CHEM 1314.03
Exam III
John III. Gelder
November 20, 1997

Name **KEY**

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, a table of bond energies 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 4a and 4b.

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	____ (30)	____ (24)	____ (22)	____ (15)	____ (9)	____ (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) $KHC_8H_4O_4$*(aq)* + KOH*(aq)* → $\mathbf{C_8H_4O_4^-}$ ***(aq)*** + $\mathbf{2K^+}$ ***(aq)*** + $\mathbf{H_2O}$***(aq)***

b) $HC_2H_3O_2$*(aq)* + NaOH*(aq)* → $\mathbf{C_2H_3O_2^-}$ ***(aq)*** + $\mathbf{Na^+}$ ***(aq)*** + $\mathbf{H_2O}$***(aq)***

c) $2Fe(NO_3)_3$*(aq)* + $3Na_2S$*(aq)* → $6\mathbf{Na^+}$ ***(aq)*** + $\mathbf{6NO_3^-}$***(aq)*** + $\mathbf{Fe_2S_3}$***(s)***

d) chromium (III) nitrate*(aq)* + nickel*(s)* → **No reaction**

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

1b)

Ionic equation:

$\mathbf{HC_2H_3O_2}$***(aq)*** + $\mathbf{Na^+}$ ***(aq)*** + $\mathbf{^-OH}$***(aq)*** → $\mathbf{C_2H_3O_2^-}$ ***(aq)*** + $\mathbf{Na^+}$ ***(aq)*** + $\mathbf{H_2O}$***(aq)***

Net Ionic equation:

$\mathbf{HC_2H_3O_2}$***(aq)*** + ~~$\mathbf{Na^+}$ ***(aq)***~~ + $\mathbf{^-OH}$***(aq)*** → $\mathbf{C_2H_3O_2^-}$ ***(aq)*** + ~~$\mathbf{Na^+}$ ***(aq)***~~ + $\mathbf{H_2O}$***(aq)***

$\mathbf{HC_2H_3O_2}$***(aq)*** + $\mathbf{^-OH}$***(aq)*** → $\mathbf{C_2H_3O_2^-}$ ***(aq)*** + $\mathbf{H_2O}$***(aq)***

1c)

Ionic equation:

$\mathbf{2Fe^{3+}}$ ***(aq)*** + $\mathbf{6NO_3^-}$***(aq)*** + $6\mathbf{Na^+}$ ***(aq)*** + $\mathbf{3S^{2-}}$***(aq)*** → $6\mathbf{Na^+}$ ***(aq)*** + $\mathbf{6NO_3^-}$***(aq)*** + $\mathbf{Fe_2S_3}$***(s)***

Net Ionic equation:

$\mathbf{2Fe^{3+}}$ ***(aq)*** + ~~$\mathbf{6NO_3^-}$ ***(aq)***~~ + ~~$\mathbf{6Na^+}$ ***(aq)***~~ + $\mathbf{3S^{2-}}$***(aq)*** → ~~$\mathbf{6Na^+}$ ***(aq)***~~ + ~~$\mathbf{6NO_3^-}$ ***(aq)***~~ + $\mathbf{Fe_2S_3}$***(s)***

$\mathbf{2Fe^{3+}}$ ***(aq)*** + $\mathbf{3S^{2-}}$***(aq)*** → $\mathbf{Fe_2S_3}$***(s)***

(10) 3. Explain why the first ionization energy for potassium is small (419 kJ·mol^{-1}) and why the ionization for the second electron in potassium is much larger (3,051 kJ·mol^{-1}). Explain your answer in terms of *effective nuclear charge* and *shielding effects*.

K: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$

The first electron is removed from the 4*s* orbital. That electron is shielded from the +19 nuclear charge by 18 electrons. So the effective nuclear charge experienced by the valence electron is approximately +1. So the electron is relative easy to remove. However, the next electron must be removed from the 3rd shell. The effective nuclear charge experienced by an electron in the 3rd shell in potassium is approximately +9. The electrons in the 3rd shell are only shielded from the +19 nuclear charge by 10 electrons. It is considerably more difficult to remove an electron which is feeling effective nuclear charge of +9.

(24) 4. A hydrogen atom is known to absorb a photon of light with a frequency of $2.47 \times 10^{15}\ s^{-1}$.

a) Calculate the wavelength of this photon.

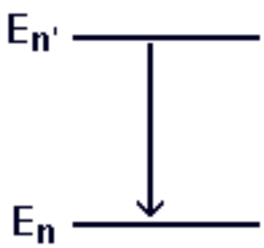
$$\lambda = \frac{c}{\nu} = \frac{3.00 \times 10^{8}\ m \cdot s^{-1}}{2.47 \times 10^{15}\ s^{-1}} = 1.21 \times 10^{-7}\ m$$

b) Calculate the energy of the photon.

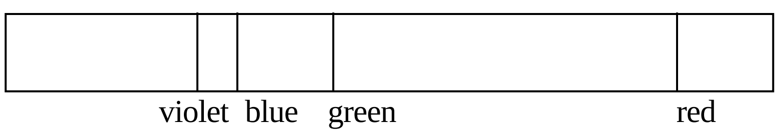
$$E = 6.626 \times 10^{-34}\ J{\cdot}s\ (2.47 \times 10^{15}\ s^{-1}) = 1.64 \times 10^{-18}\ J$$

c) Draw a picture that represents what happens to the electron when a photon is absorbed. (Label the parts of your picture.)

When the electron absorbs energy from a photon of light it is excited from an energy level, E_n, of low energy to an energy level, $E_{n'}$, of higher energy.



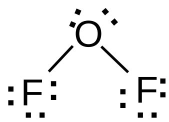
d) The emission spectrum for the hydrogen atom in the visible region of the electromagnetic spectrum is shown below. How does our model of the hydrogen atom explain why the spectrum is discrete (consists of lines).



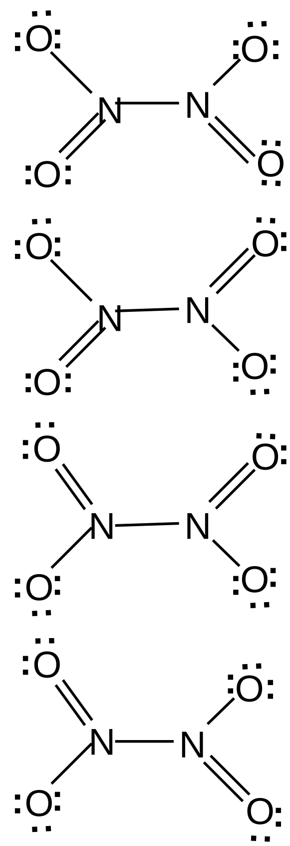
In the model of the hydrogen atom the energy an electron can have is limited to certain values, i.e. quantized. When an electron in a hydrogen atom is excited to a higher energy level it will return to a lower energy level. Since only certain energies are allowed we see discrete lines in the emission spectrum.

(12) 5. Draw a possible Lewis electron-dot structure for each of the covalent molecules below. Include all resonance structures if they are needed to adequately represent the bonding in the molecule.

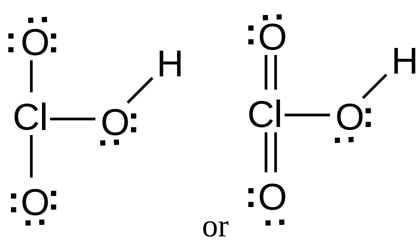
(a) OF_2



(b) N_2O_4



(c) $HClO_3$



(10) 6. In the quantum mechanical description of the hydrogen atom what characteristics of an orbital are determined by;

a) the principal quantum number, n? **Energy and distance from the nucleus**

b) the azimuthal quantum number, l? **Shape of the orbital**

c) the magnetic quantum number, m_l? **Orientation of the orbital**

(4) 7. Give the value for each of the quantum numbers for a valence electron in Se.

n = 4 **l = 1** **m_l = 0** **m_s = +1/2**

(6) 8. Write the electron configuration for,

i. Zn

$[Ar]4s^2 3d^{10}$

ii. Bi

$[Xe]6s^2 4f^{14} 5d^{10} 6p^3$

iii. Ge^{2+}

$[Ar]4s^2 3d^{10}$

(5) 8a. Arrange the following covalent diatomic molecules in order of the length of the bond

BrCl, ClF, IBr

shortest longest
ClF < BrCl < IBr

b) Which will have the weakest bond energy?

IBr

Multiple Choice: (9 points)

Print the letter (A, B, C, D) which corresponds to the answer selected.

10. **A** 11. **C** 12. **E**

ONLY THE ANSWERS IN THE AREA ABOVE WILL BE GRADED. Select the most correct answer for each question. Each question is worth 3 points.

10. In which of the following species would you expect the NO bond energy to be the lowest?

A) NO_3^- B) NO_2^+ C) ONCl D) NO_2^-

11. Which of the following species is the octet rule violated?

A) O_3
B) N_3^-
C) I_3^-
D) O_2^{2-}

12. An atom of element Z has a valence electron configuration of ns^2np^3. The formula of the compound containing magnesium and Z is;

A) MgZ
B) Mg_2Z
C) MgZ_2
D) Mg_2Z_3
E) Mg_3Z_2

Periodic Table of the Elements

	IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIII	VIII	VIII	IB	IIB	IIIA	IVA	VA	VIA	VIIA	VIIIA
1	1 **H** 1.008																	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											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

$E_n = -2.18 \times 10^{-18}\ J \left(\frac{1}{n^2}\right)$ $r_n = 0.529 \times 10^{-8}\ n^2\ cm$ $\Delta E = -2.18 \times 10^{-18}\ J \left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$

$\lambda = \frac{c}{\nu}$ $E = h\nu$ $c = 3.00 \times 10^8\ \frac{m}{s}$ $h = 6.626 \times 10^{-34}\ J\cdot s$

$\Delta H^\circ_{rxn} = \Sigma\, n\, B.E._{reactants} - \Sigma\, m\, B.E._{products}$

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

Bond	Bond Energy (kJ/mol)
H–H	435
H–Cl	431
H–C	414
H–O	463
C–C	331
C=C	590
C≡C	812
C–O	326
C=O	803
C≡O	1075
N≡N	941
O_2	495
Cl–Cl	243
S=O	523

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	$Au \rightarrow Au^{3+} + 3e^{-}$