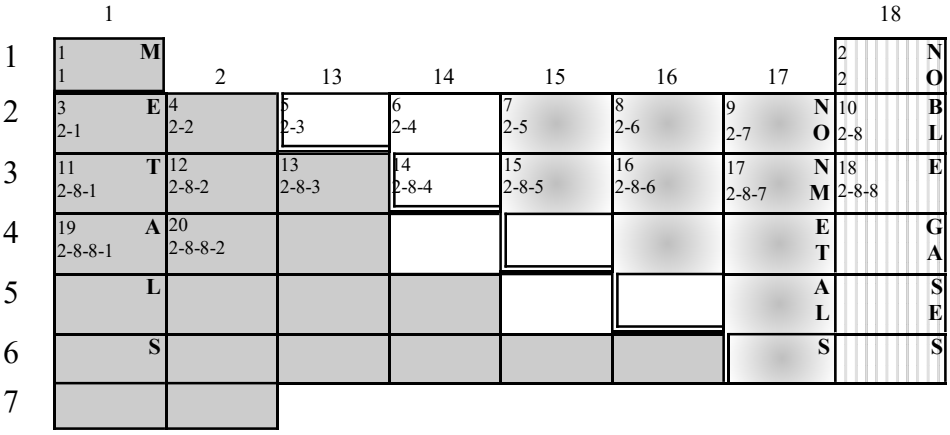
Test Review № 5

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.

Organization of the Periodic Table. The modern Periodic Table is arranged in order of increasing atomic number in vertical columns and horizontal rows. The vertical columns are elements with about the same number of outer electrons (valence electrons). They are called groups or families. Elements in the same family have similar properties. Horizontal rows are elements with the same number of shells or energy levels. They are called periods. The major divisions of the Periodic Table are: Alkali metals - Group 1; Alkaline earth metals - Group 2; Halogens - Group 17; Noble gases (Inert gases) - Group 18; Transition metals - Groups 3-12; Lanthanides - Row 6, elements 57 - 71;and Actinides - Row 7, elements 89 - 103.

Trends in the Periodic Table. Going across the table from left to right within a row or period the number of protons increases, so the pull on the electrons increases. As a result the covalent atomic radius decreases and metallic properties decrease (except in the transition elements). In addition the number of valence electrons increases and the number of shells remains the same. Going down the table within a group or family the number of protons also increases, but the number of shells increases too. As a result, the atomic radius increases, the pull on the electrons decreases, and metallic properties increase. In a family the number of valence electrons remains the same. This results in the following organization of the Periodic Table:

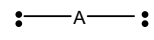
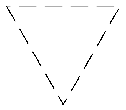
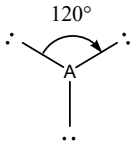
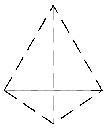
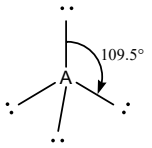
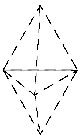
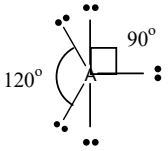
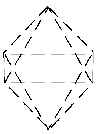
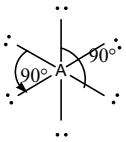


Bonding. The electrons of one atom are attracted to the protons of another. When atoms combine, there is a tug of war over the valence electrons. The combining atoms either lose, gain, or share electrons in such a way that they complete their outer shells. Whether atoms gain, lose, or share electrons depends how tightly they hold onto their own electrons and how strongly they pull on the electrons of another atom.

Ionic Bonds. Ionic bonds are caused by the attraction between oppositely charged ions. Ions form as follows: The electrons of one atom are attracted to the protons of another. Metals hold onto electrons loosely while nonmetals hold onto electrons tightly. As a result, metals lose electrons and nonmetals gain electrons in such a way that they complete their outer shells. Atoms that gain or lose electrons become electrically charged. Metals become positively charged ions by losing electrons. Nonmetals become negatively charged ions by gaining electrons. Metal cations and nonmetal anions become ionically bonded because they are oppositely charged. Atoms gain or lose electrons in such a way that they complete their outer shells. This gives them the same electron configuration as a noble gas. For example, potassium, with an electron configuration of 2-8-8-1 loses an electron to become K^+ with an electron configuration of 2-8-8, the same as argon. Chlorine, with an electron configuration of 2-8-7, gains an electron to become Cl^-, with an electron configuration also of 2-8-8.

Covalent Bonds. Covalent bonds are bonds formed by sharing electrons. The electrons of one atom are attracted to the protons of another, but neither atom pulls strongly enough to remove an electron from the other. Covalent bonds form when the electronegativity difference between the elements is less than 1.7 (see the Electronegativity table on the back of the Periodic Table) or when hydrogen behaves like a metal. When a covalent bond forms, no valence electrons are transferred, rather, they are shared. During covalent bonding, unpaired electrons pair up in such a way that the atoms complete their outer shells. This can be illustrated with electron dot diagrams. Covalent bonds with electronegativity differences of 0.4 or greater are polar.

VSEPR. One approach to predicting molecular shape is the valence shell electron repulsion model (VSEPR). According to VSEPR theory, repulsion between sets of valence shell electrons causes them to be as far apart as possible. Taking this repulsion into account, the shape of a molecule depends upon how many pairs of valence electrons surround the central atom, the number of lone pairs of electrons, and the presence of multiple bonds (double bonds or tripe bonds)

Number of Electron Pairs	Shape	Arrangement of Electron Pairs	
2	Linear		
3	Trigonal planar		
4	Tetrahedral		
5	Trigonal bipyramidal		
6	Octahedral		

Polar Molecules. Electronegativity differences between 0.4 and 1.7 are found in molecules with polar bonds. These molecules can be polar depending on their shapes. Molecules with polar bonds distributed symmetrically are nonpolar. Asymmetrical molecules with polar bonds are polar. Water is polar. An imaginary line can be drawn through a water molecule separating the positive pole from the negative pole. This is because the charges are distributed asymmetrically. Carbon dioxide is nonpolar because the electronegative oxygens are distributed symmetrically around the carbon. (O=C=O)

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

1. In the Periodic Table, the elements are arranged in order of increasing (1) atomic size, (2) atomic number, (3) atomic mass, (4) ionization energy

2. The chemical properties of the elements are periodic functions of their atomic (1) spin, (2) isotopes, (3) mass, (4) number.

3. Which pair contains elements which have the most similar chemical properties? (1) Mg and Ca (2) N and S (3) H and Li (4) Na and Cl

4. The element with an atomic number of 34 is most similar in its chemical behavior to the element with an atomic number of (1) 19 (2) 31 (3) 36 (4) 16

5. Silicon is most similar in chemical activity to (1) carbon, (2) lead, (3) sulfur, (4) nitrogen

6. The element 2–8–6 belongs in Period (1) 6, (2) 2, (3) 3, (4) 4

7. Most of the elements in the Periodic Table are classified as (1) metalloids, (2) nonmetals, (3) noble gases, (4) metals

8. Phosphorus is best classified as a (1) nonmetal, (2) metalloid, (3) metal, (4) transition element

9. The Group 1 metals all have the same (1) electronegativity, (2) atomic radius, (3) oxidation state, (4) ionization energy

10. Which Group in the Periodic Table contains the most active metals? (1) 1 (2) 2 (3) 13 (4) 14

11. In which Group of the Periodic Table would this element, 2–5, most likely be found? (1) 1 (2) 2 (3) 13 (4) 15

12. As the elements in Period 3 are considered in order of increasing atomic number, the number of principal energy levels in each successive element (1) decreases (2) increases (3) remains the same

13. Which Group contains elements which are metalloids? (1) 1 (2) 11 (3) 14 (4) 4

14. The elements with the least chemical reactivity are in Group (1) 1, (2) 18, (3) 3 (4) 16

15. Which element is a metalloid? (1) arsenic (2) neon (3) potassium (4) bromine

16. What are two properties of most nonmetals?
    (1) high ionization energy and poor electrical conductivity
    (2) high ionization energy and good electrical conductivity
    (3) low ionization energy and poor electrical conductivity
    (4) low ionization energy and good electrical conductivity

17. In which shell are the valence electrons of the elements in Period 2 found? (1) 1 (2) 2 (3) 3 (4) 4

18. Of the following, which element has the smallest atomic radius? (1) Mg (2) Ca (3) Sr (4) Ba

19. As one proceeds from lithium to fluorine in the Periodic Table, the tendency for the elements to lose electrons (1) decreases, (2) increases, (3) remains the same

20. As the elements in Period 3 are considered from left to right, the ability of each successive element to gain electrons (1) decreases, (2) increases, (3) remains the same

21. Of the following, which is the element with the most metallic character in Group 16 is (1) O, (2) S, (3) Se, (4) Te

22. As the elements in Group 14 are considered in order of increasing atomic number, the metallic properties of successive elements (1) decreases, (2) increases, (3) remains the same

23. In Period 3 of the Periodic Table, the element with the smallest atomic radius is in Group (1) 1 (2) 2 (3) 15 (4) 17

24. Of the following, which Group 2 element has the greatest tendency to lose electrons? (1) calcium (2) barium (3) strontium (4) magnesium

25. Which Group in the Periodic Table contains atoms that have –2 oxidation states? (1) 1 (2) 2 (3) 16 (4) 17

26. The elements in Group 2 have similar chemical properties primarily because they have the same (1) ionization energies, (2) reduction potentials, (3) number of principal energy levels, (4) number of electrons in the outermost shell

27. As one proceeds from left to right across Period 2 of the Periodic Table, the decrease in atomic radius is primarily due to an increase in the number of (1) orbitals, (2) protons, (3) neutrons, (4) principal energy levels

28. The most active metal in Period 4 of the Periodic Table is (1) Fe, (2) Sc, (3) K, (4) Ca.

29. In Period 3, as the atomic numbers increase, the pattern according to which the properties of the elements change is
    (1) metal → metalloid → nonmetal → noble gas
    (2) metal → nonmetal → noble gas → metalloid
    (3) nonmetal →metalloid → metal → noble gas
    (4) nonmetal → metal → noble gas → metalloid

30. In going down the Group 15 elements on the Periodic Table, the metallic properties of the elements (1) decrease, (2) increase, (3) remain the same

31. As one proceeds from left to right across Period 3 of the Periodic Table, there is a decrease in (1) ionization energy (2) electronegativity (3) metallic characteristics (4) valence electrons

32. As one proceeds from fluorine to astatine in Group 17, the electronegativity (1) decreases and the atomic radius increases, (2) decreases and the atomic radius decreases, (3) increases and the atomic radius decreases, (4) increases and the atomic radius increases.

33. As the elements in Period 3 are considered in order of increasing atomic number, the number of principal energy levels in each successive element (1) decreases, (2) increases, (3) remains the same

34. If the elements are considered from top to bottom in Group 17 the number of electrons in the outermost shell will (1) decrease, (2) increase, (3) remain the same

35. Which represents the correct order of activity for the Group 17 elements [> means greater than]
(1) bromine > iodine > fluorine > chlorine
(2) fluorine > chlorine > bromine > iodine
(3) iodine > bromine > chlorine > fluorine
(4) fluorine > bromine > chlorine > iodine

36. Which is most characteristic of metals with very low ionization energies? (1) they are very reactive (2) they have a small atomic radius (3) they form covalent bonds (4) they have a high electronegativity

37. Metallic elements usually possess
(1) low electronegativities and high ionization energies
(2) high electronegativities and low ionization energies
(3) high electronegativities and high ionization energies
(4) low electronegativities and low ionization energies

38. If the members of Group 17 are arranged in order of increasing electronegativity, they are also arranged in order of increasing (1) ionization energy, (2) atomic radius, (3) atomic mass, (4) nuclear charge

39. As the elements are considered from top to bottom in Group15 of the Periodic Table, the ionization energy (1) decreases, (2) increases, (3) remains the same

40. An element that has both a high ionization energy and a high electronegativity is most likely a (1) metal (2) metalloid (3) nonmetal (4) noble gas

41. The element with the lowest first ionization energy in any given Period will always belong to Group (1) 1 (2) 2 (3) 17 (4) 18

42. An element that exhibits the largest variety of oxidation states is (1) Li (2) O (3) C (4) N

43. Which Group in the Periodic Table contains both metals and nonmetals? (1) 11 (2) 2 (3) 18 (4) 14

44. This element assumes only a +3 oxidation state in chemical combination (1) Na (2) Si (3) Al (4) Cl

45. Which Group 18 element in the ground state has a maximum of 2 completely filled principal energy levels? (1) Kr (2) Xe (3) He (4) Ne

46. In water, the bond between hydrogen and oxygen is (1) ionic, (2) polar covalent, (3) nonpolar covalent, (4) nonpolar noncovalent.

47. Which of the following occurs during covalent bonding? (1) Electrons are lost. (2) Electrons are gained. (3) Valence electrons fall from the excited state to the ground state. (4) Unpaired electrons form pairs.

48. Which of the following is an example of a substance with a nonpolar covalent bond? (1) HCl (2) Cl_2 (3) $HClO_2$ (4) NaCl

49. The electronegativity of sulfur is (1) 16, (2) 239, (3) 2.6, (4) 32.

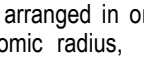
50. Which of the following elements has the highest electronegativity? (1) fluorine (2) chlorine (3) barium (4) hydrogen

51. Which compound contains a bond with the *least,* ionic character? (1) CO (2) K_2O (3) CaO (4) Li_2O

52. Which type of bond is contained in a water molecule? (1) nonpolar covalent (2) ionic (3) polar covalent (4) electrovalent

53. The bonding in NH_3 most similar to the bonding in (1) H_2O (2) MgO (3) NaCl (4) KF

54. Which is the formula of an ionic compound? (1) SO_2 (2) CH_3OH (3) CO_2 (4) KCl

55. Which electron dot formula represents a molecule that contains a nonpolar covalent bond?
(1)  (2)  (3)  (4) 

56. When a reaction occurs between atoms with ground state electron configurations 2–1 and 2–7, the predominant type of bond formed is (1) polar covalent, (2) ionic, (3) nonpolar covalent, (4) metallic.

57. The P—Cl bond in a molecule of PCl_3 is (1) nonpolar covalent, (2) coordinate covalent, (3) polar covalent, (4) electrovalent.

58. A Ca^{2+} ion differs from a Ca atom in that the Ca^{2+} ion has (1) more protons, (2) more electrons, (3) fewer protons, (4) fewer electrons.

59. In which compound does the bond between the atoms have the least ionic character? (1) HF (2) HCl (3) HBr (4) HI

60. Which substance contains a polar covalent bond? (1) Na_2O (2) Mg_3N_2 (3) CO_2 (4) N_2

61. When a chlorine atom reacts with a sodium atom to form an ion, the chlorine atom will (1) lose one electron, (2) gain one electron, (3) lose two electrons, (4) gain two electrons.

62. When a calcium atom loses its valence electrons, the ion formed has an electron configuration that is the same as the configuration of an atom of (1) Cl (2) Ar (3) K (4) Sc

63. Which of the following compounds has the most ionic character? (1) KI (2) NO (3) HCl (4) MgS

64. Which atom has the strongest attraction for electrons? (1) Cl (2) F (3) Br (4) I

65. Two atoms of element A unite to form a molecule with the formula A_2. The bond between the atoms in the molecule is (1) electrovalent, (2) nonpolar covalent, (3) ionic, (4) polar covalent.

66. When an ionic bond is formed, the atom that transfers its valence electron is the atom that has the (1) higher electronegativity value, (2) lower atomic number. (3) higher atomic mass, (4) lower ionization energy.

67. When an ionic bond is formed, the atom that transfers its valence electron becomes an ion with (1) positive charge and more protons, (2) positive charge and no change in the number of protons, (3) negative charge and more protons, (4) negative charge and no change in the number of protons.

68. Which compound best illustrates ionic bonding? (1) CCl_4 (2) $MgCl_2$ (3) H_2O (4) CO_2

69. An atom that loses or gains one or more electrons becomes (1) an ion, (2) an isotope, (3) a molecule, (4) an electrolyte

70. Which kind of bond is formed when two atoms share electrons to form a molecule? (1) ionic (2) metallic (3) electrovalent (4) covalent

71. Which type of bonding is usually exhibited when the electronegativity difference between two atoms is 1.2? (1) ionic (2) metallic (3) network (4) covalent

72. Which element will form an ion with a larger radius than its atom? (1) Na (2) Ba (3) Ca (4) Cl

73. Which element will form an ion whose radius is larger than its atomic radius? (1) F (2) Fr (3) Ca (4) Cs

74. When chlorine reacts with a Group 1 metal, it becomes an ion with a charge of (1) 1-, (2) 2-, (3) 1+, (4) 2+.

75. Which compound contains both covalent and ionic bonds? (1)HCl (2) NH_4Cl (3) $MgCl_2$ (4) CCl_4

76. When a reaction occurs between atoms with ground state electron configurations $1s^22s^1$ and $1s^22s^22p^5$ the predominant type of bond formed is (1) polar covalent, (2) ionic, (3) nonpolar covalent, (4) metallic.

77. What is the total number of electrons in a Mg^{2+} ion? (1) 10 (2) 2 (3) 12 (4) 24

78. Which compound is ionic? (1) HCl (2) $CaCl_2$ (3) SO_2 (4) N_2O_5

79. What is the electron configuration for Be^{2+} ions? (1) $1s^1$ (2) $1s^2$ (3) $1s^22s^1$ (4) $1s^22s^2$

80. As a chemical bond forms between hydrogen and chlorine atoms, the potential energy of the atoms (1) decreases, (2) increases, (3) remains the same.

81. In potassium hydrogen carbonate, $KHCO_3$, the bonds are (1) ionic, only, (2) covalent, only, (3) both ionic and covalent, (4) both covalent and metallic.

82. When potassium and chlorine form a chemical compound, energy is (1) released and ionic bonds are formed, (2) released and covalent bonds are formed, (3) absorbed and ionic bonds are formed, (4) absorbed and covalent bonds are formed.

83. Barium combines by (1) gaining two electrons, (2) losing two electrons, (3) sharing two electrons, (4) sharing 3 electrons.

84. When calcium combines, it usually (1) loses two electrons, (2) gains six electrons, (3) shares two electrons, (4) shares six electrons.

85. When a chlorine atom reacts with a sodium atom to form an ion, the chlorine atom will (1) lose one electron, (2) gain one electron, (3) lose two electrons, (4) gain two electrons.

86. Which of the following molecules has a nonlinear structure? (1) PbO_2 (2) $BeCl_2$ (3) O_3 (4) CO_2 (5) N_2O (central atom is N)

87. Which formula represents a tetrahedral molecule? (1) $CaCl_2$ (2) Br_2 (3) CH_4 (4) HBr

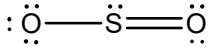
88. Which formula represents a bent molecule? (1) Br_2 (2) HBr (3) $CaCl_2$ (4) SO_2

89. The four single bonds of a carbon atom are spatially directed toward the comers of a regular (1) rectangle (2) tetrahedron (3) triangle (4) square

90. What is the molecular geometry of the NH_3? (1) octahedral (2) pyramidal (3) linear (4) bent (5) tetrahedral

91. What is the molecular shape of water? (1) bent (2) octahedral (3) pyramidal (4) linear (5) tetrahedral

92. What is the molecular shape of the following molecule?



(1) bent (2) linear (3) octahedral (4) tetrahedral (5) pyramidal

93. What would be the shape of a molecule where the central atom has two lone pairs and two bonds? (1) pyramidal (2) octahedral (3) tetrahedral (4) linear (5) bent

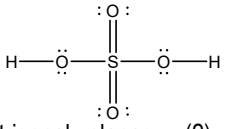
94. Which of the following molecules is linear? (1) CO_2 (2) SO_2 (3) O_3 (4) H_2O (5) all of the above

95. Which of the following molecules has two pairs of nonbonding electrons on the central atom? (1) BH_3 (2) CO_2 (3) H_2O (4) H_2S (5) choices 3 and 4

96. Which of the following molecules should have the same molecular shape and approximate bond angles as ammonia, NH_3? (1) SO_3 (2) CH_4 (3) PH_3 (4) BH_3 (5) NO_2

97. Germanium chloride, $GeCl_2$, has only two atoms surrounding the central germanium atom. Why then is the germanium chloride molecule bent? (1) It is bent only periodically as it swings between both bent and linear shapes. (2) A lone pair of electrons on germanium pushes it to this orientation. (3) There is a covalent bond between the two chlorine atoms. (4) Lone pairs of electrons on the chlorine atoms push it to this orientation.

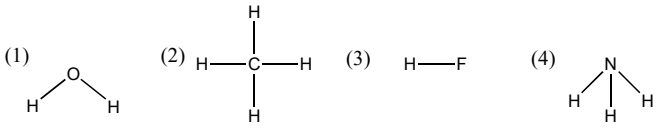
98. In two dimensions sulfuric acid, H_2SO_4, is often written as shown below. What three-dimensional shape does this molecule most likely have around the central sulfur?



(1) trigonal planar (2) octahedral (3) trigonal bipyramid (4) tetrahedal

99. Which molecule is nonpolar and contains a nonpolar covalent bond? (1) CCl_4 (2) F_2 (3) HF (4) HCl

100. Which structural formula represents a nonpolar symmetrical molecule?



101. Why is NH_3 classified as a polar molecule? (1) It is a gas at STP. (2) H—H bonds are nonpolar. (3) Nitrogen and hydrogen are both nonmetals. (4) NH_3 molecules have asymmetrical charge distributions.

102. Which statement best explains why carbon tetrachloride (CCl_4) is nonpolar? (1) Each carbon-chloride bond is polar. (2) Carbon and chlorine are both nonmetals. (3) Carbon tetrachloride is an organic compound. (4) The carbon tetrachloride molecule is symmetrical.

103. The geometry of a molecule of SO_2 is (1) linear, (2) bent, (3) trigonal planar, (4) trigonal pyramidal, (5) tetrahedral.

104. Which molecule is a polar molecule? (1) N_2 (2) H_2O (3) CH_4 (4) CO_2 (5) KCl

105. In the Lewis structure for ammonium (NH_4^+), the formal charge on nitrogen is (1) +1, (2) +2, (3) 0, (4) –1, (5) –2.

Answers

1.	2	22.	2	43.	4	64.	2	85.	2	21.	4	42.	4	63.	1	84.	1	105.	1
2.	4	23.	4	44.	3	65.	2	86.	3	20.	2	41.	1	62.	2	83.	2	104.	2
3.	1	24.	2	45.	4	66.	4	87.	3	19.	1	40.	3	61.	2	82.	1	103.	2
4.	4	25.	3	46.	2	67.	2	88.	4	18.	1	39.	1	60.	3	81.	3	102.	4
5.	1	26.	4	47.	4	68.	2	89.	2	17.	2	38.	1	59.	4	80.	1	101.	4
6.	3	27.	2	48.	2	69.	1	90.	2	16.	1	37.	4	58.	4	79.	2	100.	2
7.	4	28.	3	49.	3	70.	4	91.	1	15.	1	36.	1	57.	3	78.	2	99.	2
8.	1	29.	1	50.	1	71.	4	92.	1	14.	2	35.	2	56.	2	77.	1	98.	4
9.	3	30.	2	51.	1	72.	4	93.	5	13.	3	34.	3	55.	1	76.	2	97.	2
10.	1	31.	3	52.	3	73.	1	94.	1	12.	3	33.	3	54.	4	75.	2	96.	3
11.	4	32.	1	53.	1	74.	1	95.	5										