Chapter 2

Solutions to review problems

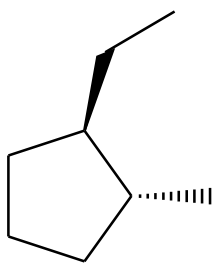
1 0.543 g of a molecule containing C, H and O is burned in air to give 1.039 g CO_2 and 0.6369 g H_2O. Calculate its empirical formula

1.039 g CO_2 contains 12/44 x 1.039 = 0.2834 g C
0.6368 g H_2O contains 2/18 x 0.638 = 0.07089 g H
So the molecule contains
52.3 % C
13.05 % H
34.65 % O
Relative # atoms C = 52.3/12 = 4.36
Relative # atoms H = 13.05
Relative # atoms O = 34.65/16 = 2.17
Dividing through by the lowest number gives
C 2
H 6
O 1
So formula is C_2H_6O

2 Vitamin C has the following percentage composition. Derive its empirical formula.
40.9 % C
4.5 % H
54.5 % O

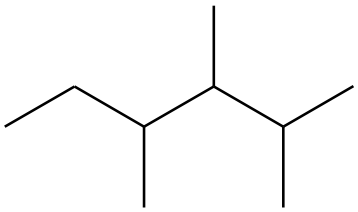
Relative # atoms C = 40.9/12 = 3.41
Relative # atoms H = 4.5
Relative # atoms O = 54.5/16 = 3.4
Dividing through by 3.4
C 1
H 1.32
O 1
We must multiply by 3 to make whole numbers of H atoms
So empirical formula is $C_3H_4O_3$
Vitamin C is actually $C_6H_8O_6$ – this is the molecular formula

3 Give a systematic name for each of the following molecules:
(a)



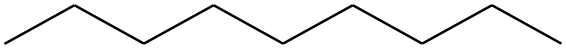
trans-1-ethyl-2-methylcyclopentane

3(b)



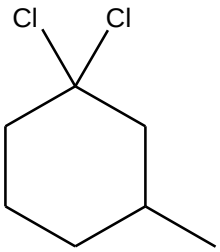
2,3,4-trimethylhexane

3(c)



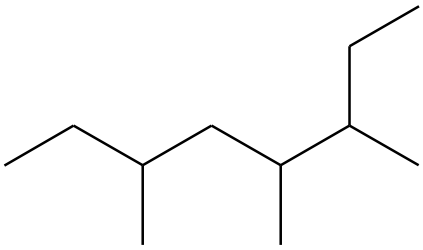
nonane

3(d)



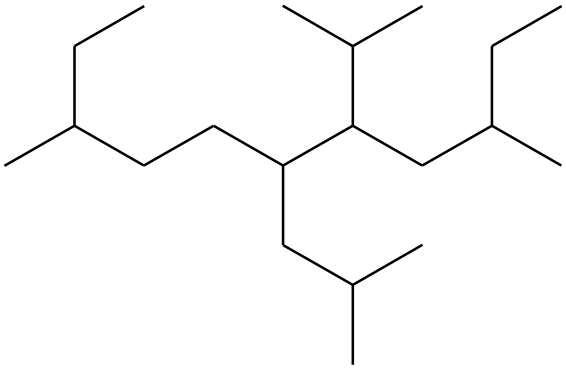
1,1-dichloro-3-methylcyclohexane

3(e)



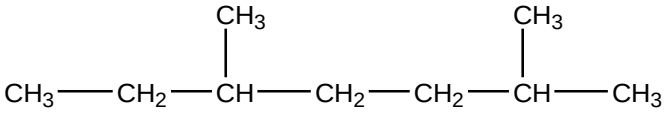
3,4,6-trimethyloctane

3(f)



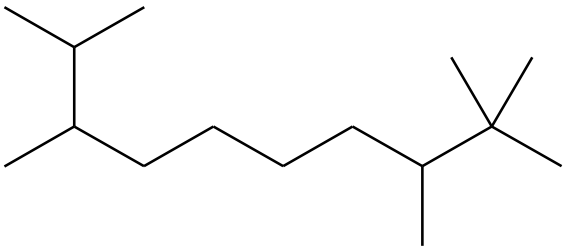
3,9-dimethyl-5-(1-methyethyl)-6-(2-methylpropyl)undecane

3(g)



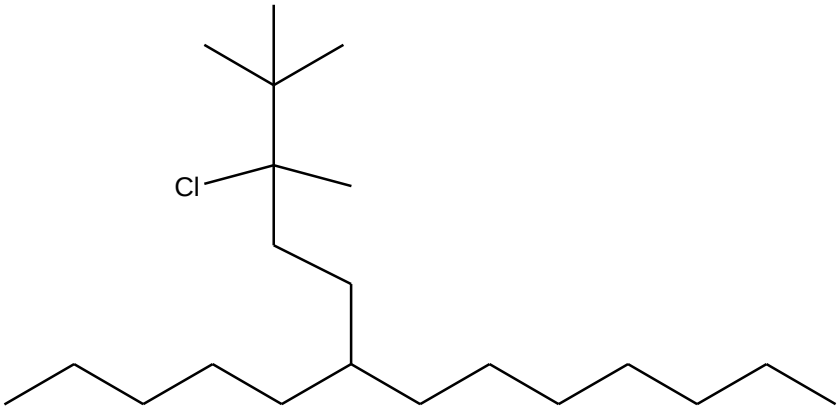
2,5-dimethylheptane

3(h)



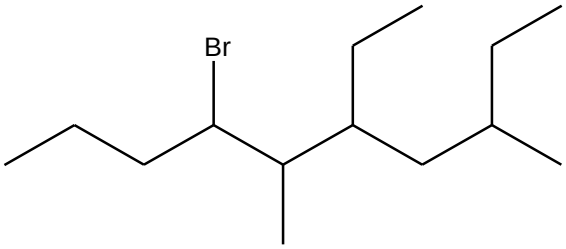
2,2,3,8,9-pentamethyldecane

3(i)



6-(3-chloro-3,4,4-trimethylpentyl)tridecane

3(j)

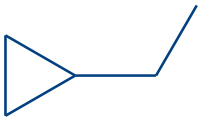


4-bromo-5,8-dimethyl-6-ethyldecane

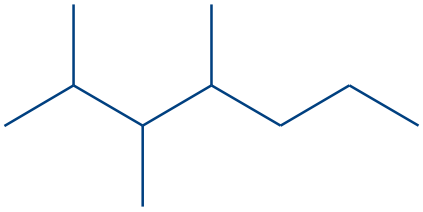
4 Draw a line structure for each of the following molecules:

(a) 2-methylheptane

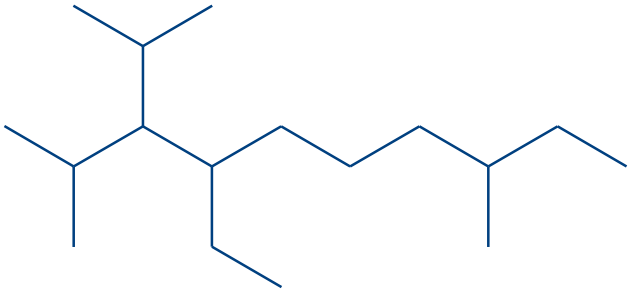
4(b) ethylcyclopropane



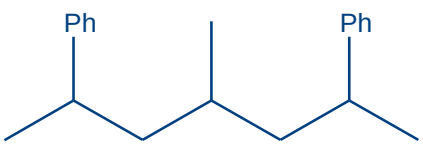
4(c) 2,3,4-trimethylheptane



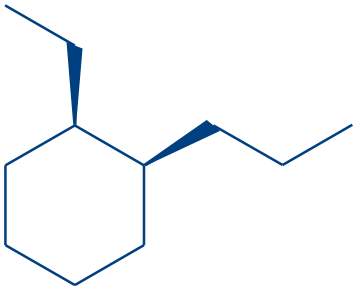
4(d) 2,8-dimethyl-4-ethyl-3-(1-methylethyl)decane



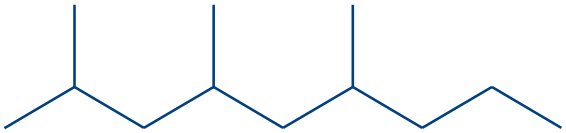
4(e) 4-methyl-2,6-diphenylheptane



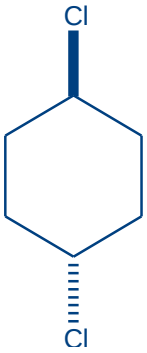
4(f) *cis*-1-ethyl-2-propylcyclohexane



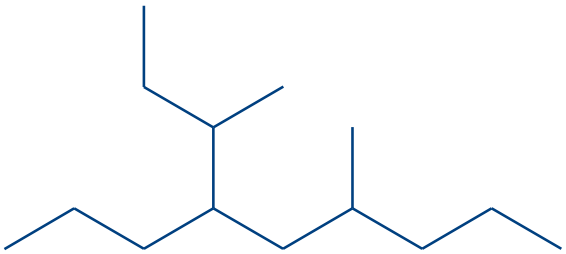
4(g) 2,4,6-trimethylnonane



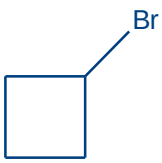
4(h) *trans*-1,4-dichlorocyclohexane



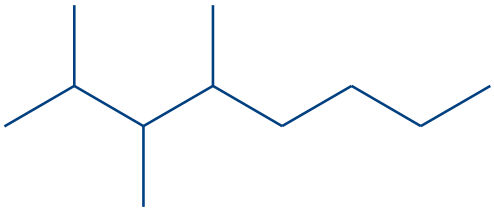
4(i) 6-methyl-4(1-methylpropyl)nonane



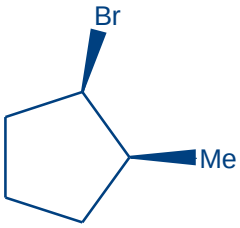
4(j) bromocyclobutane



4(k) 2,3,4-trimethyloctane



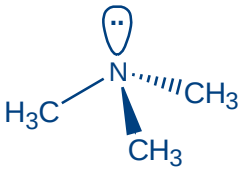
4(l) *cis*-1-bromo-3-methylcyclopentane



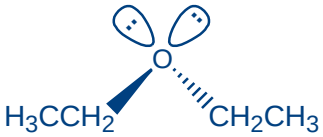
5 What hybridization and what shape would you predict for each of the following molecules?

CH_2Cl_2 $(CH_3)_3N$ $CH_3CH_2OCH_2CH_3$

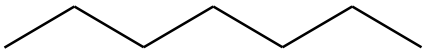
As far as the carbon atoms are concerned, CH_2Cl_2, $(CH_3)_3N$ and $CH_3CH_2OCH_2CH_3$ can all be considered as substituted methanes.
This means we have sp^3 carbon, and an approximately tetrahedral shape
$(CH_3)_3N$ can also be considered to be a substituted ammonia – the hydrogen atoms of NH_3 being replaced by methyl groups.
So at nitrogen we expect the structure to resemble that of ammonia.
sp^3 hybridisation, pyramidal geometry, and a lone pair of electrons

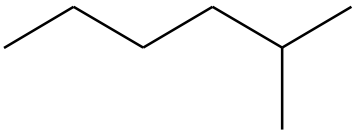


In the same way we can consider diethyl ether, $(CH_3CH_2)_2O$, to be a substituted water; the hydrogen atoms have been replaced by ethyl groups.
So at oxygen we expect the structure to resemble that of water – sp^3 hybridisation, and a bent, or angular structure.



6 For the following pair of molecules predict which would have the higher boiling point. Give a reason.





n-Heptane; the linear molecule stacks better

7 What are the most important kinds of intermolecular forces in the following atoms/molecules?

(a) Krypton
(b) Tetrafluoromethane
(c) hydrogen fluoride
(d) butane

(a) London dispersion forces
(b) London dispersion forces
(c) Hydrogen bonding
(d) London dispersion forces

8 Give an example of each of the following

(a) A diatomic molecule with a permanent dipole moment
(b) A diatomic molecule without a permanent dipole moment
(c) An sp^3 hybridized molecule with a permanent dipole moment
(d) A triatomic molecule with a permanent dipole moment

(a) HCl
(b) O_2
(c) CH_3F
(d) H_2O