General Chemistry: Atoms First, 2e **(McMurry and Fay)**
Chapter 2 Periodicity and the Electronic Structure of Atoms

2.1 Multiple Choice Questions

1) Arrange the following spectral regions in order of increasing wavelength:
infrared, microwave, ultraviolet, visible.
A) microwave < infrared < visible < ultraviolet
B) microwave < visible < infrared < ultraviolet
C) ultraviolet < infrared < visible < microwave
D) ultraviolet < visible < infrared < microwave
Answer: D
Diff: 1
Topic: Section 2.1 The Nature of Radiant Energy and the Electromagnetic Spectrum

2) The greater the energy of a photon, the
A) longer the wavelength and the higher the frequency.
B) longer the wavelength and the lower the frequency.
C) shorter the wavelength and the higher the frequency.
D) shorter the wavelength and the lower the frequency.
Answer: C
Diff: 1
Topic: Section 2.1 The Nature of Radiant Energy and the Electromagnetic Spectrum

3) Arrange the following spectral regions in order of increasing energy:
infrared, microwave, ultraviolet, visible.
A) microwave < infrared < visible < ultraviolet
B) microwave < visible < infrared < ultraviolet
C) ultraviolet < infrared < visible < microwave
D) ultraviolet < visible < infrared < microwave
Answer: A
Diff: 1
Topic: Section 2.1 The Nature of Radiant Energy and the Electromagnetic Spectrum

4) What is the frequency of a helium-neon laser light with a wavelength of 632.8 nm? The speed of light is 3.00×10^8 m/s.
A) 4.74×10^{14} s^{-1}
B) 4.74×10^{5} s^{-1}
C) 2.11×10^{-15} s^{-1}
D) 1.58×10^{-15} s^{-1}
Answer: A
Diff: 2
Topic: Section 2.1 The Nature of Radiant Energy and the Electromagnetic Spectrum

5) According to the Balmer-Rydberg equation, electromagnetic radiation with the shortest wavelength will be **emitted** when an electron undergoes which of the following transitions?
A) $m = 1 \rightarrow n = 2$
B) $m = 2 \rightarrow n = 3$
C) $n = 2 \rightarrow m = 1$
D) $n = 3 \rightarrow m = 2$
Answer: C
Diff: 2
Topic: Section 2.2 The Interaction of Radiant Energy with Atoms: Balmer's Equation

6) According to the Balmer-Rydberg equation, electromagnetic radiation with wavelength λ = 486.1 nm will be **absorbed** when an electron undergoes which of the following transitions?
A) $m = 2 \rightarrow n = 3$
B) $m = 2 \rightarrow n = 4$
C) $n = 3 \rightarrow m = 2$
D) $n = 4 \rightarrow m = 2$
Answer: B
Diff: 3
Topic: Section 2.2 The Interaction of Radiant Energy with Atoms: Balmer's Equation

7) A person is most likely to experience serious biological effects when exposed to which of the following forms of electromagnetic radiation?
A) microwaves
B) infrared
C) ultraviolet
D) x rays
Answer: D
Diff: 4
Topic: Section 2.3 Particlelike Properties of Radiant Energy: The Photoelectric Effect and Planck's Postulate

8) The work function of iron metal is 451 kJ/mol. What is the maximum wavelength of light that can be used to eject electrons from iron?
A) 3.39×10^{-7} m
B) 5.42×10^{-7}m
C) 6.36×10^{-7}m
D) 2.65×10^{-7}m
Answer: D
Diff: 3
Topic: Section 2.3 Particlelike Properties of Radiant Energy: The Photoelectric Effect and Planck's Postulate

9) The work function of copper metal is 437 kJ/mol. What is the maximum wavelength of light that can be used to eject electrons from copper?
A) 2.65×10^{-7}m
B) 2.74×10^{-7}m
C) 6.36×10^{-7}m
D) 5.42×10^{-7}m
Answer: B
Diff: 3
Topic: Section 2.3 Particlelike Properties of Radiant Energy: The Photoelectric Effect and Planck's Postulate

10) What is a quantum of light called?
A) the amplitude
B) the frequency
C) a photon
D) the wavelength
Answer: C
Diff: 1
Topic: Section 2.3 Particlelike Properties of Radiant Energy: The Photoelectric Effect and Planck's Postulate

11) A quantized variable
A) can be continuously varied.
B) can only assume certain values.
C) consists of photons.
D) is extremely small.
Answer: B
Diff: 1
Topic: Section 2.3 Particlelike Properties of Radiant Energy: The Photoelectric Effect and Planck's Postulate

12) Which of the following is **not** quantized?
A) the charge on a monatomic ion
B) the distance between two objects
C) the population of the United States
D) the static charge on a balloon rubbed with wool
Answer: B
Diff: 3
Topic: Section 2.3 Particlelike Properties of Radiant Energy: The Photoelectric Effect and Planck's Postulate

13) Of the following, which has the shortest de Broglie wavelength?
A) an airplane moving at a velocity of 300 mph
B) a helium nucleus moving at a velocity of 1000 mph
C) a nitrogen molecule moving at a velocity of 1000 mph
D) a nitrogen molecule moving at a velocity of 5000 mph
Answer: A
Diff: 3
Topic: Section 2.4 Wavelike Properties of Matter: de Broglie's Hypothesis

14) What is the de Broglie wavelength of an electron ($m = 9.11 \times 10^{-31}$ kg) moving at a velocity of 3.0×10^{7} m/s (10% of the speed of light)?
A) less than 3.9×10^{-12} m
B) 2.4×10^{-11} m
C) 3.3×10^{-8} m
D) greater than 1.1×10^{-4} m
Answer: B
Diff: 3
Topic: Section 2.4 Wavelike Properties of Matter: de Broglie's Hypothesis

15) An old copper penny has a mass 3×10^{22} times that of a copper atom. Compare the de Broglie wavelength of a penny moving at 0.5 m/s to that of a copper atom moving 10^{4} times as fast. The wavelength for the
A) copper atom is 3×10^{18} times that of the penny.
B) copper atom is 3×10^{26} times that of the penny.
C) penny is 3×10^{18} times that of the copper atom.
D) penny is 3×10^{26} times that of the copper atom.
Answer: A
Diff: 4
Topic: Section 2.4 Wavelike Properties of Matter: de Broglie's Hypothesis

16) What is the de Broglie wavelength of a 300-g object moving at a velocity of 50 m/s (about 100 mph)?
A) 4×10^{-38} m
B) 4×10^{-35} m
C) 4×10^{9} m
D) 4×10^{12} m
Answer: B
Diff: 3
Topic: Section 2.4 Wavelike Properties of Matter: de Broglie's Hypothesis

17) The wave characteristics of a large, moving object, such as an automobile, are difficult to observe because the
A) energy is not quantized.
B) energy is quantized, but the spacing between energy levels is small.
C) wavelength is very large.
D) wavelength is very small.
Answer: D
Diff: 2
Topic: Section 2.4 Wavelike Properties of Matter: de Broglie's Hypothesis

18) Which of the following is **not** true?
A) All moving objects have wave characteristics.
B) For objects moving at a given speed, the larger the mass, the shorter the wavelength.
C) The de Broglie relation and the Heisenberg uncertainty principle apply only to small particles.
D) The Heisenberg uncertainty principle is an inequality.
Answer: C
Diff: 2
Topic: Section 2.5 The Quantum Mechanical Model of the Atom: Heisenberg's Uncertainty Principle

19) According to the Heisenberg uncertainty principle,
A) the position of a particle cannot be measured precisely.
B) the momentum of a particle cannot be measured precisely.
C) neither the position nor the momentum of a particle can be measured precisely.
D) the position and momentum of a particle can be measured precisely, but not at the same time.
Answer: D
Diff: 1
Topic: Section 2.5 The Quantum Mechanical Model of the Atom: Heisenberg's Uncertainty Principle

20) A baseball with a mass of 150 g is moving at a velocity of 40 m/s (90 mph). If the uncertainity in the velocity is 0.1 m/s, the uncertainty in position
A) may be zero.
B) must be less than or equal to 4×10^{-33} m.
C) must be 4×10^{-33} m.
D) must be greater than or equal to 4×10^{-33} m.
Answer: D
Diff: 3
Topic: Section 2.5 The Quantum Mechanical Model of the Atom: Heisenberg's Uncertainty Principle

21) An oxygen molecule has a mass of 5.3×10^{-26} kg and an approximate diameter of 3.6×10^{-10} m. If the molecule is moving at 400 m/s (1000 mph) with an uncertainity in velocity of 1 m/s, the uncertainty in position
A) is less than or equal to 5×10^{-26} m.
B) must be equal to 5×10^{-26} m.
C) must be equal to 1×10^{-9} m.
D) is greater than or equal to 1×10^{-9} m.
Answer: D
Diff: 3
Topic: Section 2.5 The Quantum Mechanical Model of the Atom: Heisenberg's Uncertainty Principle

22) The intensity of a beam of light is related to its
A) frequency.
B) relative number of photons.
C) speed.
D) wavelength.
Answer: B
Diff: 1
Topic: Section 2.3 Particlelike Properties of Radiant Energy: The Photoelectric Effect and Planck's Postulate

23) Which of the following is true?
A) The Bohr atom is the model currently accepted for electrons in atoms.
B) Electrons travel around the nucleus in circular orbits.
C) There is a 5% chance of finding an electron in an atom outside its orbital.
D) The square of the wave function gives the probability of finding the electron within a given region of space around the nucleus.
Answer: D
Diff: 1
Topic: Section 2.6 The Quantum Mechanical Model of the Atom: Orbitals and the Three Quantum Numbers

24) For an electron in a given atom, the larger *n*, the
A) larger the average distance from the nucleus and the higher the orbital energy.
B) larger the average distance from the nucleus and the lower the orbital energy.
C) smaller the average distance from the nucleus and the higher the orbital energy.
D) smaller the average distance from the nucleus and the lower the orbital energy.
Answer: A
Diff: 1
Topic: Section 2.6 The Quantum Mechanical Model of the Atom: Orbitals and the Three Quantum Numbers

25) What are the possible values of *l* if *n* = 5?
A) 5
B) 0, 1, 2, 3, or 4
C) -4, -3, -2, -1, 0, +1, +2, +3, or +4
D) -5, -4, -3, -2, -1, 0, +1, +2, +3, +4, or +5
Answer: B
Diff: 2
Topic: Section 2.6 The Quantum Mechanical Model of the Atom: Orbitals and the Three Quantum Numbers
Algo. Option: algorithmic

26) How many subshells are there in the shell with *n* = 6?
A) 5
B) 6
C) 15
D) 36
Answer: B
Diff: 2
Topic: Section 2.6 The Quantum Mechanical Model of the Atom: Orbitals and the Three Quantum Numbers
Algo. Option: algorithmic

27) The subshell designations follow the alphabet after *f*. What is the first shell in which an *h* orbital would be allowed?
A) fifth
B) sixth
C) seventh
D) eighth
Answer: B
Diff: 2
Topic: Section 2.6 The Quantum Mechanical Model of the Atom: Orbitals and the Three Quantum Numbers

28) How many *h* orbitals are allowed in a given shell?
A) 5
B) 6
C) 11
D) 13
Answer: C
Diff: 3
Topic: Section 2.6 The Quantum Mechanical Model of the Atom: Orbitals and the Three Quantum Numbers

29) The number of orbitals in a given subshell, such as the 5*d* subshell, is determined by the number of possible values of
A) *n*.
B) *l*.
C) m_l.
D) m_s.
Answer: C
Diff: 2
Topic: Section 2.6 The Quantum Mechanical Model of the Atom: Orbitals and the Three Quantum Numbers

30) What are the possible values of *n* and m_l for an electron in a 5*d* orbital?
A) *n* = 1, 2, 3, 4, or 5 and m_l = 2
B) *n* = 1, 2, 3, 4, or 5 and m_l = -2, -1, 0, +1, or +2
C) *n* = 5 and m_l = 2
D) *n* = 5 and m_l = -2, -1, 0, +1, or +2
Answer: D
Diff: 2
Topic: Section 2.6 The Quantum Mechanical Model of the Atom: Orbitals and the Three Quantum Numbers
Algo. Option: algorithmic

31) How many orbitals are there in the seventh shell?
A) 6
B) 7
C) 21
D) 49
Answer: D
Diff: 3
Topic: Section 2.6 The Quantum Mechanical Model of the Atom: Orbitals and the Three Quantum Numbers
Algo. Option: algorithmic

32) How many electrons can a single orbital hold?
A) 2*n*
B) 2
C) 2*l* + 1
D) 8
Answer: B
Diff: 2
Topic: Section 2.6 The Quantum Mechanical Model of the Atom: Orbitals and the Three Quantum Numbers

33) If the quantum number m_S had possible values ±1, ±2, what would be the maximum number of electrons that be placed in a single orbital?
A) one
B) two
C) three
D) four
Answer: D
Diff: 3
Topic: Section 2.8 A Fourth Quantum Number: Electron Spin and Pauli's Exclusion Principle

34) Which of the following is **not** a valid set of quantum numbers?
A) $n = 2$, $l = 1$, $m_l = 0$, and $m_S = -1/2$
B) $n = 2$, $l = 1$, $m_l = -1$, and $m_S = -1/2$
C) $n = 3$, $l = 0$, $m_l = 0$, and $m_S = 1/2$
D) $n = 3$, $l = 2$, $m_l = 3$, and $m_S = 1/2$
Answer: D
Diff: 2
Topic: Section 2.8 A Fourth Quantum Number: Electron Spin and Pauli's Exclusion Principle

35) An electron in a 4*p* orbital can have a wave function with which of the following set of quantum numbers, (n, l, m_l, m_S)?
A) (4, 0, 0, 1/2)
B) (4, 1, –1, –1/2)
C) (5, 4, 1, –1/2)
D) (5, 4, 4, 1/2)
Answer: B
Diff: 3
Topic: Section 2.8 A Fourth Quantum Number: Electron Spin and Pauli's Exclusion Principle

36) Which orbitals do **not** have a node at the nucleus?
A) all beyond the first shell
B) all but *s*
C) none
D) *s*
Answer: D
Diff: 2
Topic: Section 2.7 Orbials and Their Shapes

37) Which orbitals have two nodal planes passing through the nucleus?
A) *s*
B) *p*
C) *d*
D) all in the third shell
Answer: C
Diff: 2
Topic: Section 2.7 Orbials and Their Shapes

38) What is the number of spherical nodes in a 4*s* orbital?
A) zero
B) two
C) three
D) four
Answer: C
Diff: 3
Topic: Section 2.7 Orbials and Their Shapes

39) For an orbital, a node is
A) the midpoint of the orbital.
B) a surface inside which there is a 90% chance of finding the electron.
C) a surface where there is a maximum probability of finding the electron.
D) a surface where there is no chance of finding the electron.
Answer: D
Diff: 2
Topic: Section 2.7 Orbials and Their Shapes

40) For a particular orbital, as one goes away from the nucleus along the z-axis, the probability density decreases to zero, then increases, and finally decreases without increasing a second time. This is consistent with a
A) 2*s* orbital.
B) $2p_Z$ orbital.
C) 2*s* or a $2p_Z$ orbital.
D) 3*s* orbital.
Answer: A
Diff: 4
Topic: Section 2.7 Orbials and Their Shapes

41) Which of the following is true? The probability density
A) for all *s* orbitals is independent of direction from the nucleus.
B) for all *s* orbitals is independent of distance from the nucleus.
C) is independent of direction from the nucleus for 1*s* orbitals only.
D) is independent of distance from the nucleus for 1*s* orbitals only.
Answer: A
Diff: 3
Topic: Section 2.7 Orbials and Their Shapes

42) For a hydrogen atom, which electronic transition would result in the **emission** of a photon with the highest energy?
A) $2s \rightarrow 3p$
B) $3p \rightarrow 6d$
C) $4p \rightarrow 2s$
D) $5f \rightarrow 3d$
Answer: C
Diff: 3
Topic: Section 2.9 The Quantum Mechanical Model and Atomic Line Spectra
Algo. Option: algorithmic

43) The Balmer-Rydberg equation can be extended to ions with only one electron, such as He^+. In that case it has the form: $1/\lambda = Z^2R(1/m^2 - 1/n^2)$, where Z is the atomic number. What is the energy of the photon required to promote an electron in He^+ from a 1*s* orbital to a 2*p* orbital?
A) $(3/4)hcR$
B) $3hcR$
C) $4hcR$
D) $12hcR$
Answer: B
Diff: 4
Topic: Section 2.9 The Quantum Mechanical Model and Atomic Line Spectra

44) What is the first ionization energy for a hydrogen atom in the ground state? The Rydberg constant is 1.097×10^{-2} nm^{-1}.
A) 7.27×10^{-36} J
B) 1.63×10^{-27} J
C) 2.18×10^{-18} J
D) 0.00823 J
Answer: C
Diff: 4
Topic: Section 2.9 The Quantum Mechanical Model and Atomic Line Spectra

45) For hydrogen, what is the wavelength of the photon emitted when an electron drops from a 4*d* orbital to a 2*p* orbital in a hydrogen atom? The Rydberg constant is 1.097×10^{-2} nm^{-1}.
A) 656.3 nm
B) 486.2 nm
C) 364.6 nm
D) 2.057×10^{-3} nm
Answer: B
Diff: 3
Topic: Section 2.9 The Quantum Mechanical Model and Atomic Line Spectra
Algo. Option: algorithmic

46) Molecular vibrational energy transitions are observed in the infrared, molecular rotational transitions in the microwave, and electronic transitions in the ultraviolet-visible range. Which transitions require the most energy and which the least energy?
A) Electronic transitions require the least energy and vibrational transitions the most.
B) Rotational transitions require the least energy and electronic transitions the most.
C) Vibrational transitions require the least energy and electronic transitions the most.
D) Vibrational transitions require the least energy and rotational transitions the most.
Answer: B
Diff: 2
Topic: Section 2.9 The Quantum Mechanical Model and Atomic Line Spectra

47) The absorption of light of frequency 1.16×10^{11} Hz is required for CO molecules to go from the lowest rotational energy level to the next highest rotational energy level. Determine the energy for this transition in kJ/mol. $h = 6.626 \times 10^{-34}$ J · s
A) 7.69×10^{-23} kJ/mol
B) 0.0463 kJ/mol
C) 46.3 kJ/mol
D) 949 kJ/mol
Answer: B
Diff: 3
Topic: Section 2.9 The Quantum Mechanical Model and Atomic Line Spectra

48) The absorption of a photon of wavelength 4.67×10^{-6} m is necessary for a CO molecule to pass from the lowest vibrational energy level to the next highest vibrational level. If this higher vibrational level has an energy of 6.41×10^{-20} J, what is the energy of the lowest vibrational level?
$h = 6.626 \times 10^{-34}$ J · s
A) 1.60×10^{-20} J
B) 2.15×10^{-20} J
C) 3.20×10^{-20} J
D) 4.26×10^{-20} J
Answer: B
Diff: 3
Topic: Section 2.9 The Quantum Mechanical Model and Atomic Line Spectra

49) The first vibrational level for NaH lies at 1.154×10^{-20} J and the second vibrational level lies at 3.406×10^{-20} J. What is the frequency of the photon emitted when a molecule of NaH drops from the second vibrational level to the first vibrational level?
A) 1.742×10^{13} Hz
B) 3.399×10^{13} Hz
C) 5.140×10^{13} Hz
D) 6.882×10^{13} Hz
Answer: B
Diff: 3
Topic: Section 2.9 The Quantum Mechanical Model and Atomic Line Spectra

50) Which of the following represent electron configurations that violate the Pauli exclusion principle?

(A) [Ne]$3s^1 3p^5$ (B) [Kr]$4d^{12} 5s^2 5p^3$ (C) [Ar]$3d^{10} 4s^2 4p^2$

A) only (A)
B) only (B)
C) (A) and (B)
D) (B) and (C)
Answer: B
Diff: 3
Topic: Section 2.8 A Fourth Quantum Number: Electron Spin and Pauli's Exclusion Principle

51) Which statement is **false**?
A) For any atom, the 4*s* orbital lies lower in energy than the 5*s* orbital.
B) For a hydrogen atom, a 4*s* orbital, a 4*p* orbital, and a 4*d* orbital all have the same energy.
C) The 4*s* orbital lies lower in energy than the 3*d* orbital for atoms K, Ca, Sc, and Ti.
D) The 4*s* orbital lies lower in energy than the 3*d* orbital for Cu and Fe^{2+}.
Answer: D
Diff: 3
Topic: Section 2.10 Orbital Energy Levels in Multielectron Atoms

52) For a multielectron atom the energy differences between the *s,p,d,*and *f* orbitals is due to
A) electron-electron repulsions.
B) the different values of quantum number *l* for each orbital.
C) the different values of quantum number m_l for each orbital.
D) the different values of quantum number m_S for each orbital.
Answer: A
Diff: 2
Topic: Section 2.10 Orbital Energy Levels in Multielectron Atoms

53) Which of the following statements is true for energy level differences seen when comparing the s,p,d, and f orbitals in the hydrogen atom for a given value of n?
A) There are no differences in energy between the *s,p,d,* and *f* orbitals.
B) There are different values of quantum number *l* for each orbital which cause differences in energy.
C) There are different values of quantum number m_l for each orbital which cause differences in energy.
D) There are different values of quantum number m_S for each orbital which cause differences in energy.
Answer: A
Diff: 2
Topic: Section 2.10 Orbital Energy Levels in Multielectron Atoms

54) Within a given shell of a multielectron atom, the lower *l* for an orbital, the
A) higher the orbital energy and the higher Z_{eff} for the electron.
B) higher the orbital energy and the lower Z_{eff} for the electron.
C) lower the orbital energy and the higher Z_{eff} for the electron.
D) lower the orbital energy and the lower Z_{eff} for the electron.
Answer: C
Diff: 3
Topic: Section 2.10 Orbital Energy Levels in Multielectron Atoms

55) For a multielectron atom, a 3*s* orbital lies lower in energy than a 3*p* orbital because
A) a 3*p* orbital has more nodal surfaces than a 3*s* orbital.
B) other electrons more effectively shield electrons in the 3*s* orbital from the nucleus.
C) other electrons more effectively shield electrons in the 3*p* orbital from the nucleus.
D) there are more *p* orbitals than *s* orbitals in a given shell.
Answer: C
Diff: 3
Topic: Section 2.10 Orbital Energy Levels in Multielectron Atoms

56) Which has the highest Z_{eff} for its valence electrons?
A) Na
B) K
C) Si
D) P
Answer: A
Diff: 3
Topic: Section 2.10 Orbital Energy Levels in Multielectron Atoms
Algo. Option: algorithmic

57) The symbol [Kr] represents
A) $4s^2 4p^6$.
B) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 4p^6$.
C) $1s^2 2s^2 2p^6 3s^2 3p^6 4^{s^2} 3d^{10} 4p^6$.
D) $1s^2 2s^2 2p^6 3s^2 3p^{6 4s^2} 3d^{10} 4p^6 4d^{10}$.
Answer: C
Diff: 2
Topic: Section 2.11 Electron Configurations of Multielectron Atoms

58) Which of the following represent electron configurations that are allowed but do **not** represent ground-state configurations?

(A) [Ne]$3s^1 3p^5$ (B) [Kr]$4d^{12} 5s^2 5p^3$ (C) [Ar]$4^{s^2} 3d^{10} 4p^2$

A) only (A)
B) only (B)
C) (A) and (B)
D) (B) and (C)
Answer: A
Diff: 3
Topic: Section 2.11 Electron Configurations of Multielectron Atoms

59) Which of the following elements would you predict to have an anomalous electron configuration?
A) Ag
B) Ce
C) Se
D) Sr
Answer: A
Diff: 3
Topic: Section 2.12 Anomalous Electron Configurations

60) Molybdenum has an anomalous electron configuration. Using the shorthand notation for electron configurations, write the electron configuration of Mo.
A) [Kr] $5s^0\ 4d^6$
B) [Kr] $5s^0\ 4d^0\ 5p^6$
C) [Kr] $5s^1\ 4d^5$
D) [Kr] $5s^2\ 4d^4$
Answer: C
Diff: 3
Topic: Section 2.12 Anomalous Electron Configurations

61) What is the general valence-electron ground-state electron configuration for neutral alkaline earth metals?
A) ns^1
B) ns^2
C) $1s^2 2s^1$
D) $1s^2 2s^2$
Answer: B
Diff: 2
Topic: Section 2.13 Electron Configurations and the Periodic Table
Algo. Option: algorithmic

62) What is the ground-state electron configuration of Co?
A) [Ar]$3d^9$
B) [Ar]$4s^1 3d^8$
C) [Ar]$4s^2 3d^7$
D) [Ar]$4s^2 4p^6 4d^1$
Answer: C
Diff: 2
Topic: Section 2.13 Electron Configurations and the Periodic Table

63) What is the ground-state electron configuration of tellurium?
A) [Kr]$5^{s^2} 4d^{10} 5p^4$
B) [Kr]$5s^2 5p^6 5d^8$
C) [Kr]$5s^2 5p^4$
D) [Kr]$4f^{14} 4d^{10} 5s^2 5p^4$
Answer: A
Diff: 2
Topic: Section 2.13 Electron Configurations and the Periodic Table

64) Which element has the ground-state electron configuration [Xe]$6s^2 4^{f^7} 5d^1$?
A) Pt
B) Eu
C) Gd
D) Tb
Answer: C
Diff: 2
Topic: Section 2.13 Electron Configurations and the Periodic Table
Algo. Option: algorithmic

65) How many unpaired electrons are in an atom of Co in its ground state?
A) 1
B) 2
C) 3
D) 7
Answer: C
Diff: 3
Topic: Section 2.13 Electron Configurations and the Periodic Table

66) Which have the largest number of unpaired electrons in *p* orbitals in their ground-state electron configurations?
A) N, P, As
B) F, Cl, Br
C) Ne, Ar, Kr
D) Te, I, Xe
Answer: A
Diff: 3
Topic: Section 2.13 Electron Configurations and the Periodic Table

67) List all the elements that have a ground-state configuration with five unpaired electrons in the 3*d* subshell.
A) Mn, Fe, Co, Cu, and Zn
B) Cr and Mn
C) Cr
D) Mn
Answer: B
Diff: 3
Topic: Section 2.13 Electron Configurations and the Periodic Table

68) Which of the following have their valence electrons in the same shell?
A) K, As, Br
B) B, Si, As
C) N, As, Bi
D) He, Ne, F
Answer: A
Diff: 2
Topic: Section 2.13 Electron Configurations and the Periodic Table
Algo. Option: algorithmic

69) Which of the following have the same number of valence electrons?
A) K, As, Br
B) B, Si, As
C) N, As, Bi
D) He, Ne, F
Answer: C
Diff: 2
Topic: Section 2.13 Electron Configurations and the Periodic Table
Algo. Option: algorithmic

70) The element In has how many valence electrons?
A) 1
B) 2
C) 3
D) 13
Answer: C
Diff: 2
Topic: Section 2.13 Electron Configurations and the Periodic Table

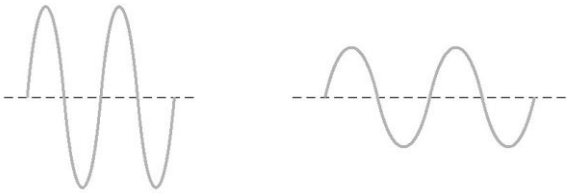
71) A neutral sulfur atom has how many valence electrons?
A) 2
B) 4
C) 6
D) 16
Answer: C
Diff: 2
Topic: Section 2.13 Electron Configurations and the Periodic Table
Algo. Option: algorithmic

72) Of the following, which atom has the largest atomic radius?
A) Na
B) Cl
C) K
D) Br
Answer: C
Diff: 3
Topic: Section 2.14 Electron Configurations and Periodic Properties: Atomic Radii
Algo. Option: algorithmic

73) Of the following, which atom has the smallest atomic radius?
A) Mg
B) S
C) Sr
D) Te
Answer: B
Diff: 3
Topic: Section 2.14 Electron Configurations and Periodic Properties: Atomic Radii
Algo. Option: algorithmic

74) Which atom in each group (I and II) has the smallest atomic radius?
(I) Sr, Zr, I (II) N, P, As
A) Sr; N
B) Sr; As
C) I; N
D) I; As
Answer: C
Diff: 2
Topic: Section 2.14 Electron Configurations and Periodic Properties: Atomic Radii
Algo. Option: algorithmic

Two electromagnetic waves are represented below.



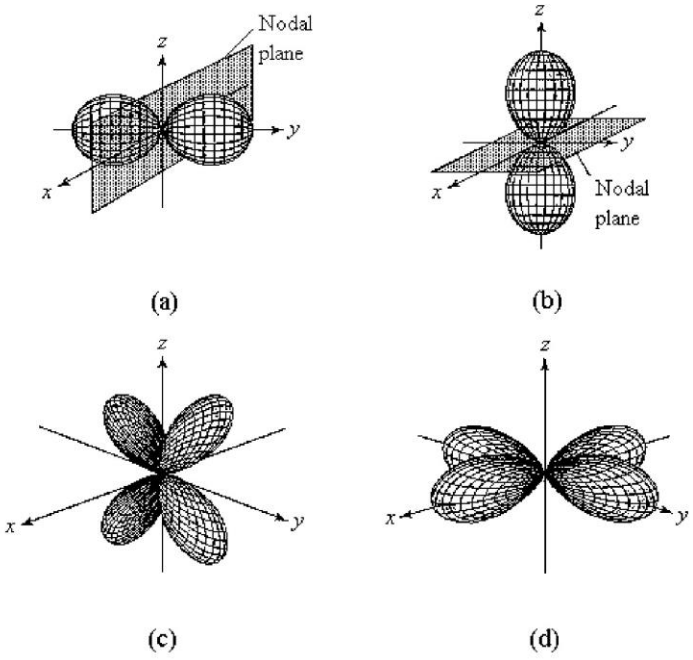
75) Wave (a) has the
A) longer wavelength and higher energy than wave (b).
B) longer wavelength and lower energy than wave (b).
C) shorter wavelength and higher energy than wave (b).
D) shorter wavelength and lower energy than wave (b).
Answer: C
Diff: 2
Topic: Conceptual Problems

76) Wave (a) has the
A) longer wavelength and higher frequency than wave (b).
B) longer wavelength and lower frequency than wave (b).
C) shorter wavelength and higher frequency than wave (b).
D) shorter wavelength and lower frequency than wave (b).
Answer: C
Diff: 1
Topic: Conceptual Problems

77) Wave (b) has the
A) higher frequency and higher energy than wave (a).
B) higher frequency and lower energy than wave (a).
C) lower frequency and higher energy than wave (a).
D) lower frequency and lower energy than wave (a).
Answer: D
Diff: 2
Topic: Conceptual Problems

78) Wave (b) has the
A) higher amplitude and greater intensity than wave (a).
B) higher amplitude and weaker intensity than wave (a).
C) lower amplitude and greater intensity than wave (a).
D) lower amplitude and weaker intensity than wave (a).
Answer: D
Diff: 1
Topic: Conceptual Problems

79) If wave (a) represents green light, wave (b) might represent
A) blue light.
B) red light.
C) ultraviolet radiation.
D) X-rays.
Answer: B
Diff: 1
Topic: Conceptual Problems



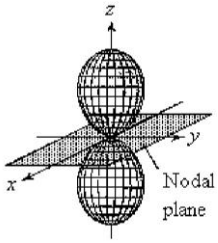
80) Which of the above fourth-shell orbitals is a $4p_Z$ orbital?
A) orbital (a)
B) orbital (b)
C) orbital (c)
D) orbital (d)
Answer: B
Diff: 1
Topic: Conceptual Problems

81) Which of the above fourth-shell orbitals is a $4p_y$ orbital?
A) orbital (a)
B) orbital (b)
C) orbital (c)
D) orbital (d)
Answer: A
Diff: 1
Topic: Conceptual Problems

82) Which of the above fourth-shell orbitals is a $4d_{x^2-y^2}$ orbital?
A) orbital (a)
B) orbital (b)
C) orbital (c)
D) orbital (d)
Answer: D
Diff: 2
Topic: Conceptual Problems

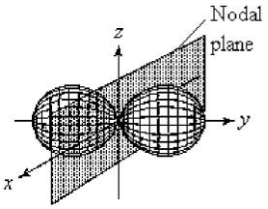
83) Which of the above fourth-shell orbitals is a $4d_{yz}$ orbital?
A) orbital (a)
B) orbital (b)
C) orbital (c)
D) orbital (d)
Answer: C
Diff: 2
Topic: Conceptual Problems

84) For the fourth-shell orbital shown below, what are the principal quantum number, *n*, and the angular momentum quantum number, *l*?



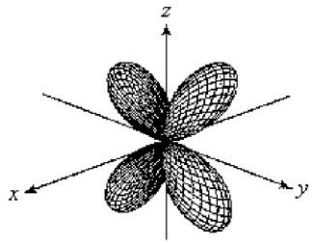
A) $n = 4$ and $l = 0$
B) $n = 4$ and $l = 1$
C) $n = 4$ and $l = 2$
D) $n = 4$ and $l = 3$
Answer: B
Diff: 2
Topic: Conceptual Problems

85) For the fourth-shell orbital shown below, what are the principal quantum number, *n*, and the angular momentum quantum number, *l*?



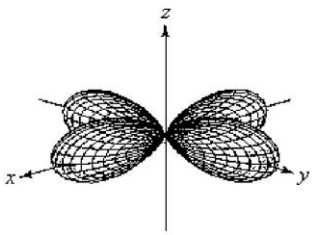
A) $n = 4$ and $l = 0$
B) $n = 4$ and $l = 1$
C) $n = 4$ and $l = 2$
D) $n = 4$ and $l = 3$
Answer: B
Diff: 2
Topic: Conceptual Problems

86) For the fourth-shell orbital shown below, what are the principal quantum number, *n*, and the angular momentum quantum number, *l*?



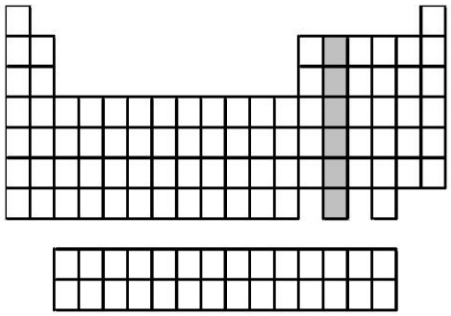
A) $n = 4$ and $l = 0$
B) $n = 4$ and $l = 1$
C) $n = 4$ and $l = 2$
D) $n = 4$ and $l = 3$
Answer: C
Diff: 2
Topic: Conceptual Problems

87) For the fourth-shell orbital shown below, what are the principal quantum number, *n*, and the angular momentum quantum number, *l*?



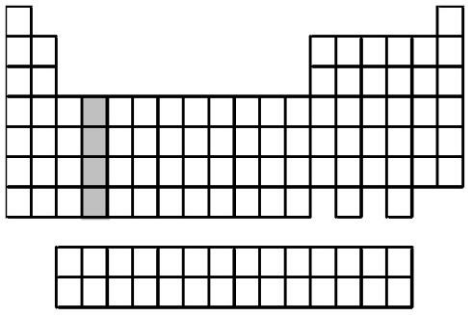
A) $n = 4$ and $l = 0$
B) $n = 4$ and $l = 1$
C) $n = 4$ and $l = 2$
D) $n = 4$ and $l = 3$
Answer: C
Diff: 2
Topic: Conceptual Problems

88) What is the ground-state valence-shell electron configuration of the group of elements indicated by the shaded portion of the periodic table?



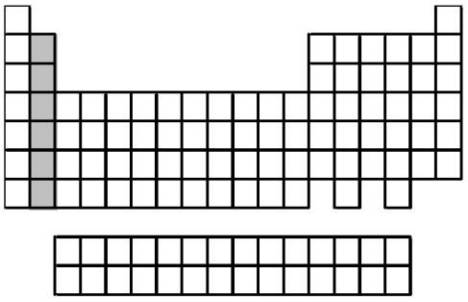
A) ns^2
B) ns^2np^2
C) $ns^2(n\text{-}1)d^2$
D) $ns^2(n\text{-}2)f^2$
Answer: B
Diff: 1
Topic: Conceptual Problems

89) What is the ground-state valence-shell electron configuration of the group of elements indicated by the shaded portion of the periodic table?

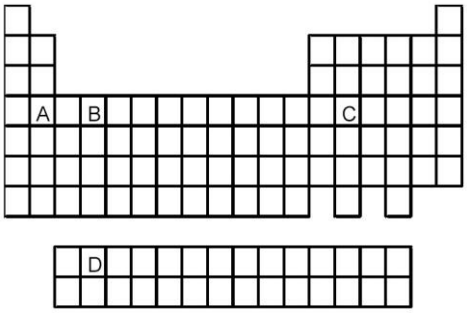


A) ns^2
B) ns^2np^2
C) $ns^2(n\text{-}1)d^2$
D) $ns^2(n\text{-}2)f^2$
Answer: C
Diff: 1
Topic: Conceptual Problems

90) What is the ground-state valence-shell electron configuration of the group of elements indicated by the shaded portion of the periodic table?



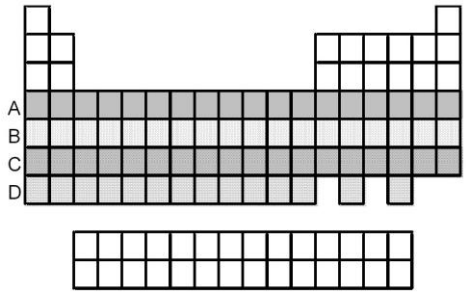
A) ns^2
B) ns^2np^2
C) $ns^2(n\text{-}1)d^2$
D) $ns^2(n\text{-}2)f^2$
Answer: A
Diff: 1
Topic: Conceptual Problems



91) Which element, indicated by letter on the periodic table above, contains one *f* electron?
A) A
B) B
C) C
D) D
Answer: D
Diff: 2
Topic: Conceptual Problems

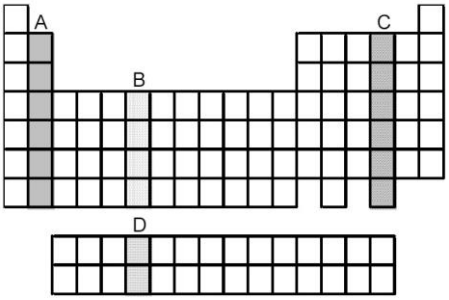
92) Which element, indicated by letter on the periodic table above, has the ground-state electron configuration [Ar]4s^2 3d^2?
A) A
B) B
C) C
D) D
Answer: B
Diff: 1
Topic: Conceptual Problems

93) Which period of elements, indicated by letter on the periodic table, has electrons whose highest principal quantum number *n* is 5?



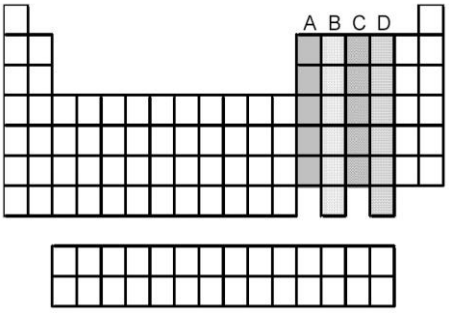
A) A
B) B
C) C
D) D
Answer: B
Diff: 1
Topic: Conceptual Problems

94) Which group of elements, indicated by letter on the periodic table, has electrons with the ground-state valence-shell electron configuration $ns^2\ np^4$?

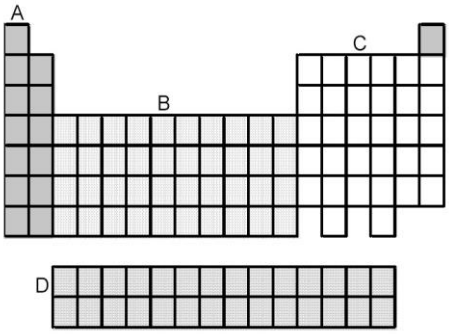


A) A
B) B
C) C
D) D
Answer: C
Diff: 1
Topic: Conceptual Problems

95) Which groups of elements, indicated by letter on the periodic table, have two unpaired *p* electrons in their valence shell?



A) A and B
B) A and C
C) B and C
D) B and D
Answer: D
Diff: 2
Topic: Conceptual Problems

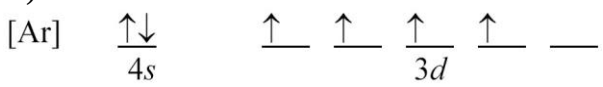


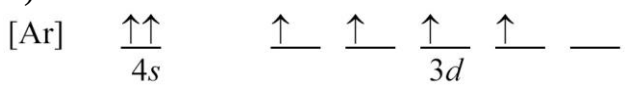
96) Which grouping of elements, indicated by letter on the periodic table above, represents the *f*-block elements?
A) A
B) B
C) C
D) D
Answer: D
Diff: 1
Topic: Conceptual Problems

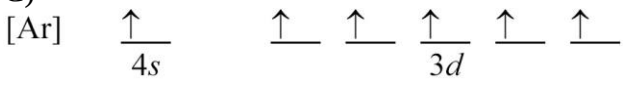
97) Which grouping of elements, indicated by letter on the periodic table above, represents the *d*-block elements?
A) A
B) B
C) C
D) D
Answer: B
Diff: 1
Topic: Conceptual Problems

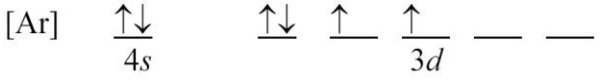
98) Which grouping of elements, indicated by letter on the periodic table above, represents the *p*-block elements?
A) A
B) B
C) C
D) D
Answer: C
Diff: 1
Topic: Conceptual Problems

99) Which grouping of elements, indicated by letter on the periodic table above, represents the *s*-block elements?
A) A
B) B
C) C
D) D
Answer: A
Diff: 1
Topic: Conceptual Problems

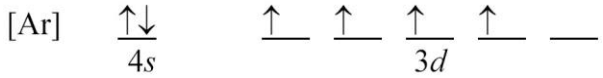
100) Which orbital-filling diagram violates the Pauli exclusion principle?
A)


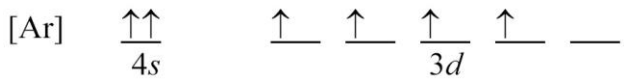
B)


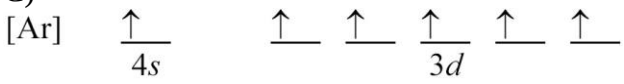
C)


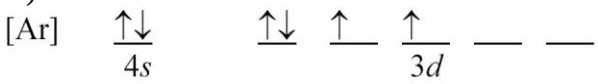
D)


Answer: B
Diff: 3
Topic: Conceptual Problems

101) Which orbital-filling diagram violates Hund's rule?
A)


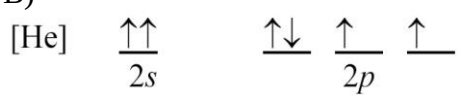
B)


C)


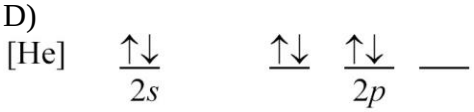
D)


Answer: D
Diff: 3
Topic: Conceptual Problems

102) Which orbital-filling diagram represents the ground state of oxygen?
A)


B)


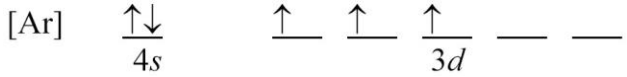
C)


D)


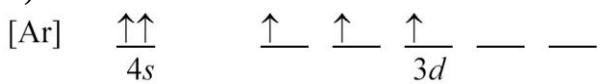
Answer: C
Diff: 3
Topic: Conceptual Problems

103) Which orbital-filling diagram represents the ground state of vanadium?

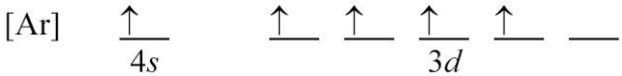
A)



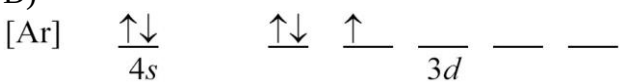
B)



C)



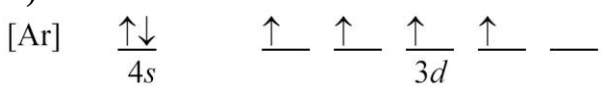
D)



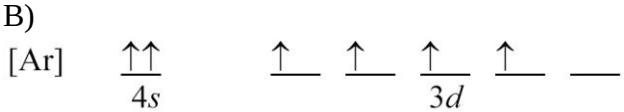
Answer: A
Diff: 3
Topic: Conceptual Problems

104) Which orbital-filling diagram represents the anomalous ground state of chromium?

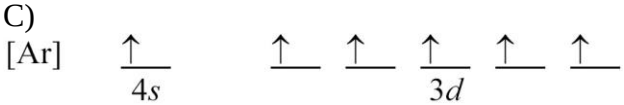
A)



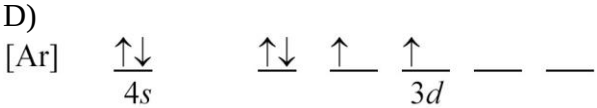
B)



C)

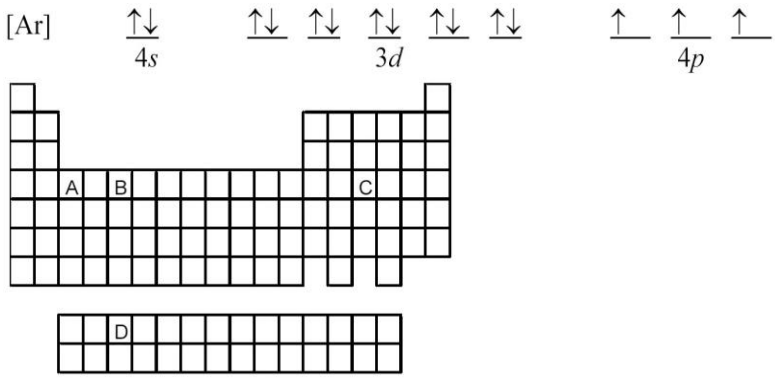


D)



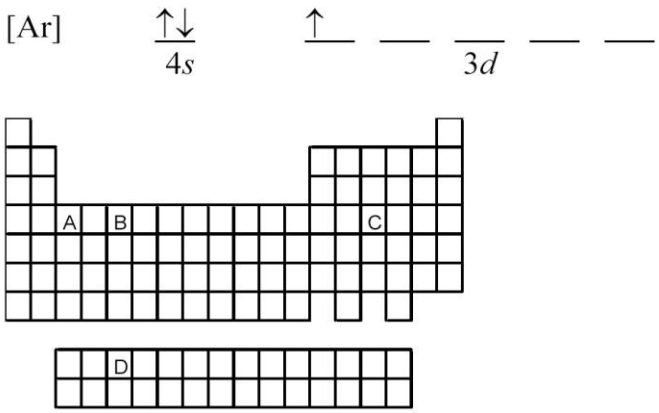
Answer: C
Diff: 4
Topic: Conceptual Problems

105) 2Atoms of which element, indicated by letter on the periodic table, have the orbital-filling diagram shown below?



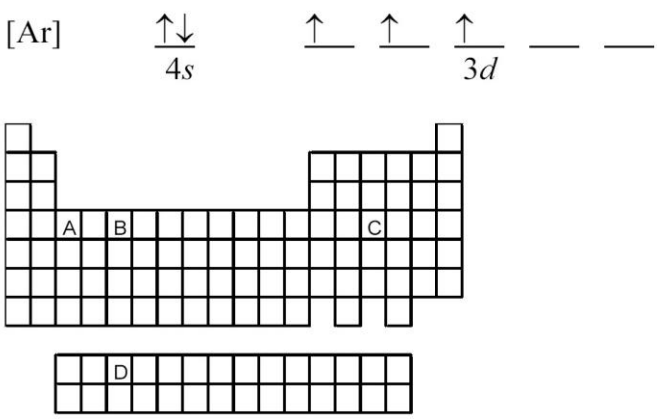
A) A
B) B
C) C
D) D
Answer: C
Diff: 2
Topic: Conceptual Problems

106) Atoms of which element, indicated by letter on the periodic table, have the orbital-filling diagram shown below?



A) A
B) B
C) C
D) D
Answer: A
Diff: 2
Topic: Conceptual Problems

107) Atoms of which element, indicated by letter on the periodic table, have the orbital-filling diagram shown below?



A) A
B) B
C) C
D) D
Answer: B
Diff: 2
Topic: Conceptual Problems

The spheres below represent atoms of Sb, As, P, and N (not necessarily in that order).

r = 75 pm (a) r = 110 pm (b) r = 120 pm (c) r = 140 pm (d)

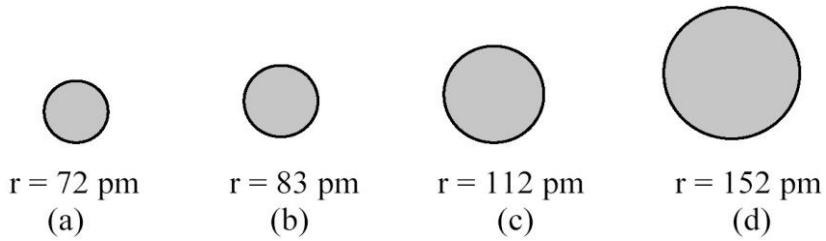
108) Which one of these spheres represents an atom of Sb?
A) sphere (a)
B) sphere (b)
C) sphere (c)
D) sphere (d)
Answer: D
Diff: 3
Topic: Conceptual Problems

109) Which one of these spheres represents an atom of P?
A) sphere (a)
B) sphere (b)
C) sphere (c)
D) sphere (d)
Answer: B
Diff: 2
Topic: Conceptual Problems

110) Which one of these spheres represents an atom of N?
A) sphere (a)
B) sphere (b)
C) sphere (c)
D) sphere (d)
Answer: A
Diff: 2
Topic: Conceptual Problems

111) Which one of these spheres represents an atom of As?
A) sphere (a)
B) sphere (b)
C) sphere (c)
D) sphere (d)
Answer: C
Diff: 3
Topic: Conceptual Problems

The spheres below represent atoms of Li, Be, B, and F (not necessarily in that order).



112) Which one of these spheres represents an atom of Be?
A) sphere (a)
B) sphere (b)
C) sphere (c)
D) sphere (d)
Answer: C
Diff: 2
Topic: Conceptual Problems

113) Which one of these spheres represents an atom of F?
A) sphere (a)
B) sphere (b)
C) sphere (c)
D) sphere (d)
Answer: A
Diff: 2
Topic: Conceptual Problems

114) Which one of these spheres represents an atom of Li?
A) sphere (a)
B) sphere (b)
C) sphere (c)
D) sphere (d)
Answer: D
Diff: 2
Topic: Conceptual Problems

115) Which one of these spheres represents an atom of B?
A) sphere (a)
B) sphere (b)
C) sphere (c)
D) sphere (d)
Answer: B
Diff: 2
Topic: Conceptual Problems

2.2 Algorithmic Questions

1) The work function of cesium metal is 188 kJ/mol. What is the minimum frequency of light needed to eject electrons from cesium?
A) 4.71×10^{14} Hz
B) 5.54×10^{14} Hz
C) 1.09×10^{15} Hz
D) 1.13×10^{15} Hz
Answer: A
Diff: 3
Topic: Section 2.3 Particlelike Properties of Radiant Energy: The Photoelectric Effect and Planck's Postulate
Algo. Option: algorithmic

2) What are the possible values of n and m_l for an electron in a 4*d* orbital?
A) n = 1, 2, 3, or 4 and m_l = 2
B) n = 1, 2, 3, or 4 and m_l = -2, -1, 0, +1, or +2
C) n = 4 and m_l = 2
D) n = 4 and m_l = -2, -1, 0, +1, or +2
Answer: D
Diff: 2
Topic: Section 2.6 The Quantum Mechanical Model of the Atom: Orbitals and the Three Quantum Numbers
Algo. Option: algorithmic

3) How many subshells are there in the shell with n = 4?
A) 3
B) 4
C) 6
D) 18
Answer: B
Diff: 2
Topic: Section 2.6 The Quantum Mechanical Model of the Atom: Orbitals and the Three Quantum Numbers
Algo. Option: algorithmic

4) What are the possible values of l if n = 6?
A) 6
B) 0, 1, 2, 3, 4, or 5
C) -4, -3, -2, -1, 0, +1, +2, +3, or +4
D) -5, -4, -3, -2, -1, 0, +1, +2, +3, +4, or +5
Answer: B
Diff: 2
Topic: Section 2.6 The Quantum Mechanical Model of the Atom: Orbitals and the Three Quantum Numbers
Algo. Option: algorithmic

5) How many orbitals are there in the fourth shell?
A) 3
B) 4
C) 6
D) 16
Answer: D
Diff: 2
Topic: Section 2.6 The Quantum Mechanical Model of the Atom: Orbitals and the Three Quantum Numbers
Algo. Option: algorithmic

6) For a hydrogen atom, which electronic transition would result in the **emission** of a photon with the highest energy?
A) $2s \rightarrow 3p$
B) $2p \rightarrow 6d$
C) $6p \rightarrow 4s$
D) $7f \rightarrow 5d$
Answer: C
Diff: 2
Topic: Section 2.9 The Quantum Mechanical Model and Atomic Line Spectra
Algo. Option: algorithmic

7) For hydrogen, what is the wavelength of the photon emitted when an electron drops from a 4*d* orbital to a 2*p* orbital in a hydrogen atom? The Rydberg constant is 1.097×10^{-2} nm^{-1}.
A) 656.3 nm
B) 486.2 nm
C) 364.6 nm
D) 2.057×10^{-3} nm
Answer: B
Diff: 3
Topic: Section 2.9 The Quantum Mechanical Model and Atomic Line Spectra
Algo. Option: algorithmic

8) Which has the highest Z_{eff} for its valence electrons?
A) Li
B) Na
C) C
D) F
Answer: D
Diff: 3
Topic: Section 2.10 Orbital Energy Levels in Multielectron Atoms
Algo. Option: algorithmic

9) Which of the following have their valence electrons in the same shell?
A) Li, N, F
B) B, Si, As
C) N, As, Bi
D) He, Ne, F
Answer: A
Diff: 2
Topic: Section 2.13 Electron Configurations and the Periodic Table
Algo. Option: algorithmic

10) Which of the following have the same number of valence electrons?
A) Rb, Sb, I
B) Ga, Sn, Bi
C) As, Sb, Bi
D) Ar, Kr, Br
Answer: C
Diff: 2
Topic: Section 2.13 Electron Configurations and the Periodic Table
Algo. Option: algorithmic

11) What is the general valence-electron ground-state electron configuration for neutral alkaline earth metals?
A) ns^1
B) ns^2
C) $1s^2 2s^1$
D) $1s^2 2s^2$
Answer: B
Diff: 2
Topic: Section 2.13 Electron Configurations and the Periodic Table
Algo. Option: algorithmic

12) Which element has the ground-state electron configuration [Xe]$6s^2$ $4f^7$?
A) Re
B) Ir
C) Eu
D) Gd
Answer: C
Diff: 2
Topic: Section 2.13 Electron Configurations and the Periodic Table
Algo. Option: algorithmic

13) How many valence electrons does a neutral polonium atom have?
A) 2
B) 4
C) 6
D) 84
Answer: C
Diff: 2
Topic: Section 2.13 Electron Configurations and the Periodic Table
Algo. Option: algorithmic

14) Of the following, which atom has the largest atomic radius?
A) Rb
B) I
C) Cs
D) At
Answer: C
Diff: 2
Topic: Section 2.14 Electron Configurations and Periodic Properties: Atomic Radii
Algo. Option: algorithmic

15) Of the following, which atom has the smallest atomic radius?
A) K
B) As
C) Rb
D) Sb
Answer: B
Diff: 2
Topic: Section 2.14 Electron Configurations and Periodic Properties: Atomic Radii
Algo. Option: algorithmic

16) Which atom in each group (I and II) has the smallest atomic radius?
(I) Ba, Hf, Bi (II) As, Sb, Bi
A) Ba; As
B) Ba; Bi
C) Bi; As
D) Hf; Bi
Answer: C
Diff: 3
Topic: Section 2.14 Electron Configurations and Periodic Properties: Atomic Radii
Algo. Option: algorithmic

2.3 Short Answer Questions

1) Compared to ultraviolet radiation, infrared radiation occurs at _____ wavelengths, _____ frequencies, and _____ energies.
Answer: longer, lower, lower
Diff: 2
Topic: Section 2.1 The Nature of Radiant Energy and the Electromagnetic Spectrum

2) The visible region of the electromagnetic radiation spectrum extends from _____ nm to _____ nm.
Answer: 380, 780
Diff: 1
Topic: Section 2.1 The Nature of Radiant Energy and the Electromagnetic Spectrum

3) Light behaves as if it were a stream of small particles, called _____, each having an amount of energy called a _____.
Answer: photons, quantum
Diff: 2
Topic: Section 2.3 Particlelike Properties of Radiant Energy: The Photoelectric Effect and Planck's Postulate

4) A solution to the Schrödinger wave equation is a _____, or orbital, represented by the symbol Ψ, and the probability of finding an electron defined by Ψ within a given volume of space around the nucleus is _____.
Answer: wave function, Ψ^2
Diff: 2
Topic: Section 2.6 The Quantum Mechanical Model of the Atom: Orbitals and the Three Quantum Numbers

5) The energy of an electron in a multielectron atom depends on the quantum numbers _____ and _____.
Answer: *n*, *l*
Diff: 2
Topic: Section 2.6 The Quantum Mechanical Model of the Atom: Orbitals and the Three Quantum Numbers

6) An orbital with $n = 4$ and $l = 1$ is a _____ orbital.
Answer: 4*p*
Diff: 2
Topic: Section 2.6 The Quantum Mechanical Model of the Atom: Orbitals and the Three Quantum Numbers

7) According to the Bohr model of the atom, when an electron goes from a higher-energy orbit to a lower-energy orbit, it _____ electromagnetic energy with an energy that is equal to the _____ between the two orbits.
Answer: emits, energy difference or amount of energy
Diff: 2
Topic: Section 2.9 The Quantum Mechanical Model and Atomic Line Spectra

8) Copper has the anomalous electron configuration _____.
Answer: [Ar] $4s^1\ 3d^{10}$
Diff: 2
Topic: Section 2.12 Anomalous Electron Configurations

9) Using shorthand notation, the electron configuration of Ni is _____.
Answer: [Ar] $4s^2\ 3d^8$
Diff: 2
Topic: Section 2.13 Electron Configurations and the Periodic Table

10) Compared to sulfur, chlorine has a _____ effective nuclear charge, Z_{eff}, and a _____ atomic radius.
Answer: higher, smaller
Diff: 2
Topic: Section 2.14 Electron Configurations and Periodic Properties: Atomic Radii