Chapter 2 - Atomic Structure and Periodicity

1. When ignited, a uranium compound burns with a green flame. The wavelength of the light given off by this flame is greater than that of _____.
   a. red light
   b. infrared light
   c. radio waves
   d. ultraviolet light
   e. none of these

ANSWER: d
POINTS: 1

2. Which form of electromagnetic radiation has the longest wavelengths?
   a. Gamma rays
   b. Microwaves
   c. Radio waves
   d. Infrared radiation
   e. X-rays

ANSWER: c
POINTS: 1

3. Which of the following frequencies corresponds to light with the longest wavelength?
   a. $3.00 \times 10^{13}\ s^{-1}$
   b. $4.12 \times 10^{5}\ s^{-1}$
   c. $8.50 \times 10^{20}\ s^{-1}$
   d. $9.12 \times 10^{12}\ s^{-1}$
   e. $3.20 \times 10^{9}\ s^{-1}$

ANSWER: b
POINTS: 1

4. Which of the following are incorrectly paired?
   a. Wavelength – λ
   b. Frequency – ν
   c. Speed of light – c
   d. Hertz – s^{-1}
   e. X-rays – shortest wavelength

ANSWER: e
POINTS: 1

5. When a strontium salt is ignited, it burns with a red flame. The frequency of the light given off by this flame is greater than _____.
   a. yellow light
   b. infrared light

c. ultraviolet light
d. radio waves
e. x-rays

ANSWER: b
POINTS: 1

6. A line in the spectrum of atomic mercury has a wavelength of 258 nm. When mercury emits a photon of light at this wavelength, the frequency of this light is:

a. $8.61 \times 10^{-16}\ s^{-1}$

b. $7.70 \times 10^{-19}\ s^{-1}$

c. $1.16 \times 10^{15}\ s^{-1}$

d. $77.3\ s^{-1}$

e. none of these

ANSWER: c
POINTS: 1

7. What is the wavelength of a photon of red light (in nm) whose frequency is 4.58×10^{14} Hz?

a. 655 nm
b. 1.53×10^{6} nm
c. 153 nm
d. 458 nm
e. None of these

ANSWER: a
POINTS: 1

8. Yellow light can have a wavelength of 576 nm. The energy of a photon of this light is:

a. 1.14×10^{-31} J.
b. 5.76×10^{-7} J.
c. 3.45×10^{-19} J.
d. 5.20×10^{14} J.
e. 2.90×10^{18} J.

ANSWER: c
POINTS: 1

9. Which one of the following types of radiation has the shortest wavelength, the greatest energy, and the highest frequency?

a. Ultraviolet radiation

b. Infrared radiation
c. Visible red light
d. Visible blue light
e. None, because short wavelength is associated with low energy and low frequency, not high energy and high frequency

ANSWER: a
POINTS: 1

10. What is the energy of a photon of blue light that has a wavelength of 479 nm?
a. 4.79×10^{-7} J
b. 4.15×10^{-19} J
c. 6.26×10^{14} J
d. 9.52×10^{-32} J
e. 2.41×10^{18} J

ANSWER: b
POINTS: 1

11. How many of the following is/are *incorrect*?
i. The importance of the equation $E = mc^2$ is that energy has mass.
ii. Electromagnetic radiation can be thought of as a stream of particles called photons.
iii. Electromagnetic radiation exhibits wave properties.
iv. Energy can only occur in discrete units called quanta.
a. 0
b. 1
c. 2
d. 3
e. 4

ANSWER: a
POINTS: 1

12. From the following list of observations, choose the one that most clearly supports the following conclusion:electrons have wave properties.
a) emission spectrum of hydrogen
b) the photoelectric effect
c) scattering of alpha particles by metal foil
d) diffraction
e) cathode "rays"

Reference: Ref 2-1

a. observation a
b. observation b

c. observation c
d. observation d
e. observation e

ANSWER: d
POINTS: 1

13. From the following list of observations, choose the one that most clearly supports the following conclusion: electromagnetic radiation has wave characteristics.

a) emission spectrum of hydrogen
b) the photoelectric effect
c) scattering of alpha particles by metal foil
d) diffraction
e) cathode "rays"

Reference: Ref 2-1

a. observation a
b. observation b
c. observation c
d. observation d
e. observation e

ANSWER: d
POINTS: 1

14. From the following list of observations, choose the one that most clearly supports the following conclusion: electrons in atoms have quantized energies.

a) emission spectrum of hydrogen
b) the photoelectric effect
c) scattering of alpha particles by metal foil
d) diffraction
e) cathode "rays"

Reference: Ref 2-1

a. observation a
b. observation b
c. observation c
d. observation d
e. observation e

ANSWER: a
POINTS: 1

15. From the following list of observations, choose the one that most clearly supports the following conclusion: spacing between atoms in a crystal is on the same order as the de Broglie wavelength of accelerated electrons.

a) emission spectrum of hydrogen
b) the photoelectric effect
c) scattering of alpha particles by metal foil
d) diffraction
e) cathode "rays"

Reference: Ref 2-1

a. observation a
b. observation b
c. observation c
d. observation d
e. observation e

ANSWER: d
POINTS: 1

16. Consider an atom traveling at 1% of the speed of light. The de Broglie wavelength is found to be 1.39×10^{-3} pm. Which element is this?

a. H
b. Mo
c. C
d. Ti
e. P

ANSWER: b
POINTS: 1

17. The four lines observed in the visible emission spectrum of hydrogen tell us that:

a. The hydrogen molecules they came from have the formula H_4.
b. We could observe more lines if we had a stronger prism.
c. There are four electrons in an excited hydrogen atom.
d. Only certain energies are allowed for the electron in a hydrogen atom.
e. The spectrum is continuous.

ANSWER: d
POINTS: 1

18. When a hydrogen electron makes a transition from $n = 3$ to $n = 1$, which of the following statements is *true*?

I. Energy is emitted.
II. Energy is absorbed.
III. The electron loses energy.
IV. The electron gains energy.

V. The electron cannot make this transition.

a. I, IV
b. I, III
c. II, III
d. II, IV
e. V

ANSWER: b
POINTS: 1

19. In Bohr's atomic theory, when an electron moves from one energy level to another energy level more distant from the nucleus:

a. Energy is emitted.
b. Energy is absorbed.
c. No change in energy occurs.
d. Light is emitted.
e. None of these.

ANSWER: b
POINTS: 1

20. Which of the following is *incorrect*?

a. The emission spectrum of hydrogen contains a continuum of colors.
b. Diffraction produces both constructive and destructive interference.
c. All matter displays both particle and wavelike characteristics.
d. Niels Bohr developed a quantum model for the hydrogen atom.
e. The lowest possible energy state of a molecule or atom is called its ground state.

ANSWER: a
POINTS: 1

21. Consider the following portion of the energy-level diagram for hydrogen:

$n = 4$ $\quad -0.1361 \times 10^{-18}$ J
$n = 3$ $\quad -0.2420 \times 10^{-18}$ J
$n = 2$ $\quad -0.5445 \times 10^{-18}$ J
$n = 1$ $\quad -2.178 \times 10^{-18}$ J

For which of the following transitions does the light emitted have the longest wavelength?

Reference: Ref 2-2

a. $n = 4$ to $n = 3$
b. $n = 4$ to $n = 2$

c. $n = 4$ to $n = 1$
d. $n = 3$ to $n = 2$
e. $n = 2$ to $n = 1$

ANSWER: a
POINTS: 1

22. Consider the following portion of the energy-level diagram for hydrogen:

$n = 4$	-0.1361×10^{-18} J
$n = 3$	-0.2420×10^{-18} J
$n = 2$	-0.5445×10^{-18} J
$n = 1$	-2.178×10^{-18} J

In the hydrogen spectrum, what is the wavelength of light associated with the n = X to n = 1 electron transition?

Reference: Ref 2-2

a. 1.99×10^{-25} nm
b. 3.65×10^{2} nm
c. 8.22×10^{6} cm
d. 1.63×10^{-18} m
e. 1.22×10^{-7} m

ANSWER: e
POINTS: 1

23. What is the wavelength of light that is emitted when an excited electron in the hydrogen atom falls from $n = 5$ to $n = 4$?

a. 2.47×10^{5} m
b. 4.05×10^{-6} m
c. 4.90×10^{-20} m
d. 1.46×10^{-6} m
e. none of these

ANSWER: b
POINTS: 1

24. The energy of the light emitted when a hydrogen electron goes from $n = 2$ to $n = 1$ is what fraction of its ground-state ionization energy?

a. 3/4
b. 1/2
c. 1/4
d. 1/8

e. 1/9

ANSWER: a
POINTS: 1

25. The wavelength of light associated with the $n = 2$ to $n = 1$ electron transition in the hydrogen spectrum is 1.216×10^{-7} m. By what coefficient should this wavelength be multiplied to obtain the wavelength associated with the same electron transition in the Li^{2+} ion?

a. 1/9
b. 1/7
c. 1/4
d. 1/3
e. 1

ANSWER: a
POINTS: 1

26. In an investigation of the electronic absorption spectrum of a particular element, it is found that a photon having $\lambda = 500$ nm provides just enough energy to promote an electron from the second quantum level to the third. From this information, we can deduce _____.

a. the energy of the $n = 2$ level
b. the energy of the $n = 3$ level
c. the sum of the energies of $n = 2$ and $n = 3$
d. the difference in energies between $n = 2$ and $n = 3$
e. all of these

ANSWER: d
POINTS: 1

27. Which of the following is a reasonable criticism of the Bohr model of the atom?

a. It makes no attempt to explain why the negative electron does not eventually fall into the positive nucleus.
b. It does not adequately predict the line spectrum of hydrogen.
c. It does not adequately predict the ionization energy of the valence electron(s) for elements other than hydrogen.
d. It does not adequately predict the ionization energy of the first energy level electrons for one-electron species for elements other than hydrogen.
e. It shows the electrons to exist outside of the nucleus.

ANSWER: c
POINTS: 1

28. Which of the following statements is (are) true?

I. An excited atom can return to its ground state by absorbing electromagnetic radiation.
II. The energy of an atom is increased when electromagnetic radiation is emitted from it.
III. The energy of electromagnetic radiation increases as its frequency increases.

IV. An electron in the n = 4 state in the hydrogen atom can go to the n = 2 state by emitting electromagnetic radiation at the appropriate frequency.

V. The frequency and wavelength of electromagnetic radiation are inversely proportional to each other.

a. II, III, IV
b. III, V
c. I, II, III
d. III, IV, V
e. I, II, IV

ANSWER: d
POINTS: 1

29. Which of the following best describes an orbital?
a. Space where electrons are unlikely to be found in an atom
b. Space which may contain electrons, protons, and/or neutrons
c. The space in an atom where an electron is most likely to be found
d. Small, walled spheres that contain electrons
e. A single space within an atom that contains all electrons of that atom

ANSWER: c
POINTS: 1

30. Which of the following statements best describes the Heisenberg uncertainty principle?
a. The exact position of an electron is always uncertain.
b. The velocity of a particle can only be estimated.
c. It is impossible to accurately know both the exact location and momentum of a particle.
d. The location and momentum of a macroscopic object are not known with certainty.
e. The location and momentum of a particle can be determined accurately, but not the identity of the particle.

ANSWER: c
POINTS: 1

31. Which of the following is *not* determined by the principal quantum number, *n*, of the electron in a hydrogen atom?
a. The energy of the electron
b. The minimum wavelength of the light needed to remove the electron from the atom
c. The size of the corresponding atomic orbital(s)
d. The shape of the corresponding atomic orbital(s)
e. All of the above are determined by *n*

ANSWER: c
POINTS: 1

32. How many *p* orbitals have the value *n* = 1?

a. 0
b. 3
c. 5
d. 7
e. 1

ANSWER: a
POINTS: 1

33. How many *d* orbitals have $n = 4$?
a. 2
b. 5
c. 10
d. 7
e. 18

ANSWER: b
POINTS: 1

34. If $n = 2$, how many orbitals are possible?
a. 3
b. 4
c. 2
d. 8
e. 6

ANSWER: b
POINTS: 1

35. A given set of *p* orbitals consists of _____ orbitals.
a. 1
b. 2
c. 3
d. 4
e. 5

ANSWER: c
POINTS: 1

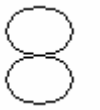
36. Which of the following is an incorrect designation for an atomic orbital?
a. 1*s*
b. 3*d*
c. 1*p*
d. 4*f*
e. 6*s*

ANSWER: c
POINTS: 1

37. The number of orbitals having a given value of l is equal to _____.
    a. $2l + 1$
    b. $2n + 2$
    c. $3l$
    d. $l + m_l$
    e. the number of lobes in each orbital

ANSWER: a
POINTS: 1

38. Consider the following representation of a 2*p*-orbital:



Which of the following statements best describes the movement of electrons in a *p*-orbital?
    a. The electrons move along the outer surface of the *p*-orbital, similar to a “figure 8” type of movement.
    b. The electrons move within the two lobes of the *p*-orbital, but never beyond the outside surface of the orbital.
    c. The electrons are concentrated at the center (node) of the two lobes.
    d. The electrons are only moving in one lobe at any given time.
    e. The electron movement cannot be exactly determined.

ANSWER: e
POINTS: 1

39. A point in the wave function where the amplitude is zero defines:
    a. the node.
    b. the excited state.
    c. the amplitude of the wave function.
    d. the frequency of radiation.
    e. none of the above.

ANSWER: a
POINTS: 1

40. How many electrons in an atom can have the quantum numbers $n = 3$, $l = 2$?
    a. 2
    b. 5
    c. 10
    d. 18
    e. 6

ANSWER: c

POINTS: 1

41. How many electrons can be described by the quantum numbers $n = 2$, $l = 2$, $m_l = -1$?
    a. 0
    b. 2
    c. 6
    d. 10
    e. 14

ANSWER: a
POINTS: 1

42. What is the l quantum number for a 4p orbital?
    a. 2
    b. 1
    c. 0
    d. 3
    e. More than one of the above

ANSWER: b
POINTS: 1

43. Which of the following could not be a valid m_l quantum number for a 4d orbital?
    a. 2
    b. 0
    c. –1
    d. 1
    e. 4

ANSWER: e
POINTS: 1

44. How many electrons in an atom can have the quantum numbers $n = 4$, $l = 2$?
    a. 14
    b. 12
    c. 5
    d. 10
    e. 6

ANSWER: d
POINTS: 1

45. Which of the following combinations of quantum numbers (n, l, m_l, m_s) do *not* represent permissible solutions of the Schrödinger equation for the electron in the hydrogen atom (i.e., which combination of quantum numbers is *not* allowed)?
    a. 9, 8, -4, 1/2

b. 8, 2, 2, 1/2
c. 6, -5, -1, 1/2
d. 6, 5, -5, 1/2
e. All are allowed.

ANSWER: c
POINTS: 1

46. If $l = 3$, how many electrons can be contained in all the possible orbitals?
a. 7
b. 6
c. 14
d. 10
e. 5

ANSWER: c
POINTS: 1

47. Which of the following combinations of quantum numbers is not allowed?
a. $n = 1, l = 1, m_l = 0, m_s = \frac{1}{2}$
b. $n = 3, l = 0, m_l = 0, m_s = -\frac{1}{2}$
c. $n = 2, l = 1, m_l = -1, m_s = \frac{1}{2}$
d. $n = 4, l = 3, m_l = -2, m_s = -\frac{1}{2}$
e. $n = 4, l = 2, m_l = 0, m_s = \frac{1}{2}$

ANSWER: a
POINTS: 1

48. How many electrons can be contained in all of the orbitals with $n = 4$?
a. 2
b. 8
c. 10
d. 18
e. 32

ANSWER: e
POINTS: 1

49. The small, but important, energy differences between 3*s*, 3*p*, and 3*d* orbitals are due mainly to _____.
a. the number of electrons they can hold
b. their principal quantum number
c. the Heisenberg uncertainty principle
d. the penetration effect
e. Hund's rule

ANSWER: d

POINTS: 1

50. Who was the first chemist to recognize patterns in chemical properties of the elements?
   a. Mendeleev
   b. Newlands
   c. Meyer
   d. Dobereiner
   e. Bohr

ANSWER: d
POINTS: 1

51. Mendeleev is given the most credit for the concept of a periodic table of the elements because:
   a. he had the longest history of research in elemental properties.
   b. he emphasized its usefulness in predicting the existence and properties of unknown elements.
   c. his representation of the table was the most understandable.
   d. his periodic table was arranged in octaves.
   e. he grouped elements into triads of similar properties.

ANSWER: b
POINTS: 1

52. Which of the following was not an elemental property usually predicted by Mendeleev for as-yet-unknown elements?
   a. Electron configuration
   b. Atomic mass
   c. Density
   d. Melting point
   e. Chemical behavior

ANSWER: a
POINTS: 1

53. The electron configuration for the barium atom is _____.
   a. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10}$
   b. $[Xe]6s^2$
   c. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$
   d. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$
   e. none of these

ANSWER: b
POINTS: 1

54. The electron configuration for the carbon atom is _____.
    a. $1s^2 2s^2 2p^2$
    b. $[He]2s^4$
    c. $[Ne]2s^2 2p^2$
    d. $1s^2 2p^4$
    e. none of these

ANSWER: a
POINTS: 1

55. The complete electron configuration of iodine is _____.
    a. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5d^{10} 5p^5$
    b. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4d^{10} 4p^5$
    c. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 4p^6 5s^2 4d^{10} 5d^{10} 5p^5$
    d. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^5$
    e. none of these

ANSWER: d
POINTS: 1

56. An atom of fluorine contains nine electrons. How many of these electrons are in *s* orbitals?
    a. 2
    b. 4
    c. 6
    d. 8
    e. none

ANSWER: b
POINTS: 1

57. Which of the following atoms or ions has three unpaired electrons?
    a. N
    b. O
    c. Al
    d. S^{2-}
    e. Ti^{2+}

ANSWER: a
POINTS: 1

58. Which of the following statements about quantum theory is *incorrect*?
    a. The energy and position of an electron cannot be determined simultaneously.

b. Lower energy orbitals are filled with electrons before higher energy orbitals.
c. When filling orbitals of equal energy, two electrons will occupy the same orbital before filling a new orbital.
d. No two electrons can have the same four quantum numbers.
e. All of these are correct.

ANSWER: c
POINTS: 1

59. The statement that "the lowest energy configuration for an atom is the one having the maximum number of unpaired electrons allowed by the Pauli principle in a particular set of degenerate orbitals" is known as _____.
a. the aufbau principle
b. Hund's rule
c. Heisenberg uncertainty principle
d. the Pauli exclusion principle
e. the quantum model

ANSWER: b
POINTS: 1

60. An element has the electron configuration [Kr] $5s^2 4d^{10} 5p^2$. The element is a(n) _____.
a. nonmetal
b. transition element
c. metal
d. lanthanide
e. actinide

ANSWER: c
POINTS: 1

61. An element with the electron configuration [Xe] $6s^2 4f^{14} 5d^7$ would belong to which class on the periodic table?
a. Transition elements
b. Alkaline earth elements
c. Halogens
d. Rare earth elements
e. None of the above

ANSWER: a
POINTS: 1

62. All halogens have the following number of valence electrons:
a. 2.
b. 3.
c. 5.
d. 7.

e. none of these.

ANSWER: d
POINTS: 1

63. Of the following elements, which has occupied *d* orbitals in its ground-state neutral atoms?

a. Ba
b. Ca
c. Si
d. P
e. Cl

ANSWER: a
POINTS: 1

64. Of the following elements, which needs three electrons to complete its valence shell?

a. Ba
b. Ca
c. Si
d. P
e. Cl

ANSWER: d
POINTS: 1

65. Which of the following atoms has three electrons in *p* orbitals in its valence shell?

a. Ba
b. Ga
c. V
d. Bi
e. None of these

ANSWER: d
POINTS: 1

66. How many of the following electron configurations for the species in their ground state are correct?

I. Ca: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$
II. Mg: $1s^2 2s^2 2p^6 3s^1$
III. V: $[Ar] 3s^2 3d^3$
IV. As: $[Ar] 4s^2 3d^{10} 4p^3$
V. P: $1s^2 2s^2 2p^6 3p^5$

a. 1
b. 2
c. 3

d. 4
e. 5

ANSWER: b
POINTS: 1

67. Which of the following is the highest energy orbital for a silicon atom?
a. 1*s*
b. 2*s*
c. 3*s*
d. 3*p*
e. 3*d*

ANSWER: d
POINTS: 1

68. An element *E* has the electron configuration [Kr] $5s^2 4d^{10} 5p^2$. The formula for the fluoride of *E* is most likely _____.
a. EF_{14}
b. EF_4
c. EF
d. EF_6
e. EF_8

ANSWER: b
POINTS: 1

69. Which of the following have 10 electrons in the *d* orbitals?
a. Mn
b. Fe
c. Cu
d. Zn
e. two of the above

ANSWER: e
POINTS: 1

70. Which of the following electron configurations is different from that expected?
a. Ca
b. Sc
c. Ti
d. V

e. Cr

ANSWER: e
POINTS: 1

71. Ti has _____ in its d orbitals.
a. one electron
b. two electrons
c. three electrons
d. four electrons
e. none of these

ANSWER: b
POINTS: 1

72. Germanium has _____ in its 4p orbitals.
a. one electron
b. two electrons
c. three electrons
d. four electrons
e. none of these

ANSWER: b
POINTS: 1

73. In which group do all the elements have the same number of valence electrons?
a. P, S, Cl
b. Ag, Cd, Ar
c. Na, Ca, Ba
d. P, As, Se
e. none of these

ANSWER: e
POINTS: 1

74. Which of the following electron configurations is correct?
a. Ga: $[Kr]4s^2 3d^{10} 4p^1$
b. Mo: $[Kr]5s^2 4d^5$
c. Ca: $[Ar]4s^1 3d^{10}$
d. Br: $[Kr]4s^2 3d^{10} 4p^7$
e. Bi: $[Xe]6s^2 4f^{14} 5d^{10} 6p^3$

ANSWER: e
POINTS: 1

75. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^3$ is the correct electron configuration for which of the following atoms?

a. Ga
b. V
c. As
d. Nb
e. none of these

ANSWER: b
POINTS: 1

76. The number of unpaired electrons in the outer subshell of a Cl atom is:
a. 0.
b. 1.
c. 2.
d. 3.
e. none of these.

ANSWER: b
POINTS: 1

77. For which of the following elements does the electron configuration for the lowest energy state show a partially filled *d* orbital?
a. Ti
b. Rb
c. Cu
d. Ga
e. Kr

ANSWER: a
POINTS: 1

78. Fe has _____ that is (are) unpaired in its d orbitals.
a. one electron
b. two electrons
c. three electrons
d. four electrons
e. none of these

ANSWER: d
POINTS: 1

79. How many unpaired electrons are there in an atom of sulfur in its ground state?
a. 0
b. 1
c. 2
d. 3
e. 4

ANSWER: c
POINTS: 1

80. Nitrogen has five valence electrons. Consider the following electron arrangements.

	2s	2p		
a)	↑↓	↑	↑	↑
b)	↑	↑↓	↑	↓
c)	↑	↑↑	↑	↑
d)	↑↓	↑	↑	
e)	↑↓	↑↓	↑	↑

Which represents the ground state for N?

Reference: Ref 2-3

a. option a
b. option b
c. option c
d. option d
e. option e

ANSWER: a
POINTS: 1

81. Nitrogen has five valence electrons. Consider the following electron arrangements.

	2s	2p		
a)	↑↓	↑	↑	↑
b)	↑	↑↓	↑	↓
c)	↑	↑↑	↑	↑
d)	↑↓	↑	↑	
e)	↑↓	↑↓	↑	↑

Which represents the ground state for the N^- ion?

Reference: Ref 2-3

a. option a
b. option b
c. option c
d. option d
e. option e

ANSWER: e
POINTS: 1

82. Which of the following statements is *true*?
a. The exact location of an electron can be determined if we know its energy.
b. An electron in a 2*s* orbital can have the same *n*, *l*, and m_l quantum numbers as an electron in a 3*s* orbital.
c. Ni has two unpaired electrons in its 3*d* orbitals.
d. In the buildup of atoms, electrons occupy the 4*f* orbitals before the 6*s* orbitals.
e. Only three quantum numbers are needed to uniquely describe an electron.

ANSWER: c
POINTS: 1

83. Which of the following statements is *false*?
a. An orbital can accommodate at most two electrons.
b. The electron density at a point is proportional to ψ^2 at that point.
c. The spin quantum number of an electron must be either + ½ or – ½.
d. A 2*p* orbital is more penetrating than a 2*s*; i.e., it has a higher electron density near the nucleus and inside the charge cloud of a 1*s* orbital.
e. In the usual order of filling, the 6*s* orbital is filled before the 4*f* orbital.

ANSWER: d
POINTS: 1

84. Which of the following processes represents the ionization energy of bromine?
a. $Br(s) \longrightarrow Br^+(g) + e^-$
b. $Br(l) \longrightarrow Br^+(g) + e^-$
c. $Br(g) \longrightarrow Br^+(g) + e^-$
d. $Br(s) \longrightarrow Br^+(s) + e^-$
e. $Br_2(g) \longrightarrow Br_2^+(g) + e^-$

ANSWER: c
POINTS: 1

85. Order the elements S, Cl, and F in terms of increasing ionization energy.
a. S, Cl, F
b. Cl, F, S
c. F, S, Cl

d. F, Cl, S
e. S, F, Cl

ANSWER: a
POINTS: 1

86. Choose the element with the highest ionization energy.
a. Na
b. Mg
c. Al
d. P
e. S

ANSWER: d
POINTS: 1

87. List the following atoms in order of increasing ionization energy: Li, Na, C, O, F.
a. Li < Na < C < O < F
b. Na < Li < C < O < F
c. F < O < C < Li < Na
d. Na < Li < F < O < C
e. Na < Li < C < F < O

ANSWER: b
POINTS: 1

88. Consider the ionization energy (IE) of the magnesium atom. Which of the following is *not* true?
a. The IE of Mg is lower than that of sodium.
b. The IE of Mg is lower than that of neon.
c. The IE of Mg is lower than that of beryllium.
d. The IE of Mg is higher than that of calcium.
e. The IE of Mg is lower than that of Mg^+.

ANSWER: a
POINTS: 1

89. Of the following elements, which has the lowest first ionization energy?
a. Ba
b. Ca
c. Si
d. P
e. Cl

ANSWER: a
POINTS: 1

90. Which of the following atoms has the largest ionization energy?

a. O
b. Li
c. Ne
d. Be
e. K

ANSWER: c
POINTS: 1

91. Which of the following atoms would have the largest second ionization energy?
a. Mg
b. Cl
c. S
d. Ca
e. Na

ANSWER: e
POINTS: 1

92. The first ionization energy of Mg is 735 kJ/mol. The second ionization energy is:
a. 735 kJ/mol.
b. less than 735 kJ/mol.
c. greater than 735 kJ/mol.
d. more information is needed to answer this question.
e. none of these.

ANSWER: c
POINTS: 1

93. Which of the following concerning second ionization energies is true?
a. That of Al is higher than that of Mg because Mg wants to lose the second electron, so it is easier to take the second electron away.
b. That of Al is higher than that of Mg because the electrons are taken from the same energy level, but the Al atom has one more proton.
c. That of Al is lower than that of Mg because Mg wants to lose the second electron, thus the energy change is greater.
d. That of Al is lower than that of Mg because the second electron taken from Al is in a p orbital, thus it is easier to take.
e. The second ionization energies are equal for Al and Mg.

ANSWER: b
POINTS: 1

94. Consider a planet where the temperature is so high that the ground state of an electron in the hydrogen atom is $n = 4$. What is the ratio of ionization energy for hydrogen on this planet compared to that on Earth?
a. 1 : 4
b. 4 : 1

c. 1 : 16
d. 16 : 1
e. 1 : 1

ANSWER: c
POINTS: 1

95. Consider the following orderings.

I. $Na^{+} < Mg^{2+} < Al^{3+} < Si^{4+}$
II. Be < Mg < Ca < Sr
III. I < Br < Cl < F
IV. Al < Si < P < Cl

Which of these give(s) a correct trend in ionization energy?

a. III
b. II, IV
c. I, IV
d. I, III, IV
e. none of them

ANSWER: d
POINTS: 1

96. The statement that the first ionization energy for an oxygen atom is lower than the first ionization energy for a nitrogen atom is:

a. consistent with the general trend relating changes in ionization energy across a period from left to right, because it is easier to take an electron from an oxygen atom than from a nitrogen atom.
b. consistent with the general trend relating changes in ionization energy across a period from left to right, because it is harder to take an electron from an oxygen atom than from a nitrogen atom.
c. inconsistent with the general trend relating changes in ionization energy across a period from left to right, due to the fact that the oxygen atom has two doubly-occupied 2*p* orbitals and nitrogen has only one.
d. inconsistent with the general trend relating changes in ionization energy across a period from left to right, due to the fact that oxygen has one doubly-occupied 2*p* orbital and nitrogen does not.
e. incorrect.

ANSWER: d
POINTS: 1

97. Of the following elements, which is most likely to form a negative ion with charge 1–?

a. Ba
b. Ca
c. Si
d. P
e. Cl

ANSWER: e

POINTS: 1

98. Which of the following statements are *false*?

I. It takes less energy to add an electron to nitrogen than to carbon because nitrogen will be closer to achieving a noble gas configuration.

II. It takes more energy to add an electron to fluorine than to oxygen because the radius of fluorine is smaller and more repulsion would occur in the *p*-orbitals.

III. It takes more energy to add an electron to nitrogen than to carbon because of the extra repulsions that would occur in the 2*p* orbitals.

IV. Less energy is released in adding an electron to iodine than to chlorine because the radius of iodine is larger and the electron is added at a distance further from the nucleus.

a. II, III
b. I, II, IV
c. III only
d. I, II
e. All of the above are false statements.

ANSWER: d
POINTS: 1

99. Which of the following statements is true?

a. The krypton 1*s* orbital is smaller than the helium 1*s* orbital because krypton's nuclear charge draws the electrons closer.
b. The krypton 1*s* orbital is larger than the helium 1*s* orbital because krypton contains more electrons.
c. The krypton 1*s* orbital is smaller than the helium 1*s* orbital because krypton's *p* and *d* orbitals crowd the *s* orbitals.
d. The krypton 1*s* orbital and helium 1*s* orbital are the same size because both *s* orbitals can only have two electrons.
e. The krypton 1*s* orbital is larger than the helium 1*s* orbital because krypton's ionization energy is lower, so it's easier to remove electrons.

ANSWER: a
POINTS: 1

100. Order the elements S, Cl, and F in terms of increasing atomic radii.

a. S, Cl, F
b. Cl, F, S
c. F, S, Cl
d. F, Cl, S
e. S, F, Cl

ANSWER: d
POINTS: 1

101. Which of the following statements is *false*?

a. A sodium atom has a smaller radius than a potassium atom.
b. A neon atom has a smaller radius than an oxygen atom.
c. A fluorine atom has a smaller first ionization energy than an oxygen atom.
d. A cesium atom has a smaller first ionization energy than a lithium atom.
e. All are true.

ANSWER: c
POINTS: 1

102. Which of the following statements is true?
a. The first ionization potential of H is greater than that of He.
b. The ionic radius of Fe^{+} is larger than that of Fe^{3+}.
c. The ionization energy of S^{2-} is greater than that of Cl^{-}.
d. The atomic radius of Li is larger than that of Cs.
e. All are false.

ANSWER: b
POINTS: 1

103. Which of the following exhibits the correct orders for both atomic radius and ionization energy, respectively? (smallest to largest)
a. S, O, F, and F, O, S
b. F, S, O, and O, S, F
c. S, F, O, and S, F, O
d. F, O, S, and S, O, F
e. none of these

ANSWER: d
POINTS: 1

104. Sodium losing an electron is an _____ process and fluorine losing an electron is an _____ process.
a. endothermic, exothermic
b. exothermic, endothermic
c. endothermic, endothermic
d. exothermic, exothermic
e. more information needed

ANSWER: c
POINTS: 1

105. Which of the following statements is true about the ionization energy of Mg^{+}?
a. It will be equal to the ionization energy of Li.
b. It will be equal to and opposite in sign to the electron affinity of Mg.
c. It will be equal to and opposite in sign to the electron affinity of Mg^{+}.
d. It will be equal to and opposite in sign to the electron affinity of Mg^{2+}.

e. None of the above.

ANSWER: d
POINTS: 1

106. The SI unit for frequency is cycles per second.
a. True
b. False
ANSWER: False
POINTS: 1

107. Diffraction results when light is scattered from a regular array of points or lines.
a. True
b. False
ANSWER: True
POINTS: 1

108. All matter exhibits either particulate or wave properties exclusively.
a. True
b. False
ANSWER: False
POINTS: 1

109. Bohr's model correctly describes the hydrogen atom and other small atoms.
a. True
b. False
ANSWER: False
POINTS: 1

110. A gamma ray of wavelength 1.00×10^{-8} cm has enough energy to remove an electron from a hydrogen atom.
a. True
b. False
ANSWER: True
POINTS: 1

111. The magnetic quantum number is related to the orientation of the orbital in space relative to the other orbitals in the atom.
a. True
b. False
ANSWER: True
POINTS: 1

112. The size of an orbital is arbitrarily defined.

a. True
b. False

ANSWER: True
POINTS: 1

113. When electron configurations differ from expected, it is because orbitals want to be half-filled.
a. True
b. False

ANSWER: True
POINTS: 1

114. Copper exhibits the expected electron configuration.
a. True
b. False

ANSWER: False
POINTS: 1

115. The second ionization energy for calcium is smaller than the first ionization energy.
a. True
b. False

ANSWER: False
POINTS: 1

116. Ionization energy increases with an increasing number of electrons.
a. True
b. False

ANSWER: False
POINTS: 1

117. Photogray lenses incorporate small amounts of silver chloride in the glass of the lens. The following reaction occurs in the light, causing the lenses to darken:

$$AgCl \rightarrow Ag + Cl$$

The enthalpy change for this reaction is 3.10×10^2 kJ/mol. Assuming all this energy is supplied by light, what is the maximum wavelength of light that can cause this reaction?

ANSWER:
3.86 × 10–7 m

Enthalpy change per AgCl = (3.10 × 102 kJ/mol)(1 mol/6.022 × 1023 molecules)(1000 J/1kJ) = 5.15 × 10–19 J/molecule
E = hc/l, therefore l = hc/E
l = (6.626 × 10–34 J×s)(2.998 × 108 m/s) / (5.15 × 10–19 J) = 3.86 × 10–7 m (or 386 nm)

POINTS: 1

118. Electromagnetic radiation can be viewed as a stream of "particles" called _____.

ANSWER: photons
POINTS: 1

119. _____ results when light is scattered from a regular array of points or lines.

ANSWER: Diffraction
POINTS: 1

120. A specific wave function is called a(n) _____.

ANSWER: orbital
POINTS: 1

121. The _____ quantum number is related to the size and energy of the orbital.

ANSWER: principal (or n)
POINTS: 1

122. Consider the following sets of quantum numbers. Which set(s) represent(s) impossible combinations?

	n	l	m_l
Set a	1	0	1
Set b	3	3	0
Set c	2	1	1
Set d	3	2	–2
Set e	3	1	–2
Set f	2	0	0

ANSWER: Sets a, b, and e represent impossible combinations.

Set a is impossible because ml can only have values from -l to +l. If l is 0, ml can only be 0.
Set b is impossible because l can only have values from 0 to n-1. When n = 3, l may be only 0, 1, or 2.
Set e is impossible because ml can only have values from -l to +l. If l is 1, ml can only be -1, 0, or +1.

POINTS: 1

123. Areas of zero probability of finding an electron are called _____.

ANSWER: nodes (or nodal surfaces)
POINTS: 1

124. The _____ states that in a given atom no two electrons can have the same set of four quantum numbers.

ANSWER: Pauli exclusion principle

POINTS: 1

125. How many electrons in an atom can have the following quantum numbers?
a) $n = 3$
b) $n = 2$, $l = 0$
c) $n = 2$, $l = 2$, $m_l = 0$
d) $n = 2$, $l = 0$, $m_l = 0$, $m_s = 1/2$
ANSWER: a) 18; b) 2; c) 0; d) 1

a) The n = 3 level consists of an s, three p, and five d orbitals, each of which may contain 2 electrons, for a total of 18 electrons.
b) n = 2, l = 0 describes the 2s orbital, which may contain 2 electrons.
c) This set of quantum numbers is impossible, since when n = 2, l can only be 0 or 1.
d) This set of four quantum numbers describes one specific electron in the 2s orbital.

POINTS: 1

126. Given the following electronic configuration of neutral atoms, identify the element and state the number of unpaired electrons in its ground state:
Reference: Ref 2-4

ANSWER: The element is Cr with six unpaired electrons in its ground state.
POINTS: 1

127. Given the following electronic configuration of neutral atoms, identify the element and state the number of unpaired electrons in its ground state:
Reference: Ref 2-4

ANSWER: The element is Cl with one unpaired electron in its ground state.
POINTS: 1

128. Given the following electronic configuration of neutral atoms, identify the element and state the number of unpaired electrons in its ground state:
Reference: Ref 2-4

ANSWER: The element is Te with two unpaired electrons in its ground state.
POINTS: 1

129. Given the following electronic configuration of neutral atoms, identify the element and state the number of unpaired electrons in its ground state:
Reference: Ref 2-4

ANSWER: The element is Cu with one unpaired electron in its ground state.
POINTS: 1

130. Given the following electronic configuration of neutral atoms, identify the element and state the number of unpaired electrons in its ground state:
Reference: Ref 2-4

ANSWER: The element is N with three unpaired electrons in its ground state.

Chapter 2 - Atomic Structure and Periodicity

POINTS: 1

131. The _____ electrons are in the outermost principal quantum level of an atom.

ANSWER: valence
POINTS: 1

132. Give the quantum numbers for the last electron in:
a) gold
b) magnesium
c) iodine
d) cadmium
ANSWER: a) gold: 5, 2, 2, (into a 5d-orbital)
b) magnesium: 3, 0, 0, (into a 3s-orbital)
c) iodine: 5, 1, 1, (into a 5p-orbital)
d) cadmium: 4, 2, 2, (into a 4d-orbital)
POINTS: 1

133. For the set of elements Li, O, Ne, and Na, which element has the largest atomic radius? Explain any deviation from the expected pattern.
ANSWER: Na has the largest atomic radius. There is no deviation from the expected pattern.

Atomic radius is larger toward the left-hand end of a row, and increases as you go down a column.

POINTS: 1

134. The calcium atom is much larger than the calcium ion, while the fluorine atom is much smaller than the fluorine ion. Explain this natural occurrence.
ANSWER: A cation has a larger proton to electron ratio than the corresponding neutral atom, so the remaining electrons are more closely held. An anion has a smaller proton to electron ratio than its corresponding neutral atom, so the electrons can not be held as closely.
POINTS: 1

135. In general, the ionization energy and electron affinity involve more energy from _____ (left to right or right to left) in a period of the periodic table. Why?

ANSWER: The increase is from left to right because of the increase in nuclear charge.
POINTS: 1

136. In general, the ionization energy and electron affinity involve more energy from _____ (top to bottom or bottom to top) in a family of the periodic table. Why?
ANSWER: The increase is from bottom to top because the electrons being removed or added are closer to the nucleus.
POINTS: 1