

chapter 30 THE NATURE OF THE ATOM

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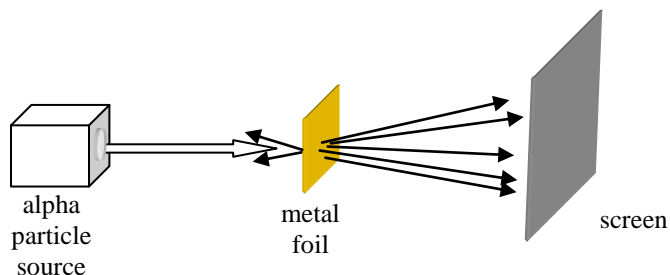
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Section 30.1 Rutherford

Scattering and the Nuclear Atom

1. Which model of atomic structure was developed to explain the results of the experiment shown?
- (a) Bohr model
 - (b) quantum mechanical atom
 - (c) billiard ball atom
 - (d) plum-pudding model
 - (e) nuclear atom



3. In the planetary model of the atom where electrons orbit a centralized nucleus, what is the approximate ratio of the radius of the nucleus to that of the electron orbits, r_n/r_e ?
- (a) 10^5
 - (b) 10^{-3}
 - (c) 10^3
 - (d) 10^{-5}
 - (e) 10^{-7}

Section 30.2 Line Spectra

Section 30.3 The Bohr Model of the Hydrogen Atom

Section 30.4 De Broglie's Explanation of Bohr's Assumption about Angular Momentum

5. Each atom in the periodic table has a unique set of spectral lines. Which one of the following statements is the best explanation for this observation?
- (a) Each atom has a dense central nucleus.
 - (b) Electrons in atoms orbit the nucleus.
 - (c) Each atom has a unique set of energy levels that electrons can move between.
 - (d) Electrons in atoms are in constant motion.
 - (e) Each atom is composed of positive and negative charges.
6. Each atom in the periodic table has a unique set of spectral lines. The model of atomic structure that provides the best explanation for this observation was proposed by
- (a) Balmer.
 - (b) Bohr.
 - (c) Einstein.
 - (d) Rutherford.
 - (e) Thomson.
7. Which one of the following pairs of characteristics of light is best explained by assuming that light can be described in terms of photons?
- (a) photoelectric effect and the effect observed in Young's experiment
 - (b) diffraction and the formation of atomic spectra
 - (c) polarization and the photoelectric effect
 - (d) existence of line spectra and the photoelectric effect
 - (e) polarization and the formation of line spectra

- 8. Which one of the following statements is the assumption that Niels Bohr made about the angular momentum of the electron in the hydrogen atom?
- (a) The angular momentum of the electron is zero.
 - (b) The angular momentum can assume only certain discrete values.
 - (c) Angular momentum is not quantized.
 - (d) The angular momentum can assume any value greater than zero because it's proportional to the radius of the orbit.
 - (e) The angular momentum is independent of the mass of the electron.
- 10. Complete the following statement: For the ground state of the hydrogen atom, the Bohr model correctly predicts
- (a) only the energy.
 - (b) only the angular momentum.
 - (c) only the angular momentum and the spin.
 - (d) the angular momentum and the energy.
 - (e) the energy, the angular momentum, and the spin.
- 11. Complete the following statement: An individual copper atom emits electromagnetic radiation with wavelengths that are
- (a) evenly spaced across the spectrum.
 - (b) unique to that particular copper atom.
 - (c) the same as other elements in the same column of the periodic table.
 - (d) unique to all copper atoms.
 - (e) the same as those of all elements.
- 12. Electrons have been removed from a beryllium atom ($Z = 4$) until only one remains. Determine the energy of the photon that can be emitted if the remaining electron is in the $n = 2$ level.
- (a) 13.6 eV
 - (b) 54.4 eV
 - (c) 122 eV
 - (d) 164 eV
 - (e) 218 eV
- 13. Which one of the following will result in an electron transition from the $n = 4$ level to the $n = 7$ level in a hydrogen atom?
- (a) emission of a 0.28 eV photon
 - (b) emission of a 0.57 eV photon
 - (c) absorption of a 0.85 eV photon
 - (d) absorption of a 0.28 eV photon
 - (e) absorption of a 0.57 eV photon
- 15. The second ionization energy (the energy required to remove the second outermost electron) of calcium is 11.9 eV. Determine the maximum wavelength of incident radiation that can be used to remove the second electron from a calcium atom?
- (a) 16.6 nm
 - (b) 52 nm
 - (c) 104 nm
 - (d) 208 nm
 - (e) 416 nm
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- 18. Determine the energy of the photon emitted when the electron in a hydrogen atom undergoes a transition from the $n = 8$ level to the $n = 6$ level.
- (a) 0.17 eV
 - (b) 0.21 eV
 - (c) 0.36 eV
 - (d) 0.57 eV
 - (e) 13.4 eV

- 19. The kinetic energy of the ground state electron in hydrogen is +13.6 eV. What is its potential energy?
(a) -13.6 eV (c) -27.2 eV (e) zero eV
(b) +27.2 eV (d) +56.2 eV
- 20. An electron is in the ground state of a hydrogen atom. A photon is absorbed by the atom and the electron is excited to the $n = 2$ state. What is the energy in eV of the photon?
(a) 13.6 eV (c) 3.40 eV (e) 0.54 eV
(b) 10.2 eV (d) 1.51 eV
- 21. According to the Bohr model, what is the radius of a hydrogen atom when its electron is excited to the $n = 9$ state?
(a) 5.87×10^{-12} m (c) 4.76×10^{-10} m (e) 1.51×10^{-8} m
(b) 5.29×10^{-11} m (d) 4.28×10^{-9} m
- 25. What energy (in eV) is required to remove the remaining electron from a singly ionized helium atom, He^+ ($Z = 2$)?
(a) 3.40 eV (c) 27.2 eV (e) 76.9 eV
(b) 13.6 eV (d) 54.4 eV

Section 30.5 The Quantum Mechanical Picture of the Hydrogen Atom

- 26. According to the quantum mechanical picture of the atom, which one of the following is a true statement concerning the ground state electron in a hydrogen atom?
(a) The ground state electron has zero kinetic energy.
(b) The ground state electron has zero binding energy.
(c) The ground state electron has zero ionization energy.
(d) The ground state electron has zero spin angular momentum.
(e) The ground state electron has zero orbital angular momentum.
- 27. A hydrogen atom is in a state for which the principle quantum number is $n = 3$. How many possible such states are there for which the magnetic quantum number is $m_\ell = 0$?
(a) 2 (c) 6 (e) 10
(b) 4 (d) 8
- 28. According to the quantum mechanical picture of the atom, which one of the following statements is true concerning the magnitude of the angular momentum L of an electron in the $n = 3$ level of the hydrogen atom?
(a) L is $0.318h$. (d) L could be $0.225h$ or $0.276h$.
(b) L is $0.477h$. (e) L could be $0.225h$ or $0.390h$.
(c) L could be $0.159h$ or $0.318h$.
- 29. An electron in a hydrogen atom is described by the quantum numbers: $n = 8$ and $m_\ell = 4$. What are the possible values for the orbital quantum number ℓ ?
(a) only 0 or 4 (d) only 4, 5, 6, or 7
(b) only 4 or 7 (e) only 5, 6, 7, or 8
(c) only 5 or 8
- 34. Determine the maximum number of electron states with principal quantum number $n = 3$?
(a) 2 (c) 6 (e) 18

- (b) 3 (d) 9
- 35. Which one of the following values of m_ℓ is not possible for $\ell = 2$?
 (a) zero (c) +1 (e) +3
 (b) -1 (d) +2
- 36. Two possible states for the hydrogen atom are labeled A and B. The maximum magnetic quantum number for state A is +3. For state B, the maximum value is +1. What is the ratio of the magnitudes of the orbital angular momenta, L_A/L_B , of an electron in these two states?
 (a) 1.22 (c) 2.00 (e) 3.46
 (b) 1.73 (d) 2.45
- Section 30.6 The Pauli Exclusion Principle and the Periodic Table of the Elements**
- 37. To which model of atomic structure does the *Pauli exclusion principle* apply?
 (a) the nuclear atom (d) the plum-pudding model
 (b) the quantum mechanical atom (e) the planetary model
 (c) the billiard ball atom
- 38. Which one of the following factors best explains why the six electrons of a carbon atom are not all in the $1s$ state?
 (a) electron spin (d) Heisenberg uncertainty principle
 (b) Coulomb's law (e) Rutherford model of atomic structure
 (c) Pauli exclusion principle
- 39. Which one of the following statements concerning the electrons specified by the notation $3p^4$ is true?
 (a) The electrons are in the M shell.
 (b) The electrons are in the $\ell = 2$ subshell.
 (c) The electrons are necessarily in an excited state.
 (d) They have principal quantum number 4.
 (e) There are 3 electrons in the specified subshell.
- 40. How many electrons could be accommodated in a g subshell?
 (a) 4 (c) 8 (e) 18
 (b) 5 (d) 9
- 41. Which one of the following subshells is not compatible with a principle quantum number of $n = 4$?
 (a) s (c) d (e) g
 (b) p (d) f
- 42. Which one of the following electronic configurations corresponds to an atomic ground state?
 (a) $1s^2 2s^1 2p^6$ (c) $1s^1 2s^2 3p^1$ (e) $1s^1 2s^2 2p^1$
 (b) $1s^1 2s^1 2p^1$ (d) $1s^2 2s^2 2p^1$
- 43. An h subshell refers to orbital quantum number
 (a) $\ell = 1$ (c) $\ell = 3$ (e) $\ell = 5$
 (b) $\ell = 2$ (d) $\ell = 4$
- 44. What is the total number of subshells in the $n = 3$ level?

- (a) 3 (c) 7 (e) 18
 (b) 6 (d) 9

Questions 47 through 49 pertain to the statement below:

A neutral atom has the following electronic configuration: $1s^2 2s^2 2p^6 3s^2 3p^5$

- 47. How many electrons are in the M shell?
 (a) 2 (c) 6 (e) 8
 (b) 5 (d) 7
- 48. How many protons are in the atomic nucleus?
 (a) 4 (c) 12 (e) 34
 (b) 7 (d) 17
- 49. To which group of the periodic table does this element belong?
 (a) I (c) III (e) VII
 (b) II (d) VI

Questions 50 through 52 pertain to the statement below:

An electron in an atom has the following set of quantum numbers:

$$n = 3, \ell = 2, m_\ell = +1, m_s = +1/2.$$

- 50. What shell is this electron occupying?
 (a) K shell (c) M shell (e) O shell
 (b) L shell (d) N shell
- 51. In which subshell can the electron be found?
 (a) s (c) d (e) g
 (b) p (d) f
- 52. According to the quantum mechanical picture of the atom, which quantum number(s) *could* be different for electrons in this same atom that have exactly the same energy?
 (a) n, ℓ, m_ℓ and m_s (c) only ℓ and m_ℓ (e) m_s
 (b) only ℓ, m_ℓ and m_s (d) only m_ℓ and m_s

Questions 53 through 57 pertain to the statement below

Consider the following list of electron configurations:

- (1) $1s^2 2s^2 3s^2$ (4) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$
 (2) $1s^2 2s^2 2p^6$ (5) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^6$
 (3) $1s^2 2s^2 2p^6 3s^1$

- 53. Which one of the above lists represents the electronic configuration for the ground state of the atom with $Z = 11$?
 (a) 1 (c) 3 (e) 5
 (b) 2 (d) 4

- 54. Which electronic configuration is characteristic of noble gases?
 (a) 1 (c) 3 (e) 5
 (b) 2 (d) 4
- 55. Which one of the above configurations represents a neutral atom that readily forms a singly charged positive ion?
 (a) 1 (c) 3 (e) 5
 (b) 2 (d) 4
- 56. Which one of the above configurations represents an excited state of a neutral atom?
 (a) 1 (c) 3 (e) 5
 (b) 2 (d) 4
- 57. Which one of the above configurations represents a transition element?
 (a) 1 (c) 3 (e) 5
 (b) 2 (d) 4

Section 30.7 X-rays

- 58. In an X-ray tube, electrons with energy 35 keV are incident on a cobalt ($Z = 27$) target. Determine the cutoff wavelength for X-ray production.
 (a) 1.4×10^{-11} m (c) 2.8×10^{-11} m (e) 3.6×10^{-11} m
 (b) 1.8×10^{-11} m (d) 3.2×10^{-11} m
- 59. Which electron energy will produce the lowest cutoff wavelength for X-ray production from a nickel ($Z = 28$) surface?
 (a) 25 keV (c) 35 keV (e) 45 keV
 (b) 30 keV (d) 40 keV
- 60. Which one of the following statements concerning the cutoff wavelength typically exhibited in X-ray spectra is true?
 (a) The cutoff wavelength depends on the target material.
 (b) The cutoff wavelength depends on the potential difference across the X-ray tube.
 (c) The cutoff wavelength is independent of the energy of the incident electrons.
 (d) The cutoff wavelength occurs because of the mutual shielding effects of K-shell electrons.
 (e) The cutoff wavelength occurs because an incident electron cannot give up all of its energy.
- 61. Calculate the K_{α} X-ray wavelength for a gold atom ($Z = 79$).
 (a) 5.13×10^{-10} m (c) 2.00×10^{-11} m (e) 2.47×10^{-13} m
 (b) 8.54×10^{-10} m (d) 3.60×10^{-11} m
- 62. Electrons in an X-ray tube are accelerated through a potential difference of 40 kV. The electrons then strike a zirconium ($Z = 40$) target. Determine the cutoff frequency for X-ray production.
 (a) 4.7×10^{19} Hz (c) 3.2×10^{18} Hz (e) 1.1×10^{16} Hz
 (b) 9.7×10^{18} Hz (d) 6.7×10^{17} Hz
- 63. What is the operating voltage of a medical X-ray machine that has a cut-off wavelength of 2.20×10^{-11} m?
 (a) 83 800 V (c) 30 700 V (e) 56 500 V
 (b) 10 900 V (d) 44 900 V

