

Test Review No 3

Skills

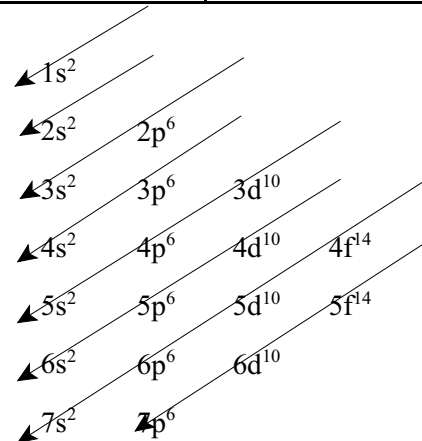
- What is the Heisenberg Uncertainty Principle and how does it affect Bohr's model
- Describe Schrödinger's model (the quantum mechanical model) of the atom
- Distinguish between s, p, d, and f sublevels
- Distinguish between principal energy levels and sublevels and know the types and numbers of sublevels and orbitals found in the first 3 principal energy levels.
- Distinguish between protons, neutrons and electrons. Compare their charges, masses, functions and locations in the atom
- Distinguish between atomic number and mass number
- Be able to write electron configurations in sublevel notation, Bohr notation, and orbital notation
- Understand Pauli's Exclusion principle, the Aufbau's principal and Hund's rule
- Be able to determine how many valence electrons and core electrons an element contains

Location of electrons. Electrons are in regions of the atom known as orbitals, which are found in subdivisions of the principal energy levels called sublevels. There are up to seven principal energy levels designated by a quantum number, n , from 1 to 7. The maximum number of sublevels in a principal energy level is n , but none of the existing elements use more than 4 sublevels even in principal energy levels 5–7. Sublevels are designated by the letters s, p, d, and f, in increasing order of energy. Orbitals are regions within a sublevel where electrons of a given energy are likely to be found. There are a maximum of 2 electrons in an orbital. The number of orbitals within a sublevel varies in a predictable pattern. The number of orbitals within a sublevel and the maximum number of electrons is as follows:

Sublevel	s	p	d	f
Number of orbitals	1	3	5	7
Maximum Number of Electrons	2	6	10	14

Rules describing the distribution of electrons. The number of electrons equals the atomic number. Electrons occupy orbitals in sequence beginning with those of the lowest energy. In a given sublevel, a second electron is not added to an orbital until each orbital in the sublevel contains one electron. No more than four orbitals are occupied in the outermost principal energy level

Element	Atomic Number	Sublevel structure	Orbital notation
boron	5	$1s^2 2s^2 2p^1$	$\begin{array}{c} \uparrow\downarrow \quad \uparrow\downarrow \quad \uparrow \\ \hline 1s \quad 2s \quad 2p \end{array}$
oxygen	8	$1s^2 2s^2 2p^4$	$\begin{array}{c} \uparrow\downarrow \quad \uparrow\downarrow \quad \uparrow\downarrow \quad \uparrow \\ \hline 1s \quad 2s \quad 2p \end{array}$
argon	18	$1s^2 2s^2 2p^6 3s^2 3p^6$	$\begin{array}{c} \uparrow\downarrow \quad \uparrow\downarrow \quad \uparrow\downarrow \quad \uparrow\downarrow \quad \uparrow\downarrow \quad \uparrow\downarrow \\ \hline 1s \quad 2s \quad 2p \quad 3s \quad 3p \end{array}$



Maximum number of electrons. As a result of the way the rules are applied for determining the maximum number of electrons per orbital, orbitals per sublevel, and sublevels per principal energy level, for any given principal energy level, n , the maximum number of orbitals is n^2 , and the maximum number of electrons is $2n^2$. An outer energy level, however, never has more than 8 electrons even if it has the room.

Principal Energy Level(n)	Number of Orbitals (n ²)	Electrons per Sublevel							Maximum Number of Electrons (2n ²)	
		s	p	d	f	g	h	i		
		1	3	5	7	9	11	13		
Electrons in each Location	1	1	2	-	-	-	-	-	-	2
	2	4	2	6	-	-	-	-	-	8
	3	9	2	6	10	-	-	-	-	18
	4	16	2	6	10	14	-	-	-	32
	5	25	2	6	10	14	18	-	-	50
	6	36	2	6	10	14	18	22	-	72
	7	49	2	6	10	14	18	22	26	98

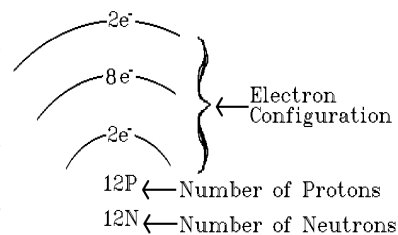
Subatomic particles.

Type of Particle	Location	Mass	Relative Mass	Charge
Proton	Center	1.67×10^{-27} kg	1	+1
Electron	Outside	9.11×10^{-31} kg	0	-1
Neutron	Center	1.67×10^{-27} kg	1	0

Neutrons. Neutrons were discovered by Sir James Chadwick in 1932. The existence of neutral particle was the only way to explain how atoms of an element could have different masses. Atoms of an element with different masses are called isotopes. The symbols for isotopes are written as follows: ${}^A_Z X$, where X = element; A = atomic mass number (mass of isotope); and Z = atomic number (number of protons). The number of neutrons (N) is determined as follows: $N = A - Z$. The isotopes of hydrogen, for example, all have one proton, but different numbers of neutrons: ${}^1_1 H$ has no neutrons, ${}^2_1 H$ has one neutron, and ${}^3_1 H$ has two neutrons.

Bohr Diagrams. Bohr diagrams show the number of protons and neutrons in the nucleus, and the distribution of electrons around the nucleus in energy levels. Atomic diagrams are extremely useful in predicting the ratios in which elements will combine. The information needed to draw atomic diagrams is found on the periodic table. The periodic table shows the atomic number which equals the number of protons or electrons, the atomic mass, and the electron configuration. It does not show the number of neutrons, but this can be determined by subtracting the atomic number from the atomic mass. This information can be used to draw a diagram.

Electron Dot Diagrams. Electron dot diagrams are a useful way to show the arrangement of outer electrons of an atom. They show valence electrons as dots at 12 o'clock, 3 o'clock, 6 o'clock, and 9 o'clock, and the rest of the atom, known as the kernel, as a symbol. Each of the clock positions represents one of the four outer orbitals. An orbital can hold a maximum of two electrons. The first orbital, represented by any one of the clock positions, is filled with a pair of electrons before putting electrons into the other orbitals. The remaining three orbitals each receive one electron before pairing occurs. Silicon, for example, has four valence electrons. As a result, it will have two electrons in one of the clock positions and one electron in each of two of the remaining three.



Average Atomic Mass

The atomic mass listed on the *Periodic Table* is the average mass of the isotopes. Carbon, for example, has two naturally occurring stable isotopes. The large majority of carbon atoms, 98.89%, are ^{12}C , while only 1.108% are ^{13}C . That is why the average mass is so close to 12.

The average mass is determined by the procedure illustrated in the box to the right. The mass of each isotope is multiplied by its percentage. Then these products are added to find the average.

Development of the Periodic Table. Dmitri Mendeleev (1869) prepared a card for each of the known elements listing the symbol, the atomic mass, and the chemical properties. He arranged the cards in order of increasing

atomic mass and noticed a pattern: *MENDELEEV'S PERIODIC LAW* – When the elements are arranged in increasing order of atomic mass, the chemical properties repeat themselves periodically. Moseley noticed that when all the elements were arranged in order of mass a few were not in the right family with respect to properties. He used a procedure called X-ray diffraction to determine the atomic number of the elements. When the elements were arranged in increasing order of atomic number, the discrepancies in Mendeleev's table disappeared. *THE PERIODIC LAW* – When the elements are arranged in increasing order of atomic number, the chemical properties repeat themselves periodically. The modern Periodic Table is arranged in order of increasing atomic number

Average Atomic Mass

$$m_{\text{avg}} = p_1m_1 + p_2m_2 + \dots p_nm_n$$

m_{avg} – average mass; p_1 – percentage of isotope 1;
 m_1 – mass of isotope 1; p_2 – percentage of isotope 2;
 m_2 – mass of isotope 2; p_n – percentage of isotope n ;
 m_n – mass of isotope n ; n – the number of isotopes

Example

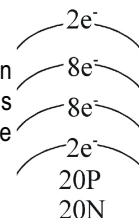
What is the average mass of chlorine if a sample consists of 77.35% Cl-35 and 22.65% Cl-37 ?

$$\begin{aligned} m_{\text{avg}} &= (0.7735)(35) &+& (0.2265)(37) \\ &= 27.07 &+& 8.381 \\ &= 35.45 \end{aligned}$$

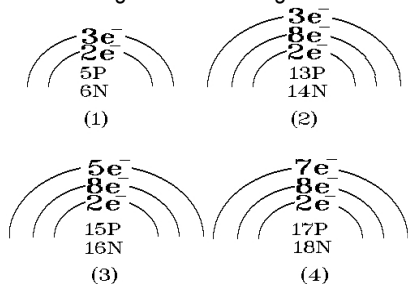
Answer the questions below by circling the number of the correct response

- What is the maximum number of orbitals in the second principal energy level? (1) 1 (2) 2 (3) 3 (4) 4
- The sublevel of lowest energy is (1) 2s (2) 3s (3) 2p (4) 3d
- What is the number of orbitals in a 4d sublevel? (1) 1 (2) 5 (3) 3 (4) 7
- A neutral atom in the ground state has an atomic number of 8. How many electrons are in the 2p sublevel? (1) 1 (2) 2 (3) 3 (4) 4
- What is the maximum number of orbitals in a d sublevel? (1) 1 (2) 5 (3) 3 (4) 7
- Which orbital in an atom of calcium would contain electrons with the highest energy? (1) 3s (2) 3p (3) 2p (4) 4s
- A completely filled principal energy level contains 32 electrons. The principal quantum number (n) of this level is (1) 5 (2) 2 (3) 3 (4) 4
- What is the maximum number of electrons in the third principal energy level? (1) 6 (2) 2 (3) 10 (4) 18
- In the third principal energy level, the sublevel of highest energy is (1) s (2) p (3) f (4) d
- A completely filled principal energy level contains 8 electrons. The principal energy level is number (1) 5 (2) 2 (3) 3 (4) 4
- What is the maximum number of electrons in the first principal energy level? (1) 6 (2) 2 (3) 10 (4) 18
- How many f orbitals have the value $n = 3$? (1) 0 (2) 3 (3) 5 (4) 7 (5) 1
- How many electrons can be contained in all of the orbitals with $n = 4$? (1) 2 (2) 8 (3) 10 (4) 18 (5) 32
- Unlike in an orbit, in an orbital (1) an electron's position cannot be known precisely. (2) an electron has no energy. (3) electrons cannot be found. (4) protons cannot be found.
- How many electrons are needed to completely fill the fourth energy level? (1) 8 (2) 18 (3) 32 (4) 40
- One main energy level can hold 18 electrons. What is n ? (1) +1 (2) 3 (3) 6 (4) 18
- The electron configuration of an atom is $1s^22s^22p^63s^23p^3$. The atomic number of the atom is (1) 15 (2) 6 (3) 3 (4) 5
- The total number of protons in the nucleus of the element $1s^22s^22p^63s^23p^2$ is (1) 7 (2) 8 (3) 14 (4) 28
- What is the total number of protons in the nucleus of the atom $1s^22s^22p^63s^23p^4$? (1) 5 (2) 11 (3) 16 (4) 27
- Which electron configuration represents an atom in an excited state? (1) $1s^22s^22p^64s^1$ (2) $1s^22s^22p^6$ (3) $1s^22s^2$ (4) $1s^22s^22p^63s^23p^1$
- Which is the electron configuration for a neutral atom with an Atomic Number of 18? (1) $1s^22s^22p^63s^13p^7$ (2) $1s^22s^22p^63s^23p^6$ (3) $1s^22s^22p^63s^73p^1$ (4) $1s^22s^22p^63s^23p^4$

22. An atom with the electron configuration $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$ has an incomplete (1) 2nd principal energy level (2) 2s sublevel (3) 3rd principal energy level (4) 3s sublevel
23. The electron configuration of a phosphorous atom is (1) $1s^2 2s^2 2p^3$ (2) $1s^2 2s^2 2p^6 3s^2 3p^3$ (3) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$ (4) $1s^2 2s^2 2p^1$
24. How many orbitals are half filled in an atom: $1s^2 2s^2 2p^6 3s^2 3p^4$ of this element in the ground state? (1) 1 (2) 2 (3) 3 (4) 6
25. A neutral atom in the ground state has an atomic number of 8. How many electrons are in the 2p sublevel? (1) 1 (2) 2 (3) 3 (4) 4
26. What is the electron configuration for a neutral atom of the radioisotope $^{32}_{15}\text{P}$ in its ground state? (1) $1s^2 2s^2 2p^6 3s^2 3p^2$ (2) $1s^2 2s^2 2p^6 3s^1 3p^4$ (3) $1s^2 2s^2 2p^6 3s^2 3p^3$ (4) $1s^2 2s^2 2p^6 3s^2 3p^6$
27. The element with electron configuration $1s^2 2s^2 2p^6 3s^2 3p^2$ is (1) Mg ($Z = 12$) (2) C ($Z = 6$) (3) S ($Z = 16$) (4) Si ($Z = 14$)
28. The electron configuration for an atom is $1s^2 2s^2 2p^2$. The atomic number is (1) 3 (2) 6 (3) 11 (4) 12
29. What is the electron configuration for nitrogen, atomic number 7? (1) $1s^2 2s^2 2p^3$ (2) $1s^2 2s^3 2p^2$ (3) $1s^2 2s^3 2p^1$ (4) $1s^2 2s^2 2p^2 3s^1$
30. The electron notation for aluminum is (1) $1s^2 2s^2 2p^3 3s^2 3p^3 3d^1$ (2) $1s^2 2s^2 2p^6 3s^2 3p^1$ (3) $1s^2 2s^2 2p^6 3s^2 2d^1$ (4) $1s^2 2s^2 2p^9$
31. What is the number of filled orbitals in a neutral atom of sulfur-32 in the ground state? (1) 1 (2) 6 (3) 7 (4) 9
32. Which represents the outermost electron configuration of an Na atom in the ground state? (1) $1s^1$ (2) $2s^1$ (3) $3s^1$ (4) $4s^1$
33. What is a possible electronic configuration of a nitrogen atom? (1) $1s^1 2s^3 2p^3$ (2) $1s^2 2s^2 2p^3$ (3) $1s^2 2s^3 2p^2$ (4) $1s^3 2s^3 2p^1$
34. What is the total number of unpaired electrons in an atom with the electron configuration $1s^2 2s^2 2p^6 3s^2 3p^4$? (1) 6 (2) 2 (3) 3 (4) 4
35. Which of the following is the correct orbital notation for oxygen?
 (1) $\frac{\uparrow\downarrow}{1s} \frac{\uparrow\downarrow}{2s} \frac{\uparrow\downarrow\uparrow}{2p} \frac{\uparrow}{2p}$ (2) $\frac{\uparrow\downarrow}{1s} \frac{\uparrow\downarrow}{2s} \frac{\uparrow\downarrow\uparrow\downarrow}{2p}$
 (3) $\frac{\uparrow\uparrow}{1s} \frac{\uparrow\uparrow}{2s} \frac{\uparrow\uparrow\uparrow}{2p} \frac{\uparrow}{2p}$ (4) $\frac{\uparrow}{1s} \frac{\uparrow}{2s} \frac{\uparrow}{2p} \frac{\uparrow}{2p} \frac{\uparrow}{3s} \frac{\uparrow}{3p}$
36. A neutral atom always has an equal number of (1) neutrons and electrons, (2) neutrons and protons, (3) protons and electrons, (4) protons, electrons, and neutrons.
37. How many electrons does potassium have in its 4th principal energy level? (1) 1 (2) 2 (3) 3 (4) 4
38. What is the atomic number of helium? (1) 1 (2) 2 (3) 3 (4) 4
39. Which of the following represents the electron configuration of an atom in the ground state? (1) 2-8-8-2 (2) 2-8-9-1 (3) 2-8-10 (4) 2-8-8-1-1
40. The atomic number of an atom with an electron configuration 2-8-18-2 is (1) 64, (2) 2, (3) 30, (4) 35.
41. Which of the following particles is negatively charged? (1) electron (2) proton (3) neutron (4) cation
42. How many neutrons does $^{35}_{17}\text{Cl}$ have? (1) 35 (2) 17 (3) 52 (4) 18
43. Isotopes are atoms which have different (1) atomic masses, (2) atomic radii, (3) atomic numbers, (4) electron configurations
44. An atom that contains 35 protons, 45 neutrons, and 35 electrons has an atomic number of (1) 35, (2) 80, (3) 45, (4) 115
45. Two isotopes of the same element will have the same number of (1) neutrons and electrons, (2) neutrons and nucleons, (3) protons and nucleons, (4) protons and electrons
46. An atomic mass unit is defined as exactly (1) $\frac{1}{12}$ the mass of a ^{12}C atom, (2) $\frac{1}{14}$ the mass of a ^{14}N atom, (3) $\frac{1}{16}$ the mass of a ^{16}O atom, (4) $\frac{1}{19}$ the mass of a ^{19}F atom
47. Which correctly represents an atom of neon containing 11 neutrons? (1) $^{11}_{10}\text{Ne}$ (2) $^{21}_{10}\text{Ne}$ (3) $^{20}_{11}\text{Ne}$ (4) $^{21}_{11}\text{Ne}$
48. How many electrons are in a neutral atom of ^7_3Li ? (1) 7 (2) 10 (3) 3 (4) 4
49. The nucleus of a fluorine atom has a charge of (1) 1^+ , (2) 19^+ , (3) 9^+ , (4) 0
50. What is the total number of neutrons in an atom of $^{39}_{19}\text{K}$? (1) 19 (2) 20 (3) 39 (4) 58
51. Hydrogen-3 differs from hydrogen-1 in that hydrogen-3 has (1) 1 more proton, (2) 2 more protons, (3) 1 more neutron, (4) 2 more neutrons.
52. What is the mass number of carbon-14? (1) 12 amu (2) 14 amu (3) 6 amu (4) 8 amu
53. The property of all carbon atoms that is the same is (1) the mass, (2) the number of neutrons, (3) the number of protons, (4) the number of nucleons [particles in the nucleus]
54. To the right is a Bohr-Rutherford diagram of an element. Which element could be represented by this diagram? (1) calcium (2) cadmium (3) chlorine (4) no known element

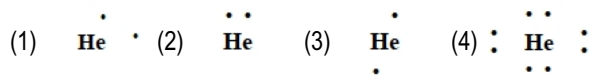


55. Which of the following is a correct diagram of aluminum [Al]?



56. The number of neutrons in a typical atom with an electron configuration of 2-8-7 is (1) 17, (2) 18, (3) 35, (4) 7.

57. Which of the following is the correct electron dot diagram for helium?



58. Frisium comes in three isotopes with the following abundances: 90.000 percent Fs-500; 8.0000 percent Fs-501; and 2.0000 percent Fs-503. The average mass is (1) 598.2 amu (2) 501.33 amu (3) 499.85 amu (4) 500.14 amu

For questions 59-69, which of the following describes (1) protons only, (2) electrons only, (3) neutrons only, (4) protons and neutrons only, (5) protons and electrons only, (6) protons, electrons, and neutrons.

- 59. Positively charged
- 60. Subatomic particle
- 61. Charged particle
- 62. Particle with a mass of 1 amu
- 63. Negatively charged
- 64. Affects the mass of an atom, but not the properties
- 65. Affects the properties of an atom, but not the mass
- 66. Affects the properties of an atom, and the mass
- 67. Neutral particle
- 68. Revolves around the nucleus
- 69. Found in the nucleus

- 70. Name the subatomic particles contained in the nucleus of the atom.
- 71. State the charge associated with each type of subatomic particle contained in the nucleus of the atom.

- 72. How many protons, neutrons and electrons are in Uranium-238? The symbol is U.
- 73. Suppose you measure the temperature of a hot cup of tea with a cold thermometer. How does the use of a cold thermometer affect the temperature reading? How is this analogous to the uncertainty principle?
- 74. In the Periodic Table, the elements are arranged in order of increasing (1) atomic size, (2) atomic number, (3) atomic mass, (4) ionization energy
- 75. The chemical properties of the elements are periodic functions of their atomic (1) spin, (2) isotopes, (3) mass, (4) number

Answers

1.	4	22	3	43	1	64	3
2.	1	23	2	44	1	65	2
3.	2	24	2	45	4	66	1
4.	4	25	4	46	1	67	3
5.	2	26	3	47	2	68	2
6.	4	27	4	48	3	69	4
7.	4	28	2	49	3	70	protons, neutrons
8.	4	29	1	50	2	71	p = +1; n = 0
9.	4	30	2	51	4	72	92 protons, 146 neutrons, 92 electrons
10.	2	31	3	52	2	73	A cold thermometer absorbs heat from the cup of tea. As a result of the measurement, you can't be certain what the temperature was before measuring.
11.	2	32	3	53	3	74	2
12.	1	33	2	54	1	75	4
13.	5	34	2	55	2		
14.	1	35	1	56	2		
15.	3	36	3	57	2		
16.	2	37	1	58	4		
17.	1	38	2	59	1		
18.	3	39	1	60	6		
19.	3	40	3	61	5		
20.	1	41	1	62	4		
21.	2	42	4	63	2		