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**WS 9.1 Introduction to Quantum Mechanics**

1. What are the frequency and wavelength ranges of visible light?

2. What type of electromagnetic radiation has the highest energy? Which has the lowest?

3. Which has more energy: A photon of light in the ultraviolet region or a photon of light in the infrared region?

4. Which has more energy, visible light that is red or visible light that is blue?

5. How are the wavelength and frequency of electromagnetic radiation related?

6. How are the energy and wavelength of electromagnetic radiation related?

7. Convert 6.3 X 10-7 m into nanometers.

8. How many micrometers (μm) would you have if you had 13,000 cm?

9. Determine the frequency of light with a wavelength of 4.257  10-7cm. (**7.05x1016 Hz**)

10. A wave of light has a frequency of 3.75 X 1021 Hz. What is its wavelength in nm? (**8.0x10-5 nm**)

11. Determine the frequency of light with a wavelength of 359 nm. (**8.36x1014 Hz**)

12. What is the wavelength (in cm) for a light wave with the frequency of 9.72 X 10 14 Hz. (**3.09x10-5 cm**)

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**WS 9.2 Quantum Energy**

1. How are the energy and frequency of electromagnetic radiation related?

2. Using the two equations E = *h* and *c* = , derive an equation expressing E in terms of *h*, *c*, and .

3. Determine the energy in joules of a photon whose frequency is 3.55  1017 Hz. (**2.35x10-16 J**)

4. Cobalt-60 is an artificial radioisotope that is produced in a nuclear reactor for use as a gamma ray source in the treatment of certain types of cancer. If the wavelength of the gamma radiation from a cobalt source is 1.00  10-3 nm, calculate the energy of a photon of this radiation. (**1.99x10-13 J**)

5. Given the speed of light as 3.0  108 m/s, calculate the wavelength of the electromagnetic radiation whose frequency is 7.500  1012 Hz. (**4.00x10-5 m**)

6. What is the frequency of a radio wave with and energy of 1.55  10-24 J/photon? (**2.34x109 Hz**)

7. When sodium is heated, a yellow spectral line whose energy is 3.37  10-19 J/photon is produced. What is the frequency of this light? What is its wavelength? (**5.09x1014 Hz, 5.89x10-7 m**)

8. Light with a wavelength of 465 nm lies in the blue region of the visible spectrum. Calculate the frequency of this light. (**6.45x1014 Hz**)

9. Radio waves in the AM region have frequencies in the range 550 to 1600 kilocycles per second (550 to 1600 kHz). Calculate the wavelength corresponding to a radio wave of frequency 1.25  106/s (1255 kHz) (**2.4x102 m**)

10. Two states differ in energy by 2.88  10-18 J. When an electron moves from the higher to lower state, calculate the wavelength () in nanometers. (**69 nm**)

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11. An x-ray has a  of 4.00 nm. Calculate the  associated with this radiation. Then calculate the energy in joules associated with this radiation. (**v = 7.5x1016 Hz, E = 4.97x10-17 J**)

12.

a. Calculate the energy in joules of a photon having a frequency of 3  1015 Hz. (**1.99 x 10-18 J**)

b. If a photon has an energy of 2  10-20J, what is its wavelength in meters? (**9.94x10-6 m**)

13.

a. Calculate the wavelength of light in nanometers whose frequency is 8.0  1015 Hz. (**37.5 nm**)

b. Calculate the frequency of light(in hertz) whose wavelength is 200.0 nm. (**1.5x1015 Hz**)



14. Radio station WCBS in New Yok broadcasts its FM signal at a frequency of 101.1 megahertz (MHz). The AM signal is broadcast at 880 kilohertz (kHz). What are the wavelengths of these signals expressed in meters? (**2.97m, 3.4x102 m**)

15. Calculate the energy in joules of one mole of photons that has the following. (**a. 1.04 x 10-5 J, b. 2.19 x 105 J**)

a. A frequency of 2.6  1014 Hz.

b. A wavelength of 546 nm.

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**WS 9.3 Orbital Notation and Electron Configuration**

1. Write the orbital notation for the following elements:

a. P

b. B

c. Na d. C

2. Complete the electron configuration for barium and calcium. How do they compare?

1. How many half filled orbitals do each of the following elements have?

a. Oxygen b. Boron

c. Argon

d. Manganese e. Potassium

f. Zinc

4. In each of the following pairs of sublevels, which of the two is higher in energy?

a. 3d or 4s b. 4p or 5s c. 4f or 6s

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5. Draw the orbital diagram for

 a. Sulfur

b. Calcium c. Copper

6. Draw the electron configuration for each of the following:

a. Sn b. Br c. Ba

7. Write the electron configuration for an unidentified element that contains the following numbers of electrons:

a. 3 b. 6 c. 8

d. 13

8. Write the electron configuration for silicon.

9. Write the complete electron configuration for the following:

a. Ar b. Br c. Al

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**WS 9.4 Electron Configuration Including Noble Gas Configuration**

1. Write the electron configuration and noble-gas notation for each of the elements that follow:

a. Cl b. Cu c. Se

2. What element is represented by the notation: [Ne]3*s*2?

3. Write the abbreviated (noble gas) electron configuration for the following elements:

a. Einsteinium b. Samarium

c. Gold

d. Iodine

4. Write the noble gas notation for the electron configuration of each of the following elements:

a. Hf b. Sc

c. Mo d. Ac

e. Zn

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5. For each of the following elements, determine which element is more stable and explain why.

a. Chlorine or argon b. Copper or zinc

c. Magnesium or manganese

6. For each of the following sets, rank the elements from most stable to least stable:

a. Cadmium, nitrogen, krypton, zirconium

b. Technetium, sulfur, xenon, zinc

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**Simulation: Arranging the Periodic Table**

1. Identify six properties/characteristics of the “elements” that you are organizing.

List these in the table below. List number on back of cards here \_\_\_\_\_\_\_\_\_\_.

2. Arrange your card so that there is a trend/pattern for all six properties. When you have a final arrangement, take a picture of it.

3. Explain how your arrangement makes sense with respect to each property. What patterns does each property follow? Describe these in the table below.

4. There is an element that has not yet been discovered, and so it is missing from your collection of elements. Predict what all six properties of this element will be when it is finally discovered.

5. Draw a picture beside the table as to what the missing card looks like.

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Property** | **Observed Pattern or Trend** | **Description of****Undiscovered****Element** |
| **1.** |  |  |  |
| **2.** |  |  |  |
| **3.** |  |  |  |
| **4.** |  |  |  |
| **5.** |  |  |  |
| **6.** |  |  |  |

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**WS 9.5 More electron configuration**

a. Use noble gas configuration to write the electron configuration for each of the following:

i. Gallium ii. Arsenic

iii. Rubidium iv. Tin

 b. Write full electron configurations for each of the following elements.

i. Germanium ii. Krypton

iii. Lithium

 c. Complete orbital diagrams for each of the following elements:

i. Be ii. C iii. F

iv. Ne

 d. Write electron configurations for the following elements:

i. Chromium ii. Nitrogen

iii. Copper

iv. Tin

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 e. Which of the following (if any) is more stable?

i. Tantalum or cadmium ii. Calcium or potassium iii. Arsenic or gallium

iv. Argon or oxygen

 f. Rank the following elements from most stable to least stable:

i. Magnesium, rhenium, bromine, radon ii. Palladium, zinc, phosphorus, neon

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**WS 9.6 More electron configuration**

**In this worksheet, we are going to look at trends in electron configuration and the periodic table. For time sake, it would be preferable that you use noble gas configuration, however, if you are still struggling with that, do the full electron configuration.**

1. Complete the noble gas configuration for each of the following elements from the alkali metal family.

a. Sodium

b. Rubidium c. cesium

2. Complete the noble gas configuration for each of the following elements from the alkaline earth metal family.

a. Magnesium b. Calcium

c. Barium

3. Complete the noble gas configuration for each of the following elements from the halogens:

a. Fluorine b. Chlorine c. Bromine

4. Complete the noble gas configuration for each of the following elements from the transition metals:

a. Scandium

b. Yttrium

c. Lanthanum d. Iron

e. Ruthenium

f. osmium

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5. Based on what you observed in number 1, which of the following would you predict to be the correct ending for potassium?

3s1 4s1 4s2

6. Based on what you observed in number 2, what would you expect to be the correct ending for strontium?

 5s2 5p4 5s1

7. Based on what you observed in number 3, what would you expect to be the correct ending for iodine?

4p5 4p4 5p5

8. Based on what you observed in number 3, what would you expect to be the correct ending for actinium and cobalt?

7d1, 4d7 6d1, 3d7 5d1, 1d7

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**WS 9.7 Electron Configuration and the Periodic Table**

**You may use a noble gas notation and electron configuration due to absence of space.**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Element** |  **Electron Configuration** | **# of Valence Electrons** |
| **1.** | **Oxygen** |  |  |
| **2.** | **Argon** |  |  |
| **3.** | **Arsenic** |  |  |
| **4.** | **Calcium** |  |  |
| **5.** | **Sodium** |  |  |
| **6.** | **Aluminum** |  |  |
| **7.** | **Tungsten** |  |  |
| **8.** | **Cobalt** |  |  |
| **9.** | **Iodine** |  |  |
| **10.** | **Silicon** |  |  |

1. What is nuclear charge?

2. What is nuclear shielding?

3. Why do the metallic elements of a given period typically have much lower ionization energy than do the nonmetallic elements of the same period?

4. Explain why the atoms of the elements at the bottom of a given group (vertical column) of the periodic table are larger than the atoms of the elements at the top of the same group.

5. Though all the elements in a given period of the periodic table have their valence electrons in the same types of orbital, the sizes of the atoms decrease from left to right within a period. Explain why.

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6. What is meant by atomic radius? What trend is observed among the atomic radii of main group elements across a period? Explain this trend.

7. What trend is observed among the atomic radii of main group elements down a group? How can this trend be explained?

8. Define ionization energy. How do the first ionization energies of main group elements vary across a period and down a group? Explain the basis for each trend.

9. Distinguish between a cation and an anion. How does the size of each compare with the size of the neutral atom from which it is formed?

10. Using the chart on page 338 in your book, describe the trends for electronegativity.

Identify the most and least electronegative element.

11. In each of the following sets of elements which element shows the least active chemical behavior?

a. Cs, Rb, Na

b. Ba, Ca, Be

c. F, Cl, Br

d. O, Te, S



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**WS 9.8 More Periodic Trends**

1. In each of the following sets of elements, which elements would be expected to have the highest 1st ionization energy?

a. Cs, K, Li

b. Ba, Sr, Ca

c. I, Br, Cl

d. Mg, Si, Cl



2. Arrange the following sets of elements in order of increasing atomic size.

a. Sn, Xe, Rb, Sr b. Rn, He, Xe, Kr c. Pb, Ba, Cs, At

3. Choose the correct term to complete the sentence: Metals have relatively (low/high) 1st ionization energies, whereas nonmetals have relatively (high/low) 1st ionization energies.

4. For each pairs of elements, which is more reactive?

a. Ca or Mg b. Fr or Be c. F or I

5. Consider the four hypothetical main-group elements Q, R, T and X with the outer electron configurations indicated below. Then answer the questions that follow.

Q: 3s23p5

R: 3s1

T: 5s24d105p5

X: 5s24d105p1

a. Identify the block location of each hypothetical main group element.

b. Which of these elements are in the same period? Which are in the same group?

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c. Which element would you expect to have the highest 1st ionization energy? Which would you expect to have the lowest 1st ionization energy?

d. Which of the elements is most likely to form a 1+ ion?

6. Among the elements gallium, bromine and calcium, which has the highest electronegativity? Explain why in terms of periodic trends.

7. Consider the five hypothetical main group elements E, G, J, L and M with the outer electron configurations shown:

E :2s22p5

G : 5s24d105p5

J : 2s22p2

L : 6s25d106p6

M : 2s22p4

a. Identify the block location for each element. Then determine which elements are in the same period and which are in the same group.

b. Which element would you expect to have the highest electron affinity?

Which would you expect to form a 1- ion? Which should have the highest electronegativity?

c. Compare the ionic radius of the typical ion formed by the element G with the radius of its neutral atom.

d. Which element(s) contains seven valence electrons?

8. Of cesium, hafnium and gold, which element has the smallest atomic radius?

Explain your answer in terms of trends in the periodic table.

9. Without looking at the electron affinity table, arrange the following elements in order of decreasing electron affinities: C, O, Li, Na, Rb and F.

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**WS 9.9 Even More Periodic Trends**

1. The two ions K+ and Ca2+ each have 18 electrons surrounding the nucleus. Which would you expect to have the smaller radius? Why?

2. Match each of the described trends below to the appropriate properties listed:

atomic radius, ionization energy, electron affinity, electronegativity, and shielding:

a. Increases from left to right, increases from bottom to top. b. Increases from right to left, increases from top to bottom.

c. Remains constant from left to right, increases from top to bottom.

3. Choose the largest atom: Ge, Sb, Sn, As

4. Choose the larger species in each pair:

a. S or Se

b. C or N

c. O+ or O-

d. S or S2-

5. Some elements form more than one positive ion. In each case the ion with the greater positive charge is smaller. Why is this so?

6. Choose the species with the larger 1st ionization energy.

a. Li or Be b. Be or O

c. C or N

d. B or O

e. Ne or Na

f. Na+ or Mg+

g. S or S+



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7. Without looking at the ionization energy table, arrange the following elements in order of decreasing first ionization energies: Li, O, C, K, Ne and F.

8. Which element is the most electronegative among C, N, O, Br and S? Which group does it belong to?

9. In each of the following groups, what element is most reactive? Explain your answer.

a. Alkali metals b. Halogens

c. Alkaline earth metals

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