

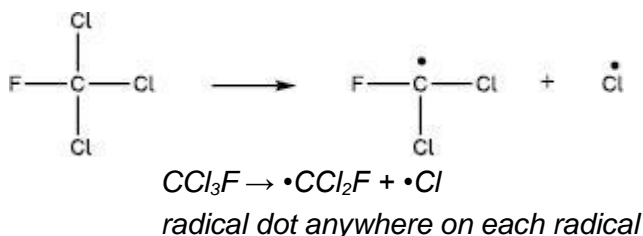
Mark schemes

Q1.

(a) trichlorofluoromethane

1

(b)



1

(c) **M1** amount of CFC-11 = $\frac{500}{137.5}$ (= 3.64) mol
Allow ECF from **M1** to **M2**

1

M2 molecules of $\text{O}_3 = 3.64 \times 100,000 \times 6.022 \times 10^{23} = 2.19 \times 10^{29}$
Allow answers in range 2×10^{29} to 2.20×10^{29} (1sf is acceptable as this is an estimate)

1

(d) Absorbs (harmful) ultraviolet / uv (light / radiation)
Protects us from (harmful) uv
Ignore other wavelengths / types of light

1

(e) One of these reasons:

- lack of evidence that ozone was being depleted
- lack of alternatives to CFCs
- commercial interest to continue to use CFCs
- hard to obtain international agreement

1

(f) **M1** absorbs infrared radiation
M1 idea of IR being taken in

1

M2 molecule has polar bonds
M2 accept polar molecule

1

[8]

Q2.

B

3-methylhex-1-ene

[1]

Q3.

D

butanenitrile

[1]

Q4.

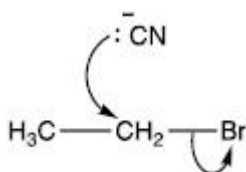
A

1-bromopropane, C–Br bond weaker than C–Cl bond

[1]

Q5.

(a)

**M1** arrow from lone pair on C of CN⁻ to the C of the CH₂ group**M2** arrow from the C–Br bond to the Br*All arrows are double-headed. Penalise one mark from the total for 2.1 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 CN⁻ ion***M2** penalise formal charges or incorrect partial charges on C–Br bond*SN1: allow SN1 mechanism with **M1** for breakage of C–Br bond and **M2** for attack by CN⁻ 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 KBr**Penalise the mark for attack by CN⁻ for any extra arrows involving CN or covalent bond in KCN*

2

(b) propanenitrile

*Ignore any gaps, hyphens, commas**Allow propane-1-nitrile*

1

(c)

$$\text{M1 } \frac{55(.0)}{108.9+65.1} (\times 100) \quad \text{or} \quad \frac{55(.0)}{174(.0)} (\times 100) \quad \text{or} \quad \frac{55(.0)}{55(.0)+119(.0)} (\times 100)$$

1

M2 31.6(%) (must be 3sf)

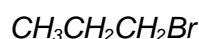
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31.6 scores 2 marks; 32 scores 1 mark
no ECF

[5]

Q6.

C



[1]

Q7.

A

2-methylbut-1-ene

[1]

Q8.

(a) 3-chloro-2,4-dimethylpentane

This answer only apart from slips with commas and dashes

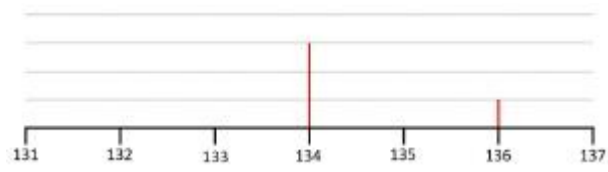
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(b) **M1** lines at 134 and 136

***M1** is for drawing the correct two lines (if other lines are drawn, penalise **M1** (but ignore any additional very small lines at 135 or 137)*

1

M2 line at 134 to be three times higher than line at 136

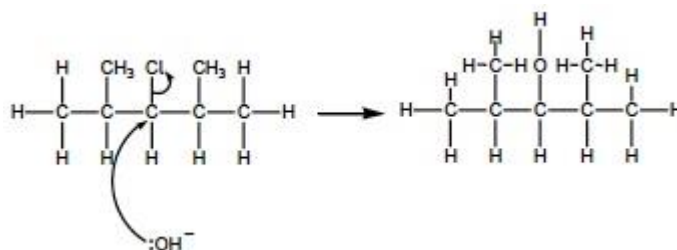


***M2** is for the line at 134 being three times as big as the one at 136 (ignore other lines)*

Accept cross to represent top of lines; if bars drawn – they should be narrow (less than 10% of division) and clear which value they refer to.

1

(c) **M1** nucleophilic substitution



1

- M2** curly arrow from lone pair on O of OH⁻ to C of C-Cl
*For SN2: penalise **M2** for any additional arrow(s) on NaOH, or for covalent NaOH; penalise **M3** for any additional arrow(s) to/from the Cl to/from anything else*
*If curly arrows represent an attempt at an elimination mechanism, cannot score **M2** or **M3***

1

- M3** curly arrow from C-Cl bond to the Cl
*Penalise **M3** for formal charge on C and/or Cl of C-Cl or incorrect partial charges on C-Cl; ignore other partial charges on uncharged atoms*
*For SN2: penalise **M2** for any additional arrow(s) on NaOH, or for covalent NaOH; penalise **M3** for any additional arrow(s) to/from the Cl to/from anything else*
*If curly arrows represent an attempt at an elimination mechanism, cannot score **M2** or **M3***
If SN1 mechanism given (loss of Cl first followed by attack by OH⁻) then:
M2 curly arrow from C-Cl bond to the Cl
M3 curly arrow from lone pair on O of OH⁻ to positive C atom of correct carbocation
*penalise **M2** for any additional arrow(s) to/from the Cl to/from anything else*
*penalise **M3** for any additional arrow(s) on NaOH*

1

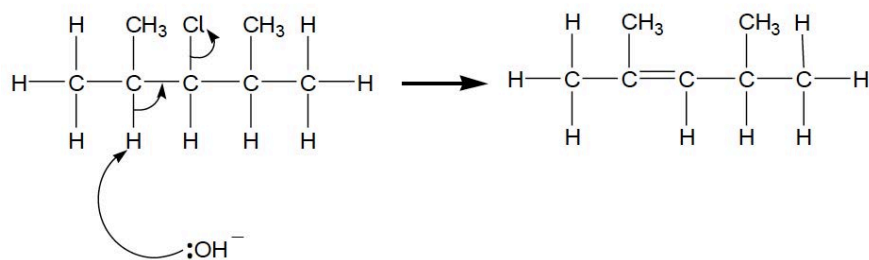
- M4** correct structure of alcohol (in any form)
M4 is independent
M4 ignore presence of non-organic products

1

- (d) **M1** elimination
M1 allow base elimination (but nothing else)

1

- M2** base



M2 allow proton acceptor

1

M3 curly arrow from lone pair on O of OH⁻ to H on one of the C atoms adjacent to the C-Cl

*If curly arrows represent an attempt at a substitution mechanism, cannot score **M3** or **M4***

1

M4 curly arrow from a correct C-H bond adjacent to the C-Cl to a correct C-C bond. Only award if an arrow is shown attacking the H atom of a correct adjacent C-H bond in **M3**

*If curly arrows represent an attempt at a substitution mechanism, cannot score **M3** or **M4***

1

M5 curly arrow from C-Cl bond to the Cl (mark is independent)

*Penalise **M5** for formal charge on C and/or Cl of C-Cl or incorrect partial charges on C-Cl; ignore other partial charges on uncharged atoms*

1

M6 correct structure of alkene (in any form)

M6 is independent

M6 ignore presence of non-organic products

If E1 mechanism given (loss of Cl first followed by attack by OH⁻) then:

M3 curly arrow from C-Cl bond to the Cl

M4 curly arrow from lone pair of OH⁻ to a correct H on the correct C adjacent to C⁺ on the carbocation

M5 curly arrow from a correct C-H bond to a correct C-C bond

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

*penalise **M4** for any additional arrow(s) on KOH*

1

(e) C as C=C 1620-1680 cm⁻¹ OR no O-H 3230-3550 cm⁻¹

need the correct compound and an explanation

full wavenumber range or value(s) within the range

on this occasion candidates do not need to refer to the O-H bond being O-H alcohol as opposed to O-H acid – just reference to O-H with wavenumbers is required

required

1

- (f) C–Br is weaker than C–Cl or
C–Br has lower bond enthalpy than C–Cl or
C–Br breaks more easily C–Cl

Must compare the C–Br and C–Cl bonds specifically

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

Penalise idea that bromine is more reactive than chlorine

1
[15]

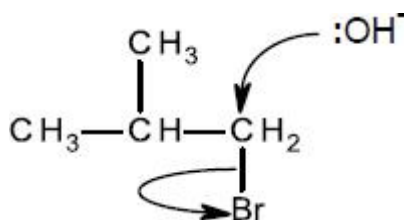
Q9.

c

[1]

Q10.

- (a) **M1** nucleophilic substitution



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

*Max 1 out of 2 for **M2** & **M3** for incorrect reactant or product (ignore poorly drawn bond from C to OH group in product if shown)*

For S_N2

*penalise **M2** for any additional arrow(s) on NaOH*

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

1

- M2** curly arrow from lone pair on O of OH^- to C of C-Br

1

- M3** curly arrow from C-Br bond to the Br

1

If S_N1 mechanism given (loss of Br first followed by attack by OH^-) then:

***M2** curly arrow from C-Br bond to the Br*

***M3** curly arrow from lone pair on O of OH^- to positive C atom of correct carbocation*

*penalise **M2** for any additional arrow(s) to/from the*

Br to/from anything else

penalise M3 for any additional arrow(s) on NaOH

If curly arrows represent an attempt at an

elimination mechanism, cannot score M2 or M3

- (b) **M1** Amount 1-bromo-2-methylpropane
 (= $(2 \times 1.26) / 136.9 = 2.52/136.9 = 0.0184 \text{ mol}$)
Correct answer scores 3 marks; answer to at least 2sf and any individual marks for M1/2 should be at least 2sf; answers that are a factor of 10^x out score 2;
- 1
- M2** mass of 2-methylpropan-1-ol expected
 (= $0.0184 \times 74.0 = 1.36 \text{ g}$)
Allow ECF through the question
- 1
- M3** % yield = $100 \times (0.895/1.36) = 65.7\%$ (65-67%)
- 1
- Alternative method:*
- M2** amount of 2-methylpropan-1-ol produced
 = $0.895/74.0 = 0.0121 \text{ mol}$
- M3** % yield = $100 \times (0.0121/0.0184) = 65.7\%$
 (65-67%)
- Allow 2 marks for 82.7-83% (comes from starting with 2 g not 2.52 g), with answers that are a factor of 10^x out from this scoring 1*
- (c) **M1** methylpropene
M1 Do not allow any names with numbers for the position of the double bond. Allow 2-methylpropene but no other answer
Ignore any drawn mechanism
- 1
- M2** elimination
M2 allow base (or basic) elimination but no other answer
- 1
- [8]

Q11.
D

[1]

Q12.
A

[1]

Q13.

C

[1]

Q14.

D

[1]

Q15.

C

[1]

Q16.

D

[1]