City College, Chemistry Department
Chemistry 10301, sections T, T2, T3. Prof. T. Lazaridis
Final exam, Dec 20, 2007
Name (last name first): _____
I.D. Number last 4:_____

Note: There are 18 questions in this exam. Fill in your answer in the blank space provided immediately following each question. 1/2 point will be subtracted every time you report a numerical result with an incorrect number of significant figures.

A Data Sheet with useful information is at the end.

1. (4) Write the names of the elements below next to their atomic symbols:

Ar **Argon**

Al **Aluminum**

S **Sulfur**

Cu **Copper**

2. (4) Write the molecular formula next to the names of the following compounds:

Sodium Nitrate **$NaNO_3$**

Barium Carbonate **$BaCO_3$**

Magnesium Sulfate **$MgSO_4$**

Potassium Hydroxide **KOH**

3. (8) Balance the following chemical equations:

$H_2 + I_2 \rightarrow \mathbf{2}\ HI$

$\mathbf{2}\ As + \mathbf{3}\ H_2 \rightarrow \mathbf{2}\ AsH_3$

$\mathbf{2}\ KClO_3 \rightarrow \mathbf{2}\ KCl + \mathbf{3}\ O_2$

$\mathbf{2}\ K + \mathbf{2}\ H_2O \rightarrow \mathbf{2}\ KOH + H_2$

4. (7) The equation for preparing chlorine gas from HCl is

$$4\ HCl\ (g) + O_2\ (g) \rightarrow 2\ Cl_2\ (g) + 2\ H_2O\ (g)$$

How many kilograms of HCl are required to produce 1750 kilograms of Cl_2?

Molar masses: Cl_2: 70.90 g/mol HCl: 36.46 g/mol

1750 Kg X 1000g/Kg X (1/70.90 g/mol) X (4 mol HCl/ 2 mol Cl_2) X 36.46 g/mol X (1 Kg/1000 g) = 1800 Kg HCl

5. (7) Chlorobenzene is prepared from benzene by the following reaction:

$$C_6H_6\ (l) + Cl_2\ (g) \rightarrow C_6H_5Cl\ (l) + HCl\ (g)$$

A 10.0-Kg sample of benzene treated with excess chlorine gas yields 10.4 Kg of chlorobenzene. Calculate the percent yield of chlorobenzene.

Molar masses: C_6H_6: 78.11 g/mol C_6H_5Cl: 112.55 g/mol

10000 g/78.11 (g/mol) = 128.0 mol benzene

theoretical yield = 128.0 mol X 112.55 (g/mol) = 14406 g chlorobenzene

percent yield: 10.4/14.4 X 100% = 72.2 %

6. (7) How many L of oxygen, measured at 0 ºC and 1.00 atm, are required for the complete combustion of 5.00 g of ethane (C_2H_6)?

$$C_2H_6 + 7/2\ O_2 \text{ ----> } 2\ CO_2 + 3\ H_2O$$

Molar mass: C_2H_6: 30.07 g/mol

5.00/ 30.07 (g/mol) = 0.166 mol , this requires 0.166X 7/2 = 0.581 mol O_2

IG equation: V= nRT/P = 0.581 X 0.082 X 273.15 K / 1 atm = 13.0 L

7. (7) Oxidation of ammonia gives nitric oxide and water:

$4\ NH_3\ (g) + 5\ O_2\ (g) \rightarrow 4\ NO\ (g) + 6\ H_2O\ (g) \qquad \Delta H^o = -905.4\ kJ$

Use this equation and data from your data sheet to calculate the enthalpy of formation of NO.

$\Delta H^o = \Delta H^o_f$ (products) – ΔH^o_f (reactants) =>
-905.4 = {6X(-241.8) + 4 ΔH^o_f(NO)} – {4X(-46.11)} =>
ΔH^o_f(NO) = +90.2 kJ

8. (7) 30.0 g of P_4O_{10} is mixed with 75.0 g of water to form phosphoric acid:

$$P_4O_{10}\ (s) + 6\ H_2O\ (l) \text{--->} 4\ H_3PO_4\ (aq)$$

a) (3) Which one is the limiting reactant?
b) (3) How many grams of phosphoric acid will form?

a) Molar masses: P_4O_{10}: 283.88 g/mol H_2O: 18.02 g/mol H_3PO_4 : 97.99 g/mol

30.0/283.88 = 0.106 mol P_4O_{10} 75.0/18.02 = 4.16 mol H_2O

0.106 mol P_4O_{10} requires 6X0.106 mol = 0.636 mol water. We have 4.16. So water is in excess and limiting reactant is P_4O_{10}.

b) 0.106 X 4 X 97.99 g/mol = 41.55 g H_3PO_4

9. (4) Calculate the molarity of each of the following solutions:

a) (2) 45.0 g of NaCl in 250 mL of solution

Molar mass : 58.44 45.0/58.44 = 0.770 mol

0.707 mol / 0.25 L = 3.08 M

b) (2) 40.0 g of H_2SO_4 in 2.00 L of solution

Molar mass : 98.09 40.0/98.09 = 0.408 mol

0.408 mol / 2 L = 0.204 M

10. (4) How many orbitals are there in

a) (2) the n=3 shell?

9 (1 3s, 3 3p, and 5 3d)

b) (2) the 3d subshell?

5

11. (4) Write an abbreviated (noble gas core) electron configuration for the following:

Si **[Ne]$3s^2 3p^2$**

Cl^- **[Ar]**

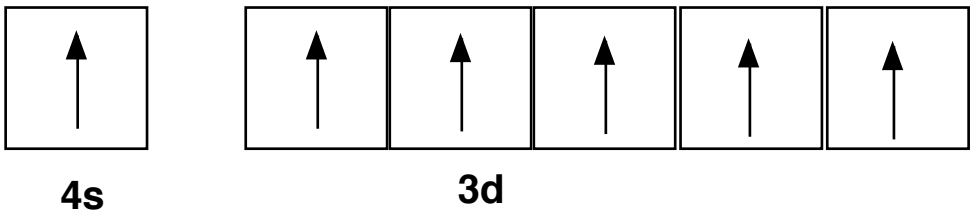
Cd **[Kr]$5s^2 4d^{10}$**

Fe^{3+} **[Ar]$3d^5$**

12. (2) Place the atoms B, K, Ga in order of increasing ionization energy.

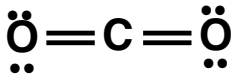
K < Ga < B

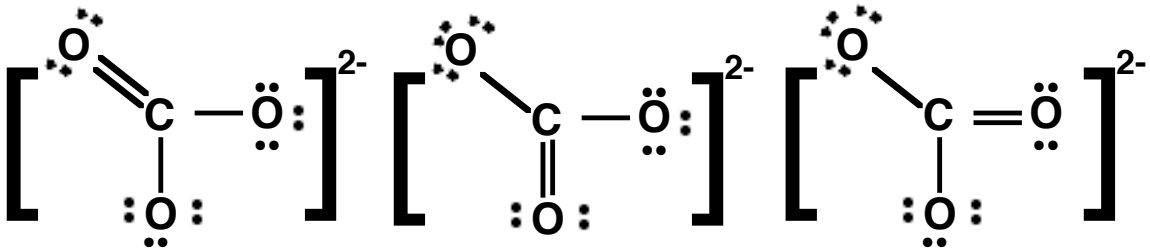
13. (5) Draw the orbital diagram for the partially filled subshells of Cr.



(Cr is an exception to Aufbau rules)

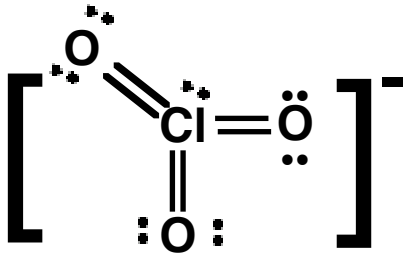
14. (10) Draw Lewis structures that satisfy the octet rule for CO, CO_2, and CO_3^{-2} and predict the order of the C···O bond lengths (which molecule will have the shortest, the longest, and the intermediate bond lengths).





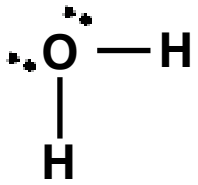
The C...O bond is shortest in CO (triple), intermediate in CO_2(double), and longest in CO_3^{-2} (single with partial double bond character)

15. (5) Use Lewis structures and the VSEPR method to predict the molecular geometry and the bond angles of ClO_3^-

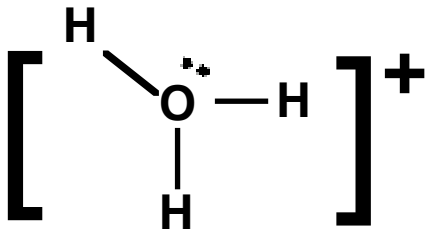


Electron group geometry: tetrahedral (bond angles slightly smaller than 109.5) , molecular geometry: trigonal pyramidal

16. (5) Compare the shapes and bond angles of H_2O and H_3O^+.

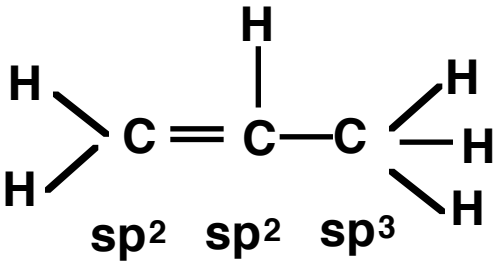


E.G. geometry tetrahedral, mol. geometry bent (angular), bond angle somewhat smaller than 109.5 due to lone pair repulsion



E.G. geometry tetrahedral, mol. geometry trigonal pyramidal, bond angle somewhat smaller than 109.5 due to lone pair repulsion (but probably not as small as in water)

17. (5) Write the structural formula for propene (C_3H_6), determine the hybridization of each central atom, and estimate all bond angles.



The angles around the left and center C are 120° and around the C on the right 109.5^o

18. (5) Give the oxidation number of each element in the following compounds:

a) $XeOF_2$ **F : -1, O: -2, Xe: +4**

b) $Sn(OH)_4^{2-}$ **O: -2, H : +1, Sn: +2**

c) PH_4^+ **H : +1, P: -3**

d) $CuCl_4^{2-}$ **Cl : -1, Cu: +2**

e) CN^- **N : -3, C: +2**

DATA SHEET

Speed of light : 2.9979 X 10^8 m/s

Planck's constant : 6.626 X 10^{-34} Js

E_n = -2.179 X 10^{-18} J/n^2

Mass of a proton: 1.67262 X 10^{-24} g

Mass of an electron: 9.10939 X 10^{-28} g

R= 0.082058 L atm / (mol K) = 62.364 L torr / (mol K) = 8.3145 J / (mol K)

Substance	ΔH_f^o, kJ/mol
NH_3 (g)	-46.11
H2O (g)	-241.8
NH_4Cl (s)	-314.4
HCl (g)	-92.31
C_2H_4 (g)	52.26
C_2H_6 (g)	-84.68