Problem Set 1 (**Due January 30th by 7:00 PM**)

Answers to the problems in **RED** need to be submitted through the course website.

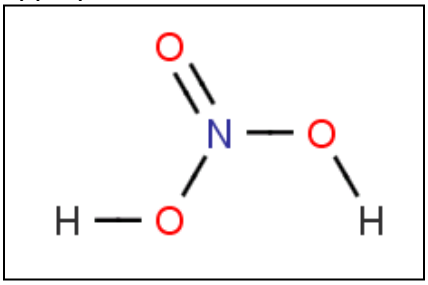
Numbers and Units (Bonus Date: January 13th)

1. Convert each of the following. Make sure you report the correct number of significant digits:
    a. 1046028 cm = _____ km
    b. 958378 μg = _____ Mg
2. How many significant digits are in each number?
    a. 14056000
    b. 0025
    c. 9.04589
3. What is the SI unit for each of the following?
    a. Mass
    b. Length
    c. Density
    d. Velocity (or speed limit)
4. Determine the identity of each metal based on its density. You can find common densities here:
    a. If a 42.86 mL of water is displaced when 0.1157 kg of a metal is added to a cylinder of water.
    b. If a 1.16 x 10^4 nL of water is displaced when 118632 μg of a metal is added to a cylinder of water. Be careful with sig figs on this one.
5. Convert each of the following (use outside resources to find appropriate conversion factors):
    a. 14.59 g mL^{-1} → pounds per cubic inch
    b. 86.84 kg m^{-3} →ounces per cubic foot
6. Using the radius of each atom, calculate the volume in SI units. Make sure to use the correct number of significant digits. ($V = \frac{4}{3}\pi r^3$)
    a. Carbon → r = 70 pm
    b. Lead → 1.80 x 10^2 pm
7. Assuming that an atom is perfectly spherical, determine the radius (in picometers) of each atom
    a. Sulfur, which has a volume of 6.5 x 10^{-25} mL
    b. Hydrogen, which has a volume of 6.54 x 10^{-29} L

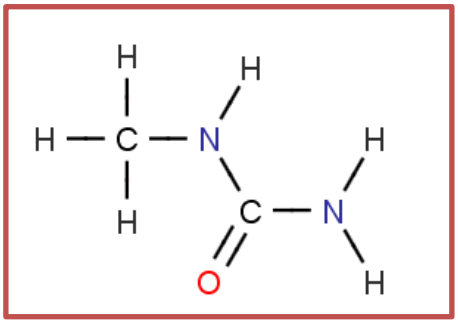
Atoms, Molecules, and Periodicity (Bonus Date: January 19th)

8. Write the chemical formula for each molecule. There is not a way to add subscripts online – just put in the appropriate letter and number combinations.

a.



b.



9. Complete the following table:

Name	Element Symbol	Number of Protons	Number of Neutrons	Number of Electrons	Mass Number
Iron-55					
				42	96
a.	^{157}Gd	**b.**	**c.**	**d.**	**e.**

10. Determine the number of electrons in each ion:
    a. Cu^{+2}
    b. As^{-3}

11. Identify the element:
    a. The element that has these three naturally occurring isotopes and determine the average isotopic mass with **6 significant digits**:
        i. 35.96754522 amu (0.3365% abundant)
        ii. 37.9627325 amu (0.0632% abundant)
        iii. 39.96238 amu (99.6003% abundant)
    b. The element that has these four naturally occurring isotopes and determine the average isotopic mass with **6 significant digits:**
        i. 135.907140 amu (0.185% abundant)
        ii. 137.905985 amu (0.215% abundant)
        iii. 139.905433 amu (88.450% abundant)
        iv. 141.898820 amu (11.150% abundant)

12. Complete the following tables:
    a.

Isotope	Exact Mass	Natural Abundance
Silicon-28	27.976927 amu	
Silicon-29	28.9764949 amu	
Silicon-30	29.9737707 amu	3.0872%

b.

Isotope	Exact Mass	Natural Abundance
Boron-10	10.012937 amu	
Boron-12	11.9305 amu	

13. Match each element with another element that is expected to have similar chemical properties:

Element	Magnesium	Phosphorus	Chlorine	Sodium	Carbon	Xenon	Aluminum
Argon							
Strontium							
Boron							
Arsenic							
Francium							
Iodine							
Tin							

Energy, Electrons and Periodic Trends (Bonus Date: January 26th)

For all periodic trend problems, make sure that you can justify your answer. You will be expected to do this on an exam.

14. For each group of atoms, determine which would have a higher 1st Ionization Energy.
    a. Xe, Kr, Ar
    b. As, Cl, Br
    c. K, Ca, Mg

15. Determine the energy (in SI Units) of a photon that has:
    a. a frequency of 2.998×10^4 pHz
    b. a wavelength of 642 nm
    c. a wavelength of 15.631 μm

16. Calculate the **threshold energy** (in Joules) of a metal surface if an electron is ejected travelling at 7.308×10^5 m/s upon irradiation with a wavelength of:
    a. 400 nm
    b. 580 nm

17. For each of the following sets of atoms, determine which has the smallest radius.
    a. P, As, S, or Se?
    b. O, Cl, Xe, or B
    c. K, Ca, Mg, Al, or Ga

18. Write the full electron configuration for each atom below. When submitting your answer in the Google Form, please format it like this: 1s2 2s2 2p6… **please make sure to put a space between each subshell**.

    Neon Sodium **Argon**

19. What orbital would hold the **highest energy** electron in the ground state for each atom in problem 18?

20. Write the full electron configuration of the **first excited state** for each atom in problem 18.

21. What orbital would hold the highest energy electron in the **first excited state** for each atom below:

    Strontium Ytterbium **Barium**

22. Write the **condensed** electron configuration for the **first excited state** of each atom below:

Strontium **Ytterbium** Barium

23. Write one possible set of quantum numbers for the excited electrons in problem 22. Use this format when entering your answer: 1,1,-1,1/2

24. How many valence electrons do each of the following element have?

Nitrogen **Sulfur** Zinc **Gold** Americium **Europium**

25. List one possible set of quantum numbers for a valence electron for all elements in problem 23. Use this format when entering your answer: 1,1,-1,1/2

26. Arrange each of the following sets of atom by **increasing** electron affinity.
    a. S, Cl, Ar, K
    b. O, N, P, F

27. Arrange each of the following sets by **increasing** radius.
    a. Ne, N^{-3}, F^{-1}, O^{-2}
    b. Ne, Mg^{+2}, K^{+} Ca^{+2}
    c. Ar, Ca^{+2}, P^{-3}, Cl^{-1}, Na^{+1}, S^{-2}

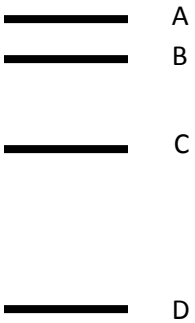
28. Calculate the ionization energy of an electron in the indicated shell of a hydrogen atom. Report the value in Joules.
    a. n = 3
    b. n = 6

29. What is the frequency (in GHz) of the photon needed to drive the ejection of each electron in problem 28?

30. What is the wavelength (in nm) of the photon needed to drive the ejection of each electron in problem 28?

31. The Paschen Series occurs in the IR region of the Hydrogen emission spectrum. Determine $n_{initial}$ for each wavelength.
    a. 1282 nm
    b. 923 nm

32. Using the image to the right, answer each of the following:
    a. What transition would **generate** the lowest energy photon?
    b. What transition would require the lowest wavelength photon?



33. What orbital corresponds with each set of quantum numbers?
    a. 1,0,0,-1/2
    b. 4,3,2,1/2
    c. 3,1,-1,1/2

34. For each ℓ, determine how many m_ℓ are possible.
    a. $\ell = 3$
    b. $\ell = 0$
    c. $\ell = 5$

35. Write a condensed electron configuration for each of the following:
    a. Se
    b. Bi^{2+}
    c. Sn^{-4}

Do you REALLY understand?

Submit your answers to this question **directly to me for bonus points**. You are strongly encouraged to stop by my office with questions.

36. The "K edge" is a term used by chemists to describe the energy that it takes to excite a 1s electron up to a 4p orbital. It has been experimentally determined that that K edge of copper and its common ions are:

    Cu^{2+} = 8979 eV Cu^{+} = 8984 eV Cu = 8987 eV

    a. Show the electron configuration and orbital diagram for the excited Cu^+ ion.
    b. An eV (electron volt) is a unit of energy. If 1 eV is 1.602×10^{-16} mJ, determine
        i. the wavelength of the photon that is absorbed at the K edge for each of the Cu samples above.
        ii. the region of the light spectrum (e.g. Visible, UV, etc.) that these photons belong to.
    c. Sometimes, excited molecules can lose energy as heat. When this happens, the photon that is absorbed to create the excited state is not the same energy as the photon that gets emitted when the sample relaxes back to ground state. Determine the percentage of energy lost by an excited Cu^+ if the photon that is emitted has a wavelength of 410 pm.
    d. Using what you've learned about periodic trends and electronic structures of atoms/ions, justify the trend in K edge energies.

Answers to black problems:

1a 10.46028 km	2a 5 s.f. 2b 2 s.f.
3 kg, m, kg/m^3 (or kg m^{-3})	4. Density = 2.70 g mL^{-1} Aluminum
5. 0.527 pounds per in^3	6. 1.4×10^{-30} m^3
7. 54 pm (or 53 depending on how you round)	8. NO_3H_2
9. Iron-55, ^{55}Fe, 26 protons, 29 neutrons, 26 electrons, A=55	9. Molybdenum-96, ^{96}Mo, 42 protons, 54 neutrons, 42 electrons, A=96
10. 27 electrons	11. Argon (39.9477 amu)
12. ^{28}Si = 92.21% ^{29}Si = 4.7%	13. Argon – Xenon Strontium – Magnesium
14. a. Ar b. Cl	15. a. 1.99×10^{-41}J b. 3.09×10^{-19}J
16. $\phi = 2.5310^{-19}$ J	17. a. sulfur b. oxygen
18. Ne: $1s^2 2s^2 2p^6$ Na: $1s^2 2s^2 2p^6 3s^1$	19. Ne – 2p Na – 3s

20. Ne: $1s^2 2s^2 2p^5 3s^1$ Na: $1s^2 2s^2 2p^6 3p^1$	21. Sr – 4d Yb: 5d
22. Sr: [Kr] $5s^1$ $4d^1$ Ba: [Xe] $6s^1$ $4f^1$	23. Sr: 4,2,{-2,-1,0,1,2},{-1/2, 1/2} (one from each bracket is possible (e.g. 4,2,0,1/2 is a correct answer) Ba: 4,3,{-3,-2,-1,0,1,2,3},{-1/2, 1/2}
24. N → 5 Zn → 2 Am → 2	25. N: 2,0,0,{1/2,-1/2} or 2,1,{-1,0,1}{1/2,-1/2} Zn: 4,0,0,{1/2,-1/2} Am: 7,0,0,{1/2,-1/2}
26. Ar<K<S<Cl	27. a Ne<F^-<O^{2-}<N^{3-} b. Mg^{2+} < Ne <Ca^{2+} < K^+
28. 2.42 x 10^{-19}J	29. a. 3.65 x 10^5 GHz
30. a. 821 nm	31. n = 5
32. A→B	33. a. 1s b. 4f
34. a 7 b. 1	35. a. [Ar] $4s^2 3d^{10} 4p^4$ b. [Xe] $6s^2 4f^{14} 5d^{10} 6p^1$