Chem 106 J-Term 2005. Exam 1

Name Key

Useful information: $E = h\nu$, h= 6.626 x 10^{-34}Js, $J = \frac{kgm^2}{s^2}$, $\lambda\nu = c$, c= 3.00 x 10^8 m/s,

$\lambda = \frac{h}{mv}$, $(\Delta x)(\Delta v) = \frac{h}{4\pi m}$, $\frac{1}{\lambda} = R\left(\frac{1}{n_{final}^2} - \frac{1}{n_{initial}^2}\right)$, R = 0.01097 nm^{-1} $U = k\left(\frac{Q_1 Q_2}{d}\right)$

(1)(4 points) What determines the color of light? If a light is made more intense, what has changed about the light? The wavelength or frequency.

When light is more intense, it is because there are more photons.

(2)(4 points) Define the following

(a) the Pauli Exclusion Principle

No 2 electrons in the same atom can have the same 4 quantum numbers

(b) Hund's rule Electrons in an atom aren't paired unless it would violate the Aufbau principle

(3)(4 points) List and name the four quantum numbers for an electron.

n = principal quantum number

l : angular momentum quantum number

m_l - magnetic quantum number

m_s : spin quantum number

(4)(3 points) List the possible quantum numbers for the following orbitals

(a) 4s $n=4$ $l=0$ $m_l=0$ $m_s=+\frac{1}{2}$ or $-\frac{1}{2}$

(b) 3d $n=3$ $l=2$ $m_l=-2,-1,0,1,$ or 2 $m_s=+\frac{1}{2}$ or $-\frac{1}{2}$

(c) 5p $n=5$ $l=1$ $m_l=-1,0,$ or 1 $m_s=+\frac{1}{2}$ or $-\frac{1}{2}$

(5)(4 points) Write out the ground state electron configuration for the following atoms or ions (do not use the noble gas shortcut)

(a) P $1s^2 2s^2 2p^6 3s^2 3p^3$

(b) Ca $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$

(c) Sc^+ $1s^2 2s^2 2p^6 3s^2 3p^6 3d^2$

(d) Cl^- $1s^2 2s^2 2p^6 3s^2 3p^6$

(6)(4 points) Label each of the following as a ground state, an excited state, or an impossible electron configuration

(a) $1s^22s^22p^53s^23p^4$ excited state

(b) $1s^22s^22p^63s^23p^64s^23d^1$ ground state

(c) $1s^22s^22p^63s^23p^44s^3$ impossible

(d) $1s^22s^22p^63s^23p^44s^24p^2$ excited state

(7) Perform the following conversions (4 points)

(a) what is the frequency of light with a wavelength of 259 nm?

$\nu\lambda = c$ 259 nm = 2.59 x 10^{-7} m

ν(2.59 x 10^{-7} m) = 3.00 x 10^{8} m/s

ν = 1.16 x 10^{15} 1/s

(b) What is the wavelength of a radio broadcast at a frequency of 1600 kilohertz?

1600 x 10^{3} Hz = 1.600 x 10^{6} 1/s

(1.600 x 10^{6} 1/s)(λ) = 3.00 x 10^{8} m/s

λ = 188 m

(8)(2 points) Place the following elements in order from smallest to largest atomic radii.

Zn, Ca, Rb, Al, B

B < Al ≮ Zn < Ca < Rb

(9)(2 points) Which of the following should have the largest first ionization energy?

O, Mg, S, Tc, or Na

O

(10)(2 points) Place the following in order from smallest to largest radius.

Na^+, Ne, Mg^{2+}, O^{2-} Mg^{2+} < Na^+ < Ne < O^{2-}

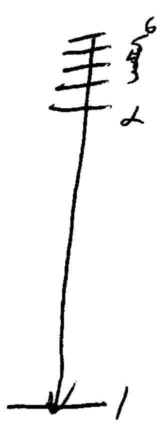
(11)(2 points) Place the following in order of increasing lattice energy.
NaCl, Li_2S, CsI, MgO, Ca_3N_2

$CsI < NaCl < Li_2S < MgO < Ca_3N_2$

(12)(4 points) A neutron with a mass of 1.67×10^{-27} kg is moving at 25 m/s. What is its deBroglie wavelength?

$$\lambda = \frac{h}{mv} \qquad \lambda = \frac{6.626 \times 10^{-34}\ \frac{kg\,m^2}{s}}{(1.67 \times 10^{-27}\ kg)(25\ \frac{m}{s})} = 1.59 \times 10^{-8}\ m$$

(13)(4 points) An electron in a hydrogen atom falls from the n=6 to the n=1 level. What is the wavelength of light emitted in this process?



$$\frac{1}{\lambda} = R\left(\frac{1}{n_{final}^2} - \frac{1}{n_{init}^2}\right)$$

$$\frac{1}{\lambda} = 0.01097\ nm^{-1}\left(\frac{1}{1^2} - \frac{1}{6^2}\right)$$

$$\frac{1}{\lambda} = 1.066 \times 10^{-2}\ nm^{-1}$$

$$\lambda = 93.76\ nm$$

(14)(4 points) Can an electron ever be trapped motionless in one spot? Explain why or why not

No, if it is motionless ($V = 0$) + in a fixed locat $\Delta x = 0$, the Heisenburg Uncertainty principle would be violated

Extra Credit(4 points): A small radio requires 255 J of energy to play for 1 hour. If the radio was solar powered, how many photons of 500 nm light would be required to power the radio for one hour?

$E = h\nu$

$(5.00 \times 10^{-7} m)\nu = 3.00 \times 10^{8} \frac{m}{s}$

$\nu = 6.00 \times 10^{14} \frac{1}{s}$

$E = (6.626 \times 10^{-34} J s)(6.00 \times 10^{14} \frac{1}{s}) = 3.98 \times 10^{-19}$ J/photon

$\frac{255 J}{3.98 \times 10^{-19} J/photon} = 6.41 \times 10^{20}$ photons

or 1.07×10^{-3} moles of photons