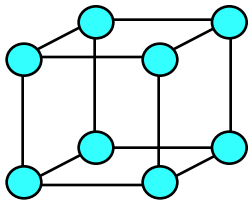
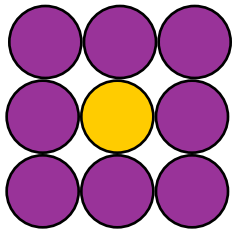
7. (Unit cells; Ch. 3 "Companion") A corner atom is part of how many unit cells? **At-Seat Demonstration:** cubes like dice can be handed out for students to examine for this question.

1, 2, 4, **8**



8. (Coordination number; Ch. 5 "Companion") In the two-dimensional square packing shown, what is the coordination number of the central atom?

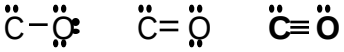
2, **4**, 6



9. (Coordination number; Ch. 5 "Companion") **At-Seat Demonstration:** Give students 10 pennies (students can share a set of ten) and ask them to pack them at their desks to determine the largest coordination number in two dimensions.

4, **6**, 8, 9

25. (Lewis dot structures, octet rule) What is a correct Lewis dot representation of carbon monoxide?



26. (Lewis dot structures, bonding) Compare O-O and O=O. Is O=O expected to be **stronger**, weaker, or the same strength?

Is O=O expected to be

longer, **shorter**, or the same length?

27. (VSEPR) **Demonstration 5.3** "Companion": Provide students with small plastic tetrahedral and octahedral models to share during VSEPR lectures. With four electron pairs, can the pairs be equally spaced and farther apart than the 90° of a square arrangement?

yes, no

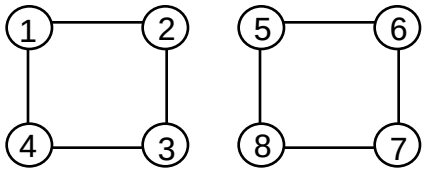
Determine the Lewis dot structure of NH_3 and use the models to determine its molecular geometry.

linear, bent, **pyramidal**

Repeat for H_2O.

linear, **bent**, pyramidal

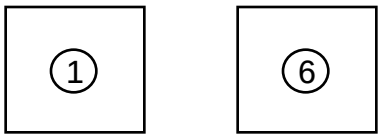
A tetrahedron can be inscribed inside a cube, represented in the layer sequence formalism shown below. If sphere 1 is part of the tetrahedron, which other three spheres are as well?



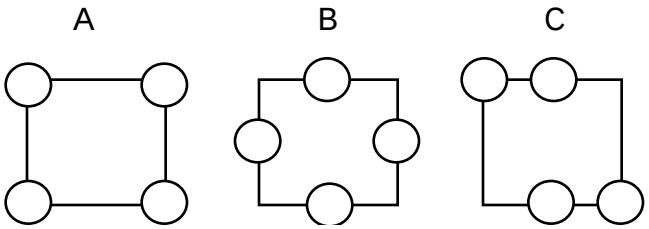
2, 3, 4 3, 5, 7 **3, 6, 8**

An octahedron can be inscribed inside a cube. If spheres 1 and 6 (below) are part of the octahedron, where do the other four spheres go?

z = 1/4, **1/2**, 3/4



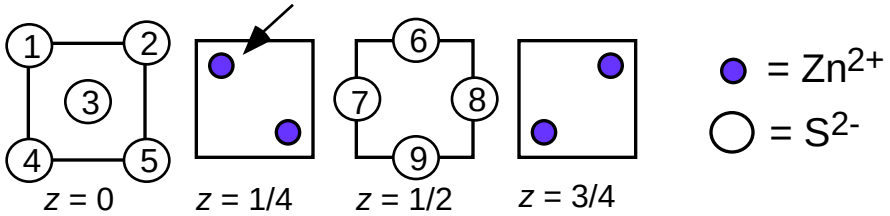
What is their arrangement?



A, **B**, C

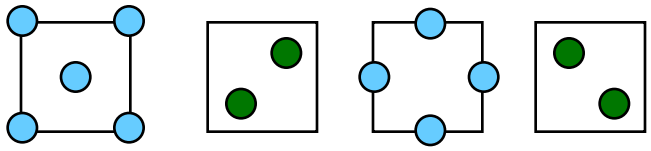
28. (VSEPR) **At-Seat Demonstration** (use models described above)**:** The center of a tetrahedron resting on three bonds
is midway from top to bottom, **is closer to the bottom**, is closer to the top
The center of a tetrahedron balanced on two bonds
is midway from top to bottom, is closer to the bottom, is closer to the top
The center of an octahedron resting on three bonds
is midway from top to bottom, is closer to the bottom, is closer to the top
The center of an octahedron balanced on one bond
is midway from top to bottom, is closer to the bottom, is closer to the top
This can be connected to location of centers of octahedral and tetrahedral holes in close-packing arrangements of atoms/ions.

29. (Close packed spheres, holes; Ch. 5 "Companion") The figure below is a ZnS (zinc blende) layer sequence. The atom indicated by an arrow sits in one of the tetrahedral holes of the structure. Which atoms form this hole?



1,4,7,8 1,3,4,7 **1,3,6,7**

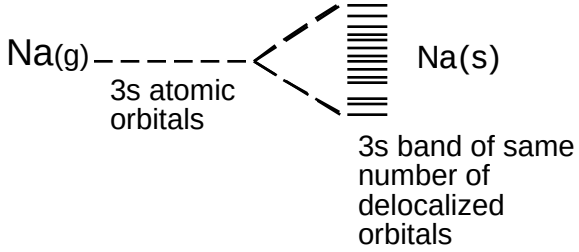
30. (Close packed spheres, holes; Ch. 5 "Companion") In the zinc blende layer sequence below, what fraction of the tetrahedral holes are filled?
1/8, 1/4, **1/2**, all



31. (Close packed spheres, holes; Ch. 5 "Companion") C_{60} (buckyball) is cubic closest packed (face-centered cubic) in its crystalline form. If you insert potassium atoms into all the tetrahedral and octahedral holes of the C_{60} structure, the formula would become K_xC_{60} . What is the value of *x*?
1, 2, **3**, other

32. (Polarity; dipole moments) **Demonstration:** Beakers of water, carbon tetrachloride, and dry ice (carbon dioxide) are to be placed into a microwave oven. Based on dipole moment, which are predicted to be heated by the microwave radiation (measure temperature with digital thermometer before and after)?
water, carbon tetrachloride, carbon dioxide

33. (Bands; Ch. 7 "Companion") The 3s band of solid Na will have as many orbitals (each delocalized over the entire solid) as the number of 3s orbitals from Na atoms in the sample. If each orbital of the band can hold two, spin-paired 3s valence electrons, to what extent will the band be filled?



completely empty, **half filled**, completely filled
To what extent will the Na 2s band be filled?
completely empty**,** half filled, **completely filled**

Which is the best electronic band population for good electrical conductivity (metallic behavior), if a net flow of electrons through a band is needed?
Demonstration 7.1 "Companion": A requirement for electrical conductivity is net electron flow in a particular direction in a sample. At what capacity should the band be filled with electrons to best promote electrical conductivity? Have three jars sealed tightly: one empty (represents empty band), one partially-filled (represents partially filled band) and one completely filled (represents filled band). If the filler (sand or packing peanuts, e.g.) represents electrons and tipping the jar represents the application of a voltage, which jar(s) will exhibit net motion of the filler?

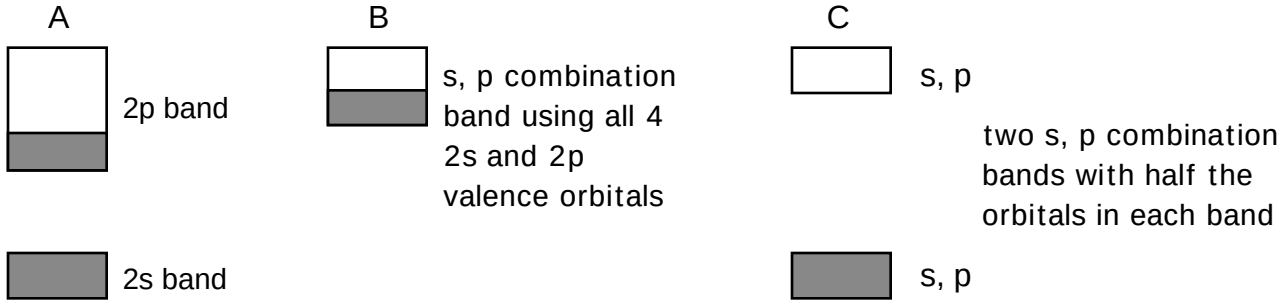
empty, **partially filled**, filled

In which part of the filled portion of the band is net motion greatest?

top, middle, bottom

35. (Bands; Ch. 7 "Companion") Which of these band diagrams is consistent with diamond being an electrical insulator?

A, B, **C**



Another approach is to have students determine which bands are filled to which extent, and then decide if each band scenario in turn (A, B, then C) corresponds correctly to diamond's being an electrical insulator rather than a conductor (metal). The s, p combination band can be related to sp^3 hybrid orbitals if desired.

36. (Semiconductors; Ch. 7 "Companion") When an electron falls back into a bond (localized picture) or valence band (delocalized picture), what change in energy occurs?

energy is released, energy is absorbed, no change in energy occurs

38. (Band gap energy, spectroscopy, semiconductors; Ch. 7 "Companion") Setup: Band gap energy has been introduced in a localized picture: it can be defined as the energy needed to remove an electron from a bond in the solid, enabling the electron to move freely through the solid to conduct electricity. When itinerant electrons return to such a one-electron bond, the band gap energy can be released as a photon. The band gap energy is to a first approximation expected to increase as the bonds become stronger and shorter and the electrons are held more tightly. The group 14 elements illustrate this effect with diamond being an electrical insulator, silicon and germanium (longer, weaker bonds in the same diamond structure) being semiconductors, and a–tin being a metal. **Demonstration 7.11** "Companion"**:** A trio of related predictions: what will happen to interatomic spacing, band gap energy, and the color of the light emitted when an orange LED is cooled in liquid nitrogen. On cooling,

atoms of the semiconductor will get closer together, atoms will get farther apart

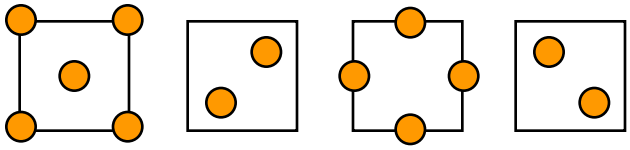
band gap energy increases, band gap energy decreases

color of light will become more red, **color of light will become more yellow**

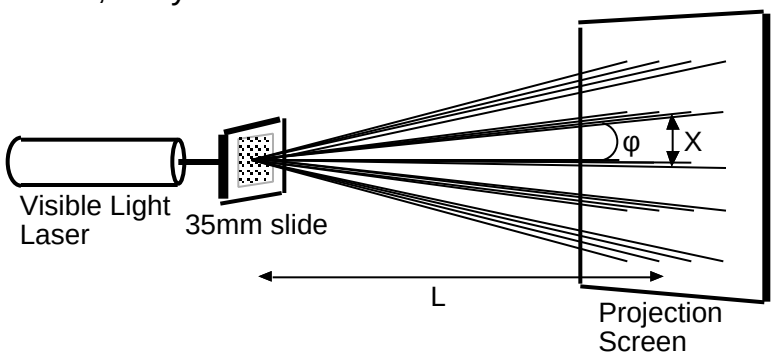
42. (Elemental analysis, diffraction, solid solutions; Ch. 3 & 4 "Companion") Sample A is an equimolar physical mixture of Si and Ge. Sample B is a $Si_{0.5}Ge_{0.5}$ solid

solution. Which measurements will be identical and which different for the two samples?
elemental analysis: **same**, different
x-ray diffraction: same, **different**
absorption spectrum: same, **different**

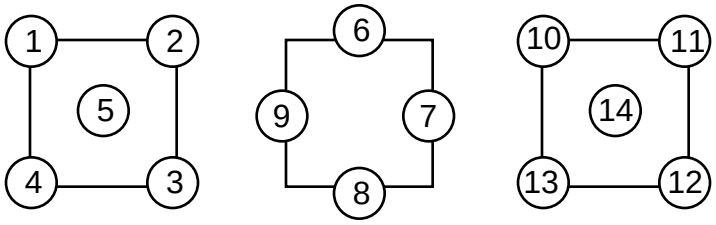
50. (Layer sequences; Ch. 3 & 5 "Companion") How many atoms are in the following layer sequence of the diamond structure?
4, 6, **8**, 13
What is the coordination number?
4, 6, 8
What is the coordination geometry?
tetrahedral, square, octahedral, cubic



54. (Diffraction, optical transforms; Ch. 4 "Companion," **Demonstration 4.1**) The equation dx = lL defines the relationship between incident wavelength l, spacing of repeating features d, spacing between diffracted spots x, and distance between transform slide and screen L. Consider which variables are directly and inversely related to predict the following.
When the wavelength is decreased from red to green (demonstration with 633 and 543 nm HeNe lasers), should the spacing between diffraction spots
increase, **decrease,** stay the same
(This relationship can also be seen by having students view a point source of white light through their personal transform slide, as described in Demonstration 4.1, and having them note which part of the full spectrum they observe for each diffracted spot, violet or red, is giving rise to the largest spacing).
When the distance between slide and screen is increased, the spacing between diffraction spots should
increase, decrease, stay the same
When the spacing between features on the transform slide increases, the spacing between diffraction spots should
increase, **decrease**, stay the same



65. (Unit cells, layer sequences, close packed spheres; Ch. 3 & 5 "Companion") A layer sequence for an FCC = CCP metal is shown below.



A face diagonal passes through the center of atom 4 and the center(s) of which other atom(s)?

1, **2**, **5**, 11 Also correct: **8, 12** & **9, 10**

A body diagonal passes through the center of atom 4 and the center(s) of which other atom(s)?

2, 5, **11**, 14

A close-packed plane is comprised of six atoms. If atoms 2, 4, 5 are three of the six atoms, which other three atoms are need to define the plane?

11, 13, 14; 6, 9, 13; **7, 8, 12**; **6, 9, 10**

71. (Organic chemistry) In the shorthand for organic molecules, octane is written as follows: 

How many hydrogen atoms are present in this molecule?

16, **18**, 20

How many hydrogen atoms are present in ethene, C═C ?

2, **4**, 6, 8

73. (Chirality) Do enantiomers have the same density?

yes, no

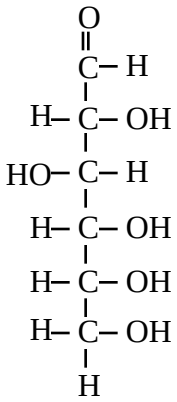
melting point?

yes, no

If acids, the same pK_a?

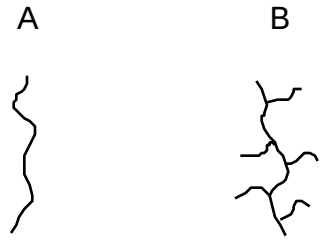
yes, no

74. (Chirality) How many stereogenic carbon atoms are present in the glucose molecule pictured below? 3, **4**, 5, 6



76. (Polymers) Some polymerization reaction conditions lead largely to linear chains of polyethylene, A, and other conditions cause considerable branching, B. Which structure corresponds to high density polyethylene (HDPE)?

A, B



86. (Semiconductors, bands; Ch.8 "Companion") Pictured below is an energy band diagram for silicon.

When doped into Si, Al is a(n)

donor, **acceptor**

When doped into Si, P is a(n)

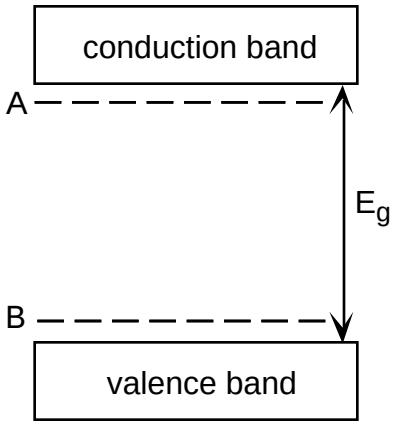
donor, acceptor

Which energy level corresponds to Al?

A, **B**

Which energy level corresponds to P?

A, B



$Al <=> Al^- + h^+$

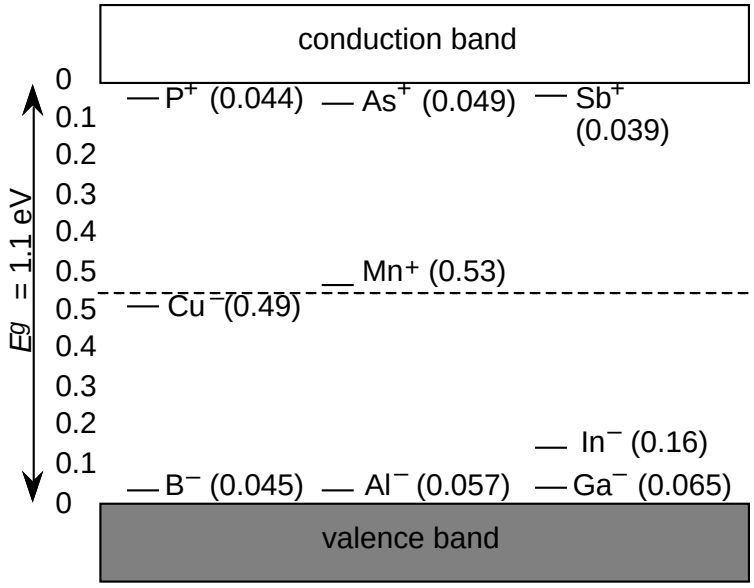
$P <=> P^+ + e^-$

87. (Semiconductors, doping; Ch 8 "Companion") Which is a weaker acceptor (analogous to weaker acid)

In, **Cu**

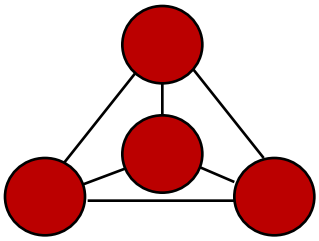
Which is a weaker donor (analogous to weaker base)?

As, **Mn**



92. (Close packed spheres, holes) **Demonstration:** If four identical spheres are placed in contact to form a tetrahedral hole, can an identical sphere fit into the hole?

yes, **no**



93. (Close packed spheres, holes) **Demonstration:** Which is a smaller hole?

One formed by a tetrahedron of identical spheres, one formed by an octahedron of identical spheres

A sphere that fits snugly into an octahedron can be shown not to fit into a tetrahedral hole.

94. (Bonding) **Demonstration:** Obtain samples of copper and silicon. Hit each with a hammer. Which would be predicted to have directional covalent bonds?

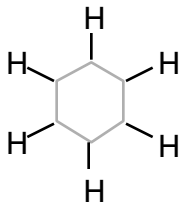
Cu, Si

97. (Chelation) What is the maximum number of ethylenediamine bidentate ligands that can bond to Ni to form an octahedral complex?

2, **3**, 6

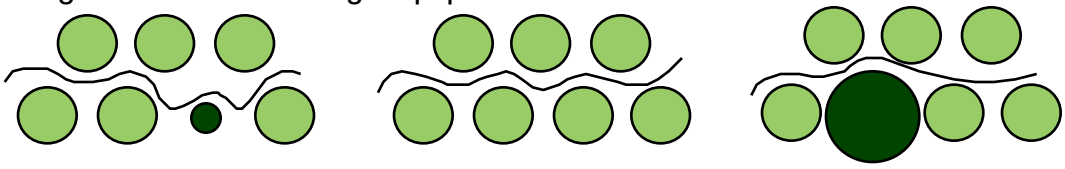
104. (Organic chemistry, bonding, Lewis dot structure) To complete the Lewis dot structure of benzene, how many double bonds must be added?

1, 2, **3**, 6



112. (Density, close packed spheres) **Demonstration:** Which is denser?
Stacking a second close-packed layer of spheres directly atop a close-packed layer below,
Stacking a second close-packed layer of spheres in the depressions formed by spheres in the close-packed layer below.

114. (Plastic deformation, slip planes; Ch. 6 “Companion”) Which situation allows easiest slippage of planes of atoms past one another, as sketched below?
identical spheres in both layers, a layer with a large impurity atom, a layer with a small impurity atom
Which of the two impurities acts like a "speed bump" and which like a "pothole," in impeding movement along slip planes?



"pothole" **"speed bump"**

115. (Electronegativity, bonding, band gap energy; Ch. 7 “Companion”) The atoms below have the following electronegativities:
Zn Ga Ge As Se
1.6 1.7 1.9 2.1 2.4
The three isoelectronic semiconductors Ge, GaAs, and ZnSe all have roughly the same size unit cell and internuclear separation (exclusively Ge-Ge, Ga-As, and Zn-Se bonds, respectively). If under these conditions, band gap energy increases with ionic character, which isoelectronic solid should have the largest band gap energy?
Ge, GaAs, **ZnSe**

117. (Chelation, coordination chemistry, chirality) **At-Seat Demonstration:** Pass out three small rubber bands with the plastic octahedra (see problem 27). Instruct students to share two octahedra and six rubber bands. Have them make mirror image tris chelate complexes, using the rubber band as a chelating ligand. Are these superimposable?
yes, **no**

118. (Tetrahedron, chirality) **At-Seat Demonstration:** Four colors of circular paper stickers (green, yellow, pink, and orange, e.g.) can be obtained on long sheets. Instruct students to share two tetrahedra and two stickers of each of the four colors. Have them make mirror image tetrahedra with a different color on each leg (representing four different substituents). Are these superimposable?

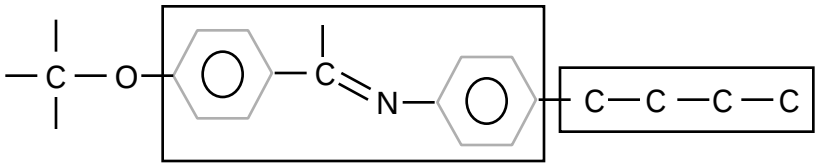
yes, **no**

Repeat using two different colors (two substituents identical). Are these superimposable?

yes, no

128. (Liquid crystals, phase changes) How many hydrogen atoms are present in the structure of the liquid crystal shown below?

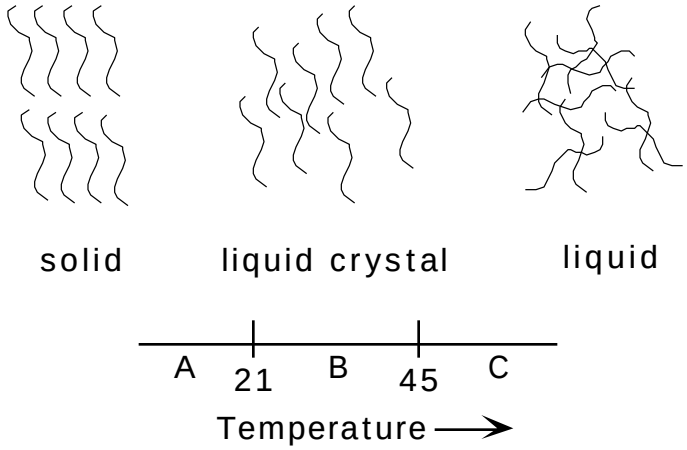
13, 17, **21**



Which part of the molecule is more rigid?

left box, right box

Schematically, the solid liquid crystal has molecules aligned in a repeating pattern. In the liquid, order is lost. In the liquid crystal, there is still orientational order. Phase transitions are observed at 21 and 45 degrees C.



In which region would the liquid crystal be the stable phase?

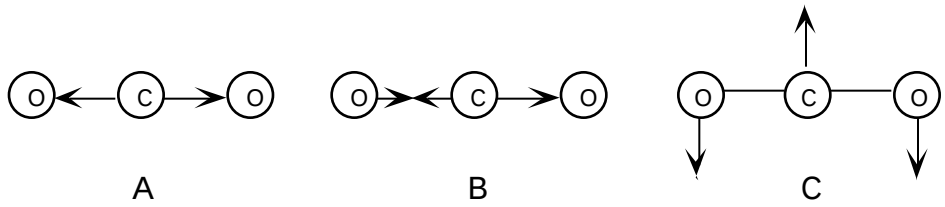
A, **B**, C

136. (Coordination chemistry) **At-Seat Demonstration:** Octahedral models and rubber bands are distributed, and the rubber bands represent bidentate ligands. The formula for an octahedral complex with one bidentate ethylenediamine (en) ligand is $Ni(en)(H_2O)_x$ with x =?

2, **4**, 6

140. (Dipole moments, polarity) Which of the following normal stretching modes for the carbon dioxide molecule will cause a change in dipole moment and thus allow the molecule to absorb infrared radiation?

A, **B**, **C**



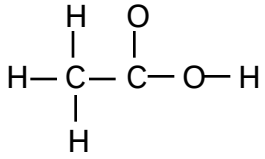
A B C

145. (Chirality) In experiment A the *d* optical isomer of a chiral anion is added to equal concentrations of the *d* and *l* isomers of a chiral cation. Only the *d* isomer of the chiral cation precipitates out in the salt. If in experiment B, the *l* isomer of the chiral anion is added, which of the cations will precipitate out?
d isomer, ***l* isomer**, both

Demonstration: Use gloves and hands to show the mirror-image relationship:

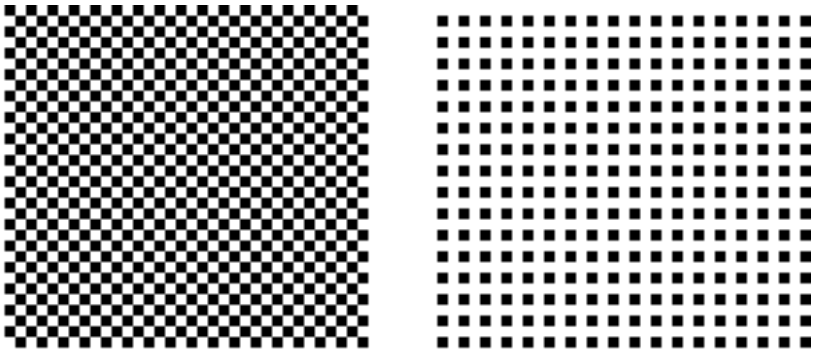
	same properties for horizontally-related pairs; mirror-image relationship; enantiomers	
different properties for vertically-related pairs; no mirror-image relationship; diastereomers	RH-RG	LH-LG
	RH-LG	LH-RG

151. (Acids and bases, Lewis dot structure) Are more bonds needed to complete the Lewis dot structure of acetic acid?
yes, no



155. (Density, equilibrium) **Demonstration:** In beaker A, an ice cube of pure D_2O is to be placed in pure liquid H_2O. In beaker B, an ice cube of pure H_2O is to be placed in pure liquid D_2O. In which of the two beakers will the ice cube sink?
A, B

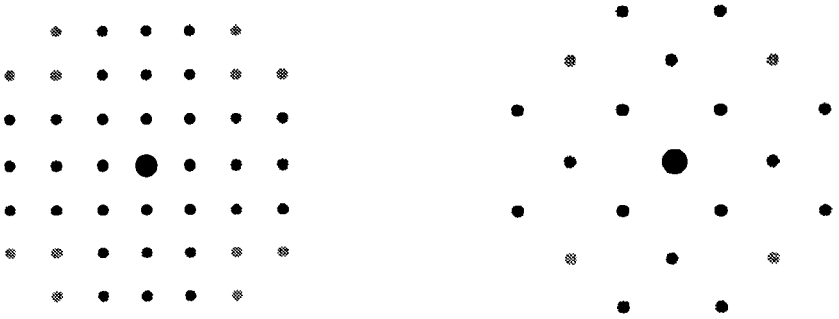
159. (Diffraction, optical transforms, layer sequences; Ch. 3 & 4 "Companion" Experiment 4) When looking down onto a face of the FCC and BCC cubic unit cells, the two arrangements of atoms shown below are seen by superimposing layer sequences. Which corresponds to the FCC structure?
A, **B**



A B

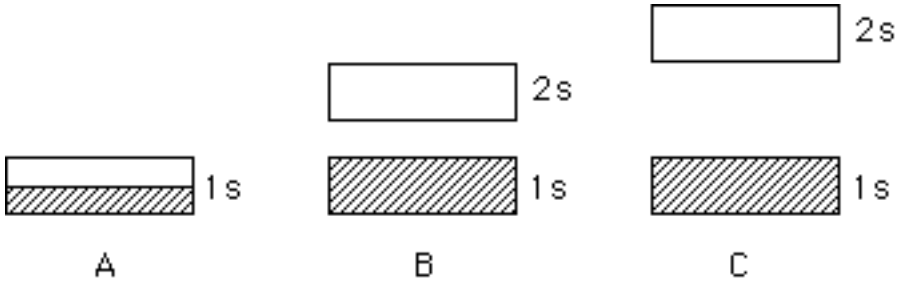
Which X-ray diffraction pattern corresponds to the FCC structure?

A, B



A B

183. I t has been predicted that if we could put the element hydrogen, normally an invisible gas of diatomic molecules at room temperature and pressure, under sufficiently high pressure - millions of atmospheres - it can become a metal!



Which of the above three band diagrams represents solid hydrogen?

A, B, C

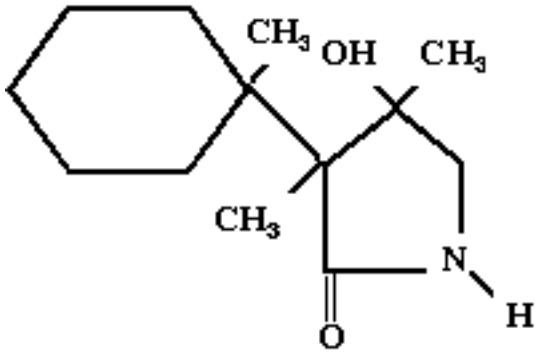
To conduct the experiment, the gas is compressed in a so-called anvil. The anvil must be made of a material that is 1) strong enough to withstand high pressures and 2) transparent, so that the sample can be viewed while it is being squeezed. Which of the following materials is the best choice for the anvil material?

diamond, NaCl, graphite

If you could conduct a diffraction experiment on the hydrogen sample while it was being squeezed, what do you predict would happen to the spacing between diffraction spots as the atoms are placed under increasing pressure?

the spacing would increase
the spacing would decrease
the spacing would stay the same

196. How many chiral carbon centers are in the following molecule?



0, 1, **2**, 3

219. (Companion, Ch. 2) Dipoles can also occur in the solid state. If positive and negative charges are distributed around a regular hexagon, as shown in Figure A, is there a net dipole moment?

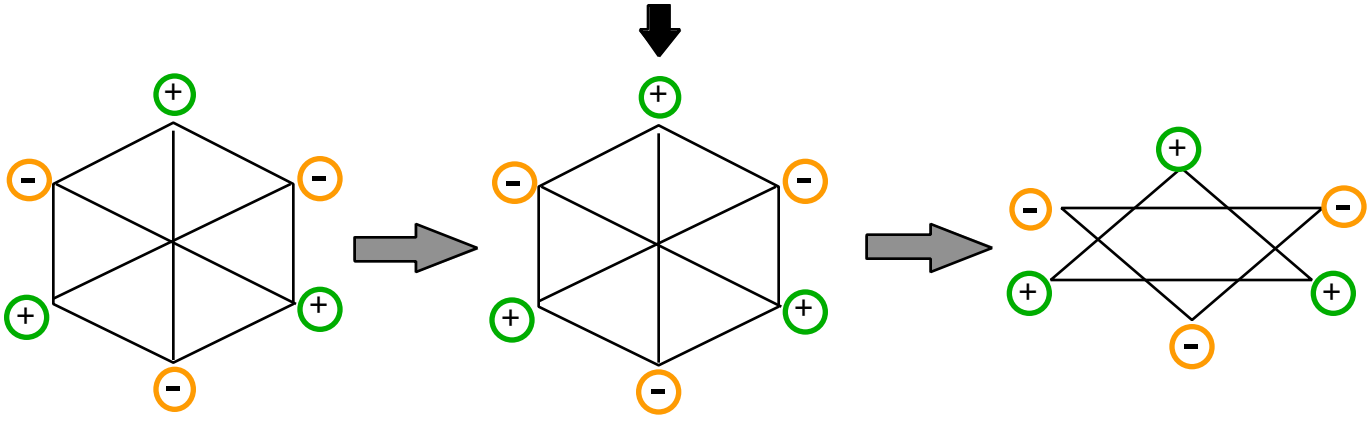


Figure A Figure B

yes, **no**

If the hexagon is compressed in the vertical direction, as shown in Figure B, is there a net dipole moment?

yes, no

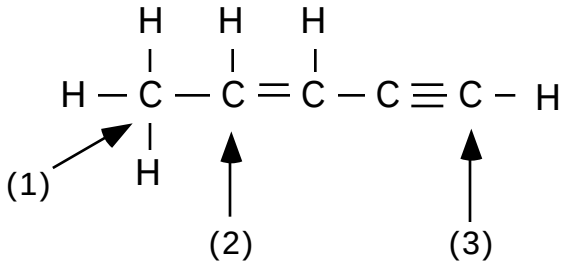
225. The unstable fulminate ion (CNO^-) has two possible resonance structures. Based on formal charge considerations, which is the better structure?

A. $[\ddot{C} = N = \ddot{O}]^-$

B. $[\ C \equiv N - \ddot{O}\ ]^-$

A, **B**

226. In the organic molecule diagrammed below which carbon uses trigonal planar geometry (or sp^2 hybrid orbitals) in the bonding?



1, **2**, 3

236. Dissecting a Polymerization Reaction

Polyethylene is formed when the molecule ethylene is polymerized. Approximately how many C-C single bonds are formed from n molecules of ethylene? [The instructor may want to draw approximately half a dozen $H_2C=CH_2$ molecules in a line, sketch electron movement with arrows, and draw the resulting alkane to help students visualize this process.]

n
2n
3n

For the net reaction
$nC_2H_{4(g)}$ ---> $-[CH_2\text{-}CH_2]\text{-}_{n(s)}$

What is the sign of ΔS?
ΔS>0
ΔS<0

ΔS=0

Given that a mole of C=C double bonds is worth approximately 600 kJ/mol and a C-C single bond is worth approximately 350 kJ/mol, what is the sign of ΔH?

ΔH>0
ΔH<0
ΔH=0

Does ΔH or ΔS drive this reaction?

ΔH
ΔS