CHEM 105 – Dr. Lammi Name: ________________________

EXAM I – Sept. 12, 2019

You will have until 10:50 to complete this exam. Please show all work and/or reasoning in the space provided or on the attached scratch page. Partial credit for incorrect answers may only be awarded if work/reasoning is shown. Remember to report the final results of your calculations with the appropriate significant figures. A Periodic Table and a page of helpful information are provided for your use. GOOD LUCK!!

1. (6 pts) Please indicate whether each statement below is **True (T) or False (F)**.

   ______ a. A sample of an element may contain either atoms or molecules.

   ______ b. NaCl is a pure substance.

   ______ c. Anions have more protons than electrons.

2. (5 pts) What does it mean to say that energy is ***quantized***? Why do we **not** notice this in our everyday lives?

3. (6 pts) For each question below, **please circle** the atom or ion that has the specified property.

   a. **Smallest radius:** W, Sb, or Fr

   b. **Greatest electron affinity:** W, Sb, or Fr

   c. **Smallest radius:** Xe, Cs^{+}, or Te^{2-}

4. (12 pts) For each atom or ion below, please give:

   a. the ground-state (lowest energy) **electron configuration**. You may choose to abbreviate the noble gas core.
   b. the **orbital "box" diagram** corresponding to your configuration. Be sure to label orbitals clearly.

   Tellurium

   Pr

   Pr^{2+} (configuration only; no "box" diagram)

5. (6 pts) Please write the **complete chemical symbol** for the **rhenium atom or ion** with 112 neutrons and 73 electrons.

6. (4 pts) What **name** is given to the decimal values listed under the elements on the Periodic Table (for example, 6.941 under Li)? **<u>Briefly</u> explain** how these values are calculated.

7. (12 pts) The following questions relate to ***first ionization energy***.

   a. Please **define** first ionization energy. **Include a chemical equation for ionization of silicon** to illustrate your definition.

   b. **Fill in the blank:** Moving from left to right across a period of the Periodic Table, first ionization energy _______________ (*increases, decreases*, or *stays the same*).

   c. **Briefly explain** your answer to part (b). **<u>Why</u>** is this the trend?

   d. **Fill in the blank:** Moving from top to bottom within a group of the Periodic Table, first ionization energy _______________ (*increases, decreases*, or *stays the same*).

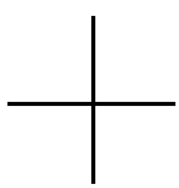
   e. **Briefly explain** your answer to part (d). **<u>Why</u>** is this the trend?

8. (14 pts) The following questions relate to quantum numbers and orbitals:

   a. **How many orbitals** are there in the $n = 3$ shell? Please **<u>list each orbital by name</u>**.

   b. Please give the **atomic number** of the first element that would contain electrons in an **8s orbital**. Also, **which subshell** would be filled next, after the 8s?

   c. Please sketch a $\boldsymbol{d_{yz}}$ orbital on the axes below. Be sure to **label the axes** appropriately; also, use shading to indicate **regions of different sign** and dashed lines to show the location(s) of any **node(s)**.



9. (12 pts) Niels Bohr is credited with advancing our understanding of atomic emission spectroscopy and electronic structure. Please answer each of the following questions **as briefly (but completely) as possible.**

   a. Bohr proposed a theory explaining the **cause** for the hydrogen emission lines observed by other scientists. What **specific events** did Bohr suggest were responsible? <u>Include a diagram and one or more equations</u> (but **no** calculations) in support of your answer.

   b. Briefly list the one **major success** of Bohr's model. (What did Bohr get right that we still use today?)

   c. Briefly list one **significant limitation** of Bohr's model. (About what was he incorrect? Or, what could his model **not** explain?)

10. (14 pts) You may have heard about the lead-contaminated drinking water in Flint, Michigan. In 2015, researchers from Virginia Tech measured lead-contaminated water in over 200 Flint homes. In the worst case they found, the lead concentration was as high as 13.2 g/m^3 (which is more than 2500 times the threshold level deemed unsafe for drinking). Suppose that the homeowner drank 64 ounces (oz) of this highly contaminated water per day. How many grams of lead would she ingest in a year (assuming she lived that long)?

    Note: 1 L = 33.814 oz = 1000 cm^3

11. (14 pts) As I've mentioned in class, a technique called photoelectron spectroscopy uses the photoelectric effect to experimentally determine orbital energies and, from them, electron configurations. This is done by bombarding atoms with high-energy photons and measuring the speeds at which electrons are ejected: from the measured speeds one can calculate the binding energies with which the electrons had been held in their atoms (allowing for determination of which subshells the electrons had occupied).

Suppose that you bombard an aluminum surface with X-rays 850.0 pm in wavelength and measure the speed of some ejected (2*p)* electrons to be 2.17×10^7 m/s.

a. What is the **energy of each X-ray photon**?

b. Given the measured speed of the ejected electrons (2.17×10^7 m/s), **with what binding energy** were these 2*p* electrons bound to the Al nuclei (until the instant of ejection)? The mass of an electron is 9.10938×10^{-31} kg.

[**Hint:** Which quantity in your equation for the photoelectric effect corresponds to the binding energy – the amount of energy holding the electron in the atom?]

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If there is material to be graded here, make sure that it is clearly labeled and write your name on this page.

Useful Constants, Conversion Factors and Equations

Constants and conversion factors:

$h = 6.626 \times 10^{-34}$ J·s

$c = 2.9979 \times 10^{8}$ m/s

$1 \text{ J} = 1 \dfrac{\text{kg} * \text{m}^2}{\text{s}^2}$

Equations:

$$d = \frac{m}{V}$$

$$\nu = \frac{c}{\lambda}$$

$$E_{photon} = h\nu$$

$$E_K \text{ (ejected electron)} = E_{photon} - \phi$$

$$E_K = \frac{1}{2}mv^2$$

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

$$E_{photon} = |\Delta E|$$

$$\lambda_{matter} = \frac{h}{mv}$$

Main groups		Transition metals										Main groups					
1 1A	2 2A	3 3B	4 4B	5 5B	6 6B	7 7B	8 8B	9 8B	10 8B	11 1B	12 2B	13 3A	14 4A	15 5A	16 6A	17 7A	18 8A
1 **H** 1.00794																	2 **He** 4.00260
3 **Li** 6.941	4 **Be** 9.01218											5 **B** 10.81	6 **C** 12.011	7 **N** 14.0067	8 **O** 15.9994	9 **F** 18.998403	10 **Ne** 20.1797
11 **Na** 22.98977	12 **Mg** 24.305											13 **Al** 26.98154	14 **Si** 28.0855	15 **P** 30.97376	16 **S** 32.066	17 **Cl** 35.453	18 **Ar** 39.948
19 **K** 39.0983	20 **Ca** 40.078	21 **Sc** 44.9559	22 **Ti** 47.88	23 **V** 50.9415	24 **Cr** 51.996	25 **Mn** 54.9380	26 **Fe** 55.847	27 **Co** 58.9332	28 **Ni** 58.69	29 **Cu** 63.546	30 **Zn** 65.39	31 **Ga** 69.72	32 **Ge** 72.61	33 **As** 74.9216	34 **Se** 78.96	35 **Br** 79.904	36 **Kr** 83.80
37 **Rb** 85.4678	38 **Sr** 87.62	39 **Y** 88.9059	40 **Zr** 91.224	41 **Nb** 92.9064	42 **Mo** 95.94	43 **Tc** (98)	44 **Ru** 101.07	45 **Rh** 102.9055	46 **Pd** 106.42	47 **Ag** 107.8682	48 **Cd** 112.41	49 **In** 114.82	50 **Sn** 118.710	51 **Sb** 121.757	52 **Te** 127.60	53 **I** 126.9045	54 **Xe** 131.29
55 **Cs** 132.9054	56 **Ba** 137.33	57 ***La** 138.9055	72 **Hf** 178.49	73 **Ta** 180.9479	74 **W** 183.85	75 **Re** 186.207	76 **Os** 190.2	77 **Ir** 192.22	78 **Pt** 195.08	79 **Au** 196.9665	80 **Hg** 200.59	81 **Tl** 204.383	82 **Pb** 207.2	83 **Bi** 208.9804	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
87 **Fr** (223)	88 **Ra** 226.0254	89 **†Ac** 227.0278	104 **Rf** (261)	105 **Db** (262)	106 **Sg** (263)	107 **Bh** (262)	108 **Hs** (265)	109 **Mt** (266)	110 **Uun**	111 **Uuu**	112 **Uub**		114 **Uuq**		116 **Uuh**		

*Lanthanide series	58 **Ce** 140.12	59 **Pr** 140.9077	60 **Nd** 144.24	61 **Pm** (145)	62 **Sm** 150.36	63 **Eu** 151.96	64 **Gd** 157.25	65 **Tb** 158.9254	66 **Dy** 162.50	67 **Ho** 164.9304	68 **Er** 167.26	69 **Tm** 168.9342	70 **Yb** 173.04	71 **Lu** 174.967
†Actinide series	90 **Th** 232.0381	91 **Pa** 231.0359	92 **U** 238.0289	93 **Np** 237.048	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)