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

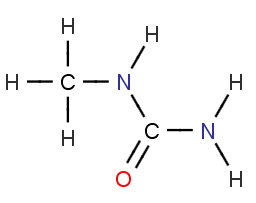
Answers to the problems in **RED** need to be submitted through the course website.

**Numbers and Units (Bonus Date: January 13th)**

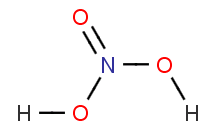
1. Convert each of the following. Make sure you report the correct number of significant digits:
   1. 1046028 cm = \_\_\_\_\_\_\_\_\_ km
   2. **958378 g = \_\_\_\_\_\_\_\_\_\_ Mg**
2. How many significant digits are in each number?
   1. 14056000
   2. 0025
   3. **9.04589**
3. What is the SI unit for each of the following?
   1. Mass
   2. Length
   3. Density
   4. **Velocity (or speed limit)**
4. Determine the identity of each metal based on its density. You can find common densities [here](https://sites.google.com/site/chempendix/densities-of-pure-metals):
   1. If a 42.86 mL of water is displaced when 0.1157 kg of a metal is added to a cylinder of water.
   2. **If a 1.16 x 104 nL of water is displaced when 118632 g 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):
   1. 14.59 g mL-1 🡪 pounds per cubic inch
   2. **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. ()
   1. Carbon 🡪 r = 70 pm
   2. **Lead 🡪 1.80 x 102 pm**
7. Assuming that an atom is perfectly spherical, determine the radius (in picometers) of each atom
   1. Sulfur, which has a volume of 6.5 x 10-25 mL
   2. **Hydrogen, which has a volume of 6.54 x 10-29 L**

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

1. 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.



* 1. **b**.



1. Complete the following table:

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

1. Determine the number of electrons in each ion:
   1. Cu+2
   2. As-3
2. Identify the element:
   1. The element that has these three naturally occurring isotopes and determine the average isotopic mass with **6 significant digits**:
      1. 35.96754522 amu (0.3365% abundant)
      2. 37.9627325 amu (0.0632% abundant)
      3. 39.96238 amu (99.6003% abundant)
   2. **The element that has these four naturally occurring isotopes and determine the average isotopic mass** with **6 significant digits:**
      1. **135.907140 amu (0.185% abundant)**
      2. **137.905985 amu (0.215% abundant)**
      3. **139.905433 amu (88.450% abundant)**
      4. **141.898820 amu (11.150% abundant)**
3. Complete the following tables:

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

|  |  |  |
| --- | --- | --- |
| **Isotope** | **Exact Mass** | **Natural Abundance** |
| Boron-10 | 10.012937 amu |  |
| Boron-12 | * 1. amu |  |

1. 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.***

1. For each group of atoms, determine which would have a higher 1st Ionization Energy.
   1. Xe, Kr, Ar
   2. As, Cl, Br
   3. **K, Ca, Mg**
2. Determine the energy (in SI Units) of a photon that has:
   1. a frequency of 2.998 x 104 pHz
   2. a wavelength of 642 nm
   3. **a wavelength of 15.631 m**
3. Calculate the **threshold energy** (in Joules) of a metal surface if an electron is ejected travelling at 7.308 x 105 m/s upon irradiation with a wavelength of:
   1. 400 nm
   2. **580 nm**
4. For each of the following sets of atoms, determine which has the smallest radius.
   1. P, As, S, or Se?
   2. O, Cl, Xe, or B
   3. **K, Ca, Mg, Al, or Ga**
5. 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**

1. What orbital would hold the **highest energy** electron in the ground state for each atom in problem 18?
2. Write the full electron configuration of the **first excited state** for each atom in problem 18.
3. What orbital would hold the highest energy electron in the **first excited state** for each atom below:

Strontium Ytterbium **Barium**

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

Strontium **Ytterbium** Barium

1. 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
2. How many valence electrons do each of the following element have?

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

1. 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
2. Arrange each of the following sets of atom by **increasing** electron affinity.
   1. S, Cl, Ar, K
   2. **O, N, P, F**
3. Arrange each of the following sets by **increasing** radius.
   1. Ne, N-3, F-1, O-2
   2. Ne, Mg+2, K+ Ca+2
   3. **Ar, Ca+2, P-3, Cl-1, Na+1, S-2**
4. Calculate the ionization energy of an electron in the indicated shell of a hydrogen atom. Report the value in Joules.
   1. n = 3
   2. **n = 6**
5. What is the frequency (in GHz) of the photon needed to drive the ejection of each electron in problem 28?
6. What is the wavelength (in nm) of the photon needed to drive the ejection of each electron in problem 28?
7. The Paschen Series occurs in the IR region of the Hydrogen emission spectrum. Determine ninitial for each wavelength.
   1. 1282 nm
   2. **923 nm**
8. Using the image to the right, answer each of the following:

A

B

C

D

* 1. What transition would **generate** the lowest energy photon?
  2. **What transition would require the lowest wavelength photon?**

1. What orbital corresponds with each set of quantum numbers?
   1. 1,0,0,-1/2
   2. 4,3,2,1/2
   3. **3,1,-1,1/2**
2. For each l, determine how many ml are possible.
   1. l = 3
   2. l = 0
   3. **l = 5**
3. Write a condensed electron configuration for each of the following:
   1. Se
   2. Bi2+
   3. **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.

1. 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:

Cu2+ = 8979 eV Cu+ = 8984 eV Cu = 8987 eV

* 1. Show the electron configuration and orbital diagram for the excited Cu+ ion.
  2. An eV (electron volt) is a unit of energy. If 1 eV is 1.602 x 10-16 mJ, determine
     1. the wavelength of the photon that is absorbed at the K edge for each of the Cu samples above.
     2. the region of the light spectrum (e.g. Visible, UV, etc.) that these photons belong to.
  3. 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.
  4. 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  3 kg, m, kg/m3 (or kg m-3)  5. 0.527 pounds per in3  7. 54 pm (or 53 depending on how you round)  9. Iron-55, 55Fe, 26 protons, 29 neutrons, 26 electrons, A=55  10. 27 electrons  12. 28Si = 92.21% 29Si = 4.7%  14. a. Ar b. Cl  16.  = 2.5310-19 J  18. Ne: 1s22s22p6 Na: 1s22s22p63s1  20. Ne: 1s22s22p53s1 Na: 1s22s22p63p1  22. Sr: [Kr] 5s1 4d1 Ba: [Xe] 6s1 4f1  24. N 🡪 5 Zn 🡪 2 Am 🡪 2  26. Ar<K<S<Cl  28. 2.42 x 10-19J  30. a. 821 nm  32. A🡪B  34. a 7 b. 1 | 2a 5 s.f. 2b 2 s.f.  4. Density = 2.70 g mL-1 Aluminum  6. 1.4 x 10-30 m3  8. NO3H2  9. Molybdenum-96, 96Mo, 42 protons, 54 neutrons, 42 electrons, A=96  11. Argon (39.9477 amu)  13. Argon – Xenon Strontium – Magnesium  15. a. 1.99 x 10-41J b. 3.09 x 10-19J  17. a. sulfur b. oxygen  19. Ne – 2p Na – 3s  21. Sr – 4d Yb: 5d  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}  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}  27. a Ne<F-<O2-<N3- b. Mg2+ < Ne <Ca2+ < K+  29. a. 3.65 x 105 GHz  31. n = 5  33. a. 1s b. 4f  35. a. [Ar] 4s23d104p4 b. [Xe] 6s24f145d106p1 |