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Solutions to Even-Numbered Exercises:

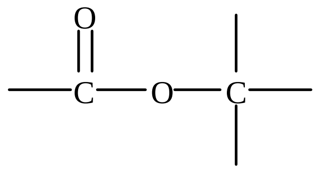
11.2 The number of bonds that an atom can form is equal to the number of electrons that it needs to fill its outer shell. Therefore:

(a) 4	(b) 1	(c) 3	(d) 2	(e) 2
(f) 1	(f) 1	(g) 1	(h) 1	

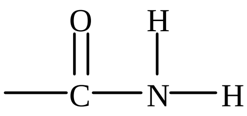
11.4 In the molecular formula, the carbons must have four bonds and the hydrogens must have one bond. The only formula that obeys this rule is (b).

11.6 The molecular formula must be a structure that has all of the atoms attaining the correct combining power. The only formula where this is true is (c).

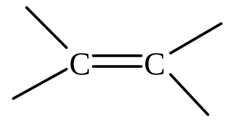
11.8 (a)



(b)



(c)



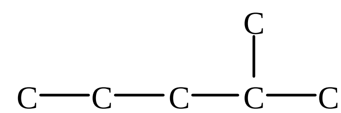
11.10 (a) alcohol (b) alkene (c) ketone (d) ether

(e) amine (f) aromatic (g) alkene (h) carboxylic acid

11.12 All C-C-C bond angles in alkanes are 109.5° = A = B = C.

11.14 The skeleton structure shows only the C-C bonds of the structure; thus, the answers are:

(a) C–C–C (b) C–C–C–C–C (c)



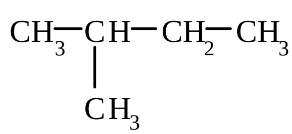
11.16 (a) $(CH_3)_2\,CHC(CH_3)_3$ (b) $(CH_3)_2CHCH_2CH_2C(CH_3)_2$

11.18 (a) Both compounds have a molecular formula of C_5H_{12}, therefore, they are either the same compound or constitutional isomers. Draw the expanded structural formula of the second compound. Inspection of these two compounds shows that they both have a tertiary carbon that is connected to two methyl groups and an ethyl group. Therefore, they must be the same compound.

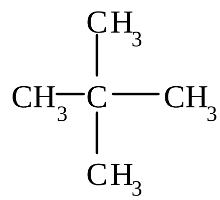
(b) Both compounds have a molecular formula of C_6H_{14}, therefore, they are either the same compound or constitutional isomers. Draw the expanded structural formula of the second compound. Inspection of these two compounds shows that they both have a tertiary carbon that is connected to two methyl groups and a $–CH_2CH_2CH_3$ group. Therefore, they must be the same compound.

(c) The first compound has six carbons, while the second has five carbons; therefore, they must be different compounds that are not isomers.

11.20 (a) The methyl groups must be at a chain end. This leaves two other carbons and three hydrogens, which must combine as a CH and a CH_2 group. Thus, the structure is:



(b) Again, the CH_3 groups must be at the end of the chain. This leaves only a single carbon, which must be the center, connected to all four methyl groups:



(c) Two CH_3 groups at two chain ends leaves three CH_2 groups in the middle to form the linear alkane:

$$CH_3{-}CH_2{-}CH_2{-}CH_2{-}CH_3$$

11.22 Method for naming alkanes:

(i) Find longest carbon chain. Form base name accordingly.

(ii) Find and name groups that are attached to this primary chain.

(iii) Put names of these groups in alphabetical order at beginning of name. Include numbers to denote which carbon(s) the groups are attached to. Assign numbers so that lowest numbers are used.

(a.) (i) 5 carbons = pentane

(ii) 2 CH_3 groups = methyl attached

(iii) 3,3-dimethylpentane

(b.) (i) 5 carbons = pentane

(ii) 1 CH_3 group = methyl; 1 C_2H_5 group = ethyl

(iii) 3-ethyl-2-methylpentane

(c.) (i) 7 carbons = heptane

(ii) 1 CH_3 group = methyl; 1 isopropyl group

(iii) 4-isopropyl-3-methylheptane

(d.) (i) 9 carbons = nonane

(ii) 4 CH_3 groups = methyl; 1 ethyl group attached

(iii) 5-ethyl-2,3,3,8-tetramethylnonane

(e.) (i) 8 carbons = octane

(ii) 1 CH_3 group = methyl; 1 $CH_3C(CH_3)CH_3$ = tert-butyl group

(iii) 4-*t*-butyl-3-methyloctane

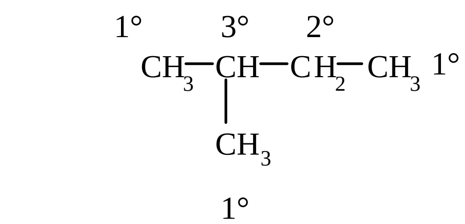
11.24 1° - primary - carbons are connected to one other carbon.

2° - secondary - carbons are connected to two other carbons.

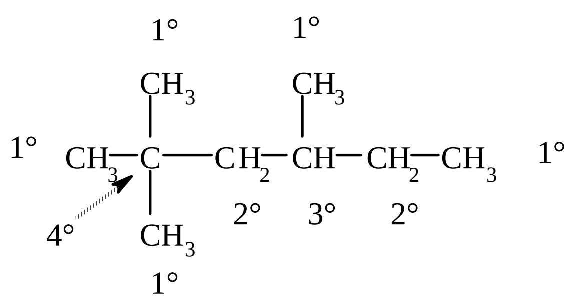
3° - tertiary - carbons are connected to three other carbons.

4° - quaternary - carbons are connected to four other carbons.

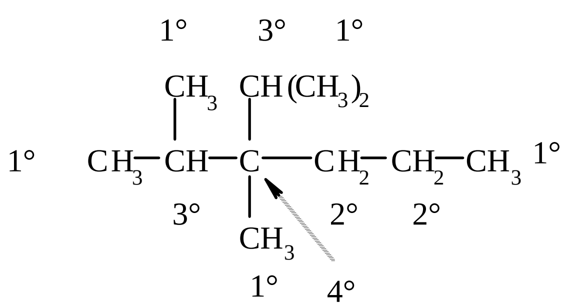
(a)



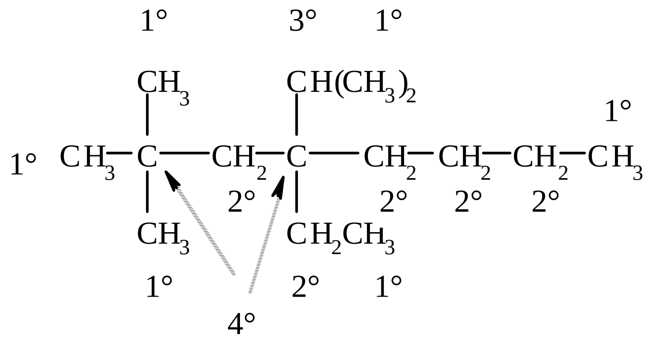
(b)



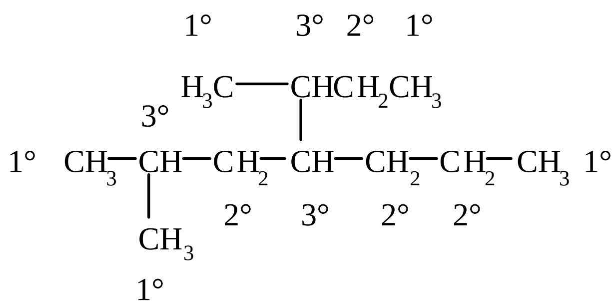
(c)



(d)



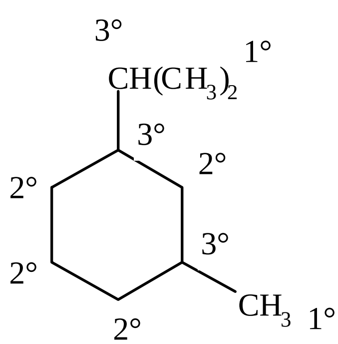
(e)



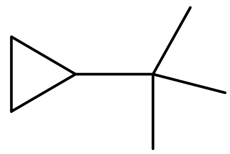
11.26 (a) Cyclopentane

(b) 1-ethyl-1-methylcyclobutane

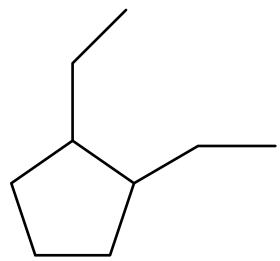
(c) 3-isopropyl-1-methylcyclohexane



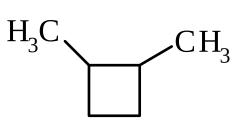
11.28 (a) Cyclopropane has three carbons. *t*-butyl means that there is a tert-butyl group on the cyclopropane ring, thus:



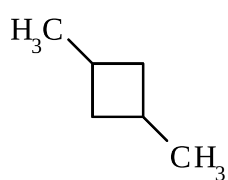
(b) Cyclopentane has five carbons. 1,2 diethyl means that there are two ethyl groups connected to the ring on adjacent carbons.



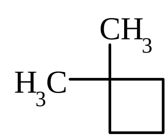
11.30 Two methyl groups = CH_3 + CH_3 = C_2H_6, which cannot be a part of the ring structure. Thus, the ring must consist of C_4H_7 = cyclobutane. The possible isomers of this structure differ by where the methyl groups are placed on the ring. Thus, the possible compounds are:



1,2 dimethylcyclobutane



1,3 dimethylcyclobutane



1,1 dimethylcyclobutane

11.32 (a) Both compounds have a molecular formula of $C_7H_{13}Cl$, therefore, they are either the same compound or isomers. As the first compound has both the methyl and chloro groups on the same side of the ring, and the second has them on the opposite sides, they must be cis-trans isomers.

(b) Both compounds have a molecular formula of $C_7H_{13}Cl$, therefore, they are either the same compound or isomers. As the first compound has both the methyl and chloro groups on the same side of the ring, and the second one does also, they must be the same compound. Flipping either compound about the ring will result in the other compound.

(c) Both compounds have a molecular formula of C_6H_{14}, therefore, they are either the same compound or isomers. As the first compound has both the methyl and chloro groups on different carbons, and the second has them on the same carbon, the two compounds must be constitutional isomers.

(d) As the first compound does not have a chloro group while the second does, these two structures must be different compounds that are not isomers.

11.34 (a) Solution occurs because the two substances are similar in their secondary forces: both cyclohexane and hexane are nonpolar.

(b) Solution does not occur because of the dissimilarity of the substances: hexane is nonpolar, whereas water is a strong hydrogen-bonding compound.

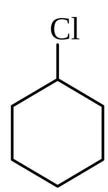
(c) Solution does not occur because of the dissimilarity of the substances: hexane is nonpolar, whereas sodium chloride is an ionic compound.

(d) Solution occurs because NaCl separates into ions that interact strongly with polar water.

11.36 Alkanes (and cycloalkanes) are very inert substances that do not undergo many reactions. The only two common reactions that they undergo are (i) combustion with oxygen and (ii) halogenation = substitution of a hydrogen with a halogen (F, Cl, Br, etc.) in the presence of UV or heat.

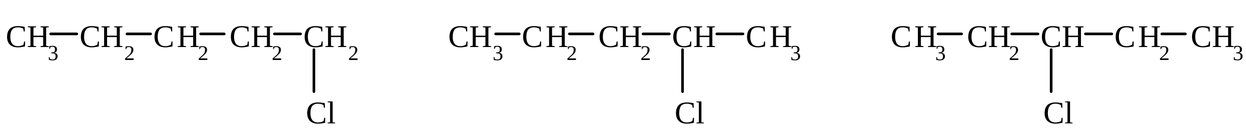
Thus, there is no reaction for a, b, c, d, and e.

(e) This halogenation reaction will proceed where a Cl will replace one of the hydrogens on the cyclohexane to form:

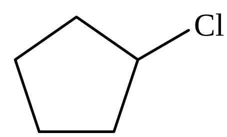


11.38 In a monochlorination reaction, the chlorine can replace any hydrogen to form different isomers:

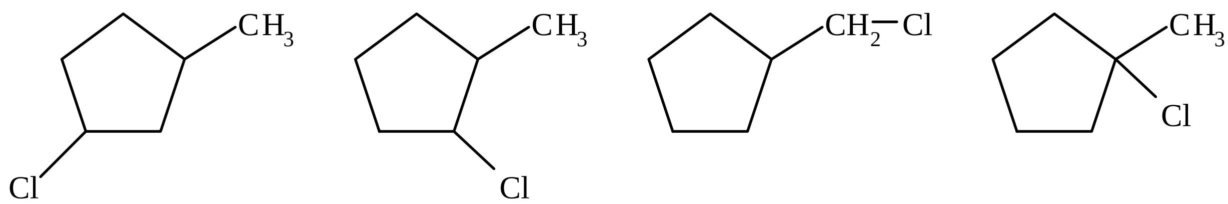
(a) For pentane, these are:



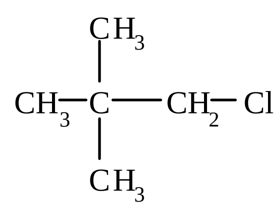
(b) For cyclopentane, all of the hydrogens are equivalent, and therefore the only compound formed is:



(c) For methylcyclopentane, these compounds are:



(d) For 2,2-dimethylpropane, all of the hydrogens are equivalent, and therefore the only compound formed is:



11.40 For linear alkanes, the formula must be C_nH_{2n+2}, while for cycloalkanes, the formula must be C_nH_{2n}. For the values of n given by the number of carbons in these structures, only (a) and (c) agree with the rules described above and are therefore possible structures.

11.42 (a) $CH_3CH_2CH_2CH_2CH_3$ (b) $CH_3CH_2CH_2CH(CH_3)_2$

(a.) $CH_3CH_2CH(CH_3)CH[CH(CH_3)_2]CH_2CH_2CH_3$

(b.) $(CH_3)_3CC(CH_3)_3$

11.44 (a) The compound should be named from the end of the continuous chain that yields the lowest number for the methyl group. Correct name: 3-methylhexane.

(b) The compound should be named on the basis of the longest continuous carbon chain. Correct name: 3-methylhexane.

(c) The compound should be named in the direction around the ring that gives the set of lowest numbers. Correct name: 1,2,4-trimethylcyclohexane.

(d) The compound must be named in the direction around the ring that gives the set of lowest numbers. Correct name: 1-methyl-2-propylcyclopentane.

(e) The compound does not exist as cis-trans isomers. Correct name: 1,1,2-trimethylcyclopentane.

11.46 Cyclic alkanes have the general formula C_nH_{2n} while acyclic alkanes have the formula C_nH_{2n+2}. $C_7H_{16} = C_nH_{2n+2}$ when $n = 7$; therefore, this compound must be an acyclic alkane.

11.48 Alkanes (and cycloalkanes) are very inert substances that do not undergo many reactions. The only two common reactions that they undergo are (i) combustion with oxygen and (ii) halogenation = substitution of a hydrogen with a halogen (F, Cl, Br, etc.) in the presence of UV or heat.

Therefore, a, b, c, d, and e have no reaction.

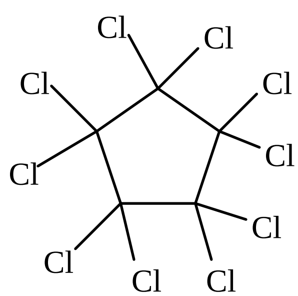
(f) This halogenation reaction will proceed where a Cl will replace one of the hydrogens on the ethane to form: CH_3CH_2Cl

11.50 Structures are the same as the initial alkanes with all the hydrogens replaced by chlorine.

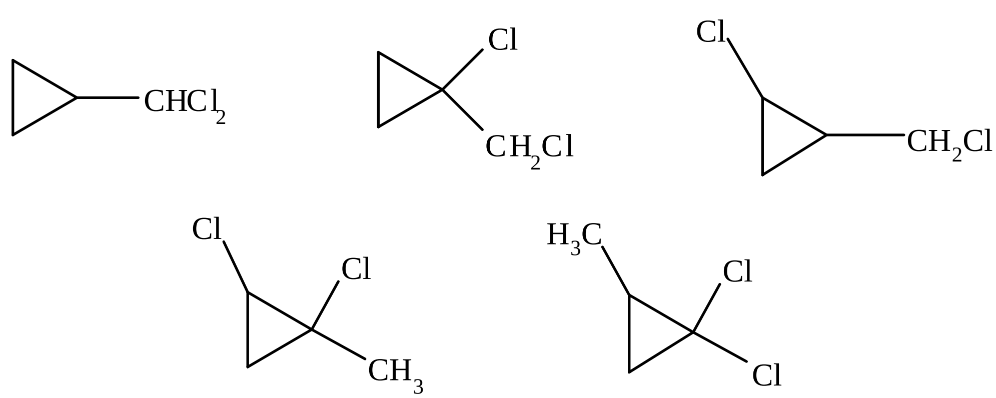
(a)

$$CCl_3—CCl_2—CCl_2—CCl_2—CCl_3$$

(b)



11.52



11.54 There are six compounds other than Halothane:

HF_2C-CBrClF	BrF_2C-CHFCl	ClF_2C-CHFBr
HClFC-CF_2Br	BrClFC-CHF_2	HBrFC-CF_2Cl

11.56 Test 1: Pour some of each liquid into separate cups and then add salt to each cup. Salt will dissolve in water but not in gasoline (a mixture of hydrocarbons).

Test 2: Add some of each liquid into the same cup. The two liquids do not mix. Observe which liquid is the lower layer. Water has a higher density than gasoline and sinks to the bottom.

11.58 To go from ethane to ethyl chloride, a halogenation reaction must proceed. The conditions needed for chlorination, or any other halogenation, is UV or heat in the presence of Cl_2.

11.60 $CH_3(CH_2)_{13}CH_3 + H_2 \rightarrow CH_3(CH_2)_6CH_3 + CH_3(CH_2)_5CH_3$

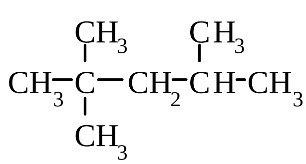
11.62 Modern technology (various transportation modes, factory production, heating, and air conditioning, etc) has resulted in a large increase in carbon dioxide emissions. The carbon dioxide traps heat near the earth and the result is increased temperatures on earth. Global warming may result in melting of polar ice caps, increase in the level of oceans, and loss of shorelines.

11.64 Both natural gas and petroleum are found in nature and are the decay products of plant and animal remains. Natural gas is a gas, mostly methane (about 85%) with small amounts of ethane, propane, and butane. Petroleum is a liquid, composed of five-carbon molecules and larger, mostly alkanes, but also cyclics, aromatics, and alkenes.

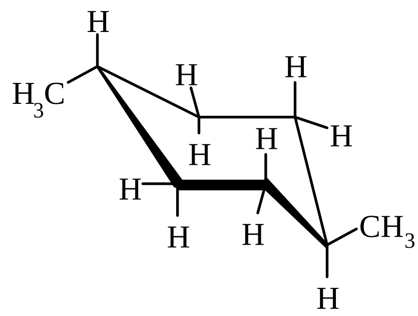
11.66 Each carbon atom will react with the oxygen that is present to create a CO_2 molecule; thus, the 70 moles of C atoms yields 70 moles of carbon dioxide. The amount of water that will be produced depends on the exact composition of the gasoline. If the gasoline consists entirely of alkanes, the ratio of C:H is n:(2n + 2). The moles of hydrogen atoms in the one gallon of gasoline = $(2 \times 70) + 2 = 142$, and combustion yields 71 moles of water.

11.68 Bill is certainly correct that any compound is the same regardless of the source. However, Mary may be trying to make the point that the orange contains additional nutritious compounds, which are not available to Bill in the vitamin C pill.

11.70 The branching of molecules increases the octane number.



11.72



The conformation with axial methyl groups places each methyl group closer to the axial hydrogens on the same side of the ring as the methyl group. This results in repulsive interactions, which destabilize the molecule. When the methyl groups are in equatorial positions, there are much fewer repulsive interactions.

11.74 Each carbon-chlorine bond is polarized with chlorine and partially negative and the carbon-end partially positive. The two dipoles are aimed in opposite directions in the trans compound and largely cancel each other, which means that the molecule as a whole is only slightly polar and does not have a significant dipole. The two dipoles are aimed in the same direction and reinforce each other in the cis structure. This results in a polar compound with significant intermolecular interactions and a higher boiling point.

11.76 CO_2 > acetic acid > ethylene > ethane