CHEM 1314 3;30 pm Theory
Exam III
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November 13, 2002

Name ______________________

TA's Name ______________________

Lab Section ______________________

INSTRUCTIONS:

1. This examination consists of a total of 8 different pages. The last page include a periodic 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.

4. No credit will be awarded if your work is not shown in problems 5a, 5c, 7b, 8fi and 8fii.

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	____ (31)	____ (20)	____ (17)	____ (22)	____ (10)	____ (100)

(9) 1. Write the chemical formula(s) of the product(s) and balance all of the following reactions. Identify all products phases as either (g)as, (l)iquid, (s)olid or (aq)ueous

a) $Mg(NO_3)_2(aq)$ + $Na_2CO_3(aq)$ $\rightarrow$ **$MgCO_3(s) + 2NaNO_3(aq)$**

b) **2**$HCl(aq)$ + $Ba(OH)_2(aq)$ $\rightarrow$ **$BaCl_2(aq) + 2H_2O(l)$**

c) **2**$Cr(s)$ + **3**$NiSO_4(aq)$ $\rightarrow$ **$Cr_2(SO_4)_3(aq)$ + $3Ni(s)$**

(6) 2. Write the ionic and net ionic chemical equations for 1a) **or** 1b).

Ionic equation:

$Mg^{2+}(aq)$ + ~~$2NO_3^-(aq)$~~ + ~~$2Na^+(aq)$~~ + $CO_3^{2-}(aq)$ $\rightarrow$ $MgCO_3(s)$ + ~~$2Na^+(aq)$~~ + ~~$2NO_3^-(aq)$~~

Net Ionic equation:

$Mg^{2+}(aq) + CO_3^{2-}(aq) \rightarrow MgCO_3(s)$

(12) 3. Write the complete electron configuration and indicate the number of unpaired electrons for each of the following species in their ground state,

i. Cu — **1** unpaired electrons

$1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^{10}$

ii. Na^+ — **0** unpaired electrons

$1s^2 2s^2 2p^6$

iii. Re — **5** unpaired electrons

$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^6 6s^2 4f^{14} 5d^5$

(4) 4. Draw the orbital diagram for the valence electrons for selenium (Se) in its ground state

(20) 5a. Calculate the wavelength, in nanometers, of a photon that will excite an electron in a hydrogen atom from the n = 2 to n = 4 energy level.

$$\Delta E = -2.18 \text{ x } 10^{-18}\text{ J}\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$$

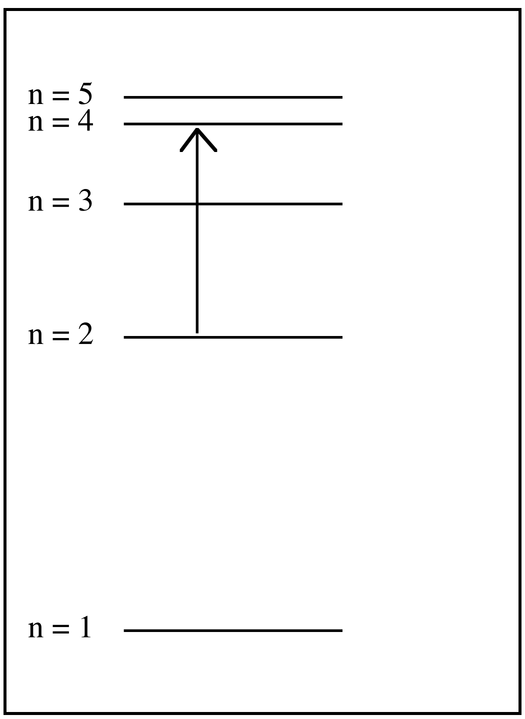
$$\Delta E = -2.18 \text{ x } 10^{-18}\text{ J}\left(\frac{1}{4_f^2} - \frac{1}{2_i^2}\right) = 4.09 \text{ x } 10^{-19}\text{ J}$$

$$\lambda = \frac{c}{\nu} \text{ and } E = h\nu$$

$$\lambda = \frac{hc}{E} = \frac{(6.626 \text{ x } 10^{-34}\text{ J}\cdot\text{s})(3.00 \text{ x } 10^{8}\ \frac{\text{m}}{\text{s}})}{4.09 \text{ x } 10^{-19}\text{ J}} = 4.86 \text{ x } 10^{-7}\text{ m}$$

$$= 4.86 \text{ x } 10^{-7}\text{ m}\left(\frac{10^9\text{ nm}}{1\text{ m}}\right) = 486\text{ nm} = 486\text{ nm}$$

b) Draw and label an energy level diagram for the hydrogen atom and show the transition for the electron as stated in part a.



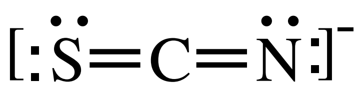
c) How much energy would be required to ionize an electron from the n = 4 level in a hydrogen atom?

$$\Delta E = -2.18 \text{ x } 10^{-18}\text{ J}\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$$

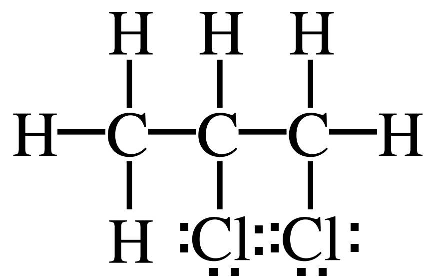
$$\Delta E = -2.18 \text{ x } 10^{-18}\text{ J}\left(\frac{1}{\infty_f^2} - \frac{1}{4_i^2}\right) = 1.36 \text{ x } 10^{-19}\text{ J}$$

(9) 6. Draw the Lewis electron-dot structure for each of the covalent molecules below.

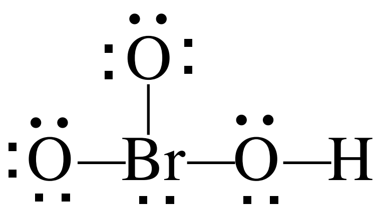
(a) SCN^-



(b) $C_3H_6Cl_2$



(c) $HBrO_3$



(8) 7. Last week in laboratory you standardized a solution of NaOH of unknown concentration using KHP ($KHC_8H_4O_4$) by titration.

a) Write the neutralization equation that occurs when NaOH reacts with KHP.

$$\mathbf{KHC_8H_4O_4 + NaOH \rightarrow KNaC_8H_4O_4 + 2H_2O}$$

b) Calculate the mass of KHP needed to react with 18.5 mLs of 0.115 M NaOH.

$$\mathbf{18.5\ mLs \left(\frac{1\ L}{1000\ mL}\right)\left(\frac{0.115\ mol}{1\ L}\right)\left(\frac{204\ g}{1\ mol\ KHP}\right)\left(\frac{1\ mol\ KHP}{1\ mol\ NaOH}\right) = 0.435\ g\ KHP}$$

(32) 8. Short Answer:

a) according to the quantum mechanical model of the hydrogen atom, how many subshells are allowed in the n = 4 shell? (2)

4 subshells

b) The three ions Ca^{2+}, Cl^{-}, K^{+} are isoelectronic. Do they all have the same radius? Explain. (6)

No, they will all have different radii. All have the same electron configuration ($1s^2 2s^2 2p^6 3s^2 3p^6$), but different in the number of protons, Ca^{2+}(20), Cl^{-}(17), K^{+}(19).

The effective nuclear charge is differ for each ion. Ca^{2+} has an ENC of +10, Cl^{-} has an ENC of +7, K^{+} has an ENC of +9. So the valence electrons of Ca^{2+} feel a greater attraction to the nucleus and has the smallest radius, next is K^{+} and then Cl^{-} has the largest radius.

c) Provide a definition for an orbital. (2)

A 3-dimensional region of space where the probability of finding an electron is high.

d) Do all orbitals have the same shape? Provide an example that supports your answer. (2)

No, an ‘s’ orbital is spherical and a ‘p’ orbital has a dumbbell shape (3D).

e) Write the following chemical equations; (10)

i) the formation equation for MgO;

$$Mg_{(s)} + 1/2 O_{2(g)} \rightarrow MgO_{(s)}$$

ii) the equation describing the lattice energy of MgO;

$$MgO_{(s)} \rightarrow Mg^{2+}_{(g)} + O^{2-}_{(g)}$$

iii) is the lattice energy as described by the chemical equation in ii) endothermic or exothermic? Explain.

The lattice energy is endothermic, because it takes energy to break an ionic bond.

8. (Continued)

f) For the element Co; (10)

i) determine the effective nuclear charge on an electron in the n = 4 level;

$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^7$

The ENC on an electron in the n = 4 level is 27 – 25 = +2

ii) determine the effective nuclear charge on an electron in the n = 3 level;

$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^7$

The ENC on an electron in the n = 3 level is 27 – 10 = +17

iii) from which level and which sublevel will the first electron be ionized in Co? Explain.

The first electron is removed from the 4s sublevel because it takes the least amount of energy, and the s sublevel is the only sublevel in the n = 4 level in cobalt.

iv) from which level and which sublevel will the third electron be ionized from Co? Explain.

The third electron is removed from the 3d sublevel because the 3d sublevel is the highest in energy of the three sublevels in the n = 3 level. It takes the least amount of energy to remove an electron in the highest energy level.

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 **Rf** (261)	105 **Db** (262)	106 **Sg** (266)	107 **Bh** (264)	108 **Hs** (269)	109 **Mt** (268)	110 (271)	111 (272)	112 (277)		114 (285)		116 (289)		

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

$E_n = -2.18 \times 10^{-18}\ \text{J} \left(\frac{1}{n^2}\right)$ $r_n = 0.529 \times 10^{-8}\ n^2\ \text{cm}$ $h = 6.626 \times 10^{-34}\ \text{J}\cdot\text{s}$

$\Delta E = -2.18 \times 10^{-18}\ \text{J} \left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$ $\nu = \frac{c}{\lambda}$ $E = h\nu$ $c = 3.00 \times 10^{8}\ \frac{\text{m}}{\text{s}}$

$U = \frac{kQ_1Q_2}{d}$

Avogadro's number = 6.02×10^{23}

density of water = $1.00\ \frac{\text{g}}{\text{mL}}$

Activity Series

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

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