Please put your name in the upper RIGHT hand corner.

Do this one

1. (15 points) 200.00 mL of 0.200 M hydrochloric acid is mixed with 2.00 g of calcium hydrogen carbonate. The reaction proceeds to completion. Carbon dioxide gas is collected over water. The water temperature is 26.13°C, the atmospheric pressure is 784 torr, and the vapor pressure of water is 25.40 torr at this temperature.

$$Ca(HCO_3)_{2(s)} + \overset{2}{HCl}_{(aq)} \rightarrow CaCl_{2(aq)} + CO_{2(g)} + H_2O_{(l)}$$

need to BEQ

(a) What is the limiting reagent (or reactant)? Show how you determined this.
(b) What is the volume of gas formed?
(c) Calculate the amount of the excess reactant left over after the reaction.

Continue the answer on the page attached. Please don't try to cram it all on this page.

$200.0\ mL \times \frac{0.200\ mol\ HCl}{L} = 40.0\ mmol\ HCl \times \frac{1\ mol}{1000\ mmol} = 0.0400$

$\frac{2.00\ g\ Ca(HCO_3)_2}{} \cdot \frac{1\ mol}{162.04\ g} = 0.0123\ mol\ Ca(HCO_3)_2$

$Ca(HCO_3)_2$ is LR $0.0123 < 0.02$

A $Ca(HCO_3)_2$

$\cancel{n = \frac{PV}{RT}}$ $V = \frac{nRT}{P}$ $n_{CO_2} = n_{Ca(HCO_3)_2}$

$0.0123\ mol\ CO_2 \left| \frac{0.08206\ L\ atm}{K\ mol} \right| \frac{273.15\ K + 26.13\ K}{784\ torr} \left| \frac{760\ torr}{1\ atm} \right.$

b) 0.294 L

Use this page for problem 1

$0.0123\ mol \left| \frac{2\ mol\ HCl}{1\ mol\ Ca(HCO_3)_2} \right. = 0.0246$ mol HCl used

0.0400 mol HCl − 0.0246 mol used =

0.0154 mol HCl remain

c)

do this!

(14 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.

Then, using the molality in part (c), determine the boiling point and the freezing point of this solution. For water, K_f = 1.86 °C/m and K_b = 0.51 °C/m.

a) $\% = \frac{g\ VitC}{total} \times 100 = \frac{80.5g\ VitC}{(80.5 + 210.0g)} \times 100 = \boxed{27.7\%\ VitC}$

b) mole fraction

27.7 g VitC

72.3 g H_2O

or use initial values!

$\boxed{0.397}$

$\frac{27.7g\ VitC}{} \Big| \frac{1\ mol\ VitC}{176.12g\ VitC} = 0.157\ mol\ VitC$

$\frac{72.3g\ H_2O}{} \Big| \frac{1\ mol\ H_2O}{18.02g\ H_2O} = 4.01\ mol\ H_2O$

$\frac{0.157}{4.169} =$

c) $\text{molality} = \frac{\text{mole VitC}}{\text{kg } H_2O} = \frac{0.157\ mol}{0.0723\ kg} = 2.18\ m\ VitC$

d) Molarity = mol VitC/L sol'n

density

$\frac{0.157\ mol\ VitC}{100.0g\ Solution} \Big| \frac{1.22g\ solution}{1\ mL\ solution} \Big| \frac{1000mL}{1L} = 1.92\ M\ VitC$

this is moles in from a & b

2. (8 points) The following statements refer to intermolecular forces. Correct the false statements and give supporting evidence for the true statements using complete sentences.

(a) The more polarizable the molecules, the stronger the dispersion forces between them.

(b) The boiling points of the noble gases decrease as one goes down the column in the periodic table.

(c) In general, the smaller the molecule, the strong the dispersion forces.

SKIP!!!

ch 13 — covered this early in semester

(d) All other factors being the same, dispersion forces between molecule increases with the number of electrons in the molecules.

a) is true. more polarizable means the cloud moves and can have a strong London force

b) false. boiling pt of noble gases increase w/ Z b/c more e^-, larger cloud, more polarizible, stronger forces. this makes it HARDER to separate the attractive forces so the BP is higher

c) in general, smaller molecules are LESS polaizible and have weaker attractions

d) true, more e^- = larger cloud = more polarizible

3. (8 points) The following statements refer to carbon tetrachloride and carbon tetrabromide. Correct the false statements and give supporting evidence for the true statements using complete sentences.

skip

(a) CBr_4 is more volatile than CCl_4.
(b) CBr_4 has a higher boiling point than CCl_4.
(c) CBr_4 has weaker intermolecular forces than CCl_4.
(d) CBr_4 has a higher vapor pressure at the same temperature than CCl_4.

a) is false CBr_4 is less volatile b/c it is larger w/more e^-, so harder to go into gas phase

b) true

c) false b/c it is not as volatile as CCl_4

d) false if it is not as volatile it has a lower vapor pressure

High BP = more energy added to break attractions.

4. (8 points) Identify the types of intermolecular forces present in each of the following substances, and select the substance in each pair that has the higher boiling point. Briefly explain your choice:

maybe

(a) C_6H_{14} or C_8H_{18} London dispersion in both the larger molecule has the higher B.P.

(b) C_3H_8 or CH_3OCH_3 - London vs polar CH_3OCH_3 for "same" mass polar stronger

(c) HOOH or HSSH hydrogen bond vs polar H- bonds are stronger

(d) NH_2NH_2 or CH_3CH_3 H Bonds vs London H Bonds are stronger

5. (8 points) 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
(b) Density
(c) Average kinetic energy of the molecules
(d) Rate of effusion through a pinhole.

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

a) Since the gases are at STP both have same # mol/L and L/mol (22.4 L = 1 mol), ∴ no. of molecules are same

b) $MM_{N_2} > MM_{CH_4}$ ∴ $d_{N_2} > d_{CH_4}$ since $Vol_{N_2} = V_{CH_4}$

c) T are the same ∴ $\overline{KE}$ are same

d) $r_{N_2} >$ slower b/c it is a heavier molecule rate $\propto \frac{1}{MM}$

6. (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.

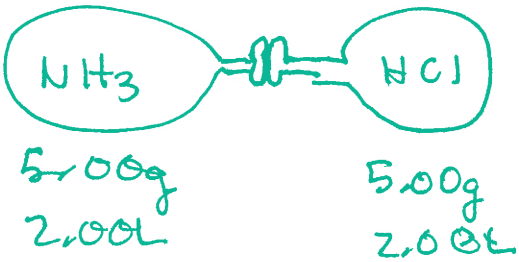
$PV = nRT$

$n = PV/RT$ → # molecules $= 6.022 \times 10^{23} \times n$

$$\frac{\left(735\text{ torr} \times \frac{1\text{ atm}}{760\text{ torr}}\right)(2.25\text{ L})}{\left(0.08206\ \frac{\text{L atm}}{\text{K mol}}\right)(273.15 + 37.\text{ K})}$$

$$0.08549\text{ mol} \times \frac{6.022 \times 10^{23}\text{ Air}}{1\text{ mol}} = 5.15 \times 10^{22}\text{ molecules}$$

moles NH_3



$\frac{5.00g\ NH_3 \mid 1\ mol\ NH_3}{17.03g\ NH_3}$

~~0.0~~ 0.2935 mol NH_3

$V_T = 4.00L$

$T = 293.15K$

7. 10 points) Ammonia and hydrogen chloride react to form solid ammonium chloride.

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

LR since 1:1

do this!

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? (6 points) NH_3 will remain

(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. (4 points)

mol HCl = $\frac{5.00g\ HCl \mid 1\ mol\ HCl}{36.46g\ HCl}$ = 0.1371 mol HCl

mol gas = 0.2935 mol NH_3 − 0.1371 mol used = 0.1565 mol remain

$P = \frac{nRT}{V} = \frac{(0.1565\ mol\ NH_3)(0.08206\ \frac{L \cdot atm}{K \cdot mol})(293.15K)}{4.00L}$

0.941 atm or 715 torr

8. (15 points) Sulfur tetrafluoride (SF_4) reacts slowly with oxygen to form sulfur tetrafluoride monoxide (OSF_4) according to the following unbalanced reaction:

$$SF_{4(g)} + O_{2(g)} \rightarrow OSF_{4(g)}$$

do this

see next page

(a) Balance the equation (1 point)

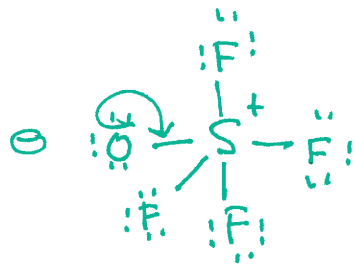
(b) Write a Lewis structure of OSF_4 in which the formal charges of all atoms are zero. (4 points)

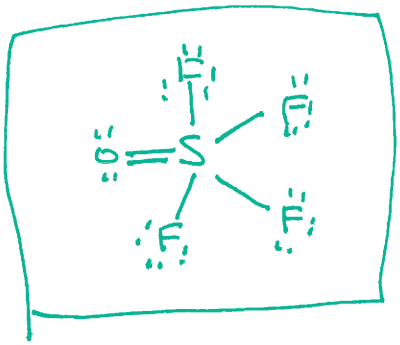
(c) Use average bond enthalpies to estimate the enthalpy of the reaction. Is it endothermic or exothermic? Explain. (4 points)

(d) Determine the electron domain geometry of OSF_4, (1 points)
(e) Determine the molecular geometry (1 points)
(f) Draw two possible isomers for the molecule based on this geometry. (4 points

a) $2SF_{4(g)} + O_{2(g)} \rightarrow 2OSF_{4(g)}$

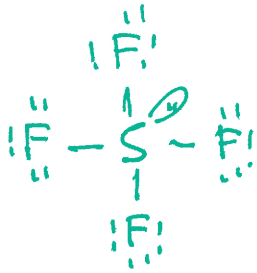
b)
$$\begin{array}{r} 6 \\ 28 \\ 6 \\ \hline 40 \\ -\ 10 \\ \hline 30 \\ 30 \\ \hline 0 \end{array}$$





c) SF_4

$$\begin{array}{r} 16 \\ 28 \\ \hline 34 \\ -\ 8 \\ \hline 26 \\ -\ 24 \\ \hline 2 \end{array}$$

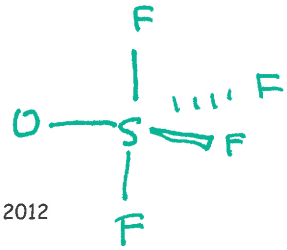


$\Delta H_{Rxn} = 2\times(4\ S\text{-}F\ bonds) + 1O_2 - [2\times 4\ SF\ Bonds + 1\ S{=}O]$

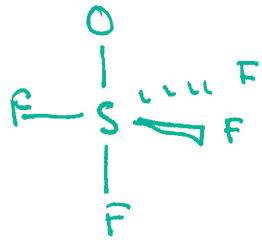
d) 5 Regions of electron density = trigonal bipyramidal

e) same as "d"

(f)



or



do this one!!

9. (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.
   (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? (7 points)
   (b) Suppose the microwave's power is 900W (1 Watt = 1 joule/sec). How long would you have to heat the coffee based on the energy from part a? (3 points)

$$\Delta E_{photon} = \frac{hc}{\lambda} = \frac{(6.626\times10^{-34}\,J\cdot s)(2.998\times10^{8}\,ms^{-1})}{11.2\times10^{-2}\,m}$$

$$= 1.774\times10^{-24}\,J$$ make sense it has long λ

ΔE need to heat H_2O = $\frac{4.184\,J}{g\cdot C}\times 200.0\,g\times(60.0-23.0)$

(assume $d = 1.00\,g/mL$) $= 30961.6\,J$

$$\#\text{ photons} = \frac{30961.6\,J}{1.774\times10^{-24}\,J} = 1.75\times10^{28}\text{ photons}$$

$$\frac{900\,W}{900}\left|\frac{1\,J/s}{1\,W}\right.$$

$$\frac{30961.6\,J}{}\left|\frac{1\,s}{900\,J}\right. = 34.4\text{ sec}$$

10. (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.

do this

11. (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.

do this

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

(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)

$$\frac{14.8\,mL}{} \cdot \frac{1\,L}{1000\,mL} \cdot \frac{0.134\,M\ KMnO_4}{1\,L} \cdot \frac{5\,H_2O_2}{2\,MnO_4^-} \cdot \frac{1}{10.0\,mL} \cdot \frac{1000\,mL}{1\,L}$$

$= 0.496\,M\ H_2O_2$

N_{ox} Mn $\Rightarrow$ $Mn + 4O_x = -2$

$Mn + -8 = -2$

$Mn = 6$

(7+)

$MnO_4^- \Rightarrow Mn^{2+}$ represents a reduction. e^- must be gained to lower the oxidation number.

12. (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?

do this

a) Ti^{2+} [Ar] $3d^2$ Ca: [Ar] $4s^2$ e^- in Ti^{2+} are in 3d orbitals while Ca are in 4s orbital.

b) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$ vs $1s^2 2s^2 2p^6 3s^2 3p^6 3d^2$

$Z = 20$ $Z = 22$ Ti^{2+} has a more stable 2s orbital b/c Z is higher than Ca.

c) no) ~~not~~ Ca has

13. (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?

do this

see next page

no unpaired e^- the 2S orbital is complete while Ti^{2+} has two unpaired e^- in the 3d shell

a higher Z means a stronger attraction. Ti^{2+} e^- penetrate the nucleus more effectively ∴ energy is lower and more stable

sorry about that $HA + NaOH \rightarrow NaA + H_2O$

$15.0\ mL \times 0.1008 \frac{mol}{L} = 1.512\ mmol\ NaOH$

$= 1.512\ mmol\ HA$

$5.89\ g\ H \div 1.008\ g/mol = 5.84\ mol\ H$

$70.6\ g\ C \div 12.01 = 5.88\ mol\ C$

$23.5\ g\ O \div 16.00 = 1.47\ mol\ O$

$\frac{H}{O} = \frac{5.84}{1.47} = \frac{3.97}{1}$ $\quad \frac{C}{O} = \frac{5.88}{1.47} = \frac{4}{1}$

EF = C_4H_4O

$\frac{0.2053\ g}{1.512 \times 10^{-3}\ mol} = 135.98\ g/mol$

$\frac{135.98}{68.07} = \frac{2.00}{1}$

$C_8H_8O_2$

14. (10 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) hydrogen carbonate $Co(HCO_3)_2$

(f) Hypochlorus acid HClO

(g) SF_6 → ~~sulfer~~ sulfur hexafluoride

(h) XeO_3 xenon trioxide

(i) Dinitrogen tetroxide → N_2O_4

(j) P_4S_6 ~~phosphorus~~ tetraphosphorus hexasulfide

15. (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.

$Pb(NO_3)_2(aq) + Na_2S(aq) \rightarrow PbS(s) + 2NaNO_3(aq)$

$Pb^{2+}(aq) + 2NO_3^-(aq) + 2Na^+(aq) + S^{2-}(aq) \rightarrow PbS(s) + 2Na^+(aq) + 2NO_3^-(aq)$

$Pb^{2+}(aq) + S^{2-}(aq) \rightarrow PbS(s)$

$2C_8H_{18(l)} + 25\,O_{2(g)} \rightarrow 16\,CO_{2(g)} + 18\,H_2O_{(l)}$

~~16 Ox + 4Ox = 20Ox~~

16 + 9 = 25

16. (12 points) The use the combustion of octane, $C_8H_{18(l)}$, the main component of gasoline, to answer the following questions.

(a) Write the balanced equation for the complete combustion of octane to produce water and carbon dioxide. (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)

$\frac{1.00\ \text{gal}\ C_8H_8}{} \cdot \frac{3.78\ L}{1\ \text{gal}} \cdot \frac{1000\ mL}{1\ L} \cdot \frac{0.692\ g}{1\ mL} \cdot \frac{1\ mol\ C_8H_8}{104.1\ g\ C_8H_8} \cdot \frac{10\ O_2}{1\ C_8H_8} \cdot \frac{32.00\ g\ O_2}{1\ mol\ O_2}$

$= 8040.7\ g\ O_2$ $\quad 8.04 \times 10^3\ g$ $\quad \boxed{8.04\ kg}$

OOPS

$-1227.2\ kJ = -\Delta H_f^\circ$

$\Delta H^\circ_{Rxn} = 4 \cdot \Delta H^\circ_f H_2O + 8 \times \Delta H^\circ_f CO_2 - \Delta H^\circ_f C_8H_8$

$-5520\ kJ - 4(285.83\ \frac{kJ}{mol}) - 8(393.85\ kJ) = -\Delta H^\circ_f C_8H_8$

$\boxed{\Delta H^\circ_f = 1227\ \frac{kJ}{mol}}$

17. (5 points) From the following enthalpies of reaction (2 equations) listed below, calculate the ΔHrxn for the reaction of sulfur with oxygen gas:

$S_{(s)} + O_{2(g)} \rightarrow SO_{2\,(g)}$

$\Delta H_{Rxn} = -297\ kJ$

See next page

$2\,SO_{2\,(g)} + O_{2(g)} \rightarrow 2\,SO_{3(g)}$ $\quad \Delta H = -196\ kJ$

$2\,S_{(s)} + 3\,O_{2(g)} \rightarrow 2\,SO_{3(g)}$ $\quad \Delta H = -790\ kJ$ ← oops

$\frac{2}{2}SO_{3(g)} \rightarrow \frac{1}{2}O_{2(g)} + \frac{2}{2}SO_{2(g)}$ $\quad +196\ kJ \div 2$

$\frac{2}{2}S_{(s)} + \frac{3}{2}O_{2(g)} \rightarrow \frac{2}{2}SO_{3(g)}$ $\quad -790\ kJ \div 2$

or $= 3.0 \times 10^2\ kJ$

$0.3\ MJ$

18. (7 points) Carbonated drinks are canned under about 4 atm of carbon dioxide at the processing plant. When the can (or bottle) is opened, most of the gas is released as the total pressure above the liquid is lowered to 1 atm. The excess CO_2 bubbles out of solution. The partial pressure of CO_2 at this point is 3.00 X 10^{-4} atm.

skip

over ⇒ we skipped this all together

(a) On a particular day, the canning company used 3.87 atm of CO_2 in the sealed can. How many moles of CO_2 are dissolved in a 355-mL can of soda before it is opened? (2 points)
(b) When the can is opened, the excess gas escapes, and a new pressure is is established. How many moles of CO_2 remain after the can is open? (2 points)
(c) What volume (in L) would the released CO_2 occupy at 1.00 atm and 25°C? (You need the answer from part a to solve this problem. Use 0.0678 moles if you did not solve a.) (3 points)

[k(Henry's law for CO_2) = 3.31 X 10^{-2}mol/(L•atm)]

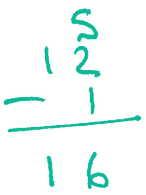
$$\frac{\Delta H^\circ_{Rxn}}{1\ mol\ C_8H_{18}} = 16\ mol\ \Delta H^\circ_{f\,CO_2} + 18\ mol\ \Delta H^\circ_{f\,H_2O} - 2\ mol\ \Delta H^\circ_{f\,C_8H_{18}}$$

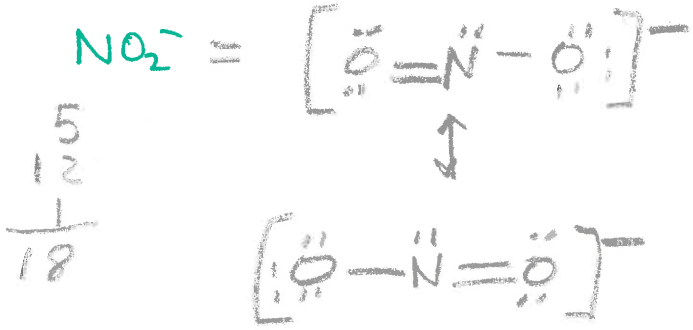
$$\frac{-5520\ kJ}{1\ mol\ Oct} = 2\ mol\ oct - 16(-393.\ kJ) + 18(-285\ kJ) = -2\ mol \cdot X$$

$$\approx -200\ \frac{kJ}{mol}$$

do this

19. (10 points) Nitrogen can form several types of compounds when it reacts with oxygen. Two of these compounds are NO_2^+ and NO_2^-. Draw the best Lewis structure for these two ions and based on resonance (or the lack thereof) pick the ion that has the longest N=O bond. Explain your answer.

NO_2^+ 

NO_2^- = 

NO_2^- has the longer double bond. both bonds are the same length ~~1½ yes~~ in the NO_2^- ion, the e^- density is spread out more, this lowers the attraction and the atoms move further away

20. (7 points) Complete the following statements by filling in the blanks:

a. Two electrons in the same orbital must have opposite spin.

skip b. The presence of un paired electrons in an atom gives rise to para magnatism

c. When l= 3, ml may have values from -3 to +3.

d. The neutral fourth period atom having a total of six d electrons is Fe.

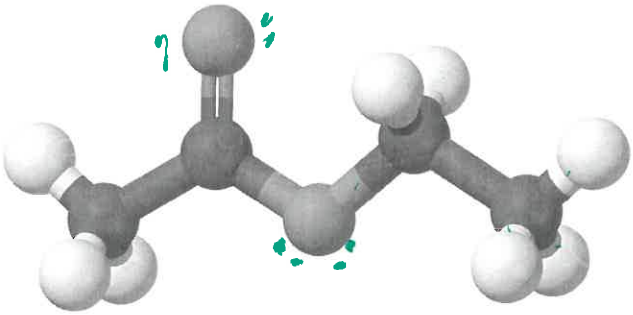
and this e. Orbital with the same energy are said to be degenerate

f. The 2p orbitals of an atom have identical shapes but differ in there orientation

g. A nodal surface is one at which the probability of finding and electron is Ø

a. (3 points) Ethyl acetate, $C_4H_8O_2$, is a fragrant substance used both as a solvent and as an aroma enhancer. Its molecular structure is shown below. What is the hybridization at each of the carbon atoms of the molecule? What is the hybridization at each of the oxygen molecules? How many σ (sigma) bonds are in the molecule? How many π (pi) bonds are in the molecule?

and this you will have a chart



C#1	C#2	O#1	O#2	C#3

Please put your answer in the table below

Atom in the molecule or bond type	Hybridization
C#1	Sp3 (4 bonds) Regions
C#2	Sp2 (3 regions
C#3	Sp3
O#1	~~Sp3~~ Sp2
O#2	Sp3
# sigma bonds	13
# pi bonds	1

http://en.wikipedia.org/wiki/File:Ethyl-acetate-3D-balls.png