

Development of the Periodic Table

Aim

- describe how elements are arranged on the Periodic Table
- state the Periodic Law

Notes

Definitions

- ★ Classification - grouping elements based on similarities
- ★ Cross Classification - classifying into more than one group at a time
 - ☆ Examples
 - ★ Deck of cards – Suits and Numbers
 - ★ Periodic Table – Groups or Families and Periods
 - ☆ Purpose - organize, explain, and predict information about the elements

History

- ★ Mendeleev's Periodic Table
 - ☆ Dmitri Mendeleev (1869) prepared a card for each of the known elements listing the
 - ☆ symbol
 - ☆ atomic mass
 - ☆ chemical properties
 - ☆ very active metal - loses electrons very easily
 - ☆ active metal - loses electrons easily
 - ☆ metal - loses electrons
 - ☆ metalloid - gains or loses electrons
 - ☆ nonmetal - gains electrons
 - ☆ active nonmetal - gains electrons easily
 - ☆ very active nonmetal - gains electrons very easily
 - ☆ 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.
 - ☆ Mendeleev moved the card of the second and third very active metal, etc., by the card of the first very active metal, keeping the cards in order of mass.
 - ☆ The cards thus arranged formed groups or families with similar properties.
 - ☆ this arrangement forms the basis for the first Periodic Table
- ★ Moseley's Periodic Table (Modern Periodic Table)
 - ☆ 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
 - ☆ Moseley 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.

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

- In the Periodic Table, the elements are arranged in order of increasing
 - atomic size
 - atomic mass
 - atomic number
 - ionization energy
- The chemical properties of the elements are Periodic functions of their atomic
 - spin
 - mass
 - isotopes
 - number
- Which pair contains elements which have the most similar chemical properties?
 - Mg and Ca
 - H and Li
 - N and S
 - Na and Cl
- The element with an atomic number of 34 is most similar in its chemical behavior to the element with an atomic number of
 - 19
 - 31
 - 31
- Silicon is most similar in chemical activity to
 - carbon
 - sulfur
 - lead
 - nitrogen

The Organization of the Periodic Table

Aim

- describe the organization of the periodic table

*Notes***Cross Classification in the Periodic Table**

- ★ The Periodic Table is arranged in order of increasing atomic number in vertical columns and horizontal rows
- ★ Vertical Columns
 - ☆ elements with the same number of outer electrons (valence electrons)
 - ☆ called Groups or Families
 - ☆ have similar properties
- ★ Horizontal rows
 - ☆ elements with the same number of shells or energy levels
 - ☆ called periods

Divisions of the Periodic Table

- ★ Alkali metals - Group 1 (IA)
- ★ Alkaline earth metals - Group 2 (IIA)
- ★ Halogens - Group 17 (VIIA)
- ★ Noble gases (Inert gases) - Group 18 (0)
- ★ Transition metals - Groups 3-13 (IB - VIII)
- ★ Lanthanides - Row 6, elements 57 - 71 (f-block)
- ★ Actinides - Row 7, elements 89 - 103 (f-block)

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

- This element 2–8–6 belongs in Period
(1) 6 (3) 2
(2) 3 (4) 4
- Most of the elements in the Periodic Table are classified as
(1) metalloids (3) nonmetals
(2) noble gases (4) metals
- Phosphorus is best classified as a
(1) nonmetal (3) metalloid
(2) metal (4) transition element
- The alkali metals all have the same
(1) electronegativity (3) atomic radius
(2) oxidation number (4) ionization energy
- The alkaline earth metals are those elements in Group
(1) 1 (IA) (3) 2 (IIA)
(2) 11 (IB) (4) 12 (IIB)
- The elements in Group 2 (IIA) have similar chemical properties primarily because they have the same
(1) ionization energies
(2) oxidation potentials
(3) number of principal energy levels
(4) number of electrons in the outermost shell
- Which Group in the Periodic Table contains the alkali metals?
(1) 1 (IA) (3) 2 (IIA)
(2) 13 (IIIA) (4) 14 (IVA)
- In which Group of the Periodic Table would this element, 2–5, most likely be found?
(1) 1 (IA) (3) 2 (IIA)
(2) 13 (IIIA) (4) 14 (IVA)
- 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 (3) increases
(2) remains the same
- Which is an alkaline earth metal?
(1) Na (3) Ca
(2) Ga (4) Ta
- A metallic element whose aqueous ions produce colorless solutions would be found in Period 4 and Group
(1) 1 (IA) (3) 17 (VIIA)
(2) 8 (VIII) (4) 18 (0)
- Which Group contains elements which are metalloids?
(1) 1 (IA) (3) 11 (IB)
(2) 14 (IVA) (4) 4 (IVB)
- Which is a transition element?
(1) Ag (3) Mg
(2) Sb (4) Si
- The elements with the least chemical reactivity are in Group
(1) 1 (IA) (3) 18 (0)
(2) 3 (IIIB) (4) 16 (VIA)
- Which element is a metalloid?
(1) arsenic (3) neon
(2) potassium (4) bromine
- Silicon is most similar in chemical activity to
(1) carbon (3) lead
(2) sulfur (4) nitrogen
- Which Group of elements exhibits all three phases of matter at room temperature?
(1) 2 (IIA) (3) 14 (IVA)
(2) 15 (VA) (4) 17 (VIIA)
- 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
- Which element is classified as a noble gas at STP?
(1) hydrogen (3) neon
(2) oxygen (4) nitrogen
- In which shell are the valence electrons of the elements in Period 2 found?
(1) 1 (3) 3
(2) 2 (4) 4

Families of Elements

Aim

- predict the properties of elements based on their location in the Periodic Table

Notes

Families of Elements

- ☆ Alkali metals - Group 1
 - ☆ extremely reactive (not found free in nature) - form stable ionic compounds
 - ☆ react with water to form a base
 - ☆ react with air to form oxides
 - ☆ react with acids to form salts
- ☆ Alkaline earth metals - Group 2
 - ☆ reactive (not found free in nature) - form stable ionic compounds
 - ☆ react with water to form a base
 - ☆ react with air to form oxides
 - ☆ react with acids to form salts
- ☆ Nitrogen family - Group 15
 - ☆ Members range from typical nonmetals (nitrogen and phosphorus) through metalloids (arsenic and antimony) to metals (bismuth)
 - ☆ Nitrogen
 - Forms stable diatomic molecules with a triple bond
 - Component of protein
 - Forms some unstable compounds that are used as explosives
 - ☆ Phosphorus
 - Component of nucleic acids (DNA, RNA)
 - More reactive than nitrogen at room temperature
- ☆ Oxygen family - Group 16
 - ☆ Members range from typical nonmetals (oxygen and sulfur) through metalloids (selenium and tellurium) to metals (polonium)
 - ☆ Solids except oxygen
- ☆ Halogens (salt formers) - Group 17
 - ☆ very reactive nonmetals - high electronegativity
 - ☆ not found free in nature
 - ☆ form diatomic molecules when free
 - ☆ react with metals to form salts
 - ☆ Tendency to form positive oxidation state increases with atomic number
 - ☆ Found in all three phases due to differences in Van der Waals forces

- ☆ Noble gases
 - ☆ have complete outer shells
 - ☆ Almost inert (not reactive)
 - Krypton, xenon, and radon form compounds with oxygen and fluorine
- ☆ Transition elements
 - ☆ Positive oxidation state
 - ☆ Lose electrons from two outermost energy levels
 - ☆ Ions form colored solutions

Comparing Metals and Nonmetals

- ☆ Metals
 - ☆ Chemical properties - tend to lose electrons easily
 - have low ionization energy (energy needed to remove electrons)
 - have low electron affinity (attraction for electrons)
 - form positive ions when combining with other atoms
 - ☆ Physical properties
 - good conductors of heat and electricity
 - lustrous - reflect light, shine when they are polished
 - flexible
 - **malleable** - can be rolled or hammered into sheets
 - **ductile** - can be drawn into wires
 - are solids at room temperature except for mercury
- ☆ Nonmetals
 - ☆ Chemical properties - tend to gain electrons
 - have high electron affinities
 - produce covalent bonds by sharing electrons with other nonmetals
 - ☆ Physical properties
 - exist as gases, molecular solids, or network solids at room temperature except bromine
 - solids are brittle - not ductile or malleable
 - solids are dull - do not reflect light even when polished
 - poor conductors of heat and electricity
- ☆ Metalloids (semi-metals) - elements at the border between metals and nonmetals that have some properties of both
 - ☆ have properties intermediate to metals and nonmetals (special case of nonmetals)

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

- Which term best describes the element nitrogen at room temperature? (1) unstable (2) inactive (3) inert (4) explosive
- The elements that react with water to form strong bases are found in Group (1) 1 (2) 15 (3) 13 (4) 17
- Phosphorus is best classified as a (1) nonmetal (2) metal (3) metalloid (4) transition element
- The alkali metals all have the same (1) electronegativity (2) oxidation number (3) atomic radius (4) ionization energy
- The alkaline earth metals are those elements in Group (1) 1 (IA) (2) 2 (IIA) (3) 11 (IB) (4) 12 (IIB)
- An element that exhibits the largest variety of oxidation states is (1) Li (2) O (3) C (4) N
- Which Group in the Periodic Table contains both metals and nonmetals? (1) 11 (IB) (2) 2 (IIA) (3) 18 (0) (4) 14 (IVA)
- This element assumes only a +3 oxidation state in chemical combination (1) Na (2) Si (3) Al (4) Cl
- Which is an alkaline earth metal? (1) Na (2) Ga (3) Ca (4) Ta
- Elements in which electrons from more than one energy level may be involved in bond formation are called (1) alkali elements (2) transition elements (3) alkaline earth elements (4) halogens
- Which is a transition element?
(1) Rb (3) Sb
(2) Au (4) Xe
- Which type of element frequently forms colored compounds and generally exhibits more than one positive oxidation state?
(1) alkaline earths (3) transition elements
(2) alkali metals (4) noble gases
- Which Group in the Periodic Table contains the most active metals?
(1) 1 (IA) (3) 11 (IB)
(2) 17 (VIIA) (4) VIIB(7)
- Which Period contains elements that are all gases at STP ?
(1) 1 (3) 2
(2) 3 (4) 4
- Which Group 18 (0) element in the ground state has a maximum of 2 completely filled principal energy levels?
(1) Kr (3) Xe
(2) He (4) Ne
- A nonmetal which exists in the liquid state at room temperature is
(1) aluminum (3) hydrogen
(2) mercury (4) bromine
- The only metal which is a liquid at STP is in Period
(1) 5 (3) 6
(2) 3 (4) 4
- Which Group contains an element that is a liquid at room temperature?
(1) 18 (0) (3) 2 (IIA)
(2) 16 (VIA) (4) 17 (VIIA)

Trends in the Periodic Table

Task

- describe the trends in the Periodic Table within a group or period

Notes

Going across the table from left to right within a row or period

- ★ the number of protons increases
- ★ the pull on the electrons increases
- ★ the covalent atomic radius decreases
- ★ metallic properties decrease (except in the transition elements)
 - ☆ Ionization energy increases
 - ★ Ionization energy - energy needed to remove the most loosely held electron from an element in the gaseous phase
 - ★ found in Table S
 - ★ second ionization energy - it requires more energy to remove each successive electron
 - ☆ Electronegativity increases (also Table S)
 - ☆ There is a gradual change from positive oxidation states to negative oxidation states
- ★ the number of valence electrons increases
- ★ the number of shells remains the same

Going down the table within a group or family

- ★ the number of protons increases
- ★ the number of shells increases
- ★ the atomic radius increases
- ★ the pull on the electrons decreases
- ★ metallic properties increase
- ★ the number of valence electrons remains the same

Resulting organization of the Periodic Table

| | | | | | | | | | | |
|---|----------|---|----------|----------|----------|---------|---------|----------|----------|---------|
| | 1 | | | | | | | | | 18 |
| 1 | 1 H | M | | | | | | | | 2 He |
| 2 | 3 Li | E | 4 Be | 5 B | 6 C | 7 N | 8 O | 9 F | 10 Ne | |
| 3 | 11 Na | T | 12 Mg | 13 Al | 14 Si | 15 P | 16 S | 17 Cl | 18 Ar | |
| 4 | 19 K | A | 20 Ca | | | | | | E | G |
| 5 | | L | | | | | | | T | A |
| 6 | | S | | | | | | | A | S |
| 7 | | | | | | | | | L | E |
| | | | | | | | | | S | S |

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

- Which element has the smallest atomic radius? (1) Mg (2) Ca (3) Sr (4) Ba
- As one proceeds from lithium to fluorine in the Periodic Table, the tendency for the elements to be oxidized (1) decreases, (2) increases, (3) remains the same
- Which ion has the smallest radius? (1) K^+ (2) Na^+ (3) Mg^{+2} (4) Al^{+3}
- As the elements in Period 3 are considered from left to right, the ability of each successive element to act as a reducing agent (1) decreases, (2) increases, (3) remains the same
- The element with the most metallic character in Group 16 (VIA) is (1) O, (2) S, (3) Se, (4) Te
- As the elements in Group 14 (IVA) are considered in order of increasing atomic number, the metallic properties of successive elements (1) decreases, (2) increases, (3) remains the same
- 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
- Which Group 2 (IIA) element has the greatest tendency to form ions? (1) calcium (2) barium (3) strontium (4) magnesium
- Which Group in the Periodic Table contains atoms that form -2 ions? (1) 1 (IA) (2) 2 (IIA) (3) 16 (VIA) (4) 17 (VIIA)
- The elements in Group 2 (IIA) have similar chemical properties primarily because they have the same (1) ionization energies, (2) oxidation potentials, (3) number of principal energy levels, (4) number of electrons in the outermost shell
- 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
- The most active metal in Period 4 of the Periodic Table is (1) Fe, (2) Sc, (3) K, (4) Ca.
- In Period 3, as the atomic numbers increase, the pattern according to which the properties of the elements change is (1) metal \rightarrow metalloid \rightarrow nonmetal \rightarrow noble gas (3) metal \rightarrow nonmetal \rightarrow noble gas \rightarrow metalloid (2) nonmetal \rightarrow metalloid \rightarrow metal \rightarrow noble gas (4) nonmetal \rightarrow metal \rightarrow noble gas \rightarrow metalloid
- In going down the Group 15 (VA) elements on the Periodic Table, the metallic properties of the elements (1) decrease, (2) increase, (3) remain the same
- As one proceeds from left to right across Period 3 of the Periodic Table, there is a decrease in (1) ionization energy (3) metallic characteristics (2) electronegativity (4) valence electrons
- 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.
- 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
- If the elements are considered from top to bottom in Group 17 (VIIA), the number of electrons in the outermost shell will (1) decrease, (2) increase, (3) remain the same
- Which represents the correct order of activity for the Group 17 (VIIA) elements [$>$ means greater than] (1) bromine $>$ iodine $>$ fluorine $>$ chlorine (2) fluorine $>$ chlorine $>$ bromine $>$ iodine (3) iodine $>$ bromine $>$ chlorine $>$ fluorine (4) fluorine $>$ bromine $>$ chlorine $>$ iodine
- 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
- 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
- If the members of the halogen family 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
- As the elements are considered from top to bottom in Group 15 (VA) of the Periodic Table, the ionization energy (1) decreases, (2) increases, (3) remains the same
- 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
- The element with the lowest first ionization energy in any given Period will always belong to Group (1) 1 (IA) (2) 2 (IIA) (3) 17 (VIIA) (4) 18 (0)