CHEMISTRY CLASS XI
CHAPTER – 3 STRUCTURE OF ATOM

Q.1. What is the basic theme of organisation in the periodic table?

Ans. The basic theme of organisation of elements in the periodic table is to simplify and systematize the study of the numerous properties of all the elements and their compounds. This has been done by arranging the elements in such a way that similar elements are placed together while dissimilar elements are separated from one another. This has made the study simple to remember because the properties of the elements are now studied in the form of groups or families having similar properties rather than studying the elements individually.

Q.2. Which important property did Mendeleev use to classify the elements in his periodic table and did he stick to that?

Ans. Mendeleev used atomic weight as the important property for the classification of elements. Mandeleev arranged all the known elements in the form of a table known as periodic table. He observed that some of the elements did not fit in very will with his scheme of classification if the order of atomic weight was strictly followed. He showed courage to ignore the order of atomic weights thinking that the atomic weight measurements might be incorrect. He placed the elements with similar properties together. For example, iodine has lower atomic weight than tellurium (of Group VI) but he placed iodine in Group VII alongwith fluorine, chlorine and bromine because of the similarities in their

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properties. He even left some spaces or gaps for some undiscovered elements. By considering the properties of the adjacent elements, he predicted the properties of the undiscovered elements. Later on, when these elements were discovered, their properties were found to be exactly similar to those predicted by Mandeleev. For example, gallium and germanium were not discovered at that time, when Mendeleev formulated his periodic table and therefore, he left gaps for these elements. He not only predicted the existence of the elements but he estimated their properties. He tentatively named these elements as eka-aluminium and eka-silicon. When these elements were discovered, the prediction of mandeleev proved to be remarkably correct. However, after the discovery of atomic number as more fundamental property than atomic weight by Moseley in 1913, the basis of classification was changed to atomic number.

Q.3. What is the basic difference in approach between the Mandeleev's periodic law and the Modern periodic law?

Ans. According to Mandeleev's periodic law, the physical and chemical properties of the elements are periodic function of their atomic weight. On the other hand, according to modern periodic law, the properties are periodic function of their atomic numbers.

Q.4. Write the atomic number of the element present in the third period and seventeenth group of the periodic table.

Ans. Since it belongs to 3^{rd} period, it will have outermost shell, n=3. Its configuration will be $3s^2 3p^5$.

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Therefore, its atomic number will be 17.

Q.5. Why do elements in the same group have similar physical and chemical properties?

Ans. Elements in the same group have similar properties because they have similar outer electronic configuration. For detail, please refer text.

Q.6. What does atomic radius and ionic radius really mean to you ?

Ans. Atomic radius is one half of the distance between the nuclei of two covalently bonded atoms of the same element in a molecule. In case of metals, the atomic radius is called metallic radius. It corresponds to one half of the distance between two adjacent atoms in a crystals lattice.

Ionic radius means the size of the ion i.e., a cation or anion. This gives the effective distances from the nucleus of the ion upto which it has an influence in the ionic bond. The size of the cation is always smaller than that of the parent atom while the size of the anion is always larger than that of the parent atom.

Q.7. How does atomic radius vary in a period and in a group? How do you explain the variation?

Ans. The atomic size decreases as we move from left to right in a period. This is because when we move along a period the nuclear charge increases and therefore, the attraction of the nucleaus for the outer electrons increases and hence the atomic size decreases.

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Within a group, the atomic size increases down the group. This is because of addition of a new energy shell at each succeeding element while the number of valence electrons remain the same.

Q.8. Consider the following species :

N^3 , O^{2-} , F^- , Na^+ , Mg^{2+} **and** Al^{3+}

(a) What is the common in them?

(b) Arrange them in the order of increasing ionic radii.

Ans. (a) All these ions have same number (10) of electrons. Therefore, these are also called isoelectronic species.

(b Since the number of electrons are same, the ionic size decreases with increase in nuclear charge. Therefore, the ions can be arranged in increasing order of ionic radii as

$$Al^{3+} < Mg^{2+} < Na^+ < F^- < O^{2-} < N^{3-}$$

Q.9. Explain why cations are smaller and anions larger in radii than their parent atoms?

Ans. A cation is formed by the loss of one or more electrons from the gaseous atom. With the loss of electrons from an atom, the magnitude of the nuclear charge remains same while the number of electrons decreases. As a result, the same nuclear charge now acts on lower number of electrons and therefore, the effective nuclear charge per electron increases. As a result, electrons are more

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strongly attracted and are pulled towards the nucleus and therefore, the size decreases.

The anion is formed by the gain of one or more electrons and therefore, the number of electrons increases while the magnitude of nuclear charge remains same. As a result, the electrons are less tightly held by the nucleus and therefore, the size increases.

Q.10. What are the various factors due to which the ionization enthalpy of the main group elements tends to decrease down a group?

Ans. Within the main group elements, the ionization enthalpy decreases regularly as we move down the group. This is due to the following factors :

(i) Atomic size : On moving down the group, there is a gradual increase in atomic size due to an additional main energy shell (n).

(ii) Shielding effect : There is increase in shielding effect on the outermost electron due to increase in the number of inner electrons.

(iii) Nuclear charge : In going from top to bottom in a group, the nuclear charge increases.

The effect of increase in atomic size and the shielding effect is much more than the effect of increase in nuclear charge. As a result, the electron becomes less tightly held to the nucleus as we move down the group. Hence there is a gradual decrease in the ionisation enthalpies in a group.

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Q.11. The first ionization enthalpy values (in Kj mol^{-1}) of group 13 elements are :

B	Al	Ga	In	T1
801	577	579	558	589

How would you explain this derivation from the general trend ?

Ans. In general, ionization enthalpy in a group decreases with increase in atomic number. This is true from B to Al. However, Ga has unexpectedly higher ionization enthalpy than Al. This is because in case of Ga, there are ten d – electrons in its inner electronic configuration. The d-electrons are less penetrating and therefore, shield the nuclear charge less effectively than s – and p – electrons. As a result, the outer electron is held fairly strongly by the nucleus and therefore, ionization enthalpy increases slightly inspite of the increase in atomic size from Al to Ga. The similar increase is observed from In to TI, which is due to the presence of 14f-electrons in the inner electronic configuration of TI which have very poor shielding effect.

Q.12. Which of the following pairs of elements would have a more negative electron gain enthalpy?

(i) O or F **(ii) F or Cl**

Ans. (i) F (ii) Cl

Q.13. Would you expect the second electron gain enthalpy of O as positive, more negative or less negative than the first ? Justify your answer.

Ans. The second electron gain enthalpy of oxygen would be positive. This is because after the addition of one electron, it becomes negatively charged ion and

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the addition is opposed by coulombic repulsions. Therefore, energy has to be supplied to force the second electron into the anion and hence second electron into the anion and hence second electron gain enthalpy would be positive.

Q.14. What is the basic difference between the terms electron gain enthalpy and electronegativity ?

Ans. Electron gain enthalpy refers to the tendency of an atom in its gaseous isolated state to accept an additional electron to form a negative ion. Electronegativity refers to the tendency of an atom to attract the shared pair of electrons towards it in a covalent bond. Thus, electron gain enthalpy is the property of isolated atoms whereas electronegativity is the property of atoms in molecules.

Q.15. How would you react to the statement that electronegativity of N on Pauling scale is 3.0 in all its compounds ?

Ans. The electronegativity of nitrogen will not be 3.0 in all its compounds. It depends upon the other atoms attached to it. It also depends on the state of hybridisation and the oxidation state to the element.

Q.16. Describe the theory associated with the radius of an atoms as it

(a) gains an electron

(b) loses an electron

Ans. (a) When an atom gains one electron to form an anion, its radius increase. The anions are always larger in size than the corresponding atoms. For reasons .

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(b) When an atom loses an electron, it forms a cation and its radius decreases. The cations are always smaller in size than the corresponding atoms.

Q.17. Would you expect the first ionization enthalpies for two isotopes of the same element to be the same or different? Justify your answer.

Ans. Isotopes are atoms of the same element which have same atomic number but different mass number. Therefore, they have same number of electrons and nuclear charge (protons). Thus, they will have almost same first ionization enthalpies.

Q.18. What are the major differences between metals and non metals ?

Ans. Elements which have strong tendency to lose electrons to form cations are called metals whereas those which have a strong tendency to accept electrons to form anions are called non-metals. Thus, metals are strong reducing agents, they have low ionization enthalpies, low negative electron gain enthalpies, low electronegativity, form basic oxides and ionic compounds.

On the other hand, nonmetals are strong oxidising agents, they have high ionisation enthalpies, have high negative electron gain enthalpies, high electronegativity, form acidic oxides and covalent compounds.

Q.19. (a) Identify an element with five electrons in the outershell.

(b) Identify an element that would tend to lose two electrons.

(c) Identify an element that would tend to gain two electrons.

(d) Identify the group having metal, non-metal, liquid as well as gas at the room temperature.

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Ans. (a) Chromium (Z = 24). It has five electrons in the outer 3d subshell.

(b Magnesium (Z = 12) can lose two electrons readily.

(c Oxygen (Z = 8) can gain two electrons.

(d Halogens (group 17). It has metal (iodine), non-metals (F, Cl, Br), liquid bromine and gases.

Q.20. The increasing order of reactivity among group 1 elements is Li < Na < K < Rb < Cs whereas that among group 17 elements is F > Cl > Br > I. Explain.

Ans. The elements of group 1 have only one electron in their outermost shells and therefore, have strong tendency to lose this electron. The tendency of these elements to lose the valence electron depends upon the ionization enthalpy. Since ionization enthalpy decreases down the group, therefore, the reactivity of group 1 elements increases in the same order Li < Na < K < Rb < Cs.

On the other hand, the elements of group 17 have seven electrons in their respective valence shells and therefore, they have strong tendency to accept one more electron. The tendency to accept additional electrons depends upon the electrode potentials of group 17 elements. The electrode potential of group 17 elements decreases from F to I [F = + 2.86 V, Cl = + 1.36 V , Br = + 1.08 V and I = + 0.53 V] and therefore, their reactivities also decrease in the same order as F > Cl > Br > I.

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