Homework Chapter 14

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1:19 AM

Problems:
2,3,11,15,16,22,27,28,42,47,52,53,57,61,68,69,80,83,87,92,105,109,111,112,127,132,138,154,172

1. (oops started didn't need to do)
   a. Electron configuration - distribution of electrons in energy levels and sublevels of an atom
      i. N indicates energy and relative distance from the nucleus of orbitals
      ii. L (disignations of s,p,d,f) indicates the shape of orbitals in the sublevel.
      iii. Superscript # tells the number of electrons in sublevel
   b. Atomic size - based on atomic radius, one-half the distance between nuclei of identical bonded atoms
      i. Decreases left to right
      ii. Increases down a group
   c. Ionization energy (IE) - energy required to remove the highest energy electron from 1 mol of gaseous atoms
      i. Increases left to right
      ii. Decreases down group
   d. Electronegativity (EN) - number that refers to the relative ability of an atom in a covalent bond to attract shared electrons
      i. Increases left to right
      ii. Decreases down group

2.
   a. Z_{eff} across period and down a group -> increases left to right, increases slight down.
   b. Z_{eff} effects:

Atomic size	Increasing Z_{eff} across period pulls outer electrons closer (smaller atomic size) due to higher number of protons and generally same number of electron shells. Increasing Z_{eff} down a group increases atomic size because outer electrons lie farther from nucleus.
IE_1	Across period higher Z_{eff} holds electrons tighter and down group greater distance from nucleus lowers attraction for electrons.
EN	Increases left to right: Higher Z_{eff} and shorter distance from the nucleas strengthen the attraction for the shared pair; decreases down a group: greater distance from the nucleus weakens the attraction for shared pair

3. Iodine monochloride and elemental bromine have nearly the same molar mass and liquid density but very different boiling points.
   a. What molecular property is primarily responsible for this difference in boiling point? What atomic property gives rise to it? Explain.
      Intermolecular forces such as dipole-dipole forces.

   b. Which substance has a higher boiling point? Why?
      ICl has a higher boiling point because it has polarity while Br_2 is not polar.

11.
   a. How does the type of bonding in element oxides correlate with the electronegativity of the elements?
      Elements with low EN form basic oxides, elements with high EN form acidic oxides, and elements with intermediate EN form amphoteric oxides.

   b. How does the acid-base behavior of element oxides correlate with the electronegativity of the elements?
      Acidity increases form left to right and from bottom to top of the periodic table. EN increases form left to right and also from bottom to top of the periodic table.

15. Rank increasing
   a. Atomic size: Mg<Sr<Ba

b. IE_1 : Na<Al<P
c. EN: Se<Br<Cl
d. Number of valence electrons: Ga<Sn<Bi

16. Rank decreasing
    a. Atomic size: N, Si, P
       Si>P>N
    b. IE_1: Kr, K, Ar
       K>Kr>Ar
    c. EN: In, Rb, I
       Rb>In>I
    d. Number of valence electrons: Sb, S, Cs
       Se=S>Cs

22. Rank the following in order of decreasing bond energy:
    NF_3, NI_3, NCl_3
    NF_3>NCl_3>NI_3

27. Which member of each pair gives the more basic solution in water:
    a. CaO or SO_3
    b. BeO or BaO
    c. CO_2 or SO_2
    d. P_4O_{10} or K_2O

    Write an equation for the dissolving of each oxide from part a)

$CaO + H_2O \rightarrow 2OH^- + Ca^{2+}$

$SO_3 + H_2O \rightarrow H_2SO_4$

28. Which member of each pair gives the more acidic solution in water. Write an equation for the dissolving of each oxide to support your answer.
    a. CO_2 or SrO

$CO_2 + H_2O \rightarrow 2H^+ + CO_3$

$SrO + H_2O \rightarrow OH^- + HSrO^+$

    b. SnO or SnO_2

$SnO + H_2O \rightarrow 2H^+ + SnO_2$

$SnO_2 + H_2O \rightarrow 2OH^- + SnO$

    c. Cl_2O or Na_2O

$Cl_2O + H_2O \rightarrow 2H^+ + Cl_2O_2$

$Na_2O + H_2O \rightarrow 2OH^- + 2Na^+$

    d. SO_2 or MgO

$SO_2 + H_2O \rightarrow 2H^+ + SO_3$

$MgO + H_2O \rightarrow 2OH^- + Mg^+$

42. What correlation, if any, exists for the Period 2 elements between group number and the number of covalent bonds the element typically forms? How is the correlation different for elements in Periods 3 to 6?

    The number of covalent bonds is related to the oxidation number. For example, nitrogen has oxidation number of -3 and like to form 3 covalent bonds, oxygen has ON of -2 and likes to form 2 covalent bonds, and florine has an ON of -1 and like to form 1 covalent bond. This trend hold true for nonmetals since metals do not form covalent bonds. The trend follows in periods 3-6 for all halogens but has some anomalous behavior on the jagged line of metalliods.

47. Lithium salts are often much less soluble in water than the corresponding salts of other alkali metals. For example, at 18C the concentration of a saturated LiF solution is 1.0×10^{-2} M wheras that of a saturated KF solution is 1.6M. How would you explain this behavior?

    Lithium salts have a very covalent character and they are more soluble in polar organic solvents suc has ethanol and acetone when compared to Na and K salts. In water though, lithium salts are much less soluble than other alkali salts. The small, highly positive Li^+ makes dissociation of Li salts into ions more difficult in water.

$RbOH + HBr \rightarrow RbBr + H_2O$

52. Write a balanced equation for the formation from its elements of sodium peroxide, an industrial bleach.

$2Na(s) + O_2(g) \rightarrow Na_2O_2(s)$

53. Write a balanced equation for the formation of rubidium bromide through a reaction of a strong acid and a strong base.

57. Alkaline earth metals are involved in two key diagonal relationships in the periodic table.
    a. Give the 2 pairs of elements in these diagonal relationships.
        Li and Mg; B and Si
    b. For each pair, cite two similarities that demonstrate the relationship
        Atomic size is similar
        Form salts with similar solubility
    c. Why are the members of each pair so similar in behavior?
        Their size (both atomic and ionic) because it increases down a period and decreases from left to right.

61. Lime (CaO) is one of the most abundantly produced chemicals in the world. Write balanced equations for
    a. The preparation of lime from natural sources

$Ca^{2+} + O^{-2} \rightarrow CaO$

    b. The use of slaked lime to remove SO_2 from flue gases

$CaO + H_2O \rightarrow Ca^{2+} + 2OH^-$

$Ca^{2+} + 2OH^- + SO_2 \rightarrow CaO + HSO_3$

    c. The reaction of lime with arsenic acid (H_3AsO_4) to manufacture the insecticide calcium arsenate

$6CaO + 4H_3AsO_4 \rightarrow 2As_2Ca_3O_8 + 11O_2$

    d. The regeneration of NaOH in the paper industry by reaction of lime with aqueous sodium carbonate

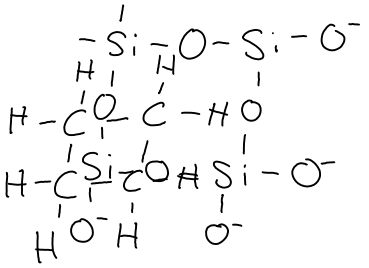
$H_2O + CaO + Na_2CO_3 \rightarrow 2NaOH + 6O_2$

68. Rank the following oxides in order of increasing aqueous acidity:
    Ga_2O_3, Al_2O_3, In_2O_3.
    $Al_2O_3 > Ga_2O_3 > In_2O_3$

69. Rank the following hydroxides in order of increasing aqueous basicity
    $Al(OH)_3$, $B(OH)_3$, $In(OH)_3$.
    $B(OH)_3 < Al(OH_3) < In(OH)_3$

80. What is an allotrope? Name two group 4A(14) elements that exhibit allotropism, and name two of their allotropes.
    Allotropes are different crystalline or molecular forms of a substance. Examples in group 4A: Carbon has graphite, diamond, buckyball, and nanotube allotropes. Tin has β-Tin and α-Tin allotropes.

83. Draw a Lewis structure for
    a. The cyclic silicate ion $Si_4O_{12}^{8-}$



    b. A cyclic hydrocarbon with formula C_4H_8

1 week | 1 mol Ca^{2+} | 1 mol Zeolite

$\_\_\_ \times 2191.26\text{g Zeolite} = 7.06 \times 10^5$

1 day 1 week 1 mol Ca^{2+} 1 mol zeolite

87.

$4.5\times10^{-3}\ \text{mol } Ca^{2+} \times \frac{25{,}000\text{ L}}{1\text{ L hard water}} \times \frac{7\text{ days}}{1\text{ day}} \times \frac{2\text{ mol zeolite}}{1\text{ mol } Ca^{2+}} \times \frac{2191.26\text{ g zeolite}}{1\text{ mol zeolite}} = 3.45\times10^{6}$

$9.2\times10^{-4}\ \text{mol } Mg^{2+} \times \frac{25{,}000\text{ L}}{1\text{ L hard water}} \times \frac{7\text{ days}}{1\text{ day}} \times \frac{2\text{ mol zeolite}}{1\text{ mol } Mg^{2+}}$

total = 4.2×10^{6} g zeolite

92.

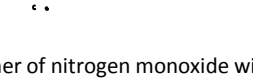
a. What is the range of oxidation states shown by the elements of Group 5A(15) as you move down the group?
   N: -3, +5, +4, +3, +2, +1
   P: -3, +5, +3
   As: -3, +5, +3
   Sb: -3, +5, +3
   Bi: +3

b. How does this range illustrate the general rule for the range of oxidation states in groups on the right side of the periodic table?
   As we go down groups less oxidation numbers occurs. This holds true for 3A 4A and 5A.

105. In addition to those in table 14.3, other less stable nitrogen oxides exist. Draw a Lewis structure for each of the following:

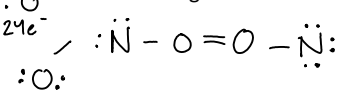
a. N_2O_2, a dimer of nitrogen monoxide with an N-N bond

12 + 10 = 24 e⁻



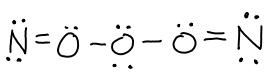
b. N_2O_3, a dimer of nitrogen monoxide with no N-N bond

24 e⁻

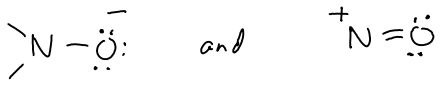


c. N_2O_3 with no N-N bond

18 + 10 = 28 e⁻



d. NO^+ and NO_3^-, products of the ionization of liquid N_2O_4



109. The oxygen and nitrogen families have some obvious similarities and differences

a. State two general physical similarities between Group 5A(15) and 6A(16) elements.
   Density increases going down groups.
   Boiling point increases down groups.

b. State two general chemical similarities between Group 5A(15) and 6A(16) elements.
   Most have covalent bonds
   Metallic character increases down the group.

c. State two chemical similarities between P and S
   Both have allotropes and covalently bond

d. State two physical similarities between N and O

© Both are form covalent bonds with themselves at STP

e. State two chemical differences between N and O
   Diatomic oxygen is reactive while diatomic nigrogen is not.

111. Complete and balance the following:

(a) $N_2S_8(s) + 8O_2(g) + 20OH^- \rightarrow 2Na^+ + H_2O(l) + SO_4^{2-}$

(b) $S_8(s) + \text{excess } 24F_2(g) \rightarrow 8SF_6$

$FeS(s) + 2HCl(aq) \rightarrow H_2S + FeCl_2$

(d) $Te(s) + 2I_2(s) \rightarrow TeI_4$

112. .

(b) $SO_3(g) + H_2O(l) \rightarrow H_2SO_4$

(c) $SF_4(g) + 2H_2O(l) \rightarrow 4HF + SO_2$

(d) $Al_2Se_3(s) + H_2O(l) \rightarrow$

127. (a) $Rb(s) + Br_2(l) \rightarrow 2RbBr(s)$

(b) $I_2(s) + H_2O(l) \rightarrow HI(aq) + HIO(aq)$

(c) $Br_2(l) + 2I^-(aq) \rightarrow I_2 + Br_2$

(d) $CaF_2(s) + H_2SO_4(l) \rightarrow 2HF + CaSO_4(s)$

132. An industrial chemist treats solid NaCl with concentrated H_2SO_4 and obtains gaseous HCl and $NaHSO_4$. When she substitutes solid NaI for NaCl, gaseous H_2S, solid I_2, and S_8 are obtained but no HI.

a. What type of reaction did the H_2SO_4 undergo with NaI?

$NaCl(s) + H_2SO_4 \xrightarrow{(aq)} HCl(g) + NaHSO_4$ double displacement

$NaI(g) + H_2SO_4(aq) \rightarrow H_2S(g) + I_2(s) + S_8(s)$ decomposition

b. Why does NaI, but not NaCl, cause this type of reaction?

NaI cannot react with H_2SO_4 to get SI because the S and I atom bond would be too weak and far apart due to electron density. Instead NaI decomposes in the presence of concentrated N_2SO_4.

c. To produce HI(g) by the reaction of NaI with an acid, how does the acid have to differ from sulfuric acid?

SI will not form due to high electron density and steric strain, so a different acid such as HBr that does not contain sulfur could be used to produce HI.

138.

a. Why do stable xenon fluorides have an even number of F atoms?

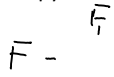
The known crystal xenon fluorides XeF_2, XeF_4, and XeF_6 have fluorine existing in even numbers. This is due to the fact that oxidation states follow a trend of changing by two. Xe with a configuration of 8 valance electrons has oxidation stats of +6, +4, and +2 as shown in these xenon fluoride compounds. The change in oxidation state by two from its original state is due ot the fact that stable molecules have paired electrons and when bonds form or break, wo electrons are involved, so the oxidation states changes by 2.

b. Why do the ionic species XeF_3^+ and XeF_7^- have odd numbers of F atoms?

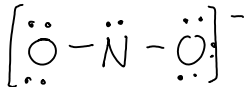
This follows the same trend explained in part a. Xe will have oxidation states of +6, +4, and +2 which are all are stemmed off of xenon's original 8 valance electron configuration. Since the electrons exist in pairs, the formation of breakage of bonds involves two electrons. All the ions of xenon fluorides will have an odd number of fluorine atoms bonded.

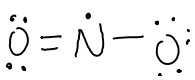
c. Predict the shape of XeF_3^+.

XeF_4 is tetrahedral. XeF_3^+ and XeF_4 both have Xe in +4 oxidation state. By VESPR of the Lewis structure below, XeF_3^+ would be trigonal pyramidal.



154. Producer gas is a fuel formed by passing air over red-hot coke (amorphous carbon). It consists of approximately 25% CO, 5.0% CO_2, and 70% N_2 by mass. What mass of producer gas can be formed from 1.75 metric tons of coke, assuming an 87% yield?





172. The bond angles in the nitrite ion, nitrogen dioxie, and the nitronium ion (NO_2^+) are 115°, 134°, and 180°, respectively. Explain these values using Lewis structures and VSEPR theory.

nitrite ion bent - linear

nitrogen dioxide - trigonal planar 120°