Atomic Theory Practice Items

1. The weighted average mass of the atoms of the stable isotopes of an element as they occur in nature is called the

A. atomic mass
B. atomic weight
C. atomic number
D. relative isotopic frequency

2. Photon energy

A. is directly proportional to its wavelength.
B. is inversely proportional to its frequency.
C. is directly proportional to its frequency.
D. equals the wave number.

3. Carbon monoxide has carbon and oxygen in the simple mass ratio 3:4, while carbon dioxide has the ratio 3:8. Similarly, water has oxygen and hydrogen in the simple mass ratio 8:1, while hydrogen peroxide has the ratio of 16:1. These examples illustrate which of the following?

A. conservation of matter and energy
B. the Bohr frequency rule
C. the law of partial pressures
D. the law of multiple proportions

4. A cathode ray

A. consist of a stream of positively charged particles.
B. will not be affected in passing through an orthogonal electric field.
C. is composed of electrons.
D. possesses no mass.

5. Analysis of the emission spectrum of hydrogen led Bohr to conclude that

A. the hydrogen atom consists of an electron and a proton.
B. electron energy states are quantized.
C. light comes in discreet packages of energy called quanta.
D. one cannot determine the exact position of an electron concurrently with its exact momentum.

6. In the Bohr theory of the atom the energy of the n-th level for any atom is given by the following equation

$$E \approx \frac{-13.6Z^2}{n^2} \text{ eV}$$

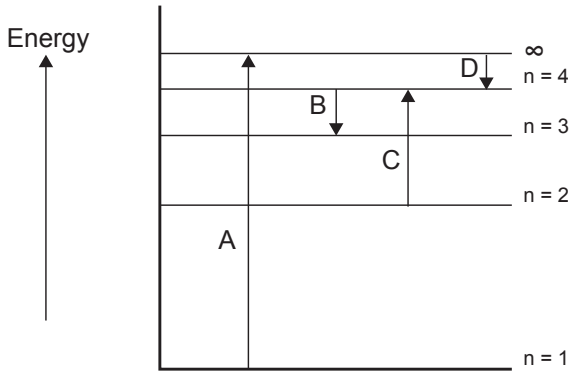
where Z is the atom's atomic number. Which of the following would be predicted by the Bohr model of the hydrogen atom?

A. The ionization energy of hydrogen is equal to 13.6 eV.
B. The electron affinity of hydrogen is equal to 0.75 eV.
C. The lowest possible energy state of a hydrogen atom is zero.
D. A longer wavelength photon is absorbed in elevating an electron from the ground state to the 2nd energy level than from the 2nd to the 3rd.

7. In the Schroedinger model, which of the following describes the shape of the orbital inhabited by an electron?

A. principle quantum number, n
B. magnetic quantum number, m_l
C. angular momentum quantum number, l
D. spin quantum number, m_s

Questions 8 and 9 are based on the following energy level diagram for the hydrogen atom.



8. Of the labeled electronic transitions shown in the figure, photons of the shortest wavelength are being emitted by the atom by the transition labeled:

A. A
B. B
C. C
D. D

9. The arrow representing ionization energy is:

A. A
B. B
C. C
D. D

10. How many p-orbitals are occupied in a ground state Ne atom?

A. 1
B. 2
C. 3
D. 6

11. Which of the following is the proper ground state orbital diagram for neutral carbon?

A. 1*s* (↑↓) 2*s* (↑) 2*p* (↑) (↑) (↑)

B. 1*s* (↑↓) 2*s* (↑↓) 2*p* (↑) (↑) ( )

C. 1*s* (↑↓) 2*s* (↑↓) 2*p* (↓) (↑) ( )

D. 1*s* (↑↓) 2*s* (↑↓) 2*p* (↑↑) ( ) ( )

12. An electron exists in a *p* orbital, therefore

A. the principle quantum number is at least 1.
B. the angular momentum quantum number must be 2.
C. the spin number must be either -1 or 1.
D. the magnetic quantum number could be either -1, 0, or 1.

13. Which of the following electronic configurations is the ground state configuration for ruthenium (Z = 44)?

A. [Kr] $5s^2\ 4d^6$

B. [Kr] $4s^2\ 4d^6$

C. [Kr] $4d^8$

D. [Kr] $5s^1\ 4d^7$

The following passage pertains to questions 14-18.

In 1913 Henry Moseley found an empirical relationship between the strongest X-ray line emitted by metals under electron bombardment (then known as the K-alpha line) and their atomic number Z.

In contrast to the UV and visible light spectrometers employed on similar work with hydrogen by researchers such as Ångström and Lyman, Moseley required an X-ray spectrometer for his work with metals. Inside an evacuated glass-bulb electron tube, electrons were fired at a pure metallic substance, causing the ionization of electrons from the inner electron shells of the element. The rebound of electrons into these holes in the inner shells caused the emission of X-ray photons. These exited the tube in a semi-beam, through an opening in the external X-ray shielding. The X-ray photons were next diffracted by a standardized salt crystal, with angular results recorded by X-ray film oriented a fixed distance from the vacuum tube. Analysis of the diffraction pattern allowed the wavelength of the emitted X-rays to be calculated.

The energy lost by an electron dropping from the second shell to the first is described by Moseley's law for K-alpha lines:

$$E = hf = E_i - E_f = R_E(Z - 1)^2 \left(\frac{1}{1^2} - \frac{1}{2^2} \right)$$

Z is atomic number and R_E is the Rydberg constant, equal to 2.180×10^{-18} J.

It was assumed that this X-ray line came from a transition between energy levels with quantum numbers 1 and 2. Moseley's empiric formula was found to be derivable from earlier formulas put forth by Rydberg and Bohr, but the atomic number Z when used in the formula for atoms heavier than hydrogen was diminished by 1 to (Z–1).

At the time it was thought that the innermost "K" shell of electrons should have at least four electrons, so Moseley published his results without a theoretical explanation for the reduction in atomic number by 1. Later, after the inner shell was demonstrated to contain only 2 electrons, it was realized that the effect was caused by charge screening. In the experiment, one of the innermost electrons in the atom is knocked out, leaving a vacancy in the lowest Bohr orbit, which contains a single remaining electron. Therefore, the n=2 electrons aren't pulled inward by the full nuclear charge of +Z but an effective charge of Z–1.

Moseley's law not only established the objective meaning of atomic number, but, as Bohr noted, it established the validity of the nuclear model of the atom with place on the periodic table determined by whole units of nuclear charge.

14. Which of the following statements is true regarding Moseley's model of X-ray production by metal atoms under electron bombardment?

- **A.** The model could account for the emission spectrum of hydrogen.
- **B.** The model was based on the wave properties of the electron.
- **C.** The model was successful in explaining the systematic variation of X-ray emission spectra with atomic number.
- **D.** The model provided the first coherent description of the photoelectric effect.

15. Following the ejection by X-rays of electrons from the inner shells of metal atoms, the rebound of electrons into these holes

- **A.** causes ionization of the metal atom.
- **B.** corresponds to a decrease in the energy of the metal atom.
- **C.** occurs across a distance equal to the wavelength of the emitted X-ray.
- **D.** occurs with absorption of an X-ray.

16. Which of the following can be deduced from the information presented in the passage?

A. X-rays are required to ionize larger metal atoms.

B. An electron transition from the K shell to the L shell may cause a metal atom to release an X-ray photon.

C. An X-ray photon is produced by ionization when a high energy electron collides with a ground state metal electron.

D. The transition energy for an electron from quantum number 2 to 1 is greater with large atoms than with hydrogen.

17. Why is the appropriate charge for the nucleus acting on a rebounding electron from the n=2 shell equal to (Z – 1) in the Moseley formula?

A. An electron in the lowest Bohr orbit screens the nuclear charge.

B. The ejected electron leaves a vacancy in the lowest Bohr orbit.

C. It was thought that the innermost shell should have at least four electrons.

D. The emission of a positron decreases the nuclear charge.

18. Which of the following data might have been collected during the empirical derivation of Moseley's Law?

A. a graph showing a geometric increase in emission wavelength with atomic number

B. a graph showing logarithmic increase of emission frequency with atomic number

C. a graph showing an exponential increase in emission frequency with atomic number.

D. a linear plot of the square root of X-ray frequency against atomic number