# Grade 10 Elite Chemistry
June 7, 2022
4:00-7:00 PM

# Grade 10 Content Details for EOT

- S.Y.: 2021-2022 – Term 3

Chapter 5: Chemical Bonding 1 page 251-285

Chapter 6: Chemical Bonding 2 page 295-338

Textbook Reference:

ASP Chemistry, UAE Edition, 2020 McGraw-Hill Education

Page172-214

| 1. | Determine Lewis dot symbols of elements. (Sec. 9.1) | Chapter 5, Section 5.1 Questions & Problems # 5.3 | Page |
|---|---|---|---|

EOT LOs

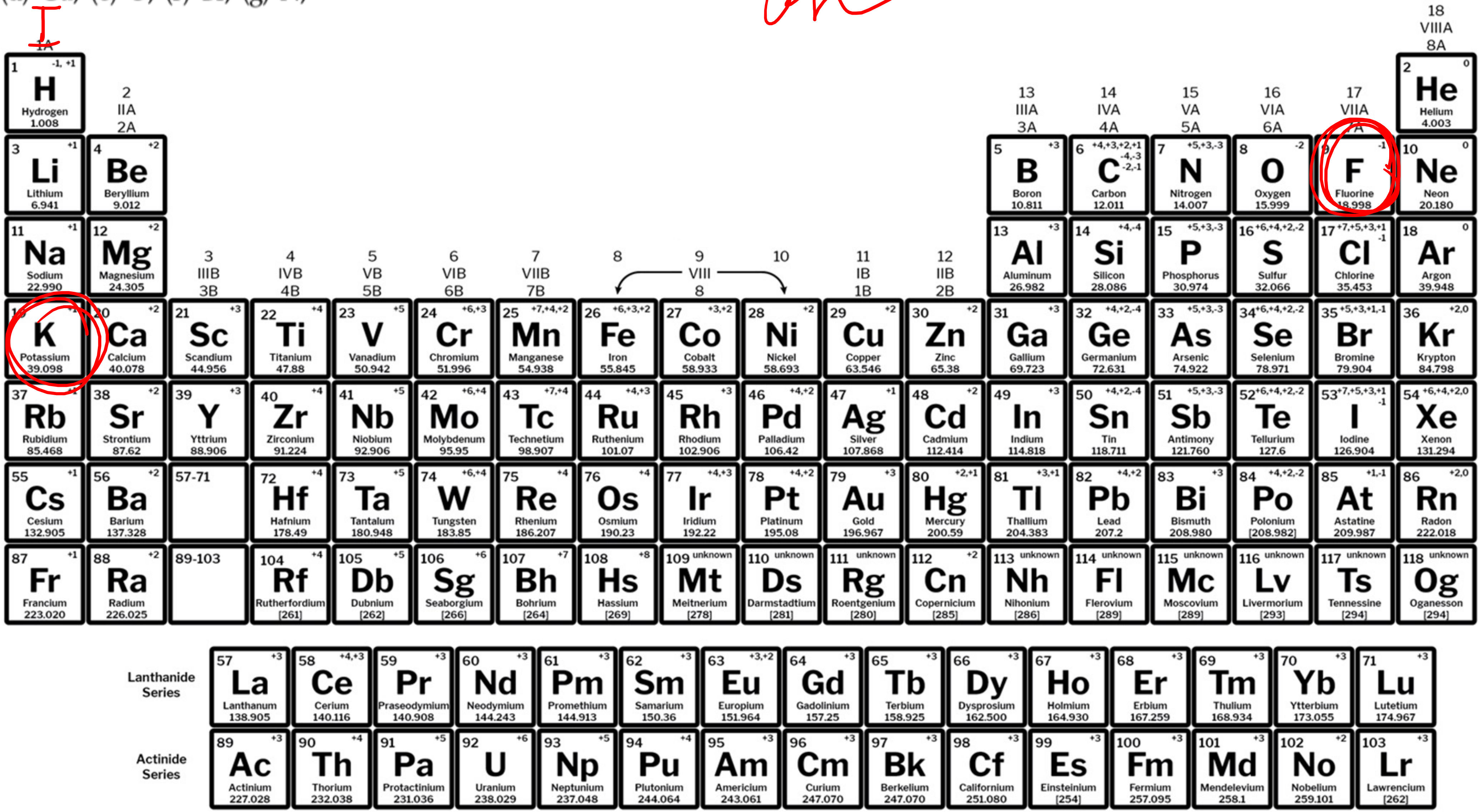
5.3 Without referring to Figure 5.1, write Lewis dot symbols for atoms of the following elements: (a) Be, (b) K, (c) Ca, (d) Ga, (e) O, (f) Br, (g) N, (h) I, (i) As, (j) F.

I

oh

K

F



| | | | |
|---|---|---|---|
| 1. | Determine Lewis dot symbols of elements. (Sec. 9.1) | Chapter 5, Section 5.1 Questions & Problems # 5.3 | Page 286 |

Which of the following is the correct Lewis dot structure of $F^-$?

(A) 

(D) 

(B) 

(C) 

5.4 Write Lewis dot symbols for the following ions: (a) $Li^+$, (b) $Cl^-$, (c) $S^{2-}$, (d) $Sr^{2+}$, (e) $N^{3-}$.

| | | | |
|---|---|---|---|
| 1. | Determine Lewis dot symbols of elements. (Sec. 9.1) | Chapter 5, Section 5.1 Questions & Problems # 5.3 | Page 286 |

5.4 Write Lewis dot symbols for the following ions: (a) $Li^{+}$, (b) $Cl^{-}$, (c) $S^{2-}$, (d) $Sr^{2+}$, (e) $N^{3-}$.

(-) add

(+) remove

cation (+)

anion (-)

$Sr^{2+}$

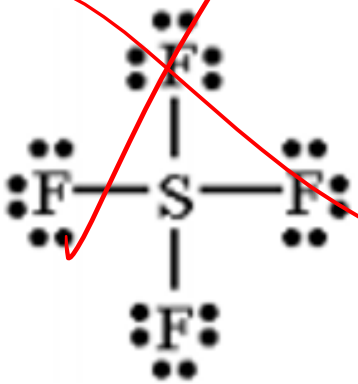
$[:\ddot{\underset{..}{N}}:]^{-3}$

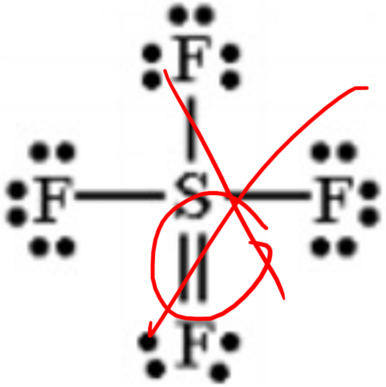
| 1A | 2 IIA 2A | 3 IIIB 3B | 4 IVB 4B | 5 VB 5B | 6 VIB 6B | 7 VIIB 7B | 8 | 9 VIII 8 | 10 | 11 IB 1B | 12 IIB 2B | 13 IIIA 3A | 14 IVA 4A | 15 VA 5A | 16 VIA 6A | 17 VIIA 7A | 18 VIIIA 8A |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 H Hydrogen 1.008 (-1, +1) | | | | | | | | | | | | | | | | | 2 He Helium 4.003 (0) |
| 3 Li Lithium 6.941 (+1) | 4 Be Beryllium 9.012 (+2) | | | | | | | | | | | 5 B Boron 10.811 (+3) | 6 C Carbon 12.011 (+4,+3,+2,+1,-4,-3,-2,-1) | 7 N Nitrogen 14.007 (+5,+3,-3) | 8 O Oxygen 15.999 (-2) | 9 F Fluorine 18.998 (-1) | 10 Ne Neon 20.180 (0) |
| 11 Na Sodium 22.990 (+1) | 12 Mg Magnesium 24.305 (+2) | | | | | | | | | | | 13 Al Aluminum 26.982 (+3) | 14 Si Silicon 28.086 (+4,-4) | 15 P Phosphorus 30.974 (+5,+3,-3) | 16 S Sulfur 32.066 (+6,+4,+2,-2) | 17 Cl Chlorine 35.453 (+7,+5,+3,+1,-1) | 18 Ar Argon 39.948 (0) |
| 19 K Potassium 39.098 (+1) | 20 Ca Calcium 40.078 (+2) | 21 Sc Scandium 44.956 (+3) | 22 Ti Titanium 47.88 (+4) | 23 V Vanadium 50.942 (+5) | 24 Cr Chromium 51.996 (+6,+3) | 25 Mn Manganese 54.938 (+7,+4,+2) | 26 Fe Iron 55.845 (+6,+3,+2) | 27 Co Cobalt 58.933 (+3,+2) | 28 Ni Nickel 58.693 (+2) | 29 Cu Copper 63.546 (+2) | 30 Zn Zinc 65.38 (+2) | 31 Ga Gallium 69.723 (+3) | 32 Ge Germanium 72.631 (+4,+2,-4) | 33 As Arsenic 74.922 (+5,+3,-3) | 34 Se Selenium 78.971 (+6,+4,+2,-2) | 35 Br Bromine 79.904 (+5,+3,+1,-1) | 36 Kr Krypton 84.798 (+2,0) |
| 37 Rb Rubidium 85.468 (+1) | 38 Sr Strontium 87.62 (+2) | 39 Y Yttrium 88.906 (+3) | 40 Zr Zirconium 91.224 (+4) | 41 Nb Niobium 92.906 (+5) | 42 Mo Molybdenum 95.95 (+6,+4) | 43 Tc Technetium 98.907 (+7,+4) | 44 Ru Ruthenium 101.07 (+4,+3) | 45 Rh Rhodium 102.906 (+3) | 46 Pd Palladium 106.42 (+4,+2) | 47 Ag Silver 107.868 (+1) | 48 Cd Cadmium 112.414 (+2) | 49 In Indium 114.818 (+3) | 50 Sn Tin 118.711 (+4,+2,-4) | 51 Sb Antimony 121.760 (+5,+3,-3) | 52 Te Tellurium 127.6 (+6,+4,+2,-2) | 53 I Iodine 126.904 (+7,+5,+3,+1,-1) | 54 Xe Xenon 131.294 (+6,+4,+2,0) |
| 55 Cs Cesium 132.905 (+1) | 56 Ba Barium 137.328 (+2) | 57-71 | 72 Hf Hafnium 178.49 (+4) | 73 Ta Tantalum 180.948 (+5) | 74 W Tungsten 183.85 (+6,+4) | 75 Re Rhenium 186.207 (+4) | 76 Os Osmium 190.23 (+4) | 77 Ir Iridium 192.22 (+4,+3) | 78 Pt Platinum 195.08 (+4,+2) | 79 Au Gold 196.967 (+3) | 80 Hg Mercury 200.59 (+2,+1) | 81 Tl Thallium 204.383 (+3,+1) | 82 Pb Lead 207.2 (+4,+2) | 83 Bi Bismuth 208.980 (+3) | 84 Po Polonium [208.982] (+4,+2,-2) | 85 At Astatine 209.987 (+1,-1) | 86 Rn Radon 222.018 (+2,0) |
| 87 Fr Francium 223.020 (+1) | 88 Ra Radium 226.025 (+2) | 89-103 | 104 Rf Rutherfordium [261] (+4) | 105 Db Dubnium [262] (+5) | 106 Sg Seaborgium [266] (+6) | 107 Bh Bohrium [264] (+7) | 108 Hs Hassium [269] (+8) | 109 Mt Meitnerium [278] (unknown) | 110 Ds Darmstadtium [281] (unknown) | 111 Rg Roentgenium [280] (unknown) | 112 Cn Copernicium [285] (+2) | 113 Nh Nihonium [286] (unknown) | 114 Fl Flerovium [289] (unknown) | 115 Mc Moscovium [289] (unknown) | 116 Lv Livermorium [293] (unknown) | 117 Ts Tennessine [294] (unknown) | 118 Og Oganesson [294] (unknown) |

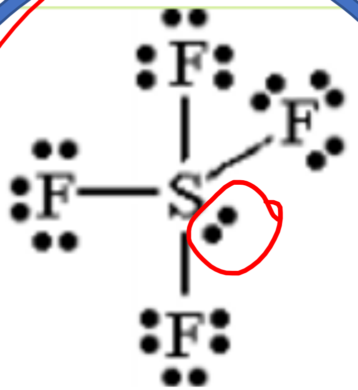
| Series | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lanthanide Series | 57 La Lanthanum 138.905 (+3) | 58 Ce Cerium 140.116 (+4,+3) | 59 Pr Praseodymium 140.908 (+3) | 60 Nd Neodymium 144.243 (+3) | 61 Pm Promethium 144.913 (+3) | 62 Sm Samarium 150.36 (+3) | 63 Eu Europium 151.964 (+3,+2) | 64 Gd Gadolinium 157.25 (+3) | 65 Tb Terbium 158.925 (+3) | 66 Dy Dysprosium 162.500 (+3) | 67 Ho Holmium 164.930 (+3) | 68 Er Erbium 167.259 (+3) | 69 Tm Thulium 168.934 (+3) | 70 Yb Ytterbium 173.055 (+3) | 71 Lu Lutetium 174.967 (+3) |
| Actinide Series | 89 Ac Actinium 227.028 (+3) | 90 Th Thorium 232.038 (+4) | 91 Pa Protactinium 231.036 (+5) | 92 U Uranium 238.029 (+6) | 93 Np Neptunium 237.048 (+5) | 94 Pu Plutonium 244.064 (+4) | 95 Am Americium 243.061 (+3) | 96 Cm Curium 247.070 (+3) | 97 Bk Berkelium 247.070 (+3) | 98 Cf Californium 251.080 (+3) | 99 Es Einsteinium [254] (+3) | 100 Fm Fermium 257.095 (+3) | 101 Md Mendelevium 258.1 (+2) | 102 No Nobelium 259.101 (+2) | 103 Lr Lawrencium [262] (+3) |

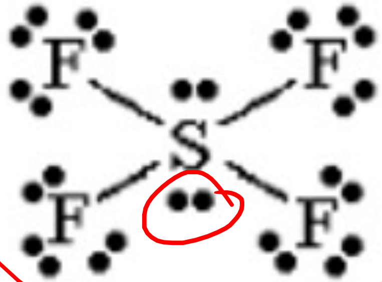
Determine the correct Lewis structure of $SF_4$.

Sulfur tetrachloride









$SF_4$

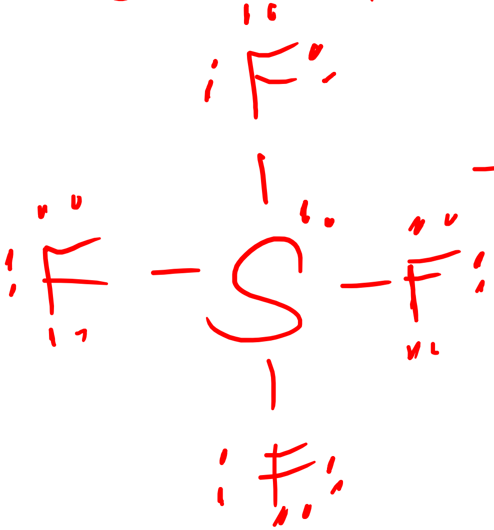
$6 + 7 \times 4 = 34$

$-8$

$26$

$-24$

$2$



According to the VSEPR model, the progressive decrease in the bond angles in the series of molecules $CH_4$, $NH_3$, and $H_2O$ is best accounted for by the

a. increasing strength of the bonds

b. decreasing size of the central atom

c. increasing electronegativity of the central atom

d. increasing number of unshared pairs of electrons

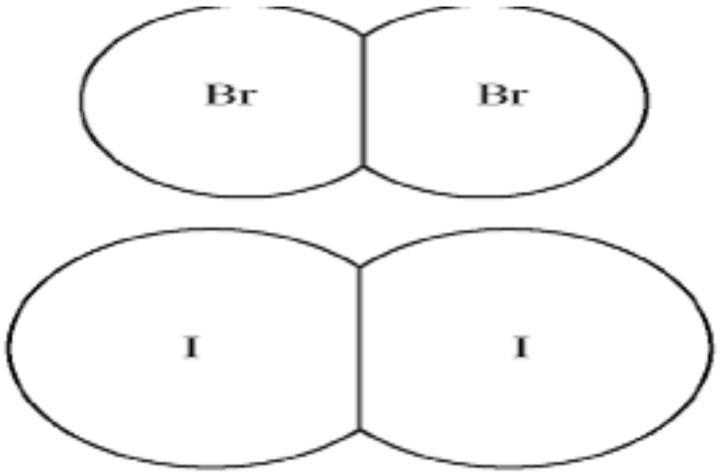



**Figure 5**

The diagram in Figure 5 above shows molecules of $Br_2$ and $I_2$ drawn to the same scale. Which of the following is the best explanation for the difference in the boiling points of liquid $Br_2$ and $I_2$, which are 59°C and 184°C, respectively?

a. Solid iodine is a network covalent solid, whereas solid bromine is a molecular solid.

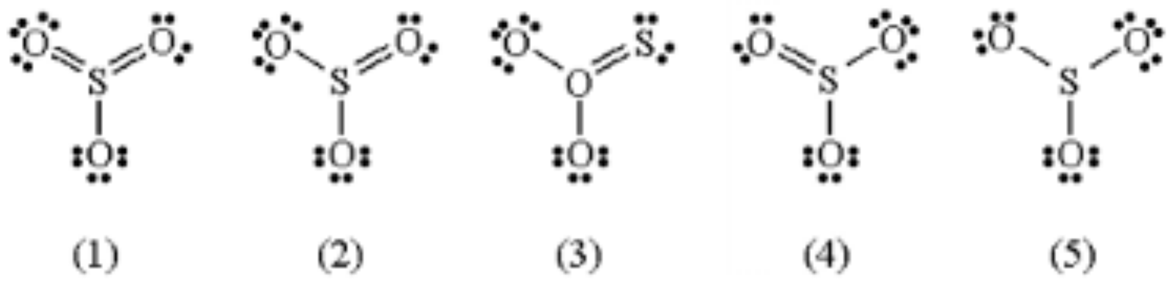
b. The covalent bonds in $I_2$ molecules are weaker than those in $Br_2$ molecules.

c. $I_2$ molecules have electron clouds that are more polarizable than those of $Br_2$ molecules, thus London dispersion forces are stronger in liquid $I_2$.

are

d. Bromine has a greater electronegativity than iodine, thus there are stronger dipole-dipole forces in liquid bromine than in liquid iodine.

Which of the following are correct resonance structures of $SO_3$?



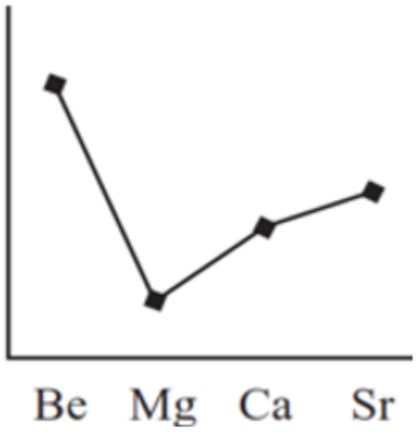
a. (2) and (4)

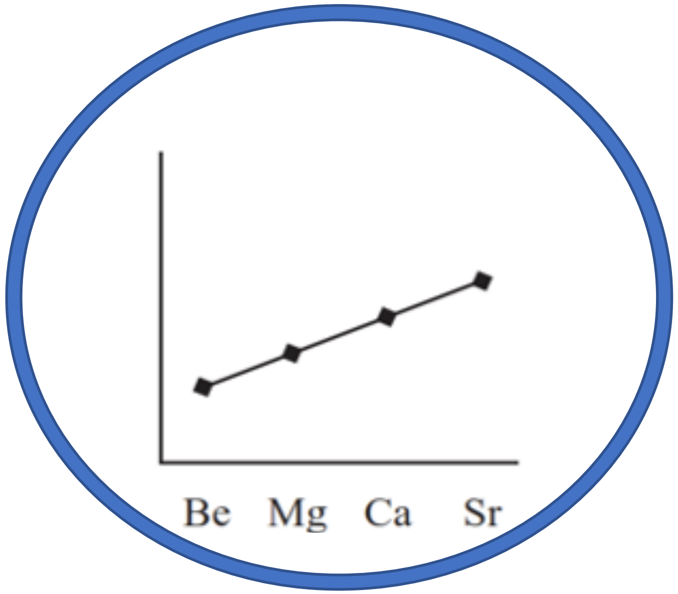
b. (1) and (5)

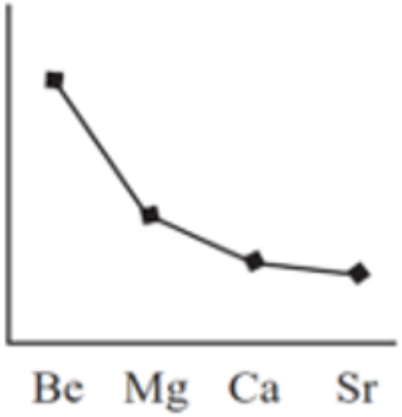
c. (1), (2), and (4)

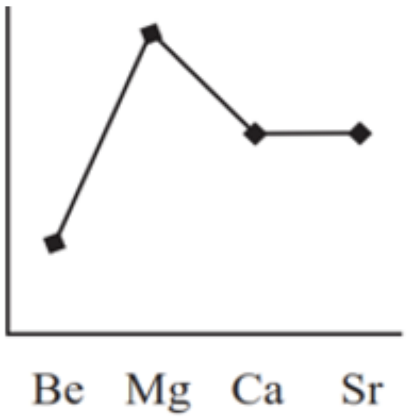
d. (2), (3) and (4)

Which of the following graphs shows the variation in the ionic radius of the Group 2 elements?

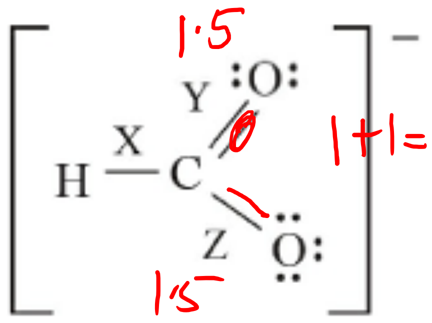


The formate ion, $HCO^{2-}$, is best represented by the Lewis diagram in Figure 7 below. Each bond is labeled with a different letter.




$1+1=2 \quad \frac{3}{2} = \boxed{1.5}$

**Figure 7**

What is the bond order for each bond?

| | X | Y | Z |
|---|---|---|---|
| (A) | 1 | 1 2 | 2 1 |
| (B) | 2 | 2 | 1 |
| (C) | 1 | 1.5 | 1.5 |
| (D) | 1.33 | 1.33 | 1.33 |

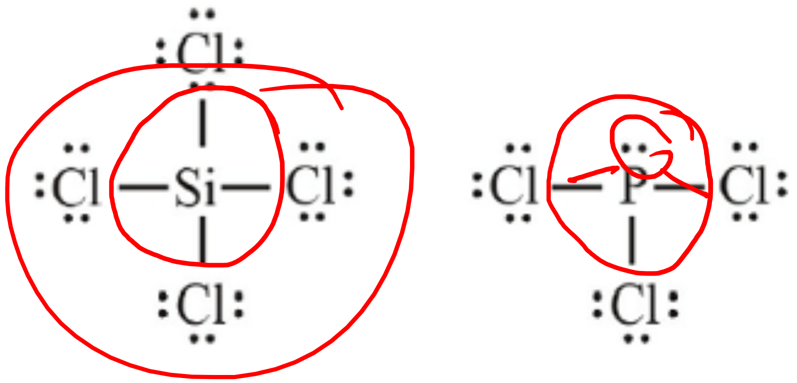


Figure 6

The Lewis diagrams for $SiCl_4$ and $PCl_3$ are drawn in Figure 6 above. What are the approximate bond angles between the terminal chlorine atoms in each structure?

Lone Pair = 1

Bonded Pair = 3

domain 4

| | $SiCl_4$ | $PCl_3$ |
|---|---|---|
| (A) | 90° | 90° |
| (B) | 109.5° | < 109.5° |
| (C) | 90° | 109.5° |
| (D) | < 109.5° | > 90° |

| Total Domains | Generic Formula | Picture | Bonded Atoms | Lone Pairs | Molecular Shape | Electron Geometry | Example | Hybridi-zation | Bond Angles |
|---|---|---|---|---|---|---|---|---|---|
| 1 | AX | A—X | 1 | 0 | Linear | Linear | $H_2$ | s | 180 |
| 2 | $AX_2$ | X—A—X | 2 | 0 | Linear | Linear | $CO_2$ | sp | 180 |
| | AXE | A—X | 1 | 1 | Linear | Linear | $CN^-$ | | |
| 3 | $AX_3$ | | 3 | 0 | Trigonal planar | Trigonal planar | $AlBr_3$ | $sp^2$ | 120 |
| | $AX_2E$ | | 2 | 1 | Bent | Trigonal planar | $SnCl_2$ | | |
| | $AXE_2$ | X—A | 1 | 2 | Linear | Trigonal planar | $O_2$ | | |
| 4 | $AX_4$ | | 4 | 0 | Tetrahedral | Tetrahedral | $SiCl_4$ | $sp^3$ | 109.5 |
| | $AX_3E$ | | 3 | 1 | Trigonal pyramid | Tetrahedral | $PH_3$ | | |
| | $AX_2E_2$ | | 2 | 2 | Bent | Tetrahedral | $SeBr_2$ | | |
| | $AXE_3$ | | 1 | 3 | Linear | Tetrahedral | $Cl_2$ | | |

# Neon has a smaller atomic radius than phosphorus because.

a. Phosphorus has more protons than neon, which increases the repulsive forces in the atom.

b. The electrons in a neon atom are all found in a single energy level.

c. Unlike neon, phosphorus has electrons in its third energy level.

d. Phosphorus can form anions, while neon is unable to form any ions.

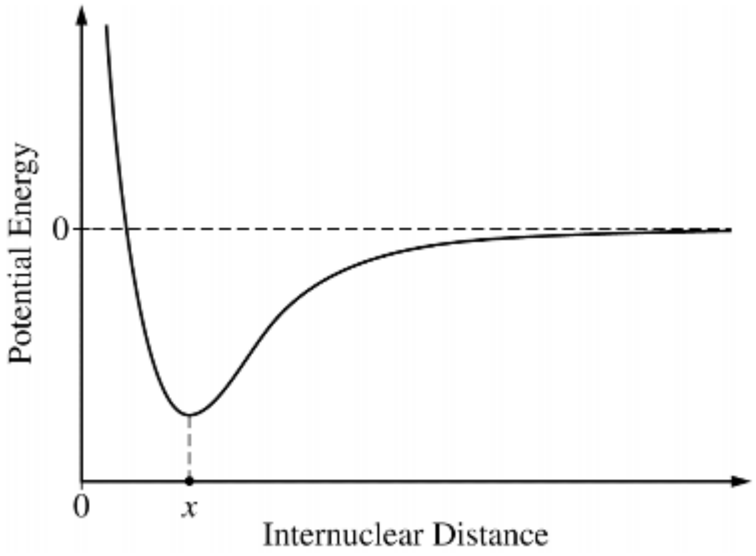



Figure 2

The potential energy of a system of two atoms as a function of their internuclear distance is shown in Figure 2 on the left. Which of the following statement describe the curve?

a. It cannot be determined whether the forces between atoms are balanced, attractive or repulsive because the diagram shows only the potential energy.

b. The attractive and repulsive forces are balanced, so the atoms will maintain an average internuclear distance x.

c. There is a net repulsive force pushing the atoms apart, so the atoms will move further apart.

d. There is a net attractive force pulling the atoms together, so the atoms will move closer together.

Nitrogen trichloride is a yellow, oily, pungent smelling liquid. Using VSEPR determine which of the following characteristics apply to $NCl_3$ shown in Figure 4 below.

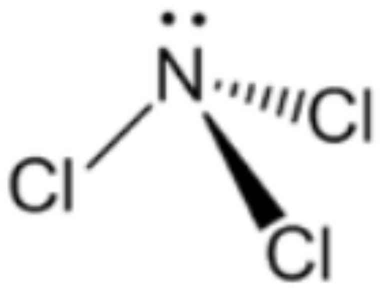



**Figure 4**

I nonpolar molecule

II polar bonds

III trigonal-pyramidal molecular geometry

IV trigonal planar

**a.** I and II

**b.** II and III

**c.** III and IV

**d.** II, III, and IV

| | | | |
|---|---|---|---|
| 2. | Summarize ionic bonding and provide examples of compounds containing ionic bonds. (Sec. 9.2) | Chapter 5, Section 5.2 Questions & Problems # 5.6 | Page2 |

EOT LOs

5.6 Explain what an ionic bond is.

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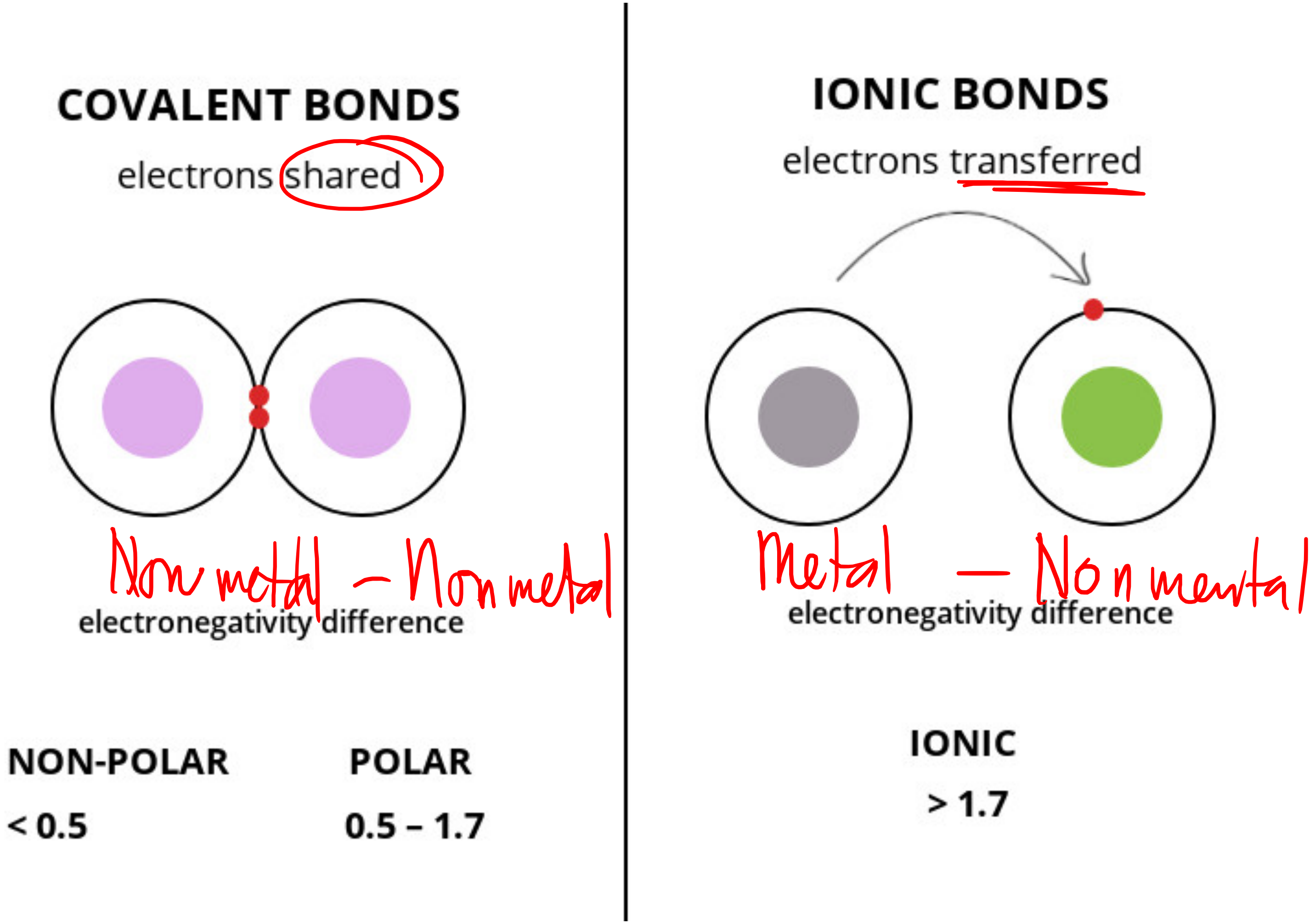


| | | | |
|---|---|---|---|
| 3. | Summarize ionic bonding and provide examples of compounds containing ionic bonds. (Sec. 9.2) | Chapter 5, Question Bank # 107 | Page2 |

EOT LOs

Which of the elements listed below would most likely form an ionic bond when bonded to chlorine? → NM

NM – M

Cl

H

Br

O

Sr –

N

Which one of the following is most likely to be an ionic compound?

- $ClF_3$
- $FeCl_3$
- $NH_3$
- $PF_3$
- $SO_3$

| | | | |
|---|---|---|---|
| 3. | Summarize ionic bonding and provide examples of compounds containing ionic bonds. (Sec. 9.2) | Chapter 5, Question Bank # 107 | Page287 |

Which of the elements listed below would most likely form an ionic bond when bonded to chlorine?

Cl

H

Br

O

Sr

N

Which one of the following is most likely to be an ionic compound?

- $ClF_3$
- $FeCl_3$
- $NH_3$
- $PF_3$
- $SO_3$

| 3. | Summarize ionic bonding and provide examples of compounds containing ionic bonds. (Sec. 9.2) | Chapter 5, Question Bank # 107 | Page287 |
|---|---|---|---|

Which one of the following is most likely to be an ionic compound?

- $CaCl_2$
- $CO_2$
- $CS_2$
- $SO_2$
- $OF_2$

Select True or False: Of the following substances, KCl, KBr, and KF, KF will have the highest melting point.

- TRUE
- FALSE

| | | | |
|---|---|---|---|
| 3. | Summarize ionic bonding and provide examples of compounds containing ionic bonds. (Sec. 9.2) | Chapter 5, Question Bank # 107 | Page287 |

Which one of the following is most likely to be an ionic compound?

- ○ $CaCl_2$
- ○ $CO_2$
- ○ $CS_2$
- ○ $SO_2$
- ○ $OF_2$

Select True or False: Of the following substances, KCl, KBr, and KF, KF will have the highest melting point.

- ○ TRUE
- ○ FALSE

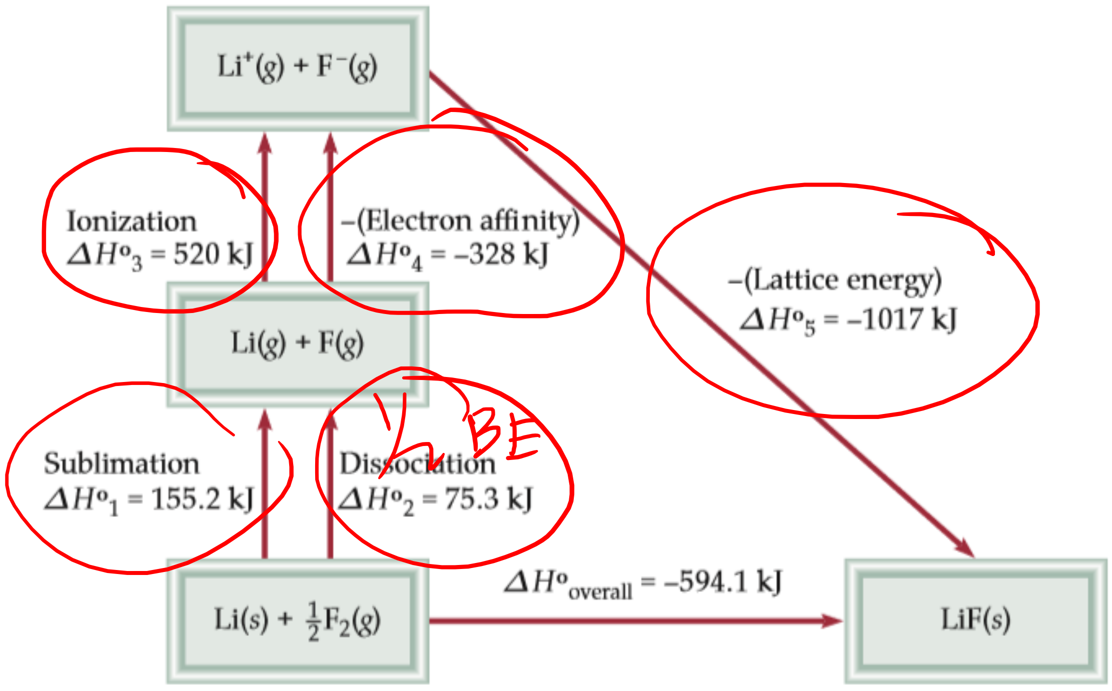
| | | | |
|---|---|---|---|
| 4. | Solve for lattice energies using a Born-Haber cycle. (Sec. 9.3) | Ch. 9: Assessments: Question Bank #55 | Question Ba |

EOT LOs

Use the Born-Haber cycle to calculate the lattice energy of NaBr(s) given the following data:

ΔH(sublimation) Na = 109 kJ/mol $\Delta H_{sub}$
$I_1$ (Na) = 496 kJ/mol $\Delta H_{I}$
Bond energy (Br–Br) = 192 kJ/mol $\Delta H_{BE}$
EA (Br) = 324 kJ/mol $= \Delta H_{EA}$
$\Delta H_f$ $\boxed{\text{NaBr(s)}}$ = –361 kJ/mol $= \Delta H_{over}$

- 738 kJ/mol
- 748 kJ/mol
- 758 kJ/mol
- 768 kJ/mol
- None of the above




$$\Delta H_{overall} = \Delta H_{sub} + \Delta H_{I} + \left(\tfrac{1}{2}\Delta H_{BE}\right) + (-\Delta H_{EA}) + (-\Delta H_{LE})$$

$$-361 = 109 + 496 + \left(\tfrac{1}{2}192\right) + (-324) + (-\Delta H_{LE})$$

$$\boxed{\Delta H_{LE} = 738 \ \frac{kJ}{mol}}$$

| | | | |
|---|---|---|---|
| 4. | Solve for lattice energies using a Born-Haber cycle. (Sec. 9.3) | Ch. 9: Assessments: Question Bank #55 | Question Ba |

EOT LOs

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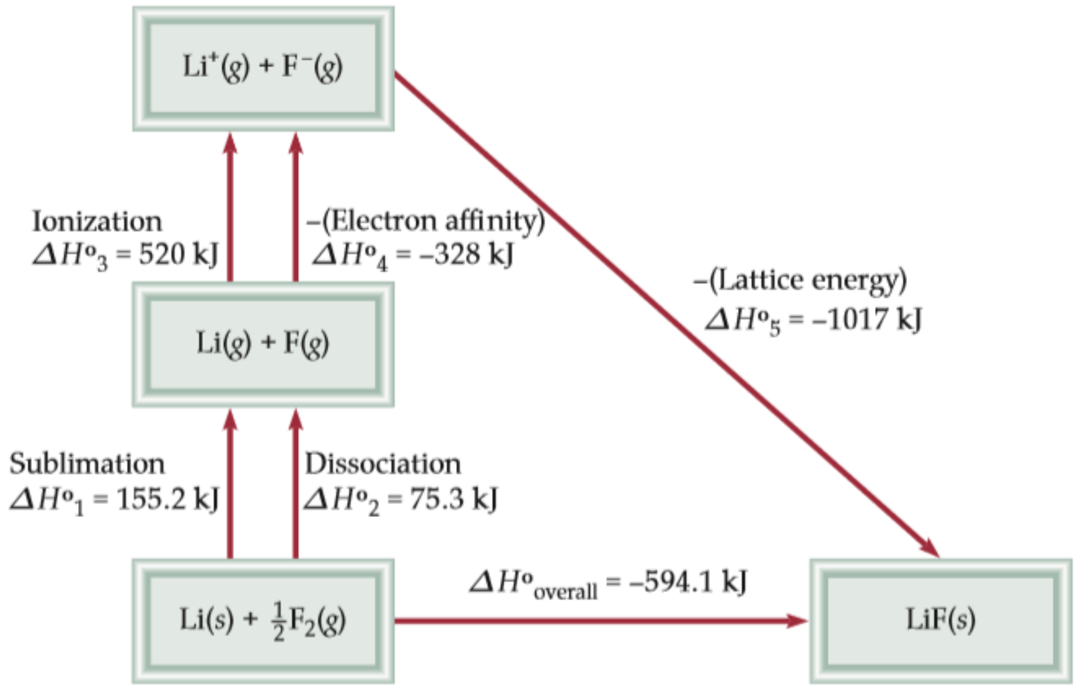
$\Delta H_f$ (NaBr(s)) = –361 kJ/mol

- 738 kJ/mol
- 748 kJ/mol
- 758 kJ/mol
- 768 kJ/mol
- None of the above



| | | | |
|---|---|---|---|
| 4. | Solve for lattice energies using a Born-Haber cycle. (Sec. 9.3) | Ch. 9: Assessments: Question Bank #55 | Question Bank |

Use the Born-Haber cycle to calculate the lattice energy of KCl(s) given the following data:

ΔH(sublimation) K = 79.2 kJ/mol

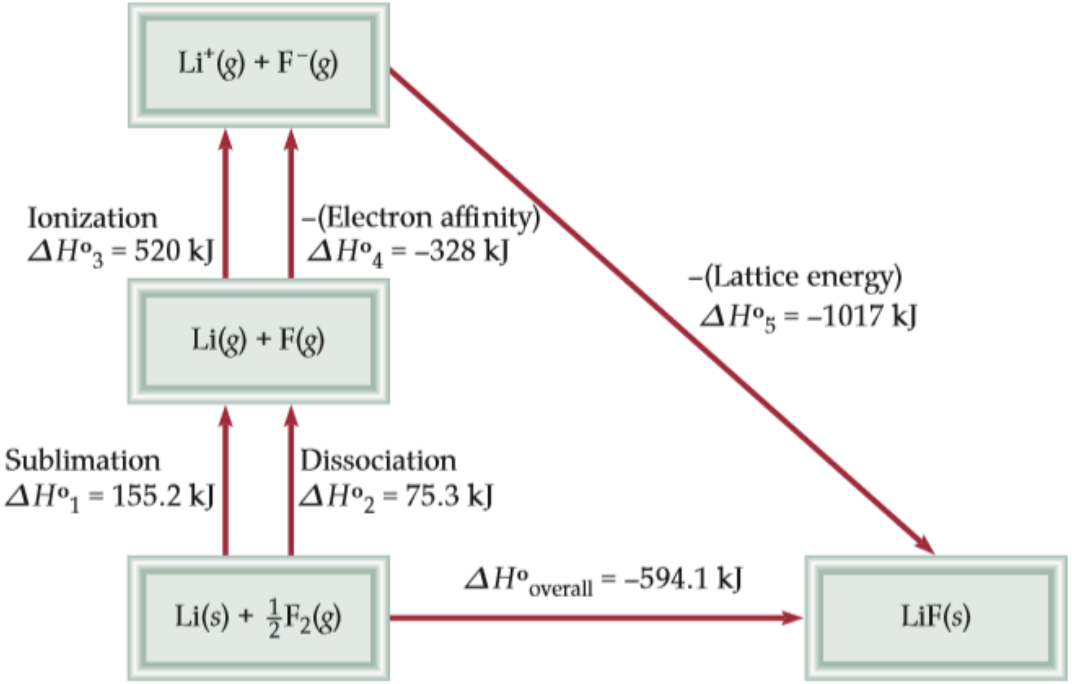
$I_1$ (K) = 418.7 kJ/mol

Bond energy (Cl–Cl) = 242.8 kJ/mol

EA (Cl) = 348 kJ/mol

$P_2I_4$

(KCl(s)) = –435.7 kJ/mol




- ○ –165 kJ/mol
- ○ 288 kJ/mol
- ○ 629 kJ/mol
- ○ 707 kJ/mol
- ○ 828 kJ/mol

| | | | |
|---|---|---|---|
| 4. | Solve for lattice energies using a Born-Haber cycle. (Sec. 9.3) | Ch. 9: Assessments: Question Bank #55 | Question Bank |

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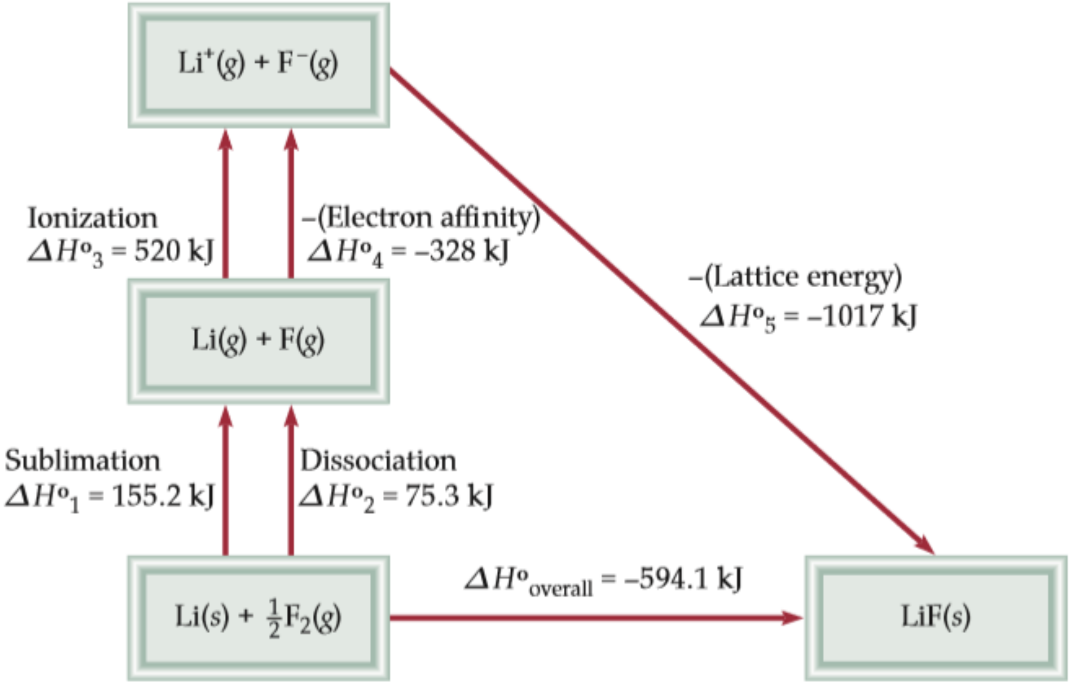
$I_1$ (K) = 418.7 kJ/mol

Bond energy (Cl–Cl) = 242.8 kJ/mol

EA (Cl) = 348 kJ/mol

$P_2I_4$

(KCl(s)) = –435.7 kJ/mol




- –165 kJ/mol
- 288 kJ/mol
- 629 kJ/mol
- 707 kJ/mol
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| | | | |
|---|---|---|---|
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$I_1$ (K) = 418.7 kJ/mol $\Delta H_I$

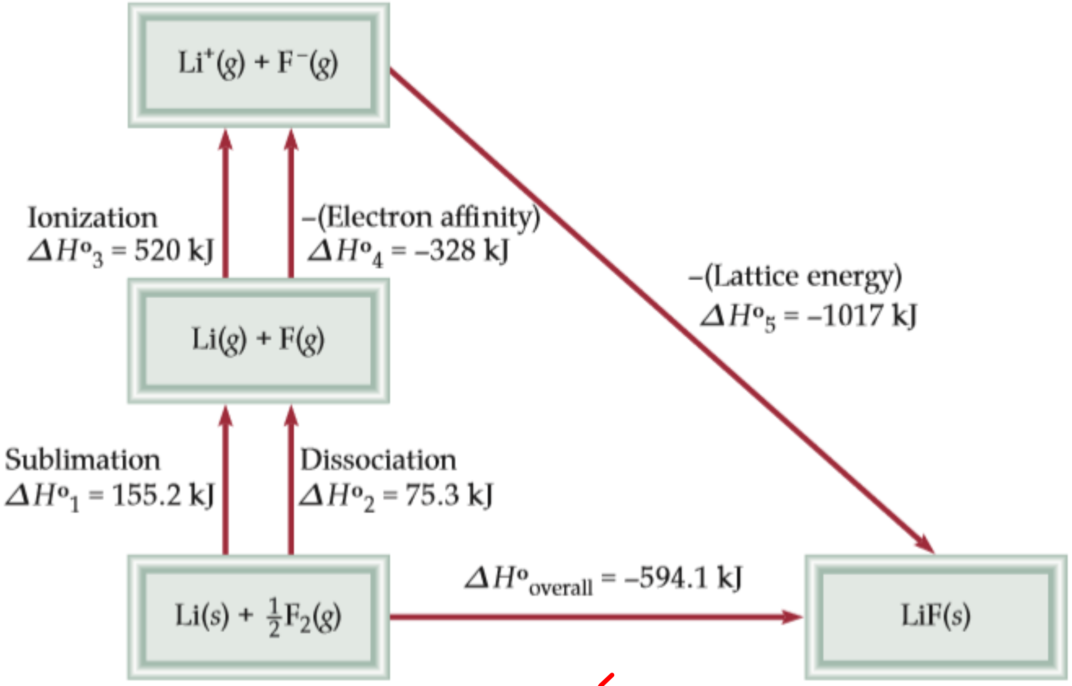
Bond energy (Cl–Cl) = 242.8 kJ/mol $\Delta H_{BE}$

EA (Cl) = 348 kJ/mol $\Delta H_{EA}$

$P_2I_4$

(KCl(s)) = –435.7 kJ/mol $\Delta H_{overall}$

- –165 kJ/mol
- 288 kJ/mol
- 629 kJ/mol
- 707 kJ/mol
- 828 kJ/mol




$$\Delta H_{overall} = \Delta H_{sub} + \Delta H_I + \left(\tfrac{1}{2}\Delta H_{BE}\right) + (-\Delta H_{EA}) + (-\Delta H_{LE})$$

$$\cancel{-435.7} = 79.2 + 418.7 + \left(\tfrac{1}{2}\,242.8\right) + (-348) + (\cancel{-\Delta H_{LE}})$$

$$\Delta H_{LE} \quad \cancel{+435.7} \qquad +435.7 \qquad \cancel{+\Delta H_{LE}}$$

$$\Delta H_{LE} =$$

| 4. | Solve for lattice energies using a Born-Haber cycle. (Sec. 9.3) | Ch. 9: Assessments: Question Bank #55 | Question Bank |
|---|---|---|---|

Use the Born-Haber cycle to calculate the lattice energy of MgO (s) given the following data:

$\Delta H$(sublimation) Mg = 130 kJ/mol

$I_1$ (Mg) = 738.1 kJ/mol

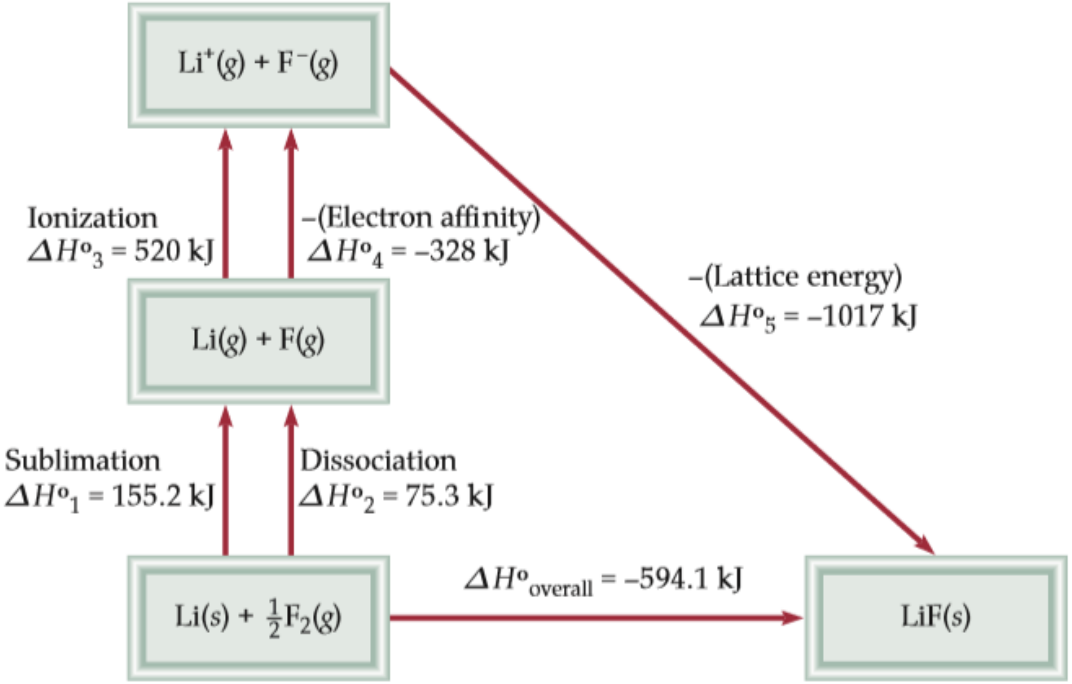
$I_2$ (Mg) = 1450 kJ/mol

Bond energy (O=O) = 498.7 kJ/mol

EA (O) = 141 kJ/mol

EA ($O^-$) = –780 kJ/mol

$P_2I_4$ (MgO(s)) = –601.8 kJ/mol




- ○ 2200 kJ/mol
- ○ 2800 kJ/mol
- ○ 3200 kJ/mol
- ○ 3800 kJ/mol
- ○ 4100 kJ/mol

| | | | |
|---|---|---|---|
| 4. | Solve for lattice energies using a Born-Haber cycle. (Sec. 9.3) | Ch. 9: Assessments: Question Bank #55 | Question Bank |

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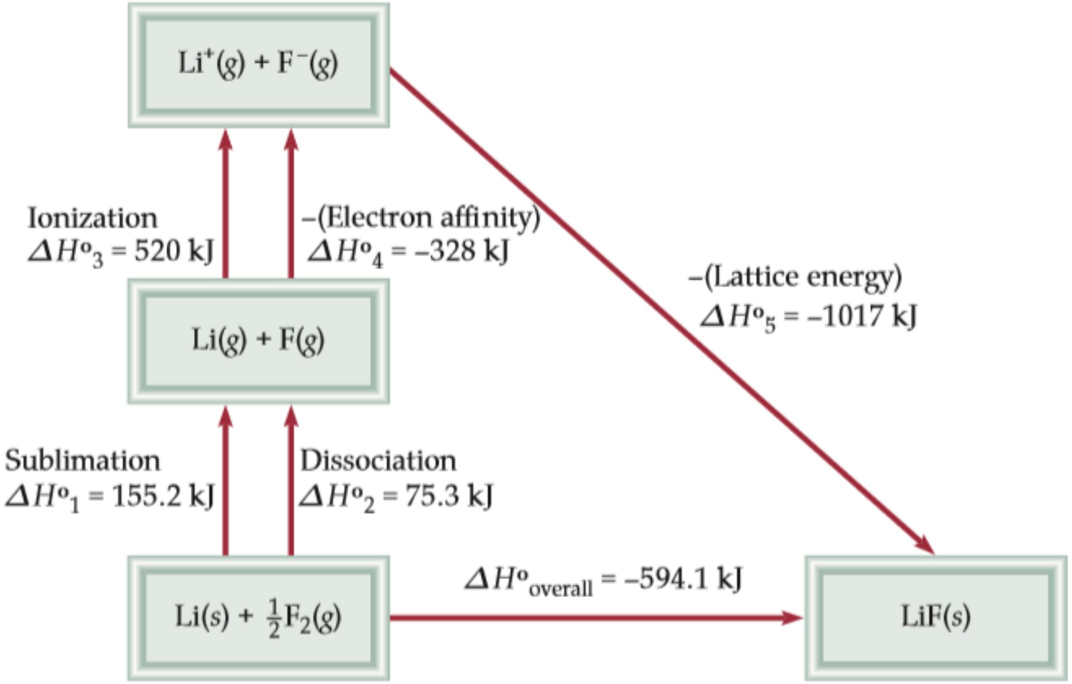



- 2200 kJ/mol
- 2800 kJ/mol
- 3200 kJ/mol
- 3800 kJ/mol
- 4100 kJ/mol

| 5. | Rank lattice energies of ionic compounds. (Sec. 9.3) | Ch. 9: Assessments: Question Bank #86 | Question Ba |
|---|---|---|---|

EOT LOs

Which of the following ionic solids would have the largest lattice energy?

+ remove / lose

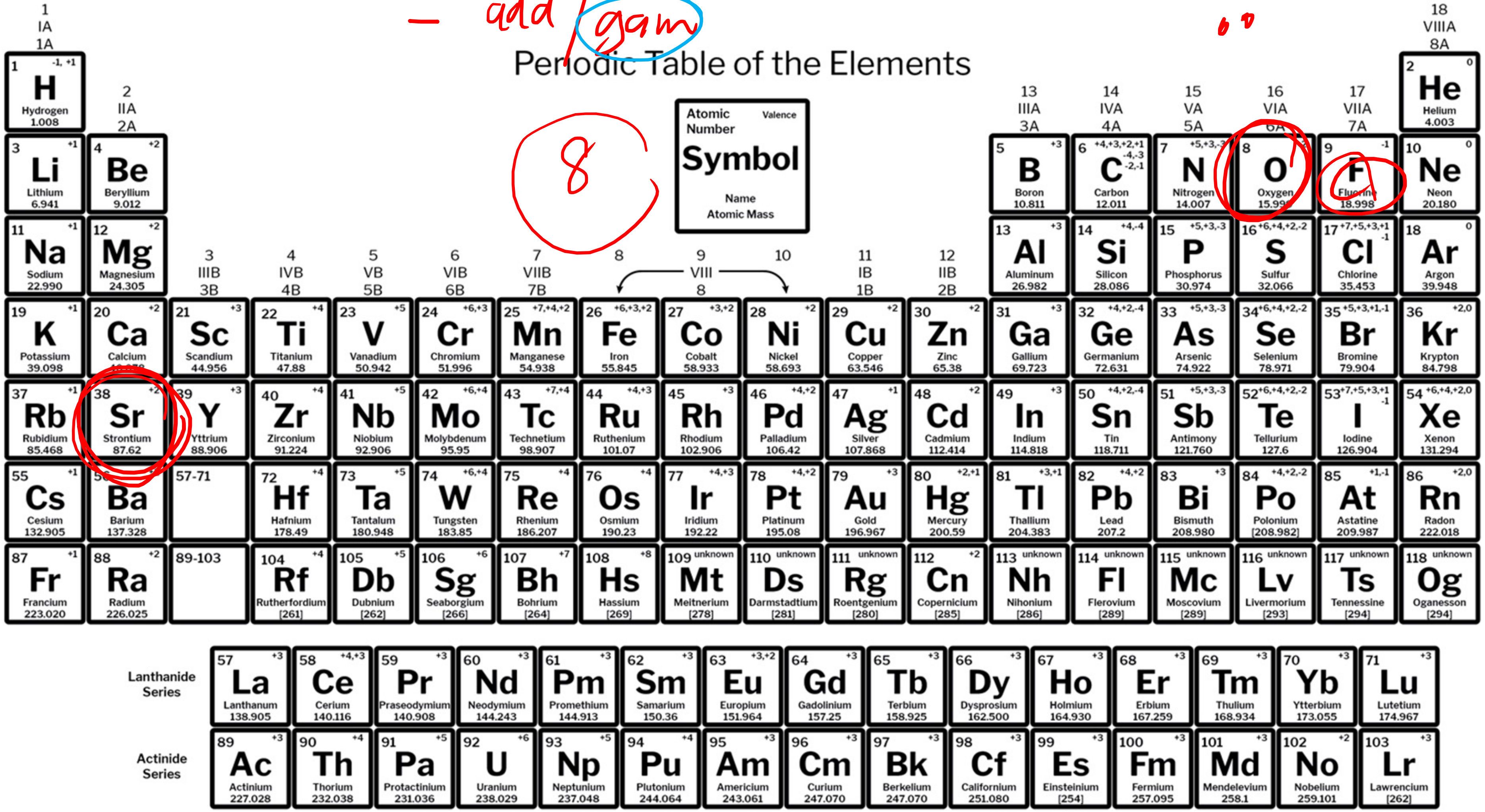
− add / gain

- SrO = −4 ($+2\ -2$)
- ~~NaF~~ = −1 ($+1\ -1$)
- ~~$CaBr_2$~~ = −2 ($+2\ -1$)
- ~~CsI~~ = −1 ($+1\ -1$)
- $BaSO_4$ ($+2\ x\ -2$) = −4

$SO_4^{-2}$

F −1

8




$$F = k\frac{q_1 q_2}{r^2}$$

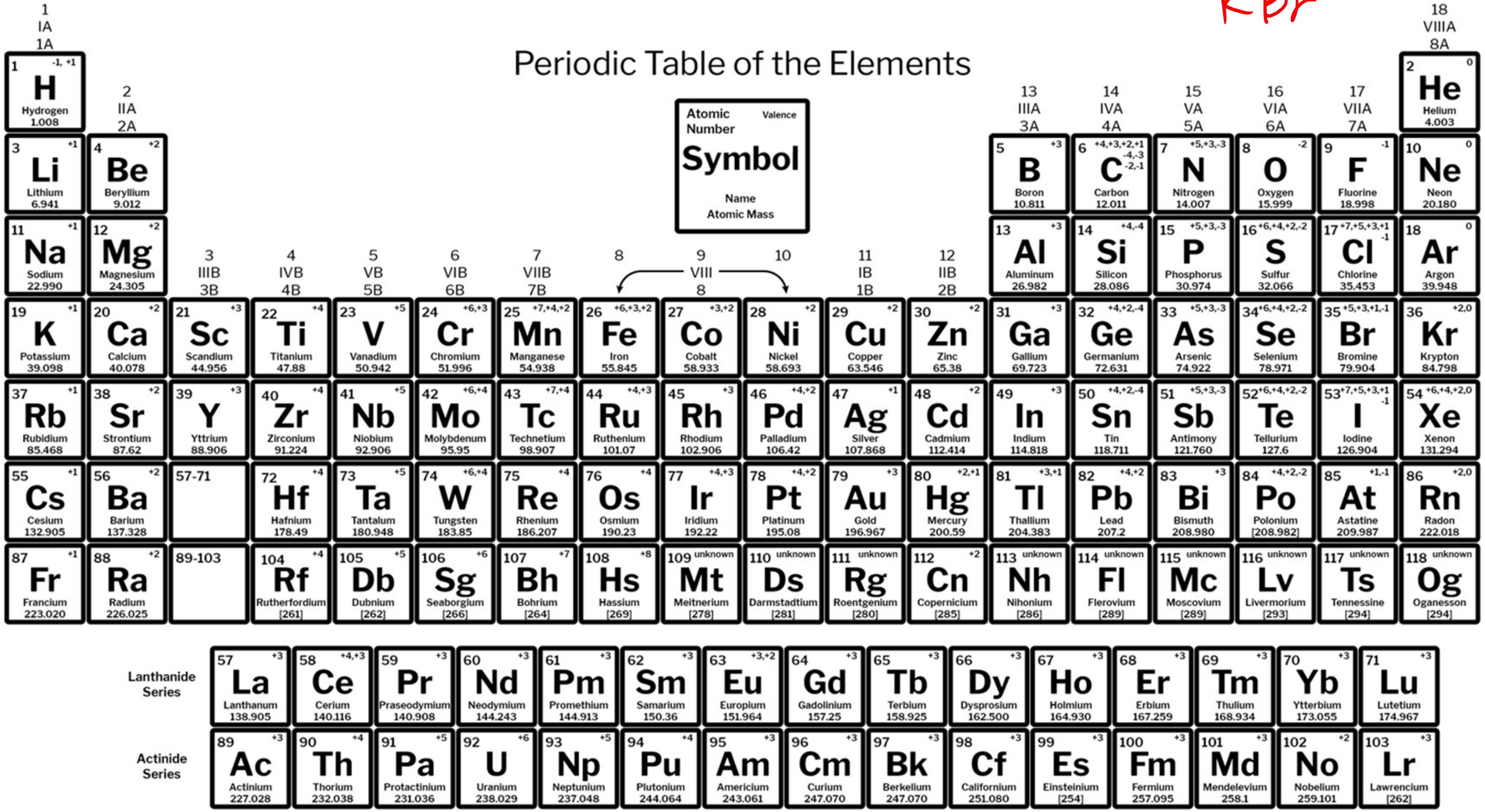
| | | | |
|---|---|---|---|
| 5. | Rank lattice energies of ionic compounds. (Sec. 9.3) | Ch. 9: Assessments: Question Bank #86 | Question Ba |

EOT LOs

KF
KCl
KBr

Which of the following ionic solids would have the largest lattice energy?

- SrO
- NaF
- $CaBr_2$
- CsI
- $BaSO_4$

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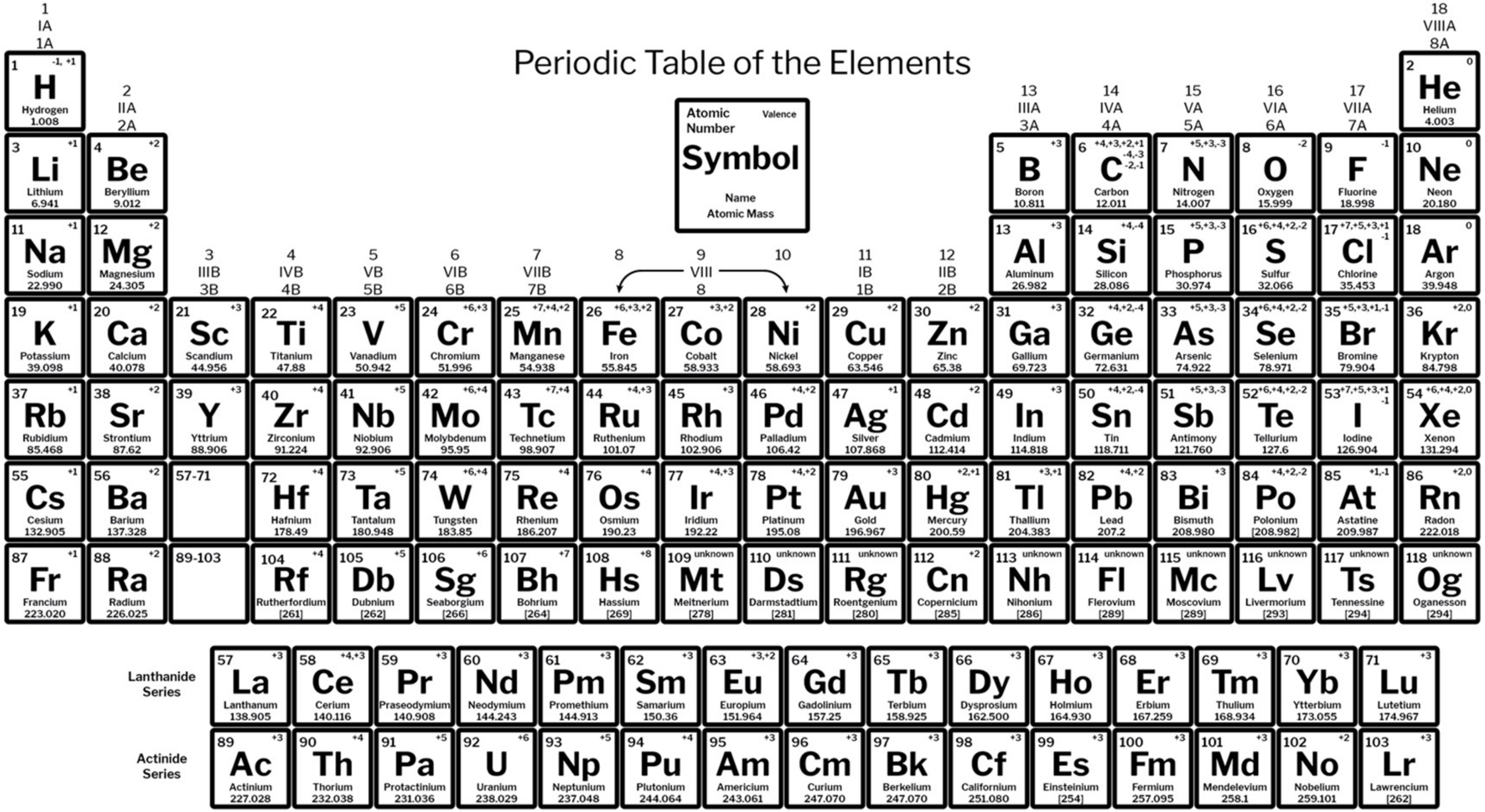
| | | | |
|---|---|---|---|
| 5. | Rank lattice energies of ionic compounds. (Sec. 9.3) | Ch. 9: Assessments: Question Bank #86 | Question Bank |

Which one of the following ionic solids would have the largest lattice energy?

- ○ $NaCl$
- ○ $NaF$
- ○ $CaBr_2$
- ○ $CsI$
- ○ $CaCl_2$

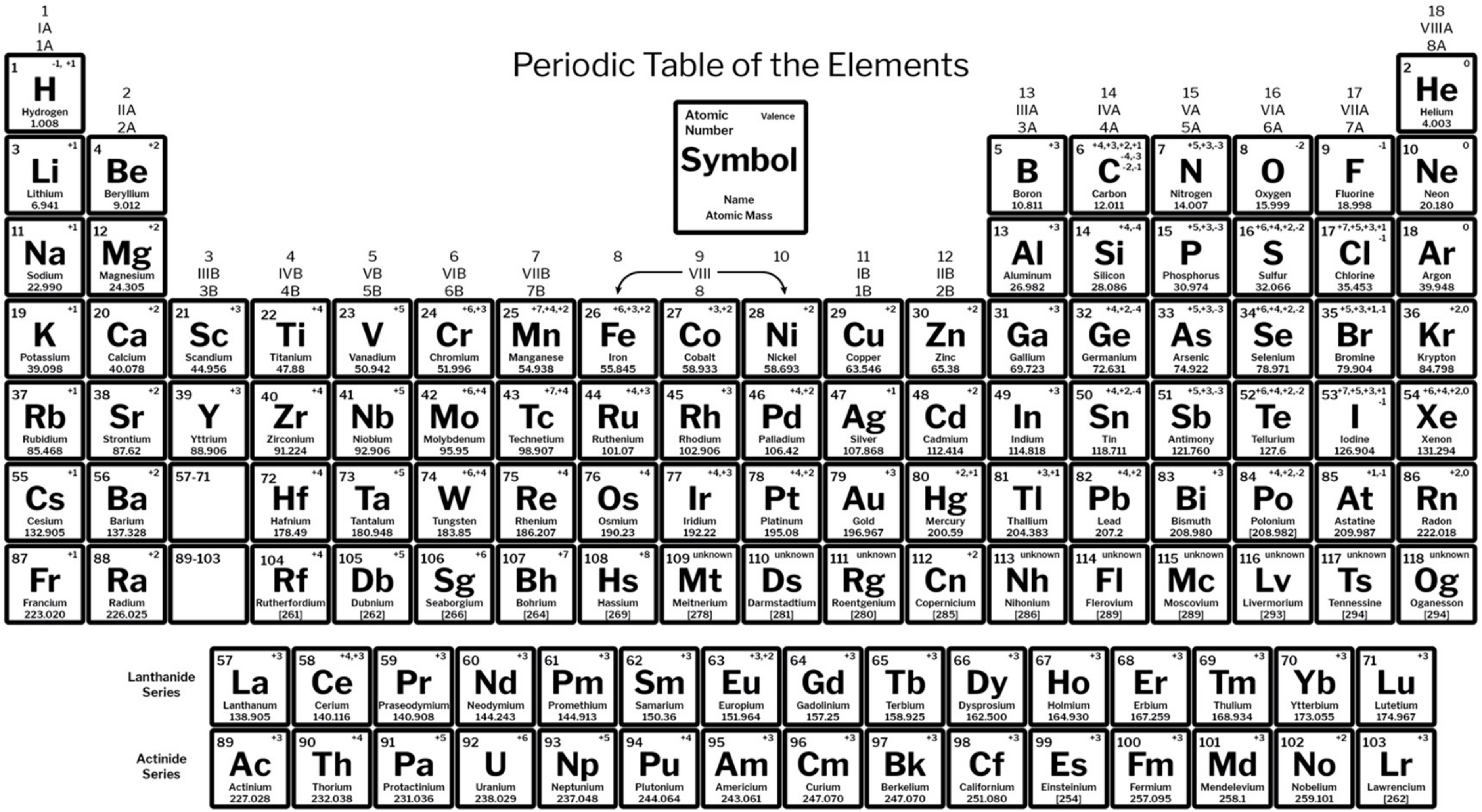



$$F = k\frac{q_1 q_2}{r^2}$$

| | | | |
|---|---|---|---|
| 5. | Rank lattice energies of ionic compounds. (Sec. 9.3) | Ch. 9: Assessments: Question Bank #86 | Question Bank |

Which one of the following ionic solids would have the largest lattice energy?

- NaCl
- NaF
- $CaBr_2$
- CsI
- $CaCl_2$

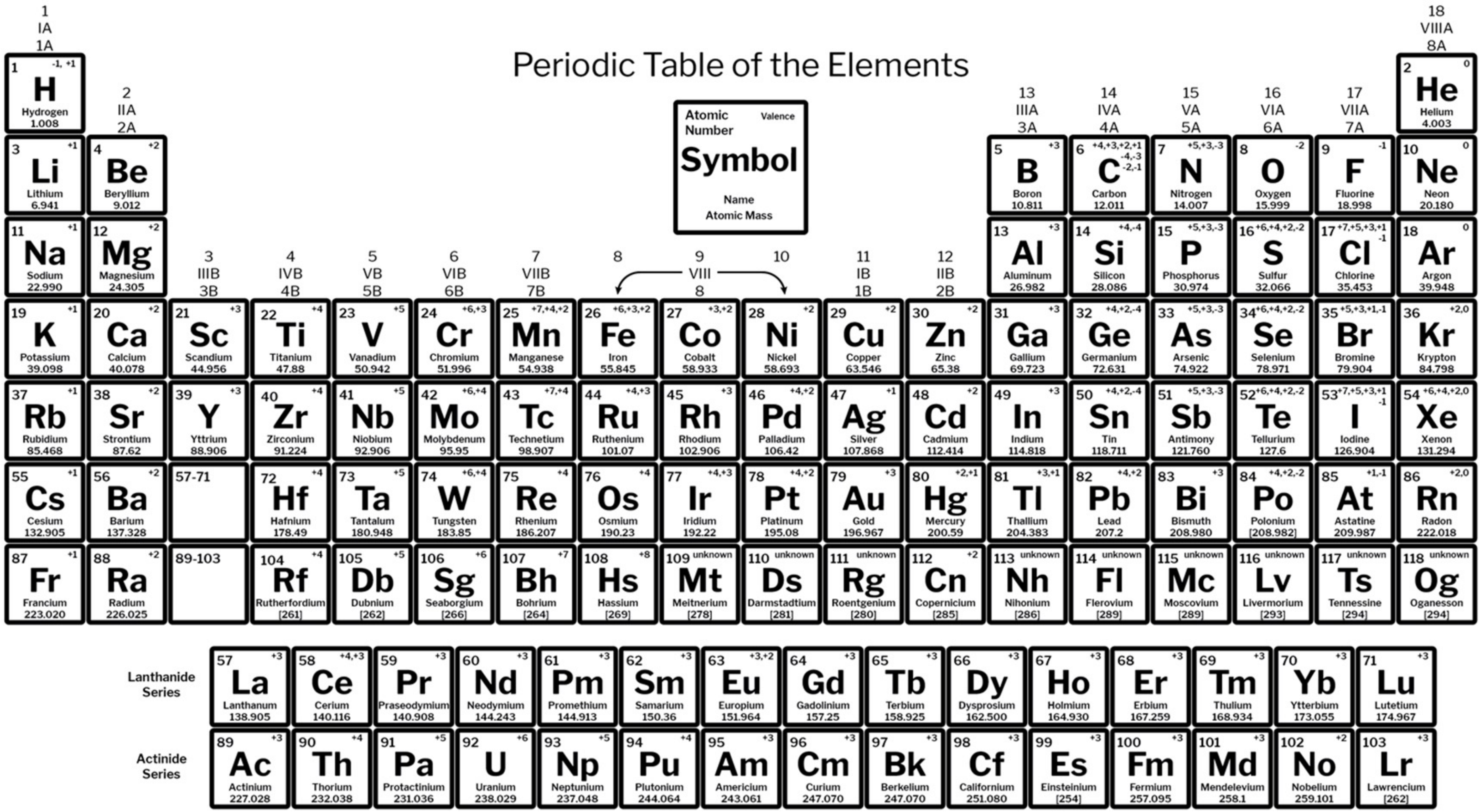



$$F = k\frac{q_1 q_2}{r^2}$$

| | | | |
|---|---|---|---|
| 5. | Rank lattice energies of ionic compounds. (Sec. 9.3) | Ch. 9: Assessments: Question Bank #86 | Question Bank |

Which of the following ionic solids would have the largest lattice energy?

- ○ KF
- ○ KI
- ○ LiF
- ○ LiI
- ○ NaF

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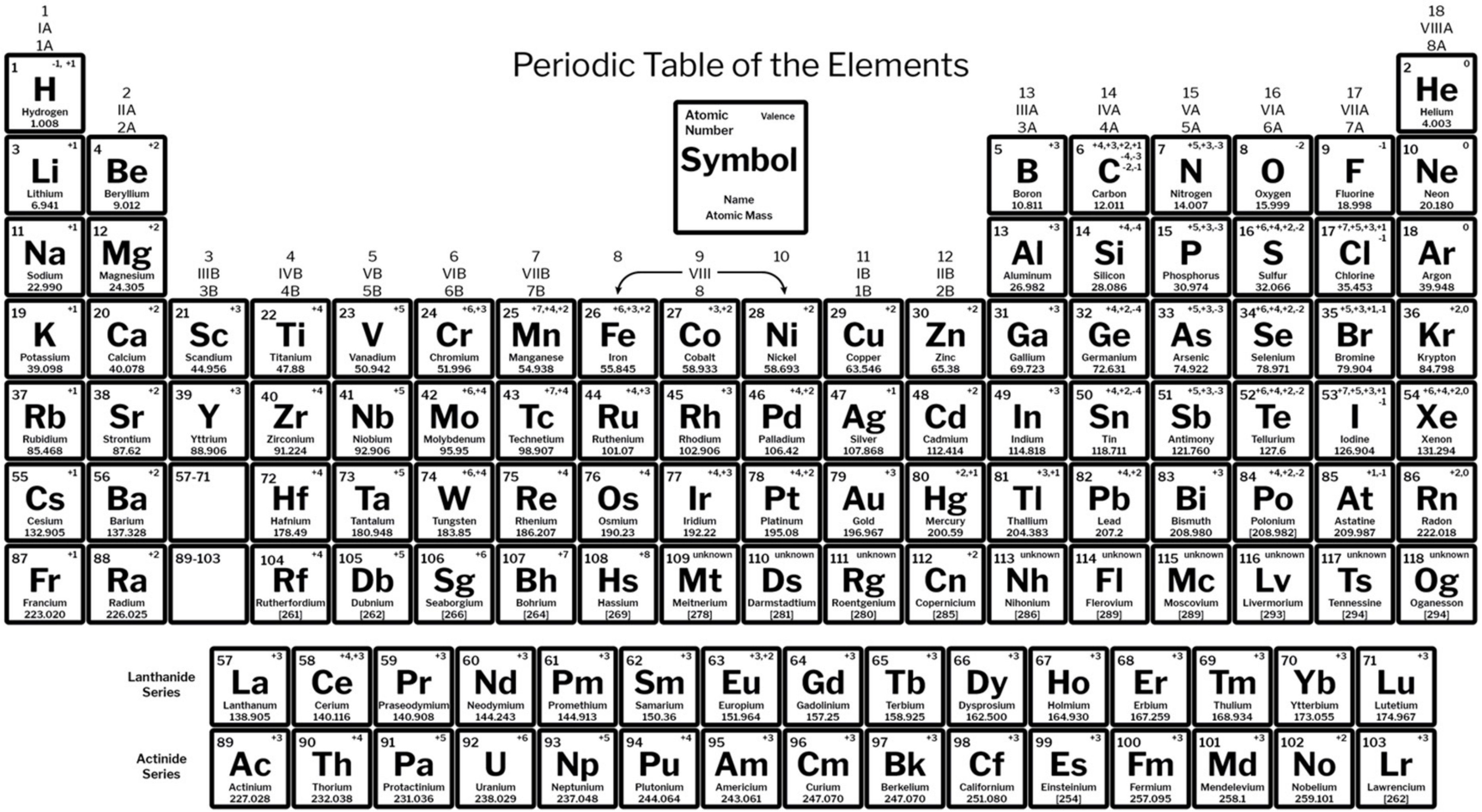
- LiF
- LiI
- NaF




$$F = k\frac{q_1 q_2}{r^2}$$

| | | | |
|---|---|---|---|
| 6. | Explain the Lewis theory of bonding. (Sec. 9.4) | Ch. 9 Sect. 4 Questions & Problems # 9.27 | 402 |

EOT LOs

5.27 What is Lewis's contribution to our understanding of the covalent bond?

5.28 Use an example to illustrate each of the following terms: lone pairs, Lewis structure, the octet rule, bond length.

| | | | |
|---|---|---|---|
| 6. | Explain the Lewis theory of bonding. (Sec. 9.4) | Ch. 9 Sect. 4 Questions & Problems # 9.27 | 402 |

EOT LOs

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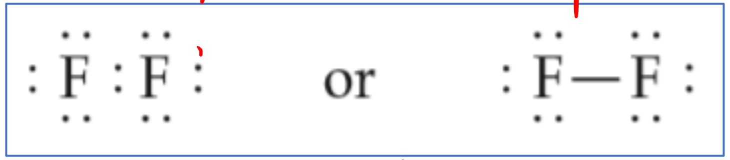
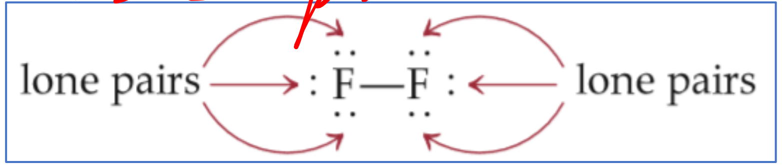
5.28 Use an example to illustrate each of the following terms: lone pairs, Lewis structure, the octet rule, bond length.

lewis structure




lone pair



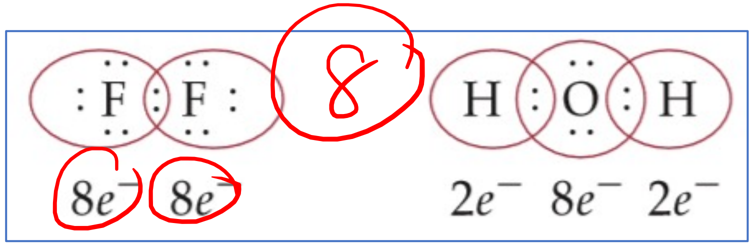

5.27. Lewis structures use to show the interaction between atoms which shares in a covalent compound and shows bonded atoms and lone pairs.

5.28. **Lone pairs** – pairs of electrons that are not involved in covalent formation.

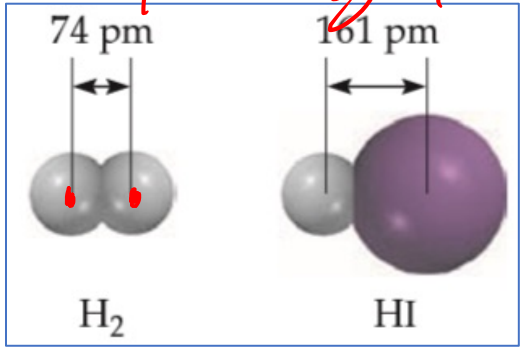
**Lewis structures** – is a representation of covalent bonding in which shared electron pairs are shown either as lines or as pairs of dots between two atoms, and lone pairs are shown as pairs of dots on individual atoms.

**Octet rule** – an atom other than hydrogen tends to form bonds until it is surrounded by eight valence electrons.

**Bond length** – is the distance between the nuclei of two covalently bonded atoms in a molecule.




bond length



| | | | |
|---|---|---|---|
| 7. | Define electronegativity and appraise its role in predicting bond polarity. (Sec. 9.5) | Ch. 9: Assessments: Question Bank #127 | Question B |

EOT LOs

Define *electronegativity:*

- an atoms ability to attract electrons that are shared in a chemical bond
- an atoms ability to form an ionic bond with another atom
- an atoms ability to donate valence electrons to another atom
- an atoms ability to form a cation
- an atoms ability to form double and triple bonds

Arrange the elements F, P, and Cl in order of increasing electronegativity.

- F < P < Cl
- P < Cl < F
- Cl < P < F
- P < F < Cl
- Cl < F < P

| 7. | Define electronegativity and appraise its role in predicting bond polarity. (Sec. 9.5) | Ch. 9: Assessments: Question Bank #127 | Question B |
|---|---|---|---|

EOT LOs

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- ○ an atoms ability to form double and triple bonds

Arrange the elements F, P, and Cl in order of increasing electronegativity.

- ○ F < P < Cl
- ○ P < Cl < F
- ○ Cl < P < F
- ○ P < F < Cl
- ○ Cl < F < P

| 8. | Define electronegativity and appraise its role in predicting bond polarity. (Sec. 9.5) | Ch. 9: Assessments: Question Bank #131 | Question Ba |
|---|---|---|---|

EOT LOs

A polar covalent bond would form in which one of the following pairs of atoms?

- Cl — Cl non polar
- Si — Si non polar
- ~~Ca — Cl~~
- ~~Cr — Br~~
- P — Cl

NM - NM

O = non polar

O - 2 polar

P - Cl
NM NM

Ca - Cl
M - NM

Cr - Br
M - NM

Which one of these polar covalent bonds would have the greatest *percent ionic character*?

- H — Br
- H — Cl
- H — F
- H — I

| 8. | Define electronegativity and appraise its role in predicting bond polarity. (Sec. 9.5) | Ch. 9: Assessments: Question Bank #131 | Question Ba |
|---|---|---|---|

EOT LOs

A polar covalent bond would form in which one of the following pairs of atoms?

- Cl — Cl
- Si — Si
- Ca — Cl
- Cr — Br
- P — Cl

Which one of these polar covalent bonds would have the greatest *percent ionic character*?

- H — Br
- H — Cl
- H — F
- H — I

NM

| | | | |
|---|---|---|---|
| 9. | Utilize the guidelines for writing Lewis structures of compounds and polyatomic ions. (Sec. 9.6) | Ch. 9 Sect. 9.6 Questions & Problems # 9.44 | 404 |

EOT LOs

5.44 Write Lewis structures for the following molecules and ions: (a) $OF_2$, (b) $N_2F_2$, (c) $Si_2H_6$, (d) $OH^-$, (e) $CH_2ClCOO^-$, (f) $CH_3NH_3^+$.

$OF_2$

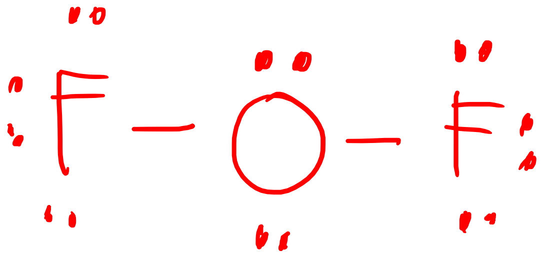
$6 + (7 \times 2) = 20$

$-4$

$16$

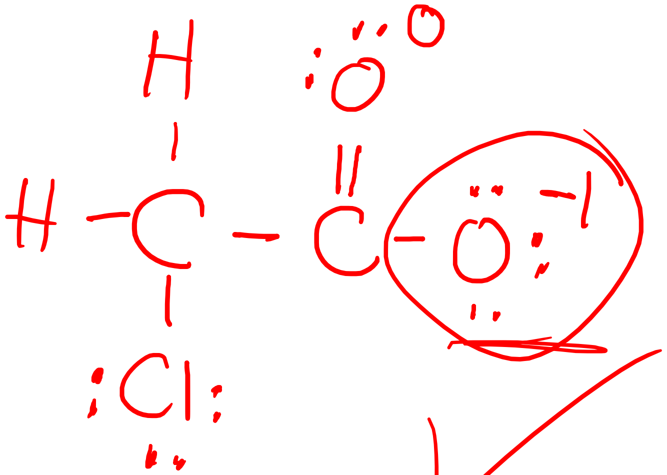
$-12$

$4$



FC = Ve − #ELP − Bow

$6 - 4 - 2 = 0$



O F

8

C, H, O, Cl

| | | | |
|---|---|---|---|
| 9. | Utilize the guidelines for writing Lewis structures of compounds and polyatomic ions. (Sec. 9.6) | Ch. 9 Sect. 9.6 Questions & Problems # 9.44 | 404 |

EOT LOs

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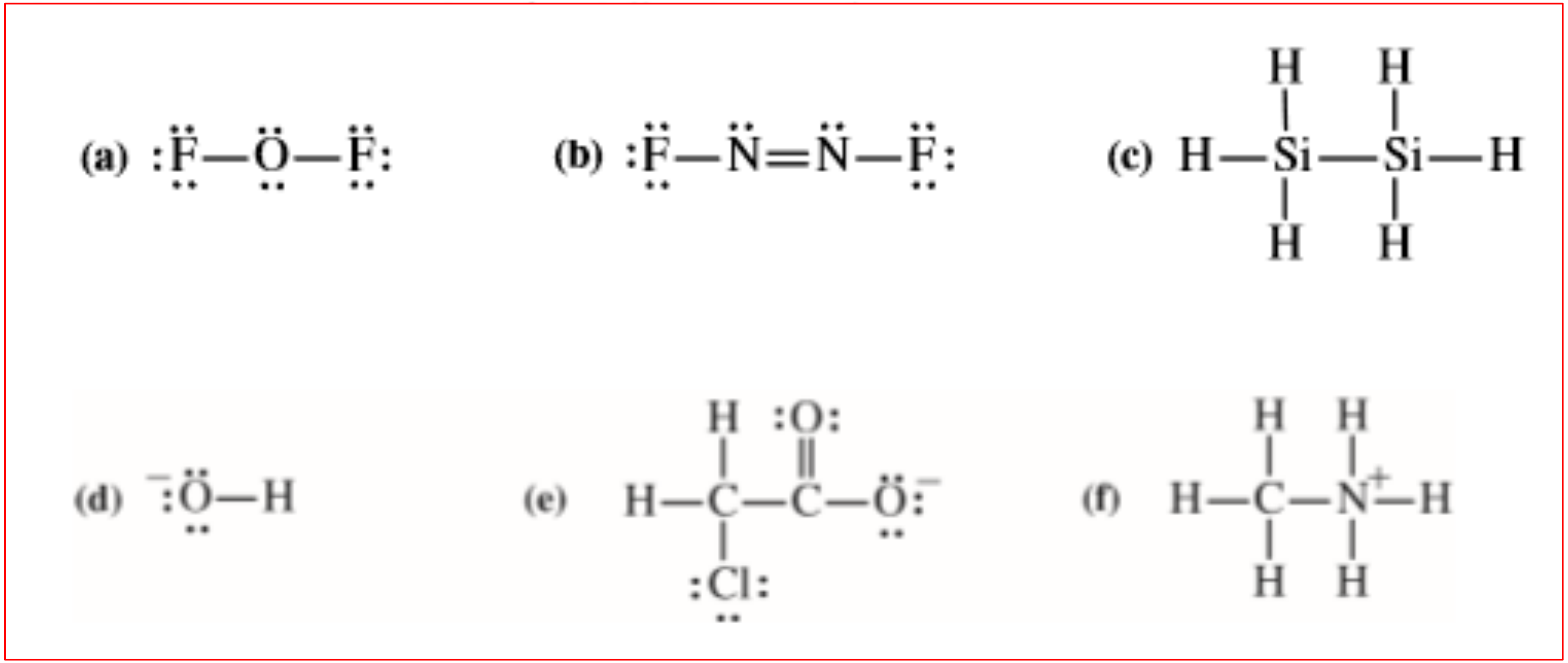


| | | | |
|---|---|---|---|
| 10. | Calculate formal charges on atoms in a Lewis structure. (Sec. 9.7) | Ch. 9: Assessments: Question Bank #131 | Question B |

EOT LOs

Nitrous oxide, $N_2O$, is sometimes called "laughing gas". What is the formal charge on the central nitrogen atom in the most favorable Lewis structure for nitrous oxide based on minimizing formal charge overall? (The atom connectivity is N–N–O.)

- –2
- –1
- 0
- +1
- +2

$N_2O$

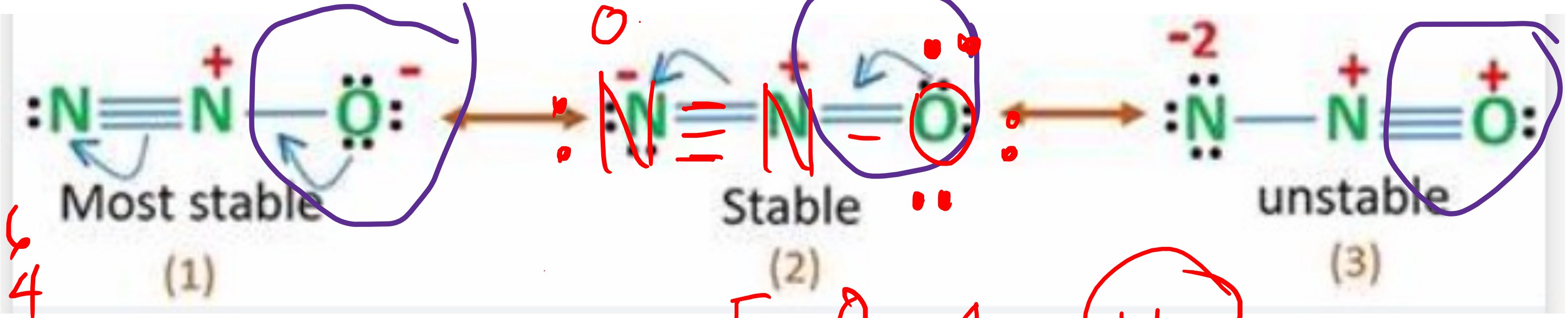
$(5 \times 2) + 6 = 16$

$-4$

$12$

$-12$

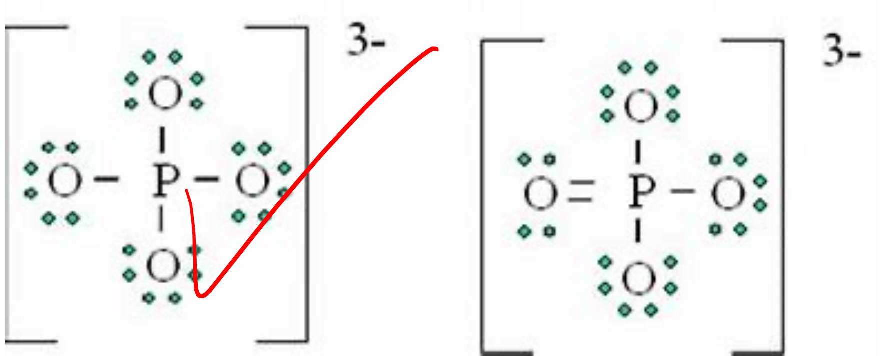
$0$




$5 - 0 - 4 = +1$

What is the formal charge on phosphorus in a Lewis structure for the phosphate ion that satisfies the octet rule?

- –2
- –1
- 0
- +1
- +2



| | | | |
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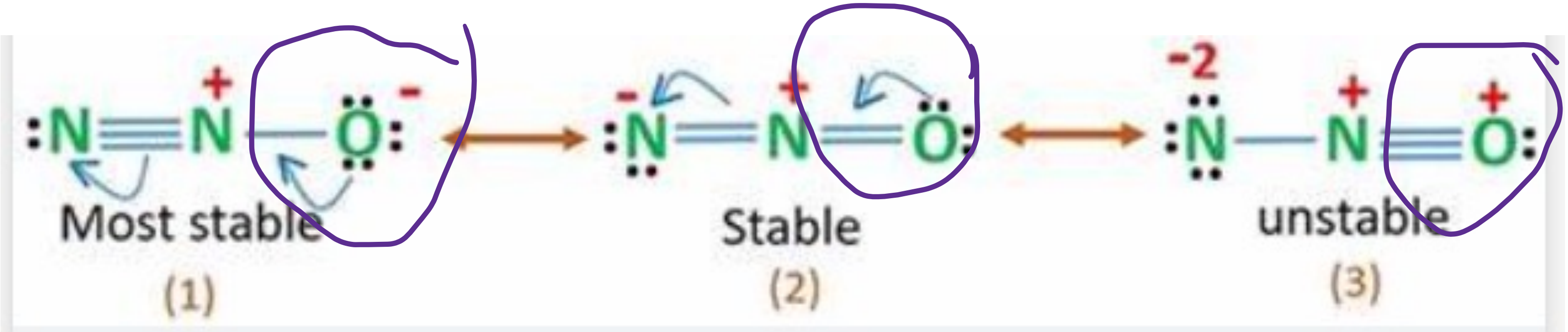


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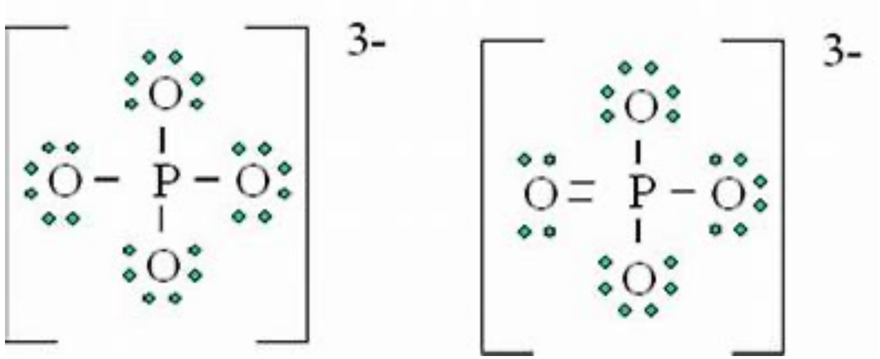

| | | | |
|---|---|---|---|
| 10. | Calculate formal charges on atoms in a Lewis structure. (Sec. 9.7) | Ch. 9: Assessments: Question Bank #131 | Question Bank |

What is the formal charge on the central nitrogen atom in the most favorable Lewis structure for the fulminate ion, $CNO^-$, based on minimizing formal charge overall?

- +2
- +1
- 0
- –1
- –2

In the Lewis structure of the iodate ion, $IO_3^-$, that satisfies the octet rule, the formal charge on the central iodine atom is

- +2.
- +1.
- 0.
- –1.
- –2.

| | | | |
|---|---|---|---|
| 10. | Calculate formal charges on atoms in a Lewis structure. (Sec. 9.7) | Ch. 9: Assessments: Question Bank #131 | Question Bank |

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- ○ 0
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In the Lewis structure of the iodate ion, $IO_3^-$, that satisfies the octet rule, the formal charge on the central iodine atom is

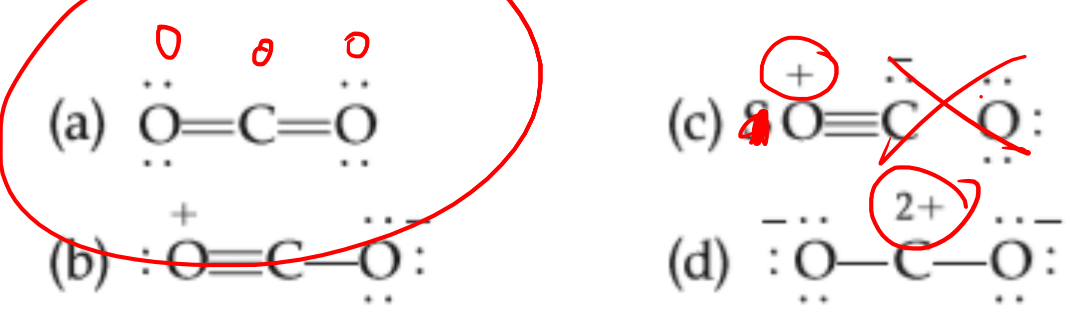
- ○ +2.
- ○ +1.
- ○ 0.
- ○ –1.
- ○ –2.

| | | | |
|---|---|---|---|
| 11. | Employ formal charges to identify the most likely structure of a compound when multiple Lewis structures are possible. (Sec. 9.7) | Ch. 9 Sect. 9.7 Questions & Problems # 9.104 | 406 |

EOT LOs

Several resonance structures for the molecule $CO_2$ are shown next. Explain why some of them are likely to be of little importance in describing the bonding in this molecule.

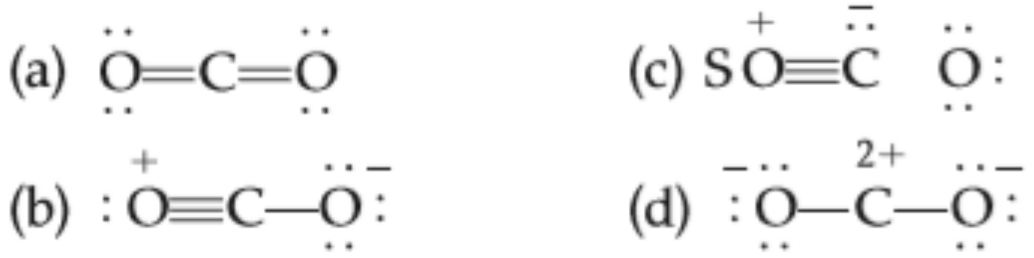
Lowest FC



| | | | |
|---|---|---|---|
| 11. | Employ formal charges to identify the most likely structure of a compound when multiple Lewis structures are possible. (Sec. 9.7) | Ch. 9 Sect. 9.7 Questions & Problems # 9.104 | 406 |

EOT LOs

Several resonance structures for the molecule $CO_2$ are shown next. Explain why some of them are likely to be of little importance in describing the bonding in this molecule.




**(a)** This is a very good resonance form; there are no formal charges and each atom satisfies the octet rule.

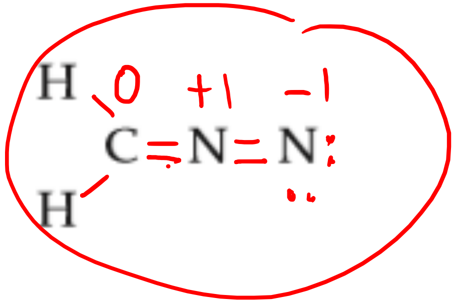
**(b)** This is a second choice after (a) because of the positive formal charge on the oxygen (high electronegativity).

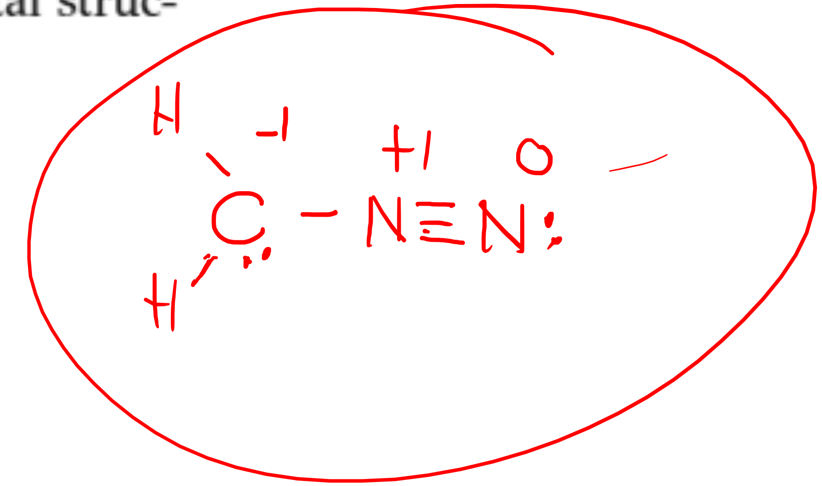
**(c)** This is a poor choice for several reasons. The formal charges are placed counter to the electronegativities of C and O, the oxygen atom does not have an octet, and there is no bond between that oxygen and carbon!

**(d)** This is a mediocre choice because of the large formal charge and lack of an octet on carbon.

| | | | | |
|---|---|---|---|---|
| 12. | Evaluate the concept of resonance and draw resonance structures of a given compound or polyatomic ion. (Sec. 9.8) | Ch. 9 Sect. 9.8 Questions & Problems # 9.58 | 404 | EOT LOs |

5.54 Draw two resonance structures for diazomethane, $CH_2N_2$. Show formal charges. The skeletal structure of the molecule is





$CH_2N_2$

$4+(2\times1)+(2\times5)$

$=16$

$-8$

$8$

$-6$

$2$

$-2$

$0$

| | | | |
|---|---|---|---|
| 12. | Evaluate the concept of resonance and draw resonance structures of a given compound or polyatomic ion. (Sec. 9.8) | Ch. 9 Sect. 9.8 Questions & Problems # 9.58 | 404 |

EOT LOs

5.54 Draw two resonance structures for diazomethane, $CH_2N_2$. Show formal charges. The skeletal structure of the molecule is

The structures of the most important resonance forms are:

| | | | |
|---|---|---|---|
| 13. | Write Lewis structures for species that do not obey the octet rule. (Sec. 9.9) | Ch. 9: Assessments: Question Bank #59 | Question Bank |

Which of the following substances will display an incomplete octet in its Lewis structure?

- $CO_2$
- $Cl_2$
- ICl
- NO
- $SO_2$

Which of the elements listed below is most likely to exhibit an expanded octet in its compounds?

- O
- S
- Na
- C
- N

| 13. | Write Lewis structures for species that do not obey the octet rule. (Sec. 9.9) | Ch. 9: Assessments: Question Bank #59 | Question Bank |
|---|---|---|---|

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- S
- Na
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| | | | |
|---|---|---|---|
| 13. | Write Lewis structures for species that do not obey the octet rule. (Sec. 9.9) | Ch. 9: Assessments: Question Bank #59 | Question B |

EOT LOs

Which one of the following compounds does not follow the octet rule?

- $NF_3$
- $CF_4$
- $PF_5$
- $AsH_3$
- HCl

Which response includes all the molecules below that do not follow the octet rule?
(1) $H_2S$ (2) $BCl_3$ (3) $PH_3$ (4) $SF_4$

- (2) and (4)
- (2) and (3)
- (1) and (2)
- (3) and (4)
- (1) and (4)

| | | | |
|---|---|---|---|
| 13. | Write Lewis structures for species that do not obey the octet rule. (Sec. 9.9) | Ch. 9: Assessments: Question Bank #59 | Question B |

EOT LOs

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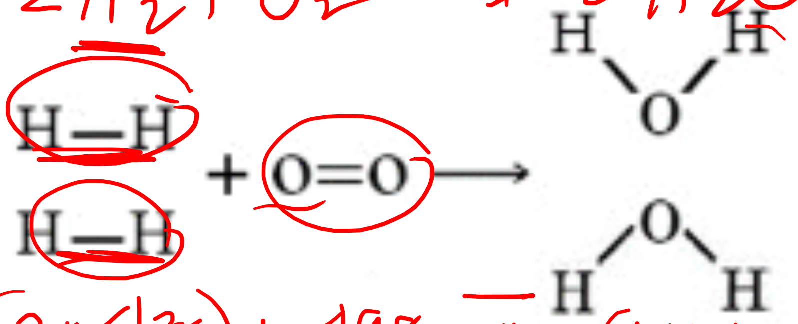
- (2) and (4)
- (2) and (3)
- (1) and (2)
- (3) and (4)
- (1) and (4)

| | | | |
|---|---|---|---|
| 14. | Demonstrate the use of bond enthalpies to estimate the enthalpy change in a reaction. (Sec. 9.10) | Ch. 9: Assessments: Question Bank #77 | Question Bank |

<u>Example</u>: Calculate the enthalpy change when water is formed from $H_2$ and $O_2$.

$2H_2 + O_2 \rightarrow 2H_2O$



$(2 \times 436) + 498 \rightarrow (4 \times 464)$

**STEP 1 Bonds Broken**

2 x (H-H) = 2 x 436 = 872

1 x (O=O) = 498

Total = 872 + 498 = 1370

**STEP 2 Bonds Made**

4 x (O-H) = 4 x 464 = 1856

| Bond | Bond Enthalpy |
|---|---|
| H-H | 436 |
| H-O | 464 |
| O=O | 498 |

**STEP 3**

Reacta Product

Enthalpy change = bonds broken – bonds made

= 1370 – 1856 = -486

− exo
+ endo

The negative sign means its exothermic.

| 14. | Demonstrate the use of bond enthalpies to estimate the enthalpy change in a reaction. (Sec. 9.10) | Ch. 9: Assessments: Question Bank #77 | Question B |
|---|---|---|---|

EOT LOs

Use bond energies to estimate the enthalpy of formation of HBr(g).

BE(H–H) = 436 kJ/mol
BE(Br–Br) = 192 kJ/mol
BE(H–Br) = 366 kJ/mol

- +262 kJ/mol
- +104 kJ/mol
- +52 kJ/mol
- –52 kJ/mol
- –104 kJ/mol

$H_2 + Br_2 \rightarrow 2HBr$

H-H Br-Br Product 2 H-Br

$$\Delta H^\circ = \Sigma BE(\text{reactants}) - \Sigma BE(\text{products})$$
$$= \text{total energy input} - \text{total energy released}$$

$(436 + 192) - (2 \times 366)$

$\boxed{\Delta H = -104}$ exothermic (release)

| 14. | Demonstrate the use of bond enthalpies to estimate the enthalpy change in a reaction. (Sec. 9.10) | Ch. 9: Assessments: Question Bank #77 | Question B |
|---|---|---|---|

EOT LOs

Use bond energies to estimate the enthalpy of formation of HBr(g).
BE(H–H) = 436 kJ/mol
BE(Br–Br) = 192 kJ/mol
BE(H–Br) = 366 kJ/mol

- +262 kJ/mol
- +104 kJ/mol
- +52 kJ/mol
- –52 kJ/mol
- –104 kJ/mol

$$\Delta H^\circ = \Sigma BE(\text{reactants}) - \Sigma BE(\text{products})$$
$$= \text{total energy input} - \text{total energy released}$$

| 14. | Demonstrate the use of bond enthalpies to estimate the enthalpy change in a reaction. (Sec. 9.10) | Ch. 9: Assessments: Question Bank #77 | Question Bank |
|---|---|---|---|

Estimate the enthalpy change for the combustion of one mole of acetylene, $C_2H_2$, to form carbon dioxide and water vapor.

BE(C–H) = 456 kJ/mol
BE(C≡C) = 962 kJ/mol
BE(O=O) = 499 kJ/mol
BE(C=O) = 802 kJ/mol
BE(O–H) = 462 kJ/mol

- ○ +1010 kJ/mol
- ○ +653 kJ/mol
- ○ –155 kJ/mol
- ○ –1010 kJ/mol
- ○ –1759 kJ/mol

$C_2H_2 + O_2 \rightarrow CO_2 + H_2O$

H–C≡C–H O=O → O=C=O H–O–H

$\Delta H^\circ = \Sigma BE(\text{reactants}) - \Sigma BE(\text{products})$
$= \text{total energy input} - \text{total energy released}$

$$\left[\begin{pmatrix} \overset{2\ C-H}{2 \times 456} \\ +\ 962 \end{pmatrix} + 499\right] \rightarrow \left[\overset{2\ C=O}{(2 \times 802)} + \overset{2\ O-H}{(2 \times 462)}\right]$$

$2373 - 2528$

$\boxed{\Delta H^\circ = -155}$

| 14. | Demonstrate the use of bond enthalpies to estimate the enthalpy change in a reaction. (Sec. 9.10) | Ch. 9: Assessments: Question Bank #77 | Question Bank |
|---|---|---|---|

Estimate the enthalpy change for the combustion of one mole of acetylene, $C_2H_2$, to form carbon dioxide and water vapor.
BE(C–H) = 456 kJ/mol
BE(C≡C) = 962 kJ/mol
BE(O=O) = 499 kJ/mol
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BE(O–H) = 462 kJ/mol

- ○ +1010 kJ/mol
- ○ +653 kJ/mol
- ○ –155 kJ/mol
- ○ –1010 kJ/mol
- ○ –1759 kJ/mol

$$\begin{aligned}\Delta H^\circ &= \Sigma \mathrm{BE(reactants)} - \Sigma \mathrm{BE(products)} \\ &= \text{total energy input} - \text{total energy released}\end{aligned}$$

| 14. | Demonstrate the use of bond enthalpies to estimate the enthalpy change in a reaction. (Sec. 9.10) | Ch. 9: Assessments: Question Bank #77 | Question Bank |
|---|---|---|---|

Use bond energies to estimate the enthalpy change for the reaction of one mole of $CH_4$ with chlorine gas to give $CH_3Cl$ and hydrogen chloride.

BE(C–H) = 414 kJ/mol
BE(C–Cl) = 326 kJ/mol
BE(H–Cl) = 432 kJ/mol
BE(Cl–Cl) = 243 kJ/mol

- ○ –106 kJ/mol
- ○ –101 kJ/mol
- ○ +101 kJ/mol
- ○ +106 kJ/mol
- ○ +331 kJ/mol

$$\begin{aligned}\Delta H^\circ &= \Sigma\text{BE(reactants)} - \Sigma\text{BE(products)} \\ &= \text{total energy input} - \text{total energy released}\end{aligned}$$

| | | | |
|---|---|---|---|
| 14. | Demonstrate the use of bond enthalpies to estimate the enthalpy change in a reaction. (Sec. 9.10) | Ch. 9: Assessments: Question Bank #77 | Question Bank |

Use bond energies to estimate the enthalpy change for the reaction of one mole of $CH_4$ with chlorine gas to give $CH_3Cl$ and hydrogen chloride.

BE(C–H) = 414 kJ/mol
BE(C–Cl) = 326 kJ/mol
BE(H–Cl) = 432 kJ/mol
BE(Cl–Cl) = 243 kJ/mol

- –106 kJ/mol
- –101 kJ/mol
- +101 kJ/mol
- +106 kJ/mol
- +331 kJ/mol

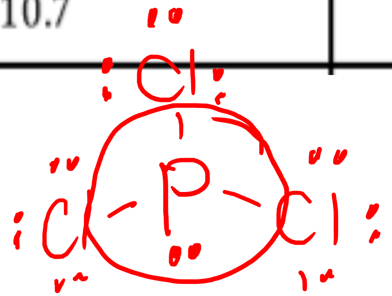
$$\Delta H^\circ = \Sigma \text{BE(reactants)} - \Sigma \text{BE(products)}$$
$$= \text{total energy input} - \text{total energy released}$$

| 15. | Apply the valence-shell electron-pair repulsion (VSEPR) model to predict the shape of a molecule or polyatomic ion. (Sec 10.1) | Ch. 10 Sect. 10.1 Questions & Problems # 10.7 | 454 |
|---|---|---|---|

EOT LOs

6.7 Predict the geometries of the following species using the VSEPR method: (a) $PCl_3$, (b) $CHCl_3$, (c) $SiH_4$, (d) $TeCl_4$.

$PCl_3$
$5+(7\times3)$
$=26$



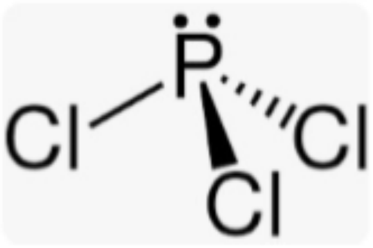
$26 - 6 = 20$
$20 - 18 = 2$

| | |
|---|---|
| Total number of Domains(Electron Pairs) | 4 |
| Number of Bonding Pairs | 3 |
| Number of Lone Pairs | 1 |
| Arrangement of Electron Pairs | tetrahedral |
| Molecular Geometry/Shapes | trigonal pyramidal |
| Bond Angle | 109.5 |
| Hybridization | $sp^3$ |

| Total Domains | Generic Formula | Picture | Bonded Atoms | Lone Pairs | Molecular Shape | Electron Geometry | Example | Hybridi-zation | Bond Angles |
|---|---|---|---|---|---|---|---|---|---|
| 1 | AX | A — X | 1 | 0 | Linear | Linear | $H_2$ | s | 180 |
| 2 | $AX_2$ | X — A — X | 2 | 0 | Linear | Linear | $CO_2$ | sp | 180 |
| | AXE | | 1 | 1 | Linear | Linear | $CN^-$ | | |
| 3 | $AX_3$ | | 3 | 0 | Trigonal planar | Trigonal planar | $AlBr_3$ | $sp^2$ | 120 |
| | $AX_2E$ | | 2 | 1 | Bent | Trigonal planar | $SnCl_2$ | | |
| | $AXE_2$ | | 1 | 2 | Linear | Trigonal planar | $O_2$ | | |
| 4 | $AX_4$ | | 4 | 0 | Tetrahedral | Tetrahedral | $SiCl_4$ | $sp^3$ | 109.5 |
| | $AX_3E$ | | 3 | 1 | Trigonal pyramid | Tetrahedral | $PH_3$ | | |
| | $AX_2E_2$ | | 2 | 2 | Bent | Tetrahedral | $SeBr_2$ | | |
| | $AXE_3$ | | 1 | 3 | Linear | Tetrahedral | $Cl_2$ | | |

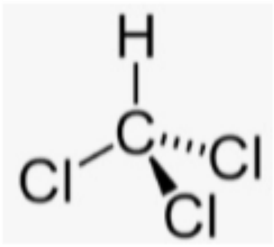
| | | | | |
|---|---|---|---|---|
| 15. | Apply the valence-shell electron-pair repulsion (VSEPR) model to predict the shape of a molecule or polyatomic ion. (Sec 10.1) | Ch. 10 Sect. 10.1 Questions & Problems # 10.7 | 454 | EOT LOs |

6.7 Predict the geometries of the following species using the VSEPR method: (a) $PCl_3$, (b) $CHCl_3$, (c) $SiH_4$, (d) $TeCl_4$.

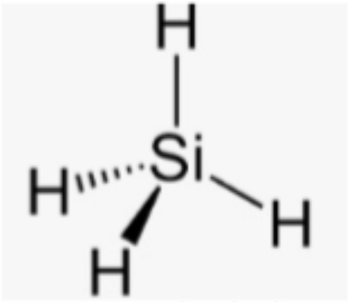



Trigonal Pyramidal

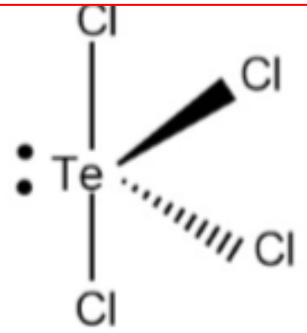
P= 5 ve
Bonding with 3 Cl
So 5+3=8/2= 4pairs
3 bonding pairs and 1 lone pair
For 4 pair of electron the regular geometry is tetrahedral, since one lone pair is present the shape changes to trigonal.




Tetrahedral
C= 4ve
Bonding with 4 other atom.
So, 4+4 = 8/2=4 pairs
All four pairs are bonding.
So its having a regular tetrahedral geometry.




Tetrahedral
Si= 4ve
Bonding with 4 other atom.
So, 4+4 = 8/2=4 pairs
All four pairs are bonding.
So its having a regular tetrahedral geometry.




Sea Saw
Te= 6ve
So, 6+4= 10/2=5 pairs
4 bonding and 1 lone pair. For a molecule with 5 pair of electron is trigonal bipyramidal since a lone pair is present it changes into Sea Saw

| | | | | |
|---|---|---|---|---|
| 16. | Predict deviations from ideal bond angles in structures based on presence of lone pairs on a central atom. (Sec 10.1) | Ch. 10 Sect. 10.1 Questions & Problems # 10.14 | 454 | EOT LOs |

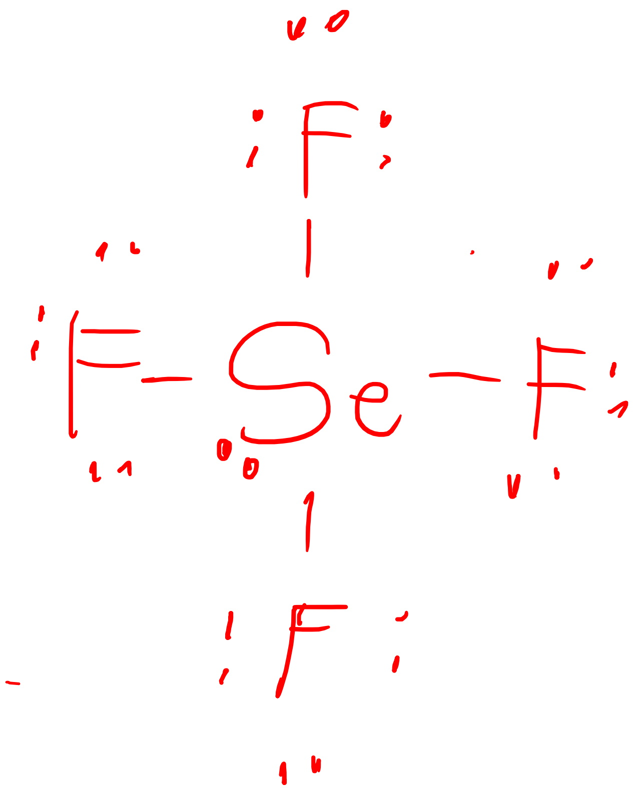
**6.14** Which of the following species are tetrahedral?
$SiCl_4$, ~~$SeF_4$~~, ~~$XeF_4$~~, $CI_4$, $CdCl_4^{2-}$

$SiCl_4$ – tetrahedral

$SeF_4$

$6 + 7 \times 4$

$= 34$
$-8$
$26$
$-24$ ✓



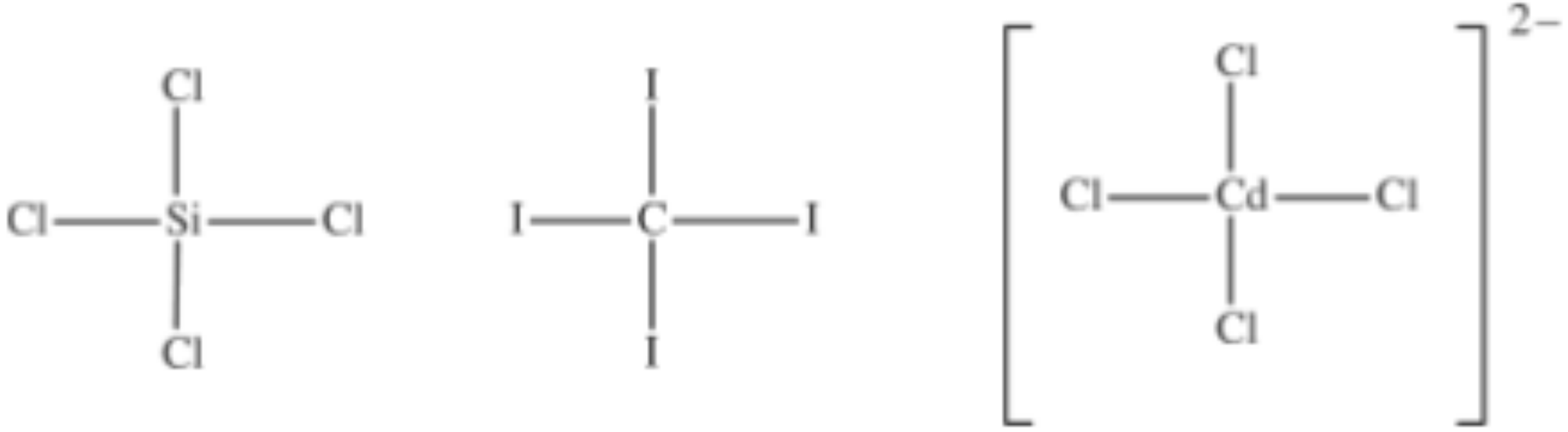
trigonal bipyramidal

| | | | |
|---|---|---|---|
| 16. | Predict deviations from ideal bond angles in structures based on presence of lone pairs on a central atom. (Sec 10.1) | Ch. 10 Sect. 10.1 Questions & Problems # 10.14 | 454 |

EOT LOs

**6.14** Which of the following species are tetrahedral?
$SiCl_4$, $SeF_4$, $XeF_4$, $CI_4$, $CdCl_4^{2-}$

**10.14** Only molecules with four bonds to the central atom and no lone pairs are tetrahedral ($AB_4$).



What are the Lewis structures and shapes for $XeF_4$ and $SeF_4$?

| 17. | Predict deviations from ideal bond angles in structures based on presence of lone pairs on a central atom. (Sec 10.1) | Ch. 10: Assessments: Question Bank #38 | Question |
|---|---|---|---|

EOT LOs

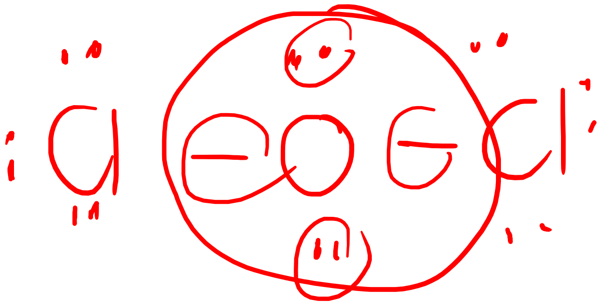
June 8, 2022

The bond angle in $Cl_2O$ is expected to be approximately

- 90°.
- 109.5°.
- 120°.
- 145°.
- 180°.

$Cl_2O$

$$\begin{array}{r} 20 \\ -\ 4 \\ \hline 16 \\ -\ 12 \\ \hline 4 \end{array}$$



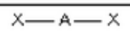
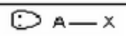
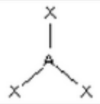
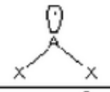
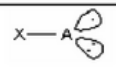
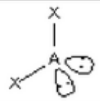
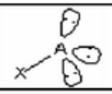
| Total Domains | Generic Formula | Picture | Bonded Atoms | Lone Pairs | Molecular Shape | Electron Geometry | Example | Hybridization | Bond Angles |
|---|---|---|---|---|---|---|---|---|---|
| 1 | AX | A — X | 1 | 0 | Linear | Linear | $H_2$ | s | 180 |
| 2 | $AX_2$ | X — A — X | 2 | 0 | Linear | Linear | $CO_2$ | sp | 180 |
| | AXE | A — X | 1 | 1 | Linear | Linear | $CN^-$ | | |
| 3 | $AX_3$ | | 3 | 0 | Trigonal planar | Trigonal planar | $AlBr_3$ | $sp^2$ | 120 |
| | $AX_2E$ | | 2 | 1 | Bent | Trigonal planar | $SnCl_2$ | | |
| | $AXE_2$ | X — A | 1 | 2 | Linear | Trigonal planar | $O_2$ | | |
| 4 | $AX_4$ | | 4 | 0 | Tetrahedral | Tetrahedral | $SiCl_4$ | $sp^3$ | 109.5 |
| | $AX_3E$ | | 3 | 1 | Trigonal pyramid | Tetrahedral | $PH_3$ | | |
| | $AX_2E_2$ | | 2 | 2 | Bent | Tetrahedral | $SeBr_2$ | | |
| | $AXE_3$ | | 1 | 3 | Linear | Tetrahedral | $Cl_2$ | | |

| | | | |
|---|---|---|---|
| 17. | Predict deviations from ideal bond angles in structures based on presence of lone pairs on a central atom. (Sec 10.1) | Ch. 10: Assessments: Question Bank #38 | Question |

EOT LOs

The bond angle in $Cl_2O$ is expected to be approximately

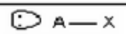
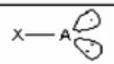
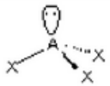
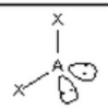
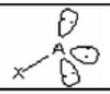
- 90°.
- 109.5°.
- 120°.
- 145°.
- 180°.

| Total Domains | Generic Formula | Picture | Bonded Atoms | Lone Pairs | Molecular Shape | Electron Geometry | Example | Hybridi -zation | Bond Angles |
|---|---|---|---|---|---|---|---|---|---|
| 1 | AX |  | 1 | 0 | Linear | Linear | $H_2$ | s | 180 |
| 2 | $AX_2$ |  | 2 | 0 | Linear | Linear | $CO_2$ | sp | 180 |
| | AXE |  | 1 | 1 | Linear | Linear | $CN^-$ | | |
| 3 | $AX_3$ |  | 3 | 0 | Trigonal planar | Trigonal planar | $AlBr_3$ | $sp^2$ | 120 |
| | $AX_2E$ |  | 2 | 1 | Bent | Trigonal planar | $SnCl_2$ | | |
| | $AXE_2$ |  | 1 | 2 | Linear | Trigonal planar | $O_2$ | | |
| 4 | $AX_4$ |  | 4 | 0 | Tetrahedral | Tetrahedral | $SiCl_4$ | $sp^3$ | 109.5 |
| | $AX_3E$ |  | 3 | 1 | Trigonal pyramid | Tetrahedral | $PH_3$ | | |
| | $AX_2E_2$ |  | 2 | 2 | Bent | Tetrahedral | $SeBr_2$ | | |
| | $AXE_3$ |  | 1 | 3 | Linear | Tetrahedral | $Cl_2$ | | |

| | | | |
|---|---|---|---|
| 17. | Predict deviations from ideal bond angles in structures based on presence of lone pairs on a central atom. (Sec 10.1) | Ch. 10: Assessments: Question Bank #38 | Question Bank |

The C–N–O bond angle in nitromethane, $CH_3NO_2$, is expected to be approximately

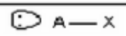
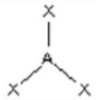
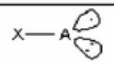
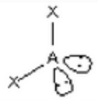
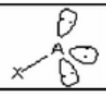
- 60°.
- 90°.
- 109.5°.
- 120°.
- 180°.

| Total Domains | Generic Formula | Picture | Bonded Atoms | Lone Pairs | Molecular Shape | Electron Geometry | Example | Hybridi -zation | Bond Angles |
|---|---|---|---|---|---|---|---|---|---|
| 1 | AX |  | 1 | 0 | Linear | Linear | $H_2$ | s | 180 |
| 2 | $AX_2$ |  | 2 | 0 | Linear | Linear | $CO_2$ | sp | 180 |
| | AXE |  | 1 | 1 | Linear | Linear | $CN^-$ | | |
| 3 | $AX_3$ |  | 3 | 0 | Trigonal planar | Trigonal planar | $AlBr_3$ | $sp^2$ | 120 |
| | $AX_2E$ |  | 2 | 1 | Bent | Trigonal planar | $SnCl_2$ | | |
| | $AXE_2$ |  | 1 | 2 | Linear | Trigonal planar | $O_2$ | | |
| 4 | $AX_4$ |  | 4 | 0 | Tetrahedral | Tetrahedral | $SiCl_4$ | $sp^3$ | 109.5 |
| | $AX_3E$ |  | 3 | 1 | Trigonal pyramid | Tetrahedral | $PH_3$ | | |
| | $AX_2E_2$ |  | 2 | 2 | Bent | Tetrahedral | $SeBr_2$ | | |
| | $AXE_3$ |  | 1 | 3 | Linear | Tetrahedral | $Cl_2$ | | |

| | | | |
|---|---|---|---|
| 17. | Predict deviations from ideal bond angles in structures based on presence of lone pairs on a central atom. (Sec 10.1) | Ch. 10: Assessments: Question Bank #38 | Question Bank |

The C–N–O bond angle in nitromethane, $CH_3NO_2$, is expected to be approximately

- 60°.
- 90°.
- 109.5°.
- 120°.
- 180°.

| Total Domains | Generic Formula | Picture | Bonded Atoms | Lone Pairs | Molecular Shape | Electron Geometry | Example | Hybridi -zation | Bond Angles |
|---|---|---|---|---|---|---|---|---|---|
| 1 | AX | A — X | 1 | 0 | Linear | Linear | $H_2$ | s | 180 |
| 2 | $AX_2$ | X — A — X | 2 | 0 | Linear | Linear | $CO_2$ | sp | 180 |
| | AXE |  | 1 | 1 | Linear | Linear | $CN^-$ | | |
| 3 | $AX_3$ |  | 3 | 0 | Trigonal planar | Trigonal planar | $AlBr_3$ | | |
| | $AX_2E$ |  | 2 | 1 | Bent | Trigonal planar | $SnCl_2$ | $sp^2$ | 120 |
| | $AXE_2$ |  | 1 | 2 | Linear | Trigonal planar | $O_2$ | | |
| 4 | $AX_4$ |  | 4 | 0 | Tetrahedral | Tetrahedral | $SiCl_4$ | | |
| | $AX_3E$ |  | 3 | 1 | Trigonal pyramid | Tetrahedral | $PH_3$ | $sp^3$ | 109.5 |
| | $AX_2E_2$ |  | 2 | 2 | Bent | Tetrahedral | $SeBr_2$ | | |
| | $AXE_3$ |  | 1 | 3 | Linear | Tetrahedral | $Cl_2$ | | |

| | | | |
|---|---|---|---|
| 18. | Assess whether or not a molecule will have a dipole moment. (Sec 10.2) | Ch. 10: Assessments: Question Bank #16 | Question B |

EOT LOs

POLAR = assymmetrical NON-POLAR = symmetrical

dipole → + −

Which one of the following molecules has a zero dipole moment?

- CO
- $CH_2Cl_2$
- $SO_3$
- $SO_2$
- $NH_3$

$PCl_3$ polar

$OCl_2$ Cl–O–Cl polar

$6+7\times2$

20
−4
16
−12
4

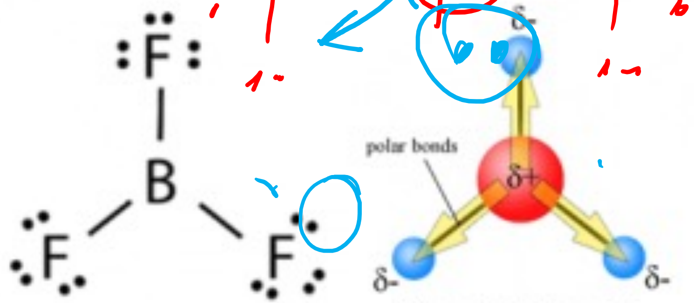
$BF_3$

$3+(7\times3) = 24$
−6
18

Cancel

Which of the following molecules has polar bonds but is a nonpolar molecule?

- $PCl_3$
- $NCl_3$
- $BF_3$
- HF
- $OCl_2$



Boron Trifluoride

| | | | |
|---|---|---|---|
| 18. | Assess whether or not a molecule will have a dipole moment. (Sec 10.2) | Ch. 10: Assessments: Question Bank #16 | Question B |

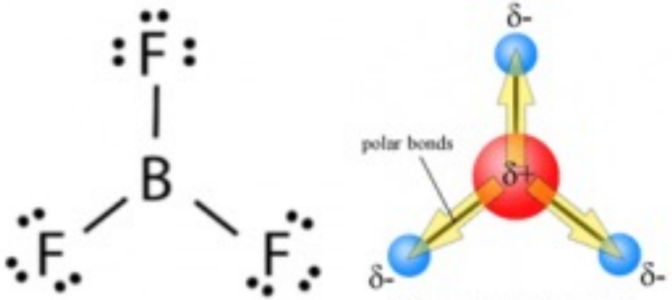
EOT LOs

Which one of the following molecules has a zero dipole moment?

- CO
- $CH_2Cl_2$
- $SO_3$
- $SO_2$
- $NH_3$

Which of the following molecules has *polar* bonds but is a *nonpolar* molecule?

- $PCl_3$
- $NCl_3$
- $BF_3$
- HF
- $OCl_2$

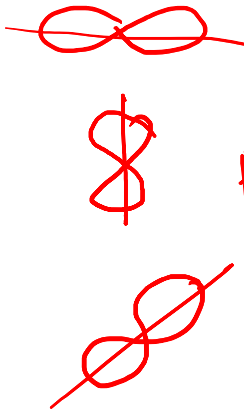



Boron Trifluoride

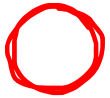
| | | | |
|---|---|---|---|
| 19. | Employ valence bond theory to describe the bonding in covalent molecules. (Sec. 10.3) | Chapter 6, Section 6.3 Questions & Problems # 6.26 | Page3 EOT LOs |

6.26 Use valence bond theory to explain the bonding in $Cl_2$ and HCl. Show how the atomic orbitals overlap when a bond is formed.

Cl = p



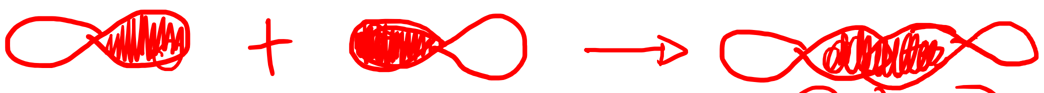

H = s



σ = single bond

Cl – Cl

P P



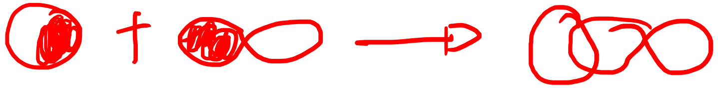
σ p+p bond

NaCl ionic

s p

H – F

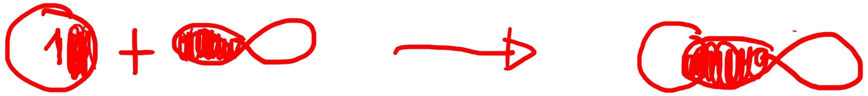
s p



σ s,p bond

H – Cl

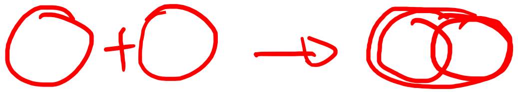
s p



σ s p bond

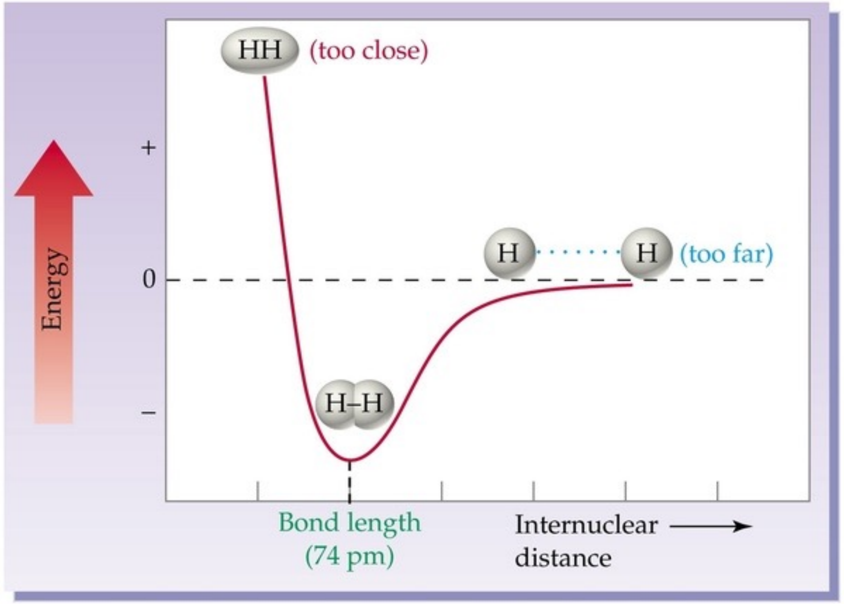
$H_2$ ⇒ H–H

s s

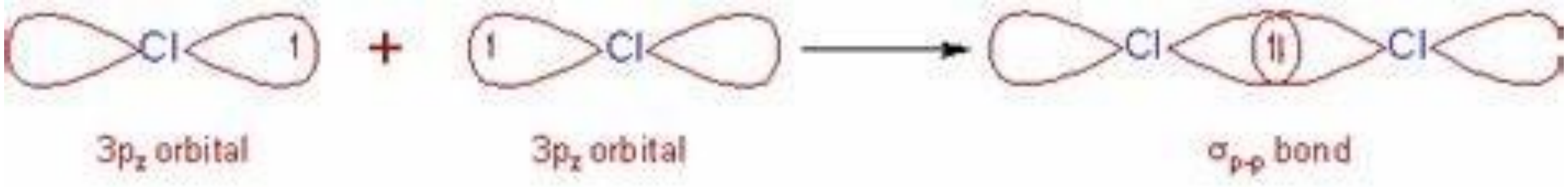


$Br_2$

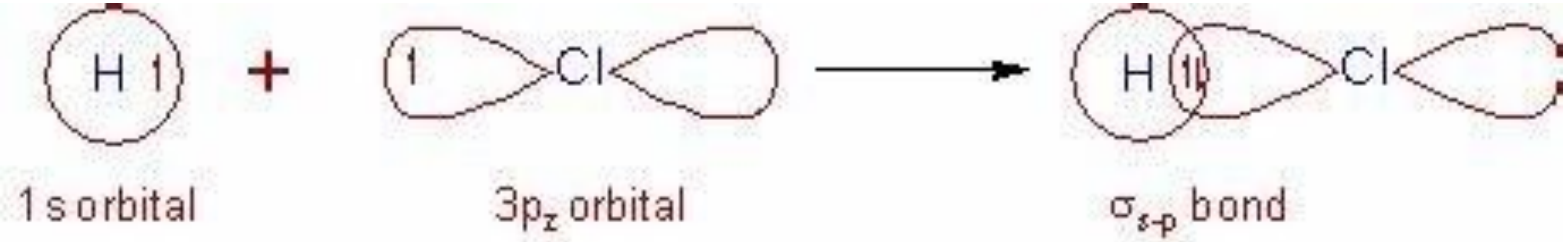
6.26 Use valence bond theory to explain the bonding in $Cl_2$ and HCl. Show how the atomic orbitals overlap when a bond is formed.




## $Cl_2$




## HCl



| 19. | Employ valence bond theory to describe the bonding in covalent molecules. (Sec. 10.3) | Chapter 6, Section 6.3 Questions & Problems # 6.26 | Page341 |
|---|---|---|---|

6.31 Describe the bonding scheme of the $AsH_3$ molecule in terms of hybridization.

| | | | |
|---|---|---|---|
| 19. | Employ valence bond theory to describe the bonding in covalent molecules. (Sec. 10.3) | Chapter 6, Section 6.3 Questions & Problems # 6.26 | Page341 |

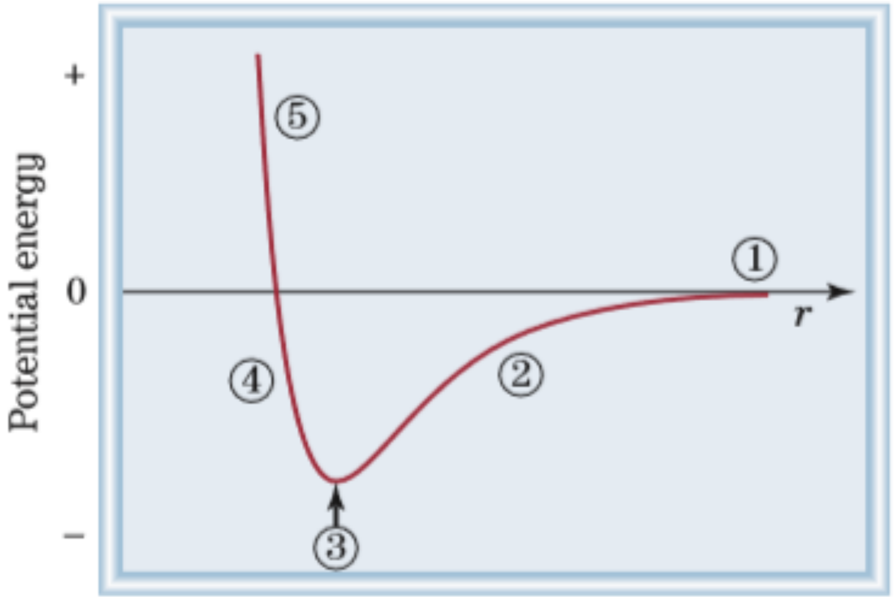
6.31 Describe the bonding scheme of the $AsH_3$ molecule in terms of hybridization.

$AsH_3$ has the Lewis structure shown below. There are three bond pairs and one lone pair. The four electron pairs have a tetrahedral arrangement, and the molecular geometry is trigonal pyramidal ($AB_3E$) like ammonia (See Table 10.2). The As (arsenic) atom is in an $sp^3$ hybridization state.

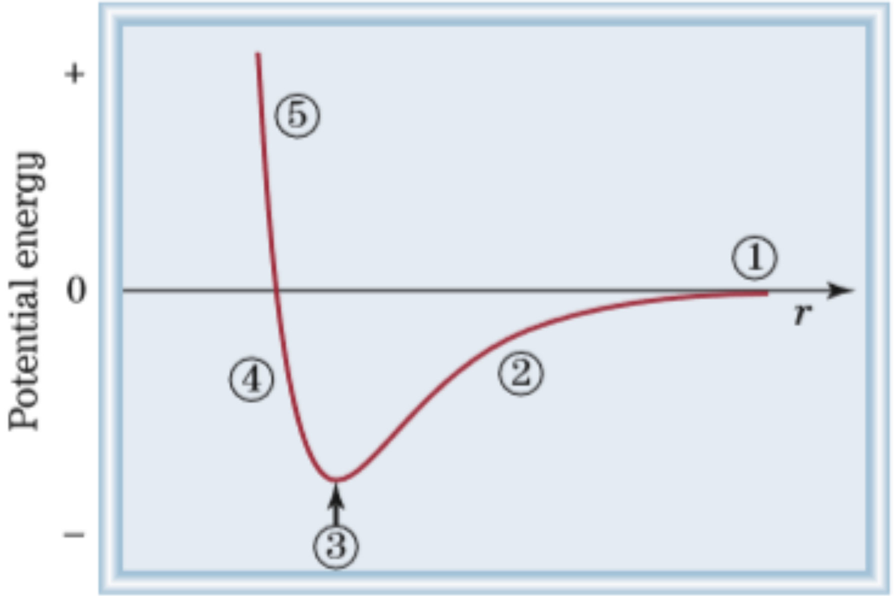

Three of the $sp^3$ hybrid orbitals form bonds to the hydrogen atoms by overlapping with the hydrogen 1*s* orbitals. The fourth $sp^3$ hybrid orbital holds the lone pair.

| 19. | Employ valence bond theory to describe the bonding in covalent molecules. (Sec. 10.3) | Chapter 6, Section 6.3 Questions & Problems # 6.26 | Page341 |
|---|---|---|---|

**6.62** The following potential energy curve represents the formation of $F_2$ from two F atoms. Describe the state of bonding at the marked regions.



**6.62** The following potential energy curve represents the formation of $F_2$ from two F atoms. Describe the state of bonding at the marked regions.




1) Atoms are far apart. There is no interaction.
2) Atoms approach each other. Attractive forces are stronger than repulsive forces, so the potential energy of the system decreases. The 2*p* orbitals on F begin to overlap.
3) The system is most stable; potential energy reaches a minimum. This point represents the equilibrium bond length of $F_2$. There is significant orbital overlap, and the electrons spend time in the region between nuclei where they can interact with both nuclei.
4) As the distance between nuclei continues to decrease, nuclear-nuclear and electron-electron repulsions increase leading to an increase in potential energy.
5) If the distance between nuclei were to decrease further, the potential energy would continue to rise until it becomes positive. The $F_2$ molecule is no longer stable.

According to Valence Bond Theory which orbital is left vacant in the molecule $BF_3$?

- $sp^3$
- $sp^2$
- $sp$
- $p$
- $s$

$BF_3$

↓ ↓

p p

According to Valence Bond Theory, which orbital is left vacant in the molecule $BH_3$?

- $sp^3$
- $sp^2$
- $sp$
- $p$
- $s$

| 20. | Determine the hybridization of an atom in a molecule or polyatomic ion. (Sec. 10.4) |
|---|---|

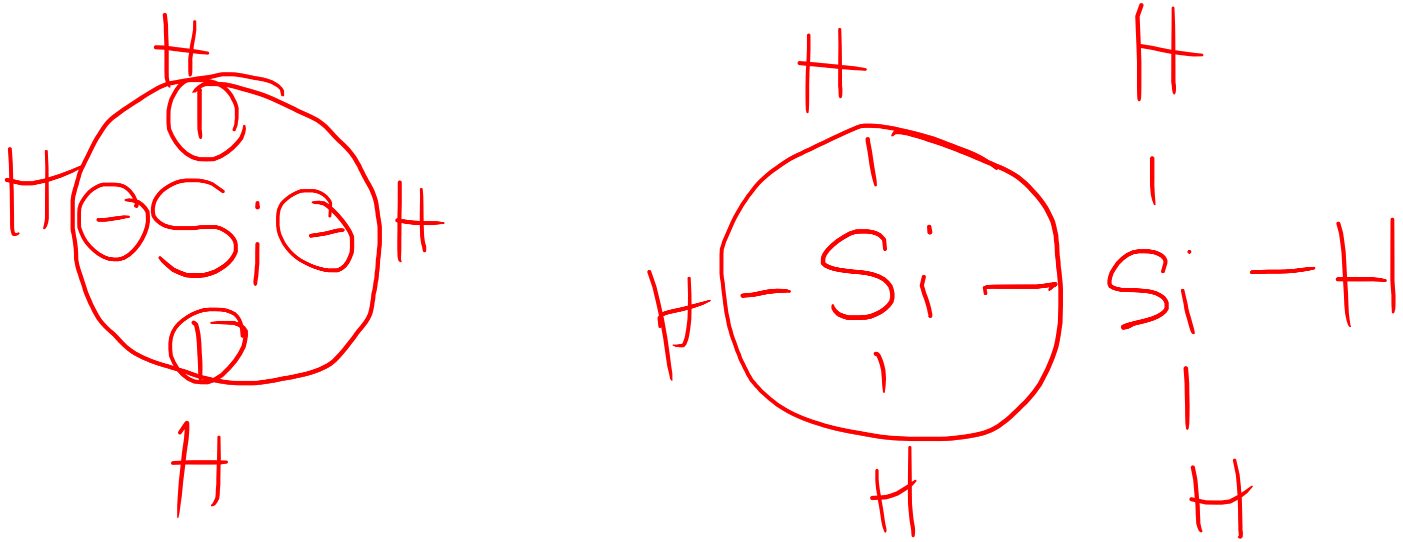


**6.32** What is the hybridization state of Si in $SiH_4$ and in $H_3Si—SiH_3$?

$SiH_4$

$4 + (4 \times 1)$

$= 8$



$sp^3$

| 20. | Determine the hybridization of an atom in a molecule or polyatomic ion. (Sec. 10.4) | Chapter 6, Section 6.4 Questions & Problems # 6.32 | Page3 |
|---|---|---|---|

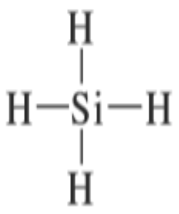
EOT LOs

## 6.32 What is the hybridization state of Si in $SiH_4$ and in $H_3Si—SiH_3$?

**Strategy:** The steps for determining the hybridization of the central atom in a molecule are:

draw Lewis Structure of the molecule → use VSEPR to determine the electron pair arrangement surrounding the central atom (Table 10.1 of the text) → use Table 10.4 of the text to determine the hybridization state of the central atom

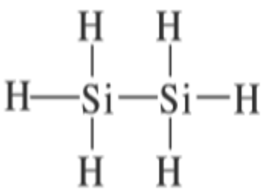
Write the Lewis structure of the molecule.



Count the number of electron pairs around the central atom. Since there are four electron pairs around Si, the electron arrangement that minimizes electron-pair repulsion is **tetrahedral**.

We conclude that Si is ***sp***$^3$ **hybridized** because it has the electron arrangement of four *sp*$^3$ hybrid orbitals.

Write the Lewis structure of the molecule.



Count the number of electron pairs around the "central atoms". Since there are four electron pairs around each Si, the electron arrangement that minimizes electron-pair repulsion for each Si is **tetrahedral**.

We conclude that each Si is ***sp***$^3$ **hybridized** because it has the electron arrangement of four *sp*$^3$ hybrid orbitals.

What is the hybridization on the central atom in $NO_3^-$?

- sp
- $sp^2$
- $sp^3$
- $sp^3d$
- $sp^3d^2$

$NO_3^-$

$5+(6\times3)+1$

$= 24$

$-6$

$18$

$18$

$0$

$= sp^2$

$sp^3 = 4$

Indicate the type of hybrid orbitals used by the central atom in $BrF_3$.

- sp
- $sp^2$
- $sp^3$
- $sp^3d$
- $sp^3d^2$

$sp^3d$

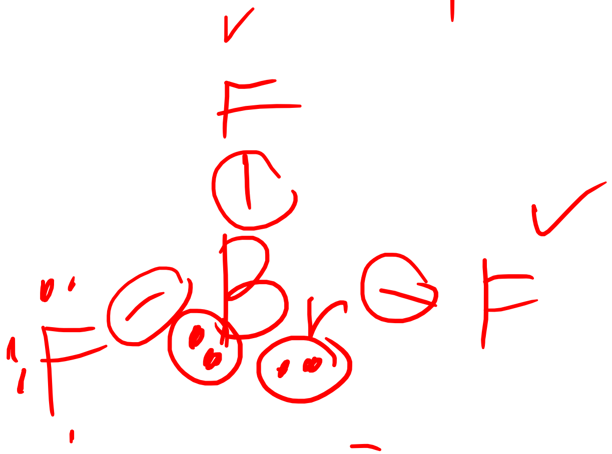
$7+7\times3=28$

$-6$

$22$

$-18$

$4$



5

$sp^3d$

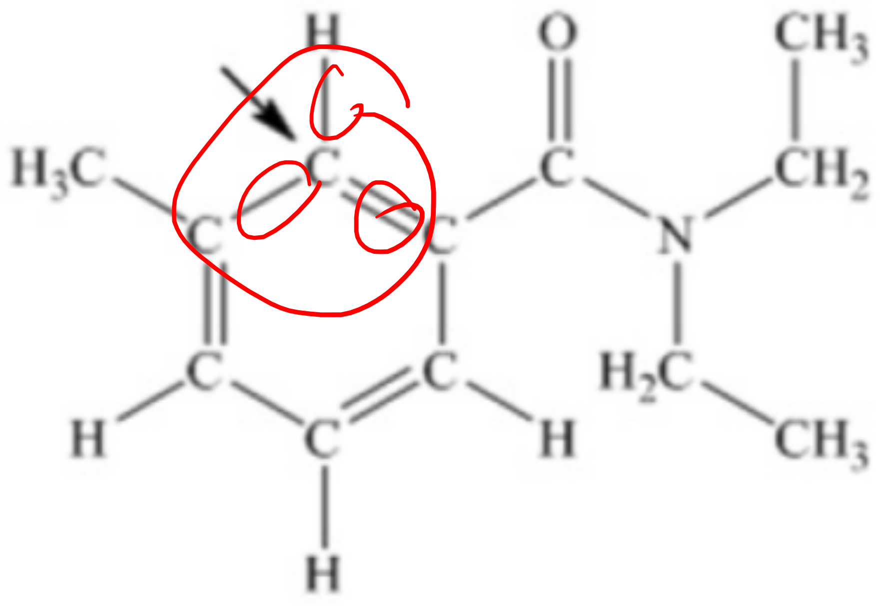
In which one of the following molecules is the central atom $sp^2$ hybridized?

- $SO_2$
- $N_2O$
- $BeCl_2$
- $NF_3$
- $PF_5$

The hybridization of the central nitrogen atom in the molecule $N_2O$ is

- *sp*.
- $sp^2$.
- $sp^3$.
- $sp^3d$.
- $sp^3d^2$.

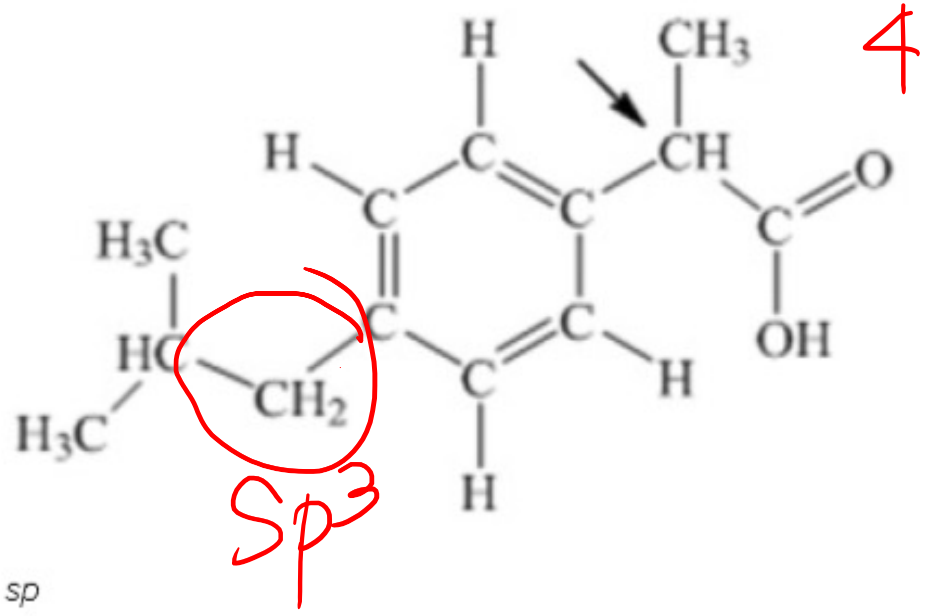
*N*,*N*-diethyl-*m*-tolumide (DEET) is the active ingredient in many mosquito repellents. What is the hybridization state of carbon indicated by the arrow in the structure of DEET shown below?



- sp
- $sp^2$
- $sp^3$
- $sp^3d$
- $sp^3d^2$

Ibuprofen is used as an analgesic for the relief of pain, and also to help reduce fever. What is the hybridization state of carbon indicated by the arrow in the structure of ibuprofen shown below?

4 $sp^3$



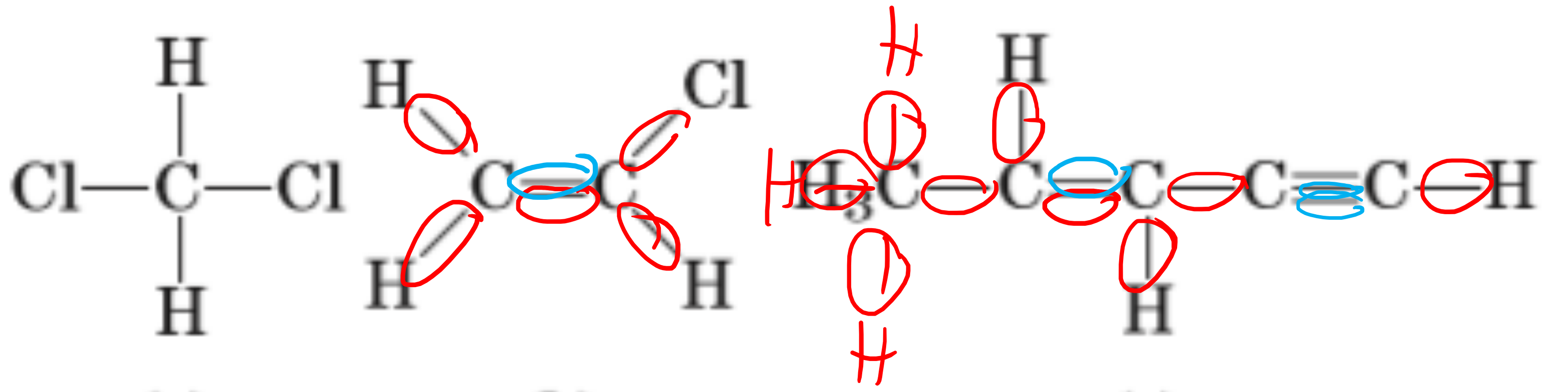
$sp^3$

- sp
- $sp^2$
- $sp^3$
- $sp^3d$
- $sp^3d^2$

| 21. | Analyze the bonding in molecules containing multiple bonds. (Sec 10.5) | Chapter 6, Section 6.5 Questions & Problems # 6.41 | Page3 |
|---|---|---|---|

EOT LOs

6.41 How many sigma bonds and pi bonds are there in each of the following molecules?



(a) (b) (c)

Sigma σ = single

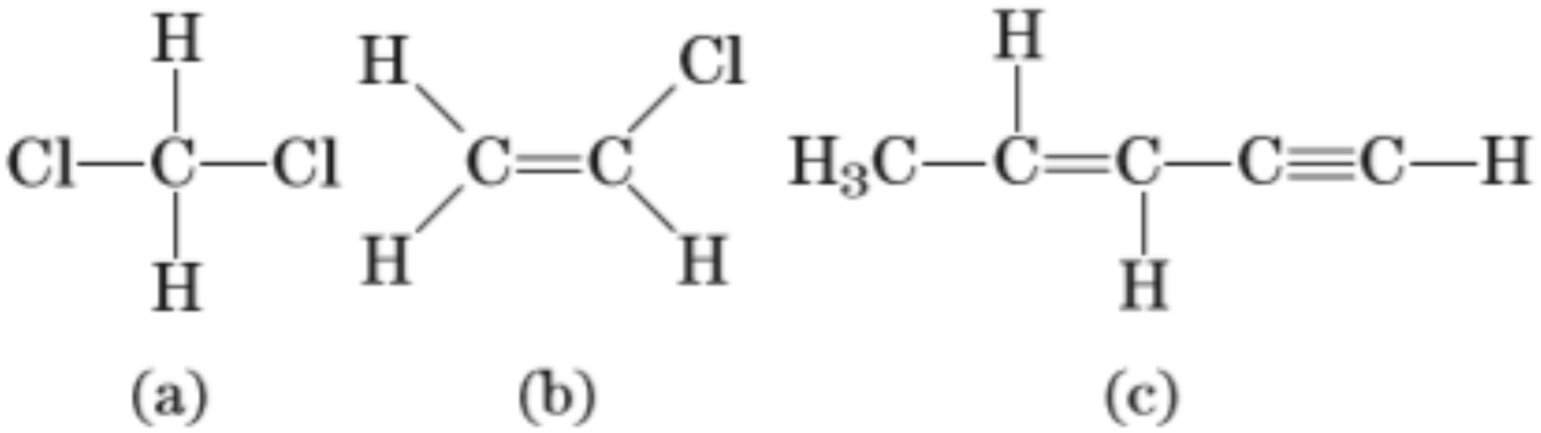
Pi π =

Sigma = 4
Pi = 0

Sigma = 5
Pi = 1

Sigma = 10
Pi = 3

6.41 How many sigma bonds and pi bonds are there in each of the following molecules?

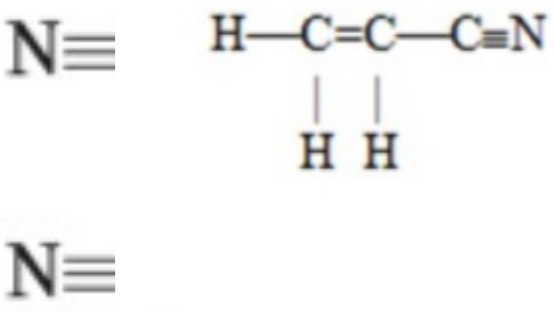


a. Sigma=4 ; pi=0
b. Sigma=5 ; pi=1
c. Sigma=10 ; pi=3

| | | | |
|---|---|---|---|
| 21. | Analyze the bonding in molecules containing multiple bonds. (Sec 10.5) | Chapter 6, Section 6.5 Questions & Problems # 6.41 | Page341 |

**6.42** How many pi bonds and sigma bonds are there in the tetracyanoethvlene molecule?

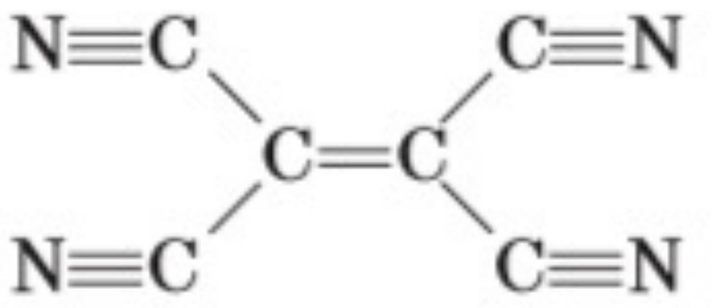
The number of pi bonds in the molecule below is



- 1
- 2
- 3
- 5
- 9

| 21. | Analyze the bonding in molecules containing multiple bonds. (Sec 10.5) | Chapter 6, Section 6.5 Questions & Problems # 6.41 | Page341 |
|---|---|---|---|

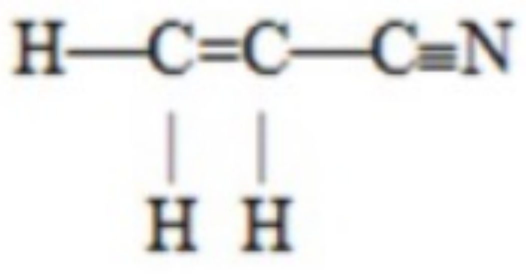
**6.42** How many pi bonds and sigma bonds are there in the tetracyanoethylene molecule?



a. Sigma=9 ; pi=9

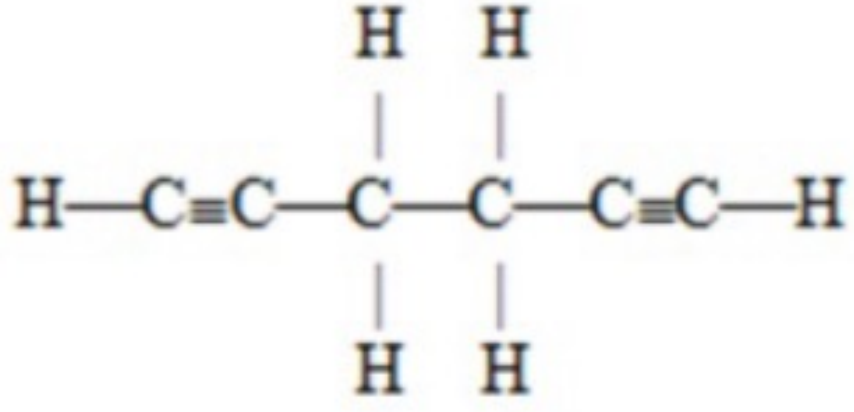
| | | | |
|---|---|---|---|
| 21. | Analyze the bonding in molecules containing multiple bonds. (Sec 10.5) | Chapter 6, Section 6.5 Questions & Problems # 6.41 | Page341 |

The number of pi bonds in the molecule below is



- 1
- 2
- 3
- 5
- 9

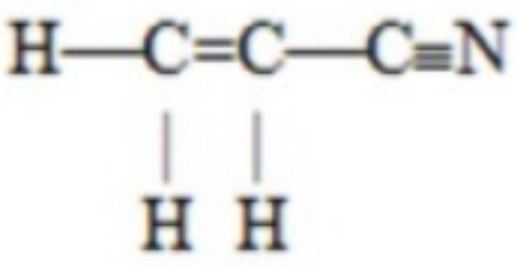
The number of pi bonds in the molecule below is



- 2
- 4
- 6
- 10
- 15

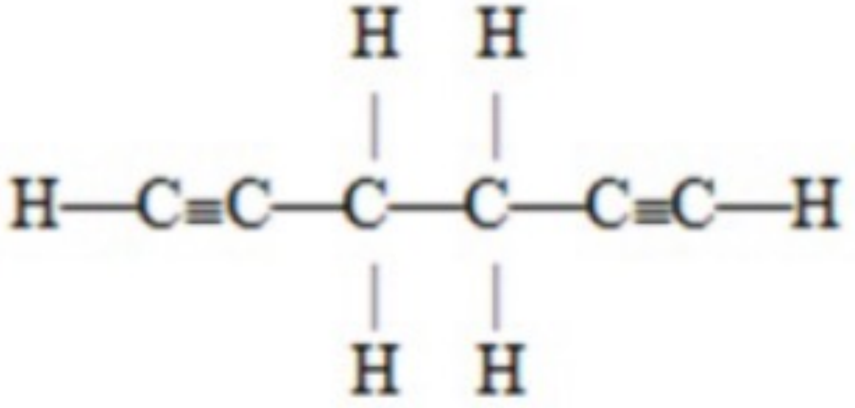
| 21. | Analyze the bonding in molecules containing multiple bonds. (Sec 10.5) | Chapter 6, Section 6.5 Questions & Problems # 6.41 | Page341 |
|---|---|---|---|

The number of pi bonds in the molecule below is



- 1
- 2
- 3
- 5
- 9

The number of pi bonds in the molecule below is



- 2
- 4
- 6
- 10
- 15

| 22. | Explain how atomic orbitals overlap to form molecular orbitals according to molecular orbital theory. (Sec. 10.6) | Chapter 6, Section 6.6 Question Bank # 74 | Page3 |
|---|---|---|---|

EOT LOs

According to Molecular Orbital Theory, two separate 1s orbitals interact to form what molecular orbital(s)?

- σ only
- σ and σ*
- π only
- π and π*
- σ and π

bonding | antibonding
σ | σ*
π | π*

Cl–Cl
σ p p

σ = single bond
π = double bond

H - F
σ s - p

O=O → O|O
π p p π*

Single bond

According to Molecular Orbital Theory, two separate $p_x$ orbitals interact about the x-axis to form what molecular orbitals?

- σ and σ*
- π and π*
- σ, σ* and π
- π, π*, and σ
- σ, σ*, π, and π*

| 22. | Explain how atomic orbitals overlap to form molecular orbitals according to molecular orbital theory. (Sec. 10.6) |
|---|---|

Chapter 6, Section 6.6 Question Bank # 74



EOT LOs

According to Molecular Orbital Theory, two separate 1s orbitals interact to form what molecular orbital(s)?

- σ only
- σ and σ*
- π only
- π and π*
- σ and π

According to Molecular Orbital Theory, two separate $p_x$ orbitals interact about the x-axis to form what molecular orbitals?

- σ and σ*
- π and π*
- σ, σ* and π
- π, π*, and σ
- σ, σ*, π, and π*

| | | | |
|---|---|---|---|
| 22. | Explain how atomic orbitals overlap to form molecular orbitals according to molecular orbital theory. (Sec. 10.6) | Chapter 6, Section 6.6 Question Bank # 74 | Page341 |

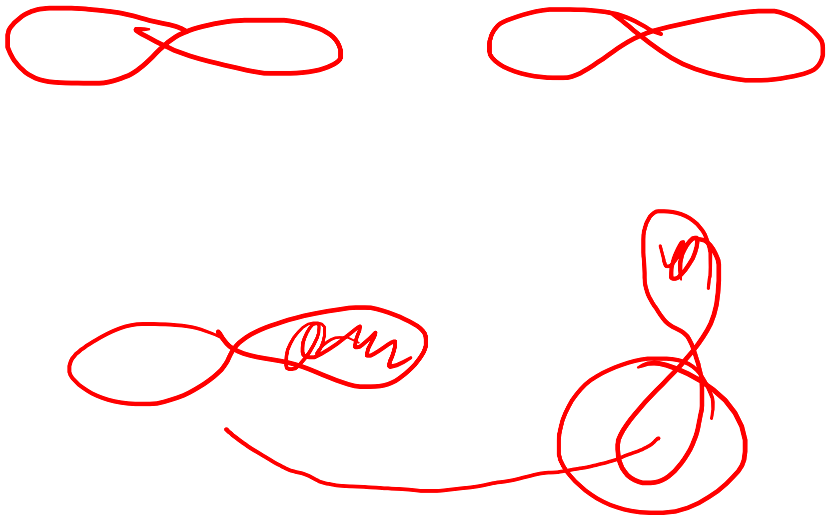
According to Molecular Orbital Theory, two separate $p_x$ orbitals interact about the y-axis to form what molecular orbitals?

- σ and σ*
- π and π*
- σ, σ* and π
- π, π*, and σ
- σ, σ*, π, and π*

22. Explain how atomic orbitals overlap to form molecular orbitals according to molecular orbital theory. (Sec. 10.6)

According to Molecular Orbital Theory, two separate $p_x$ orbitals interact about the y-axis to form what molecular orbitals?

- σ and σ*
- π and π*
- σ, σ* and π
- π, π*, and σ
- σ, σ*, π, and π*



s, p, d, f

| 23. | Identify bonding and antibonding molecular orbitals. (Sec. 10.6) | Chapter 6, Section 6.6 Question & Problems 6.46 | Page3 |
|---|---|---|---|

EOT LOs

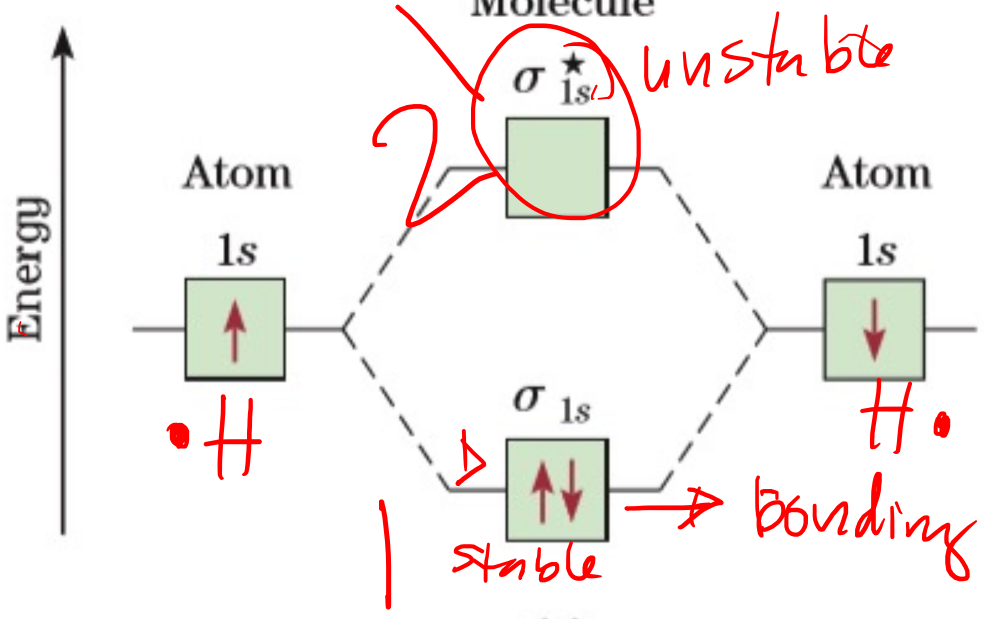
6.46 Sketch the shapes of the following molecular orbitals: $\sigma_{1s}$, $\sigma^{\star}_{1s}$, $\pi_{2p}$, and $\pi^{\star}_{2p}$. How do their energies compare?

| 23. | Identify bonding and antibonding molecular orbitals. (Sec. 10.6) | Chapter 6, Section 6.6 Question & Problems 6.46 | Page3 |
|---|---|---|---|

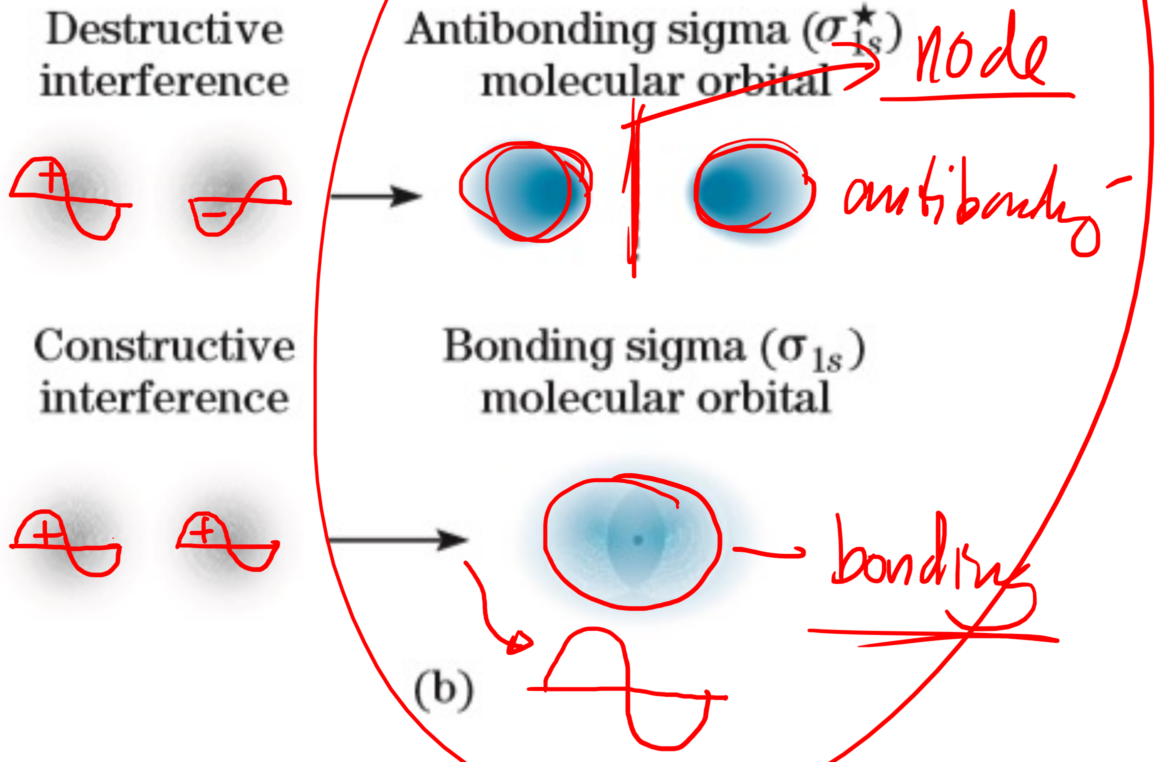
EOT LOs

**6.46** Sketch the shapes of the following molecular orbitals: $\sigma_{1s}$, $\sigma^{\star}_{1s}$, $\pi_{2p}$, and $\pi^{\star}_{2p}$. How do their energies compare?

antibonding




(a)




(b)

- Sigma (σ): all *single* bonds are σ bonds
- Pi (π): only *double* and *triple* bonds have π bonds

**Bond vs. antibond**

- Bond: stabilizing interaction between two atoms
- Antibond: destabilizing interaction between two atoms

**6.46** Sketch the shapes of the following molecular orbitals: $\sigma_{1s}$, $\sigma^{\star}_{1s}$, $\pi_{2p}$, and $\pi^{\star}_{2p}$. How do their energies compare?

σ = lower energy

π* = higher energy

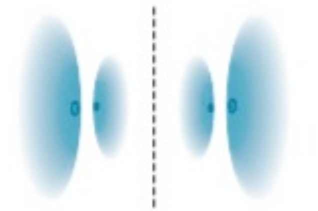
pp

p

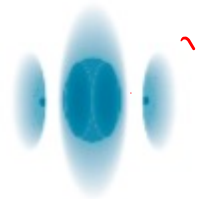
s

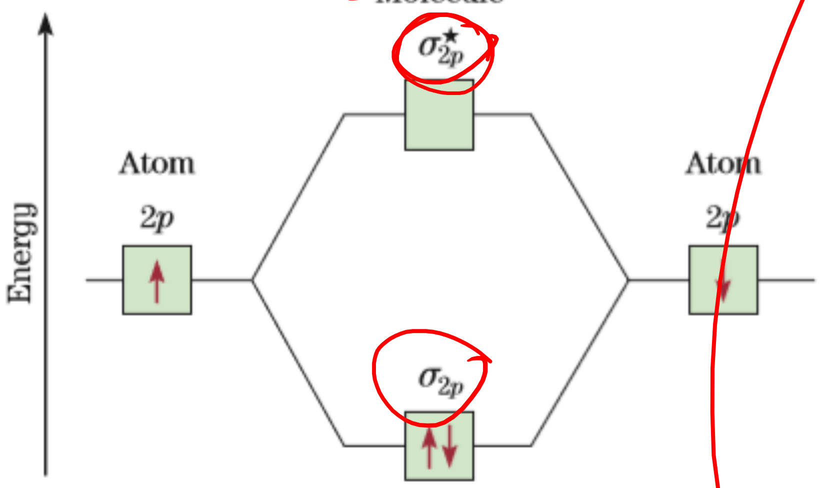
node

Antibonding sigma ($\sigma^{\star}_{2p}$) molecular orbital

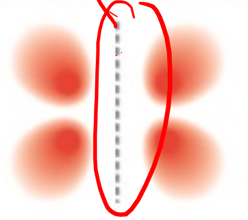


Bonding sigma ($\sigma_{2p}$) molecular orbital

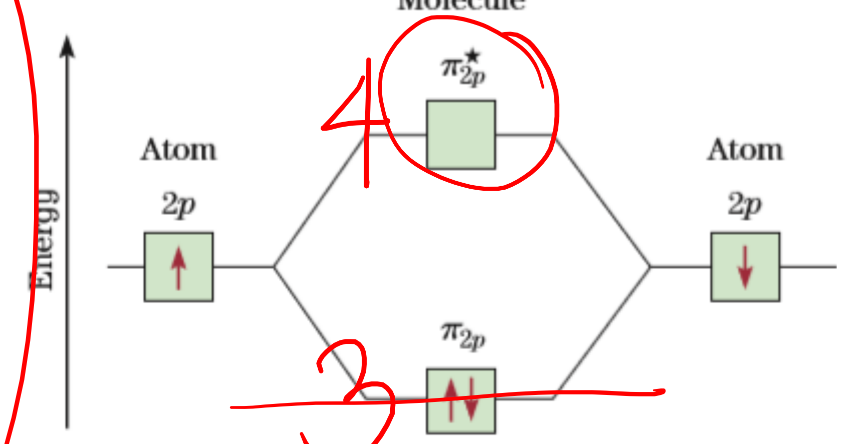





Antibonding pi ($\pi^{\star}_{2p}$) molecular orbital



Bonding pi ($\pi_{2p}$) molecular orbital



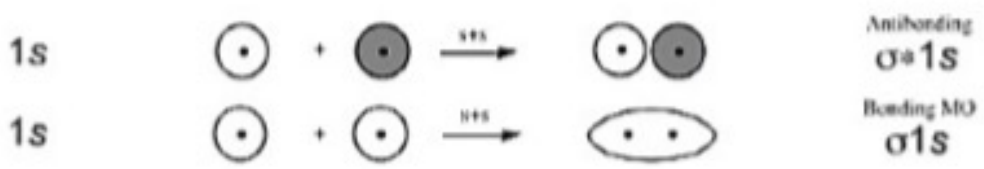

- Sigma (σ): all *single* bonds are σ bonds
- Pi (π): only *double* and *triple* bonds have π bonds

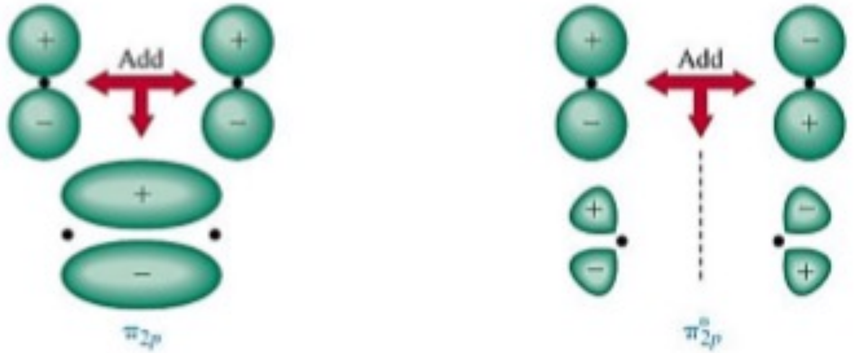
**Bond vs. antibond**

- Bond: stabilizing interaction between two atoms
- Antibond: destabilizing interaction between two atoms

| | | | | |
|---|---|---|---|---|
| 23. | Identify bonding and antibonding molecular orbitals. (Sec. 10.6) | Chapter 6, Section 6.6 Question & Problems 6.46 | Page3 | EOT LOs |

**6.46** Sketch the shapes of the following molecular orbitals: $\sigma_{1s}$, $\sigma^{\star}_{1s}$, $\pi_{2p}$, and $\pi^{\star}_{2p}$. How do their energies compare?




The energy is lowest for sigma 1s and highest for pi *2p.
Pi bond has higher energy and weaker than sigma bond. The order of increasing energies is

: $\sigma_{1s}$, $\sigma^{*}_{1s}$, $\pi_{2p}$, and $\pi^{*}_{2p}$.

| 24. | Draw Lewis structures with and without expanded octets for species where both are | Ch. 10: PDF | PDF #24 |
|---|---|---|---|

EOT LOs

- Q24. Which of the elements listed below is most likely to exhibit an expanded octet in its compounds? O; S; Na; C; N

period 3 S, Na

S

| | | | |
|---|---|---|---|
| 24. | Draw Lewis structures with and without expanded octets for species where both are | Ch. 10: PDF | PDF #24 |

EOT LOs

- Q24. Which of the elements listed below is most likely to exhibit an expanded octet in its compounds? O; S; Na; C; N

Ans : S as it is in 3rd period and due to the availability of d orbitals it can accommodate more than 8 electrons.

| | | | |
|---|---|---|---|
| 24. | Draw Lewis structures with and without expanded octets for species where both are | Ch. 10: PDF | PDF #24 |

EOT LOs

5.66 Write Lewis structures for the reaction

$$AlCl_3 + Cl^- \longrightarrow AlCl_4^-$$

What kind of bond joins Al and Cl in the product?

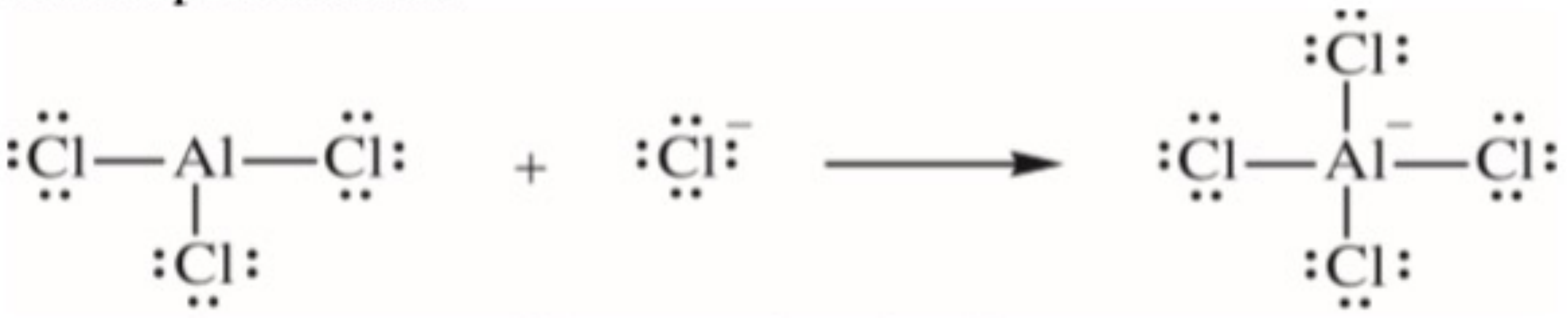
| | | | |
|---|---|---|---|
| 24. | Draw Lewis structures with and without expanded octets for species where both are | Ch. 10: PDF | PDF #24 |

5.66 Write Lewis structures for the reaction

$$AlCl_3 + Cl^- \longrightarrow AlCl_4^-$$

What kind of bond joins Al and Cl in the product?

The reaction can be represented as:

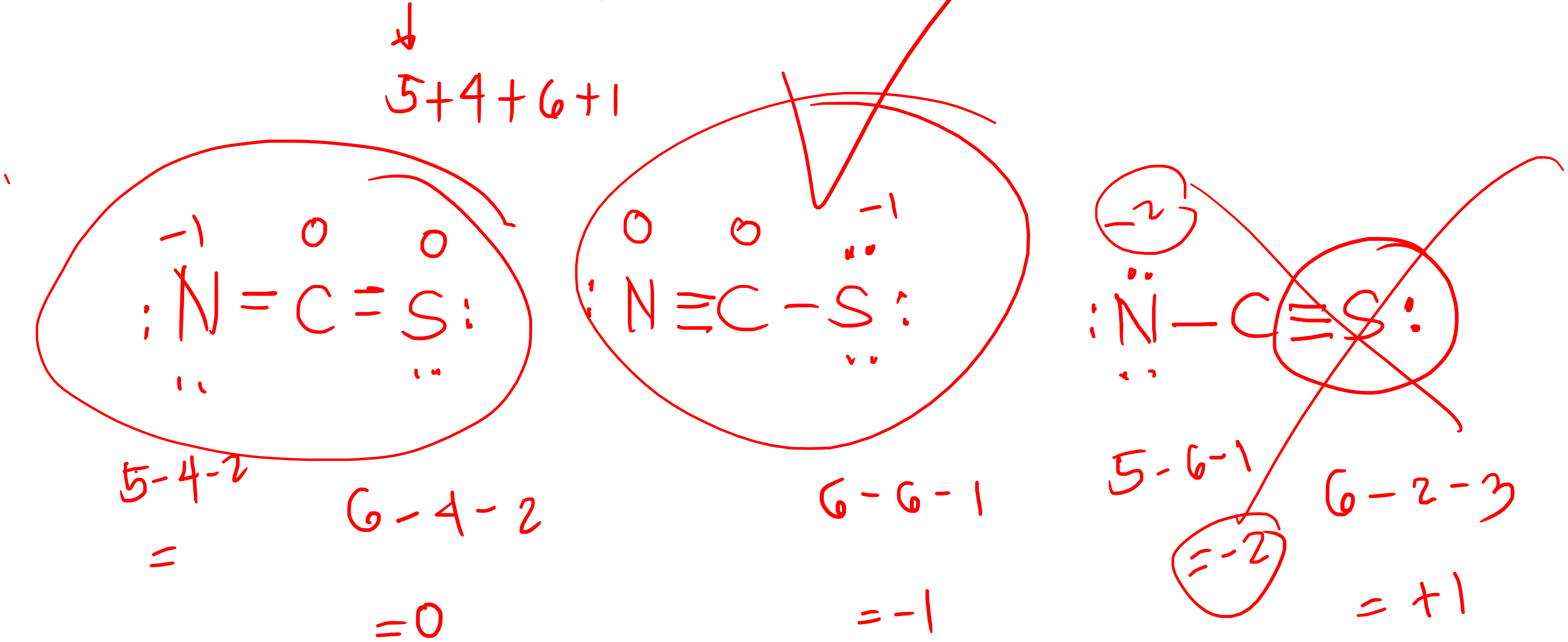


The new bond formed is called a **coordinate covalent bond**.

| 25. | Evaluate the concept of resonance and draw resonance structures of a given | Ch. 9: PDF | PDF #25 |
|---|---|---|---|

EOT LOs

Draw the resonance for NCS- and predict the stable structure.



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| 25. | Evaluate the concept of resonance and draw resonance structures of a given | Ch. 9: PDF | PDF #25 |

EOT LOs

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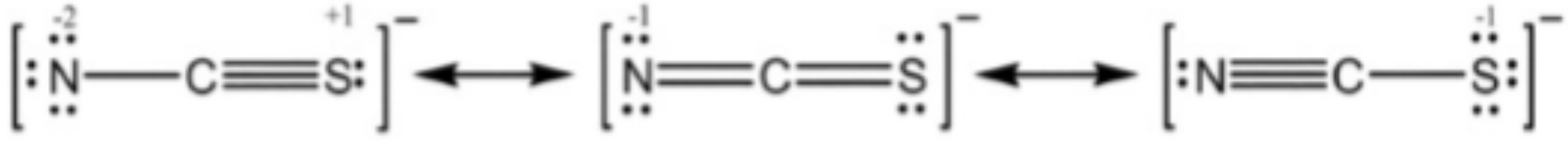

II structure is most stable because N- can hold negative charge as it is more electronegative than Sulphur

Ans : Whenever a single Lewis structure cannot describe all the properties of a molecule a number of structures with similar energy are written to describe all the properties. The actual structure is in between of all these contributing structures and is known as the resonance hybrid. The individual structures are resonance structures and the phenomenon is resonance.

The End

Good Luck!!!