Worksheet No. 4

Name _____

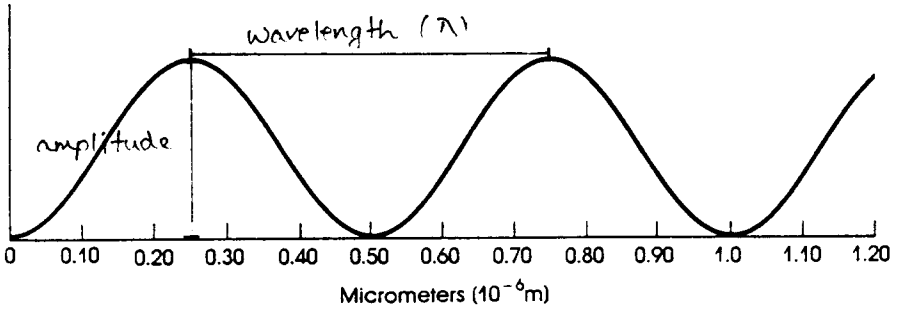
Class _____ Date _____

Electrons in Atoms

A. Waves

Light travels through space by means of waves. Each wave has a frequency (ν), a wavelength (λ), and an amplitude.

The figure below represents a light wave. Label the wavelength and amplitude. Then answer the following questions.



1. Given the distance scale, in micrometers, μm (1.0×10^{-6}m), shown in the figure, what is the value, in meters per wave, of the wavelength?

$0.50 \frac{\mu m}{wave} \times 1.0 \times 10^{-6} \frac{m}{\mu m} = 5.0 \times 10^{-7}$ m/wave

2. Given that 6.0×10^{8} crests of the wave pass a point in 1.0 microsecond (1.0×10^{-6} sec), what is the value of the frequency, in waves/sec (or hertz), of this wave?

$\frac{6.0 \times 10^{8} \text{ waves}}{1.0 \times 10^{-6} \text{ s}} = 6.0 \times 10^{14}$ waves/s

3. Calculate the product of the answers to questions 1 and 2, above.

$(5.0 \times 10^{-7}$ m/wave$)(6.0 \times 10^{+14}$ waves/s$) = 3.0 \times 10^{8}$ m/s

4. What is the significance of the value just calculated?

Equal to c, the speed of light

5. Write a mathematical equation, in symbols, that expresses what you have just found.

$c = \lambda \times \nu$

6. The light wave in the figure corresponds to green light. Describe how the value of the wavelength would differ if the light were red.

Wavelength of red light would be longer.

7. How would the frequency of red light compare to that of the green light?

It would be lower.

8. How would the value of the product of wavelength and frequency for red light compare to that for the green light? Account for your answer in terms of what you know about light and in terms of the relative magnitudes of the quantities.

The value would be the same, since the speed of light (c) is constant for all colours of light. This also makes sense mathematically because the wavelength of green light is less than that of red light, but its frequency is greater than that of red light. Thus, the two products could be similar or equal in value.

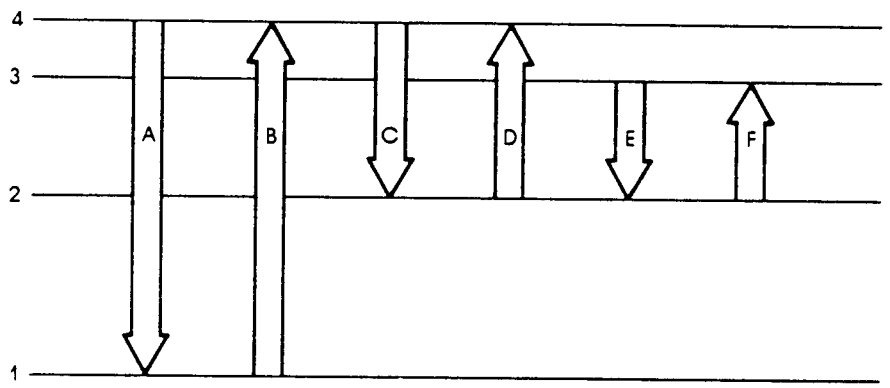
9. How do the energies of green and red light photons compare? What equation expresses this relationship?

The green light has higher energy, since the energy increases with frequency, as is expressed by the equation $E = h\nu$

B. Light and Energy Levels of the Atom

The quantum level occupied by an electron in an atom depends on the energy of the electron. Changes in quantum level are related to absorption or emission of energy.

The figure below represents the four lowest energy levels of an atom, (n = 1 to 4). The six lettered arrows represent changes in energy level of an electron.



1. Which three of the lettered energy changes involve absorption of energy by the atom?

B, D, F

2. Which three of the lettered energy changes involve emission of light energy by the atom?

A, C, E

3. Of the three lettered energy changes that involve emission, one results in emission of blue light, one involves the emission of yellow light, and one involves the emission of ultraviolet light. Which lettered change involves emission of the blue light?

B, D, F, A, C, E
↓E ↑E

C

Which change involves emission of the yellow light?

E

Which change involves emission of the ultraviolet light?

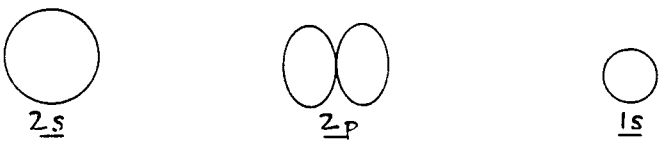
A

Account for your answers.

ultraviolet light is of higher frequency, and therefore higher energy, than is blue light, which is of higher frequency and energy than is yellow light. A involves the largest energy change, because the energy difference between levels is greatest, C involves the second-largest energy difference, and E involves the smallest energy difference. Therefore, the correspondence is A – ultraviolet, C – blue, E – yellow.

C. Orbitals and Orbital Shape

An orbital is a region of space in which an electron is likely to be found. The figure below shows three orbitals of the same many-electron atom. One of the orbitals represents a 2*p* orbital, one represents a 2*s* orbital, and one represents a 1*s* orbital. Label each orbital with its proper designation and answer the following questions.



1. How many electrons can the 2*p* orbital hold? 2 as drawn

   How many can the 2*s* orbital hold? 2

2. Which orbital has the highest energy? 2p

   Which orbital has the lowest energy? 1s

3. If the atom has four electrons in the ground state, how many electrons will be located in each orbital?

   2 e⁻ in 1s orbital; 2 e⁻ in 2s orbital; 0 e⁻ in 2p

D. Orbital Diagrams

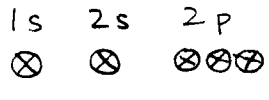
The placement of electrons in a many-electron atom can be represented by slashes in circles that represent orbitals. Answer the following questions involving orbital filling order and orbital diagrams.

1. What is the filling order (lowest energy to highest energy) of orbitals, through the 5*p* level?

   1s 2s 2p 3s 3p 4s 3d 4p 5s 4d 5p

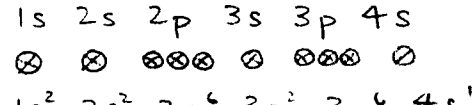
2. Draw orbital diagrams for the following neutral atoms in the ground state, and also write short-form electron configurations for each ($1s^2$ etc.).

Ne (element 10)



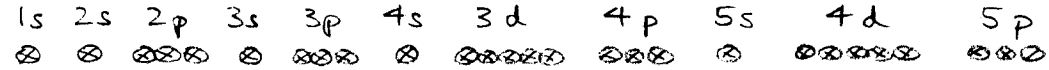
$1s^2\ 2s^2\ 2p^6$

K (element 19)



$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1$

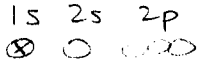
I (element 53)



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

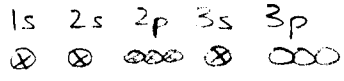
3. Draw orbital diagrams and write short-form electron configurations for each of the following ions, given the atomic numbers of each element.

B^{3+} (element 5)



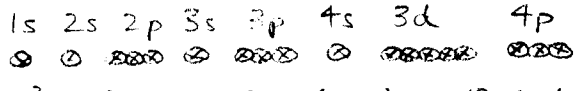
$1s^2$

Si^{2+} (element 14)



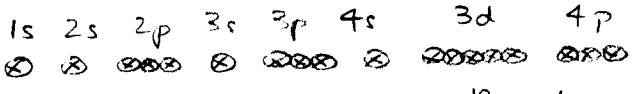
$1s^2\ 2s^2\ 2p^6\ 3s^2$

As^{3+} (element 33)



$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6$

Br^- (element 35)



$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6$