

1. (2 points) The photoelectric effect shows (*circle all correct answers*)
- that light can be thought of as having particle-like properties.
 - that the intensity of light is related to its energy.
 - that photons of any wavelength will dislodge an electron from the surface of a metal.
 - that a certain minimum frequency of light is required to cause an electron to be ejected from a metal surface.

2. (4 points) Place the following in order of increasing energy:

- Light with $\lambda = 700 \text{ nm}$
- X-rays
- Microwaves (in a microwave oven)
- Ultraviolet light
- Light with $f = 100 \text{ Hz}$ (or 100 cycles per second)

_____ *lowest energy*

_____ *highest energy*

3. (4 points) You bombard a piece of cherry pie in a microwave oven with photons having a wavelength of 0.25 m. What is the frequency of these photons?

- $8.3 \times 10^{-10} \text{ sec}^{-1}$
- 4.0 sec^{-1}
- $7.5 \times 10^7 \text{ sec}^{-1}$
- $1.2 \times 10^9 \text{ sec}^{-1}$

What is the energy of 1 mol of photons with a wavelength of 0.25 m?

- $3.3 \times 10^{-19} \text{ J}$
- $1.6 \times 10^{-9} \text{ J}$
- 0.030 J
- 0.48 J
- $1.5 \times 10^{34} \text{ J}$

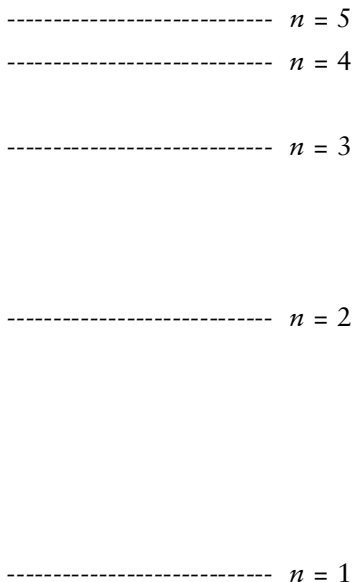
4. (2 points) Which of the following CANNOT be a valid set of quantum numbers for an atomic orbital?

- $n = 2, \ell = 1, m_\ell = 0$
- $n = 6, \ell = 5, m_\ell = -1$
- $n = 3, \ell = 3, m_\ell = 0$

5. (2 points) Which of the following subshells CANNOT exist? (*Circle all that apply.*)

- 3p
- 4s
- 2f
- 5g
- 1p

6. (5 points) Consider *only* the following energy levels for the H atom. (The diagram below does not attempt to show the correct energy level spacings.)



The emission spectrum of an excited H atom consists of transitions between these levels.

- a) How many emission lines are possible, considering only the five quantum levels?

- b) The emission line having the longest wavelength corresponds to a transition from the level with $n =$ _____ to the level with $n =$ _____.
- c) The emission line having the highest energy corresponds to a transition from the level with $n =$ _____ to the level with $n =$ _____.
7. (3 points) Complete the following table:

<i>Quantum Number</i>	<i>Atomic Property</i>
_____	Orbital size
_____	Relative orbital orientation
_____	Orbital shape

8. (4 points) Suppose that elements on planet Suco have the same periodicity as elements on Earth. Also suppose the planet Suco has a periodic table of elements. Given below is a part of Suco's table, and an incomplete table of atomic radii. Decide on the most likely radius for each element.

	On	
Ch	E	M

<u>Element</u>	<u>Atomic Radius (pm)</u>
_____	90
_____	120
_____	140
_____	180

9. (23 points) Answer the following questions.

- a) The maximum number of *orbitals* that may be associated with the following set of quantum numbers $n = 4$ and $\ell = 2$ is _____.
- b) The maximum number of orbitals that may be associated with the quantum number set $n = 3$, $\ell = 2$, and $m_\ell = -2$ is _____.
- c) Label each of the orbital pictures below with the appropriate letter:



Letter _____

ℓ value _____

- d) When $n = 5$, the possible values of ℓ are _____.
- e) The maximum number of orbitals that can be assigned to the $n = 4$ shell is _____.
- f) A subshell with 3 planar nodes is a _____ orbital (*give its letter designation*).
- g) Consider an orbital labeled $2p_z$. At which point is the electron density greater?
- (i) A point with $z = 0.10$ nm, $x = 0$, and $y = 0$.
- (ii) A point with $z = 0$, $x = 0.10$ nm, and $y = 0$
- h) What is the maximum number of electrons that can be associated with each of the following sets of quantum numbers? (A possible answer is "none.")

<i>Quantum Number Set</i>	<i>Maximum Number of Electrons Described</i>
$n = 4, \ell = 3$	_____
$n = 6, \ell = 1, m_\ell = -1$	_____
$n = 3, \ell = 3, m_\ell = -3$	_____
$n = 2, \ell = 1, m_\ell = 1, m_s = +1/2$	_____

- i) How many *orbitals* are there in a subshell labeled f ? _____
- j) How many *electrons* can be assigned to the $n = 3$ shell? _____
- k) For a $4d$ orbital, $n =$ _____, $\ell =$ _____, and a possible value of m_ℓ is _____. An element from the series of elements that is filling the $4d$ subshell is _____.
- l) Which ion or ions are unlikely based on your knowledge of electron configurations and ionization energies: Li^{2+} , Ca^{2+} , Mg^{3+} , Ti^{3+} , Cl^{2-} , Zn^{2+} , Ga^{3+} ? _____

10. (10 points) Electron Configurations

- a) Use the *orbital box notation* to give the electron configuration for *sulfur*. Show *all* orbitals in your diagram.
- b) Using the *spectroscopic notation*, give the electron configuration for the *sulfide ion*, S^{2-} .

With what neutral atom is the sulfide ion isoelectronic? _____

- c) Use the *orbital box notation* (and noble gas abbreviation) to show the electron configuration for the silver(I) ion, Ag^+ .

Is the Ag^+ ion paramagnetic or diamagnetic? _____

- d) Use the *spectroscopic notation* (and noble gas abbreviation) to show the electron configuration for the europium(III) ion, Eu^{3+} .

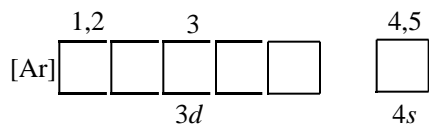
11. (8 points) Name the element, or give the symbol of the element, that corresponds to each characteristic below:

- a) The element with the electron configuration $1s^2 2s^2 2p^6 3s^2 3p^3$. _____
- b) The element whose +2 ion has the configuration $[Kr]4d^5$. _____
- c) The element with the configuration $[Xe]6s^2 5d^1 4f^1$. _____
- d) The element whose -1 ion has the configuration $1s^2$. _____

12. (10 points) Compare the elements Si, K, Ge, and Ca.

- Which has the largest atomic radius? _____
- Which has the largest ionization energy? _____
- Which is the least metallic? _____
- Which should have the most positive electron affinity? _____
- Which should have the largest difference between the 1st and 2nd ionization energy?

13. (9 points) The configuration of an element is given here.

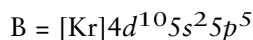
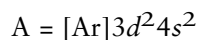


- What is the identity of the element? _____
- The element is found in Group _____ and period _____.
- Is the element a nonmetal, a main group element, a transition element, a lanthanide element, or an actinide element? _____
- Write a complete set of quantum numbers for electrons 1, 2, and 4.

Electron	n	l	m_l	m_s
1	_____	_____	_____	_____
2	_____	_____	_____	_____
4	_____	_____	_____	_____

- If two electrons are removed to form the 2+ ion, the two electrons removed are _____ and the ion is (*diamagnetic or paramagnetic*) _____

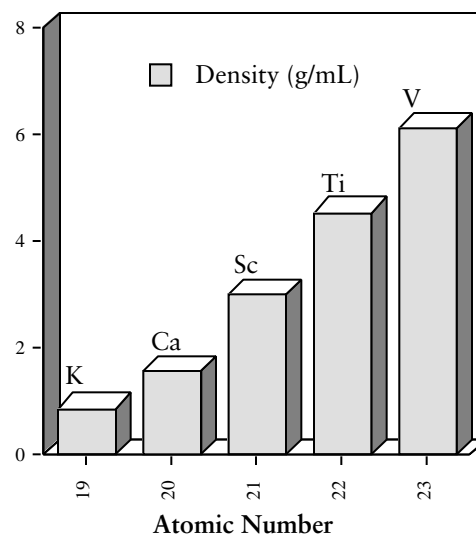
14. (8 points) Answer the questions below about the elements A and B, which have the electron configurations shown.



- Is element A a metal, nonmetal, or metalloid? _____
- Which element has the larger (more positive) ionization energy? _____
- Which element has larger (more positive) electron affinity? _____
- Which of the two elements is the more likely to form a cation? _____

15. (2 points) Explain why a compound such as NaCl_2 or NeCl does not exist. (You may choose to base your answer on either compound.)

16. (2 points) The densities of elements from the same period are plotted here. Explain why the density of the elements increases in the observed order



17. (2 points) The first ionization energies for several elements from the same period are plotted here. Explain why the energies do not simply increase in the order Si < P < S < Cl < Ar. That is, why are the ionization energies for S, Cl, and Ar lower than expected?

