Chapter 2: Quantum Mechanics In Action: Atoms

1. The total number of orbitals in a shell with principal quantum number 5 is
   A) 32. B) 50. C) 25. D) 40. E) 5.
   Ans: C

2. Which set of quantum numbers, n, l, m_l, could correspond to one of the highest energy electrons in Zr?
   A) 4, 2, –2 B) 4, 2, +3 C) 3, 2, –2 D) 4, 3, –2
   Ans: A

3. Which set of quantum numbers could correspond to a 4f-orbital?
   A) $n = 4, l = 4, m_l = +3$
   B) $n = 4, l = 3, m_l = +4$
   C) $n = 4, l = 3, m_l = –3$
   D) $n = 3, l = 2, m_l = +1$
   E) $n = 3, l = 2, m_l = 0$
   Ans: C

4. Which set of quantum numbers corresponds to the electrons in He?
   A) $n = 1, l = 0, m_l = 1$
   B) $n = 1, l = 0, m_l = 0$
   C) $n = 1, l = 1, m_l = –0$
   D) $n = 1, l = 0, m_l = -1$
   E) $n = 1, l = 2, m_l = 0$
   Ans: B

5. What is the only secondary quantum number associated with the 4s orbital?
   A) $l = 0$
   B) $l = 1$
   C) $l = 2$
   D) $l = 3$
   E) $l = 4$
   Ans: A

6. What are the possibilities of the spin quantum number for Mg?
   A) $m_s = 1$
   B) $m_s = 0$
   C) $m_s = + 1/2$
   D) $m_s = - ½$
   E) *Both C and D*
   Ans: E

7. What is the principle quantum number for gallium?
   A) $n = 1$
   B) $n = 2$
   C) $n = 3$
   D) $n = 4$
   E) $n = 5$
   Ans: D

8. What is the *l* corresponding to the outermost p electrons in sulfur?
   A) $l = 0$
   B) $l = 1$
   C) $l = 2$
   D) $l = 3$
   E) $l = 4$
   Ans: B

9. How many total nodal planes are present in the 3d-orbitals?
   A) 15 B) 0 C) 5 D) 20 E) 10
   Ans: E

10. How many nodes are present in a 3s- and a 3p-orbital, respectively?
    A) 2;1 B) 0; 1 C) 0; 2 D) 1; 1 E) 2; 2
    Ans: E

11. Nodal planes in orbitals can be accounted for by the wavelike behavior of electrons.
    Ans: True

12. How many nodal planes are present in an f-orbital?
    A) 2 B) 3 C) 7 D) 4 E) 5
    Ans: B

13. Which of the following statements is true?
    A) A 2s orbital has one nodal plane.
    B) An electron in a p-orbital has zero probability of being found at the nucleus.
    C) A p-orbital has a spherical boundary surface.
    D) An s-orbital becomes more dense as the distance from the nucleus increases.
    E) An electron in an s-orbital has a zero probability of being found at the nucleus.
    Ans: B

14. Where is the nodal plane in a 1s orbital?
    A) Along the x-axis.
    B) Along the y-axis.
    C) Along the z-axis.
    D) Mid-way between the x and y-axes.
    E) There is none.
    Ans: E

15. What shape do the p-orbitals have that each accommodates one nodal plane?
    A) A spherical shape.
    B) A dumbbell shape centered at the nucleus.
    C) A clover leaf shape centered at the nucleus.
    D) A clover leaf shape centered above and below the nucleus.
    E) A toroidal shape around a dumbbell.
    Ans: B

16. Which set of orbitals encompass two shapes?
    A) The s orbitals.
    B) The p orbitals.
    C) The d orbitals.
    D) Both B and C, above.
    E) Both A and C, above.
    Ans: C

17. Which of the following statements is true?
    A) The s orbital is spherical.
    B) The s orbital has no nodal planes.
    C) The s orbital is symmetrical.
    D) The s orbital is associated with the *l* quantum number 0.
    E) All of the above.
    Ans: E

18. Where is the nodal plane for the p_x orbital?
    A) On the x-z plane.
    B) On the y-z plane.
    C) On the x-y plane.
    D) Midway between the x-y and the y-z plane.
    E) The p_x orbital does not have a nodal plane.
    Ans: B

19. Which orbitals have the greatest number of nodes?
    A) The s orbitals.
    B) The p orbitals.
    C) The d orbitals.
    D) The f orbitals.
    E) All orbitals have the same number of nodes.
    Ans: D

20. The three quantum numbers for an electron in a hydrogen atom in a certain state are n = 4, l = 1, m_l = 1. The electron is located in what type of orbital?
    A) 4*s* B) 3*p* C) 3*d* D) 4*d* E) 4*p*
    Ans: E

21. The three quantum numbers for an electron in a hydrogen atom in a certain state are n = 4, l = 2, m_l = 1. The electron is located in what type of orbital?
    A) 4*p* B) 3*p* C) 4*s* D) 4*d* E) 3*d*
    Ans: D

22. Which of the following statements is true?
    A) A *p*-electron penetrates more than an *s*-electron through the inner shells of an atom.
    B) A *p*-electron penetrates less than a *d*-electron through the inner shells of an atom.
    C) A *p*-electron has a nonzero probability density at the nucleus.
    D) A *d*-electron has a nonzero probability density at the nucleus.
    E) A *p*-electron experiences a smaller effective nuclear charge than an *s*-electron.
    Ans: E

23. How many unpaired electrons are in a chromium atom?
A) 0 B) 5 C) 6 D) 4 E) 3
Ans: C

24. How many unpaired electrons are in a calcium atom?
A) 1 B) 2 C) 3 D) 4 E) 5
Ans: B

25. An aluminum atom contains how many unpaired electrons?
A) 7 B) 6 C) 5 D) 4 E) 3
Ans: E

26. How many *f* electrons are in a gadolinium atom?
A) 7 B) 6 C) 5 D) 4 E) 3
Ans: A

27. How many unpaired electrons are in a chromium trivalent ion?
A) 0 B) 5 C) 6 D) 4 E) 3
Ans: E

28. How many unpaired electrons are in a xenon atom?
A) 0 B) 1 C) 2 D) 3 E) 4
Ans: A

29. A chloride ion contains how many unpaired electrons?
A) 8 B) 6 C) 4 D) 2 E) 0
Ans: E

30. Write the ground-state electron configuration of a europium atom.
A) $[Xe]5d^7 6s^2$
B) $[Xe]4f^2 5d^5 6s^2$
C) $[Xe]4f^9$
D) $[Xe]4f^7 6s^2$
E) $[Xe]4f^5 5d^2 6s^2$
Ans: D

31. Write the ground-state electron configuration of a terbium atom.
A) $[Xe]4f^{11}$
B) $[Xe]4f^{10}6s^1$
C) $[Xe]4f^9 6s^2$
D) $[Xe]4f^4 5d^5 6s^2$
E) $[Xe]4f^6 5d^5$
Ans: C

32. Write the ground-state electron configuration of a lead atom.
A) $[Xe]4f^{14}5d^{5}6s^{1}6p^{6}7s^{2}$
B) $[Xe]4f^{14}5d^{10}6s^{2}6p^{2}$
C) $[Xe]4f^{14}5d^{10}6s^{1}6p^{3}$
D) $[Xe]4f^{14}5d^{10}6p^{4}$
E) $[Xe]4f^{14}5d^{9}6s^{2}6p^{3}$
Ans: B

33. Write the ground-state electron configuration of Ru^{2+}.
A) $[Kr]4d^{5}5s^{1}$ B) $[Kr]4d^{7}$ C) $[Kr]4d^{5}5p^{1}$ D) $[Kr]4d^{8}$ E) $[Kr]4d^{6}$
Ans: E

34. Write the ground-state electron configuration of a samarium atom.
A) $[Xe]4f^{7}5d^{1}$ B) $[Xe]5d^{8}$ C) $[Xe]4f^{7}6s^{1}$ D) $[Xe]4f^{8}$ E) $[Xe]4f^{6}6s^{2}$
Ans: E

35. Write the ground-state electron configuration of a tin(IV) ion.
A) $[Kr]4d^{3}5s^{1}5p^{6}$
B) $[Kr]4d^{4}5p^{6}$
C) $[Kr]4d^{5}5s^{2}5p^{3}$
D) $[Kr]4d^{5}5p^{5}$
E) $[Kr]4d^{10}$
Ans: E

36. Write the ground-state electron configuration of In^{+}.
A) $[Kr]4d^{7}5s^{2}5p^{3}$
B) $[Kr]4d^{8}5s^{1}5p^{3}$
C) $[Kr]4d^{5}5s^{1}5p^{6}$
D) $[Kr]4d^{10}5s^{2}$
E) $[Kr]4d^{10}5s^{1}5p^{1}$
Ans: D

37. Write the ground-state electron configuration of Tl^{+}.
A) $[Xe]4f^{14}5d^{10}6p^{2}$
B) $[Xe]4f^{14}5d^{10}6s^{2}$
C) $[Xe]4f^{14}5d^{10}6s^{1}6p^{1}$
D) $[Xe]4f^{14}5d^{8}6s^{1}6p^{3}$
E) $[Xe]4f^{14}5d^{5}6s^{1}6p^{6}$
Ans: B

38. Write the ground-state electron configuration of Pb^{2+}.
A) $[Xe]4f^{14}5d^{5}6s^{1}6p^{6}$
B) $[Xe]4f^{14}5d^{10}6s^{2}$
C) $[Xe]4f^{14}5d^{5}6s^{2}6p^{5}$
D) $[Xe]4f^{14}5d^{10}6s^{1}6p^{1}$
E) $[Xe]4f^{14}5d^{10}6p^{2}$
Ans: B

39. Write the ground-state electron configuration of Sb^{3+}.
A) $[Kr]4d^{8}5s^{1}5p^{3}$
B) $[Kr]4d^{5}5s^{1}5p^{6}$
C) $[Kr]4d^{10}5p^{2}$
D) $[Kr]4d^{10}5s^{1}5p^{1}$
E) $[Kr]4d^{10}5s^{2}$
Ans: E

40. Write the ground-state electron configuration of Sb.
A) $[Kr]4d^8 5s^1 5p^3$
B) $[Kr]4d^5 5s^1 5p^6$
C) $[Kr]4d^{10} 5p^2$
D) $[Kr]4d^{10} 5s^2 5p^3$
E) $[Kr]4d^{10} 5s^2$
Ans: D

41. What is the ground-state electron configuration of Rb^+?
A) [Kr]
B) $[Kr]5s^1$
C) [Ar]
D) $[Ar]4s^1$
E) $[Kr]4d^{10}$
Ans: A

42. For F^-, write the ground-state electron configuration.
A) $[Ne]2p^5$
B) [Ne]
C) [Ar]
D) $[He]2p^5$
E) $[He]1s^2$
Ans: B

43. Write the ground-state electron configuration of Fe^{3+}.
A) $[Ar]3d^5 4s^2$
B) $[Ar]3d^3 4s^2$
C) $[Ar]3d^3 4s^0$
D) $[Ar]3d^6 4s^1$
E) $[Ar]3d^3 4s^3$
Ans: B

44. What is the ground-state electron configuration of Nb?
A) $[Kr]4d^4 5s^1$
B) $[Kr]4d^5 5s^2$
C) $[Kr]5d^3 4s^2$
D) $[Kr]5d^3 5s^2$
E) $[Kr]4d^3 5s^2$
Ans: E

45. Write the ground-state electron configuration of Cl^+.
A) $[Ne]3s^2 3p^4$
B) $[Ne]3s^2 3p^5$
C) $[Ne]3s^1 3p^4$
D) $[Ne]3s^2 3p^6$
E) $[Ar]3s^2 3p^4$
Ans: A

46. All the following can have the ground-state electron configuration $[Xe]4f^{14} 5d^{10}$ except
A) Pb^{4+}. B) Hg^{2+}. C) Bi^{5+}. D) Tl^+. E) Au^+.
Ans: D

47. All the following can have the ground-state electron configuration $[Kr]4d^{10}$ except
A) Cd^{2+}. B) Ag^+. C) Pd. D) In^+. E) Sn^{4+}.
Ans: D

48. Which of the following has the smallest atomic radius?
A) Cl B) P C) S D) Si E) Al
Ans: A

49. Which of the following has the largest atomic radius?
A) S^{2-} B) Cl C) Cl^{-} D) K^{+} E) S
Ans: A

50. Which of the following species is isoelectronic with S^{2-}?
A) Mg^{2+} B) Rb^{+} C) Ar D) As^{3-} E) Br^{-}
Ans: C

51. Which of the following species is isoelectronic with Kr?
A) K^{+} B) Cl^{-} C) Ar D) Xe E) Sr^{2+}
Ans: E

52. Which of the following species is isoelectronic with As^{3-}?
A) Na^{+} B) Cl^{-} C) Ar D) Kr E) Ba^{2+}
Ans: D

53. Si^{4+} is isoelectronic with which of the following?
A) K^{+} B) Ne C) Kr D) Cl^{-} E) Sr^{2+}
Ans: B

54. Which of the following atoms or ions is isoelectronic with Be^{2+}?
A) Na^{+} B) Br^{-} C) He D) Xe E) He^{+}
Ans: C

55. Which of the following has the largest atomic radius?
A) F B) O C) N D) C E) B
Ans: E

56. Of the following, which has the largest atomic radius?
A) Ga B) Ge C) As D) Se E) Br
Ans: A

57. Which of the following species is isoelectronic with Ra^{2+}?
A) I^{-} B) Kr C) Xe D) Rn E) Fr
Ans: D

58. From the data below, which element is likely to be a metal?

Element	First ionization energy, kJ·mol^{-1}
1	1310
2	1011
3	418
4	2080
5	947

A) 2 B) 5 C) 3 D) 1 E) 4
Ans: C

59. From the data below, which elements are likely to be nonmetals?

Element	First ionization energy, kJ·mol^{-1}
1	1310
2	980
3	418
4	2080
5	947

A) 3 and 5 B) 3 only C) 1 and 4 D) 1 and 2 E) 2 and 5
Ans: C

60. Which of the following is likely to form ions two units lower in charge than expected from the group number?
A) Tl B) Hg C) Zn D) Se E) Cd
Ans: A

61. Which of the following is likely to form ions two units lower in charge than expected from the group number?
A) Hg B) Cd C) Sb D) Ge E) Zn
Ans: C

62. Given the elements Cl, Ge, and K and three values of possible first ionization energies, 418, 1255, 784 kJ·mol^{-1}, match the atoms with their first ionization energies.
A) Cl (418), Ge (784), and K (1255 kJ·mol^{-1})
B) Cl (1255), Ge (784), and K (418 kJ·mol^{-1})
C) Cl (784), Ge (1255), and K (418 kJ·mol^{-1})
D) Cl (1255), Ge (418), and K (784 kJ·mol^{-1})
E) Cl (418), Ge (1255), and K (784 kJ·mol^{-1})
Ans: B

63. If the second ionization energy of copper is 1958 kJ·mol^{-1}, the first ionization energy is likely to be greater than 1958 kJ·mol^{-1}. True or false?
Ans: False

64. Consider the following ground-state electronic configurations. Which atom has both the highest first ionization energy and the highest electron affinity?
A) [Ne] $3s^2 3p^5$ B) [Ne] $3s^2 3p^3$ C) [Ne] $3s^2 3p^1$ D) [Ne] $3s^2 3p^4$
Ans: A

65. Which atom has the highest first ionization energy?
A) Mg B) Ca C) Sr D) Ba
Ans: A

66. Which atom has the highest second ionization energy?
A) Cs B) Na C) Li D) K
Ans: C

67. Consider the following ground-state electronic configurations. Which atom has the highest electron affinity?
A) [He] $2s^2 2p^5$ B) [He] $2s^2 2p^3$ C) [He] $2s^2 2p^1$ D) [He] $2s^2 2p^4$
Ans: A

68. Which atom has the highest first ionization energy?
A) Pb B) Sn C) Ge D) Si
Ans: D

69. Which atom has the lowest electron affinity?
A) Al B) Si C) P D) S
Ans: A

70. Consider the following ground-state electronic configurations. Which atom has the lowest first ionization energy?
A) [Ne] $3s^2 3p^5$ B) [Ne] $3s^2 3p^3$ C) [Ne] $3s^2 3p^1$ D) [Ne] $3s^2 3p^4$
Ans: C

71. In each pair, which ionization reaction is larger?
(a) I_3 of B; or I_3 of Be
(b) I_4 of C; or I_3 of B
Ans: (a) I_3 of Be
(b) I_4 of C

72. What are the subshell notation and the number of orbitals having the quantum numbers $n = 4$, $l = 3$?
A) 4*d* and 5 B) 4*p* and 3 C) 3*f* and 7 D) 3*d* and 5 E) 4*f* and 7
Ans: E

73. What are the subshell notation and the number of orbitals having the quantum numbers $n = 4$, $l = 2$?
A) 4*d* and 10 B) 4*f* and 14 C) 4*d* and 5 D) 4*p* and 3 E) 4*f* and 7
Ans: C

74. Which of the following would be most reactive with air and water?
A) Ba B) Mg C) Ga D) Br
Ans: A

75. Which of the following has similar properties to Al?
A) Li B) Be C) Si D) Ga E) Mg
Ans: B

76. Which of the following elements has the least metal character?
A) In B) Ge C) Te D) I E) Tl
Ans: D

77. All the following are metalloids except:
A) B. B) As. C) Ge. D) Sb. E) Si.
Ans: A

78. All the following are metals except:
A) Cd. B) Zn. C) Ge. D) Al. E) Ga.
Ans: C

79. All the following are transition metals except:
A) Cd. B) Cu. C) Pd. D) Pb. E) Ag.
Ans: D

80. All the following are non-metals except
A) C. B) S. C) Ga. D) Se. E) Cl.
Ans: C

81. Which of the following is not a metal?
A) Ba. B) Br. C) Ga. D) Al. E) Hg.
Ans: B

82. Of the following, which is not an alkali metal?
A) Cs. B) Fr. C) K. D) Rb. E) Re.
Ans: E

83. All the following are diatomic gases except
A) Hydrogen. B) Fluorine. C) Oxygen. D) Neon. E) Nitrogen.
Ans: D

84. How many nodal planes are expected for 2*s* and 4*f* orbitals, respectively?
A) 0 and 4 B) 0 and 3 C) 2 and 4 D) 1 and 4 E) 1 and 3
Ans: B

85. Which of the following subshells cannot exist in an atom?
A) 4*d* B) 5*g* C) 5*f* D) 4*f* E) 3*f*
Ans: E

86. What is the inert-pair effect?
Ans: The inert-pair effect is the tendency to form ions two units lower in charge than expected from the group number.

87. When an electron is added to a gaseous chlorine atom, 349 $kJ \cdot mol^{-1}$ of energy is released. What is the ionization energy of a gaseous chloride ion?
Ans: $+349\ kJ \cdot mol^{-1}$

88. Which of the following atoms has the highest electron affinity?
A) Ar B) P C) Al D) Si
Ans: D

89. Because of fluorine's high electronegativity, less energy is required to make F^{2-} from F^- than to make O^{2-} from O^-. True or false?
Ans: False

90. Which of the following has the largest effective nuclear charge?
A) F
B) Na
C) Li
D) He
E) N
Ans: A

91. Which of the following has the largest radius?
    A) P^{3-}
    B) Cl^{-}
    C) K^{+}
    D) Cl
    E) N^{3-}
    Ans: A

92. Which of the following has the largest radius?
    A) Cr
    B) Cl
    C) Cu
    D) Gd
    E) Ga
    Ans: D

93. Which of the following has the smallest radius?
    A) P^{+5}
    B) P^{3-}
    C) N^{+5}
    D) N
    E) N^{3-}
    Ans: C

94. Which of the following has the largest radius?
    A) Fe^{3+}
    B) Fe^{2+}
    C) Fe
    D) F
    E) F^{-}
    Ans: C

95. Which of the following has the largest effective nuclear charge?
    A) Al
    B) Si
    C) P
    D) S
    E) Cl
    Ans: E

96. Which of the following has the largest radius?
    A) N^{3-}
    B) F^{-}
    C) H^{+}
    D) He
    E) O^{2-}
    Ans: A

97. Which of the following has the smallest radius?
    A) B^{3+}
    B) C^{4+}
    C) Fe^{2+}
    D) Fe
    E) Fe^{3+}
    Ans: E

98. How many unpaired electrons exist in the ground state of a Cu^{+} ion?
    A) 0
    B) 2
    C) 1
    D) 3
    E) 5
    Ans: A

99. Which of the following pairs of elements has members with similar properties?
    A) B and Si
    B) Li and Be
    C) Mg and Al
    D) Na and Ca
    E) Se and I
    Ans: A

100. Which of the following pairs of elements has members with similar properties?
    A) Mg and Al
    B) Li and Be
    C) Mg and Ge
    D) Na and Ca
    E) None of the above.
    Ans: E