Mark schemes

Q1.

(a) Trichlorofluoromethane

No other names

1

(b) $CHFCl_2 + \bullet Cl \rightarrow \bullet CFCl_2 + HCl$

Equations in either order

$\bullet CFCl_2 + Cl_2 \rightarrow CFCl_3 + \bullet Cl$

Allow dot anywhere on each radical species

Allow 1 mark for two equations with missing dots that are otherwise correct

Ignore any arrows for electron movement

2

(c) $CFCl_3 \rightarrow \bullet CFCl_2 + \bullet Cl$

Allow dot anywhere on each radical species

Ignore any arrows for electron movement

1

(d) $O_3 + \bullet Cl \rightarrow \bullet OCl + O_2$

$\bullet OCl + O_3 \rightarrow 2\ O_2 + \bullet Cl$

Equations in either order

Allow dot anywhere on each radical species

Allow 1 mark for two equations with missing dots that are otherwise correct

(Accept alternative pair of equations for M2 (both needed for M2)

$O_3 \rightarrow O + O_2$

$ClO\bullet + O \rightarrow Cl\bullet + O_2$)

2

(e) Absorbs/removes ultraviolet/UV radiation that is harmful/causes (skin) cancer/causes (cell) mutations

Answer must refer to removal of UV <u>and</u> idea of it being harmful/the harm it causes

Ignore stopping UV/blocking UV/preventing UV/protecting from UV

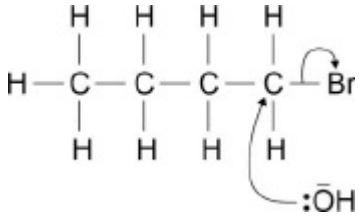
ignore reference to greenhouse effect/gases/absorption of IR/global warming

1

[7]

Q2.

(a)



M1 arrow from lone pair on O of OH^- to the correct C

M2 arrow from the C-Br bond to the Br

All arrows are double-headed. Penalise one mark from the total if half headed arrows are used

Do not penalise the "correct" use of "sticks"

Penalise only once in mechanism for a line and two dots to show a bond

Allow the minus sign to be anywhere on the OH^- ion

***M2** penalise formal charges or incorrect partial charges on C-Br bond*

Allow SN1 mechanism with

***M1** for breakage of C-Br bond*

***M2** for attack by OH^- on correct carbocation*

***Max 1 of 2 marks** for wrong organic reactant*

Ignore wrong organic product (if shown)

Extra arrows or incorrect covalent bonds:

*Penalise the mark for breaking of C-Br bond for any extra arrows involving Br or covalent bond in NaBr in **M2***

*Penalise the mark for attack for any extra arrows involving OH^- or covalent bond in NaOH in **M1***

***M2** could potentially score if an elimination mechanism is shown*

2

(b) **M1** Iodide ions are produced more rapidly than bromide ions or gradient (of iodide ions graph) is steeper

M2 C-I is weaker than C-Br **or**
C-I has lower bond enthalpy than C-Br **or**
C-I breaks more easily than C-Br

M2 *Must compare the C-I and C-Br bonds specifically*

Ignore references to bond length, size of atoms, shielding, electronegativity and polarity

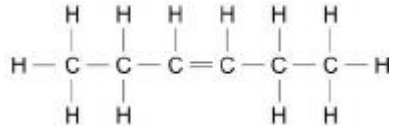
Penalise idea that iodine is more reactive than bromine

2

[4]

Q3.

(a)

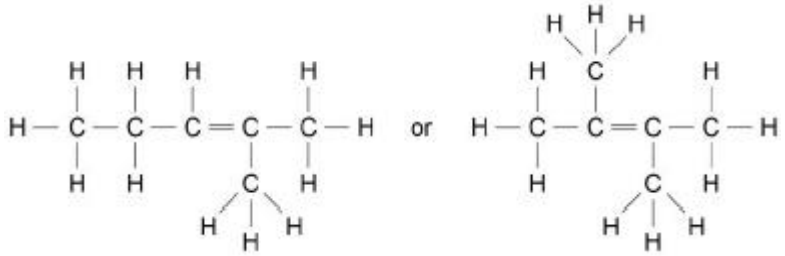


Displayed *structure of hex-3-ene (E or Z isomer)*

Award 1 mark if correct molecules given in (a) and (b) but they are not displayed structures

1

(b)



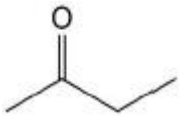
Displayed *formula of 2-methylpent-2-ene or 3,4-dimethylbut-2-ene*

Allow molecules that are both chain and position isomers, eg 2-methylpent-1-ene, 3-methylpent-1-ene, 4-methylpent-1-ene, 3,3-dimethylbut-1-ene, 2,3-dimethylbut-1-ene, 2-ethylbut-1-ene

Award 1 mark if correct compounds given in part (a) and (b) but they are not displayed formulas

1

(c)

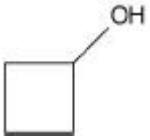


Skeletal *formula*

Award 1 mark if correct compounds given in part (c) and (d) but they are not skeletal formulas

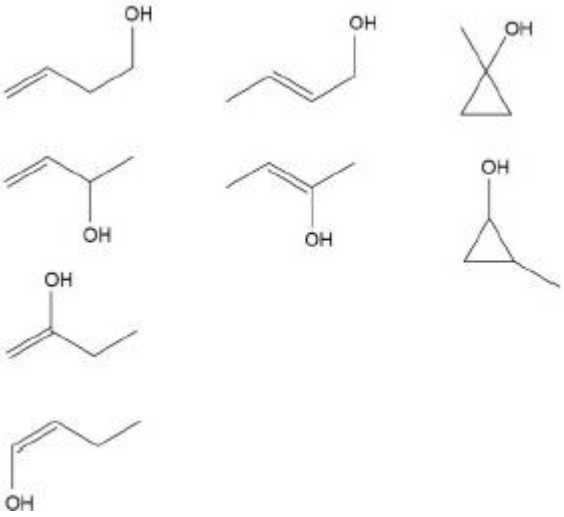
1

(d)



Skeletal *formula*

Alternative answers:



Award 1 mark if correct compounds given in part (c) and (d) but they are not skeletal formulas

1

(e) **M1** divide %s by relative atomic masses:

$$C\ \frac{17.8}{12.0} = 1.48 \qquad H\ \frac{3.0}{1.0} = 3.00 \qquad Br\ \frac{79.2}{79.9} = 0.99$$

*Allow ECF from **M1** to **M2** for a correct empirical formula for their working in **M1***

1

M2 (1.48 : 3.00 : 0.99 = 3 : 6 : 2) empirical formula = $C_3H_6Br_2$

*Allow ECF from **M2** to **M3/4** for compounds that are saturated halogenoalkanes*

1

M3,4 any 2 of:

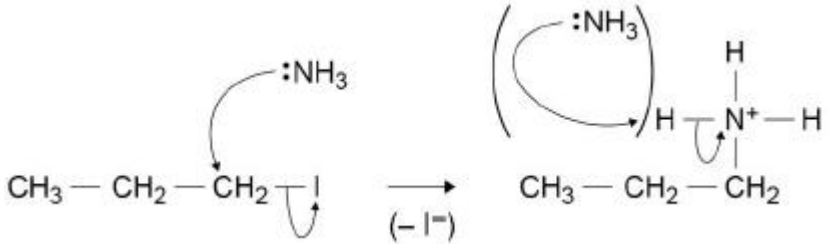
1,1-dibromopropane
1,2-dibromopropane
1,3-dibromopropane
2,2-dibromopropane

2

[8]

Q4.

(a) **M1** nucleophilic substitution



1

M2 attack by NH_3: arrow from lone pair on N of NH_3 towards C of C-I bond

1

M3 breaking of C-I bond: arrow from C-I bond to I

1

M4 structure of intermediate

1

M5 loss of H^+: arrow from N-H bond to N

1

*Penalise **M3** for formal charge on C and / or I of C-I or incorrect partial charges on C-I; ignore other partial charges on uncharged atoms*

***M4** is independent*

*For **M5** there is no need to show attack by a second NH_3 molecule, but if it is shown, it must be correct (but, if the NH_3 is charged and has been penalised in **M2** (or **M3** for SN1), then do not penalise the same error again in **M5**); penalise removal of H^+ by attack with I^-*

For SN2:

*penalise **M2** for any additional arrow or charge on NH_3;*

*penalise **M3** for any additional arrow(s) to / from the I to / from anything else*

If SN1 mechanism given (loss of I first followed by attack by NH_3):
***M2** curly arrow from C-I bond to the I*
***M3** curly arrow from lone pair on N of NH_3 to positive C atom of correct carbocation*
*penalise **M2** for any additional arrow(s) to / from the I to / from anything else*
*penalise **M3** for any additional arrow or charge on NH_3*

(b) **M1** amount of 1-iodopropane = $\frac{5.0 \times 1.75}{169.9}$ (= 0.0515 mol)

*Allow ECF from **M1** to **M2** based on an attempt to find the amount of 1-iodopropane in moles using the M_r*

1

M2 number of molecules = **M1** × 6.022×10^{23}

= $3.1(0) - 3.13(144) \times 10^{22}$

***M2** Answer should be standard form (and be at least 2sf)*

1

(c) **M1** amount of propylamine = $\frac{2.3}{59.0}$ (= 0.0390 mol)

AND amount of 1-iodopropane = $\frac{10.3}{169.9}$ (= 0.0606 mol)

*Allow ECF from **M1** to **M2***

1

M2 % yield = $\frac{0.0390}{0.0606} \times 100$ = 63.9 to 64(.4 %)

Alternative method

***M1** mass of 1-iodopropane* = $\frac{10.3 \times 59.0}{169.9}$ *(= 3.58 g)*

***M2** % yield* = $\frac{2.3}{M1} \times 100$ *= 63.9 to 64(.4 %)*

1

Correct answer scores 2 marks

[9]

Q5.

(a) (for alkenes) elimination

Allow *base elimination*

Not *nucleophilic elimination*

1

(for alcohols) nucleophilic substitution

1

(b) (Different molecules/compounds with the) same (molecular and) structural formula

1

Different spatial arrangement of atoms

Allow *different spatial arrangement of bonds/groups*

1

(c) **A** = but-1-ene

Not *butene*

1

two groups/atoms/Hs the same on one of the C=C carbons

Allow *two groups/atoms/Hs the same on first C*

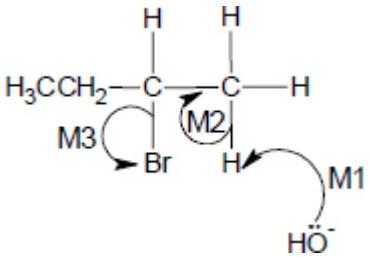
Not *two groups the same on one <u>side</u> of C=C*

Ignore *references to no chiral carbon*

Ignore *'priority' i.e. 2 groups with the same priority… gets M2 for '2 groups the same…'*

1

(d)



If wrong halogenoalkane used then max 2/3

M1 *lone pair on O, negative charge (anywhere) and curly arrow from lone pair to H on carbon 1*

Not *if (covalent) NaOH / additional arrows to or from NaOH / additional arrows to or from Na^+*

1

M2 *curly arrow from C(1)−H to C(1)−C(2)*

M2 *is standalone from* ***M1***

Allow *ecf if H on carbon 3 attacked in* ***M1*** *for curly arrow from C(3)−H to C(2)−C(3)*

Not *as ecf if H on carbon 2 attacked in M1 for curly arrow from C(2)−H*

1

M3 *Curly arrow from C−Br to Br (mark is independent)*

Not *if any additional arrows / incorrect polarity or formal charges on C−Br*

1

Allow *ecf for mechanism to form but-2-ene from (c)*

Allow *E1 mechanism*
M1 curly arrow from C−Br bond to the Br
M2 curly arrow from lone pair on O of OH^- to a correct H on the correct C adjacent to C^+ on the carbocation
M3 curly arrow from a correct C−H bond to a correct C−C bond
penalise M1 for any additional arrow(s) to/from the Br to/from anything else
penalise M2 for any additional arrow(s) on NaOH

(e) *Z*-but-2-ene **AND** *E*-but-2-ene

Allow *'cis'/'trans' and* ***B*** *and* ***C*** *either way round*

Allow *E/Z but-2-ene, cis/trans but-2-ene*

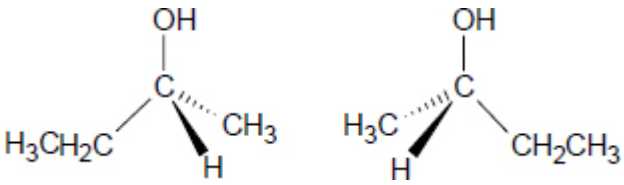
1

lack of/restricted/no (free) rotation around C=C/double bond

Allow *C=C/double bond cannot rotate*

1

(f)



M1 *any correct 2D or 3D structure of butan-2-ol*

Allow C_2H_5

1

M2 *must show at least one wedge bond and one dash bond in each structure from the chiral C and any bonds* ***in the plane*** *cannot be at 180° to each other*

1

second structure could be drawn as mirror image of first ***or*** *with same orientation of bonds and two groups swapped round*

Allow *ECF for second structure from incorrect first structure, providing molecule is chiral*

(g) Silver iodide then silver bromide then silver chloride

Allow *yellow then cream then white*

Allow *iodide/AgI then bromide/AgBr then chloride/AgCl*

Allow *iodo(butane) then bromo(butane) then chloro(butane)*

Ignore *iodine then bromine then chlorine*

1

bond strength C−I < C−Br < C−Cl

Ignore *incorrect formulae*

Allow *carbon-halogen bond strength decreases down the group / from Cl to I*

1

[15]