CHAPTER
5

Periodic Classification of Elements

CASE STUDY / PASSAGE BASED QUESTIONS

Syllabus

Need for classification, early attempts at classification of elements (Dobereiner's Triads, Newlands' Law of Octaves, Mendeleev's Periodic Table), Modern periodic table, gradation in properties, valency, atomic number, metallic and non-metallic properties.

1

Read the following and answer any four questions from 1(i) to 1(v).

After the discovery of large number of elements it became necessary to classify them and arrange them in a regular manner in order of their periodic properties. In 1817, Johann Wolfgang Dobereiner tried to arrange the elements with similar properties into groups. He identified some groups of three elements having similar physical and chemical properties, known as Dobereiner's triads.

In 1865, John Newlands arranged all known elements in the order of increasing atomic masses and found that the properties of every eighth element are similar to the properties of the first element.

(i) If Cl, Br, I is a Dobereiner's triad and the atomic masses of Cl and I are 35.5 and 127 respectively, then the atomic mass of Br is

(a) 162.5 (b) 91.5
(c) 81.25 (d) 45.625

(ii) Example of Dobereiner's triad is

(a) Li, Al, Ca (b) Li, Na, K
(c) Li, K, Na (d) K, Al, Ca

(iii) *A* and *B* are two elements having similar properties which obey Newlands' law of octaves. How many elements are there in between *A* and *B*?

(a) 7 (b) 8
(c) 5 (d) 6

(iv) According to the Newlands' law of octaves, the properties of magnesium are similar to those of

(a) beryllium (b) lithium
(c) sodium (d) potassium.

(v) On what basis the elements are arranged in Dobereiner's triad?

(a) Atomic number (b) Atomic mass
(c) Number of neutrons (d) Number of electrons

2

Read the following and answer any four questions from 2(i) to 2(v).

Mendeleev arranged the 63 elements known at that time in order of their ascending atomic masses and prepared a periodic table. Mendeleev's periodic table contains vertical columns called 'groups' and horizontal rows called 'periods'. Elements with similar properties were placed in same groups.

The basis of Mendeleev's classification is his periodic law which states that :

(I) Atomic mass is the fundamental property of elements.

(II) The physical and chemical properties of elements are periodic function of their atomic masses.

(i) Which of the following metals is not placed in eighth group of Mendeleev's periodic table?

(a) Fe (b) Na (c) Co (d) Ni

(ii) In Mendeleev's periodic table, silver belongs to IB group. The group to which silver belongs in the modern periodic table is

(a) first (b) eleventh (c) tenth (d) sixteenth.

(iii) In Mendeleev's periodic table, gaps were left for the elements to be discovered later. Which of the following elements found a place in the periodic table later?

(a) Chlorine (b) Silicon (c) Oxygen (d) Germanium

(iv) The properties of *eka*-aluminium predicted by Mendeleev were the same as properties of which element that was discovered later?

(a) Scandium (b) Germanium (c) Gallium (d) Aluminium

(v) Which of the following statements is not correct about Mendeleev's periodic table?

(a) In the Mendeleev's periodic table, some places were left vacant for new elements which were not discovered at that time.

(b) Group VIII like groups I-VII has been divided into two sub-groups A and B.

(c) The group of an element in the periodic table represents its valency.

(d) Li and C belong to same period in Mendeleev's periodic table.

3

Read the following and answer any four questions from 3(i) to 3(v).

In 1913, Henry Moseley showed that the atomic number of an element is the more fundamental property than its atomic mass. Accordingly, Mendeleev's periodic law was modified and atomic number was adopted as the basis of modern periodic table.

In this periodic table, the elements are arranged in increasing order of their atomic numbers.

There are 18 vertical columns in the periodic table which constitute 18 groups or families. The groups are numbered as 1, 2, 3, ... upto 18. All the members of a particular group have similar outer shell electronic configuration. There are seven horizontal rows of the periodic table which are known as periods.

(i) According to modern periodic law, the properties of elements are the periodic function of their

(a) atomic masses (b) atomic volumes (c) atomic numbers (d) densities.

(ii) All the elements in a period in the periodic table have the same

(a) atomic number (b) electronic configuration

(c) atomic weight (d) valence shell.

(iii) Which of the following combinations of elements belong to the same group?

(a) N, P, As (b) Li, Be, Al (c) Na, Mg, Al (d) O, S, Cl

(iv) The atoms of elements belonging to the same group of periodic table have same number of
(a) protons (b) electrons
(c) neutrons (d) electrons in outermost shell.

(v) In the periodic table, the element with atomic number 16 will be placed in the group
(a) fourteen (b) sixteen (c) thirteen (d) fifteen.

4

Read the following and answer any four questions from 4(i) to 4(v).

Maximum number of electrons that can be accommodated in a shell is given by the formula : $2n^2$, where n is the number of the outermost from the nucleus.

For example,

K shell – $2 \times (1)^2 \Rightarrow 2$, hence, K-shell can accommodate maximum 2 electrons.

L shell – $2 \times (2)^2 \Rightarrow 8$, hence, L-shell can accommodate maximum 8 electrons.

In the modern periodic table, elements are placed according to their electronic configuration. The elements present in any group have the same number of valence electrons. The elements present in any period contain the same number of shells. The first period of the modern periodic table corresponds to the filling of electrons in the first energy shell, *i.e.*, K-shell, first period has two elements. The second period of the periodic table corresponds to the filling of electrons in the second energy shell, *i.e.*, L-shell, second period contains eight elements. The third, fourth, fifth, sixth and seventh periods have 8, 18, 18, 32 and 32 elements respectively.

(i) Electronic configuration of an element 'X' is 2, 1. The number of elements present in the period to which 'X' belongs is
(a) 8 (b) 32 (c) 18 (d) 2

(ii) Among the given elements A, B, C, D and E with atomic numbers 2, 3, 7, 10 and 30 respectively, which of these belong to the same period?
(a) A, B, C (b) B, C, D (c) A, D, E (d) B, D, E

(iii) The elements A, B, C and D have atomic numbers 4, 12, 17 and 19 respectively. Which pair of elements belong to the same period?
(a) B and C (b) A and B (c) A and D (d) C and D

(iv) Which of the following have the same number of electrons in outermost shell?
(a) Elements with atomic numbers 3, 11, 19 (b) Elements with atomic numbers 14, 15, 16
(c) Elements with atomic numbers 12, 20, 28 (d) Elements with atomic numbers 10, 18, 26

(v) Which of the following elements has two shells and both are completely filled?
(a) Helium (b) Neon (c) Calcium (d) Fluorine

5

Read the following and answer any four questions from 5(i) to 5(v).

All the elements on the left side and in the middle of the periodic table (except hydrogen) are metallic elements or metals. Also, majority of elements in periodic table are metals. In the modern periodic table, the metals are separated from non-metals by a zig-zag line. Some non-metals are gases, some are liquids and rest are solids at room temperature. They generally differ from metals in appearance and in other physical properties. Some elements that lie along the zig-zag line that separates metals from non-metals, have properties that fall between those of metals and non-metals. These elements are regarded as semi-metals or metalloids.

(i) From the given set of metals and non-metals, identify the non-metals.

S, Mg, Al, P, N, Na, K

(a) S, P, K (b) Mg, Al, Na (c) S, P, N (d) S, Al, K

(ii) Which of the following groups contains metals, non-metals and metalloids?

(a) Group 1 (b) Group 17 (c) Group 14 (d) Group 2

(iii) Which of the following elements is a metalloid?

(a) Pb (b) Sb (c) Bi (d) Zn

(iv) Silicon is a metalloid because

(a) its valency is 4 (b) it has three electron shells

(c) it shows properties of both metals and non-metals (d) it is a liquid metal.

(v) The lightest metal is

(a) Li (b) Fe (c) Cu (d) Ag

6

Read the following and answer any four questions from 6(i) to 6(v).

Generally metals possessing 1, 2 or 3 electrons in their respective valence shells have a strong tendency to lose electrons to form positive ions. Non-metals, on the other hand, having 4 to 8 electrons in their respective outermost shells generally have a tendency to gain electrons to form negative ions. Metallic character is called electropositive character and non-metallic character is called electronegative character. The metallic character increases down a group and non-metallic character increases along a period.

(i) Which of the following electronic configurations represent most electropositive element?

(a) 2, 1 (b) 2, 8, 1 (c) 2, 2 (d) 2, 8, 2

(ii) Considering the elements B, C, N, F and Si, the correct order of their non-metallic character is

(a) B > C > Si > N > F (b) Si > C > B > N > F (c) F > N > C > B > Si (d) F > N > C > Si > B

(iii) Which of the following is least metallic?

(a) N (b) P (c) As (d) Sb

(iv) To which of the following categories does the element with atomic number 14 belong?

(a) Metal (b) Metalloid

(c) Non-metal (d) Left-hand side element

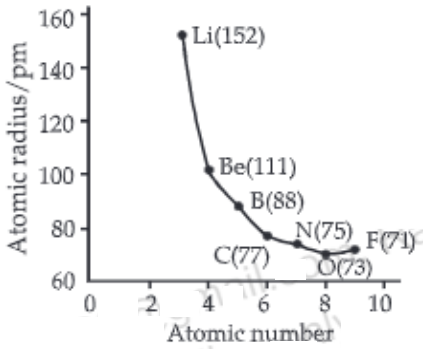
(v) Non-metals are present in the periodic table at

(a) right side (b) left side (c) middle (d) both right and left.

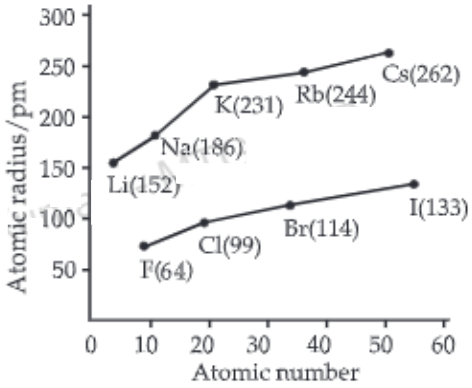
7

Read the following and answer any four questions from 7(i) to 7(v).

The distance between the centre of the nucleus and the outermost shell of electrons is known as atomic radius. On moving from left to right along a period, atomic radii decrease because effective nuclear charge increases. For example, the atomic size decreases regularly from Li to F in the second period and from Na to Cl in the third period. It may, however, be noted that in any period, the noble gas has the largest size. On moving down in a group, atomic radii increase.



Atomic radius across a period



Atomic radius in a group

(i) Which of the following has the maximum atomic radius?
(a) Al (b) Si (c) P (d) Mg

(ii) The element with the smallest size in group 13 is
(a) gallium (b) thallium (c) aluminium (d) boron.

(iii) The atomic radius decreases as we move across a period because
(a) atomic mass increases (b) atomic number decreases
(c) effective nuclear charge increases (d) electrons are removed.

(iv) In the third period of the periodic table, the element having smallest size is
(a) Na (b) Ar (c) Cl (d) Si

(v) Among O, C, F, Cl, Br, the correct order of increasing atomic radii is
(a) F, O, C, Cl, Br (b) F, C, O, Cl, Br (c) F, Cl, Br, O, C (d) C, O, F, Cl, Br

8

Read the following and answer any four questions from 8(i) to 8(v).

Study the following table in which positions of six elements *A*, *B*, *C*, *D*, *E* and *F* are shown as they are in the modern periodic table :

Group → / Period ↓	1	2	3-12	13	14	15	16	17	18
2	*A*					*B*			*C*
3				*D*	*E*				*F*

(i) Which element in the given table has same number of electrons as in K^+ and Cl^-.
(a) *C* (b) *F* (c) *E* (d) *D*

(ii) The formula of the oxide of element *D* will be
(a) *DO* (b) D_2O (c) D_2O_3 (d) D_2O_5

(iii) Which of the following elements has most metallic character?
(a) *F* (b) *D* (c) *E* (d) *B*

(iv) Element *E* forms a chloride with formula
(a) ECl_2 (b) ECl_3 (c) ECl_4 (d) *E*Cl

(v) Which of the following elements is a metalloid?
(a) *A* (b) *B* (c) *C* (d) *E*

9

Read the following and answer any four questions from 9(i) to 9(v).

The recurrence of properties of the elements after a certain regular intervals, when they are arranged in the increasing order of their atomic numbers, is called periodicity. There are a number of physical properties such as atomic size, metallic and non-metallic character, etc. which show periodic variation. In periodic table, various properties vary differently from moving left to right in a period and going down in a group. In a period, properties vary because from moving left to right in a period, number of shells remain same but valence electron increases by one number hence nuclear charge increases. In a group, on going down, number of valence shells increases while number of valence electrons remains same.

(i) From top to bottom in a group of the periodic table, the electropositive character of the element
(a) increases (b) decreases (c) remains unchanged (d) changes irregularly.

(ii) Which element has the largest size in the second period?
(a) N (b) F (c) Li (d) Be

(iii) Which of the following elements has three valence electrons?
(a) Cs (b) Ca (c) Al (d) S

(iv) In the periodic table, the metallic character of elements
(a) decreases from left to right and decreases down the group
(b) decreases from left to right and increases down the group
(c) increases from left to right and increases down the group
(d) increases from left to right and decreases down the group.

(v) Which of the following increases along the period?
(a) Number of valence electrons (b) Atomic size
(c) Electropositive character (d) All of these

10

Read the following and answer any four questions from 10(i) to 10(v).

"Properties of elements are the periodic function of their atomic numbers." This is known as modern periodic law. It means that the properties of elements depend on their atomic numbers and the elements are given positions in the periodic table on the basis of their increasing atomic number. Atomic number determines the distribution of electrons in the orbit, and electrons of the outermost orbit determine the properties of an element. There are 18 groups (vertical columns) and 7 periods (horizontal lines) in modern form of the periodic table. The number of the period is equal to the number of shells in the atoms of the elements belonging to that period.

(i) What is the atomic number of element of period 3 and group 17?
(a) 10 (b) 14 (c) 17 (d) 12

(ii) Atomic number of an element is 2, 8, 6. Its period number and valency are respectively
(a) 3, 2 (b) 6, 6 (c) 6, 2 (d) 2, 2

(iii) An element has mass number 40 and contains 20 neutrons in its atom. To which period and group of the periodic table does it belong?
(a) Period-3, Group-3 (b) Period-4, Group-3 (c) Period-4, Group-2 (d) Period-4, Group-4

(iv) An elements '*X*' has an atomic number of 16. With which of the following elements will it show similar chemical properties?

(a) Ne (10) (b) N (7) (c) O (8) (d) Be (4)

(v) Identify the statement(s) which is(are) true for the modern periodic table.

(a) It reflects trends in physical and chemical properties of the elements.

(b) It helps to reflect the relative atomicity of bonds between any two elements.

(c) It helps to predict the stable valency state of the elements.

(d) All of these

ASSERTION & REASON

For question numbers 11-30, two statements are given-one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below :

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

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

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

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

11. **Assertion :** Atomic radius in general decreases along a period.
Reason : In a period, effective nuclear charge decreases.

12. **Assertion :** Decreasing order of atomic radii is : Cl > F > O > S.
Reason : Atomic radius increases as the number of energy level increases and decreases as nuclear charge increases.

13. **Assertion :** Elements in the same vertical column have similar properties.
Reason : Periodic properties of elements is a function of atomic number.

14. **Assertion :** Number of valence electrons decreases down the group.
Reason : Number of valence electrons increases when we move left to right in a period.

15. **Assertion :** Down the group, atomic radius increases.
Reason : Electrons are added in new shell.

16. **Assertion :** Atomic size of potassium is greater than that of sodium.
Reason : As we go down the group, atomic radius increases.

17. **Assertion :** Increasing order of non-metallic character is : Si < B < C < N < F.
Reason : Non-metallic character increases along a period and decreases down the group.

18. **Assertion :** Nobel elements were not included in Mendeleev's periodic table.
Reason : Mendeleev arranged the then known elements in order of their increasing atomic mass.

19. **Assertion :** Atomic mass of certain elements are expressed in fraction taking in account the availability of its various isotopes.
Reason : Isotopes of an element have the same atomic mass but different atomic number.

20. **Assertion :** Increasing order of metallic character is : P < Si < Be < Mg < Na
Reason : Metallic character increases along a period and decreases down a group.

21. **Assertion :** Li and Mg are elements of second period.
Reason : Both are metals.

22. **Assertion :** According to Mendeleev's periodic law, the properties of elements is the periodic function of their atomic numbers.
Reason : Mendeleev placed some elements with higher atomic mass before the elements with lower atomic mass.

23. **Assertion :** Alkali metals do not form dipositive ions.
Reason : After loss of one electron alkali metals achieve stable configuration of noble gas.

24. **Assertion :** The group 18 consists of elements which are in gaseous state under ordinary conditions.
Reason : All the elements of group 18 have stable configuration.

25. **Assertion :** In Dobereiner's triad, the three elements present have same gaps of atomic numbers.
Reason : Elements in a triad have similar properties.

26. **Assertion :** Argon (at. mass 39.94) has been placed before potassium (at. mass 39.10) in the periodic table.
Reason : In modern periodic table, elements have been placed in order of their increasing atomic numbers.

27. **Assertion :** In Newlands' octaves, the properties of lithium and sodium were found to be same.
Reason : Sodium is the eighth element after lithium.

28. **Assertion :** Group18 is placed at the extreme right of the periodic table.
Reason : It is in accordance with their electronic configuration.

29. **Assertion :** Chlorine is the most electronegative element of the halogen family.
Reason : Size of chlorine is more than that of fluorine.

30. **Assertion :** Atomic size of As is more than that of P.
Reason : Atomic size decreases along a period.

HINTS & EXPLANATIONS

1. (i) (c) : In a triad, the atomic mass of the central atom is near average of the atomic masses of the other two atoms. In the triad, Cl, Br, I, the mass of Br will be the average mass of Cl and I.

$$\text{Atomic mass of bromine} = \frac{35.5 + 127}{2} = 81.25$$

(ii) (b) : Li, Na, K is a Dobereiner's triad. The atomic mass of middle element is approximately the arithmetic mean of the atomic masses of other two elements of the triad.

(iii) (d)

(iv) (a) : Properties of magnesium are similar to those of beryllium because magnesium is eighth element starting from beryllium.

(v) (b)

2. (i) (b) **(ii) (b)**

(iii) (d)

(iv) (c) : Scandium – *eka*-boron
Gallium – *eka*-aluminium
Germanium – *eka*-silicon

(v) (b) : Group VIII consists of three triads such as Fe, Co, Ni; Ru, Rh, Pd and Os, Ir, Pt arranged in 4^{th}, 5^{th} and 6^{th} periods respectively.

3. (i) (c) : According to modern periodic law, the properties of elements are the periodic function of their atomic numbers.

(ii) (d) : All the elements in a period have the same valence shell.

(iii) (a) : N, P and As belong to the same group (group 15).

(iv) (d)

(v) (b) : Element with atomic number 16 has electronic configuration 2, 8, 6. Hence, it will be placed in $10 + 6 = 16^{th}$ group.

4. **(i)** **(a):** '*X*' is Li. It belongs to second period. Number of elements present in a period $= 2 \times n^2$, where n is the number of outermost shell from the nucleus. Thus, second period has 2×2^2 *i.e.*, 8 elements.

(ii) **(b):** *B* is Li, *C* is N, *D* is Ne and they all belong to second period.

(iii) **(a):** Electronic configurations of

	K	*L*	*M*	*N*	
A :	2,	2			$\Rightarrow 2^{nd}$ period
B :	2,	8,	2		$\Rightarrow 3^{rd}$ period
C :	2,	8,	7		$\Rightarrow 3^{rd}$ period
D :	2,	8,	8,	1	$\Rightarrow 4^{th}$ period

Thus, *B* and *C* belong to the same period.

(iv) **(a):** Li, Na and K belong to group 1.

(v) **(b):**

	K	*L*
$_{10}$Ne :	2	8

Both *K* and *L* shells are completely filled.

5. **(i)** **(c):** S, P, N are non-metals while Mg, Al, K and Na are metals.

(ii) **(c):** Group-14 $\underbrace{C}_{\text{Non-metal}}$ $\underbrace{Si \quad Ge}_{\text{Metalloids}}$ $\underbrace{Sn \quad Pb}_{\text{Metals}}$

(iii) **(b)** **(iv)** **(c)**

(v) **(a):** Li is the lightest metal.

6. **(i)** **(b):** Metallic character or electropositive character increases down a group and decreases along a period. The given elements are Li, Na, Be and Mg respectively. Among these elements, Na is most electropositive.

(ii) **(c):** Non-metallic character increases left to right in a period and decreases from top to bottom in a group.

(iii) **(a)**

(iv) **(b):** The element with atomic number 14 is Si which is a metalloid.

(v) **(a)**

7. **(i)** **(d):** In general, the atomic radii decrease along a period and increase down a group.

Atom	$_{12}$Mg	$_{13}$Al	$_{14}$Si	$_{15}$P
Radius (pm)	160	143	118	110

Thus, Mg has maximum atomic radius.

(ii) **(d):** Boron is the first element of group 13, hence it is smallest in size.

(iii) **(c):** Effective nuclear charge increases along a period and due to addition of electrons in the same shell it causes the incoming electron to experience more force of attraction by the nucleus. Therefore, the size of the atom decreases.

(iv) **(c):** Atomic size decreases across the period. Cl has smaller size than Ar. Argon has larger atomic size as compared to Cl due to the inert nature (it has completely filled outer shell).

(v) **(a):** Atomic size decreases from left to right in a period and increases from top to bottom in a group. Thus, the order is F < O < C < Cl < Br.

8. **(i)** **(b):** *F* is argon which has atomic number 18. It has 18 electrons. K^+ and Cl^- ions also have 18 electrons each.

(ii) **(c):** *D* is aluminium which is an element of group 13. Valency of aluminium is 3. Hence, the formula of its oxide will be Al_2O_3.

(iii) **(b):** *D* is aluminium, which has the most metallic character among the given elements.

(iv) **(c):** Valency of *E* is 4. Hence, the formula of the chloride will be ECl_4.

(v) **(d):** *E* is silicon which is a metalloid.

9. **(i)** **(a):** As the size of the atom increases down the group, electropositive character increases.

(ii) **(c):** Li is the first element of the second period. As the size decreases in the period from left to right, therefore, Li is the largest atom in the period.

(iii) **(c):** Al ($Z = 13$) : 2, 8, 3

(iv) **(b):** Metallic character of elements decreases from left to right and increases down the group.

(v) **(a):** As we move from left to right along a period, the number of valence electrons increases from 1 to 8.

10. **(i)** **(c):** The element is chlorine ($Z = 17$).

(ii) **(a):** The element (sulphur) belongs to third period and its valency is 2.

(iii) **(c):** Atomic number of the element = 40 – 20 = 20
Electronic configuration of the element is 2, 8, 8, 2; *i.e.*, the element is calcium which belongs to 4^{th} period and 2^{nd} group of the periodic table.

(iv) **(c)** : The element is sulphur. Sulphur and oxygen belong to group 16.

(v) **(d)**

11. **(c)** : Effective nuclear charge increases along a period.

12. **(d)**: Correct order is S > Cl > O > F.

13. **(b)**: Elements in the same vertical column (group) have similar properties due to similar outer electronic configurations.

14. **(d)**: Number of valence electrons remains same in a group.

15. **(a)** : New shells are added down the group, hence, atomic radius increases.

16. **(a)**

17. **(a)** :

Period/Group	13	14	15	16	17
2	B	C	N	—	F
3	—	Si	—	—	—

As non-metallic character increases along a period and decreases down a group, Si is the least non-metallic element and non-metallic character increases from B to C to N to F. Hence, increasing order of non-metallic character is : Si < B < C < N < F.

18. **(b)**: The noble gases were not known at Mendeleev's time.

19. **(c)** : Isotopes have same atomic number but different atomic mass.

20. **(c)** : The elements can be arranged in different periods and groups as follows :

Period/Group	1	2	13	14	15
2^{nd}	—	Be	—	—	—
3^{rd}	Na	Mg	—	Si	P

As metallic character decreases along a period and increases down a group, so Na is the most metallic element and P is the least metallic element and among Be and Mg, Mg is more metallic. Hence, increasing order of metallic character is : P < Si < Be < Mg < Na.

21. **(d)**: Lithium belongs to second period whereas magnesium belongs to third period and both are metals.

22. **(d)**: According to Mendeleev's periodic law, the properties of elements are the periodic function of their atomic masses.

23. **(a)**

24. **(b)**: Noble gases have stable configuration and they are gases at room temperature.

25. **(d)**: In Dobereiner's triad, the atomic mass of the middle element was roughly the average of the atomic masses of other two elements.

26. **(a)** **27.** **(a)**

28. **(a)**

29. **(d)**: Fluorine is most electronegative element of the halogen family.

30. **(b)**: Atomic size increases down a group.