SAMPLE CONTENT

Challenger

NEET - UG & JEE (Main)
CHEMISTRY Vol - I

As per latest syllabus issued by NMC & NTA

2033 MCQs with Hints

For all Medical and Engineering Entrance Examinations held across India.

Gas laws and Henry's law

Scuba diving is an example of how these laws apply when a scuba diver is exposed to changes in pressure.

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Challenger

NEET (UG) & JEE (Main)

Chemistry Vol. I

Now with more study techniques

Updated as per latest syllabus for:
NEET (UG) 2024 issued by **NMC on 6th October, 2023**
JEE (Main) 2024 issued by **NTA on 1st November, 2023**

Salient Features

- Concise theory for every topic
- Eclectic coverage of MCQs under each sub-topic
- Exhaustive coverage of questions including selective questions from previous NEET (UG) and JEE (Main) examinations updated up to year 2023:
  - **2033** MCQs
  - **81** Numerical Value type (NVT)
  - Solutions to the questions are provided for better understanding
- Inclusion of '**Problems To Ponder**' to engage students in scientific enquiry.
- Multiple Study Techniques to Enhance Understanding and Problem Solving.
- Includes Question Papers and Answer Keys (Solutions through Q.R. code) of:
  - NEET (UG) 2022
  - NEET (UG) 2023
  - JEE (Main) 2022 25th July (Shift - I)
  - JEE (Main) 2023 24th Jan (Shift - II)
- Q.R. codes provide:
  - Video links for boosting conceptual retention
  - Question Paper along with Answers and Solutions of NEET (UG) 2023 (Manipur)

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PREFACE

'Challenger Chemistry Vol - I' is a compact guidebook, extremely handy for preparation of various competitive exams like NEET, JEE (Main). This edition provides an unmatched comprehensive amalgamation of theory with MCQs. The chapters are aligned with the syllabus for NEET (UG) and JEE (MAIN) examinations and runs parallel to NCERT curriculum. The book provides the students with scientifically accurate context, several study techniques and skills required to excel in these examinations.

Each chapter in the book consists of:

- **Concise theory** covering concepts that form a vital part of preparation any competitive examination in the form of pointers, tables, charts and diagrams.
- **Concept Building Problems** section is designed to boost prerequisite understanding of concepts.
- **Practice Problems** section contains questions crafted for thorough revision.
- **Diagram Based Problems** section contains questions that facilitate students' conceptual understanding and enhance their spatial thinking ability.
- **Numerical Value Type** section cater to newly added NVT questions in JEE (Main).
- **Problems to Ponder** section offers MCQs of diverse pattern created to instill the attitude of concentrating on the problems and to understand the application of various concepts in Chemistry.

All the questions included in a chapter have been specially created and compiled to enable students solve complex problems which require strenuous effort with promptness.

All the features of this book pave the path of a student to excel in examination.The features are designed keeping the following elements in mind: Time management, easy memorization or revision and non-conventional yet simple methods for MCQ solving.

To keep students updated, selected questions from examinations of NEET (UG) and JEE (Main) till year 2021 are covered exclusively.

Previous Years' Question Papers:

To keep students updated, Question Papers along with Answers and Solutions (through Q.R. code) of following papers have been provided to offer students glimpse of the complexity of questions asked in entrance examination. These papers of latest competitive examinations have been provided and split unit-wise to let the students know which of the units were more relevant as per latest Question paper.

- NEET (UG) **2022, 2023** and **2023 (Manipur)**
- JEE (Main) **2022** 25th July (Shift - I), **2023** 24th January (Shift - II)

We hope the book benefits the learner as we have envisioned.

A book affects eternity; one can never tell where its influence stops.

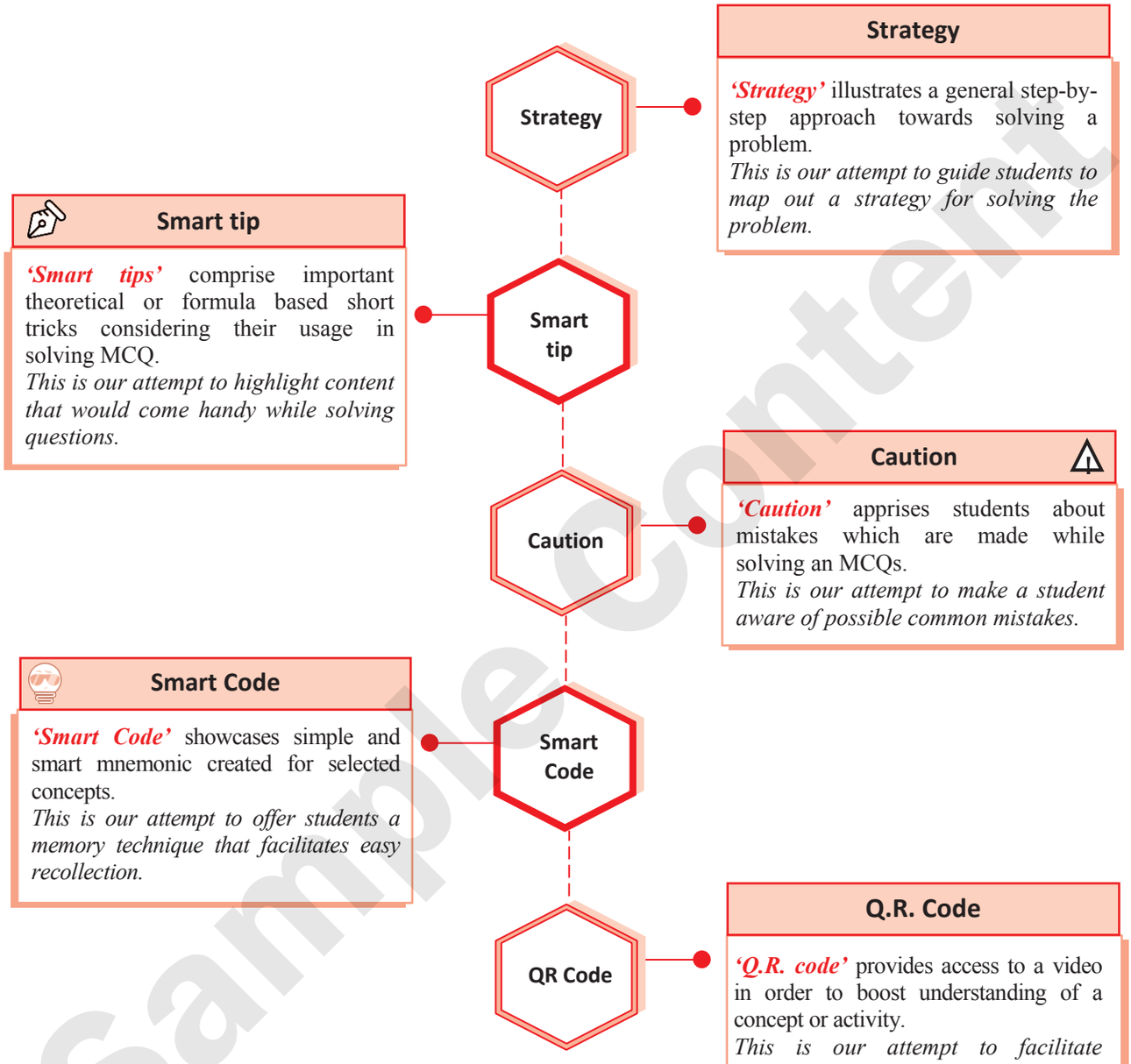
Publisher

Edition: Fourth

The journey to create a complete book is strewn with triumphs, failures and near misses. If you think we've nearly missed something or want to applaud us for our triumphs, we'd love to hear from you.

Please write to us on: mail@targetpublications.org

KEY FEATURES



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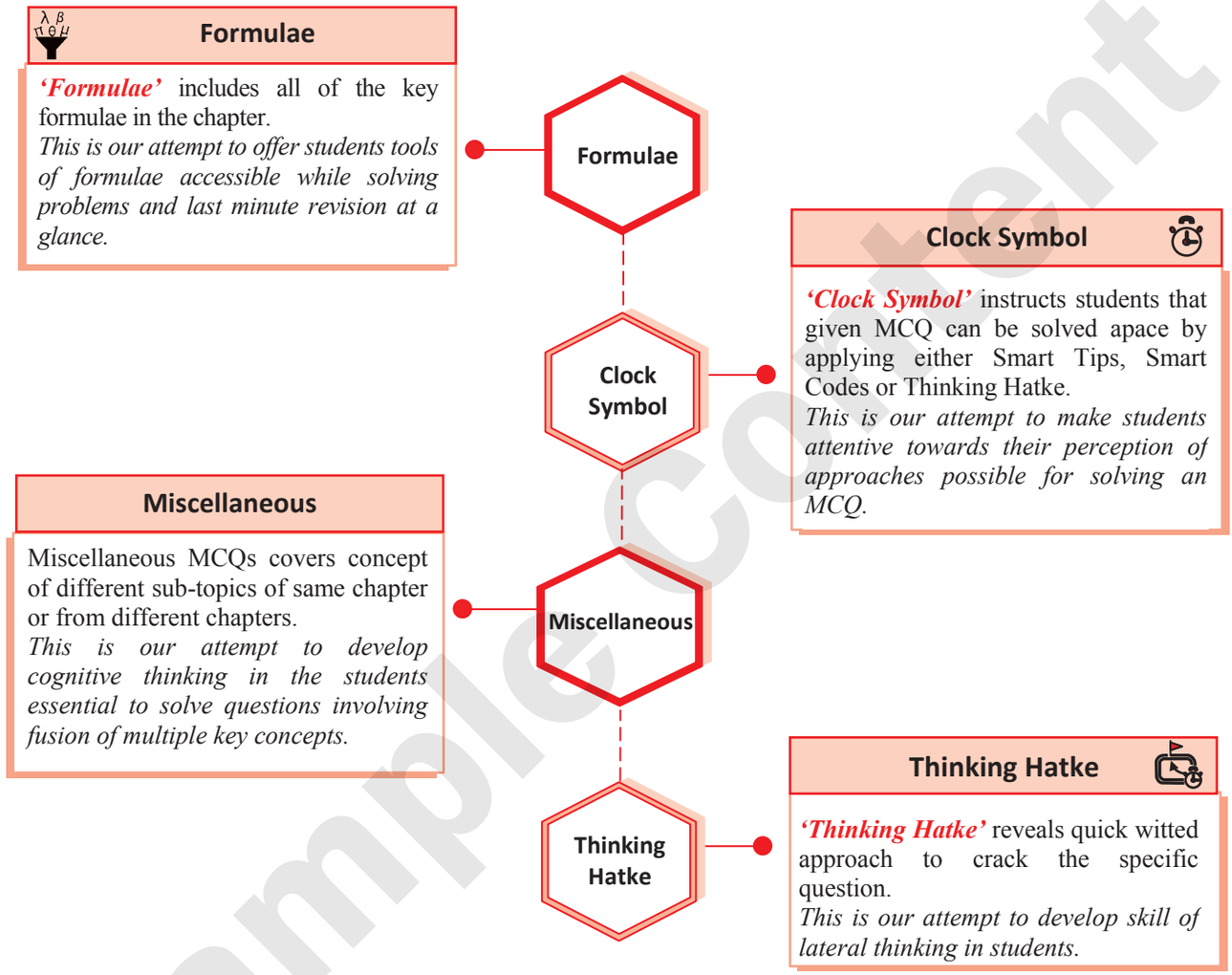

Frequently Asked Questions

➢ **Why Challenger Series?**

Gradually, every year the nature of competitive entrance exams is inching towards conceptual understanding of topics. Moreover, it is time to bid adieu to the stereotypical approach of solving a problem using a single conventional method.

To be able to successfully crack the NEET/JEE (Main) examinations, it is imperative to develop skills such as data interpretation, appropriate time management, knowing various methods to solve a problem, etc. With Challenger Series, we are sure, you'd develop all the aforementioned skills and take a more holistic approach towards problem solving. The way you'd tackle advanced level MCQs with the help of hints, Smart tips, Smart codes and Thinking Hatke would give you the necessary practice that would be a game changer in your preparation for the competitive entrance examinations.

➢ **What is the intention behind the launch of Challenger Series?**

The sole objective behind the introduction of Challenger Series is to severely test the student's preparedness to take competitive entrance examinations. With an eclectic range of critical and advanced level MCQs, we intend to test a student's MCQ solving skills within a stipulated time period.

➢ **What do I gain out of Challenger Series?**

After using Challenger Series, students would be able to:

a. assimilate the given data and apply relevant concepts with utmost ease.
b. tackle MCQs of different pattern such as match the columns, diagram based questions, multiple concepts and assertion-reason efficiently.
c. garner the much needed confidence to appear for competitive exams.
d. easy and time saving methods to tackle tricky questions will help ensure that time consuming questions do not occupy more time than you can allot per question.

➢ **How to derive the best advantage of the book?**

To get the maximum benefit of the book, we recommend :

a. Go through brief theory given at the beginning of a chapter for a quick revision. Commit Smart Tips into memory and pay attention to Caution.
b. Know all the Formulae compiled at the end of theory by heart.
c. Using subtopic wise segregation as a leverage, complete the Concept Building Problems at your own pace. Questions from JEE (Main), NEET (UG) examinations are tagged and placed along the flow of subtopic. Mark these questions specially to gauge the trends of questions in various exams.
d. Be extra receptive to Thinking Hatke, Alternate Method and application of Smart Tips. Assimilate them into your thinking.
e. After mastering stimulating questions, take up Practice Problems as self-assessment and verify answers as well as methods. Check if you could apply smart tips, alternate method, etc., as mentioned in hint. Find out if you have invented ingenious solution mapping to thinking hatke explicated in hints.
f. Watch the linked video for an efficient revision of chapter theory.
g. Ruminate over questions from Problems To Ponder and appreciate aesthetics of the concepts.

➢ ***Can the Questions presented in Problems to Ponder section be a part of the NEET Examination?***

No, the questions would not appear as it is in the NEET Examination. However, there are fair chances that these questions could be covered in parts or with a novel question construction.

Best of luck to all the aspirants!

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Note: ◑ *Part of the chapter excluded from the NEET (UG) and JEE (Main) 2024 syllabus (in index)*

☒ *Complete chapter excluded from the NEET (UG) and JEE (Main) 2024 syllabus (in index)*

Scan the adjacent QR Code in Quill - The Padhai App to view ***Question Paper and Solution of NEET (UG) 2023 (Manipur).***

Questions based on the concepts excluded from NEET (UG) and JEE (Main) 2024 Syllabus

Chapter and Excluded Subtopic		Questions excluded from 2024 Syllabus	Page No.
2. Structure of Atom 2.0 Introduction	Theory	-	32
	Concept Building	-	-
	Practice Problems	All Questions	-
2.1 Fundamental particles	Theory	-	32 and 33
	Concept Building	All Questions	53
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2.2 Atomic number and mass number	Theory	-	33 and 34
	Concept Building	All Questions	53
	Practice Problems	All Questions	58
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Miscellaneous	-	8	62
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6. Thermodynamics 6.11 Third law of thermodynamics	Theory	-	179
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9. Hydrogen *Entire Chapter Deleted*			269 to 298
10. s-Block Elements (Alkali and Alkaline Earth Metals) *Entire Chapter Deleted*			299 to 327
11. Some p-Block Elements 11.5 Preparation, properties and uses of boron	Theory	-	334
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11.7 Preparation, properties and uses of aluminium	Theory	-	338 and 339
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11.8 Important compounds of aluminium: Aluminium chloride and alum	Theory	-	340 and 341
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JEE (Main) 2022 - 25th July (Shift - I) Multiple Choice Questions	-	5, 6, 7, 8	-
Numerical Value Type Questions (NVT)	-	2	-
NEET (UG) 2023 Section A	-	2, 7, 8, 10, 11, 12, 13	
Section B	-	22	-
JEE (Main) 2023 - 24th January (Shift- II) Multiple Choice Questions		3, 4, 5, 7	

Note: i. *The above table contains the list of chapters/subtopics/question numbers that are excluded from the latest syllabus of NEET (UG) and JEE (Main) 2024.*

ii. *These questions are covered to give an idea about the variety and difficulty levels of questions asked in the examination over the years.*

3 Classification of Elements and Periodicity in Properties

* marked section is only for JEE (Main) **marked section is for NEET-UG

3.0 INTRODUCTION

- **Classification of elements:** A systematic study of elements and their compounds is possible only when the elements are arranged in such a way that similar elements are placed together while dissimilar elements are separated from one another.
- **Dobereiner's law of triads:** The middle element of each of the triad had an atomic weight about half way between the atomic weights of other two elements in the triad.

Triad	1			2			3		
Element	Li	Na	K	Ca	Sr	Ba	Cl	Br	I
Atomic weight	7	23	39	40	88	137	35.5	80	127

- **Newland's law of octaves:** On arranging the elements in the increasing order of their atomic weights, every eighth element had properties similar to the first element.
- **Mendeleev's periodic table:** Mendeleev's periodic table is based on Mendeleev's periodic law.

Statement: *The physical and chemical properties of elements are the periodic function of their atomic masses.*

- **Important features of Mendeleev's periodic table:**

i. In the Mendeleev's periodic table, all 63 elements which were discovered till then, were arranged in the increasing order of their atomic masses in such a way that the elements with similar properties occupied the same vertical **column**.
ii. In this periodic table, eight vertical columns were present called as **groups** and designated as I, II, III, IV, V, VI, VII and VIII. VIII group was further divided into **three sub-groups**.
iii. There were six horizontal rows called **periods**.
iv. He left a gap below boron, aluminium and silicon. He called these elements as **Eka-Boron**, **Eka-Aluminium** and **Eka-Silicon**, which were discovered afterwards and named as scandium, gallium and germanium, respectively.

- **Demerits of Mendeleev's periodic table:**

i. Position of hydrogen in the periodic table was not fixed but was anomalous as it resembled both alkali metals and halogens.
ii. There were anomalous pairs of elements like Ar and K, Co and Ni, Te and I. The order of atomic weights was ignored so as to place elements with similar properties together.
iii. Position of Isotopes in the periodic table was not justified.
iv. There was no separate place for lanthanides and actinides.

3.1 MODERN PERIODIC LAW AND LONG FORM OF THE PERIODIC TABLE

- **Modern periodic law:**

Statement: *The physical and chemical properties of the elements are periodic function of their atomic numbers.*

➢ **Modern periodic table (Long form of the periodic table):**

i. The horizontal rows are called periods and the vertical columns are called groups.
ii. The periods are numbered from 1 to 7 and the groups are numbered from 1 to 18.
iii. Elements having similar outer electronic configurations in their atoms are arranged in groups.
iv. The period number corresponds to the highest principal quantum number (n) of the elements in the period.

Period	Principal energy level (n)	Orbitals being filled	Number of elements present	Nature
1st Period	1	1s	2 elements ($_1$H and $_2$He)	Shortest Period
2nd Period	2	2s, 2p	8 elements ($_3$Li – $_{10}$Ne)	Short Period
3rd Period	3	3s, 3p	8 elements ($_{11}$Na – $_{18}$Ar)	Short Period
4th Period	4	4s, 3d, 4p	18 elements ($_{19}$K – $_{36}$Kr)	Long Period
5th Period	5	5s, 4d, 5p	18 elements ($_{37}$Rb – $_{54}$Xe)	Long Period
6th Period	6	6s, 4f, 5d, 6p	32 elements ($_{55}$Cs – $_{86}$Rn)	Longest Period
7th Period	7	7s, 5f, 6d, 7p	32 elements ($_{87}$Fr – $_{118}$Og)	Longest Period

v. Fourteen elements of both sixth period (lanthanides) and seventh period (actinides) are placed separately at the bottom of the periodic table.

➢ **Nomenclature of elements with atomic number greater than 100:** A systematic nomenclature is used for naming elements with atomic number greater than 100. Numerical roots for numbers 0-9 are put together in order of the digits which make up the atomic number of the element and "ium" is added at the end.

- Notation for IUPAC nomenclature of elements:

Digit	Name	Abbreviation
0	nil	n
1	un	u
2	bi	b
3	tri	t
4	quad	q
5	pent	p
6	hex	h
7	sept	s
8	oct	o
9	enn	e

E.g.
IUPAC name for element with atomic number 115:
115 = un, un, pent are the roots for 1, 1 and 5 respectively. Hence, the IUPAC name for the element with atomic number 115 will be Ununpentium (Uup).

3.2 s, p, d AND f-BLOCK ELEMENTS

➢ **Classification of elements:** The distribution of electrons into orbitals of an atom is called as electronic configuration. Depending on the type of atomic orbitals that gets filled by the electrons, elements can be classified into four blocks, viz.

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

➢ **Division of elements in s, p, d and f-block:**

Block	Last electron enters	General electronic configuration	Elements present	Types of element present
's'	s-orbital (max. $e^- = 2$)	ns^1 and ns^2 (n = 1 to 7)	Group 1 (alkali metals) Group 2 (alkaline earth metals)	Metals
'p'	p-orbital (max. $e^- = 6$)	$ns^2\ np^{1-6}$ (n = 2 to 6)	Group 13 Group 14 Group 15 Group 16 (Chalcogens) Group 17 (Halogens) Group 18 (Noble gases)	Metals, nonmetals and metalloids
'd'	d-orbital (max. $e^- = 10$)	$(n-1)d^{1-10}\ ns^{0-2}$ (n = 4 to 7)	Group 3 to Group 12 elements (Transition elements)	Metals
'f'	f-orbital (max. $e^- = 14$)	$(n-2)f^{1-14}\ (n-1)d^{0\text{ or }1}\ ns^2$ (n = 6 and 7)	Lanthanide and actinide series (Inner transition elements)	Metals

Note: i. Period number = Highest principal quantum number (n)
ii. Group number of s-block elements = Number of valence electrons
iii. Group number of p-block elements = 18 – number of electrons required to attain complete octet

3.3 PERIODIC TRENDS IN PROPERTIES OF ELEMENTS

➢ **Periodicity:**

*The periodic recurrence of elements having similar properties after regular intervals is called **periodicity**.*

Periodicity (periodic trends) is observed in a number of physical and chemical properties. These properties are directly or indirectly linked with electronic configuration.

➢ **The periodic trends in the following properties are discussed below:**

i. Atomic radius
ii. Ionic radius
iii. Ionization enthalpy
iv. Electron gain enthalpy
v. Electronegativity
vi. Valence
vii. Oxidation states
viii. Chemical reactivity

➢ **Atomic radius:**

***Atomic radius** (atomic size) of an atom may be regarded as the distance from the centre of the nucleus of an atom to the outermost shell (valence shell) of electrons.*

- **Atomic radius is of three types:**

i. **Covalent radius:** It is half the distance between the radii of two similar atoms covalently bonded to each other by a single bond.
E.g. In Cl_2 molecule, Cl – Cl bond distance = 198 pm
Covalent radius of Cl = Half of the bond distance = 99 pm

ii. **Metallic radius:** It is half the distance between the centres of nucleus of two adjacent atoms of a metallic crystal.
E.g. In solid copper, the distance between two adjacent atoms = 256 pm
Metallic radius of Cu = Half of this distance = 128 pm

iii. **van der Waals radius:** It is half the internuclear distance between two identical non-bonded isolated atoms or two adjacent identical atoms belonging to two neighbouring molecules of the same substance in the solid state.
E.g. Internuclear distance between two adjacent H-atoms of two neighbouring H_2 molecules in solid state = 240 pm
van der Waals radius of H-atom = Half of this distance = 120 pm

Note: van der Waals radius > Metallic radius > Covalent radius

- **Periodic trend:**

Variation along a period	Atomic radius decreases on moving from left to right across a period.
Variation in a group	Atomic radius increases on moving from top to bottom in a group.

- **Factors affecting atomic radius:**

Factors affecting atomic radius

Number of orbits or shells	Nuclear charge	Shielding effect or Screening effect
Atomic size (atomic radius) increases with increase in number of shells. **Atomic radius ∝ No. of shells**	With increase in nuclear charge, nucleus attracts electrons strongly and thus, atomic radius decreases. **Atomic radius** $\propto \left(\frac{1}{\text{nuclear charge}}\right)$	The inner shell electrons prevent (shield) the outermost electrons from the attractive influence of nucleus. This is called shielding effect. Atomic radius increases due to shielding effect. **Atomic radius ∝ Shielding effect**

- **Shielding effect:** In a multielectron atom, the electrons present in the inner shells shield or prevent the electrons in the valence shell from being pulled or getting attracted towards nucleus. This is known as shielding effect or screening effect.
  The shielding/screening effect decreases in the order: s > p > d > f

➢ **Ionic radius:**

- **Periodic trend:**

Variation along a period	Ionic radius decreases on moving from left to right across a period.
Variation in a group	Ionic radius increases on moving from top to bottom in a group.

i. Size of cation < Size of its parent atom ii. Size of anion > Size of its parent atom

- **Isoelectronic species:**

Isoelectronic species *are atoms or ions having same number of electrons but differ in magnitude of nuclear charge or ionic radii.*

For isoelectronic species, radius is inversely proportional to atomic number (Z).
E.g. Decreasing order of radius:

$$\underset{(Z=8)}{O^{2-}} > \underset{(Z=9)}{F^{-}} > \underset{(Z=11)}{Na^{+}}$$

Note: Among isoelectronic species: Radius of cation (greater positive charge) < Radius of cation (smaller positive charge) < Radius of neutral atom < Radius of anion (smaller negative charge) < Radius of anion (greater negative charge)

➢ **Ionization Enthalpy or Ionization Energy (IE) or Ionization Potential (IP):**

Ionization enthalpy is defined as the minimum amount of energy required to remove electron from an isolated gaseous atom of an element in its ground state.

Reaction for 1st ionization enthalpy (IE_1)	$X_{(g)} \rightarrow X^{+}_{(g)} + e^{-}$
Reaction for 2nd ionization enthalpy (IE_2)	$X^{+}_{(g)} \rightarrow X^{2+}_{(g)} + e^{-}$
Reaction for 3rd ionization enthalpy (IE_3)	$X^{2+}_{(g)} \rightarrow X^{3+}_{(g)} + e^{-}$

$IE_1 < IE_2 < IE_3$ and so on.

- **Periodic trend:**

Variation along a period	1st IE increases on moving from left to right across a period.
Variation in a group	1st IE decreases on moving from top to bottom in a group.

- **Factors affecting ionization enthalpy:**

Factors affecting Ionization Enthalpy (IE)

Size (radius) of atom	Nuclear charge	Shielding effect or Screening effect
IE increases with decrease in size of atom. $\mathbf{IE \propto \left(\frac{1}{Size\ of\ atom}\right)}$	IE increases with increase in nuclear charge. $\mathbf{IE \propto Nuclear\ charge}$	IE decreases with increase in shielding effect or screening effect. $\mathbf{IE \propto \left(\frac{1}{Shielding\ effect}\right)}$

➢ **Electron gain enthalpy ($\Delta_{eg}H$):**

When an electron is added to a neutral gaseous atom (X) to convert it into negative ion, the enthalpy change accompanying the process is defined as the ***electron gain enthalpy****.*

$$X_{(g)} + e^{-} \longrightarrow X^{-}_{(g)}$$

- **Periodic trend:**

Variation along a period	Electron gain enthalpy becomes more negative on moving from left to right in a period.
Variation in a group	Electron gain enthalpy becomes less negative on moving from top to bottom in a group.

Note:

i. Group 17 elements have very high negative electron gain enthalpies while group 18 elements have large positive electron gain enthalpies.
ii. The negative of the electron gain enthalpy is defined as the electron affinity (EA).
iii. If energy is released when an electron is added to an atom, then EA is positive.
If energy needs to be supplied to add an electron to an atom, then EA is negative.

➢ **Electronegativity:**

The qualitative measure of the ability of an atom in a chemical compound to attract shared pair of electrons towards itself is called ***electronegativity***.

Note: Pauling scale of electronegativity is a widely used scale for measuring electronegativity

$x_A - x_B = 0.208\ \sqrt{\Delta}$ and $\Delta = E_{A-B} - \sqrt{E_{A-A} \times E_{B-B}}$

Where, x_A and x_B are electronegativities of atoms A and B.
E_{A-B}, E_{A-A} and E_{B-B} represent bond dissociation enthalpies in kcal mol^{-1} of the bonds A – B, A – A and B – B, respectively.

- **Periodic trend:**

Variation along a period	Electronegativity increases on moving from left to right across a period (ending at group 17).
Variation in a group	Electronegativity decreases on moving from top to bottom in a group.

- **Factors affecting electronegativity:**

Factors affecting electronegativity

Atomic size (radius)	Nuclear charge	Shielding effect or screening effect
Electronegativity decreases with increase in atomic radius. $\textbf{Electronegativity} \propto \left(\frac{1}{\textbf{Atomic radius}}\right)$	Electronegativity increases with increase in nuclear charge. $\textbf{Electronegativity} \propto \textbf{Nuclear charge}$	Electronegativity decreases with increase in shielding or screening effect. $\textbf{Electronegativity} \propto \left(\frac{1}{\textbf{Shielding effect}}\right)$

➢ **Valence or valency:**

Valency *is defined as the number of hydrogen atoms or number of any other univalent atoms which can combine with an atom of the given element.*

➢ **Oxidation states:**

Oxidation state *of an element in a particular compound can be defined as the charge acquired by its atoms on the basis of electronegative consideration from other atoms in the molecule.*

➢ **Inert pair effect:** The tendency of the ns^2 electrons to remain unionized or unshared in certain compounds is known as inert pair effect. This effect is observed in heavier elements of groups 13, 14, 15 and 16 due to which the stability of lower oxidation state increases down the group.

➢ **Diagonal relationship:**

i. A diagonal relationship is said to exist between certain pairs of diagonally adjacent elements in the second and third period of the periodic table.
ii. These pairs such as Lithium (Li) and Magnesium (Mg), Beryllium (Be) and Aluminium (Al), Boron (B) and Silicon (Si), etc. exhibit similar properties.
iii. Such relationship occurs because moving across the period and down the group has opposite effects.

➢ **Chemical reactivity:**

i. The chemical reactivity is highest at the two extremes of a period and is lowest in the centre.
ii. This can be related to the metallic and nonmetallic character of elements.
iii. Metallic character decreases from left to right across the period, while it increases down the group.
iv. Nonmetallic character increases from left to right across the period while it decreases down the group.
v. Nature of oxides:

Elements on the left side of periodic table ⇒ Basic oxides
Elements on the right side of periodic table ⇒ Acidic oxides
Elements in the centre of the periodic table ⇒ Amphoteric or neutral oxides

vi. Reducing property of the elements decreases while oxidizing property increases across the period from left to right. The reducing property increases while the oxidizing property decreases down the group.

➢ **General trends of different properties in periods and groups:**

Periodic property	Left to right across a period	Top to bottom in a group
Atomic radius	Decreases	Increases
Ionic radius	Decreases	Increases
Ionization enthalpy	Increases	Decreases
Electron gain enthalpy	Increases	Decreases
Electronegativity	Increases	Decreases
Valence	First increases from 1 to 4 and then decreases from 4 to 0	Remains constant
Metallic character	Decreases	Increases
Nonmetallic character	Increases	Decreases
Oxidizing property	Increases	Decreases
Reducing property	Decreases	Increases

Concept Building Problems

3.0 Introduction

1. The atomic masses of Ca and Ba are 40 and 137, respectively. According to Dobereiner's law of triads, the atomic mass of strontium will be _____.
(A) 23 (B) 32
(C) 46 (D) 88

2. Which of the following set of elements exhibit the Law of Triads?
(A) Li (7), Na (23), K (39)
(B) Ca (40), Sr (88), Ba (137)
(C) Cl (35.5), Br (80), I (127)
(D) All of the above

3. According to Mendeleev's periodic law, the physical and chemical properties of elements are a periodic function of their _____.
(A) atomic masses
(B) atomic numbers
(C) empirical formulae
(D) atomic radii

4. Eka-aluminium is known as _____.
(A) Gallium
(B) Aluminium
(C) Iron
(D) Germanium

3.1 Modern Periodic Law and Long Form of the Periodic Table

1. As per the modern periodic law, the physical and chemical properties of elements are periodic functions of their _____.
(A) densities (B) atomic numbers
(C) atomic masses (D) atomic radii

2. The maximum number of elements in 4^{th} period is _____.
(A) 8 (B) 18 (C) 32 (D) 36

3. The twenty eighth element in the periodic table belongs to _____.
(A) period 5 (B) period 3
(C) group 9 (D) group 10

4. Group 18 elements are also called as _____.
(A) Transition elements
(B) Inner-transition elements
(C) Normal elements
(D) Noble elements

5. The elements with atomic numbers 19, 37, 55 and 87 belongs to _____.
(A) group 1 (B) group 2
(C) group 13 (D) group 17

6. Identify the sixth noble gas.
(A) He (B) Xe
(C) Rn (D) Kr

7. Identify the INCORRECT match.

Name		IUPAC Official Name	
(i)	Unnilunium	(a)	Mendelevium
(ii)	Unniltrium	(b)	Lawrencium
(iii)	Unnilhexium	(c)	Seaborgium
(iv)	Ununium	(d)	Darmstadtium

[NEET (UG) P-I 2020]

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

3.2 s, p, d AND f-BLOCK ELEMENTS

1. Match the following:

	Element		Group		Block
i.	Pd	a.	2	1.	s
ii.	In	b.	10	2.	p
iii.	Ba	c.	13	3.	d

(A) i – a – 1, ii – c – 3, iii – b – 2
(B) i – b – 3, ii – c – 2, iii – a – 1
(C) i – b – 3, ii – a – 2, iii – c – 1
(D) i – c – 3, ii – b – 2, iii – a – 1

2. The electronic configuration of an element is $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$. What is the atomic number of the element which is just below the given element in the periodic table?
(A) 33 (B) 35 (C) 37 (D) 53

3. In the modern periodic table, the place of the element with atomic number 33 is in _____.
(A) s-block (B) d-block
(C) p-block (D) f-block

4. Which pair of atomic numbers represents p-block elements?
(A) 11, 15 (B) 4, 12
(C) 9, 17 (D) 3, 39

5. Which of the following d-block element has the highest atomic number?
(A) Ti (B) Zr (C) Hf (D) Rf

6. The elements in which electrons are progressively filled in 5f-orbital are called _____.
(A) actinides
(B) transition elements
(C) lanthanides
(D) halogens

7. An element having electronic configuration $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^1$ belongs to which period in the periodic table?
(A) period 1 (B) period 2
(C) period 3 (D) period 4

8. The element with the electronic configuration, $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6\ 4d^{10}\ 5s^1$ is _____.
(A) a rare gas (B) a s-block element
(C) a d-block element (D) a f-block element

9. Which of the following group of elements are also called as chalcogens?
(A) Al, Sr, Ti (B) Se, Te, Po
(C) Rb, Cs, Fr (D) Mg, Ba, Ca

10. Magnesium reacts with an element (X) to form an ionic compound. If the ground state electronic configuration of (X) is $1s^2 2s^2 2p^3$, the simplest formula for this compound is _____.
[NEET (UG) 2018]
(A) Mg_2X_3 (B) MgX_2
(C) Mg_2X (D) Mg_3X_2

11. Which of the following is the atomic number of a metalloid?
(A) 32 (B) 34 (C) 36 (D) 38

12. Which of the following is a transuranic element?
(A) Am (B) Th (C) Pa (D) Ac

3.3 PERIODIC TRENDS IN PROPERTIES OF ELEMENTS

1. The CORRECT order of increasing radii of the elements Mg, Si, Al and P is _____.
(A) Si, Al, P, Mg (B) Al, Si, P, Mg
(C) P, Si, Al, Mg (D) Al, P, Si, Mg

2. With reference to the periodic table, choose the bigger atom from each of the following pairs.
i. Si and Pb ii. Se and Cl
iii. O and P
(A) (i) Pb (ii) Se and (iii) P
(B) (i) Si (ii) Se and (iii) O
(C) (i) Si (ii) Cl and (iii) P
(D) (i) Pb (ii) Cl and (iii) O

3. Which of the following statement is CORRECT regarding ionic radii?
(A) It is inversely proportional to the number of shells.
(B) It is directly proportional to effective nuclear charge.
(C) It is inversely proportional to the shielding effect.
(D) It is inversely proportional to effective nuclear charge.

4. Which of the following species will have the largest size?
(A) Mg^{2+} (B) Mg
(C) Al (D) Al^{3+}

5. The group having isoelectronic species is _____.
[JEE (Main) 2017]
(A) O^{2-}, F^-, Na^+, Mg^{2+} (B) O^-, F^-, Na, Mg^+
(C) O^{2-}, F^-, Na, Mg^{2+} (D) O^-, F^-, Na^+, Mg^{2+}

6. From the following pairs of ions which one is NOT an isoelectronic pair?
[NEET (UG) 2021]
(A) Na^+, Mg^{2+} (B) Mn^{2+}, Fe^{3+}
(C) Fe^{2+}, Mn^{2+} (D) O^{2-}, F^-

7. The ionic radii (in Å) of N^{3-}, O^{2-} and F^- are respectively _____. **[JEE (Main) 2015]**
(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

8. First ionization potential is lowest for _____ elements in a period.
(A) Group 8 (B) Group 18
(C) Group 2 (D) Group 1

9. Which of the following atoms has the highest first ionization energy? **[JEE (Main) 2016]**
(A) Rb (B) Na (C) K (D) Sc

10. For the second period elements the CORRECT increasing order of first ionization enthalpy is _____. **[NEET (UG) 2019]**
(A) Li < B < Be < C < O < N < F < Ne
(B) Li < B < Be < C < N < O < F < Ne
(C) Li < Be < B < C < O < N < F < Ne
(D) Li < Be < B < C < N < O < F < Ne

11. Consider the elements Mg, Al, S, P and Si. The CORRECT increasing order of their first ionization enthalpies is _____. **[JEE (Main) 24th Feb Shift 1 2021]**
(A) Al < Mg < Si < S < P
(B) Mg < Al < Si < P < S
(C) Mg < Al < Si < S < P
(D) Al < Mg < S < Si < P

12. Which of the following arrangement represents the CORRECT order of most negative to least negative electron gain enthalpy?
(A) Si > C > Al > F (B) Al > Si > C > F
(C) F > C > Si > Al (D) F > Si > C > Al

13. Choose the element with higher electron affinity from each of the following pairs.
i. K and Ca ii. Si and P
iii. Se and Br iv. Be and B
(A) (i) Ca (ii) P (iii) Se and (iv) Be
(B) (i) Ca (ii) Si (iii) Se and (iv) B
(C) (i) K (ii) Si (iii) Br and (iv) B
(D) (i) K (ii) P (iii) Br and (iv) Be

14. **Assertion:** Aluminium has less metallic character than sodium.
Reason: Metallic character increases as we move from top to bottom in group.
(A) Assertion and Reason are true. Reason is correct explanation of Assertion.
(B) Assertion and Reason are true. Reason is not the correct explanation of Assertion.
(C) Assertion is true. Reason is false.
(D) Assertion is false. Reason is true.

15. The tendency of an atom to attract the shared pair of electrons to itself in a bond is called as _____.
(A) Electronegativity
(B) Electropositivity
(C) Electron gain enthalpy
(D) Ionization enthalpy

16. **Assertion:** The electron gain enthalpy of F is less negative (–328 kJ mol^{-1}) than that of Cl (–349 kJ mol^{-1}).
Reason: Adding an electron to the 2p-orbital leads to greater electron-electron repulsion than adding an electron to the larger 3p-orbital.
(A) Assertion and Reason are true. Reason is correct explanation of Assertion.
(B) Assertion and Reason are true. Reason is not the correct explanation of Assertion.
(C) Assertion is true. Reason is false.
(D) Assertion is false. Reason is true.

17. The electron gain enthalpy (in kJ/mol) of fluorine, chlorine, bromine and iodine, respectively, are _____. **[JEE (Main) Jan 2020]**
(A) –333, –349, –325 and –296
(B) –349, –333, –325 and –296
(C) –296, –325, –333 and –349
(D) –333, –325, –349 and –296

18. Match the following:

	Column I		Column II
i.	CaO	a.	Acidic
ii	CO_2	b.	Basic
iii	NO	c.	Amphoteric
iv.	Al_2O_3	d.	Neutral

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

MISCELLANEOUS

1. Which of the following properties generally decreases down the group?
(A) Atomic size
(B) Ionic radius
(C) Ionization enthalpy
(D) Valency

2. Determine the oxidation state of Al in $[AlCl(H_2O)_5]^{2+}$.
(A) +2 (B) +3 (C) +4 (D) +5

3. Match the following:

	Column I		Column II
i.	$Al^{3+} < Mg^{2+} < Na^+ < F^-$	a.	Increasing metallic radius
ii.	B < C < O < N	b.	Increasing ionic size
iii.	I < Br < F < Cl	c.	Increasing first ionization enthalpy.
iv.	Li < Na < K < Rb	d.	Increasing negative electron gain enthalpy

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

4. An element has [Ar] configuration in its +5 oxidation state. Its position in the periodic table is _____.
(A) period 3, group 3 (B) period 3, group 7
(C) period 4, group 3 (D) period 4, group 5

5. The formation of the oxide ion, $O^{2-}_{(g)}$, from oxygen atom requires first an exothermic and then an endothermic step as shown below:
$O_{(g)} + e^- \longrightarrow O^-_{(g)}$; $\Delta H° = -141$ kJ mol^{-1}
$O^-_{(g)} + e^- \longrightarrow O^{2-}_{(g)}$; $\Delta H° = +780$ kJ mol^{-1}
Thus, process of formation of O^{2-} in gas phase is unfavourable even though O^{2-} is isoelectronic with neon. It is due to the fact that_____.
[AIPMT RE-TEST 2015]
(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

Practice Problems

3.0 INTRODUCTION

1. Which of the following is NOT a Dobereiner's triad?
(A) P, As, Sb (B) Ca, Sr, Ba
(C) Cl, Br, I (D) Li, Na, K

2. The law of octaves is applicable to which of the following set of elements?
(A) B, N, C (B) Be, Mg, Ca
(C) Cl, Br, As (D) Se, Te, As

3. Which of the following statements is INCORRECT regarding Mendeleev's periodic table?
(A) The elements having similar properties occupied the same group.
(B) Group VIII is subdivided into three sub-groups.
(C) All the isotopes of an element could be placed in the same position as that of the element.
(D) The element Ar is placed before the element K.

3.1 MODERN PERIODIC LAW AND LONG FORM OF THE PERIODIC TABLE

1. The plot of square root of frequency of X-rays emitted by elements against their atomic number led to suggestion of which law/rule?
(A) Periodic law
(B) Modern periodic law
(C) Mendeleev's periodic law
(D) Newland's law

2. Which one of the following elements belongs to the group that includes the element Iodine?
(A) Astatine (B) Rubidium
(C) Tungsten (D) Cerium

3. From the list given below, the elements which does NOT belong to the same group or sub-group are _____.
(A) Atomic number = 12, 20, 39, 57
(B) Atomic number = 8, 16, 34, 84.
(C) Atomic number = 11, 19, 37, 55
(D) Atomic number = 24, 42, 74, 106

4. A student sorts 16 different elements into 4 sets. In each set, he decides to arrange four elements with increasing order of their atomic number. Identify the set in which he has INCORRECTLY arranged the elements.
(A) Cr, Mn, Ni, Zn (B) C, Si, Ge, Sn
(C) B, Al, Sb, Ga (D) Na, P, Ca, Cu

3.2 s, p, d AND f-BLOCK ELEMENTS

1. In the general electronic configuration of an element $(n-2)f^{1-14}\ (n-1)d^{0-1}\ ns^2$, if the value of n = 6, the element will belong to _____.
(A) lanthanides
(B) actinides
(C) transition elements
(D) alkaline earth metals

2. An element has electronic configuration $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6\ 5s^2$. Predict its period, group and block.
(A) Period = 3, group = 16, block = p
(B) Period = 5, group = 2, block = s
(C) Period = 4, group = 10, block = p
(D) Period = 5, group = 12, block = s

3. The electronic configuration of the element which is just above the element with atomic number 42 in the same group is _____.
(A) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5\ 4s^1$
(B) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^4\ 4s^2$
(C) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6$
(D) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2$

4. Which of the following ground state electronic configuration of an atom requires the lowest energy to remove an electron from its isolated gaseous atom?
(A) $1s^2\ 2s^2\ 2p^3$ (B) $1s^2\ 2s^2\ 2p^6\ 3s^1$
(C) $1s^2\ 2s^2\ 2p^6$ (D) $1s^2\ 2s^2\ 2p^5$

5. Which of the following atoms does NOT have valence electrons in 4d-subshell?
(A) Mo (B) Tc (C) Ru (D) As

6. There are 14 neutrons in the nucleus of the element $^{27}_{Z}M$. It belongs to _____.
(A) f-block (B) s-block
(C) d-block (D) p-block

7. In the fourth row of elements, which one is a metalloid?
(A) Fe (B) S
(C) Ge (D) Ca

3.3 PERIODIC TRENDS IN PROPERTIES OF ELEMENTS

1. In P^{3-}, S^{2-} and Cl^- ions, the decreasing order of size is _____.
(A) $Cl^- < S^{2-} < P^{3-}$ (B) $P^{3-} < S^{2-} < Cl^-$
(C) $S^{2-} < Cl^- < P^{3-}$ (D) $S^{2-} < P^{3-} < Cl^-$

2. Arrange the following ions in the increasing order of their ionic radii.
Nitride ion, Oxide ion, Sodium ion, Aluminium ion.
(A) Nitride ion < Oxide ion < Sodium ion < Aluminium ion
(B) Sodium ion < Aluminium ion < Nitride ion < Oxide ion
(C) Aluminium ion < Sodium ion < Oxide ion < Nitride ion
(D) Oxide ion < Nitride ion < Sodium ion < Aluminium ion

3. Find the INCORRECT arrangement with respect to the increasing order of atomic/ionic radii.
(A) $I^+ < I < I^-$
(B) $N < C < P$
(C) $F^- < O^{2-} < N^{3-}$
(D) $Cl < Si < P$

4. **Assertion:** First ionization enthalpy of chlorine is lower than fluorine.
Reason: For same principal quantum level, an s-electron is attracted to the nucleus more than a p-electron.
(A) Assertion and Reason are true. Reason is correct explanation of Assertion.
(B) Assertion and Reason are true. Reason is not the correct explanation of Assertion.
(C) Assertion is true. Reason is false.
(D) Assertion is false. Reason is true.

5. A sudden large jump between the values of second and third ionization energies can be associated with which of the following species?
(A) Na (B) Al
(C) S (D) Mg

6. Find the most and least electronegative elements respectively amongst the given set of elements.
(A) F and Cs (B) F and I
(C) Li and At (D) Ne and Cs

7. Which of the following elements shows variable valency?
(A) Li (B) Si
(C) Cu (D) As

MISCELLANEOUS

1. Find INCORRECT electronic configuration.
[Given: Rn (Z = 86)]

	Elements		Actual electronic configuration
(A)	$_{106}Sg$	→	[Rn] $5f^{14}\ 6d^5\ 7s^1$
(B)	$_{107}Bh$	→	[Rn] $5f^{14}\ 6d^5\ 7s^2$
(C)	$_{108}Hs$	→	[Rn] $5f^{14}\ 6d^6\ 7s^2$
(D)	$_{109}Mt$	→	[Rn] $5f^{14}\ 6d^7\ 7s^2$

2. Find the INCORRECT formulae of stable binary compounds.
(A) SiO_2 (B) $AlBr_3$
(C) CaI_2 (D) Al_2C_3

3. Indicate the CORRECT decreasing order of 2nd ionization energies for Si, P, S and Cl from the options below.
(A) Si > P > S > Cl (B) Si > Cl > S > P
(C) Cl > S > P > Si (D) Cl > P > S > Si

4. Which of the following elements have same value of principal quantum number (n) for their valence shell?
i. The first element of group 16.
ii. The element having atomic number 16.
iii. The most electronegative element in the periodic table.
iv. The third element of group 2.
(A) (i) and (ii) (B) (i) and (iii)
(C) (ii) and (iv) (D) (iii) and (iv)

5. Find the INCORRECT match.
(A) Solid with highest density – Os
(B) Liquid with highest density – Hg
(C) Non-metal with highest melting point – S
(D) Metal with highest melting point – W

6. A compound 'X' is formed by elements Na and S. Using the position of this elements in the periodic table, predict the expected formula of the compound formed and calculate the mass of 1 mol of the compound X.
(A) NaS, 55g (B) NaS_2, 87 g
(C) Na_2S, 78 g (D) Na_3S, 101 g

7. For an element $_{120}X$, predict its position in the periodic table and its first stable oxide respectively.
(A) Halogen family, X_2O
(B) Group of alkali metals, X_2O
(C) Group of alkaline earth metals, XO
(D) Carbon family, XO_2

8. Calculate the electron affinity of iodine in eV per atom. Given: Electron gain enthalpy of iodine = -4.9×10^{-19} J/atom
(A) 3.06 (B) 4.81
(C) 4.96 (D) 5.20

9. Find the CORRECT match.

	Column I		Column II
i.	Eka-mercury	a.	Pm
ii.	Smallest atomic volume	b.	Tc
iii.	First synthetic element	c.	B
		d.	Cn

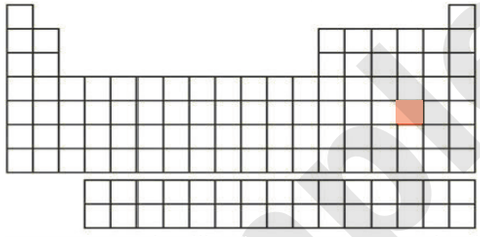
(A) i – b, ii – c, iii – d
(B) i – c, ii – b, iii – d
(C) i – d, ii – c, iii – b
(D) i – a, ii – c, iii – b

10. Ionization energy values of a certain element 'X' is given below. Identify the element.
IE_1 = 800 kJ/mol IE_2 = 2427 kJ/mol
IE_3 = 3660 kJ/mol IE_4 = 25,026 kJ/mol
(A) Be (B) C
(C) B (D) Na

11. A certain element 'X' has 32 electrons. Choose the CORRECT option that applies to 'X'.
(A) 'X' belongs to group 3.
(B) 'X' has five valence electrons.
(C) Highest principal quantum number in 'X' is 4.
(D) 'X' has zero unpaired electrons.

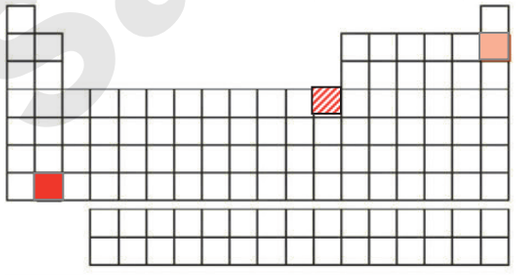
Diagram Based Problems

1. For the highlighted element in its X^{2-} form, identify the CORRECT electronic configuration.



(A) [Kr] $5s^2\ 4d^{10}\ 5p^4$ (B) [Kr] $5s^2\ 5p^4$
(C) [Kr] $5s^2\ 4d^{10}\ 5p^6$ (D) [Kr] $5s^2\ 5p^6$

2. The positions of three elements are highlighted in the below given periodic table. Identify these elements and the number of electrons in an atom of these elements.



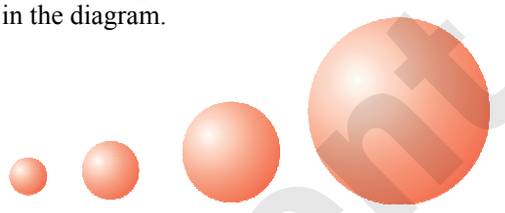
(A) = Helium, 2 = Zinc, 30
= Radon, 86

(B) = Neon, 10 = Copper, 29
= Radon, 89

(C) = Helium, 2 = Zinc, 30
= Radon, 88

(D) = Neon, 10 = Zinc, 30
= Radon, 88

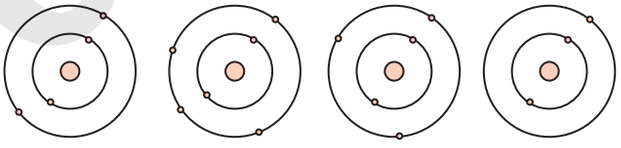
3. In the following diagram, each sphere represents an ion. Based on the size, determine which of the following has the ions in the same order as in the diagram.



(i) (ii) (iii) (iv)

(A) (i) K^+ (ii) P^{3-} (iii) Ca^{2+} (iv) S^{2-}
(B) (i) Ca^{2+} (ii) K^+ (iii) S^{2-} (iv) P^{3-}
(C) (i) S^{2-} (ii) P^{3-} (iii) K^+ (iv) Ca^{2+}
(D) (i) P^{3-} (ii) S^{2-} (iii) K^+ (iv) Ca^{2+}

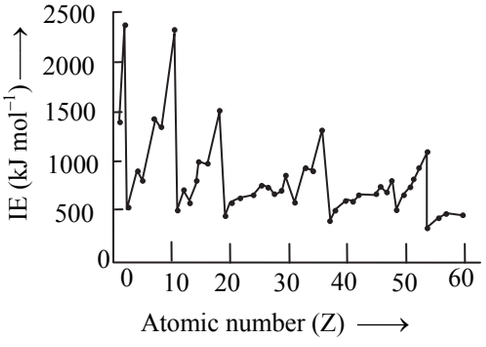
4. Following diagrams represent electron distribution of different elements in their ground state. Arrange the following in the order of decreasing effective nuclear charge experienced by the outermost electrons.



(i) (ii) (iii) (iv)

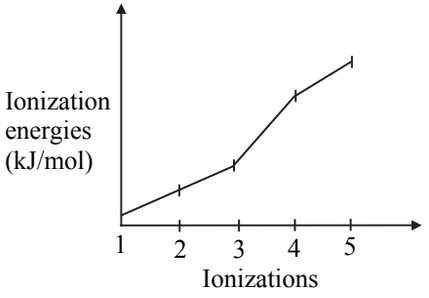
(A) iii > iv > ii > i (B) iv > i > iii > ii
(C) ii > iii > i > iv (D) i > ii > iv > iii

5. The following graph represents the variation of first ionization enthalpies (IE) with atomic numbers for elements with atomic number Z = 1 to 60. The peaks in the graph represents _____.



(A) alkali metals
(B) alkaline earth metals
(C) noble gases
(D) halogens

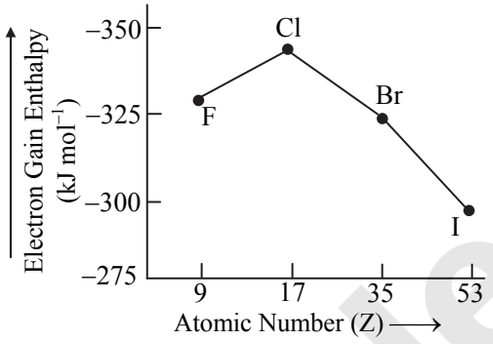
6. The graph below charts the first five ionization energies of an unknown atom "Y". Assuming that the highest principal quantum number of the element Y is 3, which of the following elements is most likely to be chemically similar to "Y".



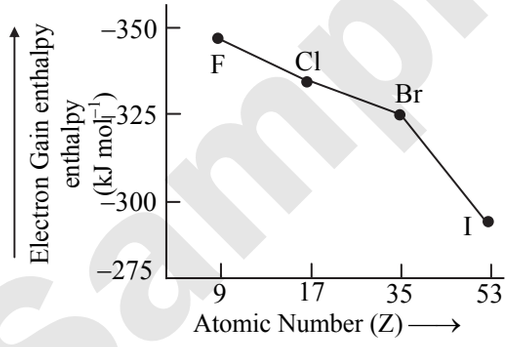
(A) Ga (B) As
(C) Si (D) Mg

7. Which of the following graphs CORRECTLY depicts the variation in electron gain enthalpy of halogens (F, Cl, Br and I)?

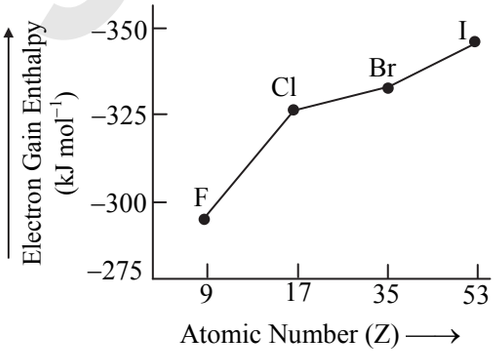
(A)



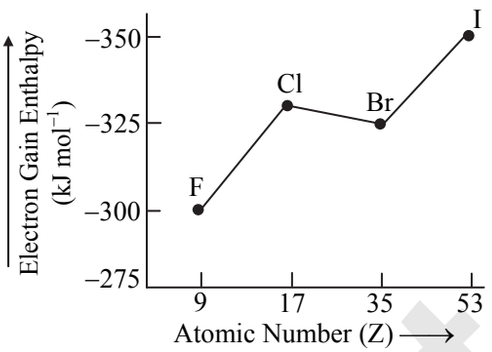
(B)



(C)



(D)



Numerical Value Type Questions

1. Atomic mass of Cl = 35.5 and that of I = 127. According to Dobereiner's triad rule, atomic mass of Br will be _____ u.

[Ans: 81.25]

2. The atomic numbers of some elements are as given below:
11, 15, 20, 27, 31, 35, 38, 48, 49, 55
From the above, the number of elements that belongs to p-block is _____.

[Ans: 4]

3. The number of valence electrons in an element with atomic number 4 is _____.

[Ans: 2]

4. Some periodic properties are given below. The number of properties that shows increase in general periodic trend down a group is _____.
   i. Atomic radius
   ii. Ionic radius
   iii. Ionization enthalpy
   iv. Electron gain enthalpy
   v. Electronegativity
   vi. Nonmetallic character
   vii. Valency

[Ans: 2]

5. Among the following, the number of species that are isoelectronic with Ne are _____.
N^{3-}, O^{2-}, Cl, F, F^-, Na^+, Mg^+, Mg^{2+}, O^-

[Ans: 5]

Problems To Ponder

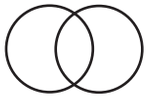
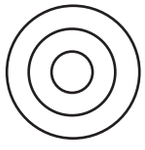
1. A natural number R is defined as R = 2a + b + 3c. Calculate the value of R if:
a = number of protons in 52 amu of He.
b = number of groups in modern periodic table.
c = number of orbitals having principal quantum number n = 4.
(A) 25 (B) 44
(C) 80 (D) 118

2. Characteristics/uses/occurrence of some of the elements are given below.
After identifying these elements, find which of them have the greatest difference between first and second ionization enthalpy.
(A) Element I → Present in caustic soda, baking soda and table salt.
(B) Element II → Metal present in chlorophyll of plants.
(C) Element III → The second most abundant element (by mass) in the earth's crust.
(D) Element IV → Group 15 element that forms phosphine gas.

3. The given set of elements are present in the 3rd period of the periodic table. Element X forms basic hydroxide which is used in the preparation of milk of magnesia and the element Y is a silvery white metal which is a good conductor of electricity. Find the largest and the smallest species in size.
i. Element X
ii. Divalent cation of element X
iii. Element Y
iv. Trivalent cation of element Y
(A) i and iv (B) ii and iii
(C) i and iii (D) ii and iv

4. Consider two ions with opposite charges separated by a distance d. What effect does doubling the positive charge and reducing the distance by one-half have on the force between the ions?
(A) Force becomes eight times.
(B) Force is quadrupled.
(C) Force reduces by one-half.
(D) Force remains the same.

5. Dietary calcium from various dairy and food products are essential for healthy bones. X-90, a radioactive isotope, a component of waste generated by nuclear power facilities enters our body through ingestion. Our body mistakes X for Ca incorporating it into our bones which results in increased risk of leukaemia and other cancers. Which of the following could possibly be X?
(A) Po (B) Th
(C) Rb (D) Sr

6. Which of the following Venn diagrams indicates the CORRECT relation between acidic oxides, basic oxides and amphoteric oxides?
(A) 
(B) 
(C) 
(D) 

Answers to MCQs

Concept Building Problems

3.0 :	1.	(D)	2.	(D)	3.	(A)	4.	(A)											
3.1 :	1.	(B)	2.	(B)	3.	(D)	4.	(D)	5.	(A)	6.	(C)	7.	(C)					
3.2 :	1.	(B)	2.	(B)	3.	(C)	4.	(C)	5.	(D)	6.	(A)	7.	(D)	8.	(C)	9.	(B)	10. (D)
	11.	(A)	12.	(A)															
3.3 :	1.	(C)	2.	(A)	3.	(D)	4.	(B)	5.	(A)	6.	(C)	7.	(C)	8.	(D)	9.	(B)	10. (A)
	11.	(A)	12.	(C)	13.	(C)	14.	(B)	15.	(A)	16.	(A)	17.	(A)	18.	(D)			
Misc.:	1.	(C)	2.	(B)	3.	(A)	4.	(D)	5.	(C)									

Practice Problems

3.0 :	1.	(A)	2.	(B)	3.	(C)													
3.1 :	1.	(B)	2.	(A)	3.	(A)	4.	(C)											
3.2 :	1.	(A)	2.	(B)	3.	(A)	4.	(B)	5.	(D)	6.	(D)	7.	(C)					
3.3 :	1.	(B)	2.	(C)	3.	(D)	4.	(A)	5.	(D)	6.	(A)	7.	(C)					
Misc.:	1.	(A)	2.	(D)	3.	(C)	4.	(B)	5.	(C)	6.	(C)	7.	(C)	8.	(A)	9.	(C)	10. (C)
	11.	(C)																	

Diagram Based Problems

1. (C) 2. (D) 3. (B) 4. (C) 5. (C) 6. (A) 7. (A)

Problems To Ponder

1. (D) 2. (A) 3. (A) 4. (A) 5. (D) 6. (B)

Hints to MCQs

Concept Building Problems

3.0 INTRODUCTION

1. According to Dobereiner's law of triads, the atomic mass of the central element is nearly the arithmetic mean of atomic masses of other two elements.

Ca	Sr	Ba	Arithmetic mean
40	88	137	$\frac{40+137}{2} = 88.5 \approx 88$

3.1 MODERN PERIODIC LAW AND LONG FORM OF THE PERIODIC TABLE

3. Atomic number of this element would be 28, since elements are arranged in the periodic table based on their atomic number.
Electronic configuration: [Ar] $3d^8\ 4s^2$
Group number = 2 + 1 = 3

5. Electronic configuration of element with atomic number:
19: 2, 8, 8, 1
37: 2, 8, 18, 8, 1
55: 2, 8, 18, 18, 8, 1
87: 2, 8, 18, 18, 32, 8, 1

Thinking Hatke - Q. 5
Electronic configuration of element with atomic number 19 is (2, 8, 8, 1) and hence, it belongs to group 1 as it has one valence electron. Therefore, rest of the elements also belong to group 1.

7. Unununium - Roentgenium

3.2 s, p, d AND f-BLOCK ELEMENTS

2. Elements belonging to the same group have same number of valence electrons. Therefore, the electronic configuration of the element below the given element would be $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^5$ and hence, its atomic number is 35.

3. Electronic configuration of the element with atomic number 33: [Ar] $3d^{10}\ 4s^2\ 4p^3$
Since the last electron enters in p-subshell, the element belongs to p-block.

4. F (9) and Cl (17) are p-block elements.

5. Rutherfordium (Rf) is the d-block element with highest atomic number of 104 amongst the given elements.

8. Since the last electron enters in d-subshell, the element belongs to d-block.

CAUTION
As per the Aufbau principle, filling of electrons takes place first in 5s-subshell, followed by 4d-subshell. Therefore, the last electron enters in 4d-subshell and the element belongs to d-block.

9. The term chalcogens are referred to elements belonging to group 16 of the periodic table. Elements Se, Te, Po belong to group 16.

10. The electronic configuration of X is $1s^2 2s^2\ 2p^3$.
∴ The valency of X will be 3.
We know, valency of Mg ($1s^2 2s^2 2p^6 3s^2$) is 2.
Magnesium reacts with X to form an ionic compound. Hence, the formula of this compound will be Mg_3X_2.

12. Elements with atomic number 93 and beyond are transuranic elements.

3.3 PERIODIC TRENDS IN PROPERTIES OF ELEMENTS

1. In a period, atomic radius generally decreases from left to right. The decrease in atomic radius or atomic size is due to the effect of successive increasing nuclear charge without addition of a new shell.

4. Atomic radii decrease across a period.
∴ Mg > Al
Cations are smaller than their parent atoms.
∴ Mg > Mg^{2+} and Al > Al^{3+}
Now, Mg^{2+} and Al^{3+} are isoelectronic species.
∴ Mg^{2+} > Al^{3+}
Thus, the largest species would be Mg.

5. Isoelectronic species have same number of electrons.

Species	O^{2-}	F^-	Na^+	Mg^{2+}
Z	8	9	11	12
Charge	–2	–1	+1	+2
Total no. of electrons	10	10	10	10

6. Fe^{2+} (Z = 26) ion contains 24 electrons while Mn^{2+} (Z = 25) ion contains 23 electrons.

7. N^{3-}, O^{2-} and F^- are isoelectronic species having 10 electrons each. Among isoelectronic species, higher the negative charge, larger is the ionic radius. Therefore, the correct order of ionic radii is, $N^{3-} > O^{2-} > F^-$.

8. Lower the number of valence electrons, lower is the value of ionization potential. Hence, alkali metals have lowest 1st ionization potential in a period.

9. Down the group, the first ionization potential (or ionization energy) decreases due to increase in atomic radius.
∴ Na > K > Rb
Sodium belongs to 3rd period while scandium belongs to 4th period. So, the atomic radius of sodium is less than the atomic radius of scandium.
∴ Ionization energy of sodium is more than that of scandium.

10. Due to half-filled stable 2p-orbitals, the ionization enthalpy of N is higher than that of O. Due to completely filled stable 2s-orbital, the ionization enthalpy of Be is higher than that of B. Ne has completely filled 2p-orbitals.

11. P has more ionization enthalpy than that of S due to half-filled stable orbitals. Al has lower ionization enthalpy than that of Mg because of effective shielding of 3p electrons from the nucleus by 3s-electrons. Hence, the order is:
Al < Mg < Si < S < P

12. Electron gain enthalpy decreases as we move from top to bottom in a group while it increases as we move from left to right within a period. Hence, the correct order of most negative to least negative elements in terms of electron gain enthalpy are F > C > Si > Al.

13. i. K and Ca:
$_{19}K$: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1$ → half-filled valence '4s' shell
$_{20}Ca$: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2$ → Completely filled valence '4s' shell

ii. Si and P:
$_{14}Si$: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^2$ → affinity to accept electrons to achieve half-filled 'p' orbital
$_{15}P$: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^3$ → half-filled 'p' orbitals make it extra stable.
Hence, P will show less affinity for electrons compared to Si.

iii. Se and Br: Br has greater affinity to accept electrons and complete its valence shell.

iv. Be and B:
$_4Be$: $1s^2\ 2s^2$ → completely filled valence '2s' shell.
$_5B$: $1s^2\ 2s^2\ 2p^1$
B can accept electrons into its 2p orbital.

14. Sodium and aluminium belong to the same period and not the same group. In a period, the metallic character decreases as we move from left to right. Therefore, metallic character of Na is higher than Al.

17. The electron gain enthalpy ($\Delta_{eg}H$) of F is less negative as compared to Cl because of its small size. Hence, the correct order of electron gain enthalpy is F < Cl > Br > I.

MISCELLANEOUS

1. The atomic size and ionic radius increase as we move down the group. Valency of all elements in a group remains the same. Ionization enthalpy generally decreases down the group.

2. Let the oxidation state of Al be *x*.
+2 = *x* + (–1) + 5 [1 × 2 + (–2)]
∴ *x* = +3
The oxidation state of Al in $[AlCl(H_2O)_5]^{2+}$ is +3.

4. The electronic configuration of the element in its +5 oxidation state is [Ar].
∴ The actual electronic configuration of the element is [Ar] $3d^3\ 4s^2$ and therefore the given element is Vanadium ($_{23}V$). It belongs to the 4th period and 5th group of the periodic table.

5. The formation of O^{2-} ion is unfavourable due to the strong electronic repulsion between negatively charged O^- ion and the incoming electron. Hence, the strong electronic repulsion outweighs the stability obtained by achieving the noble gas configuration.

Practice Problems

3.1 MODERN PERIODIC LAW AND LONG FORM OF THE PERIODIC TABLE

3. The group of elements belonging to option (B) are a group of chalcogens. Similarly, option (C) consist of alkali metals and option (D) consist of group of alkaline earth metals. The elements in option (A) do not belong to the same group.

4. For option (C) the correct arrangement of elements in increasing order of their atomic numbers is B (5), Al (13), Ga (31) and Sb (51).

3.2 s, p, d AND f-BLOCK ELEMENTS

2. Since the last electron enters in s-subshell, the element belongs to s-block in the periodic table. Hence, it is placed in 5^{th} period and group 2.

3. The element with Z = 42 lies in period 5. The atomic number of the element just immediately above it is given by
42 – 18 = 24
∴ The electronic configuration of element with Z = 24 is $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5\ 4s^1$ (i.e., Cr)

4. Ionization enthalpy represents the energy required to remove an electron from an isolated gaseous atom in its ground state. Larger the atomic size, smaller will be the value of ionization enthalpy of an element.
Hence, the atom with the electronic configuration $1s^2\ 2s^2\ 2p^6\ 3s^1$ will have the lowest ionization enthalpy.

5. As (Astatine) is a p-block element, hence, valence electrons do not enter d-orbital.

6. The number of electrons present in the given element = 27 – 14 = 13
Electronic configuration: [Ne] $3s^2\ 3p^1$
Since the last electron enters in p-subshell, the element belongs to p-block.

7. Germanium is a metalloid.

3.3 PERIODIC TRENDS IN PROPERTIES OF ELEMENTS

1. P^{3-}, S^{2-} and Cl^- are isoelectronic species having 18 electrons each. Among isoelectronic species, higher the negative charge, larger is the ionic radius. Therefore, the correct order of ionic radii is, $Cl^- < S^{2-} < P^{3-}$.

2. The ionic radii of isoelectronic species increase with decrease in atomic number.

3. i. Size of cation is always smaller while that of an anion is always bigger than the neutral atom i.e., $I^+ < I < I^-$.
ii. Atomic radii decrease from left to right in a period due to higher nuclear charge therefore, C has higher atomic radius than N. N and C belongs to 2^{nd} period and P belongs to 3^{rd} period so atomic radii of N and C is less than P. Hence, overall increasing atomic radii is N < C < P.
iii. Among isoelectronic species, the anion with higher negative charge is larger in size.
iv. Si, P and Cl all belong to 3^{rd} period. Atomic size decreases as nuclear charge increases.
Therefore, order is Cl < P < Si.

5. Mg: $1s^2\ 2s^2\ 2p^6\ 3s^2$
In the third ionization, an electron has to be removed from a stable inert gas configuration (i.e., of Ne). Hence, a sudden large jump is obtained between the values of second and third ionization energies of Mg atom.

6. The most electronegative element is fluorine (value is 4.0 on the Pauling scale). The least electronegative elements are Cs and Fr (with a value of 0.70).

7. Variable valency is a property of d block elements. The involvement of (n–1) d electron in the bond formation is the cause of variable valency in d-block elements.

MISCELLANEOUS

1. On the basis of symmetry $(n-1)\ d^4\ ns^2$ and $(n-1)\ d^9\ ns^2$ configurations are less stable and hence, they immediately change over to the corresponding more stable $(n-1)\ d^5\ ns^1$ and $(n-1)\ d^{10}\ ns^1$ configurations. However, there are exception i.e.,

Element	Atomic number	Expected E.C.	Actual E.C.
Sg	106	[Rn] $5f^{14}$ $6d^5\ 7s^1$	[Rn] $5f^{14}$ $6d^4\ 7s^2$

2. Correct formula of the binary compound is Al_4C_3.

3. For the given 3^{rd} period of elements, the Ionization Enthalpy is expected to show an increasing trend from left to right in a period due to (a) decrease in the atomic size and (b) increase in the number of protons in the nucleus. The expected trend may be disturbed by S^{+1} as it exhibits a stable half-filled 3p-orbital from which it may be difficult to pull out an electron to form S^{+2} ion. However, the shielding effect

and larger ionic radius of 3rd period elements cancel the slight increase expected from the stable configuration of S^{+1}.
Thus, the correct order is Cl > S > P > Si.

4. For the elements in the same period, valence electrons are added to the orbitals in the same principal quantum level (n).
(i) is oxygen, (ii) is sulphur, (iii) is fluorine and (iv) is calcium
The elements belonging to the same period are oxygen and fluorine. Hence, the correct answer is option (B).

6. Na belongs to group 1 with a valence of 1. S belongs to group 16 with a valence of 2. Hence, the expected formula of the compound X is Na_2S. The mass of 1 mol of the compound is $(23 \times 2) + 32 = 78$ g.

7. $_{120}X$ – [Og] $8s^2$
According to the electronic configuration, the given element belongs to group of alkaline earth metals. Stable oxide for alkaline earth metal series is given by XO.
Where X = alkaline earth metal.

8. Electron gain enthalpy = -4.9×10^{-19} J/atom
∴ Electron affinity = 4.9×10^{-19} J/atom
Now, 1 eV = 1.6×10^{-19} J
∴ Electron affinity

$$= 4.9 \times 10^{-19} \text{ J/atom} \times \frac{1 \text{ eV}}{1.6 \times 10^{-19} \text{ J}}$$

= 3.06 eV/atom

9. i. The recently discovered element was first named as Eka-mercury, which is actually
$_{112}$Cn (Copernicium) – [Rn] $5f^{14}$ $6d^{10}$ $7s^2$.
ii. Boron has the smallest atomic volume.
iii. The first synthetic element is Technetium (Tc). It is one of the fission products of Uranium. It is mainly obtained from the spent fuel rods of the nuclear reactor.

10. B: $1s^2$ $2s^2$ $2p^1$
The high value of second ionization energy indicates removal of an electron from completely filled 2s-orbital. Similarly, the high value of fourth ionization energy (IE_4) indicates removal of an electron from completely filled 1s-orbital.

11. Atomic number of 'X' is 32.
∴ Electronic configuration of $_{32}X$ is,
[Ar] $3d^{10}$ $4s^2$ $4p^2$
Therefore, the highest principal quantum number is 4.

Diagram Based Problems

2. = Neon (Z = 10)
= Zinc (Z = 30)
= Ra (Z = 88)

3. All the given ions are isoelectronic.
Among isoelectronic ions, the one with higher positive will have smaller ionic radius while the one with higher negative charge will have larger ionic radius.
Therefore, $K^+ > Ca^{2+}$ and $P^{3-} > S^{2-}$
As anions have larger ionic radii as compared to cations, correct order is,
$Ca^{2+} < K^+ < S^{2-} < P^{3-}$

4. Greater the number of inner electrons, higher is the shielding effect. Since, the number of inner electrons is same for the given examples, the effective nuclear charge will depend on 'Z'.
$Z_{eff} = Z$ – inner electrons.

5. Noble gases will show maximum ionization enthalpies due to their closed electron shells and stable electronic configuration. Hence, the peaks in the graph represents noble gases.

6. Y = Al; $1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^1$
Greatest jump in ionization energies is observed between IE_3 and IE_4.
'Al' is chemically similar to 'Ga', since they belong to the same group.

7. Halogens possess most negative electron gain enthalpies. The negative electron gain enthalpy decreases as we move down the group from Cl → Br → I but electron gain enthalpy of F is unexpectedly less negative than that of Cl. This is due to the small size of fluorine. The electron-electron repulsion in the relatively compact 2p subshell of F are comparatively large and hence, the incoming electron in not accepted with the same ease as is the case with Cl.

Numerical Value Type Questions

1. According to Dobereiner, the middle element have an atomic mass almost the average of the other two elements. Hence,

$$\frac{35.5 + 127}{2} = 81.25 \text{ u}$$

2. Elements with atomic numbers 15, 31, 35, 49, belong to p-block.

4. The periodic properties (i) and (ii) show increase in periodic trend down a group.

5. N^{3-}, O^{2-}, F^-, Na^+ and Mg^{2+} are isoelectronic with Ne.

Problems To Ponder

1. 1 He atom = 4 amu.

∴ 52 amu of Helium contains $\left(\frac{52}{4}\right)$ atoms

= 13 atoms.

1 atom of He contains 2 protons and 2 neutrons.

∴ 13 atoms contain 13 × 2 = 26 protons.

∴ a = 26 ; b = 18

The total number of orbitals having principal quantum number (n) is given as n^2.

∴ For n = 4, number of orbitals = $(4)^2 = 16$

∴ c = 16

∴ R = 2a + b + 3c

= (2 × 26) + 18 + (3 × 16) = 118

2. i. Element I is Sodium (Na).
ii. Element II is Magnesium (Mg).
iii. Element III is Silicon (Si).
iv. Element IV is Phosphorus (P).

Na is an alkali metal. It has only one electron in the valence shell. Therefore, its first ionization enthalpy is very low. After removal of one electron, it acquires noble gas configuration ($_{10}$Ne) i.e., Na^+ ($1s^2\ 2s^2\ 2p^6$). So, the second ionization enthalpy is very high. Hence, the difference in first and second ionization enthalpies would be greatest in case of Na. In case of Mg, Si and P their first ionization enthalpies are much higher than that of Na but their second ionization enthalpies will be lower than that of Na. As a result, the difference in their respective (Δ_iH_1) and (Δ_iH_2) will be much lower than that of Na.

3. The element X is magnesium. Its hydroxide $Mg(OH)_2$ is used in the preparation antacid (milk of magnesia). Its divalent cation is Mg^{2+}. The element Y is Aluminium (Al) which is a silvery white metal and it is a good conductor of electricity. Its trivalent cation is Al^{3+}. Al is smaller than Mg due to increased nuclear charge. Cations are smaller than their parent atoms. Therefore, Mg^{2+} is smaller than Mg and Al^{3+} is smaller than Al. Mg^{2+} and Al^{3+} are isoelectronic ions. Among isoelectronic species, higher the positive charge, smaller is the size of ion. Therefore, ionic radius of Al^{3+} is smaller than that of Mg^{2+}.

4. $F = \frac{Q_1Q_2}{d^2}$ $\begin{bmatrix} Q_1 \text{ and } Q_2 \Rightarrow \text{charges on ions} \\ d \Rightarrow \text{distance between ions} \end{bmatrix}$

Assume $Q_1 = +1$, $Q_2 = -1$, d = 2

∴ $F_1 = \frac{(+1)(-1)}{(2)^2} = -0.25$

When positive charge is doubled, i.e., $Q_1 = +2$ and distance is halved, i.e., d = 1.

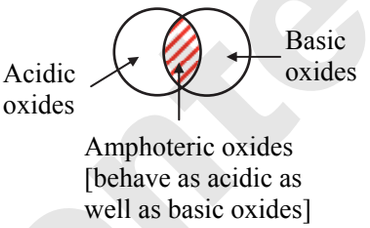
$F_2 = \frac{(+2)(-1)}{(1)^2} = -2$

$F_2 = 8 \times F_1$

∴ force becomes eight times.

5. Sr falls under the same group as Ca. Hence, Sr and Ca have similar chemical properties.

6.



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