Periodic Table of The Elements

Overview:

The Periodic Table is a systematic arrangement or classification of the elements. In the late 1800's, scientists noticed regularities in the properties of the elements, prompting them to arrange the elements based upon these recurring properties. It has passed through many stages of development in reaching its present form. This arrangement enabled scientists to predict the chemical and physical properties of elements that had not yet been discovered. This table will enable you to determine the identity of an element when given the properties of that element. The modern Periodic Law states that the properties of the elements are periodic functions of the atomic number or nuclear charge.

The Key:

Symbol – The symbol is a shorthand method of indicating the identity of the element. It consists of one or two letters from its name in English, or in many cases, from its name in Latin. The first letter is always capitalized, and the second letter (if present) is always written in lower case.

Atomic mass – The atomic mass of an element is the weighted average mass of the naturally occurring isotopes of that element. It is weighted according to the percent occurrence of each isotope. Atomic mass is expressed in atomic mass units (u). The atomic mass unit is defined relative to the mass of a C-12 atom, assigned an atomic mass of exactly 12.000 u. One atomic mass unit is 1/12 the mass of the standard C-12 atom. Since most elements occur as a mixture of isotopes, their atomic masses are decimal or fractional. It is calculated by taking the sum of the products of the percent occurrence and actual mass of each isotope. For example, Cl exists naturally as 75.40% Cl-35 (actual mass = 34.97) and 24.60% Cl-37 (actual mass = 36.97). The atomic mass of chlorine is: $(0.7540 \times 34.97) + (0.2460 \times 36.97) = 35.46$ u.

Atomic number – The atomic number of an element is the number of protons in the nucleus of an atom of that element. It is the property that identifies the element. Isotopes are atoms with the same atomic number but different mass numbers (the number of protons and neutrons in the nucleus). For example, C-12 and C-14 are isotopes. Both have 6 protons but C-12 has 6 neutrons while C-14 has 8 neutrons. The positive charge of a nucleus is equal to its atomic number.

Electron Configuration – The electron configuration given for the element shows the number of electrons in each principal energy level of an atom of that element in the ground state. The ground state is the state of lowest energy for the electrons in an atom.

Selected Oxidation States – The selected oxidation states (also referred to as oxidation number) show the charge on an atom of that element after gaining or losing an electron(s), or the apparent charge resulting from an unequal sharing of electrons with another atom. A loss of electrons (oxidation) results in a positive oxidation state. A gain of electrons (reduction) results in a negative oxidation state. Sharing of electrons with an atom of higher electronegativity results in a positive oxidation state. Sharing of electrons with an atom of lower electronegativity results in a negative oxidation state.

The Periodic Table:

Periods – The horizontal rows on the table are called periods. The properties of the elements change systematically through a period. With increasing atomic number in a given period, the properties of the elements change from metallic to metalloid to nonmetallic to inert (noble) gas. The exception is Period 1, where both elements are nonmetals. The period number is equal to the number of occupied energy levels of an atom in its ground state.

Groups – The vertical columns on the table are called groups or families. The elements in a group exhibit similar or related properties because they contain the same number of valence electrons. For example, Na and K would have similar chemical properties since they are both located in Group 1 and contain one valence electron. The Group 1 elements are called the alkali metals. Those in Group 2 are the alkaline earth elements. Group 17 elements are the halogens and those in Group 18 are the inert, rare or noble gases. The inert gases are chemically inactive, forming compounds only with the most active elements (F and O). All are monatomic gases at room conditions.

Valence Electrons – The period number is the same as the number of occupied energy levels of an atom in its ground state. The outer most energy level (last number in the electron configuration) is the valence level and the electrons in this energy level are the valence electrons. These electrons are the electrons lost, gained or shared during a chemical reaction, and therefore determine the chemical properties of the elements. For example: Lithium (Li) is in Period 2. It contains two principal energy levels and has one valence electron.

Classification of the Elements – The dark zig-zag line on the Periodic Table separates the metals from the nonmetals. Elements bordering this line, especially those to the right of the line, are called metalloids, and have properties of both metals and nonmetals. Most of the elements on the Periodic Table are metals and are found to the left of the zig-zag line. Metals are malleable, ductile, possess luster, and are good conductors of heat and electricity. All are solids at room temperature except mercury, which is a liquid. Metals lose electrons to form positive ions when reacting with nonmetals. The remaining elements are nonmetals and are found to the right of the zig-zag line. Nonmetals are brittle, lack luster and are nonconductors of heat and electricity. At room temperature, they exhibit all three phases of matter. Bromine is the only nonmetal that is a liquid at room temperature. Nonmetals tend to gain electrons during ionic bond formation, but they can form either positive or negative oxidation states during covalent bond formation with another nonmetal.

Additional Information:

- Rounding off the atomic mass to the nearest whole number gives the atomic mass number or simply the mass number of the element. The mass number is the number of protons and neutrons (nucleons) in the nucleus of an atom of that element. Due to the weighting used in calculating the atomic mass of an element, this gives the mass number of the most common isotope of that element.

- To determine the number of neutrons in the nucleus of an atom, subtract the atomic number from the mass number.

- Any energy level higher than the ground state is referred to as an excited state. For example, the ground state configuration for calcium (Ca) is 2-8-8-2. A configuration of 2-8-7-3 would be an excited state since an electron from the 3rd energy level has been raised or excited to the 4th energy level.

- When an excited atom returns to the ground state, energy is released in the form of quanta, forming a bright line spectrum.

- With increasing atomic number within a given group, the elements become more metallic in properties.

- The selected oxidation states or numbers are used to determine the correct formula for a compound. In all formulas of compounds, the sum of the oxidation states must equal zero.

- The Lewis electron-dot diagram consists of the symbol of the element surrounded by dots or x's representing valence electrons only. Usually a maximum of two dots are positioned on each side of the symbol.

  The Lewis electron-dot diagram may be used to show the structure of molecules. The valence shell electrons are represented by dots or x's surrounding the symbol. The bonding electrons are shown between the atoms sharing the electrons. For single bonds, two electrons are shown, for double bonds, four electrons are shown and for triple bonds, six electrons are shown. Shared electron pairs may be represented by dashes between the symbols.

  Lewis electron-dot diagrams may also be used to represent ionic bond formation, is which the negative ion is placed in parentheses to indicate a transfer of electrons.

- Elements with atomic numbers greater than 109 have symbols consisting of 3 letters, each the first letter of the Greek prefix representing the digits in the atomic number, until the International Union of Pure and Applied Chemistry (IUPAC) approves a trivial name.

Set 1 — Metals – Metalloids – Nonmetals

1. Which is a property of most nonmetallic solids?

   (1) high thermal conductivity
   (2) high electrical conductivity
   (3) brittleness
   (4) malleability 1 _____

2. Which of the following Group 15 elements has the greatest metallic character?

   (1) nitrogen (3) antimony
   (2) phosphorus (4) bismuth 2 _____

3. Which pair of symbols represents a metalloid and a noble gas?

   (1) Si and Bi (3) Ge and Te
   (2) As and Ar (4) Ne and Xe 3 _____

4. Which group contains a metalloid?

   (1) 1 (3) 15
   (2) 11 (4) 18 4 _____

5. Which element is malleable and can conduct electricity in the solid phase?

   (1) iodine (3) sulfur
   (2) phosphorus (4) tin 5 _____

6. At STP, which element is brittle and not a conductor of electricity?

   (1) S (3) Na
   (2) K (4) Ar 6 _____

7. Element *X* is a solid that is brittle, lacks luster, and has six valence electrons. In which group on the Periodic Table would element *X* be found?

   (1) 1 (3) 15
   (2) 2 (4) 16 7 _____

8. An element that is malleable and a good conductor of heat and electricity could have an atomic number of

   (1) 16 (3) 29
   (2) 18 (4) 35 8 _____

9. Which list of elements contains a metal, a metalloid, and a nonmetal?

   (1) Zn, Ga, Ge
   (2) Si, Ge, Sn
   (3) Cd, Sb, I
   (4) F, Cl, Br 9 _____

A metal, M, was obtained from a compound in a rock sample. Experiments have determined that the element is a member of Group 2 on the Periodic Table of the Elements.

10. *a*) What is the phase of element M at STP? _____

    b) Give 3 characteristic properties of metals. 1) _____

    2) _____

    3) _____

Set 2 — Metals – Metalloids – Nonmetals

11. The elements located in the lower left corner of the Periodic Table are classified as

(1) metals (3) metalloids
(2) nonmetals (4) noble gases 11 ____

12. As the atomic number of elements within Group 2 increases, the metallic character of each successive element

(1) decreases
(2) increases
(3) remains the same 12 ____

13. Which element has both metallic and nonmetallic properties?

(1) Rb (3) Si
(2) Rn (4) Sr 13 ____

14. In which compound is the ratio of metal ions to nonmetal ions 1 to 2?

(1) calcium bromide
(2) calcium oxide
(3) calcium phosphide
(4) calcium sulfide 14 ____

15. Arsenic and silicon are similar in that they both

(1) have the same ionization energy
(2) have the same covalent radius
(3) are transition metals
(4) are metalloids 15 ____

16. Which element is an alkali metal?

(1) hydrogen (3) sodium
(2) calcium (4) zinc 16 ____

17. The element in Period 4 and Group 1 of the Periodic Table would be classified as a

(1) metal (3) nonmetal
(2) metalloid (4) noble gas 17 ____

18. Which Period 4 element has the most metallic properties?

(1) As (3) Ge
(2) Br (4) Sc 18 ____

19. Which element is classified as a nonmetal?

(1) Be (3) Si
(2) Al (4) Cl 19 ____

20. At STP, an element that is a solid and a good conductor of heat and electricity could have an electron configuration of

(1) 2-7 (3) 2-8-5
(2) 2-8-8 (4) 2-8-18-2 20 ____

21. Which element is malleable and a good conductor of electricity at STP?

(1) argon (3) iodine
(2) carbon (4) silver 21 ____

22. Describe one chemical property of Group 1 metals that results from the atoms of each metal having only one valence electron.

_____

23. Explain, in terms of atomic structure, why liquid mercury is a good electrical conductor.

_____

Periodic Table – Metals – Metalloids – Nonmetals

Answers – Set 1

1. 3 Nonmetallic solids usually are brittle, tend to be nonconductors, show little or no luster, and are not malleable.

2. 4 Looking at the Periodic Table, locate the dark ziz-zag line. This line separates elements with metallic properties (to the left of the line) from the elements that have nonmetallic properties (to the right of the line). Bismuth is the only choice that is on the metallic side of the Periodic Table. Also, in general, metallic characteristics increase with an increase in the atomic number within a group on the Periodic Table.

3. 2 Metalloids are elements that exhibit properties of metals and nonmetals, also referred to as semimetals. Metalloids are found adjacent to the dark zig-zag line (especially to the right) on the Periodic Table. As (arsenic) is considered to be a metalloid. Ar (argon) is a Group 18 element, known as the noble or inert gases.

4. 3 Metalloids are located adjacent to the zig-zag line. Of the given choices only Group 15 contains an element that is adjacent to this line.

5. 4 Metals tend to exhibit the properties of malleability and conductivity. Tin is the only metal from the given choices. All others choices are nonmetals, which would not exhibit these properties.

6. 1 Nonmetallic solids are brittle and do not conduct electricity. Nonmetals are located on the right side of the zig-zag line on the Periodic Table. By the process of elimination Na and K are metals. Ar is an inert gas. This leaves sulfur (S) as the element that is brittle and a nonconductor of electricity.

7. 4 The properties of element X indicate that it is a nonmetal, therefore it must be located to the right of the zig-zag line. Possessing six valence electrons places it in Group 16.

8. 3 The properties given describes a metal. Atomic number 29 is the element copper, which is a metal, being is on the left side of the darken zig-zag line on the Periodic Table.

9. 3 Elements to the left of the zig-zag line found on the Periodic Table are metals. Elements to the right of this line are nonmetals. Metalloids are found adjacent to this zig-zag line. Answer 3 fulfills these requirements.

10. *a*) Answer : Solid

    Explanation: Table A gives the values of STP. Using these values and Table S, all elements in Group 2 elements have a much higher melting point than 273 K, which make them solids at STP.

    b) Answer: malleability *or* high electrical conductivity *or* high thermal conductivity *or* exhibiting luster or ductilility *or* ductility.

    Explanation: The above properties are associated with metals.