CH 06 AK

1. (5 points) Using your knowledge of the everyday and super hero world, place the following sources of light in order of increasing energy: [This means: **start with the smallest energy and end at the highest energy**. Do not put numbers next to the letters; you need to write out the correct order of letters. You will receive no credit if you are not clear about your answer.]:

   a. Gamma rays that turned Bruce Banner into the Hulk
   b. The red color in red dye no. 28; a component of an insecticide used to kill Mediterranean fruit flies
   c. Infrared heat from the wires in your toaster used to burn toast
   d. Superman's x-ray vision used to see through walls and watch nefarious evil deed doers.
   e. The green color of the Green Lantern's lamp

Starting with ROY G BIV, I know that the energies should be increasing from radio waves to microwaves to IR to vis to UV to X-ray to gamma ray. The wavelengths should be decreasing.

From low to high energy then: c ,b, e, d, a

1. (6 points) The optic nerve needs a minimum of 2.00 x 10^{-17}J of energy to trigger a series of impulses that eventually reach the brain. How many photons of yellow-orange light with a λ = 589 nm are emitted from a low-pressure sodium lamp in a parking lot, such that we can observe this light?

$$\Delta E = \frac{hc}{\lambda}$$

$$\Delta E = \frac{hc}{589x10^{-9}} = 3.372\,6x10^{-19}J$$

$$number\ of\ photons = \frac{2.00x10^{-17}J}{3.372\,6x10^{-19}J} = 59.3\ photons$$

2. ((6 points) A sample of gold metal must absorb radiation with a minimum frequency of 1.2619 X 10^{15}s-1 before it can emit an electron from its surface via the photoelectric effect.

   a. (2 points) What is the minimum energy required to produce this effect? (ϕ)

b. (2 points) What wavelength radiation will provide a photon of this energy?

c. (2 points) If the surface of the gold sample is radiated with light of wavelength 106 nm, what is the maximum possible kinetic energy of the emitted electrons?

Minimum energy (φ) $\Delta E = H\nu = 6.626\text{x}10^{-34}\text{Js x } 1.2619\text{x}10^{15\text{-}}\text{s}^{-1} =$ **$8.361\text{x}10^{-19}\text{J}$**

λ (photon)=	Speed of light [c]	= $2.998 \text{ x } 10^{8}$ m/s	=**$2.376 \text{ x } 10^{-7}$ m**
	ν	$1.2619\text{x}10^{15\text{-}}\text{s}^{-1}$	

$$\Delta E_{photon} = \frac{6.626\text{x}10^{-34}\text{Js x } 2.998 \text{ x } 10^{8} \text{ m/s}}{106 \text{ x } 10^{-19} \text{ m}} = 1.874\ 03 \text{ x } 10^{-18} \text{ J}$$

$\Delta E =$ **φ + KE so KE = ΔE – φ (you solved for this in part a.)**

$\text{KE} = 1.874\ 03 \text{ x } 10^{-18} \text{ J} - 8.361\text{x}10^{-19}\text{J} = 1.037\ 897\ 03 \text{ x } 10^{-18}\text{J}$

WHAT IF THE PROBLEM ASKED FOR THE VELOCITY OF THE ELECTRON?

$\text{KE} = \frac{1}{2} m_e v^2$,

$v = (2 \text{ x } 1.037\ 897\ 03 \text{ x } 10^{-18}\text{J}/9.109\ 4 \text{ x } 10^{-31}\text{kg})^{1/2}$

$1.51 \text{ x } 10^{7}$m/s (hope this is right, my calculator is broken.)

3. [4 points] An electron in the hydrogen atom can undergo only set transitions. Calculate the wavelength for an electron transitioning from n =12 to n =3. Is this visible, infrared, or ultraviolet light?

$1/\lambda = 1.096 \text{ x } 10^{7} \text{ m}^{-1}(1/9 - 1/144) = 1.1417 \text{ x}10^{6}$

$\lambda = 875.9$ nm

This is in the IR range. The Paschen series has an n final of 3. Also, this wavelength is longer than the longest visible wavelength, 750nm

4. (2 points) How many angular nodes does a 6f orbital have? How many radial nodes does a 12d orbital have?

There are 3 angular nodes for a sf orbital (l = 3 signifies the number of nodes). There are 9 radial nodes for a 12 d orbital, nodes = n – 1- l

We can account for the starting point of the 12 d orbital with 3d. however the 3 d orbital has no radial nodes. 12 – (3 -1)

5. (5 points) Fill in the blanks with the correct response:

a. The number of orbitals with the quantum numbers [3,2,0] is

1

b. The number of un-paired electrons in a Mn^{2+} ion is

5

c. The sub shell with the quantum numbers [4,2] is

4d

d. When n = 2, the angular momentum quantum number ,l, can be what value(s)

1 or 0

e. The total number of electrons with n=4, l = 1 is

6

Reasoning:

a) When n is stated, you include ALL of the possible orbitals. When n & l are stated, you give the number of orbitals in that subshell. When n & l & m_l are stated, you give only 1 orbital.
b) There are 7 electrons in Mn. There are 5 electrons in Mn^{+2}. These electrons are housed in the 5d subshell. Electrons are removed from the 4s subshell first. Since the 5d orbitals are degenerate, they must obey Hund's rule.
c) See a, 2 quantum numbers listed means a subshell.
d) The l value tells you there are 2 subshells. 1, 0
e) This is also describing a subshell when l = 1, it indicates a p subshell.

6. (8 points) A sample of molybdenum metal must absorb radiation with a minimum frequency of 1.09×10^{15}s-1 before it can emit an electron from its surface via the photoelectric effect.
   a. What is the minimum energy required to produce this effect? (ϕ)

Minimum energy (φ) $\Delta E = H\nu = 6.626\times10^{-34}\text{Js} \times 1.09 \times 10^{15}\text{s}^{-1} =$ **7.22×10^{-19} J**

   b. What wavelength radiation will provide a photon of this energy?

λ (photon)=	Speed of light [c]	= 2.998×10^{8} m/s	= **2.75×10^{-7} m**
	ν	1.09×10^{15}s-$^{-1}$	

c. If molybdenum is radiated with light of wavelength 122 nm, what is the maximum possible kinetic energy of the emitted electrons?

$$\Delta E_{photon} = \frac{6.626 \times 10^{-34} Js \times 2.998 \times 10^{8}\ m/s}{122 \times 10^{-9}\ m} = 1.62\,8 \times 10^{-18}\ J$$

ΔE = **φ + KE so KE = $\Delta E - \varphi$ (you solved for this in part a.)**

$1.62\,8 \times 10^{-18}\ J - 7.22 \times 10^{-19}\ J = 9.06\,3 \times 10^{-18} J$

WHAT IF THE PROBLEM ASKED FOR THE VELOCITY OF THE ELECTRON?

KE= $\frac{1}{2} m_e$

v^2, = $(2 \times 9.06\,3 \times 10^{-18} J / 9.109\,4 \times 10^{-31} kg)^{1/2}$

1.42×10^{6}m/s (hope this is right, my calculator is broken.)

7. (6 points) State which of the following sets of quantum numbers would be possible and which would not. Using one or two sentences (not <,>, =,≥, or any with slashes) explain what is wrong with the quantum numbers that are not possible. Note: missing the spin quantum number is not an error.

   a. [1,0,0] This is POSSIBLE. These values represent a 1s orbital.
   b. n =5, l = 9, ml = -1 This is NOT POSSIBLE. Since l is dependent on n, it can't be larger than n.
   c. n = 18, l =0, ml = 0 This is POSSIBLE. These values represent an 18s orbital
   d. n =9, l = 2, ml = -1 This is POSSIBLE, These values represent a 9d orbital.
   e. [-5, 0, 1] This is NOT POSSIBLE. Principal the principal quantum number , n, can't be negative.
   f. [2, -1, 0] This is NOT POSSIBLE. Since l is dependent on n, it too can't be negative.

8. (5 points) Given below are several electron configurations that might be correct for the nitrogen atom. Indicate whether each of these representations are the ground state, the excited state, or un-allowed (forbidden) state. Using Hund's rule, the Pauli principle, and aufbau (building up), BRIEFLY explain your choices. [Some might violate more than one rule.]

a) ↑↓ (1s) ↑↓ (2s) ↑ ↑ ↓ (2p) __ (3s)

Is an EXCITED state. Has one electron in the 2p subshell that violates Hund's Rule. That electron does not have the same spin as the other electrons, so the spin is not maximized

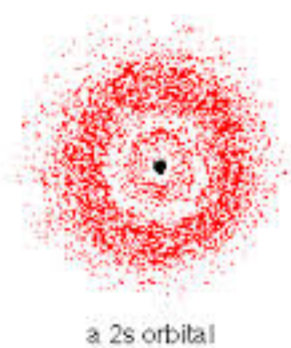
b) ↑↓ ↑↓ ↑ ↑ ↑ __
1s 2s 2p 3s
is GROUND STATE.

c) ↑↓ ↑↑ ↑ ↑ ↑ __
1s 2s 2p 3s
violate PAULI, which states that no two electrons can have the same four quantum numbers. Both electrons are [2.0.0.1/2]

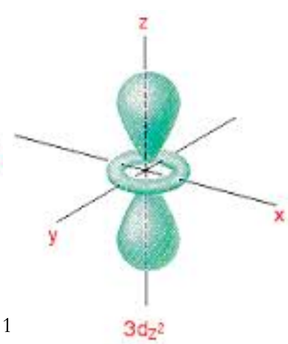
d) ↑↓ ↑ ↑ ↑ ↑ ↑
1s 2s 2p 3s
Is EXCITED STATE. Violate Aufbau, in which electrons are filled in the lowest n, l first before filling higher n, l values. The 3s can't fill before the 2s and 2 p subshells are filled.

e) ↑↓ ↑↓ ↑↓ ↑ __ __
1s 2s 2p 3s
this is an EXCITED state. Violates Hund's Rule because repulsions are not minimized and spin is not maximized.

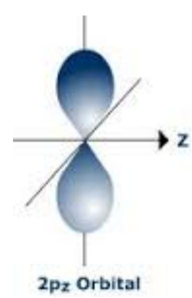
9. (11 points) Each drawing represents a type of atomic orbital.



[1]



[2]



[3]

a. (3 points) Give the angular momentum value (l) for each orbital.

In order, 0, 2, 1

b. (3 points) Give an appropriate value for ml for orbital each orbital

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[1] http://www.chemguide.co.uk/atoms/properties/2sorbital.GIF
[2] http://www.chemguide.co.uk/inorganic/complexions/dorbitals3.gif
[3] http://image.tutorvista.com/content/atomic-structure/orbital-2pz-shape.jpeg

0, -2,-1,0,-1, or -2   1,0, -1

c. (2 points) Provide two sets of quantum numbers for an electron in the 2s orbital

2,0,0,1/2 or 2,0,0,-1/2

d. (3 points) Rank the orbital in order of stability, from most stable to least.6 points)

2S, 2p, 3d, more nodes means lower stability. Electron does not penetrate the nucleus.

10. Give the name or electron configuration for the following elements or ions. [You can give noble gas core]:
    a. Ga: **$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^1$**
    b. Antimony **$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^3$**

    c. Iron(II) **Fe: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^6$**
    $1s^2 2s^2 2p^6 3s^2 3p^6 3d^6 4s^2$

    Fe^{2+} $1s^2 2s^2 2p^6 3s^2 3p^6 3d^6$

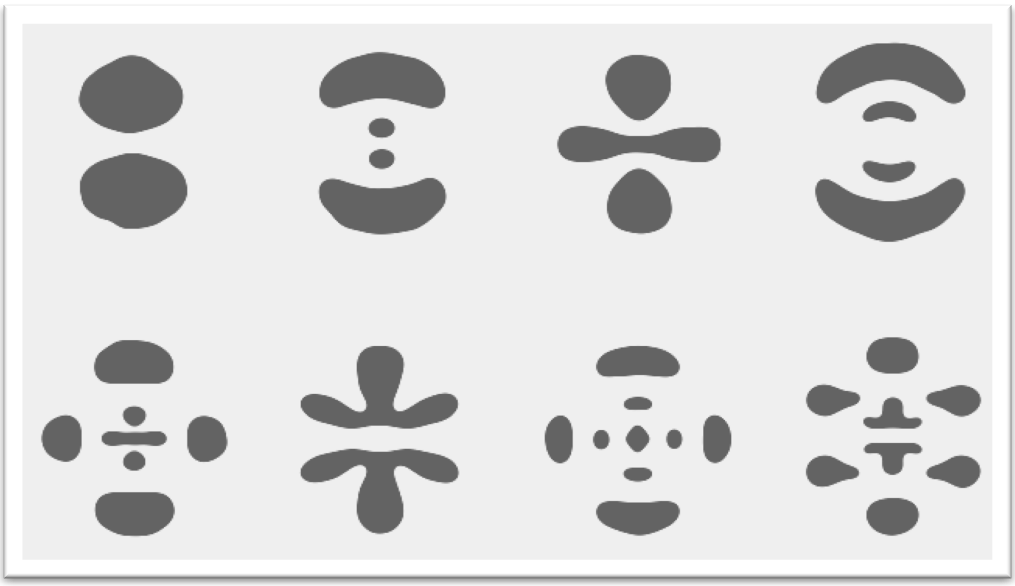
    d. $[Ar]4s^1 3d^{10}$ **Cu**
    e. $[Xe]4f^{14} 5d^{10} 6s^2$ **Mercury**
    f. Cr^{2+}**$1s^2 2s^2 2p^6 3s^2 3p^6 3d^4$**
    g. Element number 116 (yes even if it doesn't yet exist)
    $[Rn]7s^2 5f^{14} 6d^{10} 7p^4$

11. (6 points) Give the name or electron configuration for the following elements or ions.   [You can give noble gas core]:
    a. Sn^{4+} Write the atomic electron configuration in PT order: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6\ 5s^2 4d^{10} 5p^2$; rearrange in energy order; $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6\ 4d^{10} 5s^2 5p^2$; Remove outer electrons to make charge: $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6\ 4d^{10}$; or write in noble gas; $[Kr]\ 4d^{10}$
    b. Thallium (element 81) $[Xe]4f^{14} 5d^{10} 6s^2 6p^1$
    h. Iron(II) Fe: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^6$
    $1s^2 2s^2 2p^6 3s^2 3p^6 3d^6 4s^2$

    Fe^{2+} $1s^2 2s^2 2p^6 3s^2 3p^6 3d^6$
    c. $[Ar]4s^1 3d^{10}$ Cu
    d. $[Xe]4f^{14} 5d^{10} 6s^2 6p^4$Po, polonium
    e. Co^{2+} $1s^2 2s^2 2p^6 3s^2 3p^6 3d^7$

12. (13 points) Each drawing represents a type of atomic orbital.[4]

Row 1:	2p,	3p,	3d,	4p
Row 2:	4d,	4f,	5d,	5f



e. (4 points) Give the angular momentum value (l) for each orbital in row 1.

1,1,2,1

f. (3 points) Give an appropriate value for ml for a 5d orbital and a 5f orbital

-2, -1, 0, 1, OR 2
-3, -2, -1, 0, 1, 2, OR 3

g. (2 points) Provide two sets of quantum numbers for an electron in the 4p orbital

6 VALUES 4,1,0, ½; 4, 1, 1, ½; 4, 1, -1, ½; 4, 1, 1, - ½;;4, 1, 0, -1 ½;; OR 4, 1, -1, - ½;

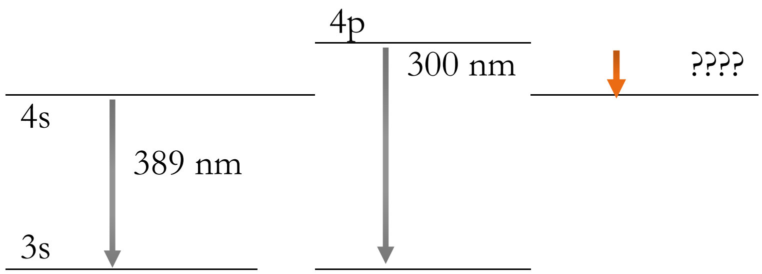
(4 points) Rank the orbitals in row 2 in order of stability, from most stable to least.

[4] http://hendrix2.uoregon.edu/~imamura/102/images/orbitals.jpg, I adjusted the contrast so that my students can see the image better.

RANKING ORBITALS RUN FROM S, P, D F. THE LOWER THE N VALUE, THE MORE STABLE.

13. (5 points) Atomic sodium emits light at 389nm when an excited electron moves from a 4s orbital to a 3s orbital (this emission is, in fact, very weak), and at 300. nm when an electron moves from a 4p orbital to the same 3s orbital.

   a. Draw an energy level diagram depicting the process. (You can leave out the core levels of n=1 and n= 2)



   b. What is the energy of these two wavelengths?

$$\Delta E_{(4s\rightarrow 3s)} = \frac{6.626\text{x}10^{-34}\text{Js x } 2.998 \text{ x } 10^{8}\text{ m/s}}{389 \text{ x } 10^{-9}\text{ m}} = \mathbf{5.106\ 6 \text{ x } 10^{-19}\ J}$$

$$\Delta E_{(4p\rightarrow 3s)} = \frac{6.626\text{x}10^{-34}\text{Js x } 2.998 \text{ x } 10^{8}\text{ m/s}}{300 \text{ x } 10^{-9}\text{ m}} = \mathbf{6.621\ 6 \text{ x } 10^{-19}\ J}$$

   c. What is the energy separation (in kilojoules/mole) when an electron moves between the 4s and the 4p orbital?

$\Delta E_{(4s\rightarrow 3s)} - \Delta E_{(4p\rightarrow 3s)} = 1.52 \text{ x } 10^{-19}$ J/electron

$$\Delta E_{(kJ/mol)} \quad \frac{1.52 \text{ x } 10^{-19}\text{ J}}{1 \text{ electron}} \Bigg| \frac{6.022 \text{ x}10^{23}\text{electrons}}{\text{Mol electrons}} \Bigg| \frac{1\text{kJ}}{1000\text{J}} \quad 915 \text{ kJ/mol}$$

14. (10 points) Microwave ovens use microwave radiation to heat food. The energy is absorbed by water molecules (and other small molecules) in food, and transferred to other components of the food.
    (a) Suppose that the microwave radiation has a wavelength of 11.2 cm. How many photons are required to heat 200.0 mL of coffee from 23.0°C to 60.0°C? (7 points) assume 1.00 mL water = 1g water

ΔE (microwave)	$=6.626\times10^{-34}$Js x 2.998 x 10^{8} m/s	$=1.77\ 4 \times 10^{-24}$ J/photon
	11.2 x 10^{-2} m	

Q water	4.184J	200.0 g	(60.0°C– 23.0°C	=30,962J
	g°C			

30,962J/1.77 4 x 10^{-24} J/photon = 1.74×10^{28} photons

    (b) Suppose the microwave's power is 900W (1 Watt = 1 joule/sec). How long would you have to heat the coffee based on the energy from part a? (3 points)

Time to heat water	30,962J	1Ws	34.4 s
	900.W	1J	

15. (7 points) Complete the following statements:

    a. Two electrons in the same ORBITAL must have opposite spin.

    b. The presence of un paired electrons in an atom gives rise to PARAMAGNITISM –not on the test

    c. When l= 3, ml may have values from —3 to +3 .

    d. The neutral fourth period atom having a total of six d electrons is IRON .

    e. Orbital with the same energy are said to be DEGENERATE .

    f. The 2p orbitals of an atom have identical shapes but differ in there ORIENTATION, AXES, DIRECTION are acceptable .

    g. A nodal surface is one at which the probability of finding and electron is ZERO