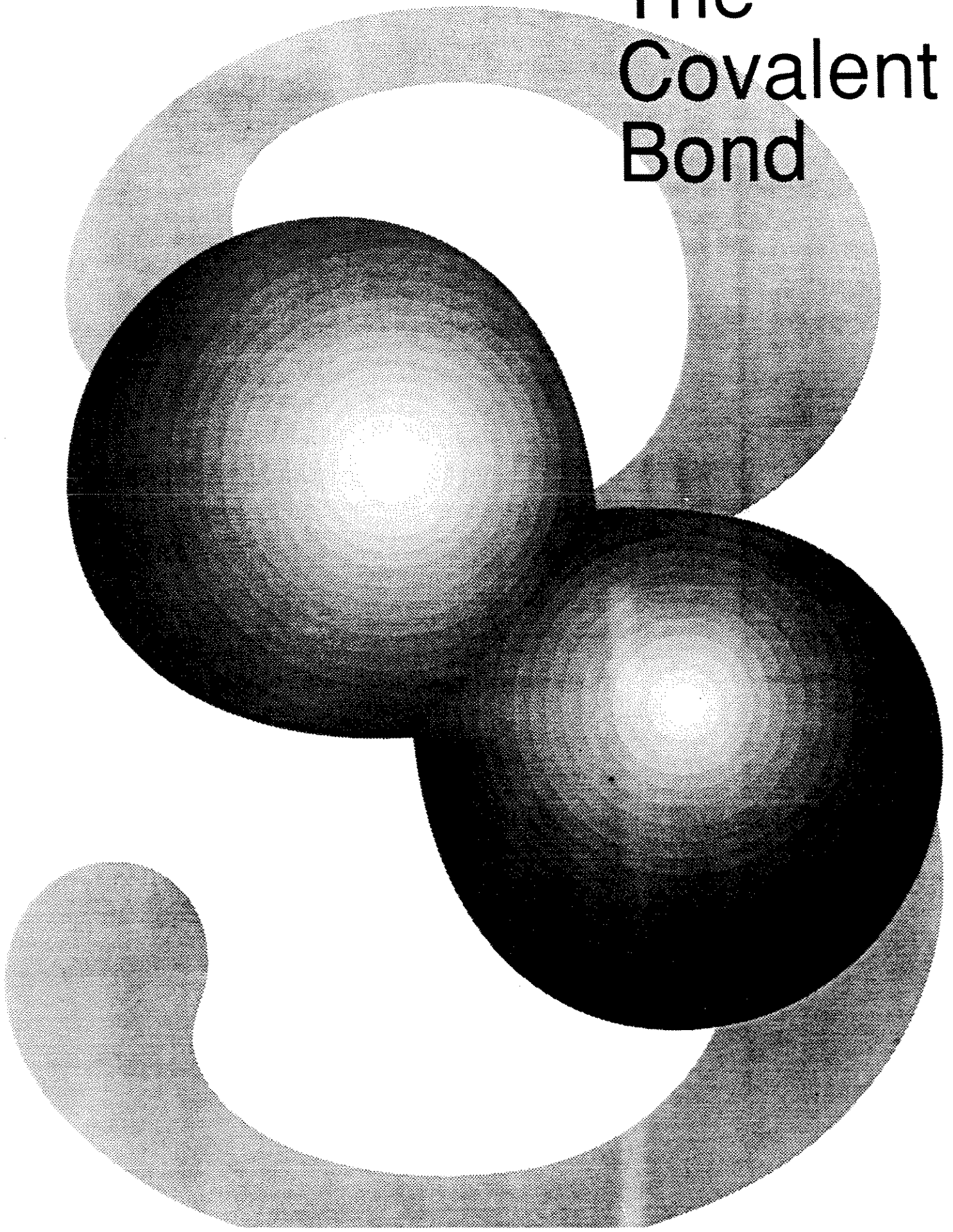


The Covalent Bond



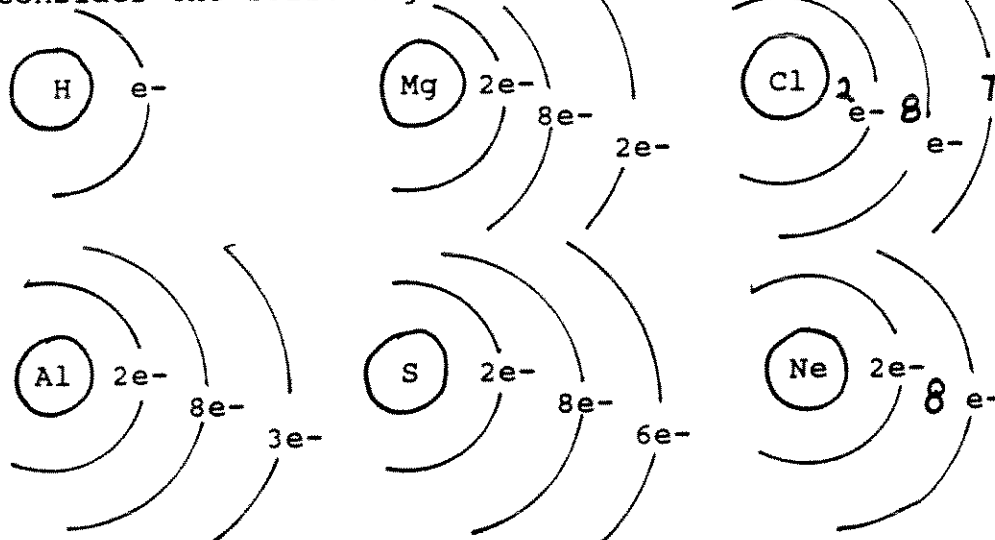
THE COVALENT BOND

134. You've already learned that atoms tend to lose electrons to form positively charged ions if they have 1, _____ or _____ electrons in their valence shell.

On the other hand, atoms that have _____ (or) _____ (or) _____ electrons in their valence shells tend to gain electrons to form _____ charged ions.

1, 2 or 3
6 or 7; negatively

135. Consider the following atoms:



(a) Which of the above atoms will lose electron(s) to form positively charged ions? _____

(b) Which of the above atoms will gain electron(s) to form negatively charged ions? _____

(c) Which of the above atoms has a complete valence shell? _____

(d) You know that such elements with a complete valence shell are usually _____

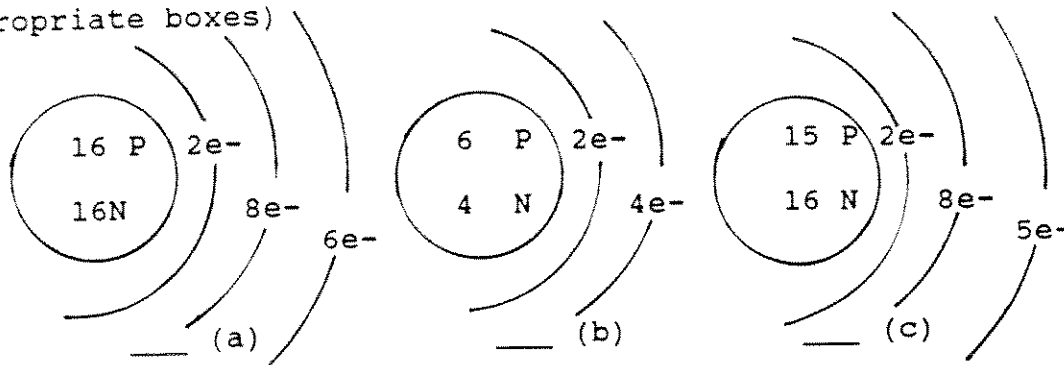
- _____ unstable and reactive
_____ stable and unreactive

(a) H, Mg, Al; (b) Cl, S; (c) Ne; (d) stable and unreactive

136. Atoms with four or five electrons in their valence shell tend to share electrons.

When atoms share electrons, they form a covalent bond.

Which of the atoms below would form covalent bonds? (check the appropriate boxes)



b and c

137. Atoms with four or five electrons in their valence shell tend to share electrons. If under some conditions those with more or fewer electrons in their valence shell may also share electrons.

When one atom loses an electron and another atom gains that electron, the ions thus formed are held together by

an ionic bond
 a covalent bond

an ionic bond

138. When two atoms share electrons, they are held together by a _____ bond.

When two atoms share electrons, no ions are produced. Will the resulting compound be an electrolyte or a non-electrolyte? _____

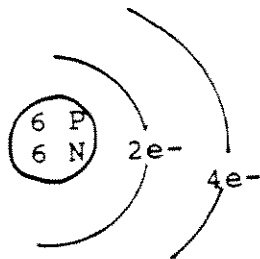
covalent; non-electrolyte

139. Compounds containing an ionic bond will be (electrolytes/non-electrolytes) _____.

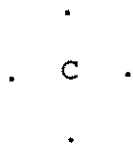
electrolytes; non electrolytes

140. The carbon atom, atomic number 6, has 4 electrons in its

valence shell.



Since the carbon atom has 4 electrons in its valence shell, it needs _____ electrons to become stable. It can get these electrons by sharing. The 4 electrons in the valence shell of the carbon atom may be represented as below, with one dot for each electron in the valence shell.



4

141. When atoms share electrons, they always try to reach a stable configuration of electrons in the valence shell.

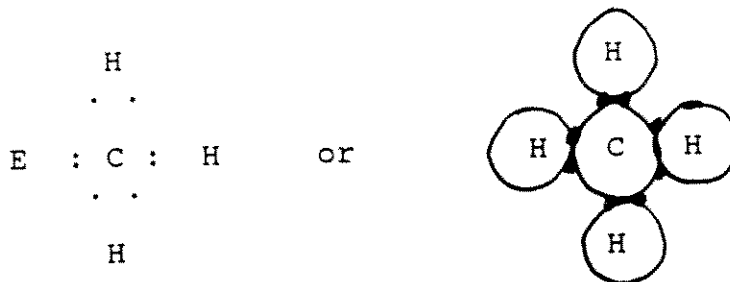
The only exception to this rule is the hydrogen atom, which reaches a stable configuration when it has two electrons in its valence shell, which is also its outer shell. This first shell can hold only _____ electrons.

2

142. Consider the carbon atom with 4 electrons in its valence shell. With how many hydrogen atoms can it share electrons to reach a stable configuration of 8 electrons in its valence shell?

4

143. The four hydrogen atoms can share electrons with a carbon atom to form a compound of the following type:



where there are _____ electrons around the carbon atoms and _____ electrons around each hydrogen atom.

8, 2

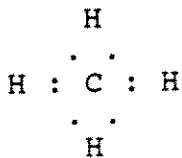
144. When two hydrogen atoms combine, they share electrons to form



where each hydrogen atom now has _____ electrons around it.

2

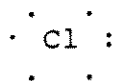
145. In this compound, what is the total number of covalent bonds?



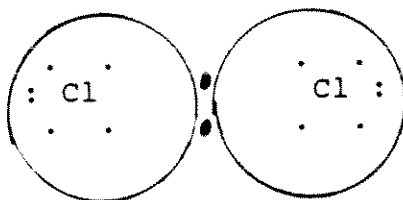
4

146. The chlorine atom, atomic number 17, has _____ electrons in its valence shell.

The 7 electrons in the valence shell of chlorine atom may be indicated as



When 2 chlorine atoms combine, they share electrons to reach a stable configuration of 8 electrons in the valence shell of each atom, or



7

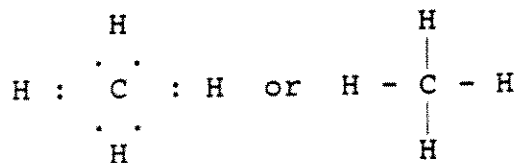
147. What type of bond is there between the two chlorine atoms?
_____.

covalent

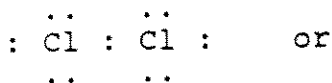
148. The covalent bond is frequently indicated by a short line rather than by dots representing shared electrons. Thus, the hydrogen molecule may be represented as



The compound CH₄ may be represented either as



Complete the second representation of the chlorine molecule, Cl₂.



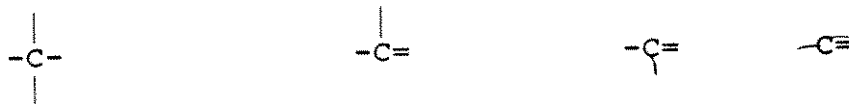
Cl-Cl

149. The carbon atom, atomic number 6, needs how many electrons to complete its valence shell? _____.

Since the carbon atom has 4 electrons in its valence shell, and since it will tend to share these electrons, how many covalent bonds will a carbon atom form? _____.

4;4

150. The carbon atom, therefore, must have four covalent bonds or must have four bonds attached to it. These bonds may be indicated as follows:



Note that each carbon atom has four bonds attached to it regardless of how these bonds are arranged.

The hydrogen atom has one electron in its valence shell, the first shell. When the hydrogen atom shares electrons, how many more does it need to complete that outer shell? _____.

1

151. The oxygen atom, atomic number 8, has _____ electrons in its valence shell.

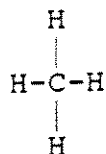
When the oxygen atom shares electrons, how many more electrons does it need to complete its valence shell? _____.

Therefore, each oxygen atom must have how many bonds attached to it? _____.

6; 2; 2

152. Draw the structure of the compound formed when four hydrogen atoms bonds with a central carbon atom.

C



153. Consider the following arrangement of carbon atoms:

C - C

This indicates a bond or a shared electron pair between two carbon atoms.

How many hydrogen atoms may be attached to the left carbon atom and the right carbon atom? _____.

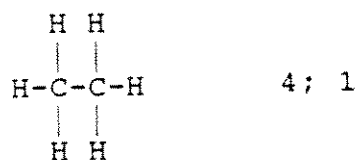
3; 3

154. Diagram all the hydrogen atoms attached to this structure.

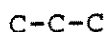
C - C

Check the total number of bonds. How many bonds does each carbon atom have? _____.

How many bonds does each hydrogen atom have? _____.



155. Consider the following arrangement of carbon atoms:



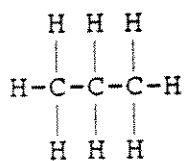
(a) How many hydrogen atoms may be attached to the left carbon atom? _____.

(b) How many hydrogen atoms may be attached to the center carbon atom? _____.

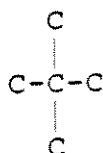
(c) How many hydrogen atoms may be attached to the right carbon atom? _____.

(a) 3; (b) 2; (c) 3

156. Diagram the compound containing three carbon atoms attached together, indicating all the hydrogen atoms connected to those carbon atoms.



157. Consider this arrangement of carbon atoms:



(a) How many hydrogen atoms may be attached to the right carbon atom? _____.

(b) How many hydrogen atoms may be attached to the left carbon atom? _____.

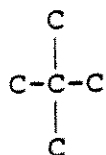
(c) How many hydrogen atoms may be attached to the upper carbon atom? _____.

(d) How many hydrogen atoms may be attached to the lower carbon atom? _____.

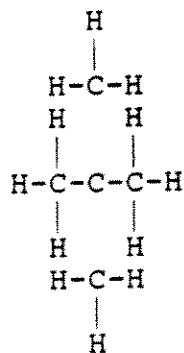
(e) How many hydrogen atoms may be attached to the center carbon atom? _____.

(a) 3; (b) 3; (c) 3; (d) 3; (e) 0 (or none)

158. Diagram the structure of the compound containing the following arrangement of carbon atoms, indicating all the hydrogen atoms.



Why can there be no hydrogen atoms on the center carbon atom?
_____.



It already has four bonds.

159. Consider the following arrangement of carbon atoms:



There are two bonds (a double bond) between the carbon atoms.
A bond (a single bond) represents one shared pair of electrons.
A double bond represents _____.

Two shared pairs of electrons

160. To come stable, the carbon atom must form how many covalent bonds? _____.

In the structure below, how many hydrogen atoms may be attached to the left carbon atom? _____.

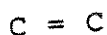
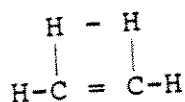


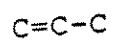
Diagram the structure of the compound containing two carbon atoms connected by a double bond, showing all the hydrogen atoms.

When you have completed your diagram, check it by counting the number of bonds around each carbon atom.

4; 2



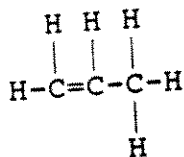
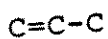
161. Consider the following arrangement of carbon atoms:



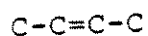
- (a) How many hydrogen atoms may be attached to the left carbon atom? _____.
- (b) How many hydrogen atoms may be attached to the center carbon atom? _____.
- (c) How many hydrogen atoms may be attached to the right carbon atom? _____.

(a) 2; (b) 1; (c) 3

162. Complete the structure of the following compound, showing all the hydrogen atoms.



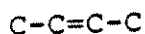
163. Consider the following arrangement of carbon atoms:



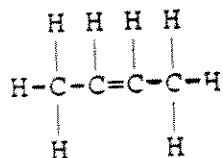
- (a) How many hydrogen atoms may be attached to the left carbon atom? _____.
- (b) How many hydrogen atoms may be attached to the carbon atom at left center? _____.
- (c) How many hydrogen atoms may be attached to the carbon atom at right center? _____.
- (d) How many hydrogen atoms may be attached to the far right carbon atom? _____.

(a) 3; (b) 1; (c) 1; (d) 3

164. Complete the structure of the following compound showing all hydrogen atoms.



Check your diagram. Each carbon atom should have how many bonds?
_____.



4

165. Consider the following arrangement of carbon atoms:



There are three bonds (a triple bond) between the two carbon atoms.

A single bond represents one pair of shared electrons.

A double bond represents _____.

A triple bond represents _____.

two shared pairs of electrons; three shared pairs of electrons.

166. In the structure below, how many hydrogen atoms may be attached to each carbon atom? _____.

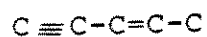


1

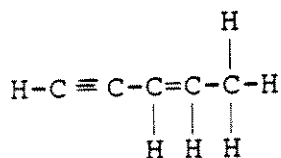
167. Complete the structure below, adding all the necessary hydrogen atoms.



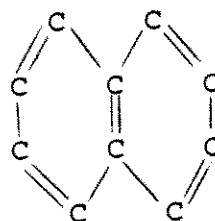
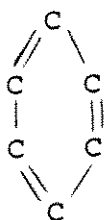
168. Complete the structure of the following compound:



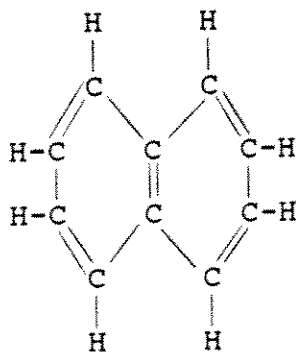
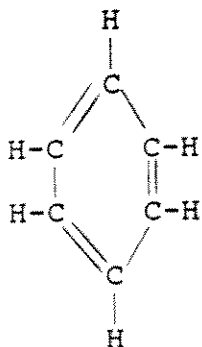
Check your diagram for the correct number of bonds around each carbon atom.



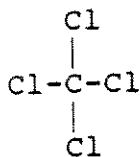
169. Complete the structure of the following compounds by adding the necessary hydrogen atoms:



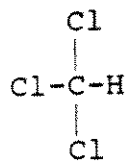
Check the number of bonds around each carbon atom.



170. Diagram the structure of carbon tetrachloride, Cl_4 , where each chlorine atom has one bond attached to it.



171. Diagram the structure of chloroform, CHCl_3 .



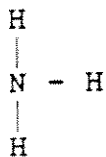
172. Diagram the structure of the water molecule, H₂O.

H-O-H

173. Nitrogen atomic number 7, has _____ electrons in its valence shell and so must have _____ bonds attached to it.

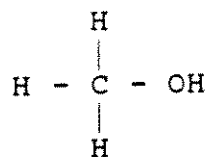
Diagram the ammonia molecule, NH₃.

5; 3



FUNCTIONAL GROUPS IN ORGANIC COMPOUNDS

174. The OH group in an ionic compound is called a hydroxide ion. The OH group in a covalent compound is called an alcohol group.

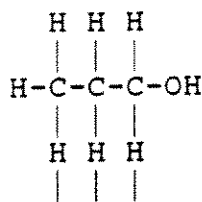


The OH group has the following bonds:

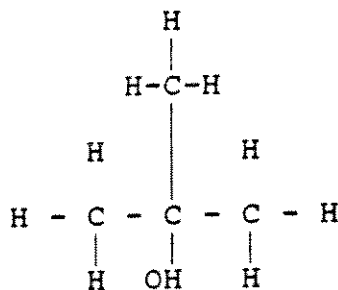


It is frequently written as -OH with the bond between the hydrogen and the oxygen being understood and not written. Note that the oxygen atom still has two bonds attached to it.

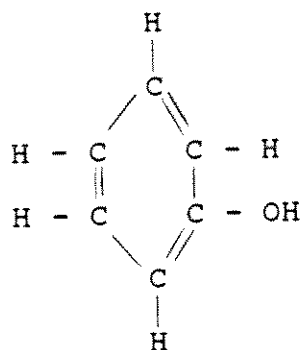
175. Check each of the following compounds that is an alcohol.



___ A



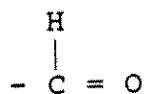
___ B



___ C

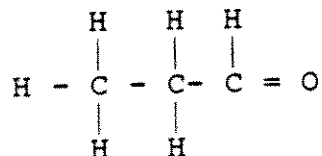
all of them (A, B, C)

176. A compound that contains a CHO group is called an aldehyde.



Note that in the aldehyde group the oxygen atom has a double bond attached to it.

177.



The compound above is an: (check one)

alcohol
 aldehyde

aldehyde

Check the correct name for each of the compounds in the next five frames, and explain why you chose the answer you did.



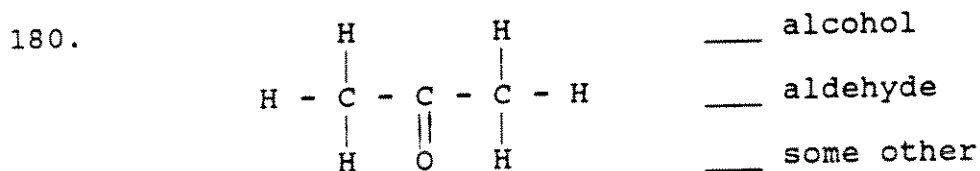
Why? _____

alcohol; it has the -OH group.



Why? _____

aldehyde; it has the H group. (or equivalent answer)

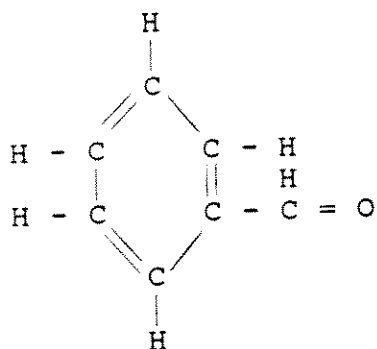


Why? _____

some other type; It has neither the -OH group or the H group



181.

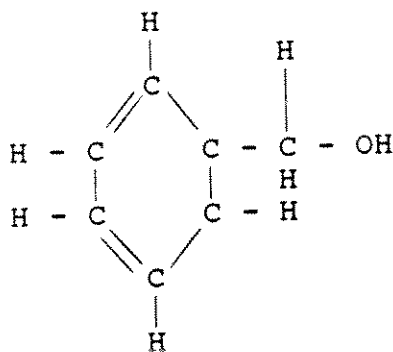


- alcohol
 aldehyde
 some other type

Why? _____

aldehyde, it has the $\begin{array}{c} \text{H} \\ | \\ -\text{C}=\text{O} \end{array}$ group

182.

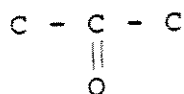


- alcohol
 aldehyde
 some other type

Why? _____

alcohol; it has the -OH group.

183. A compound that contains the following group is called a ketone.



Note that the ketone group contains a carbon atom with a double-bonded oxygen attached to it, and that this carbon atom is between two other carbon atoms.

184. (a) An alcohol contains the _____ group.

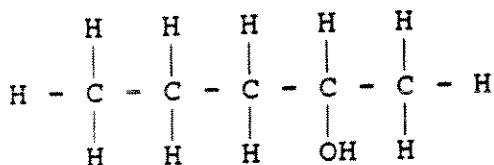
(b) An aldehyde contains the _____ group .

(c) A ketone contains the _____ group.

(a) OH; (b) CHO; (c) $\begin{array}{c} \text{C} - \text{C} - \text{C} \\ \quad \parallel \\ \quad \text{O} \end{array}$

Identify the compounds in the next seven frames as alcohols, aldehydes, or ketones.

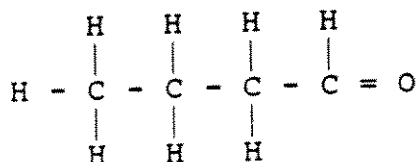
185.



— alcohol
— aldehyde
— ketone

alcohol

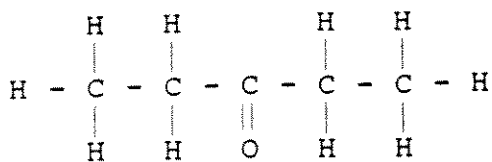
186.



— alcohol
— aldehyde
— ketone

aldehyde

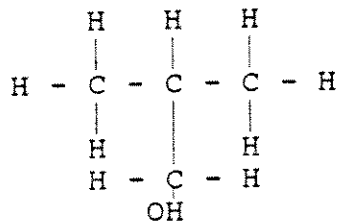
187.



— alcohol
 — aldehyde
 — ketone

ketone

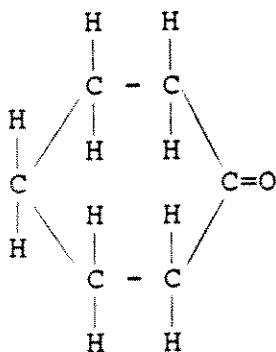
188.



— alcohol
 — aldehyde
 — ketone

alcohol

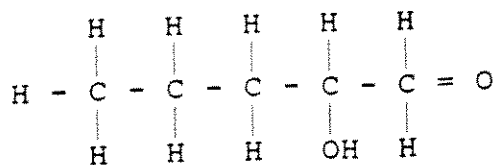
189.



— alcohol
 — aldehyde
 — ketone

ketone

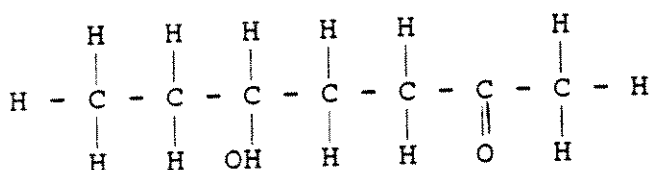
190.



- ___ alcohol and ketone
- ___ aldehyde and alcohol
- ___ ketone and aldehyde

aldehyde and alcohol

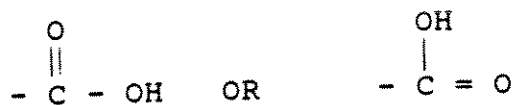
191.



- ___ alcohol and aldehyde
- ___ aldehyde and ketone
- ___ ketone and alcohol

ketone and alcohol

The COOH group may also be written as;



A compound containing a CHO group is called _____
 a compound containing a COOH group is called _____.

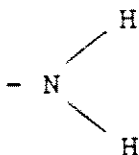
an aldehyde; an acid.

193. A compound containing an OH group is called _____
 A compound containing a C-C-C group is called _____

$$\begin{array}{c} \parallel \\ \text{O} \end{array}$$

an alcohol; a ketone

194. A compound that contains a NH₂ group is called an amine.
 In the NH₂ group,



the nitrogen atom has _____ bonds attached to it.

3

195. (a) An acid is a compound containing a _____ group.

(b) A compound containing an NH₂ group is called _____.

(c) A compound containing an OH group is called _____.

(d) A compound containing a CHO group is called _____.

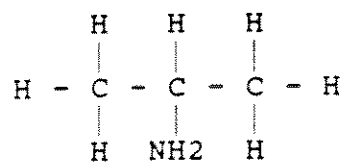
(e) a compound containing a C-C-C group is called _____

$$\begin{array}{c} \parallel \\ \text{O} \end{array}$$

(a) COOH; (b) an amine; (c) an alcohol; (d) an aldehyde; (e) a ketone

Identify the compounds in the next six frames as to type. Write the reason for your choice on the lines provided.

196.

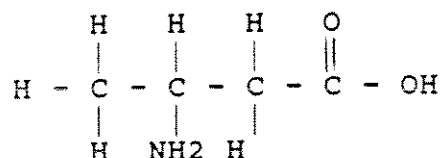


- alcohol
- amine
- ketone
- aldehyde
- acid

Why? _____

amine; it contains the NH₂ group.

197.

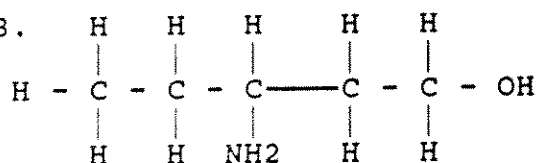


- alcohol and acid
- amine and acid
- ketone and acid
- aldehyde

Why? _____

amine and acid, or amino acid; It contains both NH₂ and COOH groups.

198.

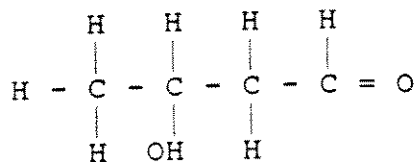


- ketone and alcohol
- aldehyde and alcohol
- acid and alcohol
- amine and alcohol

Why? _____

amine and alcohol, or amino alcohol; It contains both NH₂ and OH groups.

199.

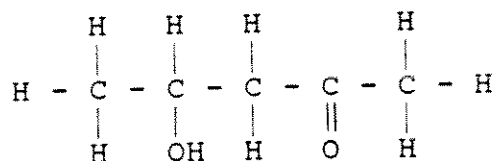


- alcohol and acid
- amine and alcohol
- alcohol and aldehyde
- ketone and alcohol

WHY?

Alcohol and aldehyde; It contains both CHO and OH groups.

200.

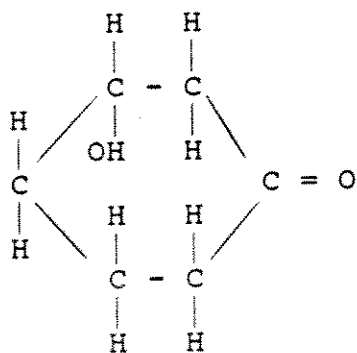


- amine and alcohol
- acid and alcohol
- alcohol and aldehyde
- alcohol and ketone

Why?

alcohol and ketone; It contains both OH and C-C-C groups.

201.

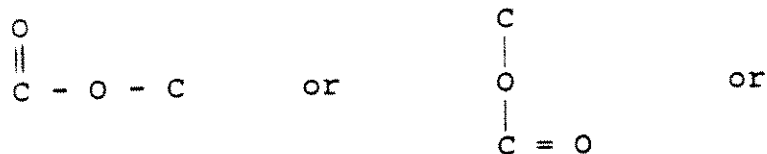


- acid and alcohol
- alcohol and amine
- ketone and acid
- alcohol and ketone

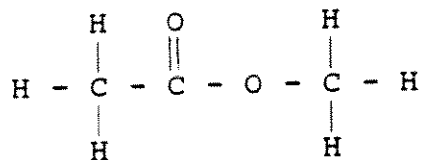
Why?

alcohol and ketone; It contains both OH and $\begin{array}{c} \text{C} \\ \diagdown \quad \diagup \\ \text{C} \quad \text{C} = \text{O} \end{array}$ groups

202. A compound that contains a COOC group is called an ester. This group may also be written as;

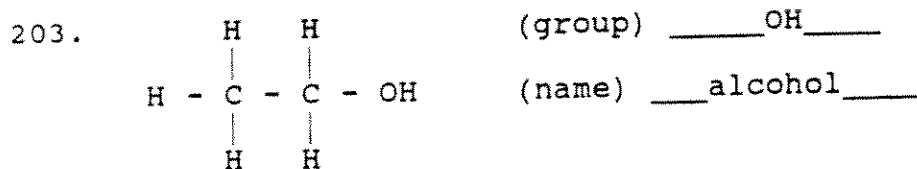


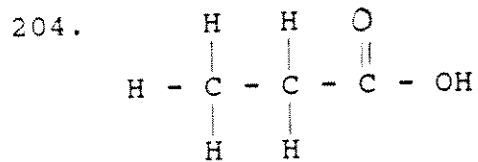
The following compound is an ester because it contains the COOC group:



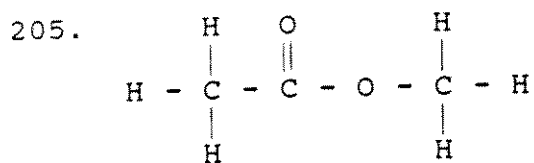
SUMMARY OF FUNCTIONAL GROUPS

Indicate the formula and the name of the functional groups following, as is done in the first example.

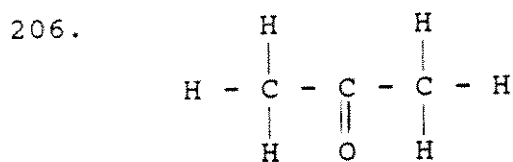




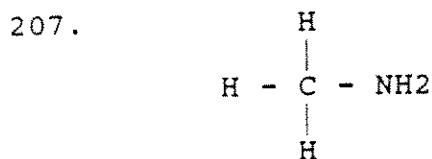
COOH; acid



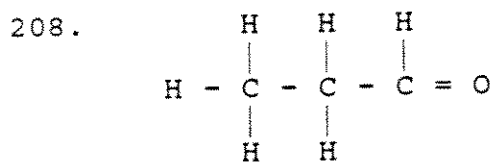
COOC; ester



C-C-C; ketone

$$\begin{array}{c}
 || \\
 \text{O}
 \end{array}$$


NH₂; amine



CHO; aldehyde