formal charges on HBr or if there are partial charges which are the wrong)
(penalise M2 if the single bond has two dots in addition to the line)

M3 correct structure for carbocation; 1

(penalise M3 if the positive charge is placed on the end of a bond)
(penalise M3 if any alkene other than ethene is used - all other marks can score)

M4 curly arrow from lone pair on bromide ion to the positive carbon of carbocation, ensuring that bromide ion has a negative charge; 1

[5]

7. (a) Ml credit a correct structure for either geometrical isomer and its designation as either *cis* or *trans.* 1
OR credit two correct geometrical isomer structures (ignore the names)
OR credit two correct names for *cis* pent-2-ene and *trans* pent-2-ene (ignore the structures)
M2 credit a second mark if all four parts of the required structures and names are correct. 1

(credit "linear" structures)
(insist on the alkyl groups being attached clearly by C-C bonds)

(b) (i) Ml curly arrow from middle of C = C bond to H atom on H-Br 1

(penalise M1 if partial negative charge or formal positive charge on H)
(penalise Ml if pent-2-ene is used)

M2 curly arrow from H-Br bond to side of Br atom 1
M3 correct structure for correct secondary carbocation 1
M4 curly arrow from lone pair on bromide ion to the positive carbon of carbocation, ensuring that bromide ion has a negative charge. 1

(with the exception of pent-2-ene, if the wrong alkene is used, only penalise the structure M3)
(penalise the use of two dots in addition to a covalent bond, once only)

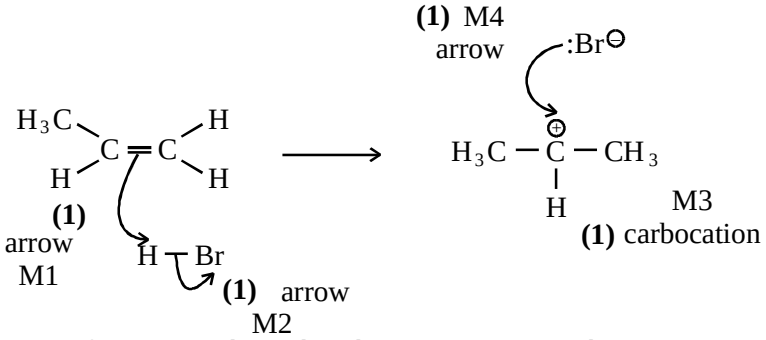
(ii) 1-bromopentane 1

(iii) Ml 2-bromopentane is formed *via* the secondary (or 2°) carbocation 1
OR 1-bromopentane is formed *via* the primary (or 1°) carbocation
M2 a secondary carbocation is more stable than a primary carbocation - 1
award this mark only if the quality of language justifies the award.
(the argument must involve clear statements about carbocations)

[9]

8.

(i)



If wrong carbocation, lose structure mark
If wrong alkene, lose structure mark
Can still score ¾ i.e. penalise M3
Penalise M2 if polarity included incorrectly
no bond between H and Br
bond is shown as ÷ or •—•

(ii) $CH_3CH_2\overset{\oplus}{C}H_2$ **(1)**
credit secondary carbocation here if primary carbocation has been used in (i)
Ignore attack on this carbocation by $\ddot{B}r^{\ominus}$

5

[5]

9. (a) melting point increases **(1)**

boiling point increases**(1)**

or they are liquids, the higher members are solids**(1)**

density increases**(1)**

viscosity increases**(1)** max 2

(b) addition **(1)**

polymerisation **(1)** 2

(c) (i) $C_2H_4 + H_2O \rightarrow C_2H_5OH$ - must show the functional group **(1)** 1

(ii) vapour phase / high temperature (300 ± 50°C) **(1)**

high pressure 70cl ± 20 **(1)**

if high *T* and high *p*, then only 1 mark, value for either gives 2nd mark
strong acidic catalyst /H_3PO_4 **(1)** 3

(iii) electrophilic **(1)**

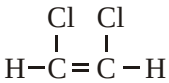
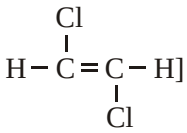
addition **(1)** 2

[10]

10. (i)

Isomer 1 either order *Isomer 2*

(1) **(1)**

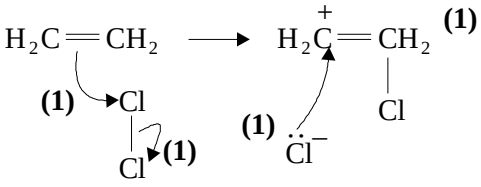
[credit  and ]

(ii) restricted <u>rotation</u> OR no <u>rotation</u> OR cannot <u>rotate</u> **(1)**

3

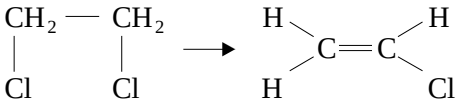
[3]

11. (a) electrophilic addition **(1)**



(1) **(1)** **(1)** **(1)**

5

(b) $C_2H_4Cl_2$ or  + HCl 1

(1)

(c) ester or alkoxy alcohol **(1)** 1

(d) (i) $HO–CH_2–CH_2–OH$ **(1)**

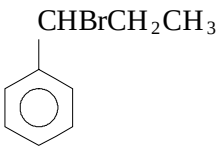
(ii) high electron density of double bond **(1)**
repels OH^- or nucleophile **(1)** 3

[10]

12. (a) geometrical or cis-trans isomers **(1)**

due to restricted rotation **(1)** 2

(b) (i)



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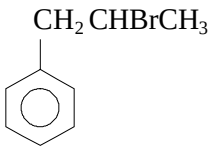


(1)

(ii) electrophilic addition **(1)**

(iii) $C_6H_5\overset{+}{C}H\,CH_2CH_3$ **(1)** $C_6H_5CH_2\overset{+}{C}H\,CH_3$ **(1)**

both secondary but one is more stable **(1)** 6

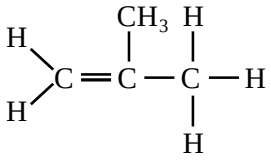
[8]

13. (i) the same general formula or C_nH_{2n} / the same functional group / a C=C / a double bond / differ from their immediate neighbour by CH_2 1

allow 'all straight chain alkenes'

(ii) increases
not just 'pent-l-ene highest'; allow 'ethene lowest, pent-l-ene highest' 1

(iii) methylpropene / 2–methylpropene **not** 2-methylprop-2-ene **(1)**
ignore wrong punctuation



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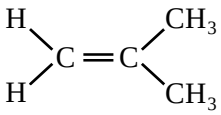


allow 1 mark for but-2-ene with its correct structure **(1)** 2

minimum structure is $CH_2 = C(CH_3)CH_3$ or $CH_2 = C(CH_3)CH_3$

[4]

14. *Catalyst* (c) phosphoric acid or (c) sulphuric acid **(1)**

Not dilute

accept correct formula

Conditions Temp = High or 200–500°C **(1)**
Temp = medium or moderate or 50-100°C

Pressure = High or 5–20 Mpa or 50–200 atoms

Pressure = High or 2–4 Mpa or 20–40 atoms

If. wrong, no catalyst given, allow phosphoric acid conditions

Equation $CH_2 = CH_2 + H_2O \rightarrow CH_3 CH_2 OH$

allow C_2H_4 *allow* $C_2 H_5OH$

not $CH_2 CH_2$ 4

[4]

15. M1 X is 1,2-dibromoethane only 1
M2 electrophilic addition 1
(both words needed)

M3 the double bond is a centre of electron density 1
OR electron-rich
OR nucleophilic
OR a source of an electron pair
OR a pi cloud/bond of electrons
M4 a dipole or polarity is induced/created/formed in the Br-Br bond/molecule - 1
award this mark only if the quality of language justifies the award.

[15]

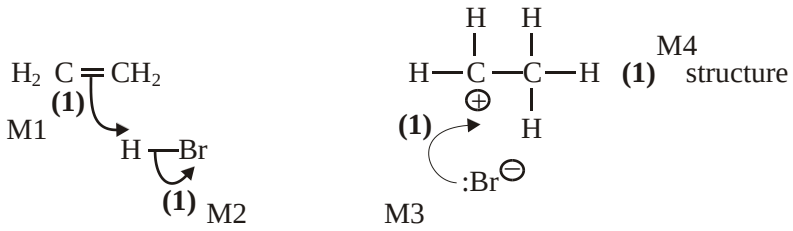
16. An appropriate alkene; $CH_3CH_2CHCH_2$ or $(CH_3)_2CCH_2$ 1
Isomer 1 1
Isomer 2 1
Position isomerism 1
Mechanism

electrophilic attack and electron shift to Br (Unless H^+ used) 1
carbocation 1
reaction with carbocation 1
[Allow mechanism marks for the alkene $CH_3CHCHCH_3$]
[Allow one mark if mechanism for minor product given]

[7]

17. (a) Reaction 1 H_2O or steam **(1)**

(b) 4



Penalise M2 incorrect δ+ / δ–
Penalise δ– on alkene (M1)
Penalise dots on bonds <u>once</u>
Penalise M4 (structure) for use of wrong alkene
Penalise M1 for use of Br_2

[5]

18. ethane tetrahedral (or 3d shown in diagram) **(1)** 109($\frac{1}{2}$)° **(1)**
ethene (trigonal) <u>planar</u> **(1)** 120° **(1)**

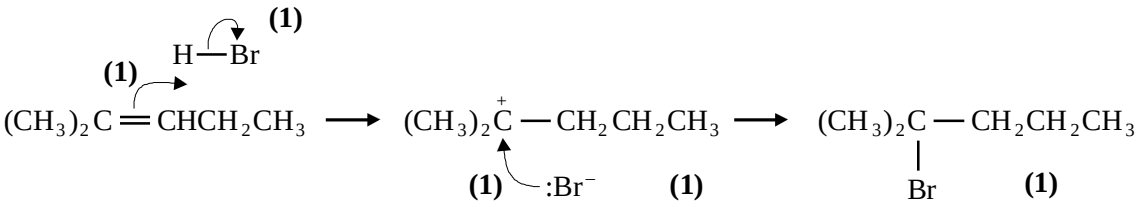
bond lengths: C – C in ethane longest or }
C = C in ethene shortest } **(1)**

in ethene : 2 pairs of e/greater electron density /π bond **(1)**

6

[6]

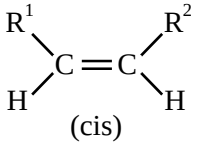
19. (a)

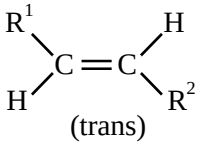


2–bromo–2–methylpentane **(1)**

tertiary carbonium ion more stable than secondary **(1)** 7

(b) geometrical or cis–trans isomerisation **(1)**
hex–3–ene or hex–2–ene **(1)**

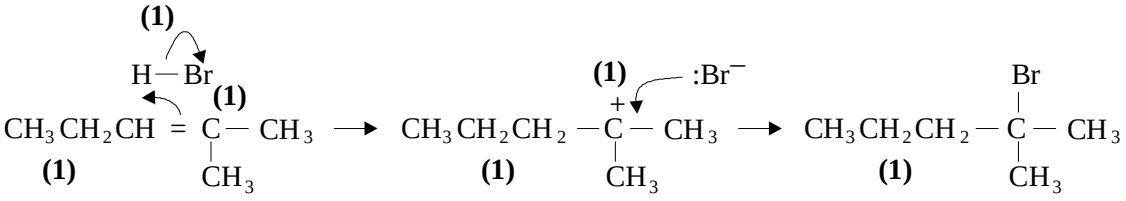

(cis) **(1)**


(trans) **(1)**

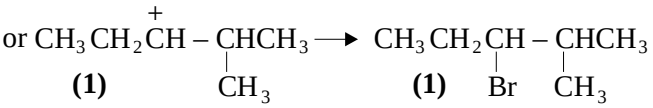
4

[11]

20.



electrophilic addn **(1)** tertiary **(1)** 2-bromo-2-methylpentane **(1)**



secondary **(1)** 3-bromo-2-methylpentane **(1)**

tertiary more stable than secondary **(1)**

[13]

21. (a) **A –** alkene **(1)**

B – halogenoalkane / bromoalkane / alkyl halide / haloalkane **(1)**

C – alcohol (ignore primary, secondary) **(1)** 3

(b) (i) addition ignore nucleophilic / electrophilic / free radical **(1)** 1

(ii) substitution **not** replacement / displacement **(1)** 1

(c) Sodium hydroxide / NaOH / KOH **not** just hydroxide **(1)**

(**B** to **C**) aqueous **not** dilute **(1)**
(**B** to **A**) alcoholic **(1)**

mark alternatives as (d)
ignore references to concentration and temperature 3

(d) (i) $CH_3CH(CH_3)Br + NaOH \rightarrow CH_3CH{=}CH_2 + NaBr + H_2O$ **(1)**

(ii) $CH_3CH(CH_3)Br + NaOH \rightarrow CH_3CH(CH_3)OH + NaBr$ **(1)**

allow molecular formulae C_3H_7Br; C_3H_8O; C_3H_6
allow ionic versions (with OH^-, Br^-) 2

(e) arrow from O of OH^- to C joined to Br **(1)**
lone pair not needed

C–Br polarity shown by $\delta+$ $\delta-$ **or**
heterolytic fission of C–Br bond shown by arrow from bond between C and Br to Br **or**
intermediate with partial bonds and minus sign **(1)**

Br^- as product **(1)**

allow all 3 marks if 1-bromopropane identified as **B** 3

[13]