SAMPLE PROBLEMS FOR TEST No. 2
ANSWERS AND SOLUTIONS TO SELECTED ODD-NUMBERED PROBLEMS

3.1 Identify the group and period to which each of the following elements belongs:
   a) Si           b) element number 21  c) zinc               d) element number 35
   Solution  
a) group IVA (14), period 3
b) group IIIB (4), period 4
   c) group IIB (12), period 4
   d) group VIIA (17), period 4

3.5 a) How many elements are located in group VB(5)?
    b) How many elements are found in period 4 of the periodic table?
    c) How many total elements are in groups IIIA(13) and IVB(4) of the periodic table?
   Solution  
a) 4 (V, Nb, Ta, Db)
b) 18 (K, Ca, Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ga, Ge, As, se, Br, Kr)
c) 6 (B, Al, Ga, In, TI, Uut) + 4 (Ti, Zr, Hf, Rf) = 10

3.7 The following statements either define or are closely related to the terms periodic law, period or group. Match the terms to the appropriate statements.
   a) This is a vertical arrangement of elements in the periodic table.
   b) The chemical properties of the elements repeat in a regular way as the atomic numbers increase.
   c) The chemical properties of elements 11, 19, & 37 demonstrate this principle.
   d) Elements 4 and 12 belong to this arrangement.
   Solution  
a) group
b) periodic law
   c) periodic law
   d) group

3.11 What is the maximum number of electrons that could be contained in each of the following?  a) a 2s orbital  b) a 2s subshell  c) the first shell
   Solution  
a) 2
b) 2
   c) 2

3.13 How many orbitals are found in the fourth shell? Write designations for the orbitals.
   Solution  
The 4 shell contains 16 orbitals, one 4s, three 4p, five 4d and 7 4f.

3.15 How many orbitals are found in a 3d subshell? What is the maximum number of electrons that could be located in this subshell?
   Solution  
The 3d subshell has five orbitals. That subshell can hold a 10 electrons.
3.17 Identify the subshells found in the fourth shell and indicate the maximum number of electrons that could occupy each subshell and the total number of electrons that could occupy the shell.

**Solution**
The fourth shell contains s, p, d, and f subshells, containing 1, 3, 5, and 7 orbitals, respectively. The s subshell could hold 2 electrons; the p, 6; the d, 10; and the f, 14 for a total of 32 electrons possible in the fourth shell.

3.19 Look at the periodic table and tell how many electrons would be in the valence shell of the following elements:

- a) element number 51
- b) the fifth element (reading left to right) in period 3
- c) Al
- d) the third element (reading down) in group VIA(16)

**Solution**
The valence shell contains the s and p subshells.

- a) 5
- b) 5
- c) 3
- d) 6

3.25 Write an electronic configuration for each of the following elements, using the form $1s^2 2s^2 2p^6$,

- a) Ca
- b) nickel
- c) element number 34
- d) V

**Solution**

- a) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$, none unpaired
- b) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^8$, two unpaired
- c) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^4$, two unpaired
- d) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^3$, three unpaired

3.29 Write the symbol and name for each of the elements described. More than one element will fit some descriptions.

- a) Contains one unpaired 2p electron
- b) Contains a half-filled 3s subshell
- c) The last electron completes the 3d subshell
- d) Contains one unpaired 5s electron
- e) The last electron half-fills the 4p subshell

**Solution**

- a) B (boron) and F (fluorine)
- b) Na (sodium)
- c) Zn (zinc)
- d) Rb (rubidium)
- e) As (arsenic)

3.31 Write the abbreviated electronic configurations for the following elements.

- a) an element that contains 22 electrons
- b) element number 23
- c) bromine
- d) iron

**Solution**

- a) [Ar] $4s^2 3d^2$
- b) [Ar] $4s^2 3d^3$
- c) [Ar] $4s^2 3d^{10} 4p^5$
- d) [Ar] $4s^2 3d^6$
3.35 Classify each of the following elements into the s, p, d, and f area of the periodic table on the basis of the distinguishing electron.
   a) Cl  b) Zn  c) element 62  d) Sr

**Solution**
   a) p  b) d  c) f  d) s

3.37 Classify the following elements as representative, transition, inner-transition, or noble gases. a) W  b) Cm  c) element number 10  d) helium  e) barium

**Solution**
   a) transition  b) inner-transition  c) noble gas  d) noble gas  e) representative

3.39 Classify the following as metals, nonmetals, or metalloids.
   a) rubidium  b) arsenic  c) element number 50  d) S  e) Br

**Solution**
   a) metal  b) metalloid  c) metal  d) nonmetal  e) nonmetal

3.41 Use trends within the periodic table to predict which member of each of the following pairs is more metallic.
   a) C or Sn  b) Sb or In  c) Ca or As  d) Al or Mg

**Solution**
   Elements to the left in a row or down in a column are more metallic.
   a) Sn  b) In  c) Ca  d) Mg

3.43 Use trends with the periodic table and indicate which member of the following pairs has the larger atomic radius.
   a) Mg or Sr  b) Rb or Ca  c) S or Te  d) I or Sn

**Solution**
   For representative elements, the radius increases to the left and increases down.
   a) Sr  b) Rb  c) Te  d) Sn

3.45 Use trends within the periodic table and indicate which member of each of the following pairs gives up one electron more easily.
   a) Mg or Al  b) Ca or Be  c) S or Al  d) Te or O

**Solution**
   The atom with the lower ionization energy loses the electron more easily.
   Ionization energy decreases from top to bottom and from right to left.
   a) Mg  b) Ca  c) Al  d) Te

3.47 Answer the following: a) How many unpaired electrons are in the outer subshell of a phosphorus atom? b) What element has 5 3p electrons in the ground state? c) How many valence electrons are needed to complete the outer valence shell of sulfur.
Solution
a) 3 p  

b) chorine (Cl)  
c) 2

3.49 Rank the following in order of increasing atomic radius: Sr, Mg, Ba and Ra.
Solution
All are members of group IIA (2) - they simply must be ordered by increasing atomic number: Mg, Sr, Ba, Ra.

3.57 Samples of three metals that belong to the same group of the periodic table are shown in Figure 3.5. When magnesium reacts with bromine, a compound with the formula MgBr$_2$ results. What would be the formulas of the compounds formed by reactions of bromine with each of the other metals shown? Explain your reasoning.
Solution
Since elements in the same group have similar chemical properties, they will have similar formulas. The formulas for calcium with bromine, and strontium with bromine, are CaBr$_2$ and SrBr$_2$ respectively.

4.3 Write abbreviated electronic configurations for the following:
a) iodine  
b) element number 38  
c) As  
d) phosphorus
Solution
a) [Kr] 5s$^2$4d$^{10}$5p$^5$  
b) [Kr] 5s$^2$  
c) [Ar] 4s$^2$3d$^1$4p$^3$  
d) [Ne] 3s$^2$3p$^3$

4.5 Draw Lewis structures for the elements given in Exercise 4.3.
Solution
a) :I:  
b) Sr :  
c) •As•  
d) •P•

4.11 Use the periodic table and predict the number of electrons that will be lost or gained by the following elements as they change into simple ions. Write an equation using elemental symbols, ionic symbols, and electrons to represent each change.  
a) Ca  
b) aluminum  
c) fluorine  
d) element number 34
Solution
a) lose 2; Ca $\rightarrow$ Ca$^{2+}$ + 2e$^-$  
b) lose 3; Al $\rightarrow$ Al$^{3+}$ + 3e$^-$  
c) gain 1; F + e$^-$ $\rightarrow$ F$^-$  
d) gain 2; Se + 2e$^-$ $\rightarrow$ Se$^{2-}$

4.17 Identify the noble gas that is isoelectronic with each of the following ions:
a) Mg$^{2+}$  
b) Te$^{2-}$  
c) N$^3-$  
d) Be$^{2+}$
Solution
a) Ne  
b) Xe  
c) Ne  
d) He
4.19 Write equations to represent positive and negative ion formation for the following pairs of elements. Then write a formula for the ionic compound that results when the ions combine. a) Mg & S  
   b) strontium & nitrogen  
   c) elements 3 & 34

Solution
a) \( \text{Mg} \rightarrow \text{Mg}^{2+} + 2e^- \); \( \text{S} + 2e^- \rightarrow \text{S}^{2-} \); \( \text{MgS} \)
b) \( \text{Sr} \rightarrow \text{Sr}^{2+} + 2e^- \); \( \text{N} + 3e^- \rightarrow \text{N}^{3-} \); \( \text{Sr}_3\text{N}_2 \)
c) \( \text{Li} \rightarrow \text{Li}^+ + e^- \); \( \text{Se} + 2e^- \rightarrow \text{Se}^{2-} \); \( \text{Li}_2\text{Se} \)

4.21 Write the formula for the ionic compound formed from \( \text{Sr}^{2+} \) and each of the following ions: a) \( \text{S}^{2-} \)  
   b) \( \text{Br}^- \)  
   c) \( \text{N}^{3-} \)  
   d) \( \text{Cl}^- \)

Solution
a) \( \text{SrS} \)  
   b) \( \text{SrBr}_2 \)  
   c) \( \text{Sr}_3\text{N}_2 \)  
   d) \( \text{SrCl}_2 \)

4.29 Name the following binary ionic compounds: 
   a) \( \text{K}_2\text{O} \)  
   b) \( \text{SrCl}_2 \)  
   c) \( \text{Al}_2\text{O}_3 \)  
   d) \( \text{LiBr} \)  
   e) \( \text{CaS} \)

Solution
a) potassium oxide  
   b) strontium chloride  
   c) aluminum oxide  
   d) lithium bromide  
   e) calcium sulfide

4.31 Name the following binary ionic compounds using a roman numeral to indicate the charge on the metal ion: 
   a) \( \text{CrCl}_2 \) and \( \text{CrCl}_3 \)  
   b) \( \text{CoS} \) and \( \text{Co}_2\text{S}_3 \)  
   c) \( \text{FeO} \) and \( \text{Fe}_2\text{O}_3 \)  
   d) \( \text{PbCl}_2 \) and \( \text{PbCl}_4 \)

Solution
a) chromium(II) chloride and chromium(III) chloride  
   b) cobalt(II) sulfide and cobalt(III) sulfide  
   c) iron(II) oxide and iron(III) oxide  
   d) lead(II) chloride and lead(IV) chloride

4.33 Name the binary compounds of Exercise 4.31 by adding the endings -ous and -ic to indicate the lower and higher ionic charges of the metal ion in each pair of compounds.

Solution
a) chromous chloride, chromic chloride  
   b) cobaltous sulfide, cobaltic sulfide  
   c) ferrous oxide, ferric oxide  
   d) plumbous chloride, plumbic chloride

4.35 Write formulas for the following binary ionic compounds: 
   a) manganese(II) chloride  
   b) iron(III) sulfide  
   c) chromium(II) oxide  
   d) iron(II) bromide  
   e) tin(II) chloride
Solution
  a) MnCl₂  
  b) Fe₂S₃  
  c) CrO  
  d) FeBr₂  
  e) SnCl₂

4.37 Determine the formula weight in atomic mass units for each of the following binary ionic compounds:
  a) Na₂O  
  b) FeO  
  c) PbS₂  
  d) AlCl₃

Solution
  a) FW = 2(22.99) + 16.00 = 61.98 u  
  b) FW = 55.85 + 16.00 = 71.85 u  
  c) FW = 207.2 + 2(32.06) = 271.32 (round to tenths) = 271.3 u  
  d) FW = 26.98 + 3(35.45) = 133.33 u

4.39 Identify the ions that would occupy lattice sites in a solid sample of each compound given in Exercise 4.37.

Solution
  a) two Na⁺ ions and one O²⁻ ion  
  b) one Fe²⁺ ion and one O²⁻ ion  
  c) one Pb⁴⁺ ion and two S²⁻ ions  
  d) one Al³⁺ ion and three Cl⁻ ions

4.43 Calculate the number of positive ions and negative ions contained in 1.00 mol of each compound given in Exercise 4.37.

Solution
  a) 12.0 x 10²³ Na⁺ ions and 6.02 x 10²³ O²⁻ ions  
  b) 6.02 x 10²³ Fe²⁺ ions and 6.02 x 10²³ O²⁻ ions  
  c) 6.02 x 10²³ Pb⁴⁺ ions and 12.0 x 10²³ S²⁻ ions  
  d) 6.02 x 10²³ Al³⁺ ions and 18.1 x 10²³ Cl⁻ ions

4.45 Represent the following reaction using Lewis structures:

Solution
  $\:\cdot\: + \:\cdot\:\rightarrow \:\cdot\:\cdot\:\cdot\:$

4.47 Represent the following molecules by Lewis structures:
  a) HF  
  b) IBr  
  c) PH₃ (each H atom is bonded to the P atom)  
  d) HClO₂ (the O atoms are each bonded to the Cl, and the H is bonded to one of the O atoms)

Solution
  a) H : F: or H - F :  
  b) I : Br : or I - Br :  
  c) H : P : H or H - P - H  
  d) O : Cl : O : H or O - Cl - O - H
4.49 DRAW LEWIS STRUCTURES FOR THE FOLLOWING POLYATOMIC IONS:
   a) ClO₃⁻ (each O atom is bonded to the Cl atom)
   b) CN⁻
   c) CO₃²⁻ (each O atom is bonded to the C atom)

**Solution**

- a) 26 electrons

- b) 10 electrons

- c) 24 electrons

4.53 PREDICT THE SHAPE OF EACH OF THE FOLLOWING MOLECULES BY FIRST DRAWING A LEWIS STRUCTURE, THEN APPLYING THE VSEPR THEORY:
   a) O₃
   b) SeO₂
   c) PH₃ (each H atom is bonded to the P atom)
   d) SO₃ (each O atom is bonded to the S atom)

**Solution**

- a) The central oxygen atom has three groups around it, a lone pair and two other oxygen atoms. There will be a triangular (trigonal) arrangement for the orbitals, the three atoms form an angular shape.

- b) The central selenium atom has three groups around it, a lone pair and two bonded to oxygen atoms. There will be a tetrahedral arrangement for the orbitals, with the atoms forming an angular shape.

- c) There are four pairs of electrons tetrahedrally arranged around the central P atom. The P and the three H atoms form a triangular pyramid.

- d) There are three groups trigonally arranged around the S atom. The shape of the molecule is trigonal planar.

4.55 PREDICT THE SHAPE OF EACH OF THE FOLLOWING POLYATOMIC IONS BY FIRST DRAWING A LEWIS STRUCTURE, THEN APPLYING THE VSEPR THEORY:
a) \( \text{NH}_2 \) (each H atom is bonded to the N atom)
b) \( \text{PO}_3^3^- \) (each O atom is bonded to the P atom)
c) \( \text{BeCl}_2^2^- \) (each Cl atom is bonded to the Be atom)
d) \( \text{ClO}_4^- \) (each O atom is bonded to the Cl atom)

**Solution**

a) \[
\begin{array}{c}
\text{H} : \text{N} : \text{H} \end{array}
\]
There are four groups, two lone pairs and two H atoms, tetrahedrally arranged around the N atom. The shape of the ion is angular.

b) \[
\begin{array}{c}
\text{O} : \text{P} : \text{O} : \\
\end{array}
\]
There are four groups, one lone pair and three O atoms, tetrahedrally arranged around the P atom. The shape of the ion is a triangular pyramid.

c) \[
\begin{array}{c}
\text{Cl} : \\
\text{Cl} : \text{Be} : \text{Cl} : \\
\text{Cl} : \\
\end{array}
\]
There are four groups tetrahedrally arranged around the Be atom. The shape of the ion is tetrahedral.

d) \[
\begin{array}{c}
\text{O} : \\
\text{O} : \text{Cl} : \text{O} : \\
\end{array}
\]
There are four groups tetrahedrally arranged around the Cl atom. The shape of the ion is tetrahedral.

**4.57** Use the periodic table and Table 4.3 to determine which of the following bonds will be polarized. Show the resulting charge distribution in those molecules that contain polarized bonds.

a) \( \text{Cl} \text{—F} \)  

**Solution**

a) polar \( \delta^+ \text{Cl—F} \) \( \delta^- \)

b) both bonds polar \( \delta^+ \text{H—Se} \) \( \delta^- \)

c) \( \text{B—B} \) bond is non-polar; \( \text{H—B} \) bonds are polar \( \delta^- \text{H—B} \) \( \delta^+ \)

**4.59** Use Table 4.4 and classify the bonds in the following compounds as non-polar covalent, polar covalent, or ionic.

a) \( \text{MgI}_2 \) (each I is bonded to Mg)  
b) \( \text{NCl}_3 \) (each Cl is bonded to N)  
c) \( \text{H}_2\text{S} \) (each H is bonded to S)  
d) \( \text{RbF} \)  
e) \( \text{SrO} \)

**Solution**

a) ionic \( \Delta\text{EN}=1.3 \)  [Although \( \Delta\text{EN}<1.7 \), it is classified as ionic because of the bonding between a metal (Mg) and a non-metal (I)]  
b) non-polar \( \Delta\text{EN}=0 \)  
c) polar \( \Delta\text{EN}=0.4 \)  
d) ionic \( \Delta\text{EN}=3.2 \)  
e) ionic \( \Delta\text{EN}=2.5 \)
4.61 On the basis of the charge distributions you drew for the molecules of Exercise 4.57, classify the molecules as polar or nonpolar.

Solution
a) polar; the bonds are not symmetrical in C\textsubscript{2}H\textsubscript{4}.
b) polar; the bonds are not symmetrical in H\textsubscript{2}Se.
c) non-polar; The polar bonds are symmetrical in B\textsubscript{2}H\textsubscript{4}.

4.63 Use Table 4.4 and predict the type of bond you would expect to find in compounds formed from the following elements:
a) sulfur and oxygen  
b) aluminum and bromine  
c) C and Cl

Solution
a) polar $\Delta$EN=1.0  
b) polar $\Delta$EN=1.3  
c) polar $\Delta$EN=1.5

4.65 Show the charge distribution in the following molecules and predict which are polar molecules.
a) S$\equiv$C$\equiv$S  
b) H$\equiv$C$\equiv$N  
c) F$\equiv$O$\equiv$F

Solution
a) nonpolar; the polar bonds are symmetrical $\delta^-$S$\equiv$C$\equiv$S$\delta^-$ (linear)
b) polar; $\delta^-$H$\equiv$C$\equiv$N$\delta^-$ (linear)
c) polar; $\delta^-$F$\equiv$O$\equiv$F$\delta^-$ (angular)

4.67 Name the following binary covalent compounds:
a) SiO\textsubscript{2}  
b) SiF\textsubscript{4}  
c) P\textsubscript{2}O\textsubscript{5}  
d) AlBr\textsubscript{3}  
e) CBr\textsubscript{4}

Solution
a) silicon dioxide  
b) silicon tetrafluoride  
c) phosphorus pentoxide  
d) aluminum bromide  
e) carbon tetrabromide

4.69 Write formulas for the following binary covalent compounds:
a) disulfur monoxide  
b) sulfur hexafluoride  
c) silicon tetrachloride  
d) carbon diselenide

Solution
a) S\textsubscript{2}O  
b) SF\textsubscript{6}  
c) SiCl\textsubscript{4}  
d) CSe\textsubscript{2}

4.71 Write the formulas and names for compounds composed of ions of the following metals and the indicated polyatomic ions.
a) calcium and the phosphate ion  
b) sodium and the dichromate ion  
c) Li and CO\textsubscript{3}$^2^-$  
d) NaPO\textsubscript{4}$^3^-$

Solution
a) Ca\textsubscript{3}(PO\textsubscript{4})\textsubscript{2} calcium phosphate  
b) Na\textsubscript{2}Cr\textsubscript{2}O\textsubscript{7} sodium dichromate
c) Li\textsubscript{2}CO\textsubscript{3} lithium carbonate  

d) Na\textsubscript{3}PO\textsubscript{4} sodium phosphate

4.73 Write formulas for the compounds named below:

a) potassium permanganate  
b) calcium hydroxide  
c) calcium phosphate  
d) ammonium dihydrogenphosphate  
e) calcium hypochlorite

**Solution**

a) KMnO\textsubscript{4}  
b) Ca(OH)\textsubscript{2}  
c) Ca\textsubscript{3}(PO\textsubscript{4})\textsubscript{2}  
d) NH\textsubscript{4}H\textsubscript{2}PO  
e) Ca(ClO)\textsubscript{2}

4.77 The following structural formulas represent molecules of ethyl alcohol and dimethyl ether. Assign the correct name to each formula and explain how your choice is consistent with your answer to Exercise 4.76.

```
H C O C H
H     H
H H
```

```
H C O H
H C O H
H H
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**Solution**

The structure on the left is nonpolar because of the symmetry; hence, it must be the lower boiling compound, dimethyl ether. The one on the right is polar and must be the higher boiling compound, ethyl alcohol.

4.79 Use the concept of interparticle forces to propose an explanation for the fact that CO\textsubscript{2} is a soft, low melting solid (dry ice), whereas SiO\textsubscript{2} is a hard solid (sand). Focus on the nature of the particles that occupy lattice sites in the solid.

**Solution**

In solid CO\textsubscript{2} the lattice site is occupied by a molecule of CO\textsubscript{2}. The attractive forces are the dispersion forces associated with the nonpolar CO\textsubscript{2}. In solid SiO\textsubscript{2} the lattice sites are occupied by oxygen, silicon, and oxygen, covalently bonded between lattice sites.

4.81 The formula for sucrose is C\textsubscript{12}H\textsubscript{22}O\textsubscript{11}, where many of the hydrogen and oxygens are combined to form OH groups that are bonded to carbon atoms. What type of predominant interparticle bonding would you now propose for solid sucrose (see Exercise 4.80.)

**Solution**

The -OH groups will have polar bonds capable of forming hydrogen bonds between the molecules.

4.83 Suppose an element from group IIA(2), and period 3 of the periodic table forms an ionic compound with the element that has an electronic configuration of 1s\textsuperscript{2} 2s\textsuperscript{2} 2p\textsuperscript{3} to form a molecule. What is the formula of this compound, and what would be the name of this compound.

**Solution**

The first element would be magnesium (Mg), the second would be nitrogen
(N). They would form magnesium nitride Mg$_3$N$_2$.

4.87 Which of the following gives the correct order of electronegativities?
   a. I < Br < Cl < F  b. Sr < Ca < Ra < Mg  
   c. Al < Si < P < S  d. Na < K < Li < H

Solution
Only (a) and (c) are correct. The electronegativity values are shown below.
   a. I (2.66) < Br (2.96) < Cl (3.16) < F (3.98)  
   b. Sr (0.95) < Ca (1.00) < Ra (0.90) < Mg (1.31) Incorrect  
   c. Al (1.61) < Si (1.90) < P (2.19) < S (2.58)  
   d. Na (0.93) < K (0.82) < Li (0.98) < H (2.20) Incorrect

4.89 Which of the following lists contains no ionic compounds?
   a. HCN, NO, Ca(NO$_3$)$_2$  b. KOH, CCl$_4$, SF$_6$  
   c. NaH, CaF$_2$, NaNH$_2$  d. CH$_2$O, H$_2$S, NH$_3$

Solution
Only d contains no ionic compounds. Ca(NO$_3$)$_2$, KOH, NaH, CaF$_2$ and NaNH$_2$ are ionic.

4.91 Give chemical formulas for the following compounds: a) sodium hypochlorite; b) ammonium chloride; c) sodium bisulfate.

Solution
a) NaClO  b) NH$_4$Cl  c) NaHSO$_4$

4.99 Neon atoms do not combine to form Ne$_2$ molecules. Explain.

Solution
Neon atoms have completely filled s and p subshells in the 2nd shell and do not want to lose nor gain electrons.

4.101 In Chemistry Around Us 4.2, NO was described as a vital biological molecule. Explain how NO forms when a fuel such as natural gas, CH$_4$, is burned in air at a high temperature?

Solution
The air contains both N$_2$ and O$_2$. N$_2$ is quite inert because of the strong, triple bond between the N atoms. Only at high temperatures, the bond can be broken allowing the N atoms to react with oxygen.