Classification of Elements and Periodicity in Properties

Case Study Based Questions

Read the following passages and answer the questions that follow:

1. Elements in the contemporary periodic table are listed in increasing atomic number order, which is related to the electronic configuration. The elements in the periodic table have been separated into four blocks s, p, d and f based on the type of orbitals receiving the last electron, namely, the contemporary periodic table is divided into seven periods and eighteen groups. Each period starts with the formation of a new energy shell. According to the Aufbau concept, each of the seven periods (1 to 7) has 2, 8, 8, 18, 18, 32 and 32 elements. To keep the periodic table from becoming excessively long, the lanthanoids and actinoids series off-block elements are placed towards the bottom of the main body of the periodic table.

(A) How many elements are there in the f-block?

(B) Which concept is used to determine the number of elements in each period?

(C) What is the difference between Lanthanoids and Actinoids in terms of position in the periodic table?

Ans. (A) Aufbau concept is used to determine the number of elements, each of the seven periods has elements.

(B) There is a distinction between Lanthanides and Actinides. The filling of 4f-orbitals is done in lanthanoids, while the filling of 5f-orbitals is done in actinoids.

(C) (c) d-block

Explanation: The position of an element in the periodic table is determined by the quantum numbers of the last orbital filled. Lanthanum has the atomic number 57. As the valence shell of lanthanum is 5d, lanthanum belongs to the d-block of the periodic table.

2. The modern table is based on Mendeleev's table, except the modern table arranges the elements by increasing atomic number instead of atomic mass. Atomic number is the number of protons in an atom, and this number is unique for each element. The modern table has more elements than Mendeleev's table because many elements have been discovered since Mendeleev's time. Rows of the modern periodic table are called periods, as they are in Mendeleev's table. From left to right across a period, each element has one more proton than the element before it. Some periods in the modern

periodic table are longer than others. Columns of the modern table are called groups, as they are in Mendeleev's table. However, the modern table has many more groups-18 compared with just 8 in Mendeleev's table. Elements in -the same group have similar properties. Periodic table is divided into 4 blocks viz. s-block, p-block, d-block and f-block.

(A) Which of the following is a f-block element?

(a) Sodium

(b) Argon

(c) Samarium

(d) Zinc

(B) s-block elements are:

(a) Groups I-A and III-B elements

(b) Groups I-A and II-A elements

(c) Groups I-A and I-B elements

(d) Groups I-A and II-B elements

(C) The number of groups and periods respectively in modern periodic table is:

(a) Seven, eighteen

(b) Eighteen, seven

(c) Seven, seven

(d) Eighteen, eighteen

(D) The element with atomic number 57-belongs to:

(a) s-block

(b) p-block

(c) d-block

(d) f-block

(E) Assertion (A): Helium is placed in group 18 along with p-block elements.

Reason (R): It shows properties similar to elements. p-block

(a) Both (A) and (R) are true and (R) is the correct explanation of (A).

(b) Both (A) and (R) are true but (R) is not the correct explanation of (A).

(c) (A) is true but (R) is false.

(d) (A) is false but (R) is true.

Ans. (A) (c) Samarium

Explanation: Samarium is a f-block element with the atomic number 62 and the

periodic table symbol Sm.
(B) (b) Groups I-A and II-A elements
Explanation: s-block elements are elements from groups I-A (alkali metals) and II-A (alkaline earth metals).
(C) (b) Eighteen, seven
Explanation: There are seven periods and eighteen groups in the modern periodic table.
(D) The elements of the f-block are listed individually at the bottom of the periodic table because they resemble each other but do not resemble any other group elements.
(D) (c) (A) is true but (R) is false.
Explanation: He (1s2) should be placed along with s-block elements because of its electronic configuration but it has a completely filled valence shell and as a result, it exhibits properties of noble gases, thus it is placed along with noble gases (ns^2, np).
(E) There are 28 elements belonging to the f-block element and have been grouped in two horizontal rows

3. The radius of the isoelectronic species might be dissimilar due to their dissimilar nuclear charges. As already described the size of the cation is usually smaller than its parent atom whereas the size of the anion is usually larger than its parent. The successful lack of electrons from an atom raises the effective nuclear charge whereas the successful achievement of electrons reduces the effective nuclear charge. This is the cause of the cation with an extra positive charge having a smaller radius due to the extranuclear attraction of the electrons. While the anion with the extra negative charge has a bigger radius because, in this situation, The electrons' net repulsion surpasses the nuclear charge, causing the size to expand.
(A) Which of the following species has the biggest size?
N, N^3, F and F
(B) Which of the following species has the smallest size?
N, N3, F and F
(C) Give a reason for the answers of (A) and (B).

Ans. (A) The biggest ion is N^3-
(B) The smallest species is F.
(C) N^3 and F are anions that indicate that their size is greater than their parent atoms. As we know more the electron gains the size of the ion compared to its parent atom so N^3-

has the largest size whereas F has the smallest size as its effective nuclear charge is greater than N.

4. Though elements are categorized into s, p, d and f-block, it is possible to classify them further into metals, non-metals, and metalloids. More than 78 per cent of all recognized elements are metals. These elements are found on the periodic table's left side and in the middle. These elements are malleable and ductile, own lustre, have high densities, and are good conductors of heat and electricity. Metals typically have excessive melting points, and boiling points, and most are solid at room temperature. Non-metals are much fewer in number than metals. There are about 17 non-metals in total. These elements are found on the periodic table's upper right- hand side. Their melting points and boiling points are generally low. At room temperature at non-metals typically are solids or gases. They aren't ductile or malleable in the least. They are poor heat and electrical conductors. The non-metallic property rises from left to right in a period. Metallic character rises down the group.

(A) Name some metalloids.

(B) Arrange the following items in ascending metallic character order:
Si, Be, Mg, Na, P The atomic number and position in the periodic table are taken into consideration.

(C) Give a reason for the order obtained in (B).

Ans. (A) Silicon, germanium, arsenic, antimony and tellurium.

(B) P<Si < Be < Mg <Na

(C) We know that on moving down the group metallic character rises whereas on moving along a period from left to right it reduces, thus, the ascending order of the metallic character is: P < Si < Be < Mg < Na.

5. The quantity of energy liberated when an electron is added to a remote gaseous atom is referred to as electron gain enthalpy. The fundamental electron affinity is usually exothermic. Because it takes energy to add an electron to an anion and overcome the force of repulsion, the second electron affinity is endothermic. In general, in a group, electron gain enthalpy reduces as the size rises and, in a period, electron gain enthalpy rises as the atomic radius reduces. However, there are numerous exceptions because of the stable electronic configurations and due to the smaller size of atoms.

(A) Which of the halogens has the highest electron affinity?

(a) Cl

(b) F

(c) Br

(d) I

(B) Choose the chalcogen with the maximum negative electron gain enthalpy.

(a) S

(b) Se

(c) O

(d) Po

(C) Element which has more negative electron gain enthalpy is:

(a) F

(b) O

(c) CL

(d) s

(D) Which of the following statements is incorrect?

(a) Helium has the highest first ionisation enthalpy in the periodic table.

(b) Chlorine has less negative electron gain enthalpy than fluorine.

(c) Mercury and bromine are liquids at room temperature.

(d) In any period, atomic radius of alkali metal is the highest.

Ans. (A) (a) Cl

Explanation: Among the species, the highest negative electron gain enthalpy is of Cl the atom. The reason for this is that as you move down the group, the electron gain enthalpy gets somewhat negative. But the introduction of an electron to the 2p orbital creates extra repulsion than the introduction of an electron to the 3p orbital.

(B) (c) O

Explanation: Oxygen has the maximum negative electron gain enthalpy. Because of the smaller atomic size.

(C) (c) CL

Explanation: Chlorine has the highest negative electron gain enthalpy in the periodic table.

(D) (b) Chlorine has less negative electron gain enthalpy than fluorine

Explanation: Chlorine has more negative electron gain enthalpy than fluorine. Due

to the very small size of fluorine, it's not able to accommodate the newly coming electron and hence has lower negative electron gain enthalpy than fluorine.

6. The minimal quantity of energy required to dispose of the outermost electron from a remoted gaseous atom is called the ionisation enthalpy (IE) of the element. From top to bottom, the ionisation energy of a group decreases, whereas the ionisation energy of a period increases from left to right. However, there are numerous exceptions because of stable electronic configurations. The energy required to dispose of the 2nd electron from the monovalent cation is referred to as second ionisation enthalpy (IE) Similarly, we've 3rd 4th... ionisation energy.

(A) Which one would have the highest difference in their first and second ionisation enthalpies?

Na, Mg, Si and P

Explain.

(B) Why solar panels are made up of silicon?

(C) The ionisation enthalpy of Nitrogen is higher than the Oxygen atom. Explain.

Ans. (A) Na (Sodium). Sodium has the greatest difference as after the removal of an electron, gives stable noble gas configuration. Electronic configuration of Na = $1s^2 2s^2 p^6 3s^1$ Thus, to remove the second electron from sodium ion, more energy is required which is now harder as it has a stable inert gas configuration. Thus, sodium has a higher difference in its first and second ionisation enthalpy.

(B) Mostly Silicon is utilized in solar panels as a semiconductor because it is a cost-efficient material that offers good energy efficiency. Furthermore, silicon has a higher corrosion resistance, a longer lifespan, ideal thermal expansion properties, excellent photoconductivity, and low toxicity.

(C) Nitrogen (Z=7) has anomalously higher first ionisation enthalpy (1402kJ/mol) than oxygen (Z=8), (1314kJ/mol) This arises due to the fact that half-filled orbitals and full-filled degenerate orbitals are extra solid than the incompletely filled degenerate orbitals. Here nitrogen ($1s2^2 s2^2 p^3$) has half- filled p-orbitals while oxygen ($1s22s22p^1$) has incompletely stuffed.