Chemistry
Atomic Theory Practice

Atomic Theory Practice2004.doc

Name Key
Date _____ Period ___

1. Determine the frequency of a light wave with a wavelength of 420nm. What is the approximate color of this light?

$\nu = \frac{c}{\lambda} = \frac{3.0\times10^{8}\ m/s}{4.20\times10^{-7}\ m} = 7.14\times10^{14}\ Hz$

Bluish

2. What is the wavelength (in meters) of a radio station that is broadcasting at 1190kHz?

$\lambda = \frac{c}{\nu} = \frac{3.0\times10^{8}\ m/s}{1.190\times10^{6}\ Hz} = 252\ m$

3. Calculate the wavelength (in nm) for an electromagnetic wave that requires 1.583×10^{-15}s for one wavelength to pass by a given point.

Period $= \frac{1}{\nu}$ $\quad \nu = \frac{1}{1.583\times10^{-15}} = 6.317\times10^{14}\ Hz$

$\lambda = \frac{c}{\nu} = \frac{3.0\times10^{8}}{6.317\times10^{14}} = 4.75\times10^{-7}\ m$ = 475nm

4. What is the energy of a photon of green light with a frequency of 5.80×10^{14}Hz?

$E = h\nu = (6.626\times10^{-34}\ Js)(5.80\times10^{14}\ Hz)$

$= 3.84\times10^{-19}\ J$

5. What is the DeBroglie wavelength of a 2500kg truck traveling at a rate of 75km/h? 20.83 m/s

$\lambda = \frac{h}{mv} = \frac{6.626\times10^{-34}\ Js}{(2500)(20.83\ m/s)} = 1.27\times10^{-38}\ m$

6. With reference to the photoelectric effect, what is the work function energy (in kJ/mol) [the energy required to remove an electron from the metallic crystal] of an electron in a metal whose threshold frequency for photoelectrons is 2.5×10^{14}Hz?

$E = h\nu = (6.626\times10^{-34}\ Js)(2.5\times10^{14}\ Hz) = 1.6565\times10^{-19}\ J/atom$

$(1.6565\times10^{-19}\ J/atom)\left(6.022\times10^{23}\ \frac{atoms}{mol}\right)\left(\frac{1\ kJ}{1000\ J}\right) = 99.8\ kJ/mol$

7. What is the energy in joules of a mole of photons associated with visible light of wavelength 486.1nm?

$E = \frac{hc}{\lambda} = \frac{(6.626\times10^{-34}\ Js)(3.0\times10^{8}\ m/s)}{(4.861\times10^{-7}\ m)} = 4.09\times10^{-19}\ J/photon$

$(4.09\times10^{-19}\ J/photon)\left(6.022\times10^{23}\ \frac{photons}{mol}\right) = 2.46\times10^{5}\ J$

8. Explain whether or not it is possible for an electron to absorb a photon of yellow light and emit a photon of green light on the downward transition. No. Green light is higher in energy than yellow. This would be a violation of conservation of energy.

9. Calculate the wavelength of the light emitted by a hydrogen atom during a transition of its electron from the n=4 to the n=1 principal energy level.

$E = -R_H\left(\frac{1}{n_2^2} - \frac{1}{n_1^2}\right)$

$= -2.180\times10^{-18}\ J\left(\frac{1}{16} - \frac{1}{1}\right)$

$= 2.044\times10^{-18}\ J = \frac{hc}{\lambda}$ $\quad \lambda = \frac{(6.626\times10^{-34})(3.0\times10^{8}\ m/s)}{2.044\times10^{-18}\ J}$

$= 9.725\times10^{-8}\ m$ = 97.25nm

10. The second line of the Balmer series occurs at a wavelength of 486.13nm. What is the energy difference between the initial and final levels of the hydrogen atom in this emission process?

$E = \frac{hc}{\lambda}$ $\quad E = \frac{(6.626\times10^{-34}\ Js)(3.0\times10^{8}\ m/s)}{(4.8613\times10^{-7}\ m)}$

$= 4.09\times10^{-19}\ J$

11. Determine the velocity of an electron (as a percentage of the speed of light) if it possesses a DeBroglie wavelength of 2.635pm.

$\lambda = \frac{h}{mv}$ $\quad v = \frac{h}{m\lambda} = \frac{6.626\times10^{-34}\ Js}{(9.11\times10^{-31}\ kg)(2.635\times10^{-12}\ m)}$

$v = \frac{2.76\times10^{8}\ m/s}{3.0\times10^{8}\ m/s} \approx 92\%c$

12. The so-called Bohr radius refers to the mean radius of the first energy level in the Bohr model of the hydrogen atom. It occurs for an electron traveling at 2.18752×10^{6}m/s. Calculate the Bohr radius in nanometers.

$2\pi r = n\lambda$ $\quad \lambda = \frac{h}{mv}$

$\frac{(6.626\times10^{-34})}{(9.11\times10^{-31})(2.18752\times10^{6})}$

$= 3.3249\times10^{-10}\ m$

(more on the back)

$2\pi(r) = (1)(3.3249\times10^{-10})$

$5.29\times10^{-11}\ m$

.0529nm

13. Determine the ionization energy (in joules) for a hydrogen electron being removed from the second Bohr orbit.

$E = -R_H \left(\frac{1}{n_{hi}^2} - \frac{1}{n_{lo}^2} \right)$

$= -2.180 \times 10^{-18} \text{ J} \left(\frac{1}{\infty^2} - \frac{1}{2^2} \right)$

$E = (-2.180 \times 10^{-18})(-.25) = 5.45 \times 10^{-19} \text{ J}$

14. Give a valid set of quantum numbers for the outermost electron of an aluminum atom.

Aluminum's last electron is in the 3rd energy level, p-sublevel

$n = 3$

$l = 1$

$m_l = -1, 0 \text{ or } +1$

$m_s = +\frac{1}{2} \text{ or } -\frac{1}{2}$

15. Circle the orbital designations that are invalid and briefly explain why.

a. 4s

(b) 3f ← There is no 3f sublevel

(c) 2d ← There is no 2d sublevel

d. 3d

16. How many electrons are in the valence shell of the following atoms?

a. barium 2 $(6s^2)$

b. sodium 1 $(3s^1)$

c. aluminum 3 $(3s^2 3p^1)$

d. oxygen 6 $(2s^2 2p^4)$

e. zinc 2 $(4s^2)$

17. Give full and condensed spectroscopic notation for each of the atoms in the previous problem.

a) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^6 6s^2$

[Xe] $6s^2$

b) $1s^2 2s^2 2p^6 3s^1$ [Ne] $3s^1$

c) $1s^2 2s^2 2p^6 3s^2 3p^1$ [Ne] $3s^2 3p^1$

d) $1s^2 2s^2 2p^4$ [He] $2s^2 2p^4$

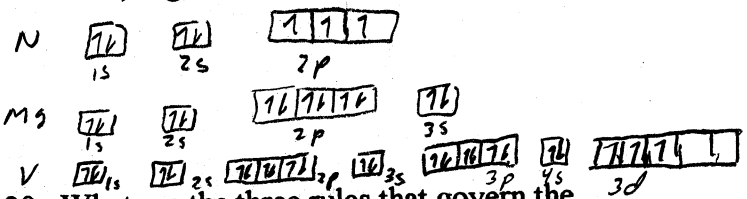
e) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10}$ [Ar] $4s^2 3d^{10}$

18. Explain the peculiar electron configuration for copper and some other atoms of the transition elements.

Sometimes atoms (such as Cr and Cu) will migrate and electron up from a lower energy level to half-fill or fill a higher energy level.

19. Give orbital box diagrams for the following elements:

N, Mg, V



20. What are the three rules that govern the filling of atomic orbitals by electrons?

Aufbau principle

Pauli Exclusion principle

Hund's Rule

21. Explain the difference between a photon and a quantum.

A photon is a particle of light a "quantum" is a "discrete" value of something, as in the energy a photon possesses

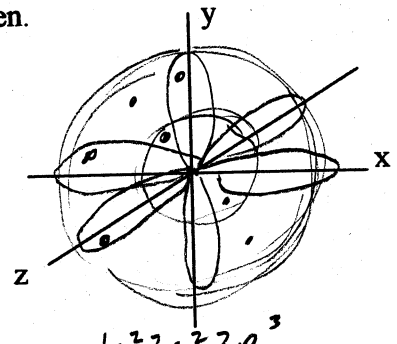
22. Arrange the following atoms in order of increasing atomic radii and in order of increasing ionization energy.

Si, S, Ca, F

F < S < Si < Ca Atomic Radii

Ca < Si < S < F ionization energy

23. Sketch a diagram that shows the proper orbitals and placement of electrons for the element nitrogen.



$1s^2 2s^2 2p^3$