Chem 127
Prof. Mark Jensen
Exam #2
10/24/08

Name KEY

Pledge:
When you have completed this exam, please consider the following:

I affirm that I have neither committed nor witnessed a violation of academic integrity in the completion of this exam.

Signed _____

Answer the questions on the following pages, paying strict attention to **significant figures** where applicable. Answers given without supporting work WILL NOT be given full credit.

Some potentially useful information: $N = 6.022 \times 10^{23}$ $c = 3.00 \times 10^{8}$ m/s $R = 1.097 \times 10^{7}$ m^{-1}

$h = 6.626 \times 10^{-34}$ J·s $\quad E_n = -\dfrac{2.18 \times 10^{-18}\,\text{J}}{n^2}$ $\quad \lambda_D = \dfrac{h}{mv}$ $\quad \dfrac{1}{\lambda} = R\left(\dfrac{1}{n_L^2} - \dfrac{1}{n_U^2}\right)$

1 IA																	18 VIIIA
1 **H** 1.008	2 IIA											13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	2 **He** 4.00
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
11 **Na** 22.99	12 **Mg** 24.31	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8 –	9 VIIIB	10 –	11 IB	12 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
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** 58.71	29 **Cu** 63.54	30 **Zn** 65.37	31 **Ga** 69.72	32 **Ge** 72.59	33 **As** 74.92	34 **Se** 78.96	35 **Br** 79.91	36 **Kr** 83.30
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** 98.91	44 **Ru** 101.07	45 **Rh** 102.91	46 **Pd** 106.4	47 **Ag** 107.87	48 **Cd** 112.40	49 **In** 114.82	50 **Sn** 118.69	51 **Sb** 121.75	52 **Te** 127.60	53 **I** 126.90	54 **Xe** 131.30
55 **Cs** 132.91	56 **Ba** 137.34	71 **Lu** 174.97	72 **Hf** 178.49	73 **Ta** 180.95	74 **W** 183.85	75 **Re** 186.2	76 **Os** 190.2	77 **Ir** 192.2	78 **Pt** 195.09	79 **Au** 196.97	80 **Hg** 200.59	81 **Tl** 204.37	82 **Pb** 207.19	83 **Bi** 208.98	84 **Po** 210	85 **At** 210	86 **Rn** 222
87 **Fr** 223	88 **Ra** 226.03	103 **Lr** 262.1	104 **Rf**	105 **Db**	106 **Sg**	107 **Bh**	108 **Hs**	109 **Mt**									

57 **La** 138.91	58 **Ce** 140.12	59 **Pr** 140.91	60 **Nd** 144.24	61 **Pm** 146.92	62 **Sm** 150.35	63 **Eu** 151.96	64 **Gd** 157.25	65 **Tb** 158.92	66 **Dy** 162.50	67 **Ho** 164.93	68 **Er** 167.26	69 **Tm** 168.93	70 **Yb** 173.04
89 **Ac** 227.03	90 **Th** 232.04	91 **Pa** 231.04	92 **U** 238.03	93 **Np** 237.05	94 **Pu** 239.05	95 **Am** 241.06	96 **Cm** 247.07	97 **Bk** 249.08	98 **Cf** 251.08	99 **Es** 254.09	100 **Fm** 257.10	101 **Md** 258.10	102 **No** 255

1. (10 pts) Give oxidation numbers for each element in the following redox reaction, and then identify the oxidizing and reducing agent.

$$\overset{+2\ -2}{FeS}(s) + 3\,\overset{+5\ -2}{NO_3^-}(aq) + 4\,\overset{+1\ -2}{H_3O^+}(aq) \rightarrow 3\,\overset{+2\ -2}{NO}(g) + \overset{+6\ -2}{SO_4^{2-}}(aq) + \overset{+3}{Fe^{3+}}(aq) + 6\,\overset{+1\ -2}{H_2O}(\ell)$$

Reactant side: Fe +2 S −2 N +5 $O_{NO_3^-}$ −2 H +1 $O_{H_3O^+}$ −2

Product side: N +2 O_{NO} −2 S +6 $O_{SO_4^{2-}}$ −2 Fe +3 H +1 O_{H_2O} −2

Oxidizing agent: NO_3^- Reducing agent: FeS

2. (16 pts) Nomenclature.

A. Give chemical formulas for the following compounds:

i) aluminum sulfate $Al_2(SO_4)_3$

ii) lead (IV) oxide PbO_2

iii) barium chlorate $Ba(ClO_3)_2$

iv) magnesium nitride Mg_3N_2

B. Give proper names for each of the following formulas:

i) $NaHSO_3$ Sodium hydrogen sulfite (sodium bisulfite)

ii) PF_5 phosphorus pentafluoride

iii) $CuCl_2$ copper (II) chloride

iv) $K_2Cr_2O_7$ potassium dichromate

3. (10 pts) What is the maximum number of electrons in an atom that can have the following combinations of quantum numbers?

a) $n = 3, m_s = -\frac{1}{2}$ — 9 ← 3s (↿) 3p (↿↿↿) 3d (↿↿↿↿↿)

b) $n = 4, \ell = 3$ — 14 ← 4f (↿↿↿↿↿↿↿)

c) $n = 3, m_\ell = 3, m_s = \frac{1}{2}$ — 0 ← $n=3 \Rightarrow \ell = 0, 1, 2 \Rightarrow m_\ell \neq 3$

d) $n = 4, \ell = 2, m_\ell = -1$ — 2 ← single 4d orbital

e) $n = 4, m_\ell = 1$ — 6 ←

	4s	4p	4d	4f
n:	4	4 4 4	4 4 4 4 4	4 4 4 4 4 4 4
ℓ:	0	1 1 1	2 2 2 2 2	3 3 3 3 3 3 3
m_ℓ:	0	-1 0 +1	-2 -1 0 1 2	-3 -2 -1 0 1 2 3

4. (10 pts) Since my eyes don't see red laser pointers very well, I'm thinking of buying a green laser pointer. I found one online that emits green light at 532 nm with a power of 5.0 mW. How many photons per second are being emitted from this laser pointer? (1 W = 1 J/s)

Energy of 1 photon = $h\nu$

$$E = h\nu = h\frac{c}{\lambda} = \frac{(6.626\times10^{-34}\ J\cdot s)(3.00\times10^{8}\ m/s)}{532\times10^{-9}\ m}$$

$$= 3.74\times10^{-19}\ J/\text{photon}$$

$$(5.0\ \text{mW})\left(\frac{1\ W}{1000\ \text{mW}}\right)\left(\frac{J}{W\cdot s}\right)\left(\frac{1\ \text{photon}}{3.74\times10^{-19}\ J}\right)$$

$$= 1.34\times10^{16}\ \text{photons/s}$$

5. (12 pts) Give the net ionic reaction that results when the following are mixed. Write NR if no reaction occurs. (*CIRCLE YOUR FINAL ANSWER!!*)

   a) NaOH(aq) and HCl(aq)

$$H^+_{(aq)} + OH^-_{(aq)} \rightarrow H_2O_{(l)}$$

   b) $NaC_2H_3O_2(aq)$ and $AgNO_3(aq)$

NR

   c) $Pb(ClO_4)_2(aq)$ and $NH_4I(aq)$

$$Pb^{2+}_{(aq)} + 2\ I^-_{(aq)} \rightarrow PbI_{2(s)}$$

   d) $Ag_2SO_4(aq)$ and $Ca(NO_3)_2(aq)$

$$Ca^{2+}_{(aq)} + SO_4^{2-}{}_{(aq)} \rightarrow CaSO_{4(s)}$$

6. (8 pts) The electron configuration for gold is an exception to the pattern of predicted arrangements based simply on the Aufbau diagram. Give both the predicted configuration, as well as your best very educated guess for the actual configuration. (Use a noble gas core.)

   a) Predicted configuration:

$$[Xe]\,6s^2\,4f^{14}\,5d^9$$

   b) Actual configuration:

$$[Xe]\,6s^1\,4f^{14}\,5d^{10}$$

7. (10 pts) Give the **correct chemical formula** for an example of each of the following:

a) an insoluble bromide salt AgBr, $PbBr_2$, or Hg_2Br_2

b) a weak acid lots of possibilities

c) an insoluble carbonate salt " " " "

d) a strong base " " " "

e) a soluble phosphate salt _____

8. (10 pts) An electron in a hydrogen atom absorbs a photon of light and is excited from the ground state to the n=5 state. Label the following statements as true (T) or false (F).

a) F The color of light needed for the excitation falls within the visible region of the electromagnetic spectrum.

b) T The electron is farther from the nucleus (on average) in n =5 than in the ground state.

c) F The wavelength of light emitted when the electron drops from n=5 to n=1 is longer than that from n=5 to n=2.

d) F The wavelength of light the atom absorbs in going from n=1 to n=5 is the longer than the wavelength emitted as it goes from n=5 to n=1.

e) T The electron has more energy at n=5 than in the ground state.

9. (8 pts) Give a unique set of four quantum numbers (n, ℓ, m_ℓ, m_s) for each of the electrons in the *highest energy* orbitals (i.e. the subshell of highest energy) for an atom of sulfur.

S 16e⁻ $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^4$

$\uparrow\downarrow$ $\uparrow\downarrow$ $\uparrow$ } highest energy subshell
3p

$\uparrow\downarrow$
3s

$\uparrow\downarrow$ $\uparrow\downarrow$ $\uparrow\downarrow$
2p

$\uparrow\downarrow$
2s

$\uparrow\downarrow$
1s

n	ℓ	m_ℓ	m_s
3	1	−1	+1/2
3	1	−1	−1/2
3	1	0	+1/2
3	1	1	+1/2

10. (8 pts) A hydrogen atom becomes ionized when its single electron is removed:

$$H(g) \rightarrow H^+(g) + e^-$$

Using the Bohr model of the hydrogen atom, calculate the ionization energy of the hydrogen atom in kJ/mol. In other words, how much energy does it take to ionize one mole of hydrogen atoms starting in their ground state? (*Hint: What energy level is the electron in after ionization?*)

Transition: $n = 1 \longrightarrow n = \infty$

$$E_1 = -\frac{2.18\times10^{-18}\ J}{1^2} = -2.18\times10^{-18}\ J \qquad E_\infty = -\frac{2.18\times10^{-18}\ J}{\infty^2} = 0$$

$$\Delta E = E_\infty - E_1 = 0 - (-2.18\times10^{-18}\ J) = 2.18\times10^{-18}\ J$$

↑ energy needed to ionize 1 atom

$$\left(\frac{2.18\times10^{-18}\ J}{atom}\right)\left(\frac{1\ kJ}{1000\ J}\right)\left(\frac{6.022\times10^{23}\ atoms}{mole}\right) = \boxed{1.31\times10^{3}\ kJ/mol}$$

11. (10 pts) Multiple Choice / Fill in the Blank.

A. The visible region of the electromagnetic spectrum extends from 400 nm to 700 nm, with the lowest wavelength corresponding to the color violet and the highest wavelength to the color red.

B. Who is credited with experimentally determining the charge on an electron?

a) Millikan
b) Mendeleev
c) Thomson
d) Rutherford
e) de Broglie

C. Who experimentally determined that the positive charge in the atom is concentrated in a very small volume?

a) Millikan
b) Mendeleev
c) Thomson
d) Rutherford
e) de Broglie

D. Which of the following regions of the electromagnetic spectrum has the longest wavelengths?

a) visible
b) IR
c) UV
d) microwave
e) x-rays

Remember to consider the pledge!!