

Chapter 2: The Structure of the Atom and the Periodic Table

1. What are the three primary particles found in an atom?
A) neutron, positron, and electron
B) electron, neutron, and proton
C) electron, proton, and nucleon
D) positron, electron, and nucleon
E) proton, electron, and neutrino
Ans: B
2. What is the value of the mass number in the isotope $^{131}_{53}\text{I}$?
A) 53
B) 78
C) 126.9
D) 131
E) 184
Ans: D
3. What term is used to describe atoms of the same element that have different masses?
A) radioactive
B) constituents
C) isotopes
D) telomers
E) isomers
Ans: C
4. Which statement explains why isotopes have different mass numbers?
A) Isotopes differ in the number of protons each contains.
B) Isotopes differ in the number of electrons each contains.
C) Isotopes differ in the number of neutrons each contains.
D) Isotopes differ in the number of protons and neutrons each contains.
E) Isotopes differ in the number of protons and electrons each contains.
Ans: C
5. When a neutral atom gains one or more electrons, what type of particle is formed?
A) an anion
B) an isotope
C) a proton
D) a positron
E) a cation
Ans: A

6. What is always true for a neutral atom?
- A) there is an equal number of protons and neutrons
 - B) there is an equal number of protons and electrons
 - C) there is an equal number of protons, neutrons, and electrons
 - D) the number of protons and neutrons is an even number
 - E) the number of protons, neutrons, and electrons is an even number
- Ans: B
7. What was J. J. Thomson's important discovery about cathode rays in 1897?
- A) Cathode rays were indestructible.
 - B) Cathode rays were heavier than anode rays.
 - C) Cathode rays consisted of a stream of electrons.
 - D) Cathode rays were produced by all radioactive atoms.
 - E) Cathode rays were able to initiate radioactive decay of an atom.
- Ans: C
8. What is Rutherford's important contribution to our knowledge of atomic structure?
- A) Atoms contain a small, dense, positively charged nucleus, surrounded largely by empty space.
 - B) The atom cannot be created, divided, destroyed, or converted to any other type of atom.
 - C) Electrons in an atom have the magnetic property of spin.
 - D) Electrons are confined to certain specific regions of space outside the nucleus.
 - E) Electrons follow circular paths around the nucleus of an atom.
- Ans: A
9. Which statement concerning atoms is FALSE?
- A) The atomic number of an atom is the number of protons it contains.
 - B) The mass number of an atom is the sum of the number of protons, neutrons, and electrons it contains.
 - C) The nucleus of an atom contains its protons and neutrons, and is positively charged.
 - D) The nucleus of an atom is the heaviest part of the atom.
 - E) Electrons reside outside the nucleus in what is called the electron cloud.
- Ans: B
10. Which describes the basic concept of Bohr's theory of the atom?
- A) Atoms contain a small, dense positively charged region called the nucleus.
 - B) The energy of an electron in an atom is quantized; it has only certain allowable values.
 - C) Light is made up of particles called photons.
 - D) Electrons have the magnetic property of spin.
 - E) Radioactive atoms spontaneously decay and release large amounts of energy from the nucleus.
- Ans: B
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11. When is an atom in its ground state?
A) when the electrons of the atom are in the lowest possible energy levels
B) when an atom loses all of its electrons to form a noble gas
C) when the electrons of the atom are in the highest possible energy levels
D) when an electron is promoted to a higher energy level, farther from the nucleus
E) when the electrons of an atom spontaneously emit energy in the form of a photon
Ans: A
12. The identity of an atom is determined by which of the following?
A) the number of electrons it contains
B) its mass number
C) the number of isotopes it has
D) the number of protons it contains
E) the number of protons and neutrons it contains
Ans: D
13. In modern atomic theory, Bohr's orbits are replaced by atomic orbitals. What is an atomic orbital?
A) a circular path around the nucleus travelled by an electron
B) a dense, positively charged region of space at the center of an atom
C) a region of space within an atom where there is a high probability of finding an electron
D) the outermost principle energy level in an atom
E) the lowest energy arrangement of electrons in an atom
Ans: C
14. Which two scientists in 1869 arranged the elements in order of increasing atomic masses to form a precursor of the modern periodic table of elements?
A) Bohr and Rutherford
B) Plank and Rutherford
C) Maxwell and Dalton
D) Thomson and Crookes
E) Mendeleev and Meyer
Ans: E
15. Who stated that the elements, when arranged according to their atomic masses, showed a distinct periodicity of their properties?
A) Dmitri Mendeleev
B) Niels Bohr
C) J.J Thomson
D) Ernest Rutherford
E) John Dalton
Ans: A
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16. Which statement about the modern periodic table is FALSE?
- A) Elements are arranged in order of increasing atomic number.
 - B) A period is a horizontal row of elements.
 - C) A group is a vertical column of elements.
 - D) A stepwise line separates the metals from the nonmetals; metals are to the left of the line, nonmetals are to the right of the line.
 - E) Elements in the same period share similar chemical and physical properties.

Ans: E

17. The modern periodic law states that the physical and chemical properties of the elements are periodic functions of what property?
- A) electrons
 - B) atomic weight
 - C) neutrons
 - D) atomic number
 - E) mass number

Ans: D

18. The ion K^+ is formed by which process?
- A) loss of an electron by K
 - B) gain of proton by K
 - C) loss of a proton by K
 - D) gain of an electron by K
 - E) none of the above

Ans: A

19. Tungsten is a metal containing 74 protons, and is used widely in the electronics industry. What is the chemical symbol for tungsten?
- A) T
 - B) Tg
 - C) Tn
 - D) W
 - E) As

Ans: D

20. Which period contains the element sodium?
- A) one
 - B) two
 - C) three
 - D) five
 - E) eleven

Ans: C

21. What are the columns of elements on the periodic table called?
A) groups
B) shells
C) periods
D) metals
E) rows
Ans: A
22. Which statement concerning the elements fluorine, chlorine, bromine, and iodine is FALSE?
A) They are all halogens.
B) They all have the same electron configuration.
C) They are all nonmetals.
D) They are all representative elements.
E) They all have the same number of valence electrons.
Ans: B
23. What is the general name given to the elements of Group IA (1)?
A) halogens
B) alkali metals
C) alkaline earth metals
D) noble gases
E) metalloids
Ans: B
24. What term is used for the elements straddling the “staircase” boundary between the metals and nonmetals?
A) transition elements
B) metalloids
C) cations
D) lanthanides
E) noble gases
Ans: B
25. What are valence electrons?
A) the electrons located in the nucleus of an atom
B) the interior electrons, located closest to the nucleus
C) the outermost electrons in an atom
D) the electrons with the lowest energy in an atom
E) the total number of electrons in an atom
Ans: C

26. What is FALSE about the three orbitals in the $2p$ sublevel?
 A) The orbitals have the same dumbbell-like shape.
 B) The orbitals have similar, but different energies.
 C) The orbitals are the same distance away from the nucleus.
 D) The orbitals are each oriented in a different direction.
 E) Each orbital can hold two electrons with opposite spins.
 Ans: B
27. What requirement must be met in order for two electrons to coexist in the same orbital?
 A) the electrons must have different energies
 B) the electrons must have the same spin
 C) the electrons must have opposite charges
 D) the electrons must be in different principle energy levels
 E) the electrons must have opposite spins
 Ans: E
28. The Aufbau Principle specifies which of the following?
 A) Each atomic orbital has a maximum capacity of two electrons.
 B) Two electrons in the same orbital must have opposite spins.
 C) Two electrons in the same orbital must be spin paired.
 D) Electrons will occupy the lowest energy orbitals that are available.
 E) Electrons will half-fill orbitals of equal energy, before any become completely filled.
 Ans: D
29. The ground state electron configuration of chlorine is shown below. Which statement concerning an atom of chlorine is FALSE?

Cl	$1s^2 2s^2 2p^6 3s^2 3p^5$
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 A) A chlorine atom has 17 total electrons.
 B) The outermost energy level in a chlorine atom is $n=3$.
 C) A chlorine atom has 5 valence electrons.
 D) A chlorine atom needs one electron to obtain an octet in its outermost energy level.
 E) A chlorine atom has 17 protons.
 Ans: C
30. In nature, the element neon exists as three different isotopes: Ne-20, Ne-21, and Ne-22. Which isotope would be the most abundant in a sample of neon?
 A) Ne-20
 B) Ne-21
 C) Ne-22
 D) All isotopes would be equally abundant.
 E) It is impossible to determine.
 Ans: A

31. How many valence electrons are present in a chloride ion, Cl^- ?
- A) 5
 B) 7
 C) 8
 D) 17
 E) 18
 Ans: C
32. Which statement correctly describes the basis for the octet rule?
- A) Atoms strive to attain eight protons in their nucleus to attain the stability of the nearest noble gas.
 B) Atoms have a tendency to form eight bonds with other atoms to attain the stability of a noble gas.
 C) Atoms will lose, gain, or share eight electrons to become a noble gas.
 D) Atoms are most stable with eight electrons in their outermost shell, and the electron configuration of a noble gas.
 E) Atoms are most stable when the number of protons they contain is identical to the noble gas closest to them in the periodic table.
 Ans: D
33. Which ion is NOT isoelectronic (i.e. has the same electron configuration) with Ar? The electron configuration of Ar is shown below.
- | | |
|----|----------------------------|
| Ar | $1s^2 2s^2 2p^6 3s^2 3p^6$ |
|----|----------------------------|
- A) Cl^-
 B) K^+
 C) Br^-
 D) Ca^{2+}
 E) S^{2-}
 Ans: C
34. The ground state electron configuration of a sulfur atom is shown below. What is the ground state electron configuration of the ion S^{2-} ?
- | | |
|---|----------------------------|
| S | $1s^2 2s^2 2p^6 3s^2 3p^4$ |
|---|----------------------------|
- A) $1s^2 2s^2 2p^6 3s^0 3p^4$
 B) $1s^2 2s^2 2p^6 3s^2 3p^6$
 C) $1s^2 2s^2 2p^6 3s^2 3p^2$
 D) $1s^2 2s^2 2p^6$
 E) $1s^2 2s^2 2p^6 3s^3 3p^5$
 Ans: B

35. Atoms with the biggest radii occur in the _____ region of the periodic table.
- A) bottom left
 - B) top right
 - C) bottom right
 - D) top left
 - E) middle
- Ans: A
36. Which best explains why an Al^{3+} ion is smaller than an Al atom?
- A) In forming the Al^{3+} ion, the Al atom loses the electrons in its outermost energy level, causing a decrease in the atomic radius.
 - B) In forming the Al^{3+} ion, the Al atom gains three protons and the resulting net positive charge keeps the electrons more strongly attracted to the nucleus, reducing the radius.
 - C) The Al^{3+} ion contains more electrons than the Al atom, which results in a greater attraction for the nucleus and a smaller atomic radius.
 - D) In forming the Al^{3+} ion, the Al atom adds electrons into a higher energy level, causing a decrease in the atomic radius.
 - E) There are more protons in an Al^{3+} ion than there are in an Al atom.
- Ans: A
37. Which element is a halogen in period 4?
- A) bromine
 - B) silicon
 - C) iodine
 - D) krypton
 - E) potassium
- Ans: A
38. Hydrogen can form two different ions: a hydrogen ion (H^+), and a hydride ion (H^-). Which statement concerning these ions is FALSE?
- A) The H^+ ion is a cation formed by the loss of one electron; this ion has no valence electrons.
 - B) The H^- ion is an anion formed by the gain of one electron; this ion has a full $n=1$ energy level.
 - C) The hydrogen ion and the hydride ion are isotopes.
 - D) The hydrogen ion and the hydride ion have the same number of protons.
 - E) The hydrogen ion and the hydride ion have different sizes.
- Ans: C

39. The element carbon forms the basis of study in Organic Chemistry. Which statement about the element carbon is FALSE?
A) Carbon is a period 2 element.
B) Carbon is a group 4 element.
C) Carbon is a nonmetal.
D) Carbon atoms have six valence electrons.
E) Carbon atoms have six protons.
Ans: D
40. What does the mass number minus the atomic number represent?
A) number of protons
B) number of electrons
C) number of neutrons
D) number of protons – number of neutrons
E) number of neutrons – number of protons
Ans: C
41. In a neutral atom, what number equals the number of electrons?
A) atomic number
B) mass number
C) mass number minus the atomic number
D) Both A and C are correct.
E) None of the choices are correct.
Ans: A
42. Given that helium has an isotope ${}^4_2\text{He}$, how many electrons does an atom of this helium isotope contain?
A) 1 B) 2 C) 4 D) 6 E) 0
Ans: B
43. How many neutrons are present in an atom of the isotope ${}^7_3\text{Li}$?
A) 3 B) 4 C) 7 D) 10 E) None of the choices are correct.
Ans: B
44. Microwaves, light, and X-rays are all forms of _____.
A) electricity
B) high energy electrons
C) electron repulsion
D) electromagnetic radiation
E) radioactivity
Ans: D
45. Where are the alkaline earth metals located on the periodic table?
A) IA (1) B) IIA (2) C) IIIA (3) D) VIIA (17) E) VIIIA (18)
Ans: B
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54. Which of the following accounts for the fact that chlorine has an atomic mass of 35.45 amu rather than a whole number?
A) isotopes B) electrons C) protons D) radioactivity E) isomers
Ans: A
55. Who discovered that cathode rays consist of a stream of negative particles, electrons?
A) Crookes B) Thomson C) Geiger D) Rutherford E) Bohr
Ans: B
56. Who discovered the existence of the atomic nucleus?
A) Crookes B) Thomson C) Geiger D) Rutherford E) Bohr
Ans: D
57. In Rutherford's experiment which led to the discovery of the atomic nucleus, what type of particle or ray was fired at the gold foil target?
A) alpha B) beta C) gamma D) neutrons E) cathode rays
Ans: A
58. In Mendeleev's table of the elements, the elements were arranged according to _____.
A) atomic number D) neutron number
B) mass number E) density
C) atomic mass
Ans: C
59. The modern periodic table is arranged according to what property?
A) atomic number D) neutron number
B) mass number E) density
C) atomic mass
Ans: A
60. What is a horizontal row of elements on the periodic table called?
A) group D) representative elements
B) period E) transition elements
C) family
Ans: B
61. What are the elements in the A-groups often called?
A) transition elements D) non-metals
B) lanthanides E) representative elements
C) metals
Ans: E

62. Which of the following elements is a metalloid?
 A) C B) Ge C) Pb D) N E) P
 Ans: B
63. Where are the halogens located on the periodic table?
 A) representative elements D) Group IIA (2)
 B) transition metals E) Group IIIA (3)
 C) Group VIIA (17)
 Ans: C
64. How many valence electrons are in an atom of carbon?
 A) 8 B) 6 C) 4 D) 1 E) 0
 Ans: C
65. What is the lowest energy sublevel of a principal level?
 A) *d* B) *e* C) *f* D) *s* E) *p*
 Ans: D
66. How many sublevels are there in the third principal energy level?
 A) 3 B) 2 C) 1 D) 0 E) 4
 Ans: A
67. How many orbitals are there in the second principal energy level?
 A) 2 B) 3 C) 1 D) 0 E) 4
 Ans: E
68. Which of the following correctly gives the electron capacity of a principal energy level in terms of the number *n*?
 A) *n* B) $2n$ C) $2n + 2$ D) n^2 E) $2n^2$
 Ans: E
69. What is the ground state electron configuration of sulfur, whose atomic number is 16?
 A) $1s^2 1p^6 2s^2 2p^6$ D) $1s^2 2s^2 2p^6 3s^2 3d^4$
 B) $1s^2 2s^2 2p^6 2d^6$ E) $1s^2 2s^2 2p^6 3s^2 2d^4$
 C) $1s^2 2s^2 2p^6 3s^2 3p^4$
 Ans: C
70. Which one of the following electron configurations is appropriate for a ground state atom?
 A) $1s^1 2s^1$ B) $1s^2 2s^1$ C) $1s^2 2s^2 2p^8$ D) $1s^2 2s^2 2p^4 3s^1$ E) $1s^2 2s^2 2p^6 3d^1$
 Ans: B
71. Which of the following elements is most likely to form a 2+ ion?
 A) Li B) K C) Al D) N E) Ca
 Ans: E

80. What can be said about the possibility of the existence of the hydrogen isotope represented by the symbol shown below?



- A) This isotope of hydrogen is not possible because it has no electrons.
- B) This isotope of hydrogen is not possible because atoms of hydrogen have one proton.
- C) This isotope of hydrogen is possible; it simply contains no protons and is an ion.
- D) This isotope of hydrogen is possible; it simply contains no neutrons.
- E) This isotope of hydrogen is possible; it simply has two neutrons.

Ans: B

81. For the imaginary element abdicinium (Ab), two isotopes exist. Isotope one has a mass of 40.005 amu with a relative abundance of 14.00%. Isotope two has a mass of 41.008 amu with a relative abundance of 86.00%. What is the atomic mass of the element?

- A) 40.99 amu B) 40.87 amu C) 40.61 amu D) 40.21 amu E) 40.05 amu

Ans: B

82. Which of the following correctly matches the ion with the total number of electrons in the ion?

- A) Br^- , 34 electrons
- B) Mg^{2+} , 14 electrons
- C) Zn^{2+} , 28 electrons
- D) P^{3-} , 15 electrons
- E) H^+ , 2 electrons

Ans: C

83. Rutherford's experiment, in which alpha particles were aimed at a thin piece of gold, led to what understanding?

- A) neutrons existed
- B) electrons existed and have a negative charge
- C) the number of electrons can be determined by the mass number and atomic number
- D) electrons can be promoted to higher energy by absorbing energy
- E) an atom is mostly empty space

Ans: E

84. What property of light is defined by the distance between identical points on adjacent waves?

- A) energy B) speed C) wavelength D) spectrum E) amplitude

Ans: C

85. Which statement is true concerning Bohr's model of an atom?

- A) The model involved the study of helium.
- B) The model led to the understanding that the energy of an electron is quantized.
- C) When electrons in an excited state return to the ground state, they absorb light.
- D) Bohr's model explains that electrons have a negative charge.
- E) The model defines the existence of orbitals.

Ans: B

86. Which of the following is a metal in the third period?
A) Ge B) Cl C) Ca D) Mg E) Cu
Ans: D
87. Which of the following is a representative nonmetal?
A) P B) K C) Si D) Ni E) Al
Ans: A
88. How many valence electrons are in Na, O and He, respectively?
A) 1, 6, 8 B) 11, 8, 8 C) 1, 6, 2 D) 11, 8, 2 E) 2, 4, 2
Ans: C
89. Which sublevel has the lowest energy?
A) 2s B) 3p C) 4p D) 4s E) 2p
Ans: A
90. What is the ground state (shorthand) electron configuration of Se?
A) [Kr] D) [Ar]4s² 4d¹⁰ 4p⁶
B) [Ar]4s² 4p⁴ E) [Ar]4s² 3d¹⁰ 4p⁴
C) [Kr]4s² 4p⁴
Ans: E
91. Which of the following gives the correct charge of the ion according to the octet rule?
A) F⁺ B) Ba²⁻ C) S²⁻ D) P³⁺ E) C²⁺
Ans: C
92. Why do atoms gain and lose electrons to have eight electrons in the valence shell?
A) Atoms/ions are stable when the n=2 principal level is full.
B) Atoms/ions are stable when the s and p sublevels of the valence shell are full.
C) Atoms/ions are stable when the d sublevel of the valence shell is full.
D) Atoms/ions are stable when the n=4 principal level is full.
E) Atoms/ions are stable when the s, p, and d sublevels of the 2nd level are full.
Ans: B
93. Which of the following atoms and ions will have the largest radius?
A) S²⁻ B) S C) Cl D) F E) He
Ans: A
94. What is the energy required to remove an electron from an isolated atom?
A) electron affinity D) kinetic energy
B) electronegativity E) potential energy
C) ionization energy
Ans: C
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95. In the calcium atom represented by the symbol ${}^{40}_{20}\text{Ca}$, there are 20 protons, 20 neutrons, and 20 electrons.
Ans: True
96. All atoms of a particular element have identical chemical properties.
Ans: True
97. An atom cannot be created, divided, destroyed, or converted to any other type of atom.
Ans: False
98. The atomic number of an ion indicates the number of protons that are present.
Ans: True
99. If an atom gains one electron, it becomes an anion.
Ans: True
100. The first experimentally based theory of atomic structure was proposed by John Dalton.
Ans: True
101. J. J. Thomson was the first to state that an atom is mostly empty space.
Ans: False
102. Bohr was the first to use the term “orbit” to explain the fixed energy levels of electrons.
Ans: True
103. Niels Bohr developed a theory that accounted for the lines in the visible region of the hydrogen spectrum.
Ans: True
104. In Mendeleev's table, the elements were arranged according to their atomic mass.
Ans: True
105. There are nine periods on the periodic table.
Ans: False
106. Sulfur (S) is one of the representative elements.
Ans: True
107. Europium (Eu) is a lanthanide element.
Ans: True
108. Arsenic (As) is a metalloid.
Ans: True
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109. Valence electrons are involved when atoms form bonds.
Ans: True
110. Atoms of the noble gas elements, Group VIII A (18), do not form bonds with any other elements.
Ans: False
111. There are eight valence electrons in a chlorine anion.
Ans: True
112. The ions formed from Group IIA (2) atoms have charges of 2+.
Ans: True
113. Cations tend to be formed from metal atoms, while anions are formed from non-metal atoms.
Ans: True
114. The atoms of smallest radius are those of elements in top left hand part of the periodic table.
Ans: False
117. The halogens, Group VII A (17), have the lowest ionization energies of any group in the periodic table.
Ans: False
118. The last period in the periodic table is incomplete.
Ans: True