CHEM 1314.03
Exam IV
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December 18, 1997

Name _____

TA's Name _____

Lab Section _____

## INSTRUCTIONS:

1. This examination consists of a total of 9 different pages. The last three pages include a periodic table, a solubility table, and some useful equations. All work should be done in this booklet.

2. PRINT your name, TA's name and your lab section number now in the space at the top of this sheet. DO NOT SEPARATE THESE PAGES.

3. Answer all questions that you can and whenever called for show your work clearly. Your method of solving problems should pattern the approach used in lecture. You do not have to show your work for the multiple choice or short answer questions.

4. No credit will be awarded if your work is not shown in problems 7, 8 and 10.

5. Point values are shown next to the problem number.

6. Budget your time for each of the questions. Some problems may have a low point value yet be very challenging. If you do not recognize the solution to a question quickly, skip it, and return to the question after completing the easier problems.

7. Look through the exam before beginning; plan your work; then begin.

8. Relax and do well.

| | Page 2 | Page 3 | Page 4 | Page 5 | Page 6 | TOTAL |
|---|---|---|---|---|---|---|
| SCORES | _____ (28) | _____ (26) | _____ (20) | _____ (18) | _____ (8) | _____ (100) |

(12) 1. Write the chemical formula(s) of the product(s) and balance the following reactions. Identify all products phases as either (g)as, (l)iquid, (s)olid or (aq)ueous. Soluble ionic compounds should be written in the form of their component ions.

a) $NH_{3(aq)} + HNO_{3(aq)} \rightarrow \mathbf{NH_4NO_{3(aq)}}$

b) $HC_2H_3O_{2(aq)} + KOH_{(aq)} \rightarrow \mathbf{KC_2H_3O_{2(aq)}} + \mathbf{H_2O_{(l)}}$

c) $\mathbf{2}Al(NO_3)_{3(aq)} + \mathbf{3}Na_2CO_{3(aq)} \rightarrow \mathbf{Al_2(CO_3)_{3(aq)}} + \mathbf{6NaNO_{3(aq)}}$

d) hydrochloric acid$_{(aq)}$ + zinc$_{(s)}$ $\rightarrow$ $\mathbf{ZnCl_{2(aq)}} + \mathbf{H_{2(g)}}$

(6) 2. Write the ionic and net ionic chemical equations for 1b) and 1c).

1a)

Ionic equation:

Net Ionic equation:

1c)

Ionic equation:

Net Ionic equation:

(10) 3. What is the difference between a localized and a delocalized bond. In your discussion indicate the type of bond and the atomic/hybrid orbitals which are involved in both cases, give an example (do not use any compounds from this exam) of a compound which exhibits each type, and for each type of bond describe where the electron density can be found.

(18) 4. Complete the following table

| Compound | Name of molecular geometry | Bond angle(s) | Hybridization on the central atom | Polar or nonpolar? |
|---|---|---|---|---|
| $NF_3$ | **Trigonal pyramidal** | **Less than 109.5°** | **$sp^3$** | **polar** |
| $ICl_2^-$ | **linear** | **180°** | | |
| $ClO_2^-$ | **bent** | **Less than 109.5°** | **$sp^3$** | |
| $SCl_2$ | **bent** | **Less than 109.5°** | **$sp^3$** | **Polar** |
| $SO_3$ | **Trigonal planar** | **120°** | **$Sp^2$** | **nonpolar** |

(8) 5. Indicate the atomic and/or hybrid orbitals on each atom in the following molecules which are involved in forming the covalent bond(s).

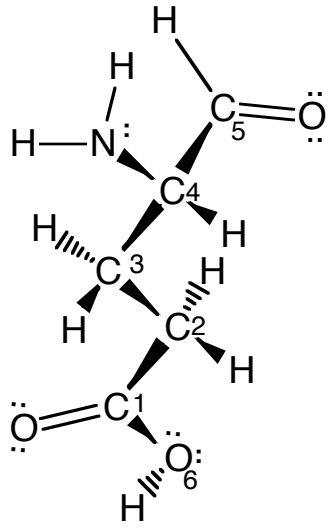
a) $CCl_4$

**$sp^3$(C) = p(Cl)**
**all C–Cl bonds are identical**

b) HCN

**s(H) = sp(C)**
**sp(C) = sp(N) sigma bond**
**p(C) = p(N) pi bond**
**p(C) = p(N) pi bond**

(12) 6. Given the following Lewis structure inwhich all atoms obey the octet rule (except hydrogen),




a) how many σ-bonds and how many π bonds. ____ σ-bonds ____ π-bonds

b) indicate the hybridization on each of the following atoms.

$C_1$ _____ $C_2$ _____ $C_3$ _____ $C_4$ _____ $C_5$ _____ N _____ $O_6$ _____

c) indicate the *ideal* bond angle for; H–$C_3$–H _____° H–N–H _____° $C_2$–$C_1$–$O_6$ _____°

(8) 7a. A 50.0 L sample of gas obtained from the upper atmosphere is at a pressure of 6.50 mmHg. Calculate the pressure required to confine the volume to 150 mLs.

b) To what volume would the original volume have to be compressed for the gas to exert a pressure of 8.50 atm?

(12) 8. Oxygen will react with iron according to the equation;

$$2O_2(g) + 3Fe(s) \rightarrow Fe_3O_4(s)$$

a) Calculate the mass of iron(III) oxide formed when 5.65 grams of iron are sealed in a 2.50 liter container of pure oxygen at 50 ˚C and a pressure of 700. mmHg.

b) Calculate the pressure exerted by the unreacted oxygen after the reaction has gone to completion. (Assume the final temperature when the reaction is complete is the same as the initial temperature.)

(6) 9. Explain, in terms of the kinetic molecular model, why decreasing the temperature of a fixed amount of an ideal gas, at constant external pressure, results in a decrease of the volume of the gas.

(8) 10. A 2.25 L container of hydrogen gas at 450. mmHg and 23.5 ˚C is connected to a 1.55 L container of helium at 635 mmHg and 23.5 ˚C. After allowing the gases to mix what is the total pressure, in mmHg? (Assume the temperature remains constant.)

# Periodic Table of the Elements

| | IA | | | | | | | | | | | | IIIA | IVA | VA | VIA | VIIA | VIIIA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 **H** 1.008 | IIA | | | | | | | | | | | | | | | | 2 **He** 4.00 |
| 2 | 3 **Li** 6.94 | 4 **Be** 9.01 | | | | | | | | | | | 5 **B** 10.81 | 6 **C** 12.01 | 7 **N** 14.01 | 8 **O** 16.00 | 9 **F** 19.00 | 10 **Ne** 20.18 |
| 3 | 11 **Na** 22.99 | 12 **Mg** 24.30 | IIIB | IVB | VB | VIB | VIIB | VIII | | | IB | IIB | 13 **Al** 26.98 | 14 **Si** 28.09 | 15 **P** 30.97 | 16 **S** 32.06 | 17 **Cl** 35.45 | 18 **Ar** 39.95 |
| 4 | 19 **K** 39.10 | 20 **Ca** 40.08 | 21 **Sc** 44.96 | 22 **Ti** 47.88 | 23 **V** 50.94 | 24 **Cr** 52.00 | 25 **Mn** 54.94 | 26 **Fe** 55.85 | 27 **Co** 58.93 | 28 **Ni** 58.69 | 29 **Cu** 63.55 | 30 **Zn** 65.38 | 31 **Ga** 69.72 | 32 **Ge** 72.59 | 33 **As** 74.92 | 34 **Se** 78.96 | 35 **Br** 79.90 | 36 **Kr** 83.80 |
| 5 | 37 **Rb** 85.47 | 38 **Sr** 87.62 | 39 **Y** 88.91 | 40 **Zr** 91.22 | 41 **Nb** 92.91 | 42 **Mo** 95.94 | 43 **Tc** (98) | 44 **Ru** 101.1 | 45 **Rh** 102.9 | 46 **Pd** 106.4 | 47 **Ag** 107.9 | 48 **Cd** 112.4 | 49 **In** 114.8 | 50 **Sn** 118.7 | 51 **Sb** 121.8 | 52 **Te** 127.6 | 53 **I** 126.9 | 54 **Xe** 131.3 |
| 6 | 55 **Cs** 132.9 | 56 **Ba** 137.3 | 57 **La** 138.9 | 72 **Hf** 178.5 | 73 **Ta** 180.9 | 74 **W** 183.8 | 75 **Re** 186.2 | 76 **Os** 190.2 | 77 **Ir** 192.2 | 78 **Pt** 195.1 | 79 **Au** 197.0 | 80 **Hg** 200.6 | 81 **Tl** 204.4 | 82 **Pb** 207.2 | 83 **Bi** 209.0 | 84 **Po** (209) | 85 **At** (210) | 86 **Rn** (222) |
| 7 | 87 **Fr** (223) | 88 **Ra** 226.0 | 89 **Ac** 227.0 | 104 (261) | 105 (262) | 106 (263) | | | | | | | | | | | | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lanthanides | 58 **Ce** 140.1 | 59 **Pr** 140.9 | 60 **Nd** 144.2 | 61 **Pm** (145) | 62 **Sm** 150.4 | 63 **Eu** 152.0 | 64 **Gd** 157.2 | 65 **Tb** 158.9 | 66 **Dy** 162.5 | 67 **Ho** 164.9 | 68 **Er** 167.3 | 69 **Tm** 168.9 | 70 **Yb** 173.0 | 71 **Lu** 175.0 |
| Actinides | 90 **Th** 232.0 | 91 **Pa** 231.0 | 92 **U** 238.0 | 93 **Np** 237.0 | 94 **Pu** (244) | 95 **Am** (243) | 96 **Cm** (247) | 97 **Bk** (247) | 98 **Cf** (251) | 99 **Es** (252) | 100 **Fm** (257) | 101 **Md** (258) | 102 **No** (259) | 103 **Lr** (260) |

## Useful Information

$R = 0.08203 \frac{L \cdot atm}{mol \cdot K}$ or $R = 8.314 \frac{J}{mol \cdot K}$ $PV = nRT$ $K = {}^\circ C + 273.15$

1 atm = 760 mm Hg

$$\left(P + \frac{an^2}{V^2}\right)(V - nb) = nRT$$

$$u = \sqrt{\frac{3RT}{MM}}$$

$$\frac{r_1}{r_2} = \sqrt{\frac{MM_2}{MM_1}}$$

## Solubility Table

| Ion | Solubility | Exceptions |
|---|---|---|
| $NO_3^-$ | soluble | none |
| $ClO_4^-$ | soluble | none |
| $Cl^-$ | soluble | except $Ag^+$, $Hg_2^{2+}$, *$Pb^{2+}$ |
| $I^-$ | soluble | except $Ag^+$, $Hg_2^{2+}$, $Pb^{2+}$ |
| $SO_4^{2-}$ | soluble | except $Ca^{2+}$, $Ba^{2+}$, $Sr^{2+}$, $Hg^{2+}$, $Pb^{2+}$, $Ag^+$ |
| $CO_3^{2-}$ | insoluble | except Group IA and $NH_4^+$ |
| $PO_4^{3-}$ | insoluble | except Group IA and $NH_4^+$ |
| $^-OH$ | insoluble | except Group IA, *$Ca^{2+}$, $Ba^{2+}$, $Sr^{2+}$ |
| $S^{2-}$ | insoluble | except Group IA, IIA and $NH_4^+$ |
| $Na^+$ | soluble | none |
| $NH_4^+$ | soluble | none |
| $K^+$ | soluble | none |

*slightly soluble

| Metal | Half-Reaction Reaction |
|---|---|
| Lithium | $Li \rightarrow Li^+ + e^-$ |
| Potassium | $K \rightarrow K^+ + e^-$ |
| Barium | $Ba \rightarrow Ba^{2+} + 2e^-$ |
| Calcium | $Ca \rightarrow Ca^{2+} + 2e^-$ |
| Sodium | $Na \rightarrow Na^+ + e^-$ |
| Magnesium | $Mg \rightarrow Mg^{2+} + 2e^-$ |
| Aluminum | $Al \rightarrow Al^{3+} + 3e^-$ |
| Manganese | $Mn \rightarrow Mn^{2+} + 2e^-$ |
| Zinc | $Zn \rightarrow Zn^{2+} + 2e^-$ |
| Chromium | $Cr \rightarrow Cr^{3+} + 3e^-$ |
| Iron | $Fe \rightarrow Fe^{2+} + 2e^-$ |
| Cobalt | $Co \rightarrow Co^{2+} + 2e^-$ |
| Nickel | $Ni \rightarrow Ni^{2+} + 2e^-$ |
| Tin | $Sn \rightarrow Sn^{2+} + 2e^-$ |
| Lead | $Pb \rightarrow Pb^{2+} + 2e^-$ |
| Hydrogen | $H_2 \rightarrow 2H^+ + 2e^-$ |
| Copper | $Cu \rightarrow Cu^{2+} + 2e^-$ |
| Silver | $Ag \rightarrow Ag^+ + e^-$ |
| Mercury | $Hg \rightarrow Hg^{2+} + 2e^-$ |
| Platinum | $Pt \rightarrow Pt^{2+} + 2e^-$ |
| Gold | $Au \rightarrow Au^{3+} + 3e^-$ |