Chemistry A: Form TR3-18A Name _____

REVIEW Date _____ Period _____

Test Review № 3

Skills

- Describe Bohr's model of the atom and how it explains the line spectra emitted by elements.
- 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

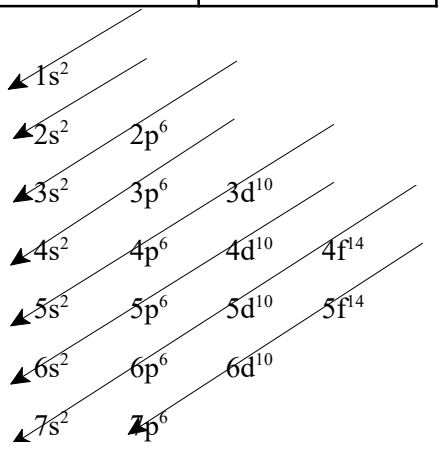
The Bohr Model. Bohr developed a model of the atom with circular pathways for the electron. These pathways were at fixed distances from the nucleus. Electrons could be found only in these circular pathways. If an electron absorbed enough energy, it could jump up to another level, but it could never be found between levels. Inevitably, the electron lost energy and fell back down to a previous level, giving off the extra energy as a specific frequency of light. Bohr had a complex equation into which he could substitute simple numbers, integers such as 1, 2, or 3, and the equation predicted the frequencies of the light. These mystery numbers represented the energy levels of the electrons. Bohr's evidence for his model was the bright line spectra formed when electrons fell from the excited state back to the ground state.

Wave Mechanical Model. The Bohr model successfully explained the bright line spectra for hydrogen, but could not explain the spectra of atoms with more electrons. The wave mechanical model solved the problem. Thinking of the electron as a standing wave also helps to explain why the electron's energy is quantized. The wave mechanical model describes the location of electrons a their most probable location rather than as orbits with fixed radii. The regions where elections are most probably found are called orbitals. An orbital can hold, at most, two electrons.

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	$1s^2 2s^2 2p^1$	↑↓ ↑↓ ↑ _ _ (1s 2s 2p)
oxygen	8	$1s^2 2s^2 2p^4$	↑↓ ↑↓ ↑↓ ↑ ↑ (1s 2s 2p)
argon	18	$1s^2 2s^2 2p^6 3s^2 3s^6$	↑↓ ↑↓ ↑↓ ↑↓ ↑↓ ↑↓ ↑↓ ↑↓ ↑↓ (1s 2s 2p 3s 3p)

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.

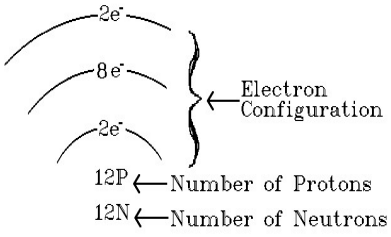
Principal Energy Level(*n*)		Number of Orbitals (n^2)	Electrons per Sublevel							Maximum Number of Electrons ($2n^2$)
			s	p	d	f	g	h	i	
			1	3	5	7	9	11	13	
Electrons in each Location	1	1	2	-	-	-	-	-	-	2
	2	4	2	6	-	-	-	-	-	8
	3	9	2	6	10	-	-	-	-	18
	4	16	2	6	10	14	-	-	-	32
	5	25	2	6	10	14	18	-	-	50
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

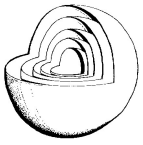
Neutrons. Neutrons were discovered by Sir James Chadwick in 1932. The existence of neutral particle was the only way to explain how atoms of an element could have different masses. Atoms of an element with different masses are called isotopes. The symbols for isotopes are written as follows: ${}^{A}_{Z}\mathrm{X}$, 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: ${}^{1}_{1}\mathrm{H}$ has no neutrons, ${}^{2}_{1}\mathrm{H}$ has one neutron, and ${}^{3}_{1}\mathrm{H}$ 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.



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

1. Which of the following particles is negatively charged? (1) electron (2) proton (3) neutron (4) cation

2. Whose model of the atom could be represented by the diagram to the right?

(1) Dalton
(2) Thomson
(3) Rutherford
(4) Bohr

3. Evidence that electrons exist in distinct energy levels outside the nucleus is provided by (1) cathode rays, (2) spectral lines, (3) atomic masses, (4) radioactivity.

4. When excited electrons return to the ground state, they lose excess energy in the form of (1) light, (2) gamma rays, (3) nuclear radiation, (4) sound.

5. The product of the frequency and the wavelength of a wave equals the (1) number of waves passing a point in a second, (2) speed of the wave, (3) distance between wave crests, (4) time for one full wave to pass.

6. Visible light, X rays, infrared radiation, and radio waves all have the same (1) energy. (2) wavelength. (3) speed. (4) frequency.

7. When the pink-colored light of glowing hydrogen gas passes through a prism, it is possible to see (1) all the colors of the rainbow. (2) only lavender-colored lines. (3) four lines of different colors. (4) black light.

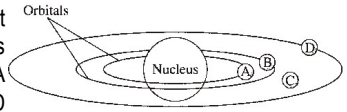
8. Bohr's theory helped explain why (1) electrons have negative charge. (2) most of the mass of the atom is in the nucleus. (3) excited hydrogen gas gives off certain colors of light. (4) atoms combine to form molecules.

9. Bohr's model of the atom works best in explaining (1) the spectra of the first ten elements. (2) only the spectrum of hydrogen. (3) only the spectra of atoms with electrons in an s orbital. (4) the entire visible spectra of atoms.

10. According to Bohr's theory, an excited atom would (1) collapse. (2) absorb photons. (3) remain stable. (4) radiate energy.

11. According to the Bohr model of the atom, the single electron of a hydrogen atom circles the nucleus (1) in specific, allowed orbits. (2) in one fixed orbit at all times. (3) at any of an infinite number of distances, depending on its energy. (4) counterclockwise.

12. According to Bohr, electrons cannot reside at which of the labeled points in the figure to the right? (1) point A (2) point B (3) point C (4) point D



13. The modern model of the atom shows that electrons are (1) orbiting the nucleus in fixed paths, (2) found in regions called orbitals, (3) combined with neutrons in the nucleus, (4) located in a solid sphere covering the nucleus

14. The characteristic bright-line spectrum of an element is produced when electrons (1) fall back to lower energy levels, (2) are gained by a neutral atom, (3) are emitted by the nucleus as beta particles, (4) move to higher energy levels

15. What is the maximum number of orbitals in the second principal energy level? (1) 1 (2) 2 (3) 3 (4) 4

16. The sublevel of lowest energy is (1) 2s (2) 3s (3) 2p (4) 3d

17. What is the number of orbitals in a 4d sublevel? (1) 1 (2) 5 (3) 3 (4) 7

18. 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

19. What is the maximum number of orbitals in a d sublevel? (1) 1 (2) 5 (3) 3 (4) 7

20. Which orbital in an atom of calcium would contain electrons with the highest energy? (1) 3s (2) 3p (3) 2p (4) 4s

21. 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

22. What is the maximum number of electrons in the third principal energy level? (1) 6 (2) 2 (3) 10 (4) 18

23. In the third principal energy level, the sublevel of highest energy is (1) s (2) p (3) f (4) d

24. A completely filled principal energy level contains 8 electrons. The principal energy level is number (1) 5 (2) 2 (3) 3 (4) 4

25. What is the maximum number of electrons in the first principal energy level? (1) 6 (2) 2 (3) 10 (4) 18

26. In Bohr's atomic theory, when an electron moves from one energy level to another energy level more distant from the nucleus (1) energy is emitted. (2) energy is absorbed. (3) no change in energy occurs. (4) light is emitted. (5) none of these

27. How many f orbitals have the value $n = 3$? (1) 0 (2) 3 (3) 5 (4) 7 (5) 1

28. How many electrons can be contained in all of the orbitals with $n = 4$? (1) 2 (2) 8 (3) 10 (4) 18 (5) 32

29. Which model of the atom explains the orbitals of electrons as waves? (1) the Bohr model (2) the quantum model (3) Rutherford's model (4) Planck's theory

30. 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.

31. How many electrons are needed to completely fill the fourth energy level? (1) 8 (2) 18 (3) 32 (4) 40

32. One main energy level can hold 18 electrons. What is n? (1) +1 (2) 3 (3) 6 (4) 18

33. The electron configuration of an atom is $1s^2 2s^2 2p^6 3s^2 3p^3$. The atomic number of the atom is (1) 15 (2) 6 (3) 3 (4) 5

34. The total number of protons in the nucleus of the element $1s^2 2s^2 2p^6 3s^2 3p^2$ is (1) 7 (2) 8 (3) 14 (4) 28

35. What is the total number of protons in the nucleus of the atom $1s^2 2s^2 2p^6 3s^2 3p^4$? (1) 5 (2) 11 (3) 16 (4) 27

36. Which electron configuration represents an atom in an excited state? (1) $1s^2 2s^2 2p^6 4s^1$ (2) $1s^2 2s^2 2p^6$ (3) $1s^2 2s^2$ (4) $1s^2 2s^2 2p^6 3s^2 3p^1$

37. Which is the electron configuration for a neutral atom with an Atomic Number of 18? (1) $1s^2 2s^2 2p^6 3s^1 3p^7$ (2) $1s^2 2s^2 2p^6 3s^2 3p^6$ (3) $1s^2 2s^2 2p^6 3s^7 3p^1$ (4) $1s^2 2s^2 2p^8 3s^2 3p^4$

38. 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

39. 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) $1s^2 2s^2 2p^1$

40. 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

41. 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

42. What is the electron configuration for a neutral atom of the radioisotope $_{15}P^{32}$ 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) $1s^2 2s^2 2p^6 3s^2 3p^6$

43. 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 ($Z = 14$)

44. 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

45. 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) $1s^2\ 2s^2\ 2p^2\ 3s^1$

46. 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) $1s^2\ 2s^2\ 2p^9$

47. 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

48. Which represents the outermost electron configuration of an Na atom in the ground state? (1) $1s^1$ (2) $2s^1$ (3) $3s^1$ (4) $4s^1$

49. 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) $1s^3 2s^3 2p^1$

50. 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

51. 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.

52. How many electrons does potassium have in its 4th principal energy level? (1) 1 (2) 2 (3) 3 (4) 4

53. What is the atomic number of helium? (1) 1 (2) 2 (3) 3 (4) 4

54. 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

55. The atomic number of an atom with an electron configuration 2–8–18–2 is (1) 64, (2) 2, (3) 30, (4) 35.

56. Which of the following particles is negatively charged? (1) electron (2) proton (3) neutron (4) cation

57. How many neutrons does $^{35}_{17}\mathrm{Cl}$ have? (1) 35 (2) 17 (3) 52 (4) 18

58. Isotopes are atoms which have different (1) atomic masses, (2) atomic radii, (3) atomic numbers, (4) electron configurations

59. An atom that contains 35 protons, 45 neutrons, and 35 electrons has an atomic number of (1) 35, (2) 80, (3) 45, (4) 115

60. 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

61. An atomic mass unit is defined as exactly (1) $^1/_{12}$ the mass of a ^{12}C atom, (2) $^1/_{14}$ the mass of a ^{14}N atom, (3) $^1/_{16}$ the mass of a ^{16}O atom, (4) $^1/_{19}$ the mass of a ^{19}F atom

62. Which correctly represents an atom of neon containing 11 neutrons? (1) $^{11}_{10}\mathrm{Ne}$ (2) $^{21}_{10}\mathrm{Ne}$ (3) $^{20}_{11}\mathrm{Ne}$ (4) $^{21}_{11}\mathrm{Ne}$

63. How many electrons are in a neutral atom of $^{7}_{3}\mathrm{Li}$? (1) 7 (2) 10 (3) 3 (4) 4

64. The nucleus of a fluorine atom has a charge of (1) 1^+, (2) 19^+, (3) 9^+, (4) 0

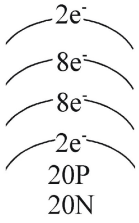
65. What is the total number of neutrons in an atom of $^{39}_{19}\mathrm{K}$? (1) 19 (2) 20 (3) 39 (4) 58

66. 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.

67. What is the mass number of carbon–14? (1) 12 amu (2) 14 amu (3) 6 amu (4) 8 amu

68. 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]

69. Below 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

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

71. 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.

For questions 72-82, 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.

72. Positively charged

73. Subatomic particle

74. Charged particle

75. Particle with a mass of 1 amu

76. Negatively charged

77. Affects the mass of an atom, but not the properties

78. Affects the properties of an atom, but not the mass

79. Affects the properties of an atom, and the mass

80. Neutral particle

81. Revolves around the nucleus

82. Found in the nucleus

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83. Name the subatomic particles contained in the nucleus of the atom.

84. State the charge associated with each type of subatomic particle contained in the nucleus of the atom.

85. How many protons, neutrons and electrons are in Uranium-238? The symbol is U.

86. How does the Bohr model explain the appearance of an emission spectrum for hydrogen? What type of spectrum is observed?

87. Which postulate of Bohr's model is no longer true? Which postulate of Bohr's model is still true today?

88. 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?

89. A student sees that Strontium emits a red color in the flame test. How can the student determine if this is the only electronic transition in the visible spectrum? Briefly explain

Answers

1.	1	28.	5	55.	3	82.	4
2.	4	29.	2	56.	1	83.	protons, neutrons
3.	2	30.	1	57.	4	84.	$p = +1$; $n = 0$
4.	1	31.	3	58.	1	85.	92 protons, 146 neutrons, 92 electrons
5.	2	32.	2	59.	1		
6.	3	33.	1	60.	4	86.	Bohr says excited electrons lose energy in the form of light. The spectrum is a line spectrum because electron energy is quantized.
7.	3	34.	3	61.	1		
8.	3	35.	3	62.	2		
9.	2	36.	1	63.	3		
10.	4	37.	2	64.	3		
11.	1	38.	3	65.	2	87.	Bohr's idea that electrons move in fixed circular pathways is no longer accepted, but his idea that electron energies are quantized is.
12.	3	39.	2	66.	4		
13.	2	40.	2	67.	2		
14.	1	41.	4	68.	3		
15.	4	42.	3	69.	1		
16.	1	43.	4	70.	2		
17.	2	44.	2	71.	2	88.	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.
18.	4	45.	1	72.	1		
19.	2	46.	2	73.	6		
20.	4	47.	3	74.	5		
21.	4	48.	3	75.	4		
22.	4	49.	2	76.	2		
23.	4	50.	2	77.	3	89.	If the red light given off by strontium is examined through a prism or diffraction grating, it will show specific frequencies that correspond to electron transitions.
24.	2	51.	3	78.	2		
25.	2	52.	1	79.	1		
26.	2	53.	2	80.	3		
27.	1	54.	1	81.	2		