Answers

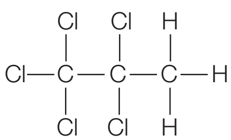
Chapter 10

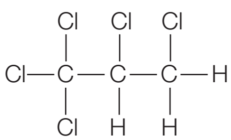
Exercises

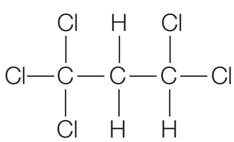
1 **(a)** carboxylic acid; butanoic acid
(b) halogenoalkane; 1,1-dichloropropane
(c) ketone; butanone
(d) ester; methyl ethanoate
(e) ether; methoxyethane
(f) ester; ethyl pentanoate

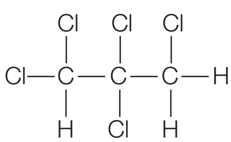
2 **(a)** $CH_3(CH_2)_4COOH$
(b) $CH_3CH_2CH_2CHO$
(c) $CH_3CH(CH_3)_2CH_3$
(d) $CH_2BrCH(CH_3)C_2H_5$
or $CH_2BrCH(CH_3)CH_2CH_3$
(e) $HCOOCH_2CH_3$
(f) $CH_3OCH_2CH_2CH_3$
(g) $CH_3C{\equiv}CCH_3$

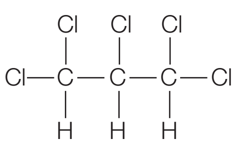
3 A   4 D

5  1,1,1,2,2-pentachloropropane

 1,1,1,2,3-pentachloropropane

 1,1,1,3,3-pentachloropropane

 1,1,2,2,3-pentachloropropane

 1,1,2,3,3-pentachloropropane

6 B

7 Benzene is a cyclic molecule with a planar framework of single bonds between the six carbon atoms and six hydrogen atoms. The carbon atoms are also bonded to each other by a delocalized cloud of electrons which forms a symmetrical region of electron density above and below the plane of the ring. This is a very stable arrangement, so benzene has much lower energy than would be expected.

8 **(a)** Similar molar mass will mean molecules have approximately equal London (dispersion) forces and so differences in boiling point can be attributed to differences in dipole–dipole or hydrogen bonding.
(b) Solubility in hexane will increase with increasing chain length as the non-polar part of the molecule makes a larger contribution to its structure.

9 **(a)** $C_5H_{14}(l) + 6O_2(g) \rightarrow 5CO(g) + 7H_2O(l)$
(b) $2C_4H_{10}(g) + 13O_2(g) \rightarrow 8CO_2(g) + 10H_2O(l)$
(c) $C_3H_4(g) + O_2(g) \rightarrow 3C(s) + 2H_2O(l)$

10 Bromine + ethane

initiation

$Br_2 \xrightarrow{\text{UV light}} 2Br^{\bullet}$ bromine radicals

propagation

$Br^{\bullet} + C_2H_6 \rightarrow C_2H_5^{\bullet} + HBr$

$C_2H_5^{\bullet} + Br_2 \rightarrow C_2H_5Br + Br^{\bullet}$

$C_2H_5Br + Br^{\bullet} \rightarrow C_2H_4Br^{\bullet} + HBr$

$C_2H_4Br^{\bullet} + Br_2 \rightarrow C_2H_4Br_2 + Br^{\cdot}$

termination

$Br^{\bullet} + Br^{\bullet} \rightarrow Br_2$

$C_2H_5^{\bullet} + Br^{\bullet} \rightarrow C_2H_5Br$

$C_2H_5^{\bullet} + C_2H_5^{\bullet} \rightarrow C_4H_{10}$

Overall, these reactions show how a mixture of products is formed.

11 (a) $CH_3CH_2CH_2CH_3$ butane
(b) $CH_3CH_2CH(OH)CH_3$ butan-2-ol
(c) $CH_3CH_2CHBrCH_3$ 2-bromobutane

12 (a) No observable change.
(b) Burns with very smoky flame.
(c) The bromine water changes from brown to colourless.

13 (a) $C_2H_5OH(l) + 3O_2 \rightarrow 2CO_2(g) + 3H_2O(l)$
$2C_3H_7OH(l) + 9O_2(g) \rightarrow 6CO_2(g) + 8H_2O(l)$
(b) $C_2H_5COOH(aq) + C_4H_9OH(aq) \rightarrow C_2H_5COOC_4H_9(aq) + H_2O(l)$

14 (a) butanone; orange → green
(b) methanal; orange → green
(c) no reaction; no colour change

15 Nucleophilic substitution involves an electron-rich species (e.g. OH^-) attacking an electron-deficient carbon atom (e.g. in chloroethane), leading to substitution of the halogen functional group by the nucleophile.
$C_2H_5Cl + OH^- \rightarrow C_2H_5OH + Cl^-$

16 Benzene has a very stable structure as a result of its symmetrical ring of delocalized electrons. Addition reactions would involve breaking this ring and therefore decreasing its stability. Substitution reactions in which one or more hydrogen atoms of the ring are replaced by other atoms or groups preserves the aromatic ring structure and therefore its stability.

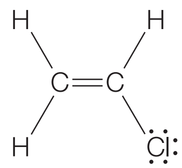
Practice questions

For advice on how to interpret the marking below please see Chapter 1.

1	C	2	A	3	A	4	A
5	B	6	A	7	A	8	A
9	C	10	B	11	C	12	A
13	B						

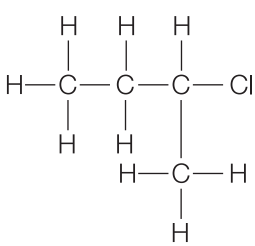
14 A: 1-bromobutane
B: 2-bromobutane
C: 2-bromo-2-methylpropane
D: 1-bromo-2-methylpropane [4]
Penalize incorrect punctuation, e.g. commas for hyphens, only once.
Accept 2-bromomethylpropane and 1-bromomethylpropane for C and D respectively.

15 (a) Colour change from yellow / orange / rust colour / red / brown to colourless [1]
No mark for change to clear, or for decolorized with no reference to original colour.
(b) Chloroethene:

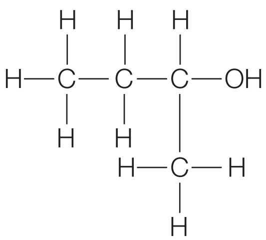


No mark if the lone pairs are missing on Cl.
Accept lines, dots or crosses for e^- pairs.
Poly(chloroethene):
$[-CH_2-CHCl-]_n$ [2]
n and square brackets are not required.
Continuation bonds must be shown.
(c) (hydration of ethene for the manufacture of) ethanol / $C_2H_4 + H_2O \rightarrow C_2H_5OH$; (synthesis of) CH_3COOH / ethanoic / acetic acid; (synthesis of) ethylene glycol / 1,2-ethanediol / ethane-1,2-diol; (synthesis of) drugs / pesticides; (hydrogenation of unsaturated oils in the manufacture of) margarine [2 max]
Accept other commercial applications.

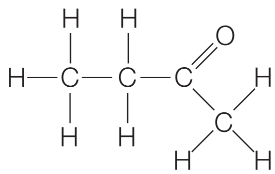
16 (a) A:



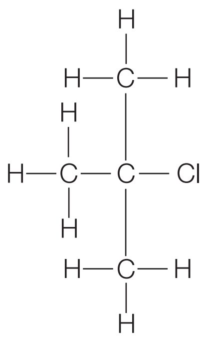
B:



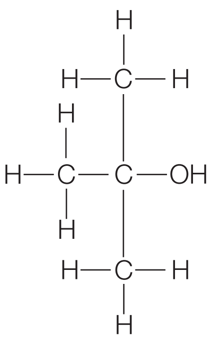
C:



D:



E:



Accept condensed formulas. [5]

*Award **[1 max]** if **A** and **D** are other way round (and nothing else correct). Award **[2 max]** if **A** and **D** are other way round but one substitution product **B** or **E** is correct based on initial choice of **A** and **D**. Award **[3 max]** if **A** and **D** are other way round but both substitution products **B** and **E** are correct based on initial choice of **A** and **D**. M2 (for **B**) and M5 (for **E**) may also be scored for substitution product if primary chloroalkane used. Penalize missing hydrogens once only.*

(b) $CH_3CH_2COOH + CH_3OH \rightleftharpoons CH_3CH_2COOCH_3 + H_2O$

[1] for reactants and [1] for products.

(concentrated) sulfuric acid / H_2SO_4

Do not accept just H^+ or acid.

methyl propanoate [4]

17 **(a)** (the solution changes) from orange to green [1]

(b) +6 [1]

Do not accept 6, 6+ or the use of Roman numerals unless they have already been penalized in 2(a).

(c) $Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$ [1]

(d) $CH_3CH_2OH \rightarrow CH_3CHO + 2H^+ + 2e^-$

$Cr_2O_7^{2-} + 3CH_3CH_2OH + 8H^+ \rightarrow 2Cr^{3+} + 3CH_3CHO + 7H_2O$ [3]

*For second equation award **[1]** for correct reactants and products and **[1]** for correct balancing.*

(e) H^+ is a reactant / *OWTTE* [1]

(f) ethanoic acid / CH_3COOH / acid [1]

Accept acetic acid.

Challenge yourself

1 Complete combustion:

$2C_2H_6 + 7O_2 \rightarrow 4CO_2 + 6H_2O$

C: $-3 \rightarrow +4$

Incomplete combustion:

$2C_2H_6 + 5O_2 \rightarrow 4CO + 6H_2O$

C: $-3 \rightarrow +2$

2 *Hetero*lytic describes breaking of the bond, producing two *different* products. The products are ions, and the reaction mechanism involves attraction of the electron density of the C=C double bond to the positive ion.

3 The repeating unit in polystyrene is $-CH(C_6H_5)-CH_2-$