09. CLASSIFICATION OF ELEMENTS – THE PERIODIC TABLE

Questions and Answers

1. Newlands proposed the law of octaves. Mendeleeff suggested eight groups for elements in his table. How do you explain these observations in terms of modern periodic classification?

A. New lands and Mendeleef both arranged the elements in the ascending order of their atomic masses. Even they does not know about the atomic number at that time, arranged elements in a systematic way. As the atomic number increases the atomic mass also increases (most of the cases). So the arrangement made by Newlands and Mendeleef is identical for the elements having less mass.

2. What are the limitations of Mendeleeff's periodic table? How could the modern periodic table overcome the limitations of Mendeleeff's table?

A. Limitations of Mendeleef's periodic table:

(i) **Anomalous pair of elements:** Certain elements of highest atomic weights precede those with lower atomic weights.

Ex: Tellurium (atomic mass 127.6) precedes Iodine (atomic weight 126.9).

(ii) **Dissimilar elements placed together:** elements with dissimilar properties were placed in same group as sub-group A and sub-group B.

Ex: Alkali metals like Li, Na, K etc., differ from coinage metals like Cu, Ag, Au .

Ex: Chlorine is a non metal. Manganese is metal. But both arranged in a same group.

(iii) Metals and non metals are arranged together.

Modern periodic table:

(i) Modern periodic table arranged in the increasing order of atomic numbers.

(ii) Anomalous pair of elements have arranged as per periodic law.

(iii) Dissimilar metals are placed in different groups.

(iv) Metals and non metals are identified easily.

(v) Elements are arranged as per the oxidation states and electronic configuration and chemical properties.

3. Define the modern periodic Law. Discuss the construction of the long form of the periodic table.

A. Modern periodic law: The physical and chemical properties of elements are the periodic functions of their electronic configurations.

Construction of Periodic table:

The horizontal rows are called as periods and the vertical columns are called as groups in modern periodic table.

i) It consists of 7 periods and 18 columns which are made into 18 groups.

ii) According to the occupation of differentiating electron the elements are classified into four blocks. They are s, p, d and f-blocks.

Groups	Name of the block
Group IA to IIA (Gr-1 to Gr-2)	s-block
Group IIIA to VIIIA (Gr-13 to Gr-18)	p-block
Elements lies between s and p-block elements.(Gr-3 to Gr-12)	d-block
The elements arranged at the bottom of the table.	f-block

iii) Based on electronic configuration elements are classified into four classes.

Groups	Name of the elements
Group VIIIA	Inert gases
Group IA to VII A	Representative elements
Elements in d-block	Transition elements
Elements in f-block	Inner Transition elements

iv) f-block consists of Lanthanides and actinides. Lanthanides means the elements from Lanthanum(Z=57) to Ytterbium(Z=70). Actinides means the elements from Actinium(Z=89) to Nobelium(Z=102).

(v) Helium, Neon, Argon, Krypton, Xenon and Radon are inert gases and placed in VIIIA or 18 group.

(vi) Metals occupied at left part and non metals at right part of table. Some metalloid elements like Boron, Silicon, Germanium, Arsenic, Antimony, Tellurium are at the middle.

(vii) 2,8,8,18,18,32, 32 elements present in the 7 periods respectively. 7^{th} period is incomplete.

(viii) f-block elements are arranged at the bottom of the table.

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4. Explain how the elements are classified into s, p, d and f- block elements in the periodic table and give the advantage of this kind of classification.

A. According to the occupation of differentiating electron the elements are classified into four blocks. They are s, p, d and f-blocks.

Groups	Name of the block
Group IA to IIA	s-block
Group IIIA to VIIIA	p-block
Elements lies between s and p-block elements.	d-block
The elements arranged at the bottom of the table.	f-block

(i) The valence electronic configuration of elements in s-block is ns^1 or ns^2. (group 1 to group 2)

(ii) The valence electronic configuration of elements in p-block is $ns^2\ np^1$ to $ns^2\ np^6$. (group 13 to group 18)

(iii) The valence electronic configuration of elements in d-block is $ns^2\ np^6\ (n-1)d^1$ to $ns^2\ np^6(n-1)d^{1-10}$. (group 3 to group 12)

(iv) The valence electronic configuration of elements in f-block is $ns^2\ np^6\ (n-1)d^{10}(n-2)f^1$ to $ns^2\ np^6\ d^{10}(n-2)f^{14}$.

This classification is very useful for expecting the properties of elements as per number of valence electrons.

5. Given below is the electronic configuration of elements A, B, C, D.

A. $1s^2\ 2s^2$ **B.** $1s^2\ 2s^2\ 2p^6\ 3s^2$

C. $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^3$ **D.** $1s^2\ 2s^2\ 2p^6$

Now answer the following.

1. Which are the elements coming with in the same period

2. Which are the ones coming with in the same group?

3. Which are the noble gas elements?

4. To which group and period does the elements 'C ' belong?

A. As per the given data, we know that

Element	Configuration	Group	Period
A	$1s^2\ 2s^2$	2	2
B	$1s^2\ 2s^2\ 2p^6\ 3s^2$	2	3
C	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^3$	15	3
D	$1s^2\ 2s^2\ 2p^6$	18	2

1) A,D and B,C belongs to the same period.

2) A and B lies in the same group.

3) D is the Noble gas element.

4) C belongs to 3rd period and 15th group.

6. Write down the characteristics of the elements having atomic number 17.

(a) Electronic configuration (b) Period number
(c) Group number (d) Element family
(e) No. of valence electrons (f) Valency
(g) Metal or non-metal

A. The details of the element having atomic number 17 are as follows.

(a) Electronic configuration : $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$

(b) Period number : 3

(c) Group number : 17

(d) Element family: Halogen family

(e) No. of valence electrons : 2+5 = 7

(f) Valency : 1

(g) Metal or non metal : Metallic property

7a. State the number of valence electrons, the group number and the period number of each element given in the following table:

Element	Valence electrons	Group number	Period number
Sulphur	6	16	3
Oxygen	6	16	2
Magnesium	2	2	3
Hydrogen	1	1	1
Fluorine	7	17	2
Aluminum	3	13	3

7b. State whether the following elements belong to a Group (G), Period (P) or Neither Group nor Period (N).

Elements	G/P/N	Elements	G/P/N
Li,C,O	Period	**Al,Si,Cl**	Period
Mg,Ca,Ba	Group	**Li,Na,K**	Group
Br,Cl,F	Group	**C,N,O**	Period
C,S,Br	None	**K,Ca,Br**	Period

8. Elements in a group generally possess similar properties, but elements along a period have different properties. How do you explain this statement?

A. The elements in a group have same number of valence electrons. Properties of elements depends upon the number of valence electrons. So the elements in a group generally possess similar properties.

No two elements in a period have same number of valence electrons. So The elements in a period have different properties.

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9. s - block and p - block elements except 18th group elements are sometimes called as 'Representative elements' based on their abundant availability in the nature. Is it justified? Why?

A. The main group elements (1 to 2 and 13 to 17) of s-block and p-block are called as representative elements. The are very reactive and most available in compound forms in nature. So they are called representative elements. Generally the element having un fulfilled s or p orbitals are called representative elements.

10. Complete the following table using the periodic table.

Period Number	Filling up orbitals (sub shells)	Maximum number of electrons, filled in all the sub shells	Total no. of elements in the period
1	1s	2	2
2	2s,2p	8	8
3	3s,3p	8	8
4	**4s, 3d, 4p**	**18**	**18**
5	5s,4d,5p	18	18
6	6s,4f,5d,6p	32	32
7	**7s, 5f, 6d, 7p**	**32**	**incomplete**

11. Complete the following table using the periodic table.

Period Number	Total no. of elements in the period	Elements		Total no. of elements in following blocks			
		From	To	s-	p-	d-	f-
1	2	H	He	2			
2	8	Li	Ne	2	6		
3	8	Na	Ar	2	6		
4	18	K	Kr	2	6	10	
5	18	Rb	Xe	2	6	10	
6	32	Cs	Rn	2	6	10	14
7	incomplete	Fr	Lv	2	0	10	14

12. The electronic configuration of the elements X, Y and Z are given below?
a) X = 2 b) Y = 2, 6 c) Z = 2, 8, 2
i) Which element belongs to second period?
ii) Which element belongs to second group?
iii) Which element belongs to 18th group?

A. Given elements and configurations are:
X =2 ; Y = 2,6 ; Z = 2,8,2
(i) The element belongs to 2nd period is Y.
(ii) The element belongs to 2nd group is Z.
(iii) The element belongs to 18th group is X.

13. Identify the element that has the larger atomic radius in each pair of the following and mark it with a symbol (√).
(i) Mg or Ca (ii) Li or Cs
(iii) N or P (iv) B or Al

A. In a group, the atomic radius increases from top to bottom. And in a period, the atomic radius decreases from left to right.
(i) Mg and Ca are in group 2 ; and Ca has large atomic radius.
(ii) Li and Cs are in group 1; and Cs has large atomic radius.
(iii) N and P are in group 15 ; and P has large atomic radius.
(iv) B and Al are in group 13; and Al has large atomic radius.

14. Identify the element that has the lower Ionization energy in each pair of the following and mark it with a symbol (√).
(i) Mg or Na (ii) Li or O
(iii) Br or F (iv) K or Br.

A. In a group, the ionization energy decreases from top to bottom. And in a period, the ionization energy increases from left to right.
(i) Mg and Na are in period 3 ; and Na has Lower ionization energy.
(ii) Li and O are in period 2; and Li has Lower ionization energy.
(iii) Br and F are in group 15 ; and Br has Lower ionization energy.
(iv) K and Br are in period 3; and K has Lower ionization energy.

15. In period 2, element X is to the right of element Y. Then, find which of the elements have:
(i) Low nuclear charge (ii) Low atomic size
(iii) High ionization energy
(iv) High electro negativity
(v) More metallic character?

A. In a period, as the atomic number increases nuclear charge increases, size decreases, ionization energy increases, electro negativity increases, metallic character decreases.
Given: two elements X and Y such that X is to the right of Y.
Means Atomic number of Y is less.
(i) Y has lower nuclear charge.
(ii) X has less atomic size.
(iii) X has high ionization energy.
(iv) X has less electro negativity property.
(v) Y has less metallic character.

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16. How does metallic character change when we move

i. Down a group ii. Across a period?

A. (i) From top to bottom in a group, metallic character increases.

(ii) From left to right in a period, metallic character decreases.

17. Why was the basis of classification of elements changed from the atomic mass to the atomic number?

A. At first Doberiener classified elements according to the atomic mass. Because the only known quality of atom is atomic mass in those days. Newlands and Mendeleef also followed the same rule but arranged different.

When electron was discovered, the atomic number comes to play a dominant role. As the properties of atoms depends upon the number of valence electrons, it is useful to arrange elements as per atomic numbers or configurations. It was done by Mosley.

18a. What is a periodic property? How do the following properties change in a group and period? Explain.

(a) Atomic radius (b) Ionization energy

(c) Electron affinity (d) Electro negativity.

A. Modern periodic law: The properties of elements are periodic functions of their atomic numbers or electronic configurations.

(a) Variation of atomic radius:

(i) In periods, as the atomic number increases the atomic radius decreases from left to right.

(ii) In groups, as the atomic number increases the atomic radius increases from top to bottom.

(b) Variation of Ionization potential:

(i) In periods, Ionization potential do not follow any regular trend from left to right. But finally it increases.

(ii) In groups, Ionization potential decreases from top to bottom.

(c) Variation of Electron affinity:

(i) In periods, as the atomic number increases electron affinity increases.

(ii) In groups, as the atomic number increases electron affinity decreases.

(d) Variation of Electro Negativity:

(i) In periods, Electro Negativity increases from left to right.

(ii) In groups, Electro Negativity decreases from top to bottom.

18b. Explain the ionization energy order in the following sets of elements:

a) Na, Al, Cl b) Li, Be, B c) C, N, O

d) F, Ne, Na e) Be, Mg, Ca.

A. In periods, Ionization potential do not follow any regular trend from left to right. But finally it increases.

In groups, Ionization potential decreases from top to bottom.

The order of given set of elements are

(i) Na, Al, Cl are in period 3. The ionization energies are Cl > Al > Na.

(ii) Li, Be, B are in period 2. The ionization energies are Be > B > Li. Because the orbitals in Be are fulfilled. So it has more stability than B.

(iii) C, N, O are in period 2. The ionization energies are N > O > C. because the outer orbitals in N has half filled. So it has more stability than O.

(iv) F, Ne, Na are not lie in a same period or in a group. Electronic configurations are

F - $1s^2\ 2s^2\ 2p^5$

Ne - $1s^2\ 2s^2\ 2p^6$

Na - $1s^2\ 2s^2\ 2p^6\ 3s^1$

The order of ionization energies are Ne > F > Na. Because Ne is an inert gas. F is the element of highest electro negativity.

(v) Be, Mg, Ca are in group 2. The ionization energy order is Be > Mg > Ca

19. Name two elements that you would expect to have chemical properties similar to Mg. What is the basis for your choice?

A. Calcium (Ca) and Strantium (Sr) are the two elements having similar chemical properties to Mg.

The properties of elements depends upon the number of valence electrons in atom. It is same for the elements which lies in same group. Be, Mg, Ca, Sr, Ba are the elements in group 2.

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20. On the basis of atomic numbers predict to which block the elements with atomic number 9, 37, 46 and 64 belongs to?

A. The differentiating electron determines the place of atom in modern periodic table. The order of occupation of electrons in orbitals is : $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6\ 5s^2\ 4d^{10}\ 5p^6\ 6s^2\ 4f^{14}$…..

Atomic number	Part of Valence configuration	Block which it belongs
9	$2p^5$	p
37	$5s^1$	s
46	$4d^8$	d
64	$4f^8$	f

21. Using the periodic table, predict the formula of compound formed between and element X of group 13 and another element Y of group 16.

A. The element X belongs to group 13. Number of valence electrons are 3. The valency of X is 3.

The element Y belongs to group 16. Number of valence electrons are 6. The valency of Y is 2.

According to Criss-cross law valencies are interchanged to write formulae of compounds. So The compound formula is X_2Y_3.

22. An element X belongs to 3rd period and group 2 of the periodic table. State

(a) The no. of valence electrons

(b) The valency

(c) Whether it is metal or a nonmetal.

A. An element belongs to 3rd period means the outer shell in that atom is 3.

An elements belongs to group 2 means the General electronic configuration is ns^2.

(a) The number of valence electrons = 2

(b) The valency of the atom = 2

(c) It is a metal with more reactivity.

23. An element has atomic number 19. Where would you expect this element in the periodic table and why?

A. An element has atomic number 19.

Electronic configuration is $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1$

The differentiating electron enters in 4s orbital, So it belongs to 4th period. The number of valence electrons are 1. So it belongs to group 1 or IA.

24. Aluminium does not react with water at room temperature but reacts with both dil. HCl and NaOH solutions. Verify these statements experimentally. Write your observations with chemical equations. From these observations, can we conclude that Aℓ is a metalloid?

A. Aluminium does not react with water at room temperature.

Take 10ml of dil. HCl in a test tube and add some pieces of aluminium to it. We can observe a gas liberates from the test tube. If we place a burning match stick near the open end of the test tube, the flame puts off. So we determined that the gas evolved is hydrogen. Hydrogen gas is evolved when acids react with metals. So by this experiment, we conclude that Aluminium is not a metalloid. It is a metal.

$$2\ Al + 6HCl \rightarrow 2AlCl_3 + 3H_2$$

Similarly We can observe that Aluminium reacts with aqueous NaOH and produce hydrogen gas.

$$2Al + 2NaOH + 2H_2O \rightarrow 2NaAlO_2 + 3H_2$$

27. How do you appreciate the role of electronic configuration of the atoms of elements in periodic classification?

A. Modern periodic table was constructed as per the ascending order of atomic numbers or electronic configurations of atoms. Modern periodic law states that the properties of elements are the periodic functions of their configurations.

Electronic configuration represent the place of atom in table. It states the number of valence electrons in the atom. As per the valency, we can predict the properties of atom like reactivity, metallic property, oxidation state, relative ionization energy, which type of bond it can form.

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28. Without knowing the electronic configurations of the atoms of elements Mendeleev still could arrange the elements nearly close to the arrangements in the Modern periodic table. How can you appreciate this?

A. Mendeleef arranged all the known elements at his time in a systematic arrangement of increasing order of the atomic masses of atoms. He explains the similarities of properties of elements. He arranged elements having similar properties in a same group.

Mendeleef estimated some unknown elements to arrange the atoms as per chemical properties. Eka-Boron, Eka-silicon, Eka-Aluminium were estimated. Later they were found by some other. So It was the extraordinary thinking of Mendeleef that made the chemists to accept the periodic table.

29. Comment on the position of hydrogen in periodic table.

A. Position of an element depends upon the electronic configuration of that element. Hydrogen can be arranged in groups 1,4 and 17.

Like alkali metals, it has one electron in its outermost orbital. So it can be placed in group 1. Alkali metals can loose electron but hydrogen can not.

Valence shell of hydrogen is half filled like group 4 elements. So it can be placed in group 4. Elements of group 4 are tetravalent but hydrogen is mono valent.

Hydrogen needs one electron for its stability like halogens. So it can be placed in group 17. They form covalent bonds. Halogens have 7 electrons in their valence shell but hydrogen has only one electron.

So There is no suitable place for hydrogen in periodic table.

30. How the positions of elements in the periodic table help you to predict its chemical properties? Explain with an example.

A. Modern periodic table was constructed on the basis of atomic number or electronic configuration. The position of element tells us the atomic number, number of valence electrons and valency of the element. This helps in predicting the reactivity, comparative atomic size, metallic character, comparative ionisaion energy, in which type of bonds it can participate.

Ex: Group 17, the elements have 7 valence electrons. The valency of the elements in that group is 1. All these elements are highly reactive. They are non metals. Atomic size increases, and ionization energy decreases from top to bottom in that group. All the elements can gain one electron for their stability. All can participate in forming covalent bonds.

ADDITIONAL QUESTIONS

31. What are Lanthanides?
32. What are Actinides?
33. Name inert gases?
34. Write the general electronic configuration of inert gases ?
35. Which group of elements have the highest electro negativity values ?
36. Classify the types of elements based on electronic configuration?
37. What is Newland's concept of octaves?
38. Define Electro Positivity ?
39. Define atomic radius.
40. Define Ionization energy ?

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