13. (d)
14. (a)
15. (c)
16. (c)
17. (c)
18. (a)
19. (b)
20. (d)

CHAPTER 4 REVIEW

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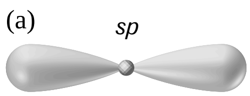
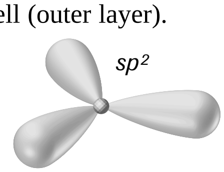
Understanding Concepts

1. (a) ·Ca· (2) (b) :C̈l· (1) (c) ·P̈· (3) (d) ·Si· (4) (e) :S̈· (2)
2. For a covalent bond to form between two approaching atoms, both atoms must have a valence orbital occupied by a single electron (or one atom must have a vacant valence orbital and the other must have a lone pair of electrons) and the orbitals must be able to overlap in space.
3. (a) three lone pairs
   (b) one lone pair
   (c) two lone pairs
   (d) no lone pairs
   (e) one lone pair
4. (a) :F̈· (b) ·P̈· (c) K· (d) :S̈e· (e) ·Sr·
5. The electron configuration that gives an atom maximum stability is one with eight electrons in the shell with the highest principal quantum number (the “valence” shell).
6. (a) $1s^2\ 2s^2\ 2p^6$
   (b) A carbide-12 ion has 6 protons and 6 neutrons in the nucleus, with 2 electrons in the first shell (inner layer), and 8 more electrons in the second shell (outer layer).
7. (a)



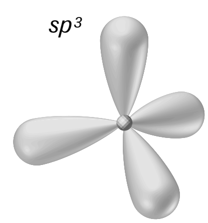
linear

(b)



trigonal planar

(c)



tetrahedral

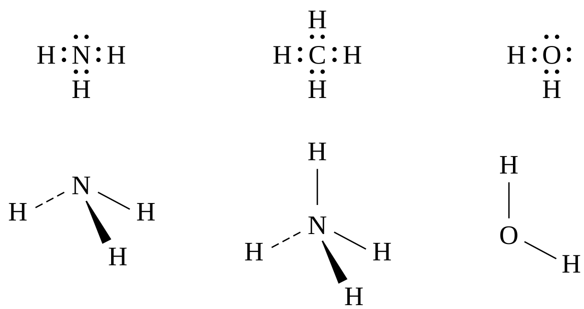
8. (a) sp^3
   (b) sp^2
   (c) sp
   (d) sp^3
9. A sigma bond involves overlap of orbitals directly, or end to end, between the atomic nuclei.
   A pi bond involves side-by-side overlap of the two lobes of *p* orbitals above and below a line between the atomic nuclei.
10. (a) 2 sigma bonds
    (b) 3 sigma bonds and 2 pi bonds
    (c) 5 sigma bonds and 1 pi bond
    (d) 7 sigma bonds
11. The B atom has sp^2 hybridization initially, and the N atom has sp^3 hybridization (with an unshared pair of elecrons in the fourth hybrid orbital). After reaction, both central atoms must be sp^3 hybridized (they are each bonded to four other atoms). This occurs because the N supplies both electrons for the B-N sigma bond.

12. (a) Valence shell refers to the energy level of electrons with the highest principal quantum number.
(b) Bonding pair refers to a pair of electrons shared between atoms in a valence orbital.
(c) Lone pair refers to a pair of electrons in a valence orbital that are not shared with another atom.
(d) Electron pair repulsion assumes that valence orbitals occupied by a pair of electrons are “full” and will repel any other full valence orbital.

13. To predict the shape of a molecule using the VSEPR model, you
first, draw a Lewis diagram for the molecule, and
second, count the lone pairs and bond pairs around the central atom(s), and
finally, predict the shape around the central atom(s) from the electron pair numbers.

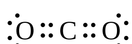
14. (a) linear
(b) trigonal planar
(c) tetrahedral
(d) tetrahedral
(e) linear
(f) V-shaped
(g) tetrahedral
(h) V-shaped (around each O)

15. (a)



pyramidal tetrahedral V–shape

(b) In methane, the bond angles are the normal tetrahedral angle. In ammonia, repulsion from the lone pair compresses the bond angles a bit, and in water, stronger repulsion from two lone pairs compresses the bond angle even more.

16. (a) 

(b) A carbon dioxide molecule is linear, with a bond angle of 180°.
(c) Carbon dioxide has two double bonds, each of which is strongly polar. The two bond polarities are exactly opposite and so the resultant is zero, and the molecule is nonpolar.

17. (a) An N−Cl bond is not noticeably polar, with an electronegativity difference of 0.0; whereas a C−Cl bond is polar, with an electronegativity difference of 0.5.
(b) A molecule of $NCl_{3(l)}$ should be nonpolar because the bonds are nonpolar. A molecule of $CCl_{4(l)}$ should be nonpolar because it is symmetrical, so the bond dipoles balance, cancelling any molecular polarity.

18. (a) BeH_2 is a nonpolar molecule because it is linear and symmetrical, so its bond dipoles balance each other. H_2S is a polar molecule because it is V-shaped and not symmetrical, so its bond dipoles combine to produce a nonzero resultant dipole.
(b) BH_3 is trigonal planar, while NH_3 is pyramidal in shape, because NH_3 has a lone pair of electrons repelling the three bond pairs.
(c) LiH has a melting point of 688˚C because solid LiH has an ionic crystal structure, with ions held together by relatively strong ionic bonding. HF has a melting point of –83˚C because solid HF has a molecular crystal structure, with molecules held together by much weaker intermolecular forces.

19. The larger molecules have stronger London force intermolecular bonding because the molecules have a greater number of electrons per molecule. Therefore, the larger the molecule in this series, the higher the boiling point.

20. $CH_{4(g)}$ (–164˚C), has London force; $NH_{3(g)}$ (–33˚C), has London force, dipole–dipole force, and hydrogen bonding; and $BF_{3(g)}$ (–100˚C), has London force. Ammonia has the strongest intermolecular bonds because of the hydrogen bonding; boron trifluoride has London force from a 32-electron molecule; and methane has weaker London force from a 10-electron molecule.

21. (a) Nickel has a much higher melting point than sodium chloride because the metallic bonding holding nickel atoms together is stronger than the ionic bonding holding sodium and chloride ions together.
(b) Solid nickel will conduct well, because the atoms' valence electrons are free to move. Solid sodium chloride will not conduct because the charges (ions) are not free to move.
(c) Solid nickel will not dissolve, because the atoms attract each other much more than water molecules can attract them. Solid sodium chloride will dissolve because the charges (ions) are strongly attracted by polar water molecules.

22. (a) Hexane has London force.
(b) 1-butanol has London force, dipole–dipole force, and hydrogen bonding.
(c) Ethylamine has London force, dipole–dipole force, and hydrogen bonding.
(d) Chloroethane has London force and dipole–dipole force.
(e) Calcium carbonate has ionic bonds.
(f) Diamond has convalent bonds.

Applying Inquiry Skills

23. (a) **Prediction**

According to intermolecular forces concepts, the order from lowest to highest solubility in water is pentane, diethyl ether, 1-butanol, and butanoic acid. Pentane, $C_5H_{12(l)}$, has symmetrical, nonpolar molecules and therefore should have little solubility in water. Diethyl ether, $(C_2H_5)_2O_{(l)}$, has polar molecules and should have some solubility in water. 1-butanol, $C_4H_9OH_{(l)}$, has polar molecules as well as the possibility for hydrogen bonding with water molecules. The solubility of 1-butanol should be high. Butanoic acid, $C_3H_7COOH_{(l)}$, is like 1-butanol but has more hydrogen bonding sites available. The solubility of butanoic acid should be very high, perhaps miscible with water.

(b) **Experimental Design**

Slowly add each of the liquids to a small quantity of distilled water until no more dissolves and two layers form. The independent variable is the substance added to the water, the dependent variable is the volume of the substance that dissolves, and the controlled variables are the volume of water and the temperature.

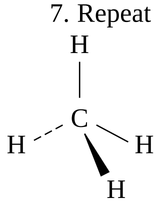
(c) **Materials**

lab apron
eye protection
medium-sized test tube with stopper
5 10-mL graduated cylinders
5 droppers or disposable pipets
waste container for organic mixtures
bottle of distilled water
samples of pentane, 1-butanol, diethyl ether, butanoic acid

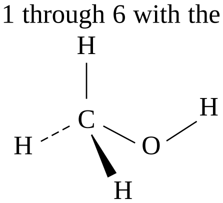
(d) **Procedure**

1. Measure 10.0 mL of water with a graduated cylinder and place it into the test tube.
2. Measure 10.0 mL of pentane in another graduated cylinder.
3. Start adding a little of the pentane to the water, and stopper and invert between each addition.
4. Stop adding pentane when a second layer is noticed in the test tube. Note the volume of pentane added.
5. Dispose of mixture into the labelled waste container.
6. Clean and dry the test tube.
7. Repeat steps 1 through 6 with the next liquid, until all liquids have been tested.

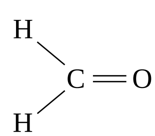
24.



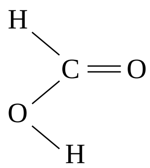
tetrahedral
(methane)



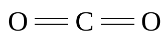
tetrahedral
and V-shape
(methanol)



trigonal planar
(methanal)



trigonal planar
and V-shape
(methanoic acid)

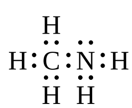


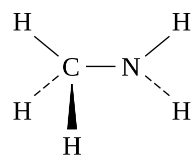
linear
(carbon dioxide)

25. (a) Metallic solids are composed of atoms with mobile valence electrons—they may be thought of as an arrangement of close-packed positive ions held together by strong mutual attraction for electrons that permeate the structure. Network solids are composed of atoms held together by very strong (directional) covalent bonds.
    (b) Network solids are composed of atoms held together by very strong (directional) covalent bonds. Molecular solids are composed of molecules held together by relatively weak intermolecular forces.
    (c) Molecular solids are composed of molecules held together by relatively weak intermolecular forces. Ionic solids are composed of positive and negative ions held together by relatively strong (nondirectional) ionic bonds.

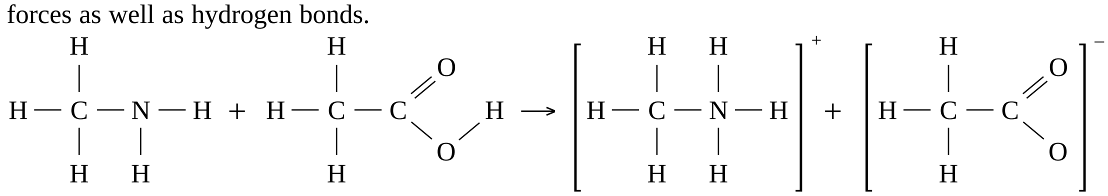
Making Connections

26. (a)





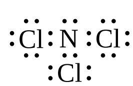
    (b) The shape around the carbon atom is tetrahedral, and the shape around the nitrogen atom is pyramidal.
    (c) Methylamine has a much higher boiling point because methylamine molecules have additional dipole–dipole forces as well as hydrogen bonds.
    (d)

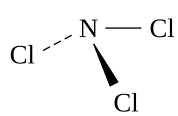


    (e) Vinegar and lemon juice reduce the odour of fish because they are acidic, and react to neutralize the basic amines that cause "fishy" odours.
27. The material used for the skin of stealth aircraft is a carbon fibre composite material. It has fibres of carbon embedded in a matrix—the same basic type of structure as fibreglass composites, but very much stronger. The material can also be structured as a "honeycomb" to give a very high strength-to-weight ratio for solid pieces. The material is suited for radar "stealthing" because it can be made to absorb microwaves, greatly reducing any detectable reflection.

Extension

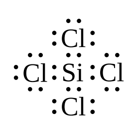
28. (a)

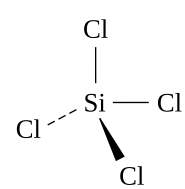




nonpolar

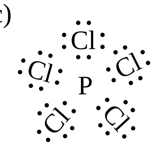
(b)

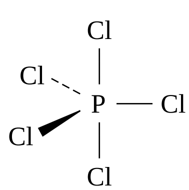




nonpolar

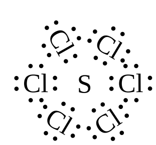
(c)

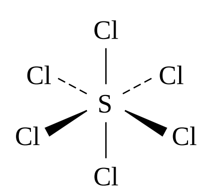




nonpolar

(d)





nonpolar