Please put your name in the upper RIGHT hand corner only on the FIRST PAGE

1. **(5 points)** 8.15 g of an unknown solute is dissolved in 65.0 g of cyclohexane (C_6H_{12}), and the freezing point of the solution is – 2.27°C. Determine the molar mass of the unknown solute.

SKIP

Important data:

$\Delta T_f = K_f \underline{m}$

$\Delta T_b = K_b \underline{m}$

normal freezing point of C_6H_{12} = 6.55°C

normal boiling point of C_6H_{12} = 80.74°C

$K_f\ C_6H_{12}$ = 20.0 °C/$\underline{m}$

$K_b\ C_6H_{12}$ = 2.79 °C/$\underline{m}$

2. **(5 points)** When iron metal is reacted with potassium permanganate in acid, the following reaction occurs.

$$5Fe_{(s)} + 3KMnO_{4(aq)} + 24HCl_{(aq)} \rightarrow 3MnCl_{2(aq)} + 5FeCl_{3(aq)} + 12\ H_2O_{(l)} + 3KCl_{(aq)}$$

What mass of iron (III) chloride, in grams, is made from the complete reaction of excess iron and hydrochloric acid with 2.56 g potassium permanganate?

do

$$2.56\text{g } KMnO_4 \left| \frac{1\text{ mol } KMnO_4}{\text{g } KMnO_4} \right| \frac{5\ FeCl_3}{3\ KMnO_4} \left| \frac{\text{g } FeCl_3}{1\text{ mol } FeCl_3} \right.$$

3. (10 points) Ascorbic acid (vitamin C, $C_6H_8O_6$) is a water-soluble vitamin. A solution containing 80.5 g of ascorbic acid dissolved in 210.0 g of water, has a density of 1.22 g/mL at 55°C. Calculate (a) the mass percentage, (b) the mole fraction, (c) the molality, and (d) the molarity of ascorbic acid in this solution.

Mass percent	27.7% V.tC
Mole fraction	0.397 V.tC
Molality	2.18 m V.tC
Molarity	1.92 M V.tC

see pg 3 of 2012 exam

4. (6 points) The concentration of hydrogen peroxide in a solution is determined by titrating a sample of the solution with a known concentration of potassium permanganate solution.

$$2MnO_4^-{}_{(aq)} + 5H_2O_{2(l)} + 6H^+{}_{(aq)} \rightarrow 2Mn^{2+}{}_{(aq)} + 5O_{2(g)} + 8H_2O_{(l)}$$

(a) It takes 14.8 mL of 0.134 M permanganate solution to reach the equivalence point when reacted with 10.00 mL of peroxide solution. What is the molarity of the hydrogen peroxide solution? (5 points)

(b) This is a redox reaction. Identify the oxidation numbers of Mn in MnO_4^-. Was manganese oxidized or reduced? Explain. (1 point)

a) 0.496 M H_2O_2

b) MnO_4^- => 7+

$MnO_4^- \rightarrow Mn^{2+}$ reduction

5. **(3 points)** Complete the following table (0.25 each):

Isotopic symbol	Atomic number	Mass number	Protons	Neutrons	Electrons	Net charge
$^{39}_{19}K$	19	39	19	20	19	0
$^{56}_{26}Fe^{2+}$	26	56	26	30	24	2+
$^{17}_{8}O^{2-}$	8	17	8	9	10	2−

6. **(8 points)** The characteristic odor of pineapple is due to ethyl butyrate, a compound containing carbon, hydrogen, and oxygen. Combustion of a 2.78 g sample of ethyl butyrate produces 6.32 g of carbon dioxide and 2.58 g of water. What is the empirical formula for this compound? [CO_2 = 44.01 amu; H_2O = 18.02 amu]

$6.32\text{g } CO_2 \left| \frac{1\text{mol } CO_2}{44.01\text{g } CO_2} \right| \frac{1\text{mol C}}{1\text{mol } CO_2} = 0.1436\text{mol C} \times \frac{12.01\text{g}}{1\text{mol C}} = 1.725\text{ g C}$

$2.58\text{g } H_2O \left| \frac{1\text{mol } H_2O}{18.02\text{g } H_2O} \right| \frac{2\text{mol H}}{1\text{mol } H_2O} = 0.2863\text{mol H} \times \frac{1.008\text{g}}{1\text{mol}} = 0.2886\text{ g H}$

$2.78\text{g} - 1.725\text{g} - 0.2886\text{g} = 0.766\text{ g O} \div 16.00\text{g/mol} = 0.0479\text{ mol O}$

$\frac{C}{O} = \frac{0.1436}{0.0479} = \frac{2.99}{1} = \frac{3}{1}$ $\quad \frac{H}{O} = \frac{0.2863}{0.0479} = \frac{5.98}{1} = \frac{6}{1}$

C_3H_6O

7. **(6 points)** A student has a solution that might contain any or all of the following cations: Cu^{2+}, Pb^{2+}, Ba^{2+}, and/or Mn^{2+}. Address the following statements about the "mixture" of ions in the solution to determine the identity of ion(s) in the solution.

   a. Addition of HCl solution to the unknown solution causes a precipitate to form.

   The precipitate that forms is: $PbCl_2$ all others won't ppt Cl^-

   b. After filtering off the precipitate from (a), a solution of $H_2SO_{4(aq)}$ is added to the remaining (UK) solution of ions and another precipitate forms.

   The precipitate that forms is: $BaSO_4$ you removed Pb^{2+}, nothing else ppt SO_4^{2-}

   c. This precipitate from (b) is filtered off and a solution of NaOH is added to the resulting solution. No precipitation forms.

   d. What cation(s) are present in the original solution?

   The cation(s) present is (are) ~~XXX~~ Pb^{2+} & Ba^{2+}

   e. Explain your choices using solubility rules.

   if Cu^{2+} or Mn^{2+} were in solution they would ppt w/ OH^-

8. (5 points) Calculate the number of molecules in a deep breath of air whose volume is 2.25 L at body temperature, 37°C, and a pressure of 735 torr.

5.15×10^{22} molecules of air see page 5 exam 2012

9. (5 points) Complete the following statements by filling in the blanks:

   a. Two electrons in the same half-filled subshell with an $l > 0$ must have [?] spin. opposite

   b. When $l = 9$, ml may have values from [?] to [?]. $-9 \rightarrow 0 \rightarrow +9$

   c. The neutral fourth period atom having a total of seven d electrons is [?]. need PT

   d. The 2s orbital and 3 s orbitals of an atom have identical shapes but differ in [?] and [?] of nodes.

   size & # ~~no~~ radial nodes

   e. A nodal surface is one at which the probability of finding and electron is [?] zero

2s has 1 radial node $(n-l-1)$

3s has 2 radial nodes

10. Suppose you have two 1-L flasks: one contains nitrogen (N_2) and the other contains methane (CH_4), both at STP. How do these systems compare with respect to:

(a) The number of molecules

since both are at STP 22.4 L = 1 mole ∴ they have same # molecules

(b) Density

$MM_{N_2} > MM_{CH_4}$ ∴ $d_{N_2} > d_{CH_4}$ b/c Vol is same

(c) Average kinetic energy of the molecules

$\overline{KE}_{N_2} = \overline{KE}_{CH_4}$ b/c $T_{N_2} = T_{CH_4} = 0°C$

(d) Rate of effusion through a pinhole.

Use complete sentences with good grammar. You will lose points for lack of clarity.

since rate $\propto \frac{1}{MM}$ heavier molecule effuses slower through pinhole

11. (10 points) Ammonia and hydrogen chloride react to form solid ammonium chloride.

$$NH_{3(g)} + HCl_{(g)} \rightarrow NH_4Cl_{(s)}$$

Two, 2.00-L flasks are connected by a stopcock. One flask contains 5.00g of ammonia and the other contains 5.00 g hydrogen chloride. Both gases at 25.00°C. When the stopcock is opened, the gases react until one is completely consumed.

(a) Which gas will remain in the system after the reaction is complete? NH_3

(b) What will be the final pressure of the system after the reaction is completed? Assume that the temperature at the end of the reaction, is 25°C, and the volume of the ammonium chloride produced is negligible.

See page 6 2012 exam

12. (6 points) Write the molecular, ionic, and net ionic equations for the reaction of lead(II) nitrate and sodium sulfide. For each equation include the phase of the ions, molecules, or compounds needed or produced. Also, when showing ions, include the correct charge.

MOLECULAR: see exam 2012

IONIC:

NET IONIC

13. (15 points) When bismuth penafluoride reacts with xenon tetrafluoride, the cation XeF_3^+ ion forms according to this reaction:

$$BiF_{5(g)} + XeF_{4(g)} \rightarrow XeF_3BiF_6$$

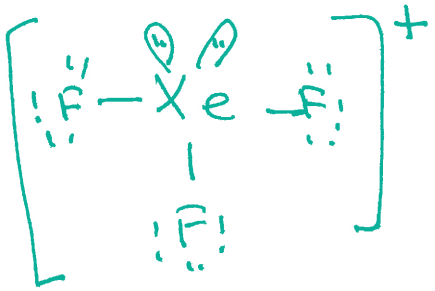
(a) Write a Lewis structure of XeF_3^+ ion. (4 points)

(b) Determine the electron domain geometry of XeF_3^+ ion (1 points)

(c) Determine the molecular geometry XeF_3^+ ion (1 points)

(d) Draw three possible isomers for the molecule based on this geometry. (3 points), one with any lone pair(s) equatorial, one with any lone pair(s) axial, and one with lone pairs in both positions.

(e) Based on the positions of lone pair(s), pick the most stable structure and explain your choices thoroughly.

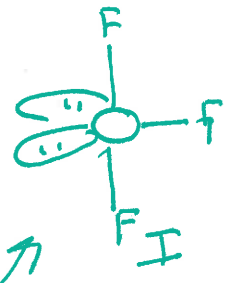
XeF_3^+ 

5 Regions of electron density = trigonal bipyramidal

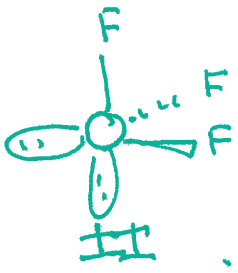
8
21
29
− 1
28
− 6
22
−18
4

Molecular geometry

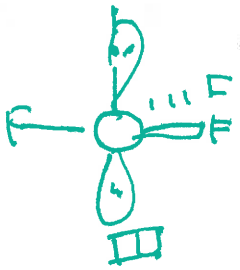
3 Bonding regions + 2 LP = T shape



I



II



III

most likely b/c minimizes 90° LP-LP interactions as seen in II and 90° LP-BP interactions

14. (10 points) Microwave ovens use microwave radiation to heat food. The energy is absorbed by water molecules (and other small molecules) in food, and transferred to other components of the food. C_p coffee = 4/184 J/g°C; d_{coffee}=1.000g/mL

(a) Suppose that the microwave radiation has a wavelength of 11.2 cm. How many photons are required to heat 200.0 mL of coffee from 23.0°C to 60.0°C?

(b) Suppose the microwave's power is 900. W (1 Watt = 1 joule/sec). How long would you have to heat the coffee based on the energy from part a?

see exam 2012

15. (6 points) A solution is prepared by dissolving 10.8 g aluminum sulfate in enough water to make 100.00-mL of stock solution. A 10.00-mL sample of this stock solution is added to enough water to make 50.00-mL of solution. Calculate the concentration of the aluminum ions and sulfate ions in the **final** solution.

$$10.0\text{g } Al_2(SO_4)_3 \left| \frac{1\text{mol}}{g Al_2(SO_4)_3} \right| \frac{1}{0.10000\text{L}}$$

$$\frac{10.0\text{mL}}{50.0\text{mL}} \times 2Al^{3+}$$

$$\times 3SO_4^{2-}$$

yes 2e⁻ in Ca atom are in 4s while 2e⁻ in Ti^{2+} ion are in 3d

16. (6 points) The titanium (II) ion is iso-electronic with the calcium atom. Briefly explain your answers.

(a) Are there any differences in the electron configurations of titanium (II) and calcium?

(b) Will the 2s orbital in calcium be more stable than the 2s orbital in titanium?

(c) Will calcium and titanium (II) have the same number of unpaired electrons?

on Exam 2012

The 2s orbital in Ti^{2+} is more stable b/c $Z_{Ti} > Z_{Ca}$ This increases the attraction between nucleus + 2s. 2s e⁻ penetrate to nucleus better in Ti^{2+}, lowering energy of 2s & stabilizing orbital

4s ↑↓ 3d ↑ ↑ _ _ _ no,

17. 10 points) Chlorine can form several types of compounds when it reacts with oxygen. Two of these compounds are (chloryl) ClO_2^+ and (chlorite) ClO_2^-.

yes!

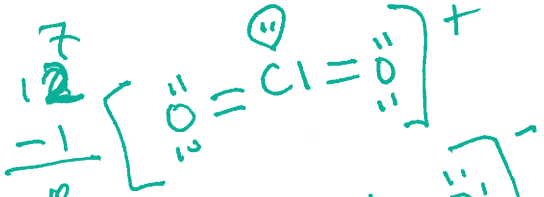
a. Draw the best Lewis structure for these two ions using formal charge rules.

b. Do these structures have resonance? Draw the resonance structures, if they exist, with clear labels.

maybe

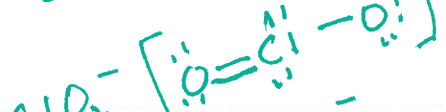
c. Chlorite has a bond angle of 111° while Chloryl has a bond angle close to 120°. Explain the difference in the bond angles based on bonding, non-bonding etc repulsions, electron domain and molecular geometries.

ClO_2^+



7 + 12 − 1 = 18

ClO_2^-



7 + 12 + 1 = 20 e⁻ = 4 / 16 − 12 = 4

this has resonance

ClO_2^+ has 3 RED the double bonds are effective at repelling each other and the lone pair.

chlorite is tetrahedral the "double" bonds of the resonance structure & L.P. repel the L.P.

18. (10 points) By titration, 15.0 mL of 0.1008 M sodium hydroxide is needed to neutralize a 0.2053-g sample of an organic acid. What is the molar mass of the acid if it is monoprotic? An elemental analysis of the acid indicates that is composed of 5.89% H, 70.6% C, and 23.5%O by mass. What is its molecular formula?

dee 2012

19. (12 points) The use the combustion of octane, $C_8H_{18(l)}$, the main component of gasoline, to answer the following questions. NOTE: thermodynamic data is also found on the equation sheet.

(a) Write the balanced equation for the complete combustion of octane to produce water and carbon dioxide. (correct phases!) (2 points)

(b) Octane has a density of 0.692 g/mL at 20 °C. How many grams of oxygen are required to burn 1.000 gal of octane. (6 points)

(c) Using the heats of formation table, calculate the heat of formation for octane, if the combustion of 1 mole of octane releases -5520kJ of energy. (4 points)

(d) Using the Average bond enthalpies, calculate the $\Delta H_{(rxn)}$. (8 points)

on 2012

LOO.

$(\Delta H^\circ_{Rxn})_{2mol} = 16mol\,CO_2 \times \Delta H^\circ_f{}_{CO_2} + 18mol\,H_2O \cdot \Delta H^\circ_f{}_{H_2O} - 2mol\,C_8H_{18} \cdot \Delta H^\circ_f{}_{C_8H_{18}}$

b/c 2mol of rct!!

$-5520\frac{kJ}{mol} \times 2 - 16(-393.5\frac{kJ}{mol}) - 18(-285.5\frac{kJ}{mol}) = -2mol\,\Delta H^\circ f\,C_8H_{18}$

$\frac{-11040kJ + 6301.6kJ + 5139kJ}{2mol} = -200.\,kJ/mol$

CK these #s!

20. (11 points) Write the correct name for the given formulas or the correct formulas for the given names:

(a) CuS Copper (II) sulfide

(b) $Al(ClO_3)_3$ aluminum chlorate

(c) Iron(III) carbonate $Fe_2(CO_3)_3$

(d) $Co(OH)_2$ cobalt (II) hydroxide

(e) Cobalt(II) chromate $CoCrO_4$

(f) Hypochlorus acid $HClO_{aq}$

(g) Hg_2SO_4 mercury (I) sulfate

(h) XeO_3 xenon trioxide

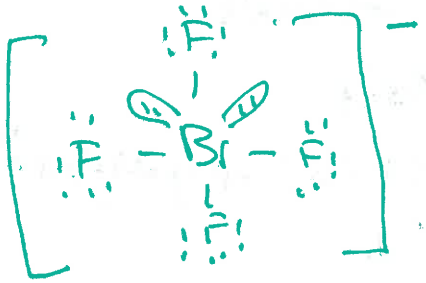
(i) Dinitrogen tetroxide N_2O_4

(j) P_4S_6 tetra phosphorus hexasulfide

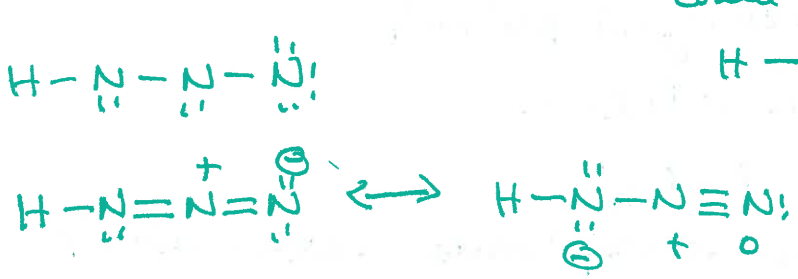
(k) $(NH_4)_3PO_4$ ammonium phosphate

21. (15 points) Draw the Lewis structures for the following structures. Follow the instructions. Clearly label the structures.

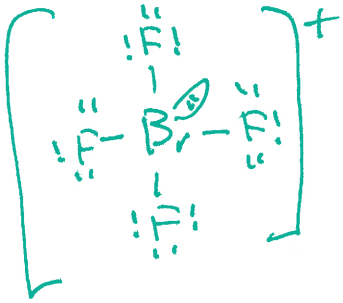
a. BrF_4^- For this structure, draw a good Lewis structure of the ion.

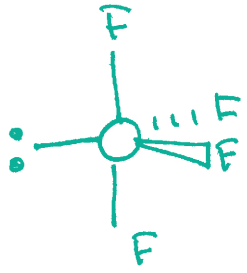


b. HN_3, Nitrogen is the central atom. The molecule is linear. There are **two** resonance structures. Draw them.

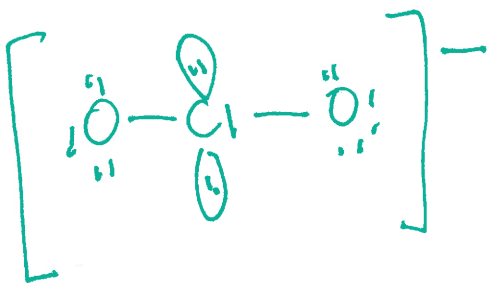


c. BrF_4^+ Use the molecular and electron domain geometry to help you determine where the lone pairs should go for the most stable molecular geometry



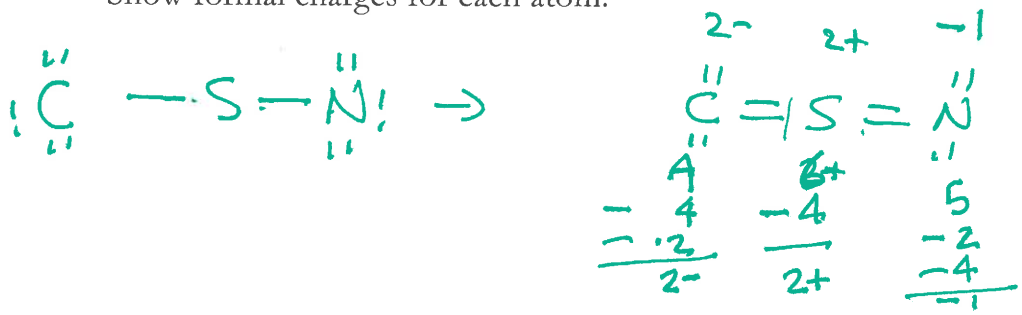


d. ClO_2^- Draw the Lewis structure that obeys the octet rule.

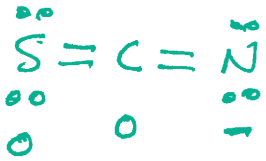


$6 + 5 + 4 + 1 = 16\,e^-$

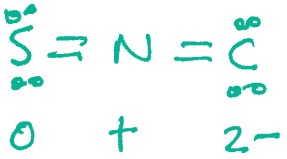
e. SCN^- Put S in the center and draw the structure that has 2 double bonds. Show formal charges for each atom.



f. SCN^- Put C in the center and draw the structure that has 2 double bonds.



g. SCN^- Put N in the center and draw the structure that has 2 double bonds. Show formal charges for each atom. Show formal charges for each atom.



h. For structures e, f, and g pick the most stable structure based on formal charge rules and explain your choice thoroughly.

The most stable structure is $[S=C=N]^-$ the overall FC are lowest, lowest magnitude with ⊖ on most electronegative atom