Chapter 1

Periodic Table

Key Concepts

IMPORTANT FACTS TO REMEMBER

1. Lowest electronegativity : Cs
2. Highest electronegativity : F
3. Highest ionization potential : He
4. Lowest ionization potential : Cs
5. Lowest electron affinity : Noble gases
6. Highest electron affinity : Chlorine
7. Least electropositive element : F
8. Lowest melting point metal : Hg
9. Highest melting point and boiling point metal : W (Tungsten)
10. Lowest melting point and boiling point non-metal : He
11. Notorious element : Hydrogen
12. Lightest element : Hydrogen
13. Smallest atomic size : H
14. Largest atomic size : Cs
15. Largest anionic size : I^-
16. Smallest cation : H^+
17. Most electropositive element : Cs
18. Element with electronegativity next to Fluorine : Oxygen
19. Group containing maximum number of gaseous elements in the periodic table : Zero group(18^{th})
20. Total number of gaseous elements in the periodic table : 11(H, N, O, F, Cl, He, Ne, Ar, Kr, Xe, Rn)
21. Total number of liquid elements in the periodic table : 6 (Ga, Br, Cs, Hg, Fr, Unb)
22. Smallest anion : F^-
23. Liquid element of radioactive nature : Fr
24. Total number of radioactive elements in the periodic table : 25
25. Volatile d-block elements : Zn, Cd, Hg, Unb
26. Element containing no neutron : H
27. Most abundant element in earth's crust : Oxygen
28. Rarest element on earth : At (astatine)
29. Most abundant metal in crust earth : Al
30. Element having maximum tendency for catenation in periodic table : Carbon
31. Non-metal having highest melting point, boiling point : Carbon (diamond)
32. Metals showing highest oxidation state : Os (+8)
33. Most electrovalent compound : CsF
34. Most stable carbonate : Cs_2CO_3
35. Strongest base : CsOH
36. Strongest basic oxide : Cs_2O
37. Best electricity conductor among metals : Ag

38. Best electricity conductor among non-metals : Graphite
39. Most poisonous element : Pu (Plutonium)
40. Liquid non-metal : Br
41. Element kept in water : Phosphorous
42. Elements kept in kerosene : IA group element (except Li)
43. Elements sublime on heating : I_2
44. Noble metals : Au, Pt etc.
45. Amphoteric metal : Be, Zn, Al, Sn, Pb
46. Amphoteric metalloid : Si
47. Metalloids elements : Si, As, Te, At, Ge, Sb
48. Non-metals having metallic lusture : Graphite, Iodine
49. Heaviest naturally occurring element : Uranium
50. Poorest conductor of electricity : Diamond
51. Hardest naturally occurring element : Diamond
52. Lightest solid metal : Li
53. Amphoteric oxides : BeO, Al_2O_3, ZnO, PbO, SnO, SnO_2, Sb_2O_3, As_2O_3, etc.
54. Neutral oxides of non metals : NO, CO, H_2O, N_2O
55. Dry bleacher : H_2O_2
56. Dry ice : Solid CO_2
57. First man-made element : $_{43}Te$ (Technicium)
58. Smallest period : I^{st} (2 elements)
59. Largest period in periodic table : 6^{th} (32 elements)
60. Largest group in periodic table : IIIB (32 elements)
61. Most abundant d-block metal : Fe
62. Most abundant s-block metal : Ca
63. Highest density (metals) : Os, Ir
64. Highest density (non-metals) : Boron
65. Most abundant gas in atmosphere : Nitrogen
66. Most abundant element in the universe : Hydrogen

MODERN PERIODIC TABLE

i. It was proposed by Henry Moseley.

ii. Modern periodic table is based on atomic number.

iii. Moseley did an experiment in which he bombarded high speed electron on different metal surfaces and obtained X-rays. He found out that $\sqrt{\nu} \propto Z$ where ν = frequency of X-rays

From this experiment, Moseley concluded that the physical and chemical properties of the elements are periodic function of their atomic number. It means that when the elements are arranged in the increasing order of their atomic number elements having similar properties after a regular interval. This is also known as **'Modern periodic Law'**.

iv. **Modern periodic Law –** The physical and chemical properties of elements are a periodic function of the atomic number.

LONG FORM/PRESENT FORM OF MODERN PERIODIC TABLE

i. It consist of 7 horizontal periods and 18 vertical columns (groups)

ii. According to IUPAC 18 vertical columns are named as 1^{st} to 18^{th} group.

iii. The co-relation between the groups in long form of periodic table and in modern form of periodic table are given below.

IA	IIA	IIIB	IVB	VB	VIB	VIIB		VIII		IB	IIB	IIIA	IVA	VA	VIA	VIIA	0
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

iv. Elements belonging to same group having same number of electrons in the outermost shell so their properties are similar.

DESCRIPTION OF PERIODS

Period	*n*	*Sub-shell*	*No.of elements*	*Element*	*Name of period*
1	1	1s	2	$_1H$, $_2He$	Shortest
2	2	2s, 2p	8	$_3Li$-$_{10}Ne$	I Short
3	3	3s, 3p	8	$_{11}Na$-$_{18}Ar$	II Short

4	4	4s, 3d, 4p	18	$_{19}K$-$_{36}Kr$	I Long
5	5	5s, 4d, 5p	18	$_{37}Rb$-$_{58}Xe$	II Long
6	6	6s, 4f, 5d, 6p	32	$_{55}Cs$-$_{86}Rn$	Longest (very long)
7	7	7s, 5f, 6d, 7p	26	$_{87}Fr$-$_{112}Unb$	Incomplete

DESCRIPTION OF GROUPS

1st/IA/Alkali metals:

General electronic configuration = ns^1 (n = Number of shell)

Number of valence shell e^- = 1

2nd/IIA/Alkaline earth metals:

General electronic configuration = ns^2

Number of valence shell e^- = 2

13th/IIIA/Boron family:

General electronic configuration = ns^2np^1

Number of valence shell e^- = 3

14th/IVA/Carbon family:

General electronic configuration = $ns^2\,np^2$

Number of valence shell e^- = 4

15th/VA/Nitrogen Family/Pricogens: (Used in fertilizer as urea)

General electronic configuration = $ns^2\,np^3$

Number of valence shell e^- = 5

16th/VIA/Oxygen family/Chalcogens: (Ore forming)

General electronic configuration = $ns^2\,np^4$

Number of valence shell e^- = 6

17th/VIIA/Halogen family/Halogens: (Salt forming)

General electronic configuration = $ns^2\,np^5$

Number of valence shell e^- = 7

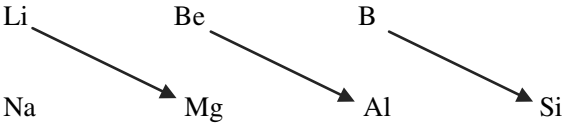
18th/Zero group/Inert gases/Noble gases:

General electronic configuration = $ns^2\,np^6$ (except He)

Number of valence shell e^- = 8

SOME IMPORTANT POINTS

(i) 2nd period elements (Li, Be, B) show diagonal relationship with 3rd period elements (Mg, Al, Si). Due to almost similar ionic potential (Ionic potential = charge/Radius) value they show similarily in properties.



(ii) 3rd period elements (Na, Mg, Al, Si, P, S, Cl) are called typical elements because they represent the properties of other element of their respective group.

(iii) In 6th period all types of elements are included (s, p, d and f)

(iv) No inert gas in 7th period.

(v) Normal elements present in all periods.

(vi) Atomic number of last inert gas element is 86.

(vii) Long form modern periodic table can be divided into four portions:

1. Left portion (IA and IIA) – s-block.
2. Right portion (IIIA to VIIA + zero group) – p-block.
3. Middle portion (IIIB to VIIB + VIII + IB and IIB) – d-block.
4. Bottom portion (IIIB) – f-block elements

NORMAL OR REPRESENTATIVE ELEMENTS

i. The elements in which ultimate orbit is incomplete while penultimate orbits are complete are called as normal elements.

ii. Their general electronic configuration is:

IA	IIA	IIIA	IVA	VA	VIA	VIIA
ns^1	ns^2	ns^2np^1	ns^2np^2	ns^2np^3	ns^2np^4	ns^2np^5
	ns^{1-2}		$ns^2\,np^{1-5}$			

TRANSITION ELEMENTS

The elements in which both ultimate (n) as well penultimate shells (n-1) are incomplete either in atomic state or in some oxidation state are called as transition elements.

Note: According to this concept Zn, Cd, Hg and Unb are not transition elements because they do not have incomplete penultimate shell either in atomic state or in some oxidation state.

Group number: IIIB to VIIB + VIII + IB and IIB

Periods: 4th to 7th

i. General electronic configuration is $(n-1)d^{1-10}$ $ns^{1\text{ or }2}$

ii. Total number of d-block elements = 40

Total number of transition elements = 36 (Except Zn, Cd, Hg and Unb)

Note: All transition elements are d-block but all d-block elements are not transition elements.

INNER-TRANSITION ELEMENTS

The elements in which all the three shells, i.e. ultimate (n), penultimate (n-1) and pre or antipenultimate (n-2) shells, are incomplete are called as inner-transition elements.

i. General electronic configuration is:
$(n-2)f^{1-14}\,(n-1)d^{0\text{ or }1}\,ns^2$

ii. These are 28 in number.

iii. Group – IIIB

iv. Period – $6^{th}$and 7^{th}

v. Inner transition elements are divided into two series:

(a) Lanthanoid series/Rare earth elements/ Lanthenones (Ce_{58}–Lu_{71} 14 elements)

(b) Actinoid series/Man-made elements/Actinones (Th_{90}–Lw_{103} 14 elements)

PERIODIC PROPERTIES

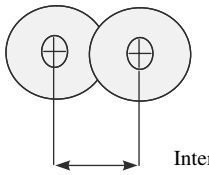
Atomic radius

1. Atomic radius of an element cannot be determined because atoms never exist in their free state and position of their outermost e^- is uncertain.
2. Atomic radius is determined in bonded state

Type of Radius

1. Covalent Radius (r_c)

a. Such type of radius is determined if a single covalent bond is present between two similar atoms.



$$r_c = \frac{d_{a-a}}{2}$$

Internuclear distance(d_{a-a})

b. If a single bond is present between two different atoms,

$d_{a-b} = r_a + r_b - 0.09\,(\Delta EN)$, Å

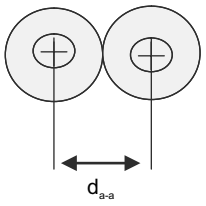
(Bond length)

r_a = covalent radius of A

r_b = covalent radius of B

ΔEN = difference in electronegativity of A and B

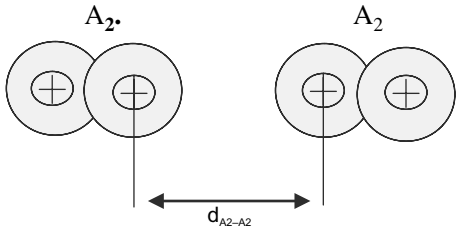
2. Metallic radius (r_m): Such type of radius is determined if atoms are bonded with metallic bond.



d_{a-a}

$$r_m = \frac{d_{a-a}}{2}$$

3. van der Waal's radius (r_v): Such type of radius is determined if molecules are bonded with van der Waal's force of attraction.



$$r_v = \frac{d_{A2-A2}}{2}$$

$r_v > r_m > r_c$

Note: Noble gases are monoatomic molecules bonded with van der Waal's force of attraction hence, for noble gases, van der Waal's radius is considered.

4. Ionic radius (radius of ions):

a. A cation is always smaller than its parent atom because it has greater Z_{eff} than its parent atom. As positive oxidation state increases, radius decreases.

$$Mn > Mn^{+2} > Mn^{+7}$$

b. An anion is always larger than its parent atom because the anion has lower Z_{eff} than its parent atom. As negative oxidation state increases, radius increases.

$$O < O^- < O^{-2}$$

Isoelectronic species

1. Species (atoms, molecules or ions) having same number of electrons are known as isoelectronic.

e.g	Si	N_2	CO	CN^-	NO^+
	$14e^-$	$14e^-$	$14e^-$	$14e^-$	$14e^-$

2. Order of radius in monoatomic isoelectronic species:

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

In isoelectronic species, as atomic number increases, radius decreases. It is due to increment in Z_{eff}.

Periodicity in atomic radius

1. <u>In periods:</u>

a. As we move left to right in a period, when Z_{eff}

increase in the atomic radius decrease except in noble gases.

Li > Be > B > C > N > O > F < < Ne

Na > Mg > Al > Si > P > S > Cl < < Ar

b. Order of radius in 3d- series:

Sc > Ti > V > Cr < Mn > Fe ≃ Co ≃ Ni < Cu < Zn

2. In groups:

a. As we move top to bottom in a group, when number of shell increase the atomic radius increases

Li < Na < K < Rb < Cs

F < Cl < Br < I

b. Exception (in d-block):

4d series ≃ 5d series (due to lanthanoid contraction)

c. Exception(in p-block): Al > Ga

Note: Radius mainly depends on number of shells.

Some exceptions are:

Li^+ > Mg^{+2}

0.76Å 0.72Å

H^- > F^-

1.40Å 1.33Å

Lanthanoid contraction

1. In lanthanoid series, as atomic number increases, atomic and ionic radius gradually decreases. It is called as lanthanoid contraction.
2. Cause: As me move from Ce to Lu, nuclear charge (Z) increases and $1e^-$ is successively added into inner 4f-subshell. Since f-e^- produces almost negligible screening effect hence, screening coefficient (σ) remains almost constant and Z_{eff} increases thus, radius decreases. (due to poor screening of 4f-e^- on outer e^-)
3. Effect of lanthanoid contraction is also present from $_{72}Hf$ to $_{82}Pb$. It is also called as post lanthanoid contraction or lanthanoid contraction. Due to this, these element have greater Z_{eff} than expected (its due to poor screening by $14e^-$ present in 4f-subshell).

Order of radius (along the group)

a. In d-block:

4d series ≃ 5d Series

(Z_{eff} high)

Zr ≃ Hf

Pd ≃ Pt

Y < La (No lanthanoid contraction)

b. In p-block:

In ≃ Tl

Sn ≃ Pb

Ionization Potential (IP) or Ionization Energy (IE)

(a) It is the energy required to remove an e^- from outermost shell of isolated (free) gaseous atom.

(b) This process is endothermic.

$M_{(g)}$ + IE of M → $M^+_{(g)} + e^-$; $\Delta H = I E$

Factors affecting IE

(i) Z_{eff}: $IE \propto Z_{eff}$

(ii) Atomic size: $IE \propto \frac{1}{\text{At. Size}}$

(iii) Penetration power of orbitals: s > p > d > f

(iv) Electronic configuration of outermost subshell:

a. Elements having fully filled or half filled outermost subshell have greater IE than expected.

(b) Such elements in a period have greater IE than adjacent elements.

1	2	13	14	15	16	17	18
ns^1	ns^2	np^1	np^2	np^3	np^4	np^5	np^6
	↑			↑			↑
	(fully filled)			(half filled)		(fully filled)	

1 < 2 > 13 < 14 < 15 > 16 < 17 < 18

1 < 13 < 2 < 14 < 16 < 15 < 17 < 18

Order of IE in second period:

Li < B < Be < C < O < N < F < Ne

Order of IE in third period:

Na < Al < Mg < Si < S < P < Cl < Ar

Periodicity in IE

1. In periods: as we move from left to right, in general, IE increases. (except for fullyfilled and half filled elements)
2. In groups: as we move top to bottom in a group, in general, IE decreases. (it is due to increase in atomic size)

Exception: (a) due to lanthanoid contraction,

In d-block:

4d series < 5d series

(Z_{eff} high)

Zr < Hf

Pd < Pt

Y > La (No lanthanoid contraction)

In p-block:

In < Tl

Sn < Pb

(b) Al < Ga

(Z_{eff} high)

General order of IE is:

s-block < f-block < d-block < p-block

Successive IE

1. Successive IE always increases because during successive removal of e^- z_{eff} increases and size decreases.

   $M_{(g)} + IE_1 \rightarrow M^+_{(g)} + e^-$; $\Delta H = + IE_1$

   $M^+_{(g)} + IE_2 \rightarrow M^{+2}_{(g)} + e^-$; $\Delta H = + IE_2$

   $M^{+2}_{(g)} + IE_3 \rightarrow M^{+3}_{(g)} + e^-$; $\Delta H = + IE_3$

   $IE_1 < IE_2 < IE_3 <$ - - - - - - -

   Energy required to remove n^{th} e^- = IE_n

   Energy required to remove ne^- = ($IE_1 + IE_2 +$ ---------- IE_n)

2. IE_2 of M = IE_1 of M^+

   IE_3 of M = IE_2 of M^+ = IE_1 of M^{+2}

3. Successive IE always increases but if during successive removal of e- electronic configuration becomes stable than rate of increment in successive I.E. is much more than expected.

   Mg = (Ne) $3s^2$

   $IE_1 < IE_2 << IE_3$ (because third electron is removed from fulfilled electronic configuration)

Order of IE_2 in second period:

IE_2 of M = IE_1 of M^+

Li^+	Be^+	B^+	C^+	N^+	O^+	F^+	Ne^+
$1s^2$	$2s^1$	$2s^2$	$2p^1$	$2p^2$	$2p^3$	$2p^4$	$2p^5$
↑ fully filled		↑ fully filled			↑ half filled		

Be < C < B < N < F < O < Ne < Li

(in a particular period alkali metal has highest IE_2 because it has very high Z_{eff})

Order of IE_3 in second period:

IE_3 of M = IE_1 of M^{2+}

Li^{+2}	Be^{+2}	B^{+2}	C^{+2}	N^{+2}	O^{+2}	F^{+2}	Ne^{+2}
$1s^1$	$1s^2$	$2s^1$	$2s^2$	$2p^1$	$2p^2$	$2p^3$	$2p^4$
	fully filled		fully filled			half filled	

B < N < C < O < Ne < F < Li < Be

(in a particular period alkaline earth metal has highest IE_3 because it has very high Z_{eff})

Electron affinity/e-gain enthalpy

1. It is the energy released when an e^- is added to outermost shell of an isolated gaseous atom.
2. This process in generally exothermic. (ΔH = -ve)

   $X_{(g)} + e^- \rightarrow X^-_{(g)}$ + EA of X ; ΔH = -EA

   ↑ e- gain enthalpy

   ΔH = -EA

   $-\Delta H$ = EA

   negative e^- gain enthalpy = EA

   EA of X = IE of X^-
3. (a) Elements having fully filled or half filled outermost sub-shell do not add another e- hence, their EA is generally zero.

   (b) If we still add e- to such elements, process becomes endothermic and formed anion becomes unstable.

   $Y_{(g)} + e^- \rightarrow Y^-_{(g)}$ – EA; ΔH = + EA

   (group 2,18 and N)
4. EA_1 process is generally exothermic while all higher EA processes are always endothermic because anions resist addition of another e^-.

   $X_{(g)} + e^- \rightarrow X^-_{(g)} + EA_1$; $\Delta H = -EA_1$

   (Except group 2, 18, N)

   $X^-_{(g)} + e^- \rightarrow X^{-2}_{(g)} - EA_2$; $\Delta H = EA_2$

   $X^{-2}_{(g)} + e^- \rightarrow X^{-3}_{(g)} - EA_3$; $\Delta H = EA_3$

Periodicity in EA

1. <u>In periods:</u> In general as we move from left to right EA increases.

   In period (2):

   Ne < Be < N < B < Li < C < O < F

   In period (3):

   Ar < Mg < Al < Na < P < Si < S < Cl
2. <u>In groups:</u> In general as we move from top to bottom in a group EA decreases.

Note: Second period elements have lower EA than expected. They have exceptionally small size. Hence, incoming e^- feels more repulsion than expected and net attraction becomes less than expected so their EA becomes less than expected.

Order of EA in various groups:

Cl > F > Br > I

S > Se > Te > O

$N < P < As < Bi < Sb$

$Si > C > Ge > Sn > Pb$

$Al > Ga > In > Tl > B$

Electronegativity (EN)

1. Tendency of an atom to attract bonded e^- pair towards itself in a bond is known as EN of that atom.
2. Noble gases do not form interatomic bond hence their EN is assumed as zero.

Factors affecting EN:

1. Z_{eff}:

$$EN \propto Z_{eff}$$

2. Atomic size: $EN \propto \frac{1}{\text{atomic size}}$

3. Oxidation state:

(a) As positive oxidation state increases, EN increases.

$A < A^+ < A^{+2}$

$\overset{+7}{K}\underline{Mn}O_4 > \overset{+4}{\underline{Mn}}O_2$

(b) As negative oxidation state increases, EN decreases.

$B > B^- > B^{-2}$

$\overset{-2}{H_2}\underline{O} < H_2\overset{-1}{\underline{O}}_2 < \overset{+2}{\underline{O}}F_2$

4. % s-character: As % s-character increases, EN increases.

$sp > sp^2 > sp^3$

50% 33.33% 25%

Periodicity in EN

1. In periods: As we move from left to right in a period, Z_{eff} increases hence, EN increases. (Except Noble gases)

$Li < Be < B < C < N < O < F$

$Na < Mg < Al < Si < P < S < Cl$

2. In groups: As we move top to bottom in a group, atomic size increases hence, EN decreases.

$F > Cl > Br > I$

a. Exception: $Al < Ga$ (High Z_{eff})

b. Exception: Due to lanthanoid contraction,

d-block:

4d-series < 5d-series (high Z_{eff})

Zr < Hf

Y > La (No lanthanoid contraction)

p-block:

In < Tl

Sn < Pb

Measurement of EN

1. Mulliken's scale:

$$X_m = \frac{IE + EA}{2} \text{ (both are in eV/atom)}$$

2. Pauling's scale:

$$\Delta EN = |X_A - X_B| = 0.208\sqrt{(E_{A\text{-}B} - \sqrt{(E_{A\text{-}A} \times E_{B\text{-}B})}}$$

Bond energies in kcal/mol

OR,

$$= 0.1017\sqrt{(E_{A\text{-}B} - \sqrt{(E_{A\text{-}A} \times E_{B\text{-}B})}}$$

Bond energies in kJ/mol

$$X_p \simeq \frac{X_m}{2.8}$$

3. Allred-Roshow scale:

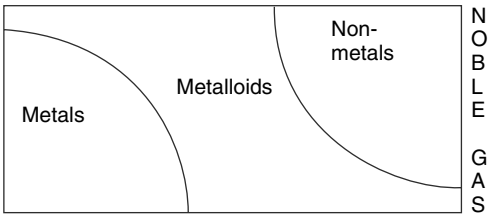
$$X = \frac{0.359\, Z_{eff}}{r^2} + 0.744 \quad (r = \text{covalent radius (in A°)})$$

Application of EN

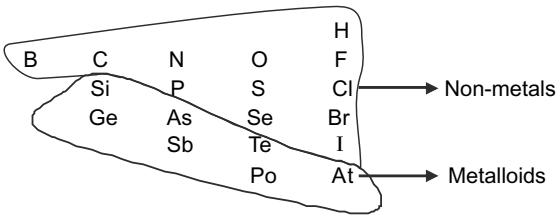
1. Metallic and Non-metallic properties:

$$\text{Metallic property} \propto \frac{1}{EN}$$

Non-metallic property $\propto$ EN



Metalloids or semi-metals: elements which can both gain or loose e^-.



s-block → Metals

d and f-block → Metals

p-block → Non-metals, metalloids, metals and noble gases.

2. Nature of bond:

Nature of interatomic bond depends on ΔEN.

ΔEN	Nature of bond	
0	Pure covalent	Covalent
0.1 – 0.8	Covalent	
0.9 – 1.6	Polar Covalent	
1.7	50% ionic and 50% covalent	
1.8 or more	Ionic	

% ionic character = $16\ (\Delta EN) + 3.5\ (\Delta EN)^2$

(Henery – Smith formula)

3. Nature of hydride:

Hydrides: Binary compounds having one element H.

eg. CH_4, H_2S, HCl etc.

(along the group)

C	N	O	F	i. Size of central atom (M) increases
Si	P	S	Cl	ii. Bond length of M-H bond increases
Ge	As	Se	Br	iii. H^+ loosing tendency increases
Sn	Sb	Te	I	iv. Acidic strength increases

(along the period)

i. EN of Central atom (M) increases

ii. ΔEN of M-H bond increases

iii. Bond polarity(or ionic character) of M-H bond increases

iv. Tendency to loose H^+ in water increases

v. acidic strength increases

Order of Acidic Strength:

HF < HCl < HBr < HI

$CH_4 < NH_3 < H_2O < HF$

$CH_4 < H_2S < HI$

4. Nature of hydroxides and oxides:

a. oxides form hydroxides in water hence, the nature of oxides and hydroxides of an element is similar.

b. Acidic strength of oxides and hydroxides ∝ EN of central atom

Order of acidic strength:

ClOH > BrOH > IOH

MgO > CaO > SrO > BaO

$Na_2O < MgO < Al_2O_3 < SiO_2 < P_4O_{10} < SO_3 < Cl_2O_7$

$\underline{MnO} < \underline{MnO_2} < \underline{Mn_2O_7}$ (+2, +4, +7)

$\underline{N_2O} < \underline{NO} < \underline{N_2O_3} < \underline{N_2O_5}$ (+1, +2, +3, +5)

c. Non-metallic oxides are generally acidic. (Some are neutral)

Neutral oxides are these which do not react with both acid and base

eg. CO, NO, N_2O, H_2O

d. Metallic oxides are generally basic. (Some are amphoteric)

Amphoteric oxides are those which react with both acid and base.

eg. s-block: $\underline{BeO}$

d-block: TiO_2, VO_2, CrO_2, Cr_2O_3, MnO_2, Mn_3O_4, ZnO etc.

p-block: Al_2O_3, Ga_2O_3, SnO, SnO_2, PbO, PbO_2, As_2O_3, Sb_2O_3 etc.

Some metallic oxides like CrO_3, Mn_2O_7 etc are acidic in nature.

Some other periodic properties

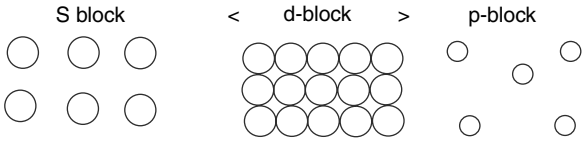
1. Atomic density:

(a) In groups: Down the group both atomic mass and atomic volume increases but increment in mass is much more than volume. Hence, atomic density increases.

Exception: Density of Na > K

Mg > Ca

(b) In periods:



Lighter metal Heavy metal

2. Melting point and boiling point:

(a) In periods: The general order is,

s-block < d-block > p-block

(b) In groups: Down the group the general order is:

s-block	d-block	groups 13 and 14	groups15 to18
decreases	increases	decreases	increases

Solved Examples

1. Which of the following is incorrect match?

(a) Z = 48, group = IIB , period No. = 5^{th}

(b) (Xe) $4f^7\ 5d^1\ 6s^2$, group = IIIB , period = 6^{th}

(c) (Rn) $6d^2\ 7s^2$, group = IVB, period = 7^{th}

(d) Z = 56, group = IIA , period = 6^{th}

Sol.(c) Element, having Z = 48, is Cd

It is member of group 12 or IIB and period 6^{th}

Element having electronic configuration (Xe) $4f^7\ 5d^1\ 6s^2$ is a lanthanoid. All lanthanoids belong to group IIIB and period 6^{th}.

Element having electronic configuration (Rn) $6d^2\ 7s^2$ is an actinoid. All actinoids belong to group IIIB and period 7^{th}.

Element, having Z = 56, is Ba. It is member of group 2 or IIA and period 6^{th}.

2. Which of the following metals give inflammable gas with both acid and base?

(a) Na and Zn (b) Mg and Al

(c) Mg and Be (d) Zn and Al

Sol.(d) Amphoteric metals like Be, Zn, Al, Sn, Pb etc give H_2 gas (inflammable) with both acid and base.

3. Which of the following have an incorrect order of ionization energy:

(a) Pb (IE) > Sn (IE)

(b) Na^+ (IE) > Mg^+ (IE)

(c) Li^+ (IE) < O^+ (IE)

(d) Be^+ (IE) < C^+ (IE)

Sol.(c) Due to lanthanoid contraction Pb has greater effective nuclear charge (z_{eff}) than Sn hence,

Pb (IE) > Sn (IE)

Na^+ has electronic configuration of noble gas hence,

Na^+ (IE) > Mg^+ (IE)

Li^+ has electronic configuration of noble gas hence,

Li^+ (IE) > O^+ (IE)

C^+ has greater effective nuclear charge (z_{eff}) than Be^+ hence,

Be^+ (IE) < C^+ (IE)

4. Which set of ions have same magnetic moment?

(a) Co^{+2}, Cr^{+3}, V^{+3}

(b) Mn^{+2}, Fe^{+3}, Cr^+

(c) Ni^{+2}, Mn^{+2}, Co^{+2}

(d) Fe^{+2}, Mn^{+2}, Co^{+2}

Sol.(b)

Ion	Electronic configuration	No. of unpaired e^-
Co^{+2}	(Ar) $4s^0\ 3d^7$	3
Cr^{+3}	(Ar) $4s^0\ 3d^3$	3
V^{+3}	(Ar) $4s^0\ 3d^2$	2
Mn^{+2}	(Ar) $4s^0\ 3d^5$	5
Fe^{+3}	(Ar) $4s^0\ 3d^5$	5
Cr^+	(Ar) $4s^0\ 3d^5$	5
Ni^{+2}	(Ar) $4s^0\ 3d^8$	2
Fe^{+2}	(Ar) $4s^0\ 3d^6$	4

Ions, having similar number of unpaired e^- , have same magnetic moment.

5. The correct order of acidic strength of the following is:

(a) $SO_2 > P_2O_3 > SiO_2 > Al_2O_3$

(b) $P_2O_3 > SO_2 > SiO_2 > Al_2O_3$

(c) $P_2O_3 > Al_2O_3 > SO_2 > SiO_2$

(d) $Al_2O_3 > SiO_2 > P_2O_3 > SO_2$

Sol.(a) Acidic strength of oxides depends on electronegativity of central atom. As electronegativity of central atom increases acidic strength also increases.

Correct order of acidic strength is:

$SO_2 > P_2O_3 > SiO_2 > Al_2O_3$

6. Ionization energy of F^- is 320 kJ mol^{-1}. The electron gain enthalpy of fluorine would be:

(a) – 320 kJ mol^{-1}

(b) – 160 kJ mol^{-1}

(c) + 320 kJ mol^{-1}

(d) + 160 kJ mol^{-1}

Sol.(a) Ionization energy of F^- is 320 kJ mol^{-1}

F^- (g) + 320 kJ mol^{-1} → F (g) + e^-; ΔH = 320 kJ mol^{-1}

Equation for electron gain enthalpy of F is:

F(g) + e^- → F^- (g) + 320 kJ mol^{-1}; ΔH = –320 kJ mol^{-1}

7. The value of IE_1, IE_2, IE_3, and IE_4 of an atom are 7.5 eV, 25.6 eV, 48.6 eV and 170.6 eV respectively. The electronic configuration of the atom will be:

(a) $1s^2\ 2s^2\ 2p^6\ 3s^1$

(b) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$

(c) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^3$

(d) $1s^2\ 2s^2\ 2p^6\ 3s^2$

Sol.(b) The biggest jump occurs from IE_3 to IE_4

$IE_3 << IE_4$

(IE_n) (IE_{n+1})

n(Valence e^-) = 3

Hence, the electronic configuration of the atom will be $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$.

8. The correct order increasing radii is:

(a) Be^{2+}, Mg^{2+}, Na^+ (b) K^+, Ca^{2+}, S^{2-}

(c) O^{2-}, F^-, N^{3-} (d) S^{2-}, O^{2-}, As^{3-}

Sol.(a) Correct order of increasing radii are:-

(a) $Be^{+2} < Mg^{+2} < Na^+$

(b) $Ca^{+2} < K^+ < S^{-2}$

(c) $F^- < O^{-2} < N^{-3}$

(d) $O^{-2} < S^{-2} < As^{3-}$

9. What will be the distance between H and Cl atom in HCl. The radius of hydrogen is 0.37 Å and the radius of chlorine is 1.67 Å?

(According to the concept of covalent radius)

(a) 2.04Å (b) 1.96Å

(c) 2.12Å (d) 1.0Å

Sol.(b) Bond length of single covalent bond = $r_A + r_B - 0.09\ (\Delta EN)$

Bond length $(d_{H\text{ - }cl}) = r_H + r_{cl} - 0.09\ (\Delta EN)$

$r_H = 0.37Å$; $r_{cl} = 1.67Å$ and $\Delta EN = 3.0 - 2.1 = 0.9$

$d_{H-cl} = 0.37 + 1.67 - 0.09\ (0.9)$

or, $d_{H-cl} = 2.04 - 0.08 = 1.96Å$

10. The ionization energy of sodium is 495 kJ mol^{-1}. How much energy is needed to convert atoms present in 2.3 mg of sodium into sodium ions?

(a) 4.95 J (b) 49.5 J

(c) 495 J (d) 0.495 J

Sol.(b) Ionization energy of Na = 495 kJ/mol

No. of moles of Na in 2.3 mg

$$= \frac{2.3\times10}{23} = 10^{-4} \text{ moles}$$

For 1 mol, energy needed is 495 kJ

Hence, for 10^{-4} mol, energy needed is $495 \times 10^3 \times 10^{-4}$ J = 49.5 J

11. The correct order of the second ionization potential of carbon, nitrogen, oxygen and fluorine is

(a) C > N > F > O (b) O > N > F > C

(c) O > F > N > C (d) F > O > N > C

Sol.(c) IE_2 of neutral element is IE_1 of cation having single positive charge. Hence, for order of IE_2, first put +1 charge to each element then write electronic configuration.

C^+	N^+	O^+	F^+
$1s^2\ 2s^2\ 2p^{\mathbf{6}}$	$1s^2\ 2s^2\ 2p^2$	$1s^2\ 2s^2\ 2p^{\mathbf{3}}$ ↑ Half filled	$1s^2\ 2s^2\ 2p^{\mathbf{4}}$

From left to right in a period, IE_1 increases and fulfilled or half filled elements have greater IE_1 than adjacent elements. Hence, correct order of IE_2 is: C > N > F > O

12. The electronegativity of the following elements increases in the order:

(a) S < P < N < O (b) P < S < N < O

(c) N < O < P < S (d) N < P < S < O

Sol. (b)

	Group 15	**Group 16**
Period (II)	N	O
Period (III)	P	S

Correct order of electro negativity is:

P < S < N < O

13. The formation of the oxide ion, $O^{2-}(g)$, from oxygen atom requires first an exothermic and then an endothermic step as shown below :

$O(g) + e^- \rightarrow O^-(g)$; $\Delta_{eg}H = -141$ kJmol^{-1}

$O^-(g) + e^- \rightarrow O^{2-}(g)$; $\Delta_{eg}H = +780$ kJmol^{-1}

Thus process of formation of O^{2-} in gas phase is unfavorable even O^{2-} is isoelectronic with neon. It is due to the fact that :

(a) Oxygen is more electronegative.

(b) Addition of electron in oxygen results in larger size of the ion.

(c) Electron repulsion outweighs the stability gained by achieving noble gas configuration.

(d) O^- ion has comparatively smaller size than oxygen atom.

Sol.(c) Process of formation of O^{2-} ion in gaseous phase is unfavorable because O^- ion (anion) resists addition of another e^- due to repulsion hence, electron repulsion outweighs the stability gained by achieving noble gas configuration.

14. Which is the correct in the following -

(a) Radius of Cl atom is 0.99 Å, while that of Cl^+ ion is 1.54 Å

(b) Radius of Cl atom is 0.99 Å, while that of Na atom is 1.54 Å

(c) Radius of Cl atom is 0.99 Å, while that of Cl^- ion is 0.81 Å

(d) Radius of Na atom is 0.95 Å, while that of Na^+ ion is 1.54 Å

Sol.(b) The atomic radius decreases along the period. Also cations are always smaller than their parent atom and anions are always larger than their parent atom.

15. Which oxide of 'N' is isoelectronic with CO_2:

(a) NO_2 (b) NO

(c) N_2O (d) N_2O_2

Sol.(c) N_2O is isoelectronic with CO_2. Both have 22 electrons.

16. Arrange Ce^{3+}, La^{3+}, Pm^3 and Yb^{3+} in increasing order of their size -

(a) $Yb^{3+} < Pm^{3+} < Ce^{3+} < La^{3+}$

(b) $Ce^{3+} < Yb^{3+} < Pm^{3+} < La^{3+}$

(c) $Yb^{3+} < Pm^{3+} < La^{3+} < Ce^{3+}$

(d) $Pm^{3+} < La^{3+} < Ce^{3+} < Yb^{3+}$

Sol.(a) Lanthanide contraction is observed in these ions, i.e., ionic radius decreases as atomic number increases.

17. In which of the following compounds chromium shows maximum radius:-

(a) $K_2Cr_2O_7$ (b) CrO_2Cl_2

(c) $Cr_2(SO_4)_3$ (d) $CrCl_2$

Sol.(d) In $CrCl_2$, oxidation state of chromium is +2 (minimum). Thus it will have maximum radius. As positive oxidation state increases, radius decreases.

18. The IP_1, IP_2, IP_3, IP_4, and IP_5 of an element are 7.1, 14.3, 34.5, 46.8, 162.2 eV respectively.

The element is likely to be-

(a) Na (b) Si

(c) F (d) Ca

Sol.(b) The jump in IP values exist in IP_5 and thus removal of fifth electron occurs from inner shell. Thus element contains four electrons in its valence shell. It means the element belongs to the group 14.

19. Following are ground state electronic configuration of some neutral atoms:

(a) $1s^2\ 2s^2\ 2p^3$ (b) $1s^2\ 2s^2\ 2p^5$

(c) $1s^2\ 2s^2 2p^6\ 3s^1$ (d) $1s^2\ 2s^2\ 2p^6$

(i) Which of the following would have lowest IE?

(ii) Arrange them in increasing order of IE

Sol. (i) Three electrons in 2p subshell (i.e. half filled) indicate for its greater stability while 6 electrons in 2p indicate for its maximum stability. Thus electronic configuration (c) having 1 electron in 3s would require minimum IE

(ii) c < a < b < d (increasing order of IE)

20. The atomic number of three elements A, B and C are a, a+1 and a+2, C is an alkali metal. In a compound of A and C, the nature of bonding is-

(a) Co-ordinate (b) Covalent

(c) Ionic (d) Metallic

Sol.(c) If C is alkali metal, A should be halogen (non-metal). Between metal and non-metal ionic bond is present.

Exercise

LEVEL I

1. X^{2-} is isoelectronic with "O_2^{+}" and has Z + 1 neutron (Z is atomic number of X^{2-}) then:
(a) Mass number of X^{2-} is 27
(b) Mass number of X^{2-} is 57
(c) Atomic number of X^{2-} is 28
(d) Number of proton X^{2-} is 15

2. Which of the following statements is not correct regarding hydrogen atom ?
(a) It resembles halogens in some properties
(b) It resembles alkali metals in some properties
(c) It can be placed in 17^{th} group of periodic table
(d) It can not be placed in first group of periodic table

3. If an atom has electronic configuration $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^3\ 4s^2$, it will be place in:
(a) Second group (b) Third group
(c) Fifth group (d) Sixth group

4. Among the following, the element with the lowest atomic number that has a ground-state electronic configuration of (n-1) $d^5\ ns^1$ is located in the:
(a) Fifth period (b) Sixth period
(c) Fourth period (d) Third period

5. In species X^{2+} the mass number is 20 and number of neutrons are 10 then calculate the number of electrons in species X^{2+}:
(a) 4 (b) 7
(c) 6 (d) 8

6. The elements which are characterised by the outer shell configuration ns^1, ns^2 and $ns^2\ np^1$to $ns^2np^5$are collectively called as:
(a) Transition elements
(b) Representative elements
(c) Lanthanides
(d) Inner-transition elements

7.

Column - I (Type of element)	Column – II (Outer electronic configuration)
(A) Inert gas elements	(i) ns^{1-2} and $ns^2\ np^1$ to ns^2np^5
(B) Representative elements	(ii) $1s^2$ and $ns^2\ np^6$
(C) Transition elements	(iii) (n-2) f^{1-14} (n-1)$d^{0-1}\ ns^2$
(D) Inner- transition elements	(iv) (n-1) $d^{1-10}\ ns^{1\ or\ 2}$

(a) A- i, B-ii,C-iii, D-iv
(b) A-ii, B-i, C-iii, D-iv
(c) A-ii, B-i, C-iv, D-iii
(d) A-i, B-ii, C-iv, D-iii

8. Which of the following is an incorrect match?
(a) Z = 65, group = IIIB, period – 6^{th}
(b) Z = 46, group = VIIIB, period – 5^{th}
(c) Z = 108, group = XB, period – 8^{th}
(d) Z = 57, group = IIIB, period – 6^{th}

9. The element with atomic number 56 is likely to have the same outer shell configuration as the element with atomic number:
(a) 12 (b) 18
(c) 14 (d) 24

10. Electronic configuration of species M^{2+} is $1s^2$, $2s^2$, $2p^6$, $3s^2$,$3p^6$,$3d^6$ and its atomic weight is 56. The number of neutrons in the nucleus of species M is:
(a) 32 (b) 26
(c) 30 (d) 28

11. Which is correct order of ionic mobility in aqueous medium?
(a) $Li^+ < Na^+ < K^+$
(b) $Na^+ < Mg^{2+} < Al^{3+}$
(c) $Al^{3+} < Na^+ < Mg^{2+}$
(d) $Li^+ > Na^+ > K^+$

12. Which one of the following is not a characteristic of p-block elements?
(a) The last electrons in them enters into a p-orbital
(b) They mostly form acidic oxides
(c) Down the group, stability of lower oxidation state increases
(d) They mostly form basic oxides

13. Which of the following species has a value of magnetic moment, $\mu = \sqrt{35}$?
(a) Cr^{3+} (b) Mn^{2+}
(c) Fe^{2+} (d) Cu^{2+}

14. The paramagnetic species among the following is:

(a) Na^+ (b) Zn^{2+}

(c) Cu^+ (d) Fe^{3+}

15. All of the following possess complete d-subshells except:

(a) Ag^+ (b) Cu^{2+}

(c) Ga^{3+} (d) Zn^{2+}

16. Calculate the 'X' in Mn^{x+} if μ=3.87 BM

(a) 2 (b) 3

(c) 4 (d) 5

17. The first element of a group in many ways differs from the other heavier members of the group. This is due to:

(a) the small size

(b) the high electronegativity and high ionization potential

(c) the unavailability of d-orbitals

(d) all of the above

18. Be and AI show diagonal relationship hence, both have:

(a) almost same of electronegativity

(b) amphoteric nature of oxides

(c) approximately same polarizing power of respective cations

(d) all the properties above

19. Which of the following set contains pair of elements that do not belong to same group but show chemical resemblance?

(a) Hf, Zr (b) K, Rb

(c) Be, Al (d) B, Al

20. Which of the following set of magic numbers is not correct for given group?

(a) 18, 18, 32 ⇒ IIIB

(b) 8, 8, 18, 18, 32 ⇒ VIA

(c) 18, 32, 32 ⇒ IB

(d) 8, 8, 18, 18, 32 ⇒ IIA

21. Correct order of ionic radius of following isoelectronic species is:

(a) $Se^{-2} > Br^- > Kr > Rb^+ > Sr^{+2}$

(b) $S^{-2} > Cl^- > K^+ > Ar > Ca^{+2}$

(c) $N^{-3} > O^{-2} > Ne > F^- > Ca^{+2}$

(d) $F^- > Ne > Na^+ > Al^{+3} > Mg^{+2}$

22. Which of the following has the largest ionic radius?

(a) Be^{2+} (b) Mg^{2+}

(c) Ca^{2+} (d) Sr^{2+}

23. The correct order of the size of C, N, P and S is:

(a) N < C < P < S (b) C < N < P < S

(c) N < C < S < P (d) C < N < S < P

24. Which of the following pair of elements have almost similar atomic radii?

(a) Zr, Hf (b) Cu, Ag

(c) Sc, Ti (d) Pd, Ni

25. In which of the following compounds, manganese shows maximum radius?

(a) MnO_2 (b) $KMnO_4$

(c) MnO (d) $K_3 (Mn(CN)_6)$

26. Ionization enthalpies tend to decrease going down any column of main group elements because---------- going down the column.

(a) Nuclear charge increases

(b) Number of shielding electrons increases

(c) Atomic size increases

(d) Effective nuclear charge increases

27. The ionization potential of nitrogen is more than that of oxygen because of:

(a) Greater attraction of electrons by the nucleus

(b) Extra stability of the half-filled p-orbitals

(c) Smaller size of nitrogen

(d) More penetration effect

28. Which of the following transition involve maximum amount of energy?

(a) $M^-_{(g)} \rightarrow M_{(g)}$ (b) $M^-_{(g)} \rightarrow M^+_{(g)}$

(c) $M^+_{(g)} \rightarrow M^{2+}_{(g)}$ (d) $M^{2+}_{(g)} \rightarrow M^{3+}_{(g)}$

29. Which of the following process refers to IE_2 of X?

(a) $X_{(g)} \rightarrow X^{2+}_{(g)}$ (b) $X^+_{(g)} \rightarrow X^{2+}(g)$

(c) $X^+_{(aq)} \rightarrow X^{2+}_{(g)}$ (d) $X_{(g)} \rightarrow X^+_{(g)}$

30. Which of the following statement concerning ionization energy is not correct?

(a) The IE_2 is always more than the first.

(b) Within a group, there is a gradual increase in ionization energy because nuclear charge increases.

(c) Ionization energy of Be is more than B.

(d) Ionization energy of noble gases are high.

31. Lanthanide contraction is related with:
(a) Sharp decrease in atomic size in lanthanide series
(b) Slow or gradual decrease in atomic size in lanthanide series
(c) Constancy in atomic size
(d) All the above

32. Relation between electron gain enthalpy and electron affinity is:
(a) EA = $\Delta H_{e.g.}$ (b) EA = $2\Delta H_{e.g.}$
(c) EA = $-2\Delta H_{e.g.}$ (d) EA = $-\Delta H_{e.g.}$

33. The process requiring absorption of energy is:
(a) $N \rightarrow N^-$ (b) $F \rightarrow F^-$
(c) $Cl \rightarrow Cl^-$ (d) $H \rightarrow H^-$

34. Second and successive electron gain enthalpy of an element
(a) is always negative (energy is released)
(b) is always positive (energy is absorbed)
(c) can be positive or negative
(d) is always zero

35. Of the following pairs, the one containing examples of metalloid elements is:
(a) B and Al (b) Ga and Ge
(c) Al and Si (d) As and Sb

36. The group in the periodic table that contains the elements in all the different physical states at room temperature is:
(a) VA (b) IA
(c) VIIA (d) IVA

37. Elements of which group form anions most readily?
(a) Oxygen family (b) Nitrogen family
(c) Halogens (d) Alkali metals

38. What is the percentage of ionic character in CsF: (according to Henry-Smith formula)
{EN of Cs = 0.7 and EN of F = 4.0}
(a) 100% (b) 10%
(c) 90.9% (d) 99%

39. In halogens, which of the following decrease from iodine to fluorine?
(a) Bond length
(b) Electronegativity
(c) The ionization energy of the element
(d) Oxidizing power

40. As we proceed from top to bottom in the periodic table:
(a) hydroxides are more basic
(b) oxyacids are less acidic
(c) neither (a) and (b) of the above
(d) Both (a) and (b) of the above

41. Among the following oxides, which is least acidic?
(a) Al_2O_3 (b) B_2O_3
(c) CO_2 (d) NO_2

42. Which of the following oxides is neutral?
(a) SiO_2 (b) CO
(c) ZnO (d) SnO_2

43. What is the nature of Al_2O_3 and B_2O_3?
(a) Acidic, Acidic
(b) Acidic, Amphoteric
(c) Amphoteric, Amphoteric
(d) Amphoteric, Acidic

44. Correct order of acidic strength is:
(a) $SiH_4 > PH_3 > CH_4 > HCl$
(b) $HCl > PH_3 > CH_4 > SiH_4$
(c) $HCl > SiH_4 > PH_3 > CH_4$
(d) $HCl > PH_3 > SiH_4 > CH_4$

45. Which of the following oxide is acidic?
(a) N_2O_5 (b) Mn_2O_7
(c) CrO_3 (d) All

LEVEL II

1. An element X belongs to fourth period and fifteenth group of the periodic table. Which one of the following is true regarding the outer electronic configuration of X? It has:
A. Partially filled d-orbitals and completely filled s-orbital
B. Completely filled s-orbital and completely filled p-orbitals
C. Completely filled s-orbital and half filled p-orbitals
D. Half filled d-orbitals and completely filled s-orbital
(a) A,B & C (b) Only A & B
(c) A, B & D (d) Only C

2. Vishal Thakur went to meet his friend Sumit, Where he saw that his friend was doing the study of a particular chemistry book. But he could not find the theoretical value of bond length in H-F but he found that r_H and r_F are 0.37 Å and 0.72 Å respectively and eletronegativity of F and H are 4.0 and 2.1 respectively. What is bond length of H-F bond?

(a) 1.09 (b) 1.784

(c) 0.92 (d) 0.46

3. Choose the correct order of ionic radius for the following species:

(a) $Cl^- > I^- > Te^{2-} > Ar^+$

(b) $Te^{2-} > I^- > Cl^- > Ar^+$

(c) $I^- > Te^{2-} > Cl^- > Ar^+$

(d) $I^- > Cl^- > Ar^+ > Te^{2-}$

4. Which statement is correct?

(a) Tl^+ ion is more stable than Tl^{3+}

(b) Pb^{4+} salts act as good oxidizing agents

(c) Bi^{5+} salts act as good oxidizing agents

(d) All of these

5. Among the elements Ca, Mg, P and Cl, the order of increasing atomic radii is:

(a) Mg < Ca < Cl < P

(b) Cl < P < Mg < Ca

(c) P < Cl < Ca < Mg

(d) Ca < Mg < P < Cl

6. Element X belongs to 4th period. It contains 18 and 1 electron in the penultimate and ultimate orbit. The element X should be:

(a) Normal element

(b) Transition element

(c) Inert gas

(d) Inner-transition element

7. General electronic configuration of outermost and penultimate shell is $(n-1)s^2\ (n-1)p^6\ (n-1)d^x\ ns^2$. If n = 4 and x = 5, then number of protons in the nucleus will be :

(a) > 25 (b) < 24

(c) 25 (d) 30

8. Select correct statement:

(a) La and Ac belong to f-block

(b) An element having atomic number 31 belongs to 3rd period

(c) General outermost shell e^- configuration of d-block element is $ns^{1-2}\ (n-1)d^{1-10}$

(d) All actinoids are man made elements

9. A°/2 atoms of X(g) are converted into $X^+(g)$ by absorbing energy E_1. A°/2 ions of $X^+(g)$ are converted into $X^-(g)$ with release of energy E_2. Hence ionization energy and electron affinity of X(g) are:

(a) $\frac{2E_1}{A^\circ}$, $\frac{2(E_1 - E_1)}{A^\circ}$

(b) $\frac{2E_1}{A^\circ}$, $\frac{2(E_2 - E_1)}{A^\circ}$

(c) $\frac{(E_1 - E_2)}{A^\circ}$, $\frac{2E_2}{A^\circ}$

(d) None of these

10. Which represents correct order of acidic strength?

(a) $NH_3 > PH_3 > AsH_3 > SbH_3 > BiH_3$

(b) $K_2O > ZnO > NO_2$

(c) NaOH < KOH < RbOH < CsOH

(d) $CH_4 < NH_3 < H_2O < HF$

11. Which of the following statements is incorrect?

(a) Cesium is the most electropositive element while F is the most electronegative element

(b) Cl has the highest -ve electron gain enthalpy out of all the elements

(c) Electron gain enthalpy of N as well as that of noble gases is positive

(d) In any period, the atomic radius of the noble gas is lowest

12. Which of the following is correct order of decreasing acidic character?

(i) $ClO_2 > SO_2 > SiO_2 > CO_2$

(ii) $ClO_2 > SO_2 > SiO_2 > SnO_2$

(iii) $N_2O_3 > P_2O_3 > As_2O_3 > Bi_2O_3$

(iv) $N_2O_5 > P_2O_5 > As_2O_5 > Bi_2O_5$

(a) i, ii, iii (b) ii, iii, iv

(c) i, iii, iv (d) i, ii, iv

13. Which of the following conclusions are correct regarding the element having atomic number equal to 113?

(i) It is present in the 8th period of the modern periodic table

(ii) It is present in the group 13 in the periodic table

(iii) It is a p-block element

(iv) Oxidation states of this element may be +1 or +3.

(a) i, iii, iv (b) ii, iii, iv

(c) i, ii, iv (d) i, iv

14. Which of the following statement(s) is(are) correct?

(a) The electronic configuration of Cr is (Ar) $3d^4$ $4s^2$ (Atomic number of Cr = 24)

(b) Cr is a representative element.

(c) In silver atom, 23 electrons have a spin of one type and 24 of the opposite type.

(d) The oxidation state of nitrogen in HN_3 is –3.

15. Find the formula of halide of a metal whose successive ionization energies are x, 2x, 5x, 20x, 25x kJ mol^{-1} respectively.

(a) MX (b) MX_2

(c) MX_3 (d) M_2X

16. Which is/are true statement(s) about s-block elements?

(a) Metals are obtained by the electrolysis of fused chlorides

(b) Only one type of valency, +1 for IA and +2 for IIA, is shown

(c) Oxides are basic except BeO

(d) all of the above are correct statements

17. Which of the following statement(s) is/are correct?

(i) Vander waal's radius of iodine is more than its covalent radius

(ii) All isoelectronic ions belong to the same period of the periodic table

(iii) IE_1 of N is higher than that of O while IE_2 of O is higher than that of N

(iv) he 1st electron gain enthalpy of Cl is negative while second is positive

(a) i, ii (b) i, ii, iii

(c) i, iii, iv (d) i, ii, iii, iv

18. Consider the following electronic configuration of an element (P):

$(Xe)4f^{14}5d^16s^2$

Then correct statement about element (P) is:

(a) It belongs to 6th period and 1st group

(b) It belongs to 6th period and 2nd group

(c) It belongs to 6th period and 3rd group

(d) None of these

19. The set representing the correct order of ionic radius is:

(a) $Na^+ > Mg^{2+} > Al^{3+} > Li^+ > Be^{2+}$

(b) $Na^+ > Li^+ > Mg^{2+} > Al^{3+} > Be^{2+}$

(c) $Na^+ > Mg^{2+} > Li^+ > Al^{3+} > Be^{2+}$

(d) $Na^+ > Mg^{2+} > Li^+ > Al^{3+} > Be^{2+}$

20. In the compound M-O-H, the M-O bond will be broken in water if:

(a) Δ (EN) of M and O < Δ (EN) of O and H

(b) Δ (EN) of M and O = Δ (EN) of O and H

(c) Δ (EN) of M and O > Δ (EN) of O and H

(d) Cannot be predicated according Δ (EN) data

21. Consider the following changes:

$M(s) \rightarrow M(g)$ ..... (i)

$M(s) \rightarrow M^{2+}(g) + 2e^-$ ..... (ii)

$M(g) \rightarrow M^+(g) + e^-$ ..... (iii)

$M^+(g) \rightarrow M^{2+}(g) + e^-$ ..... (iv)

$M(g) \rightarrow M^{2+}(g) + 2e^-$ ..... (v)

The second ionization energy of M could be calculated from the energy values associated with:

(a) i+iii+iv (b) ii-i+iii

(c) i+v (d) v-iii

22. Consider the following conversions:

(i) $O_{(g)} + e^- \rightarrow O^-_{(g)}$, ΔH_1

(ii) $F_{(g)} + e^- \rightarrow F^-_{(g)}$, ΔH_2

(iii) $Cl_{(g)} + e^- \rightarrow Cl^-_{(g)}$, ΔH_3

(iv) $O^-_{(g)} + e^- \rightarrow O^{2-}_{(g)}$, ΔH_4

That according to given information the incorrect statement is:

(a) ΔH_3 is more negative than ΔH_1 and ΔH_2

(b) $\Delta H_1$is less negative than ΔH_2

(c) ΔH_1, ΔH_2 and ΔH_3 are negative whereas ΔH_4 is positive

(d) ΔH_1 and ΔH_3 are negative whereas ΔH_2 and ΔH_4 are positive

23. Ionic radii of:

(a) $^{35}Cl^- > {}^{37}Cl^-$ (b) $Mn^{7+} > Ti^{4+}$

(c) $K^+ > Cl^-$ (d) $P^{3+} > P^{5+}$

24. The correct order of relative stability of half filled and completely filled sub-shell is:

(a) $p^3 > d^5 < d^{10} < p^6$ (b) $d^5 > p^3 < d^{10} < p^6$

(c) $d^5 < p^3 < d^{10} < p^6$ (d) $p^3 > d^{10} < d^5 < p^6$

25. The five successive ionization energies of an element are 800, 2427, 3658, 25024 and 32824 kJ Mol^{-1} respectively. The number of valence electron is:

(a) 3 (b) 5

(c) 1 (d) 2

26. What is the order of ionization energies of the coinage metal?

(a) Ag > Cu > Au (b) Cu > Ag > Au

(c) Cu < Ag < Au (d) Au > Cu > Ag

27. IE_2 for an element is invariably higher than IE_1 because:

(a) It is difficult to remove electron from cation

(b) The size of the cation is smaller than its atoms

(c) Z_{eff} is more for cation

(d) All the above

28. Two p-block elements x (outer configuration ns^2 np^3) and z (outer configuration ns^2 np^4) occupy neighbouring positions in a period. Using this information which of the following is correct with respect to their ionization potential I_x and I_z?

(a) $I_x > I_z$

(b) $I_x < I_z$

(c) $I_x = I_z$

(d) Relation between I_x and I_z is uncertain

29. Fluorine has the highest electronegativity among the group on the pauling scale, but the electron affinity of fluorine is less than that of chlorine because:

(a) The atomic number of fluorine is less than that of chlorine

(b) Fluorine being the first member of the family behaves in an unusual manner

(c) Chlorine can accommodate an electron better than fluorine by utilising its vacant 3d orbital

(d) Small size, high electron density and an increased electron repulsion make addition of an electron to fluorine less favourable than that in the case of chlorine

30. Select correct statement about radius of an atom:

(a) Values of vanderwaal's radii are larger than those of covalent radii because the vanderwaal's forces are much weaker than the forces operating between atoms in a covalently bonded molecule.

(b) The metallic radii are smaller than the vander waal's radii, since the bonding forces in the metallic crystal lattice are much stronger than the vander waal's forces.

(c) Both (a) & (b)

(d) None of these

31. Which represents alkali metals (i.e. 1^{st} group metals) based on IE_1 and IE_2 values in kJ mol^{-1}?

		IE_1	IE_2
(a)	X	500	1000
(b)	Y	600	2000
(c)	Z	550	7500
(d)	M	700	1400

32. Match the correct atomic radius with the element:

S.No.	Element	Code	Atomic radius (pm)
(i)	Be	(p)	74
(ii)	C	(q)	88
(iii)	O	(r)	111
(iv)	B	(s)	77
(v)	N	(t)	66

(a) (i)–r, (ii)–q, (iii)–t, (iv)–s, (v)–p

(b) (i)–t, (ii)–s, (iii)–r, (iv)–p, (v)–q

(c) (i)–r, (ii)–s, (iii)–t, (iv)–q, (v)–p

(d) (i)–t, (ii)–p, (iii)–r, (iv)–s, (v)–q

33. Electronic configurations of four element A, B, C and D are given below:

(i) $1s^2\ 2s^2\ 2p^6$ (ii) $1s^2\ 2s^2\ 2p^4$

(iii) $1s^2\ 2s^2\ 2p^6\ 3s^1$ (iv) $1s^2\ 2s^2\ 2p^5$

Which of the following is the correct order of increasing tendency to gain electron ?

(a) i < iii < ii < iv (b) i < ii <iii < iv

(c) iv < ii < iii < i (d) iv < i < ii < iii

34. Which of the following is the wrong statement?

(a) All the actinoid elements are radioactive.

(b) Alkali and alkaline earth metals are s-block elements.

(c) Pnictogens and halogens are p-block elements.

(d) The first member of the lanthanoid series is lanthanum

35. Which is true statement(s)?

(a) Larger the value ionization enthalpy, easier is the formation of cation.

(b) Larger the value of electron affinity, easier is the formation of anion.

(c) Larger the value of ionization energy as well as electron affinity, smaller is the Mulliken electronegativity of atom.

(d) Larger the Z_{eff}, larger is the size of atom.

36. The lithium ion (Li^+) and hydride ion (H^-) are isoelectronic ions. Which statement about these systems is true?

(a) Chemical properties of these ions are identical since they are isoelectronic.

(b) Li^+ is a stronger reducing agent than H^-

(c) More energy is needed to ionize H^- than Li^+

(d) Radius of H^- is larger than that of Li^+

37. The correct order of increasing first ionization energy is:

(a) Ca < K < Ne < P < F

(b) F < Ca < Ne < P < K

(c) K < Ca < P< F < Ne

(d) Ne < F < P < Ca < K

38. The number of d-electrons in Fe^{2+} (atomic number = 26) is not equal to that of:

(a) p-electrons in $_{10}Ne$

(b) s-electrons in $_{12}Mg$

(c) d-electrons in Fe

(d) p-electrons in Cl^-

39. Which of the following transition results in increase in magnetic moment value?

(a) $Mn^{2+} \rightarrow Mn^{4+}$ (b) $Ni^{2+} \rightarrow Ni^{4+}$

(c) $Cu^{2+} \rightarrow Cu^{+}$ (d) $Zr \rightarrow Zr^{2+}$

40. The compound of vanadium with chlorine has magnetic moment 1.73 BM. The vanadium chloride has the formula:

(a) VCl_2 (b) VCl_3

(c) VCl_4 (d) VCl_5

41. Which of the following order of radius is not correct?

(a) $Yb^{+3} < Pm^{+3} < Ce^{+3} < La^{+3}$

(b) $Mg^{+2} < Na^{+} < Al < F^{-}$

(c) K > Ca > Mg > Li

(d) $O < O^{-2} < F < F^{-}$

42. Correct trend of first ionization energy in group-13 is:

(a) B > Al > Ga > In > Tl

(b) B > Al > Ga > Tl > In

(c) B > Tl > Ga > Al > In

(d) B > Ga > Al > In > Tl

43. Which has the lowest anion to cation size ratio?

(a) LiF (b) NaF

(c) Csl (d) CsF

44. Select the incorrect statement:

(a) Size of H^- is larger than F^-

(b) Rb is more electropositive compared to Ca

(c) Na^+ is more electronegative than the Na

(d) $Cl^-$is more electronegative than that of F

45. Four elements P, Q, R and S have atomic number Z-1, Z, Z+1 and Z+2 respectively. If Z is 17, then bond between which pair of elements will be least covalent:

(a) S and Q (b) P and R

(c) S and R (d) S and P

LEVEL III

ONE OR MORE THAN ONE OPTIONS CORRECT TYPE

1. Select the correct statement(s):

(a) Alkali metals have lowest IE in respective period.

(b) Noble gases have highest IE in respective period.

(c) EA_1 of N < EA_1 of O

(d) $F^-$is the strongest reducing agent among halide ions.

2. The electronic configuration of given species (X) is $1s^2$, $2s^2$, $2p^6$,$3s^2$,$3p^6$,$3d^5$, $4s^1$. This can be its:

(a) Cationic form X^+ (b) Anionic form X^-

(c) Excited state (d) Ground state

3. In which of the following arrangements, the order is according to the property indicated against it?

(a) IE_1: O > N > C > B

(b) $\Delta_{eg}H$ (with – ve sign): Cl > F > Br > I

(c) Metallic radius: Rb > K > Na > Li

(d) Ionic size: F^-> Na^+ > Mg^{2+} > Al^{3+}

4. In which of the following arrangements, the order is according to the property indicated against it?

(a) Basic strength: $SbH_3 > AsH_3 > PH_3 > NH_3$

(b) IE_1: N > O > C > B

(c) Oxidising power: $PbO_2 > SnO_2 > SiO_2 > CO_2$

(d) Acid strength: HI > HBr > HCl > HF

5. Which of the following orders is (are) correct for size?

(a) $Al \approx Ga$ (b) $Te^{2-} > I^- > Cs^+ > Ba^{2+}$

(c) $Cr^{3+} < Cr^{6+}$ (d) $Pd \approx Pt$

6. Which of the following statements is/are correct?

(a) The second ionization enthalpy of oxygen element is greater than that of fluorine element.

(b) The third ionization enthalpy of phosphorus is greater than that of aluminium.

(c) The first ionization enthalpy of aluminium is slightly greater than that of gallium.

(d) The second ionization enthalpy of copper is greater than that of zinc.

7. Which of the following is/are correct order(s)of electron affinity?

(a) $N < C < O < F$ (b) $P < Si < S < Cl$

(c) $Si < P < S < Cl$ (d) $C < N < O < F$

8. Which of the following is correct order of electronegativity?

(a) $Cs > Rb > Na$ (b) $Li < Be < B$

(c) $C < N < O$ (d) $Cl > F > Br$

9. Poor shielding of nuclear charge by d or f- orbital electrons is responsible for which of the following facts?

(a) Atomic radius of Nb (4d- series) is comparable to that of Ta (5d- series).

(b) The 1^{st} ionization enthalpy of copper is less than that of zinc.

(c) The value of electron gain enthalpy is more negative for sulphur than for oxygen.

(d) The 1^{st} ionization energy for gold is greater than that of silver.

10. Which of the following is/are true order(s)?

(a) $B^+ < B < B^-$	Size
(b) $I < Br < Cl < F$	Electron gain enthalpy (with negative sign)
(c) $O^{2-} < O < O^+$	Z_{eff}
(d) $Na < Al < Mg < Si$	Ionization potential

11. Select the endothermic step(s):

(a) $S^-_{(g)} + e^- \rightarrow S^{2-}_{(g)}$

(b) $Ne_{(g)} + e^- \rightarrow Ne^-_{(g)}$

(c) $N_{(g)} + e^- \rightarrow N^-_{(g)}$

(d) $Al^{2+}_{(g)} \rightarrow Al^{3+}_{(g)} + e^-$

COMPREHENSIONS TYPE QUESTIONS

Read the following passage carefully and answer the question.

Comprehension # 1 (Q. 12 to 14)

It is not possible to measure the atomic radius precisely since the electron cloud surrounding the atom does not have a sharp boundary. One practical approach to estimate the size of an atom of a non-metallic element is to measure the distance between two atoms when they are bound together by a single bond in a covalent molecule and then dividing by two. For metals we define the term "metallic radius" which is taken as half the internuclear distance separating the metal cores in the metallic crystal. The van der Waal's radius represents the overall size of the atoms which includes its valence shell in a non bonded situation. It is the half of the distance between two similar atoms in separate molecules in a solid. The atomic radius decreases across a period and increases down the group. Same trends are observed in case of ionic radius of the species having same number of electrons depends on the number of protons in their nuclei. Sometimes, atomic and ionic radii give unexpected trends due to poor shielding of nuclear charge by d- and f-orbital electrons.

12. Which of the following relations is correct, if considered for the same element ?

(a) $R_{\text{Van der Waal}} > R_{\text{Covalent}} > R_{\text{Metallic}}$

(b) $R_{\text{Covalent}} > R_{\text{Metallic}} > R_{\text{Van der Waal}}$

(c) $R_{\text{Van der Waal}} > R_{\text{Metallic}} > R_{\text{Covalent}}$

(d) $R_{\text{Metallic}} > R_{\text{Covalent}} > R_{\text{Van der Waal}}$

13. K^+, Cl^-, Ca^{2+}, S^{2-} ions are isoelectronic. The decreasing order of their size is:

(a) $Ca^{2+} > K^+ > Cl^- > S^{2-}$

(b) $S^{2-} > Cl^- > K^+ > Ca^{2+}$

(c) $K^+ > Cl^- > Ca^{2+} > S^{2-}$

(d) $S^{2-} > Cl^- > Ca^{2+} > K^+$

14. Select the INCORRECT option regarding atomic/ ionic sizes:

(a) $Zn > Cu$ (b) $Pb^{2+} > Pb^{4+}$

(c) $Zr \approx Hf$ (d) $N^{3-} < Al^{3+}$

Comprehension # 2 (Q. 15 to 17)

Effective nuclear charge (Z_{eff}) is the net attractive force on electrons under Consideration and is equal to:

$Z_{eff} = Z - \sigma$ (nuclear charge – screening constant). Z_{eff} or σ is calculated by Slater's formula, as given.

If one electron is present in the outermost orbit, there will be no screening in that orbital. Each electron contribute, 0.35 (total electrons minus one electron) present in the outermost shell.

A contribution of 0.85 for each electron is taken in the (n-1)th shell.

For all other electrons contribution is 1 for each electron.

15. The screening constant (σ) for 4s electron of Mn (Z = 25) will be :

(a) 18.00 (b) 4.25

(c) 18.35 (d) 21.40

16. Which of the following statement is wrong?

(a) IE_1 of Ga > Al, due to imperfect shielding of 3d-orbitals in Ga.

(b) IE_1 of Ga > Al, due to perfect shielding of 3d-orbitals in Ga.

(c) The atomic size of Ga and Al are almost same because of poor shielding effect of electrons in d-orbitals as the effective nuclear increases in Ga.

(d) IE_1 of group 16 elements is less than that of group 15 elements.

17. Which of the following statement is wrong?

(a) The number of lobes in d-orbitals are 4.

(b) IE_1 of element increases along the period.

(c) IE_1 of the group 3 elements is more than that of the group 2 elements

(d) IE_1, IE_2 and IE_3 of an element are 9.5, 18.5 and 154.4 eV predict that the element has either two s-electrons or two p-electrons in the valence shell.

Comprehension # 3 (Q. 18 to 20)

The energy required to remove an electron from the outermost shell of an isolated gaseous atom is known as IE_1 of that atom. Similarly, the energy required for the removal of the electron from the unipositive ion, dipositive ion and tripositive ion are known as IE_2, IE_3 and IE_4 respectively, and are called successive ionization energies. The magnitude of the charge depends on the size of the orbital of electron. Electrons in smaller orbitals are on average close with each other and have more repulsion. Thus for Be ($2s^2$), the IE_1 and IE_2 are 9.3 and 18.2 eV $atom^{-1}$, whereas for Ca ($4s^2$), the vales are 6.1 and 11.9 eV.

18. The correct order of arrangement of the first ionization energies of C, N, O and F (in decreasing values) is:

(a) C > N > O > F (b) O > N > F > C

(c) O > F > N > C (d) F > N > O > C

19. Four elements have the following first ionization energies in kJ mol^{-1} : 762, 709, 59 and 558. The elements are Ga, Ge, In and Sn (not in order). Which of these elements has the ionization energy of 762 kJ mol^{-1}?

(a) In (b) Ga

(c) Sn (d) Ge

20. Among the following ionization reactions, which one will have the maximum value of ionization energy?

(a) $Be \rightarrow Be^+$ (b) $Be^+ \rightarrow Be^{2+}$

(c) $Sr \rightarrow Sr^+$ (d) $Sr^+ \rightarrow Sr^{2+}$

Comprehension # 4 (Q. 21 to 23)

Energy is released when an electron is added to neutral isolated gaseous atom in its ground state to give monoanion and this is known as EA_1 or $\Delta_{eg}H_1$. Greater is the amount of energy released the greater will be EA. EA is expressed in $eVatom^{-1}$ or kJ mol^{-1}

21. EA values of N and P are exceptionally low, because:

(a) Both N and P have half-filled p-orbitals in the valence shell.

(b) The atom is more stable than the corresponding anion.

(c) The electronic configuration of the anion N^- and P^- is relatively more stable than the corresponding atom.

(d) Both (b) and (c).

22. Select the correct statements (More than one correct):

(a) EA_1 and $\Delta_{eg}H_1$ of an atom of element have same magnitude

(b) $\Delta_{eg}H_1$(-ve) of Al > B

(c) $\Delta_{eg}H_1$(-ve)of P > N

(d) $\Delta_{eg}H_1$(-ve) of S > O

23. Select the correct statements (More than one correct):

(a) $\Delta_{eg}H_1$of noble gases have large positive values.

(b) $\Delta_{eg}H_1$ of noble gases have large negative values.

(c) $\Delta_{eg}H_1$ if helium (He) is the lowest of all the noble gases.

(d) $\Delta_{eg}H_1$ of Ar is lower than that of Ne.

SINGLE AND DOUBLE VALUE INTEGER TYPE QUESTIONS

24. Most stable oxidation state of thallium is +n. What is the value of n?

25. Total number of elements which have more ionization energy as compare to their next higher atomic number elements. Li, Be ,B, C, N, O, F, Ne

26. How many elements are more electropositive than Cl?
B, N, O, S, P, At, H, Li

27. Total number of elements which have only single oxidation state (other than zero) in their corresponding stable compounds: Cs, Ba, F, Zn, Be, Al, Sr, Ga, Pb

28. How many pairs in their first species have lower ionization energy than second species?

(a) N and O (b) Li and Li^+

(c) O and S (d) Ba and Sr

(e) I and I^- (f) Be and B

(g) Br and K

MATCHING THE COLUMN TYPE QUESTIONS

29.

	Column I		**Column II**
a.	Na > Mg > Al > B	p.	Oxidizing nature
b.	F > N > C > B > Si	q.	Lowest IE_1
c.	F > O > Cl > N	r.	Metallic character
d.	Out B, C, Al and Si, C have	s.	Non-metallic character
		t.	Highest IE_1

30.

	Column I		**Column II**
a.	N_2O	p.	Normal oxide
b.	Na_2O	q	Neutral oxide
c.	Ga_2O_3	r.	Suboxide
d.	C_3O_2	s.	Basic oxide
e.	Mn_3O_4	t.	Amphoteric oxide
f.	SnO_2	u.	Mixed oxide

PREVIOUS YEARS' QUESTIONS FOR JEE (MAIN AND ADVANCED)

1. The correct order of acidic strength is:

(a) $Cl_2O_7 > SO_2 > P_4O_{10}$

(b) $CO_2 > N_2O_5 > SO_3$

(c) $Na_2O > MgO > Al_2O_3$

(d) $K_2O > CaO > MgO$

(III-JEE, 2000)

2. The correct order of radii is:

(a) N < Be < B (b) $F^- < O^{2-} < N^{3-}$

(c) Na < Li < K (d) $Fe^{3+} < Fe^{2+} < Fe^{4+}$

(III-JEE, 2000)

3. The set representing the correct order of first ionization potential is:

(a) K > Na > Li (b) Be > Mg > Ca

(c) B > C > N (d) Ge > Si > C

(III-JEE, 2001)

4. Identify the least stable ion amongst the following:

(a) Li^- (b) Be^-

(c) B^- (d) C^-

(III-JEE, 2002)

5. Identify the correct order of acidic strengths of CO_2, CuO, CaO, H_2O is:

(a) $CaO < CuO < H_2O < CO_2$

(b) $H_2O < CuO < CaO < CO_2$

(c) $CaO < H_2O < CuO < CO_2$

(d) $H_2O < CO_2 < CaO < CuO$

(IIT-JEE, 2002)

6. Statement-1: Pb^{4+} compounds are stronger oxidizing agents than Sn^{4+} compounds.

Statement-2: The higher oxidation states for the group 14 elements are more stable for the heavier members for the group due to inert pair effect.

(a) Statement-1 is True, Statement-2 is true, Statement-2 is a correct explanation for Statement-1.

(b) Statement-1 is True, Statement-2 is true, Statement-2 is NOT a correct explanation for Statement-1.

(c) Statement-1 is True, Statement-2 is False

(d) Statement-1 is False, Statement-2 is True

(III-JEE, 2008)

7. Which of the following represent the correct order of increasing IE_1 for Ca, Ba, S, Se and Ar?
(a) S < Se < Ca < Ba < Ar
(b) Ba < Ca < Se < S < Ar
(c) Ca < Ba < S < Se < Ar
(d) Ca < S < Ba < Se < Ar

(III-JEE, 2013)

8. The correct order of ionic radius is:
(a) Ce > Sm > Tb > Lu (b) Lu > Tb > Sm > Ce
(c) Tb > Lu > Sm > Ce (d) Sm > Tb > Lu > Ce

(AIEEE, 2002)

9. Ce^{3+}, La^{3+}, Pm^{3+} and Yb^{3+} have ionic radii in the increasing order as:
(a) $La^{3+} < Ce^{3+} < Pm^{3+} < Yb^{3+}$
(b) $Yb^{3+} < Pm^{3+} < Ce^{3+} < La^{3+}$
(c) $La^{3+} = Ce^{3+} < Pm^{3+} < Yb^{3+}$
(d) $Yb^{3+} < Pm^{3+} < La^{3+} < Ce^{3+}$

(AIEEE, 2002)

10. According to the modern Periodic Law of elements, the variation in properties of elements is related to their?
(a) Nuclear masses
(b) Atomic numbers
(c) Nuclear neutron-proton number ratio
(d) Atomic masses

(AIEEE, 2003)

11. The reduction in atomic size with increase in atomic number is a characteristic of elements of:
(a) d-block
(b) f-block
(c) Radioactive series
(d) High atomic masses

(AIEEE, 2003)

12. Which one of the following groups represents a collection of isoelectronic species? (Atomic number of Cs is 55 and of Br is 35)
(a) N^{3-}, F^-, Na^+ (b) Be, Al^{3+}, Cl^-
(c) Ca^{2+}, Cs^+, Br (d) Na^+, Ca^{2+}, Mg^{2+}

(AIEEE, 2003)

13. The atomic numbers of vanadium (V), chromium (Cr), manganese (Mn) and iron (Fe) respectively 23, 24, 25 and 26. Which one of these may be expected to have the higher second ionization enthalpy?
(a) Cr (b) Mn
(c) Fe (d) V

(AIEEE, 2003)

14. Which one of the following sets of ions represents the collection of isoelectronic species?
(a) K^+, Cl^-, Mg^{2+}, Sc^{3+}
(b) Na^+, Ca^{2+}, Sc^{3+}, F^-
(c) K^+, Ca^{2+}, Sc^{3+}, Cl^-
(d) Na^+, Mg^{2+}, Al^{3+}, Cl^-

(AIEEE, 2004)

15. Which one of the following ions has the highest value of ionic radius?
(a) O^{2-} (b) B^{3+}
(c) Li^+ (d) F^-

(AIEEE, 2004)

16. Among Al_2O_3, SiO_2, P_2O_3 and SO_2 the correct order of acid strength is:
(a) $Al_2O_3 < SiO_2 < SO_2 < P_2O_3$
(b) $SiO_2 < SO_2 < Al_2O_3 < P_2O_3$
(c) $SO_2 < P_2O_3 < SiO_2 < Al_2O_3$
(d) $Al_2O_3 < SiO_2 < P_2O_3 < SO_2$

(AIEEE, 2004)

17. The formation of the oxide ion requires first an exothermic and then an endothermic step as shown below:
$O(g) + e^- = O^-(g)$ $\Delta H° = -142$ kJ mol^{-1}
$O^-(g) + e^- = O^{2-}(g)$ $\Delta H° = 844$ kJ mol^{-1}
This is because of:
(a) O^- ion will tend to resist the addition of another electron
(b) Oxygen has high electron affinity
(c) Oxygen is more electronegative
(d) O^- ion has comparatively larger size than oxygen atom

(AIEEE, 2004)

18. Which among the following factors is the most important in making fluorine the strongest oxidizing halogen?
(a) Hydration enthalpy
(b) Ionization enthalpy
(c) Electron affinity
(d) Bond dissociation energy

(AIEEE, 2004)

19. Pick out the isoelectronic structure from the following:
I. $^+CH_3$ II. H_3O^+
III. NH_3 IV. CH_3^-
(a) I and II (b) III and IV
(c) I and III (d) II, III and IV

(AIEEE, 2005)

20. Which of the following factors may be regarded as the main cause of lathanoid contraction?

(a) Poor shielding of one of 4f electron by another in the subshell.

(b) Effective shielding of one of 4f electrons by another in the subshell.

(c) Poorer shielding of 5d electrons by 4f electrons

(d) Greater shielding of 5d electrons by 4f electrons

(AIEEE, 2005)

21. In which of the following arrangements the order is NOT according to the property indicated against it?

(a) $Al^{3+} < Mg^{2+} < Na^{+} < F^{-}$ - Increasing ionic size

(b) B < C < N < O - Increasing first ionisation enthalpy

(c) I < Br < F < Cl - Increasing electron gain enthalpy (with negetive sign)

(d) Li < Na < K < Rb - Increasing metallic redius

(AIEEE, 2005)

22. The lanthanide contraction is responsible for the fact that:

(a) Zr and Y have about the same radius.

(b) Zr and Nb have similar oxidation state.

(c) Zr and Hf have about the same radius.

(d) Zr and Zn have same oxidation state.

(AIEEE, 2005)

23. Which of the following oxides is amphoteric in character?

(a) SnO_2 (b) SiO_2

(c) CO_2 (d) CaO

(AIEEE, 2005)

24. The increasing order of the first ionization enthalpies of the elements B, P, S and F (lowest first) is:

(a) F < S < P < B (b) P < S < B < F

(c) B < P < S < F (d) B < S < P < F

(AIEEE, 2006)

25. Which one of the following sets of ions represents a collection of isoelectronic species?

(a) N^{3-}, O^{2-}, F^{-}, S^{2-}

(b) Li^{+}, Na^{+}, Mg^{2+}, Ca^{2+}

(c) K^{+}, Cl^{-}, Ca^{2+}, Sc^{3+}

(d) Ba^{2+}, Sr^{2+}, K^{+}, Ca^{2+}

(AIEEE, 2006)

26. Lanthanoid contraction is caused due to:

(a) The same effective nuclear charge from Ce to Lu

(b) The imperfect shielding on outer electrons by 4f electrons from the nuclear charge

(c) The appreciable shielding on outer electrons by 4f electrons from the nuclear charge

(d) The appreciable shielding on outer electrons by 5d electrons from the nuclear charge

(AIEEE, 2006)

27. Following statements regarding the periodic trends of chemical reactivity of the alkali metals and the halogens are given. Which of these statements gives the correct picture?

(a) Chemical reactivity increases with increase in atomic number down the group in both the alkali metals and halogens

(b) In alkali metals the reactivity increases but in the halogens it decreases with increase in atomic number down the group

(c) The reactivity decreases in the alkali metals but increases in the halogens with increase in atomic number down the group

(d) In both alkali metals and the halogens the chemical reactivity decreases with increases in atomic number down the group

(AIEEE, 2006)

28. The set representing the correct order of ionic radius is:

(a) $Na^{+} > Li^{+} > Mg^{2+} > Be^{2+}$

(b) $Li^{+} > Na^{+} > Mg^{2+} > Be^{2+}$

(c) $Mg^{2+} > Be^{2+} > Li^{+} > Na^{+}$

(d) $Li^{+} > Be^{2+} > Na^{+} > Mg^{2+}$

(AIEEE, 2009)

29. The correct sequence which shows decreasing order of the ionic radii of the elements is:

(a) $Al^{3+} > Mg^{2+} > Na^{+} > F^{-} > O^{2-}$

(b) $Na^{+} > Mg^{2+} > Al^{3+} > O^{2-} > F^{-}$

(c) $Na^{+} > F^{-} > Mg^{2+} > O^{2-} > Al^{3+}$

(d) $O^{2-} > F^{-} > Na^{+} > Mg^{2+} > Al^{3+}$

(AIEEE, 2010)

30. The outer electronic configuration of Gd (Atomic number 64) is:

(a) $4f^3\ 5d^5\ 6s^2$ (b) $4f^8\ 5d^0\ 6s^2$

(c) $4f^4\ 5d^4\ 6s^2$ (d) $4f^7\ 5d^1\ 6s^2$

(AIEEE, 2011)

31. The correct order of electron gain enthalpy with negative sign of F, Cl, Br and I having atomic number 9,17, 35 and 53 respectively is:

(a) F > Cl > Br > I (b) Cl > F > Br > I

(c) Br > Cl > I > F (d) I > Br > Cl > F

(AIEEE, 2011)

32. Which one of the following orders presents the correct sequence of the increasing basic nature of the given oxides?

(a) $Al_2O_3 < MgO < Na_2O < K_2O$

(b) $MgO < K_2O < Al_2O_3 < Na_2O$

(c) $Na_2O < K_2O < MgO < Al_2O_3$

(d) $K_2O < Na_2O < Al_2O_3 < MgO$

(AIEEE, 2011)

33. The increasing order of the ionic radii of the given isoelectronic species is:

(a) $Cl^-, Ca^{2+}, K^+, S^{2-}$ (b) $S^{2-}, Cl^-, Ca^{2+}, K^+$

(c) $Ca^{2+}, K^+, Cl^-, S^{2-}$ (d) $K^+, S^{2-}, Ca^{2+}, Cl^-$

(AIEEE, 2012)

34. Which of the following presents the correct order of second ionization enthalpies of C, N, O and F?

(a) O > N > F > C (b) F > O > N > C

(c) C > N > O > F (d) O > F > N > C

(JEE Main Online 2012)

35. Which among the following elements has the highest ionization enthalpy?

(a) Nitrogen (b) Boron

(c) Carbon (d) Oxygen

(JEE Main Online 2012)

36. Electron gain enthalpy with negative sign of fluorine is less than that of chlorine due to:

(a) High ionization enthalpy of fluorine

(b) Smaller size of chlorine atom

(c) Smaller size of fluorine atom

(d) Bigger size of 2p orbital of fluorine

(JEE Main Online 2013)

37. The order of increasing sizes of atomic radii among the elements O, S, Se and As is:

(a) As < S < O < Se (b) Se < S < As < O

(c) O < S < As < Se (d) O < S < Se As

(JEE Main Online 2013)

38. What is the following represents the correct order of increasing first ionization enthalpy for Ca, Ba, S, Se and Ar?

(a) Ca < S < Ba < Se < Ar

(b) S < Se < Ca < Ba < Ar

(c) Ba < Ca < Se < S < Ar

(d) Ca < Ba < S < Se < Ar

(JEE Main, 2013)

39. The first ionization potential of Na is 5.1 eV. The value of electron gain enthalpy of Na^+ will be:

(a) -2.55 eV (b) -5.1 eV

(c) -10.2 eV (d) +2.55 eV

(JEE Main, 2013)

40. Similarity in chemical properties of the atoms of elements in a group of the periodic table is most closely related to:

(a) Atomic numbers

(b) Atomic masses

(c) Number of principal energy levels

(d) Number of valence electrons

(JEE Main Online 2014)

41. Which of the following arrangements represents the increasing order (smallest to largest) of ionic radii of the given species O^{2-}, S^{2-}, N^{3-}, P^{3-}?

(a) $O^{2-} < N^{3-} < S^{2-} < P^{3-}$ (b) $O^{2-} < P^{3-} < N^{3-} < S^{2-}$

(c) $N^{3-} < O^{2-} < P^{3-} < S^{2-}$ (d) $N^{3-} < S^{2-} < O^{2-} < P^{3-}$

(JEE Main Online 2014)

42. The ionic radii (in Å) of N^{3-}, O^{2-} and F^- are respectively:

(a) 1.36, 1.40 and 1.71 (b) 1.36, 1.71 and 1.40

(c) 1.71, 1.40 and 1.36 (d) 1.71, 1.36 and 1.40

(JEE Main, 2015)

43. Which of the following atoms has the highest first ionization energy?

(a) Na (b) K

(c) Sc (d) Rb

(JEE Main, 2016)

Answer Key

LEVEL I

1. (a)	2. (d)	3. (c)	4. (c)	5. (d)	6. (b)	7. (c)	8. (c)	9. (a)	10. (c)
11. (a)	12. (d)	13. (b)	14. (d)	15. (b)	16. (c)	17. (d)	18. (d)	19. (c)	20. (b)
21. (a)	22. (d)	23. (c)	24. (a)	25. (c)	26. (c)	27. (b)	28. (d)	29. (b)	30. (b)
31. (b)	32. (d)	33. (a)	34. (b)	35. (d)	36. (c)	37. (c)	38. (c)	39. (a)	40. (d)
41. (a)	42. (b)	43. (d)	44. (d)	45. (d)					

LEVEL II

1. (d)	2. (c)	3. (b)	4. (d)	5. (b)	6. (b)	7. (c)	8. (c)	9. (b)	10. (d)
11. (d)	12. (d)	13. (b)	14. (c)	15. (c)	16. (d)	17. (c)	18. (c)	19. (b)	20. (c)
21. (d)	22. (d)	23. (d)	24. (c)	25. (a)	26. (d)	27. (d)	28. (a)	29. (d)	30. (c)
31. (c)	32. (c)	33. (a)	34. (d)	35. (b)	36. (d)	37. (c)	38. (d)	39. (b)	40. (c)
41. (d)	42. (c)	43. (d)	44. (d)	45. (a)					

LEVEL III

1. (a,b,c)	2. (a,d)	3. (b,c,d)	4. (b,c,d)	5. (a,b,d)	6. (a,b,d)	7. (a,b)	8. (b,c)
9. (a,d)	10. (a,c,d)	11. (a,b,c,d)	12. (c)	13. (b)	14. (d)	15. (d)	16. (b)
17. (c)	18. (d)	19. (d)	20. (b)	21. (a)	22. (a,b,c,d)	23. (a,d)	24. (1)
25. (2)	26. (6)	27. (7)	28. (2)				

29. a →r; b →s; c →p;d →t

30. a →q,r; b →p,s; c →t; d →r; e → u; f →t

PREVIOUS YEARS' QUESTIONS FOR JEE (MAIN AND ADVANCED)

1. (a)	2. (b)	3. (b)	4. (b)	5. (a)	6. (c)	7. (b)	8. (a)	9. (b)	10. (b)
11. (b)	12. (a)	13. (a)	14. (c)	15. (a)	16. (d)	17. (a)	18. (a)	19. (d)	20. (c)
21. (b)	22. (c)	23. (a)	24. (d)	25. (c)	26. (b)	27. (b)	28. (a)	29. (d)	30. (d)
31. (b)	32. (a)	33. (c)	34. (d)	35. (a)	36. (c)	37. (d)	38. (c)	39. (b)	40. (d)
41. (a)	42. (c)	43. (c)							

Hints and Solutions

LEVEL I

1. **(a)** Number of e^- in O_2^+ = 15 = number of e^- in X^{2-}

Atomic number of X^{2-} is 13 (z)

Number of neutrons = Z+1 = 14

Mass number of X^{2-} = 13 + 14 = 27

2. **(d)** Hydrogen resembles halogens in some properties and also resembles alkali metals in some properties. So, it can be placed in first or 17^{th} group.

3. **(c)** This element belongs to d-block

Group number of d-block = (ns + (n – 1) d)

= 2 + 3 = 5

4. **(c)** Cr belongs to fourth period.

5. **(d)** Mass number (proton + neutron) of X^{2+} = 20

Number of neutrons = 10

Hence, Number of protons of X^{2+} =10

Number of e^- in X^{2+} = 8

6. **(b)** Elements of group 1, 2 and 13 to 17 are called as representative elements.

7. **(c)** Inert gas elements → $1s^2$ and $ns^2\ np^6$

Representative elements → ns^{1-2} and $ns^2\ np^1$ to $ns^2\ np^5$

Transition elements → $(n-1)\ d^{1-10}\ ns^{1or2}$

Inner – transition elements → $(n-2)\ f^{1-14}\ (n-1)\ d^{0-1}\ ns^2$

8. **(c)** Z = 108, group number Viii B , period – 7^{th}

9. **(a)** The element, with atomic number 56, belongs to group 2 (alkaline earth metal). The element, with atomic number 12, also belongs to group 2.

10. **(c)** e^- configuration of M^{2+}=$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^6$

e^- configuration of M = $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^6$

= atomic number is 26

Atomic weight of M = 56

Number of neutrons = 56 – 26 = 30

11. **(a)** Ionic mobility $\propto \frac{1}{\text{Size in aqueous medium}}$

Order of size in aqueous medium:

$Li^+_{(aq)} > Na^+_{(aq)} > K^+_{(aq)}$

Order of ionic mobility:

$Li^+_{(aq)} < Na^+_{(aq)} < K^+_{(aq)}$

12. **(d)** p-block elements mostly form acidic oxides not basic oxides.

13. **(b)**

Ion	e^- configuration	Number of unpaired e^-	μ
Cr^{+3}	(Ar) $4s^\circ\ 3d^3$	3	$\sqrt{15}$
Mn^{+2}	(Ar) $4s^\circ\ 3d^5$	5	$\sqrt{35}$
Fe^{+2}	(Ar) $4s^\circ 3d^6$	4	$\sqrt{24}$
Cu^{+2}	(Ar) $4s^\circ 3d^9$	1	$\sqrt{3}$

14. **(d)** e^- configuration of Fe^{+3} = (Ar) $4s^\circ\ 3d^5$

It has unpaired e^- hence, it is a paramagnetic species.

15. **(b)** Ag^+ = (Kr) $5s^\circ\ 4d^{10}$

Cu^{+2} = (Ar) $4s^\circ\ 3d^9$

Ga^{+3} = (Ar) $4s^\circ\ 3d^{10}\ 4p^\circ$

Zn^{+2} = (Ar) $4s^\circ\ 3d^{10}$

16. **(c)** μ = 3.87 BM

Hence, number of unpaired e^- in Mn^{x+} = 3

Mn = (Ar) $4s^\circ\ 3d^5$

Mn^{4+} = (Ar) $4s^\circ\ 3d^3$

17. **(d)** The first element of a group generally belongs to second period. It has a small size, high ionization potential and electronegativity. It does not have d – orbitals.

18. **(d)** Oxides of Be and Al are amphoteric. They have almost similar electronegativity and polarizing power.

19. **(c)** Be and Al show diagonal relationship.

20. **(b)** Correct set of magic numbers for group VIA is 8,18,18,32.

21. **(a)** For a given series of isoelectronic species, as atomic number increases, radius decreases. $Se^{-2} > Br^- > Kr > Rb^+ > Sr^{+2}$

22. **(d)** Order of ionic radius is:

$Be^{+2} < Mg^{2+} < Ca^{2+} < Sr^{2+}$

23. **(c)** Their relative positions in periodic table,

C N (II period)

P S (III period)

The correct order of size is:

N < C < S < P

24. **(a)** Due to lanthanoid contraction Zr and Hf have almost similar atomic radii.

25. **(c)** As positive oxidation state increases, radius decreases.

+4	**+7**	**+2**	+3
MnO_2	$KMnO_4$	MnO	$K_3[Mn(CN)_6]$

26. **(c)** Down the group, ionization enthalpy decreases. It is due to increment in atomic size.

27. **(b)** Due to extra stability of the half filled p-orbitals, N has greater ionization potential than that of O.

28. **(d)** Order of ionization energy is:

$M^- < M^+ < M^{2+}$

M^{+2}has smallest size and highest effective nuclear charge.

29. **(b)** In IE_2 process, $1e^-$ is removed from $X^+(g)$

30. **(b)** Down the group, IE decreases. It is due to increment in atomic size.

31. **(b)** In lanthanide series, as atomic number increases, atomic radius gradually decreases It is called as lanthanide contraction.

32. **(d)** Electron affinity (EA) = - Δ e.g. (e^- gain enthalpy)

33. **(a)** Outermost sub shell of N is half filled. In process, $N \rightarrow N^-$, absorption of energy takes place.

34. **(b)** Second and successive electron gain enthalpy of an element is always positive because anions resist addition of another e^-.

35. **(d)** As and Sb are metalloids.

36. **(c)** In group VIIA (Halogens),
F_2 and Cl_2 → gas
Br_2 → liquid
I_2 → solid

37. **(c)** Halogens have highest electro negativity.

38. **(c)** percentage ionic character
$= 16 (\Delta EN) + 3.5 (\Delta EN)^2$
$= 16 (3.3) + 3.5 (3.3)^2$
$= 90.9\ \%$

39. **(a)** In halogens, bond length decreases from iodine to fluorine.

40. **(d)** Acidic strength of oxides and hydroxides $\propto$ Electro negativity of central atom

41. **(a)** Order of acidic strength:
$Al_2O_3 < B_2O_3 < CO_2 < NO_2$

42. **(b)** Neutral oxides are CO, NO, N_2O, H_2O

43. **(d)** $Al_2O_3 \rightarrow$ Amphoteric
$B_2O_3 \rightarrow$ Acidic

44. **(d)** In order of acidic strength:
$HCl > PH_3 > SiH_4 > CH_4$

45. **(d)** They all are acidic.

LEVEL II

1. **(d)** The elements 'X' is 'As'. Its electronic configuration is (Ar) $4s^2\ 3d^{10}\ 4p^3$.

2. **(c)** Bond length of H – F = $r_H + r_F - 0.09\ (\Delta EN)$
$= 0.37 + 0.72 - 0.09\ (1.9)$
$= 0.92$ Å

3. **(b)** Order of ionic radius:
$I^- > Cl^-$
$Te^{2-} > I^-$ (They are isoelectronic)

4. **(d)** Due to inert pair effect the more common oxidation state for Tl, Pb and Bi are +1, +2 and +3 respectively.

5. **(b)** The relative positions of these elements in periodic table:-

Mg	P	Cl
Ca		

Order of atomic radius:-
Ca > Mg
Mg > P > Cl

6. **(b)** The element 'X' is 'Cu'. Its electronic configuration is (Ar) $4s^1\ 3d^{10}$. In third shell $18e^-$ and in fourth shell $1e^-$ is present.

7. **(c)** The electronic configuration of element is $3s^2\ 3p^6\ 3d^5\ 4s^2$. This element is 'Mn'.

8. **(c)** La and Ac belong to d - block
Element having atomic number 31 belongs to 4^{th} period.
Elements after $_{92}U$ are man-made elements.

9. **(b)** $X(g) + E_1 \rightarrow X^+(g) + e^-$
$(\frac{A_0}{2}$ atoms)
$\frac{A_0}{2}$ atoms absorbs E_1 energy
So, 1 atom absorbs $\frac{2E_1}{A_0}$ energy
Hence, ionization energy of X(g) is $\frac{2E_1}{A_0}$
$X(g) + \frac{2E_1}{A_0} \rightarrow X^+(g) + e^-$……eq (1)
$X^+(g) + 2e \rightarrow X^-(g) + E_2$
$(\frac{A_0}{2}$ ions)
$\frac{A_0}{2}$ ions release E_2 energy
So, 1 ion releases $\frac{2E_2}{A_0}$ energy
Hence, $X^+(g) + 2e^- \rightarrow X^-(g) + \frac{2E_2}{A_0}$ …....eq(2)
(1 ion)
Equation for electron affinity of X(g) is,
$X(g) + e^- \rightarrow X^-(g)$ + EA of X(g).
We can get this equation by adding equation (1) and (2),
$X(g) + e^- \rightarrow X^-(g) + \frac{2(E_2 - E_1)}{A_0}$
Hence, electron affinity of X(g) is $\frac{2(E_2 - E_1)}{A_0}$.

10. **(d)** In covalent hydrides, as we move left to right in a period acidic strength increases.

11. **(d)** In any period, noble gas has largest atomic radius because for noble gases vander waal's radius is considered.

12. **(d)** Acidic strength of Oxides $\propto$ Electronegativity of central atom.
CO_2 is more acidic than SiO_2 hence, option 'i' is incorrect.

13. **(b)** The elements having atomic number 113 belongs to group 13 and 7^{th} period.

14. **(c)** The electronic configuration of Cr is (Ar) $3d^5\ 4s^1$ and it is a representative element. In HN_3, oxidation state of nitrogen is $-^1/_3$.

15. **(c)** The biggest jump in successive ionization energy is from IE_3 to IE_4. Hence, this element has 3 valence e^-.

16. **(d)** In s-block, all oxides are basic except BeO. BeO is an amphoteric oxide. They are obtained by the electrolysis of fused chlorides.

17. **(c)** Na^+ and F^- are isoelectronic but Na belongs to 3^{rd} period while F belongs to 2^{nd} period.

18. **(c)** The element (P) is Lu, which is a lanthanoid. All lanthanoids belong to the 3^{rd} period.

19. **(b)** Ionic radius of Li^+ (0.76Å) is larger than that of Mg^{2+} (0.72Å).

20. **(c)** The bond having greater polarity (or, greater ΔEN) has greater chance of dissociation in water.

21. **(d)** The equation for second ionization energy of M is,

$M^+(g) \rightarrow M^{2+}(g) + e^-$

This equation will be obtained by (V)–(iii)

$$\begin{array}{l} M(g) \rightarrow M^{2+}(g) + 2e^- \\ -(M(g) \rightarrow M^+(g) + e^-) \\ \hline M^+(g) \rightarrow M^{+2} + e^- \end{array}$$

22. **(d)** EA_1 process is generally exothermic while EA_2 process is always endothermic. Hence, ΔH_1, ΔH_2 and ΔH_3 are negative whereas ΔH_4 is positive.

23. **(d)** As positive oxidation state increases, radius decreases.

24. **(c)** Completely filled sub-shell is more stable than half filled sub-shell.

25. **(a)** The biggest jump in successive ionization energy is from IE_3 to IE_4. Hence, the number of valence electron is 3.

26. **(d)** Due to lanthanoid contraction 5d-series elements have greater effective nuclear hence, they have higher ionization energy.

27. **(d)** IE_2 for an element is higher than IE_1 because after removal of 1^{st} electron, 2^{nd} electron is removed from the cation. The cation is smaller than its parent atom and it has greater effective nuclear charge (Z_{eff}) than its parent atom.

28. **(a)** Due to extra stability of half-filled p-subshell, elements of group 15 have higher IE than elements of group 16.

29. **(d)** Fluorine has small size, high electron density and an increased electronic repulsion.

30. **(c)** The order of radius is:

$$r_{vander\ waal} > r_{metallic} > r_{covalent}$$

31. **(c)** Z has biggest jump from IE_1 to IE_2 hence, it has 1 valence e^-.

32. **(c)** The order of radius is:

$$Be > B > C > N > O$$

33. **(a)** Elements A, B, C and D are Ne, O, Na and F respectively. Their correct order of EA is:

$Ne < Na < O < F$

34. **(d)** The first member of the lanthanoid series is Ce (cerium). Pricogens are group 15 elements.

35. **(b)** Smaller the value of IE, easier is the formation of cation. Larger the value of EA, easier is the formation of anoin.

$$\text{Electronegativity on Mulliken's scale} = \frac{IE+EA}{2}$$

$$\text{Size} \propto \frac{1}{Z_{eff}}$$

36. **(d)** For isoelectronic species, as atomic number increases radius decreases.

37. **(c)** The relative order of these elements in periodic table is:

			F	Ne
		P		
K	Ca			

The correct order of IE_1 is:

$$K < Ca < P < F < Ne$$

38. **(d)** The number of d-electrons in Fe^{2+} ([Ar] $4s^0 3d^6$) are 6.
p-electrons in Ne ($1s^2\ 2s^2\ 2p^6$) are 6.
s-electrons in Mg ($1s^2\ 2s^2\ 2p^6\ 3s^2$) are 6.
d-electrons in Fe ([Ar] $4s^2 3d^6$) are 6.
p-electrons in Cl^- ($1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$) are 12.

39. **(b)** Ni^{+2}= [Ar] $4s^0\ 3d^8$ (2 unpaired electrons)
Ni^{+4}= [Ar] $4s^0\ 3d^6$ (4 unpaired electrons)

40. **(c)** Magnetic moment = 1.73BM
The number of unpaired e^- = 1
V = [Ar] $4s^2\ 3d^3$
V^{+4} = [Ar] $4s^\circ\ 3d^1$
In VCl_4, oxidation state of 'V' is '+4'

41. **(d)** The correct order of radius is:

$$F < O < F^- < O^{-2}$$

42. **(c)** The correct trend of first ionization energy is:

$$B > Al < Ga > In < Tl$$

Higher Z_{eff} Higher Z_{eff}

$B > Tl > Ga > Al > In$ (Based on practical values)

43. **(d)** Cs^+ is largest cation and F^- is smallest anion hence, CsF has the lowest anion to cation size ratio.

44. **(d)** F is more electronegative than that of Cl^-. Anions are less electronegative than neutral atoms.

45. **(a)**

Elements	Atomic number
P	16
Q	17
R	18
S	19

The bond between S (alkali metals) and Q (halogens) will be most ionic (least covalent)

LEVEL III

1. (a, b, c) Value of ionization energy increases from left to right in a period.
Hence, alkali metals have lowest IE and noble gases have highest
IE in respective period.
Due to half filled outermost 2p-subshell, N has lower EA_1 than O

2. (a, d) If 'X' Mn then this e^- configuration represent cationic form X^+ (Mn^+)
If 'X' is 'Cr' then this e^- configuration represents ground state.

3.. (b, c, d) The correct order of IE_1 is:
$N > O > C > B$
The remaining orders are correct.

4. (b, c, d) The correct order of basic strength is:
$SbH_3 < AsH_3 < PH_3 < NH_3$
The remaining orders are correct.

5. (a, b, d) As positive charge increases, radius decreases. Hence, Cr^{+3} is larger than Cr^{+6}.

6. (a, b, d) Due to higher effective nuclear charge, Ga has greater first ionization enthalpy than Al.

7. (a, b) The correct orders of electron affinity are:
$N < C < O < F$
$P < Si < S < Cl$

8. (b, c) Down the group, electronegativity decreases. As we move from left to right in a period electronegativity increases.

9. (a, d) Due to poor shielding of nuclear charge by d or f-orbital electrons, 5d-series elements have greater elective nuclear charge.

10. (a, c, d) The correct order of ΔH_{eg}(With negative sign) is:
$Cl > F > Br > I$
The remaining orders are correct.

11. (a, b, c, d) $S^-(g) + e^- \rightarrow S^{2-}(g)$; EA_2 of S
$Ne(g) + e^- \rightarrow Ne^-(g)$; EA_1 of Ne
$N(g) + e^- \rightarrow N^-(g)$; EA_1 of N
$Al^{2+}(g) + e^- \rightarrow Al^{3+}(g)$; IE_3 of Al
These all steps are endothermic.

12. (c) $r_{Van\ der\ Waal} > r_{Metallic} > r_{Covalent}$

13. (b) In isoelectronic series, as atomic number increases, radius decreases.

14. (d) Both N^{3-} and Al^{3+} are isoelectronic. The correct order of radius is:
$N^{3-} > Al^{3+}$

15. (d) $Mn = \underbrace{1s^2\ 2s^2\ 2p^6}_{\text{Other}}\ \underbrace{3s^2\ 3p^6\ 3d^5}_{(n-1)}\ \underbrace{4s^2}_{ns}$
$\sigma = 1 \times 0.35 + 13 \times 0.85 + 10 \times 1$
$= 21.40$

16. (b) IE_1 of Ga > Al, due to imperfect shielding of 3d-orbitals in Ga.

17. (c) IE_1 of the group 2 elements is more than that of the group 3 elements.

18. (d) Order of the first ionization energy is:
$C < O < N < F$

19. (d) Relative positions of these elements in periodic table is:

Ga	Ge
In	Sn

Among these four elements, Ge has highest first ionization energy.

20. (b) Correct orders of ionization energy:
$Be > Sr$
$Be^+ > Sr^+$
$Be^+ > Be$

21. (a) Both N and P have stable half-filled p-orbitals in the outermost shell.

22. (a, b, c, d) $|EA_1| = |\Delta_{eg}H_1|$
Second period elements have lower EA_1 than third period elements.

23. (a, d) Noble gases have stable outermost shell e^- configuration hence, $\Delta_{eg}H_1$ of noble gases have large positive values.

24. Due to inert pair effect, the most stable oxidation stable of Tl is +1.

25. Order of ionization energy is:

$Li < Be > B < C < N > O < F < Ne$

26. B, S, P, At, H, Li

27. Cs, Ba, F, Zn, Be, Al, Sr

28. Li and Li^+ ($Li < Li^+$) } Order of ionization energy
Ba and Sr ($Ba < Sr$) }

29. a → r b → s c → p d → t

30. a → q, r b → p, s c → t d → r
e → u f → t

PREVIOUS YEARS' QUESTIONS FOR JEE (MAIN AND ADVANCED)

1. **(a)** Acidic strength of oxides ∝ electronegativity of central atom.

2. **(b)** In isoelectronic species, as atomic number increases radius decreases.

3. **(b)** Down the group ionization potential decreases.

4. **(b)** Alkaline earth metals anion are unstable because they have fully filled outermost subshell.

5. **(a)** Acidic strength of oxides ∝ electronegativity of central atom.

6. **(c)** The lower oxidation states for the group 14 elements are more stable for the heavier members for the group due to inert pair effect.

7. **(b)** Relative positions of these elements in periodic table,

		S	Ar
Ca	Se		
Ba			

The correct order of increasing IE_1:

$Ba < Ca < Se < S < Ar$

8. **(a)** In lanthanoids, as atomic number increases radius decreases.

9. **(b)** In lanthanoids, as atomic number increases ionic radius decreases.

10. **(b)** The variation in properties of elements is related to their atomic numbers.

11. **(b)** It is due to lanthanoid contraction.

12. **(a)** N^{-3}, F^- and Na^+ all have 10 electrons.

13. **(a)** Electronic configuration of Cr is (Ar) $4s^1\ 3d^5$ after removal $1e^-$, next will be removed from half filled d-subshell.

14. **(c)** K^+, Ca^{+2}, Sc^{+3} and Cl^- all have 18 electrons.

15. **(a)** Correct order of radius:

$B^{3+} < Li^+ < F^- < O^{-2}$

16. **(d)** Acidic strength of oxides ∝ electronegativity of central atom.

17. **(a)** $O^-(g) + e^- \rightarrow O^{-2}(g)$. This process is endothermic because anion will tend to resist the addition of another electron.

18. **(a)** Due to very high hydration enthalpy of F^-, F_2 is strongest oxidizing halogen.

19. **(d)** H_3O^+, NH_3 and CH_3^- all have $10e^-$.

20. **(c)** The main cause of lanthanoid contraction is poor shielding by 4f electrons on outer electrons.

21. **(b)** The correct order of first ionization enthalpy:

$B < C < O < N$

22. **(c)** Due to lanthanoid contraction, 4d and 5d-series elements have almost similar radius.

23. **(a)** SnO_2 is an amphoteric oxide.

24. **(d)** The correct order of first ionization enthalpy:

$S < P$

$B < F$

25. **(c)** K^+, Cl^-, Ca^{+2} and Sc^{+3} all have 18 electrons.

26. **(b)** Cause of lanthanoid contraction is the imperfect shielding on outer electrons by 4f electrons from the nuclear charge.

27. **(b)** Order of reactivity in alkali metals:

$Li < Na < K < Rb < Cs$

Order of reactivity in halogens:

$F_2 > Cl_2 > Br_2 > I_2$

28. **(a)** The correct order of ionic radius is:

$Na^+ > Li^+$

$Li^+ > Mg^{+2}$

$Mg^{+2} > Be^{+2}$

29. **(d)** In isoelectronic species, as atomic number increases ionic radius decreases. The correct order of radius is:

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

30. **(d)** The electronic configuration of Gd (atomic number 64) is:

$[Xe]\ 6s^2\ 4f^7\ 5d^1$

31. **(b)** The correct order of negative e- gain enthalpy (electron affinity) is:

$Cl > F > Br > I$

32. **(a)** Basic strength of oxides $\propto \frac{1}{\text{Electronegativity of central atom}}$

33. **(c)** In isoelectronic species, as atomic number increases ionic radius decreases. The order of radius is:

$Ca^{2+} < K^{+} < Cl^{-} < S^{2-}$

34. **(d)** IE of M = IE_1 of M^{+}

C^{+}	N^{+}	O^{+}	F^{+}
$2p^1$	$2p^2$	$2p^3$	$2p^4$

The correct order of second ionization enthalpy is:

$C < N < F < O$

35. **(a)** The correct order of ionization enthalpy is:

$B < C < O < N$

36. **(c)** F-atom has smaller size and incoming e^- feels more repulsion from already present e^- in F-atom hence, electron gain enthalpy with negative sign (electron affinity) of fluorine is less than that of chlorine.

37. **(d)** The relative position of elements in periodic table is:

	O
	S
As	Se

The correct order of atomic radius is:

$O < S < Se < As$

38. **(c)** The relative position of elements in periodic table is:

		Se	Ar
Ca		Se	
Ba			

The correct order of first ionization enthalpy is:

$Ba < Ca < Se < S < Ar$

39. **(b)** $Na\,(g) + 5.1ev \rightarrow Na^{+}\,(g) + e^{-}$

$Na^{+}\,(g) + e^{-} \rightarrow Na + 5.1ev$; $\Delta H_{eg} = -5.1ev$

(e^- gain enthalpy)

40. **(d)** All elements in a group have similar number of valence electrons.

41. **(a)** P^{-3} and S^{-2} are isoelectronic hence, their order of radius is $S^{-2} < P^{-3}$

42. **(c)** N^{-3}, $O^{-2}$and F^{-} are isoelectronic hence, their order of radius is

N^{-3}	>	O^{-2}	>	F^{-}
(1.71 Å)		(1.40 Å)		(1.36Å)

43. **(c)** Order of first ionization energy is:

$Sc > Na > K > Rb$