4. Alkynes

Alkynes

- contain only carbon and hydrogen atoms
- have at least one triple carbon-carbon bond , for example, propyne, $CH{\equiv}C-CH_3$, is an alkyne.
- have a general formula of C_nH_{2n-2} where n = 1, 2, 3 etc
- are colourless compounds
- have relatively low melting and boiling points
- are sparingly soluble in water.

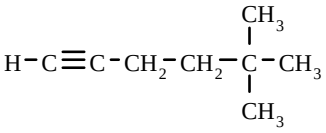
Nomenclature

Alkynes are named in the same way as alkenes except, the suffix 'yne' is used to indicate the presence of a triple bond.

The position of the triple bond is identified by numbering the carbon chain so that the triple bond has the smallest number.

If there are two or three triple bonds then the suffixes 'diyne' and 'triyne', respectively, are used.

For example, the name of the following alkyne is 5,5-dimethylhex-1-yne



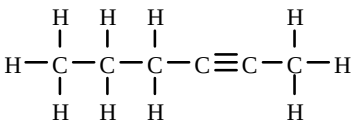
Questions

32. Draw an electron dot representation of

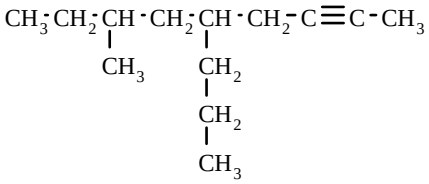
a) ethyne b) propyne

33. Name the following alkynes

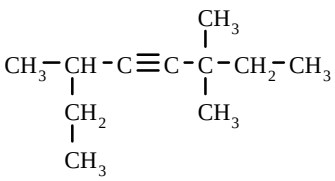
a)



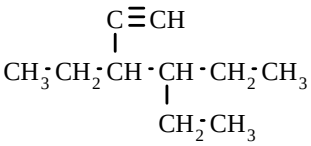
b)



c)



d)



34. Give the structural formulae of the following compounds:

a) oct-3-yne

b) 4-ethyl-5,4-dimethylhept-2-yne

c) dimethylbut-1-yne

Reactions of alkynes

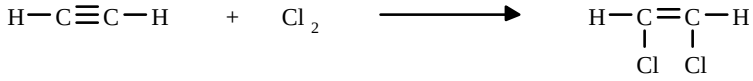
Addition reactions

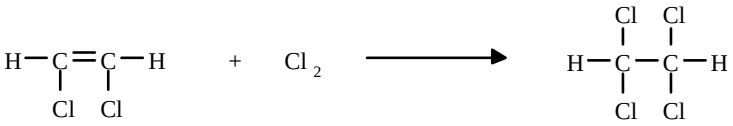
Alkynes undergo addition reaction with the halogens to form halogen-substituted alkenes or alkanes and with hydrogen (in the presence of a catalyst) to form alkenes or alkanes.

Addition reactions of alkynes occur in a two step process - first to form an alkene and then an alkane. The organic product formed in these addition reactions depends on the relative amounts of alkyne and halogen or hydrogen present. If the alkyne and halogen or hydrogen are present in a 1:1 mole ratio, then the major product formed will be a haloalkene or a alkene. If the alkyne and halogen (or hydrogen) are present in a 1:2 mole ratio, then the major organic product formed with be a haloalkane (or an alkane).

For example,

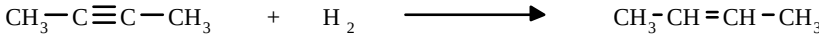
i) when ethyne reacts with excess chlorine, in the dark, the following occurs

First 

Followed by 

Or, overall $CH \equiv CH + 2Cl_2 \rightarrow Cl_2CH - CHCl_2$

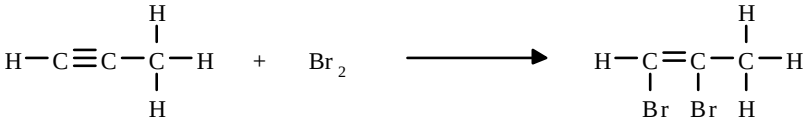
ii) when but-2-yne reacts with hydrogen in a 1:1 mole ratio, in the presence of a catalyst, the following occurs:

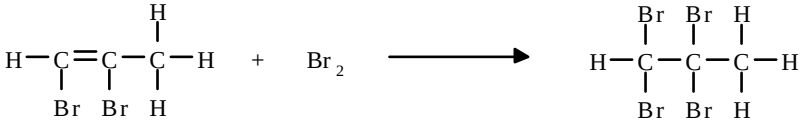


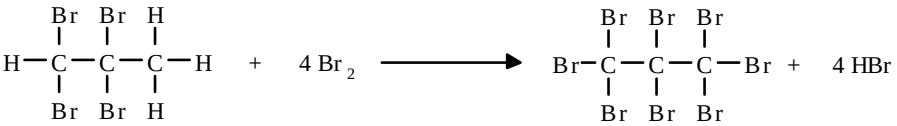
Addition and Substitution reactions

If an alkyne is reacted with an excess of a halogen in the presence of UV light, an addition reaction occurs first to form the halogen-substituted alkane, then substitution reactions occur to replace all the hydrogen atoms. The major organic product formed will again depend on the relative amounts of alkyne and halogen present in the reaction mixture.

For example, if propyne reacts with an excess of bromine in the presence of UV light the following occurs:

First 

Followed by 

Finally 

Or, overall $HC \equiv C - CH_3 + 6\,Br_2 \rightarrow CBr_3 - CBr_2 - CBr_3 + 4\,HBr$

Combustion

Alkynes undergo combustion to form carbon dioxide and water.

For example, the equation for the combustion of pent-2-yne is

$$C_5H_8 + 7\,O_2 \rightarrow 5\,CO_2 + 4\,H_2O$$

Questions

35. Give the structural formulae of the organic product formed in each of the following reactions:

a) ethyne is mixed with bromine in a 1:1 mole ratio.

b) ethyne is mixed with chlorine in a 1:2 ratio, in the presence of UV light

c) ethyne is mixed with an excess of chlorine in the absence of ultraviolet light

d) ethyne is mixed with an excess of fluorine in the presence of ultraviolet light

e) 1 mole of ethyne is reacted with 1 mole of hydrogen

36. Write balanced equations, using structural formulae, for the following reactions:

a) a mixture of propyne and an excess of fluorine are placed in a dark cupboard

b) ethyne is allowed to react with an excess of chlorine in the presence of sunlight

c) 1 mole of but-1-yne is mixed with 2 moles of chlorine

d) pent-2-yne is reacted with an excess of hydrogen, in the presence of a catalyst

e) hex-3-yne is mixed with an excess of bromine and the mixture exposed to ultraviolet light for several hours.

f) a 1:1 mole ratio mixture of but-2-yne and fluorine is allowed to react

Review Questions

Alkanes, alkenes & alkynes

37. Which of the formulae given in the box could be that of an

a) alkane?

b) alkene, with one double bond?

c) alkyne, with one triple bond?

C_4H_8	CH_4
C_8H_{14}	C_2H_2
C_9H_{20}	$C_{15}H_{30}$

38. Which of the following are structural isomers of hex-1-ene?

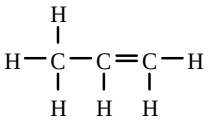
A	hexane	B	hex-1-yne
C	2-methylhex-1-ene	D	2-methylhex-3-yne
E	2-methylpent-2-ene	F	ethylpent-2-ene
G	dimethylbut-2-ene	H	dimethylbutyne
I	dimethylpropane	J	methylpropene
K	2,3-dimethylbut-1-ene	L	hex-3-ene

39. The reactants, products and reaction conditions are summarised for some reactions in the following table. Complete the table by giving the structural formula of the product/s or the reactant/s. The first example has been completed.

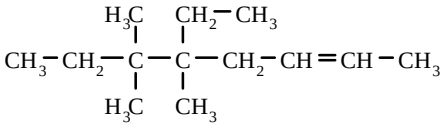
Reactants		Reaction Conditions					Product/s	
		Mole ratio (organic: halogen/H_2)			UV light	No UV light		
		1:1	1:2	excess halogen				
$CH_3CH_2CH_3$	Cl_2	✓			✓		$CH_3CH_2CH_2Cl$	HCl
$CH_3CH_2CH_2CH_3$	Br_2			✓	✓			
$CH_2=CH_2$	F_2	✓			✓			
$HC\equiv C-CH_3$	H_2		✓		catalyst used			
		✓			✓		$CH_3CH(Cl)CH_2Cl$	
$CH_3CH_2CH_2CH_2CH_3$	Cl_2			✓		✓		
				✓	✓		CBr_4	
$CH_3C\equiv CCH_2CH_3$	F_2			✓		✓		

40. Name the following compounds:

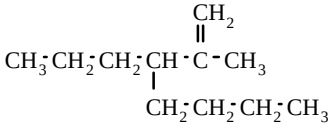
a)



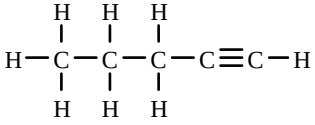
b)



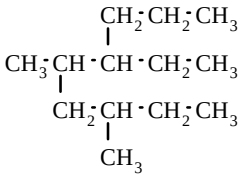
c)



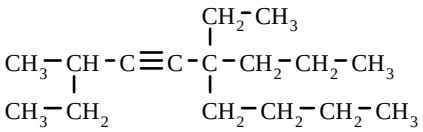
d)



e)



f)



5. Hydrocarbons

Some words/terms used to describe organic compounds are:

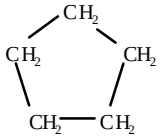
Hydrocarbon - a compound that contains only hydrogen and carbon atoms. For example, alkanes, alkenes and alkynes are examples of hydrocarbons.

Saturated compounds - compounds which contain only single covalent bonds. For example, alkanes are saturated compounds.

Unsaturated compounds - compounds which contain at least one double or triple covalent bond. For example, alkenes and alkynes are unsaturated compounds.

Aliphatic hydrocarbons - hydrocarbons which exist as open-chain molecules. For example, CH_3-CH_2-CH_2-CH_2-CH_3 is an aliphatic alkane.

Alicyclic (cyclic) hydrocarbons - hydrocarbons in which the carbon atoms are joined in a ring. For example



is a cyclic alkane.

Aromatic hydrocarbons - hydrocarbons which contain a benzene ring

Aliphatic compounds

The alkanes, alkenes and alkynes referred to in the previous sections were all aliphatic hydrocarbons i.e. their carbon atoms were arranged in an open chain arrangement.

Alicyclic compounds

In alicyclic compounds, the hydrocarbon chain is joined up in a ring.

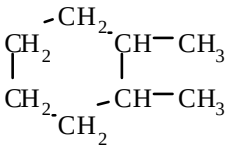
Alicyclic alkanes (cycloalkanes) and alicyclic alkenes (cycloalkenes) exist.

Cycloalkanes

The general formula of cycloalkanes is C_nH_{2n} (i.e. the same as the general formula of alkenes) .

In naming cycloalkanes, the ring is regarded as the parent chain and the prefix 'cyclo' is used. The ring is numbered so that the side-chains/groups have the smallest possible number.

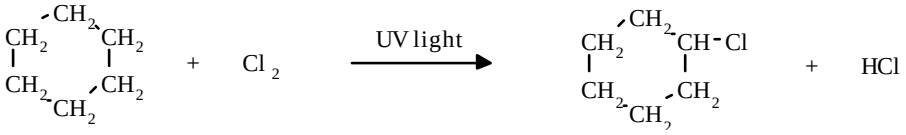
For example, the name of the following compound is 1,2-dimethylcyclohexane



The structural formulae of cycloalkanes can also be written without showing the hydrogen and carbon atoms e.g. cyclohexane can be represented as

The properties and reactions of cycloalkanes are similar to those of aliphatic alkanes i.e. they undergo substitution and combustion reactions

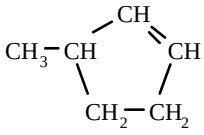
For example, the reaction of cyclohexane with chlorine, in a 1:1 molar ratio, and in the presence of UV light, is



Cycloalkenes

The general formula of cycloalkenes is C_nH_{2n-2} (i.e. the same as the general formula of alkynes).

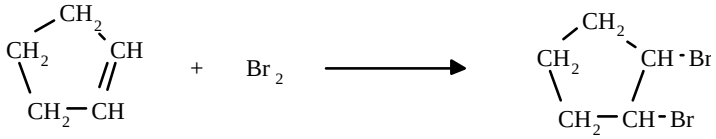
Cycloalkenes are named in a similar way to cycloalkanes, except, the double bonded carbon atoms are always numbered carbons 1 and 2. Consequently, it is not necessary to include a number in the name for this double bond. The numbering of the ring can occur clockwise or anticlockwise, depending on which direction will give the side groups the smallest number (after assigning "1" to the double bond). For example, the following compound is named 3-methylcyclopentene



The reactions of cycloalkenes are similar to those of aliphatic alkenes, i.e. they undergo addition followed substitution reactions, and combustion reactions

For example:

i) when cyclopentene reacts with bromine (in a 1:1 mole ratio), the following occurs



ii) when cyclohexene undergoes combustion, the following occurs:

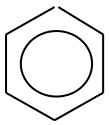
$$C_6H_{12} + 9\ O_2 \rightarrow 6\ CO_2 + 6\ H_2O$$

(Note that in the above reactions, except for combustion reactions, the ring of carbon atoms remains intact.)

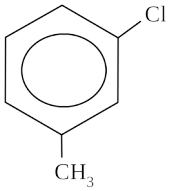
Aromatic hydrocarbons

These hydrocarbons contain a benzene ring. Benzene has the formula C_6H_6 and it is composed of six carbon atoms bonded in a ring, with one hydrogen atom singly bonded to each carbon.

All the carbon-carbon bonds in benzene are equivalent. These bonds are neither single nor double bonds. Some of the carbon bonding electrons are shared (delocalised) over the whole ring, and this results in an average of one and a half pairs of bonding electrons between the carbon atoms. Because of this structure, the benzene ring is a reasonable stable unit.

The structural formula of benzene is often written as 

Simple aromatic compounds are named by adding the appropriate prefix of the substituent group to the name "benzene".

For example,  is called 1-chloro-3-methylbenzene

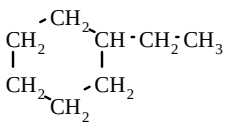
Hydrocarbons as fuels

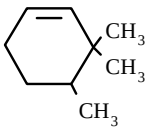
The major sources of hydrocarbons are natural gas, crude oil (petroleum) and coal.

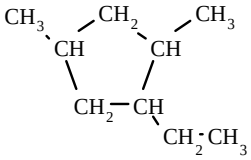
Hydrocarbons are very important as fuels because their combustion reactions are highly exothermic. Some hydrocarbons that are used for fuels are natural gas (methane), LNG (methane), LPG gas (ethane/propane), petrol (octane), kerosene and coal.

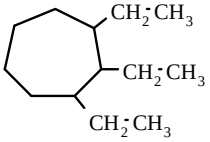
Questions

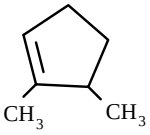
41. Name the following cyclic compounds:

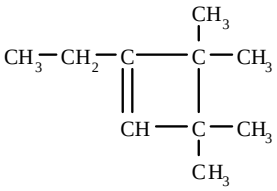
a) 

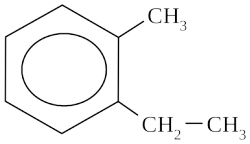
b) 

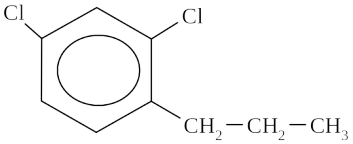
c) 

d) 

e) 

f) 

g) 

h) 

42. Give the structural formulae of the following compounds:

a) 1,1-dimethylcyclohexane

b) 2,3-diethylcyclooctene

c) 1,2,3-trimethylcyclopropane

d) 4-propylcyclohexene

e) 1,4-diethylbenzene

f) 1-bromo-3-methylbenzene

43. Give the formulae and names of all the alicyclic structural isomers with the molecular formula of C_6H_{12}.

44. Some different types of hydrocarbons are listed below

aliphatic alkane	aliphatic alkene	aliphatic alkyne
cycloalkane	cycloalkene	cycloalkyne

Which type or types of these hydrocarbons could have the following molecular formulae?

a) C_7H_{14}

b) C_4H_6

c) $C_{10}H_{22}$

d) $C_{15}H_{30}$

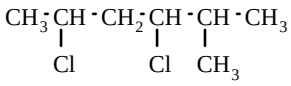
45. Give the names and structural formulae of all of the aromatic isomers with the molecular formula of C_8H_{10}.

6. Halogen-substituted alkanes

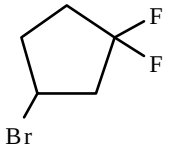
Halogen-substituted alkanes or haloalkanes contain C, H and halogen atoms.

They are named by using the prefixes 'chloro-', 'fluoro-', 'bromo-' and 'iodo-'. These prefixes are placed alphabetically in the name of the compound. Numbers are used to show the position of the halogen atoms on the carbon chain.

For example, CH_3I iodomethane CH_3-CH_2-CH_2Br 1-bromopropane



3,5-dichloro-2-methylhexane



3-bromo-1,1-difluorocyclopentane

Haloalkanes are prepared by:

i) the substitution reaction of an alkane with a halogen in the presence of UV light

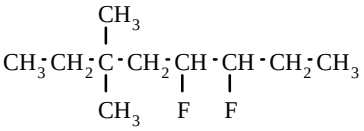
ii) the addition reaction of an alkene or an alkyne with a halogen.

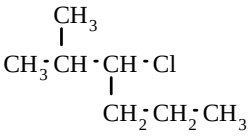
The properties of haloalkanes are similar to those of alkanes, except they tend to be more reactive.

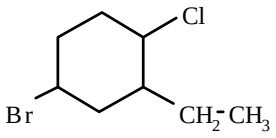
Questions

46. Give the structural formulae and names of the isomers with the formula $C_3H_6Cl_2$.

47. Name the following compounds:

a) 

b) 

c) 

48. Give the formulae of the chemicals and describe the reaction conditions you could use to prepare the following compounds:

a) CH_3Br

b) 1,2-dichloroethane

c) $CF_3 - CF_2 - CF_3$

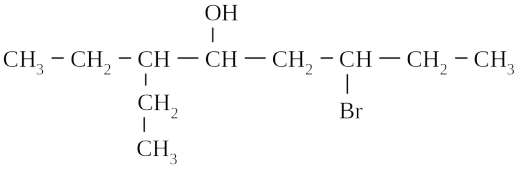
d) $CH_3 - CBr = CHBr$

e) $CH_3 - CCl_2 - CCl_2 - CH_3$

Alcohols

Alcohols

- contain the functional group -OH. For example, methanol, CH_3OH, is an alcohol
- are colourless compounds
- are often liquids at room temperature
- have higher boiling points than their parent alkane. This occurs because of the stronger hydrogen bonds between the alcohol molecules, compared to dispersion forces between the alkane molecules
- are often soluble in water (because of the hydrogen bonding which can occur between the water molecules and the alcohol molecules). However, as the length of the carbon chain increases, the solubility in water decreases.



Nomenclature

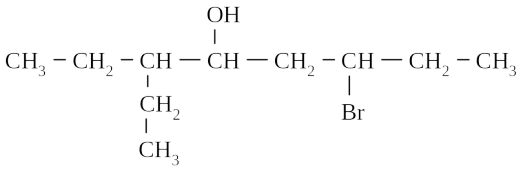
i) Alcohols are named by adding the suffix "-ol" in the place of the "e" in the alkane name.

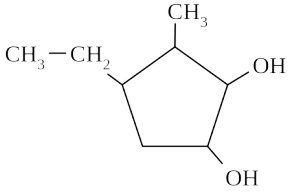
ii) The position of the alcohol functional group is indicated by the use of a number placed before the suffix "ol". (The prefix "hydroxy" is used for some compounds).

iii) If a halogen atom or an alkyl group is present in the alcohol molecule, the chain is numbered so that the alcohol group has the "smallest" number i.e. the chain is numbered from the end closest to the alcohol group.

iv) If two alcohol functional groups are present then the suffix "diol" is used and the "e" is not dropped from the alkane name.

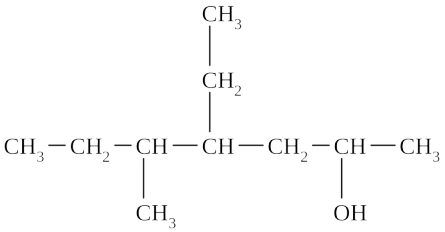
For example

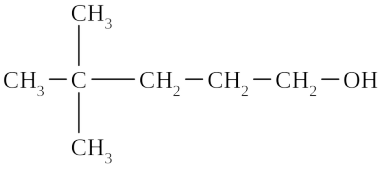
i)  is called 6-bromo-3-ethyloctan-4-ol

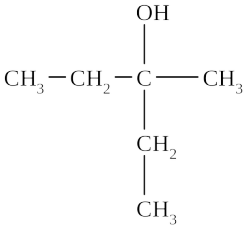
ii)  is called 4-ethyl-3-methylcyclopentane-1,2-diol

Questions

49. Name the following alcohols, according to the I.U.P.A.C. rules

a) 

b) 

c) 

50. Give the structural formulae of the following compounds:

a) ethanol

b) butan-2-ol

c) 3,3,4,4-tetramethylpentan-1-ol

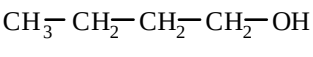
d) butane-1,2-diol

Types of alcohols

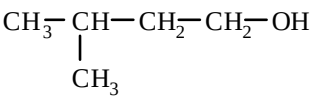
Alcohols are often classified according to the number of carbon atoms (or hydrogen atoms) attached to the carbon atom to which the -OH group is bonded.

Primary alcohol - one carbon atom and 2 hydrogen atoms are attached to the carbon atom to which the -OH group is bonded

For example butan-1-ol

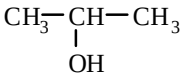


3-methylbutan-1-ol

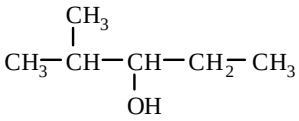


Secondary alcohol - two carbon atoms and one hydrogen atom are attached to the carbon atom to which the -OH group is bonded

For example propan-2-ol

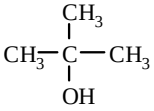


2-methylpentan-3-ol

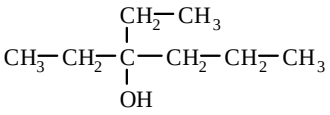


Tertiary alcohol - three carbon atoms and no hydrogen atoms are attached to the carbon atom to which the -OH group is bonded

For example: methylpropan-2-ol

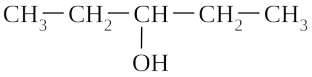


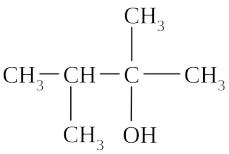
3-ethylhexan-3-ol

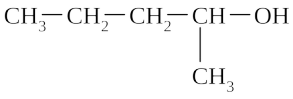


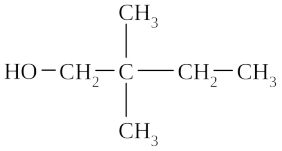
Questions

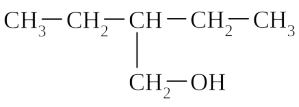
51. Identify the following alcohols as primary, secondary or tertiary alcohols:

a) 

b) 

c) 

d) 

e) 

f) $(CH_3)_3COH$

Reactions of alcohols

Alcohols react readily with sodium to form hydrogen gas and an alkoxide ion (RO^-).

For example, when propan-1-ol is added to sodium, the following reaction occurs

$$2\ CH_3 - CH_2 - CH_2 - OH + 2\ Na \rightarrow 2\ CH_3 - CH_2 - CH_2 - O^-\ Na^+ + H_2$$

Alcohols can also be oxidised. (These oxidation reactions will be covered in Organic 2.)

Questions

52. Give the equations for the following reactions:

a) small pieces of sodium are added to some methanol

b) some butan-2-ol is mixed with some sodium.

Amines

Amines

- have the functional group $-NH_2$
- are often soluble in water (they hydrogen bond with water molecules)
- often have a "fishy" smell

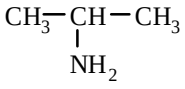
Nomenclature

i) Amines are named by using the suffix "-amine" in place of the "e" on the name of the hydrocarbon chain, or by using the prefix "amino-".

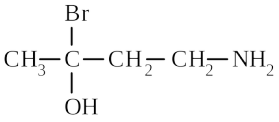
ii) The prefix "amino-" is used when an alcohol functional group is present in the molecule, as the alcohol group takes precedence i.e. the chain is numbered from the end closest to the alcohol group.

iii) The amine group, however, takes precedence over a halogen group i.e. the chain is numbered from the end closest to the amine group, and the suffix "-amine" is used in the name.

For example



propan-2-amine



4-amino-2-bromobutan-2-ol

Reactions of amines

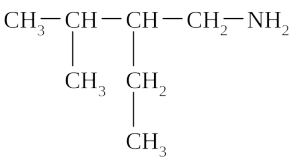
Animes act as weak bases in a similar way to ammonia i.e. they can accept a proton from an acid to form a positive ion

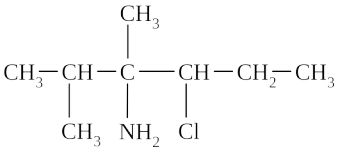
For example, when methanamine is added to hydrochloric acid, the following reaction occurs:

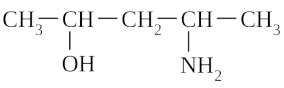
$$CH_3 - NH_2 \quad + \quad H^+ \quad \rightarrow \quad CH_3 - NH_3^+$$

Questions

53. Name the following compounds:

a) 

b) 

c) 

54. Write equations for the following reactions:

a) dilute hydrochloric acid is added to some ethanamine

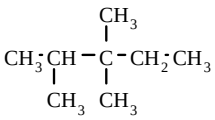
b) pentan-3-amine is mixed with some 2 mol L^{-1} sulfuric acid

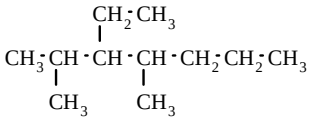
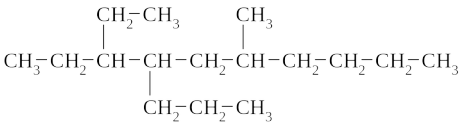
Organic Chemistry 1. - Answers

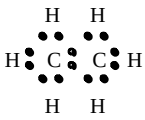
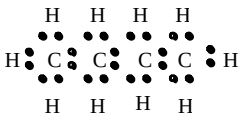
1. B, D, E

2. a) $C_3H_3Br_3$ b) C_5H_{12} c) $C_4H_{10}O$

3. a) pentane b) octane c) 2-methylhexane
   d) propane e) 3-ethylnonane f) 2-methylpentane
   g) 2,2-dimethylbutane h) 4-ethyl-6-methylnonane i) 4-ethyl-2,5-dimethylheptane
   j) decane k) 3-ethyl-6-methyl-4-propyloctane l) ethane

4. a) $CH_3CH_2CH_2CH_2CH_2CH_3$ b) $CH_3CH(CH_3)CH_3$ c) 

   d)  e) 

5. a)  b) 

6. a) $CH_3CH_2CH_2CH_3$ butane $CH_3CH(CH_3)CH_3$ methylpropane

   b) $CH_3CH_2CH_2CH_2CH_2CH_3$ hexane $CH_3CH(CH_3)CH_2CH_2CH_3$ 2-methylpentane

   $CH_3CH_2CH(CH_3)CH_2CH_3$ 3-methylpentane $CH_3C(CH_3)_2CH_2CH_3$ 2,2-dimethylbutane

   $CH_3CH(CH_3)CH(CH_3)CH_3$ 2,3-dimethybutane

7. B, D, E, F

8. D, E, F, G

9. a) CH_3Cl b) CH_3CH_2Br c) $CH_3CH_2CH_2F$ d) $CH_3C(CH_3)_2CH_2I$

10. a) CH_3F b) CBr_4

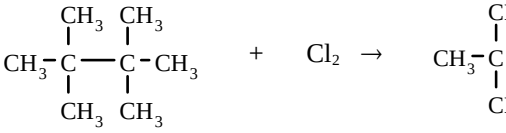
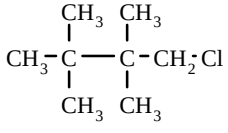
    c) $CH_3CH_2CH_3$ d) $CH_3CH_2CH_2CH_2CH_2CH_3 + Cl_2$, HCl

    e) CH_3CH_3, 6HCl f) $CBr_3\text{-}C(CBr_3)\text{-}CBr_2\text{-}CBr_3 + 12\ HBr$

11. a) $CH_3\text{-}CH_3 + 6F_2 \rightarrow CF_3\text{-}CF_3 + 6HF$

    b) $2C_4H_{10} + 13\ O_2 \rightarrow 8CO_2 + 10H_2O$

    c) No reaction

    d)  + $Cl_2 \rightarrow$  + HCl

11. e) $CH_3\text{-}\underset{\displaystyle CH_3}{\underset{|}{C}}H\text{-}CH_3 + 10Br_2 \rightarrow CBr_3\text{-}\underset{\displaystyle CBr_3}{\underset{|}{C}}H\text{-}CBr_3 + 10HBr$

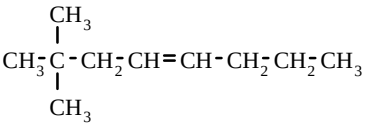
12. a) incorrect - 3-methylpentane
b) incorrect - 3-methylheptane
c) incorrect - 2,2-dimethylpentane
d) correct

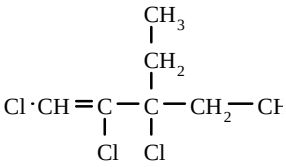
13. a) $CH_3Br + HBr$
b) Cl_2, HCl
c) CH_3CH_3
d) CH_4, $4HCl$
e) no reaction
f) $8\,O_2 \rightarrow 5CO_2 + 6H_2O$

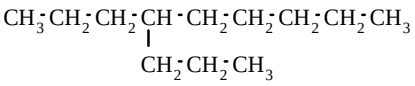
14. a) False b) False c) False d) False

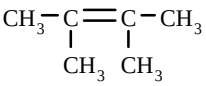
15. a) hept-3-ene
b) 4-methylpent-2-ene
c) 4-methyloct-3-ene
d) 5-ethyl-3-methylhept-2-ene
e) propene
f) 2-ethylpent-1-ene

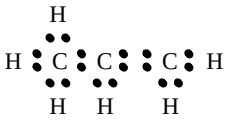
16. a) $CH_3\text{-}CH_2\text{-}CH=CH\text{-}CH_2\text{-}CH_3$

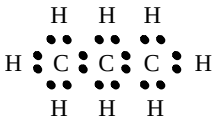
b)


c)


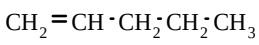
d)


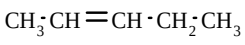
e)


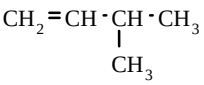
17. a)


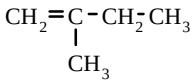
b)


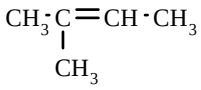
18. B and C

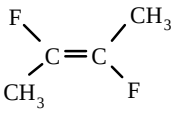
19.

pent-1-ene

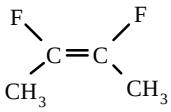

pent-2-ene

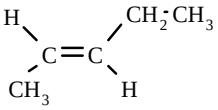

3-methylbut-1-ene

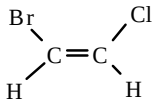

2-methylbut-1-ene


methylbut-2-ene

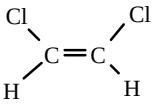
20. a)


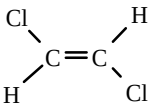
b)


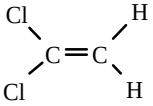
c)


d)


21. a) *cis*-hept-3-ene
b) *trans*-2,3-dichlorobut-2-ene
c) *cis*-3-methylhex-2-ene

22. a)

cis-1,2-dichloroethene


trans-1,2-dichloroethene

b)

1,1-dichloroethene - does not form geometrical isomers

23. A, B, C, D

24. a) $CH_2Cl - CH_2Cl$ b) $CH_3 - CHBr - CH_2Br$
c) $CH_3 - CH_2 - CH_2 - CH_3$ d) $CCl_3 - CCl_2 - CCl_3$

25. a) $CH_3 - CH = CH_2 + F_2 \rightarrow CH_3 - CHF - CH_2F$
b) $CH_3 - \underset{\displaystyle CH_3}{\underset{|}{C}} = CH_2 + Br_2 \rightarrow CH_3 - \underset{\displaystyle CH_3}{\underset{|}{C}}Br - CH_2Br$
c) $CH_2 = CH_2 + H_2 \rightarrow CH_3 - CH_3$
d) $CH_2 = CH - CH_2 - CH_3 + Cl_2 \rightarrow CH_2Cl - CHCl - CH_2 - CH_3$
e) $CH_3 - CH = CH - CH_2 - CH_3 + 11Br_2 \rightarrow CBr_3 - CBr_2 - CBr_2 - CBr_2 - CBr_3 + 10HBr$
f) $C_6H_{12} + 9\,O_2 \rightarrow 6CO_2 + 6H_2O$

26. a) 1:1 mole ratio of (ethene and F_2), or excess F_2 in the dark
b) excess of Cl_2 in the presence of ultraviolet light
c) 1:1 mole ratio of reactants (pent-2-ene and Br_2), or excess Br_2 in the dark
d) excess F_2 in presence of UV light

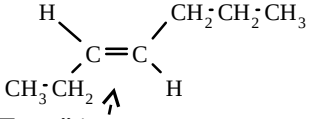
27. a) Br_2 and $CH_3 - CH = CH_2$ propene
b) Cl_2 and $CH_2 = CH_2$ ethene (or $CH_3 - CH_3$ ethane)
c) H_2 and $CH_2 = \underset{\displaystyle CH_3}{\underset{|}{C}}H - CH_3$ methylpropene
d) F_2 and $CH_3 - CH_2 - CH = CH - CH_2 - CH_2 - CH_3$ hept-3-ene
e) Br_2 and $CH_3 - CH_2 - CH_2 - CH_3$ butane (or but-1-ene or but-2-ene)
f) Cl_2 and $CH_2 = CH_2$ ethene

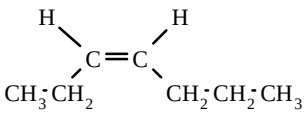
28. a C b A c E d F e D f B

29. a) $CH_3 - CH_3 + 6Cl_2 \rightarrow CCl_3 - CCl_3 + 6HCl$
b) $CH_3 - CH = CH - CH_2 - CH_2 - CH_3 + Br_2 \rightarrow CH_3 - CHBr - CHBr - CH_2 - CH_2 - CH_3$
c) $CH_3 - CH = CH - CH_3 + 9F_2 \rightarrow CF_3 - CF_2 - CF_2 - CF_3 + 8HF$
d) $CH_3 - \underset{\displaystyle CH_3}{\overset{\displaystyle CH_3}{\overset{|}{\underset{|}{C}}}} - CH_3 + Br_2 \rightarrow CH_3 - \underset{\displaystyle CH_3}{\overset{\displaystyle CH_3}{\overset{|}{\underset{|}{C}}}} - CH_2Br + HBr$
e) $CH_3 - CH_2 - CH_2 - CH_2 - CH_2 - CH_2 - CH_2 - CH_3 + 12O_2 \rightarrow 8CO_2 + 8H_2O$

30. C, F

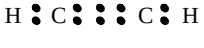
31. a)



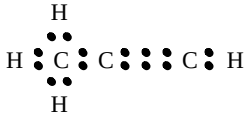


b) “Trans” isomer

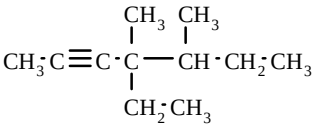
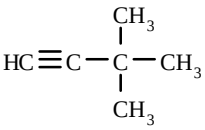
32. a)



b)



33. a) hex-2-yne b) 7-methyl-5-propylnon-2-yne
c) 3,3,6-trimethyloct-4-yne d) 3,4-diethylhex-1-yne

34. a) $CH_3 \cdot CH_2 \cdot C \equiv C \cdot CH_2 \cdot CH_2 \cdot CH_2 \cdot CH_3$ b)  c) 

35. a) CHBr = CHBr b) $CHCl_2$ - $CHCl_2$ c) $CHCl_2$ - $CHCl_2$
d) CF_3 - CF_3 e) $CH_2 = CH_2$

36. a) $CH_3 - C \equiv CH + 2F_2 \rightarrow CH_3 - CF_2 - CHF_2$
b) $CH \equiv CH + 4Cl_2 \rightarrow CCl_3 - CCl_3 + 2HCl$
c) $CH \equiv C - CH_2 - CH_3 + 2Cl_2 \rightarrow CHCl_2 - CCl_2 - CH_2 - CH_3$
d) $CH_3 - C \equiv C - CH_2 - CH_3 + 2H_2 \rightarrow CH_3 - CH_2 - CH_2 - CH_2 - CH_3$
e) $CH_3 - CH_2 - C \equiv C - CH_2 - CH_3 + 12Br_2 \rightarrow CBr_3 - CBr_2 - CBr_2 - CBr_2 - CBr_2 - CBr_3 + 10HBr$
f) $CH_3 - C \equiv C - CH_3 + F_2 \rightarrow CH_3 - CF = CF - CH_3$

37. a) CH_4, C_9H_{20} b) C_4H_8, $C_{15}H_{30}$ c) C_8H_{14}, C_2H_2

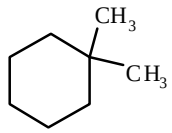
38. E, G, K, L

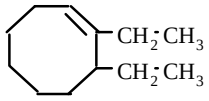
39.

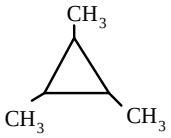
Reactants		Reaction Conditions: Mole ratio (organic: halogen/H_2) 1:1	1:2	excess halogen	UV light	No UV light	Product/s	
$CH_3 \cdot CH_2 \cdot CH_3$	Cl_2	✓			✓		$CH_3 \cdot CH_2 \cdot CH_2 \cdot Cl$	HCl
$CH_3 \cdot CH_2 \cdot CH_2 \cdot CH_3$	Br_2			✓	✓		**CBr_2-CBr_2-CBr_2-CBr_3**	**HBr**
$CH_2 = CH_2$	F_2	✓			✓		**CH_2F-CH_2F**	
$HC \equiv C - CH_3$	H_2		✓		catalyst used		**CH_3-CH_2-CH_3**	
CH_3-CH=CH_2	**Cl_2**	✓			✓		$CH_3 \cdot CH(Cl) \cdot CH_2 - Cl$	
$CH_3 \cdot CH_2 \cdot CH_2 \cdot CH_2 \cdot CH_3$	Cl_2			✓		✓	no reaction	
CH_4	**Br_2**			✓	✓		CBr_4	**HBr**
$CH_3 - C \equiv C - CH_2 \cdot CH_3$	F_2			✓		✓	**CH_3-CF_2-CF_2-CH_2-CH_3**	

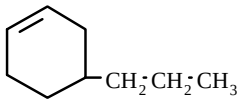
40. a) propene b) 5-ethyl-5,6,6-trimethyloct-2-ene
c) 2-methyl-3-propylhept-1-ene d) pent-1-yne
e) 6-ethyl-3,5-dimethylnonane f) 6-ethyl-3-methyl-6-propyldec-4-yne

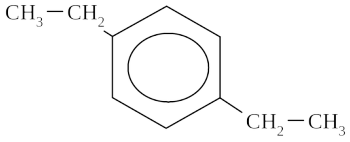
41. a) ethylcyclohexane b) 3,3,4-trimethylcyclohexene
c) 1-ethyl-2,4-dimethylcyclopentane d) 1,2,3-triethylcycloheptane
e) 2,3-dimethylcyclopentene f) 1-ethyl-3,3,4,4-tetramethylcyclobutene
g) 1-ethyl-2-methylbenzene h) 2,4-dichloro-1-propylbenzene

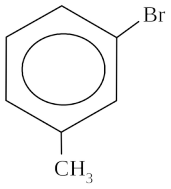
42. a) 

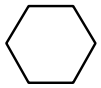
b) 

c) 

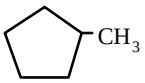
d) 

e) 

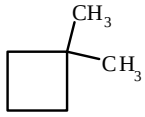
f) 

43. 

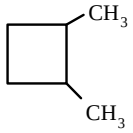
cyclohexane



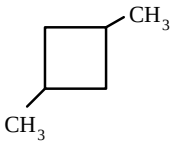
methylcyclopentane



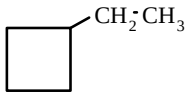
1,1-dimethylcyclobutane



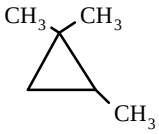
1,2-dimethylcyclobutane



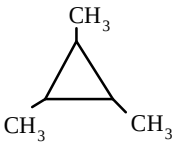
1,3-dimethylcyclobutane



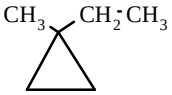
ethylcyclobutane



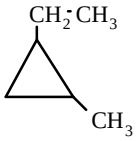
1,1,2-trimethylcyclopropane



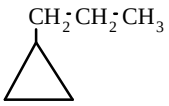
1,2,3-trimethylcyclopropane



1-ethyl-1-methylcyclopropane

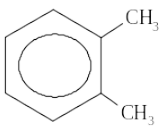


1-ethyl-2-methylcyclopropane

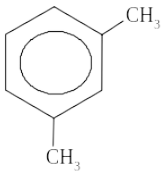


propylcyclopropane

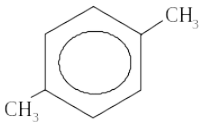
44. a) cycloalkane, aliphatic alkene b) aliphatic alkyne, cycloalkene
c) aliphatic alkane d) cycloalkane, aliphatic alkene

45. 

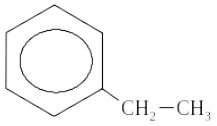
1,2-dimethylbenzene



1,3-dimethylbenzene



1,4-dimethylbenzene



ethylbenzene

46. $CH_3 - CH_2 - CHCl_2$ 1,1-dichloropropane $CH_3 - CHCl - CH_2Cl$ 1,2-dichloropropane

$CH_2Cl - CH_2 - CH_2Cl$ 1,3-dichloropropane $CH_3 - CCl_2 - CH_3$ 2,2-dichloropropane

47. a) 5,6-difluoro-3.3-dimethyloctane b) 3-chloro-2-methylhexane
c) 4-bromo-1-chloro-2-ethylcyclohexane

48. a) $CH_4 + Br_2$ - 1:1 mole ratio, in presence of ultraviolet light

b) $CH_2{=}CH_2 + Cl_2$ - excess Cl_2, in absence of UV light or 1:1 mole ratio

c) $CH_3\text{-}CH_2\text{-}CH_3 + F_2$ - excess F_2 in presence of UV light

or $CH_2{=}CH\text{-}CH_3 + F_2$ - excess F_2 in presence of UV light

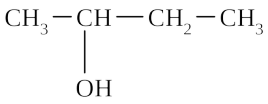
or $CH_3\text{-}C{\equiv}CH + F_2$ - excess F_2 in presence of UV light

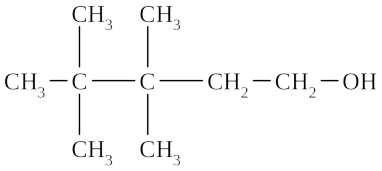
d) $CH_3\text{-}C{\equiv}CH + Br_2$ - 1:1 mole ratio

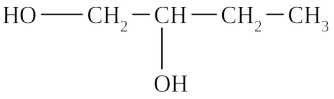
e) $CH_3\text{-}C{\equiv}C\text{-}CH_3 + Cl_2$ - in 1:2 mole ratio

49. a) 4-ethyl-5-methylheptan-2-ol b) 4,4-dimethylpentan-1-ol c) 3-methylpentan-3-ol

50. a) 

b) 

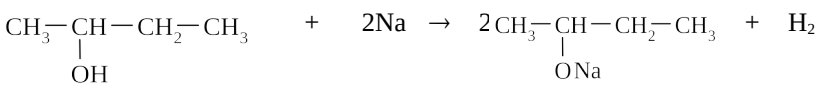
c) 

d) 

51. a) secondary alcohol b) tertiary alcohol c) secondary alcohol

d) primary alcohol e) primary alcohol f) tertiary alcohol

52. a) $2\ CH_3OH + 2\ Na \rightarrow 2\ CH_3ONa + H_2$

b) 

53. a) 2-ethyl-3-methylbutan-1-amine b) 4-chloro-2,3-dimethylhexan-3-amine c) 4-aminepentan-2-ol

54. a) $CH_3\text{-}CH_2\text{-}NH_2 + H^+ \rightarrow CH_3\text{-}CH_2\text{-}NH_3^+$

b)