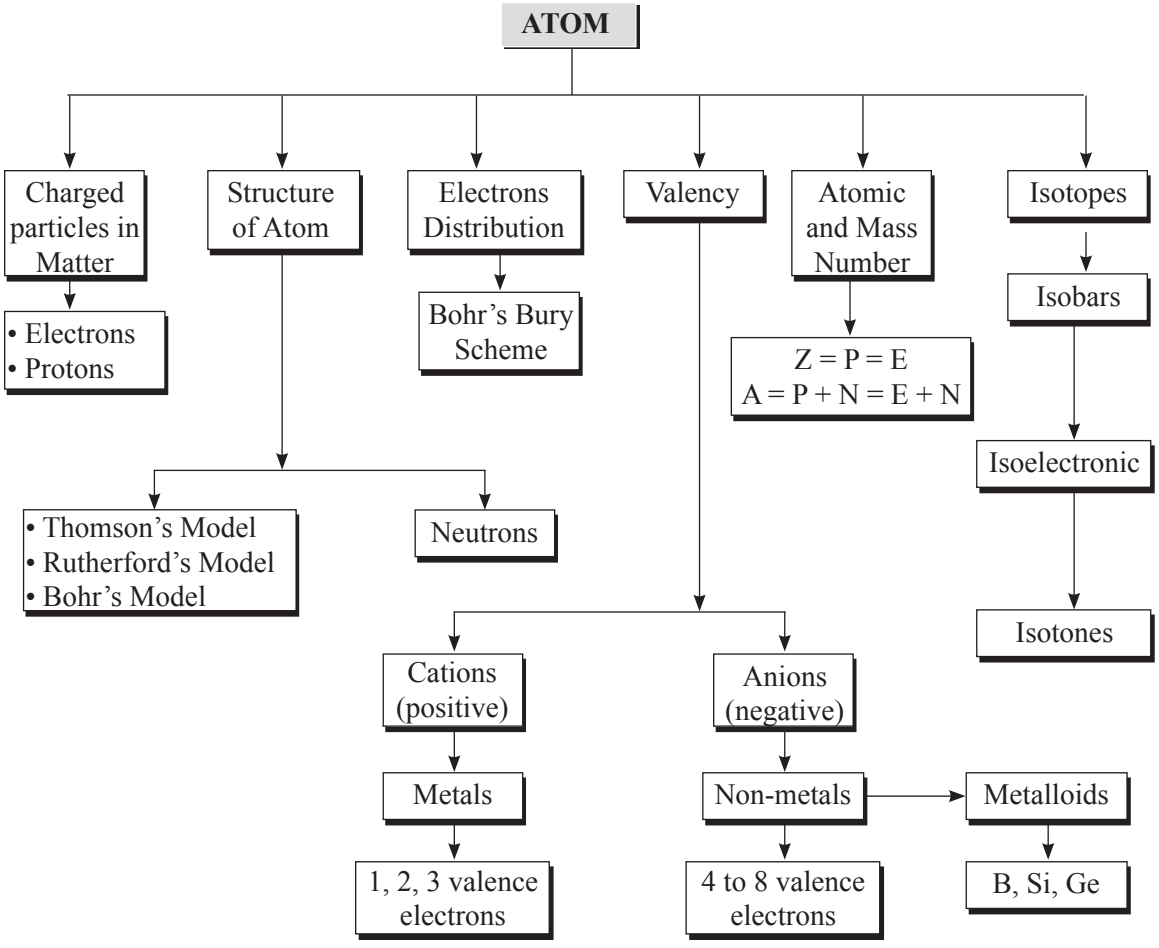
4 Structure of the Atom

Topics Covered

4.1 Charged Particles in Matter, The Structure of an Atom
4.2 Distribution of Electrons in Shells, Valency, Atomic Number, Mass Number, Isotopes and Isobars

CHAPTER MAP



Quick Revision Notes

- An atom is divisible and consist of charged particles.
- **J.J. Thomson** discovered the presence of electrons in an atom by cathode rays experiment.
- **E Goldstein** discovered the presence of new radiations called canal rays which consist of positive charged particles called protons.
- The mass of an **electron** is $\mathbf{9.1 \times 10^{-31}\ kg}$. It has $\mathbf{-1.602 \times 10^{-19}\ C}$ of charge.
- **Coloumb** (C) is the unit of charge.
- The mass of a **proton** is $\mathbf{1.67 \times 10^{-27}\ kg}$. It has $\mathbf{+ 1.602 \times 10^{-19}\ C}$ of charge
- Atom is electrically neutral due to the presence of equal number of electrons and protons.
- Chadwick discovered neutron which is a neutral particle.
- The mass of a **neutron** is $\mathbf{1.675 \times 10^{-27}\ kg}$.
- **Thomson** gave model of an atom which is similar to christmas pudding.
- The electrons are spread in a sphere of positive charge like currents (dry fruits) in a spherical christmas pudding.
- The results of other experiments could not support Thomson's model of atom.
- **Rutherford** discovered nucleus which is a positively charged centre. Almost whole of the mass and change of an atom is concentrated in the nucleus.
- **Nucleus** consists of neutrons and protons.
- Most of the part of an atom is hollow.
- Size of nucleus is $\frac{1}{100,000}$ of the size of atom.
- Electrons revolve in a well defined orbit.
- Rutherford could not explain the stability of an atom.
- **Bohr's model** of atom could overcome drawbacks of Rutherford model of atom.
- Electrons revolve in certain special orbits called energy levels. Each orbit is associated with a fixed amount of energy
- As long as electrons remains in the same energy level it does not radiate energy.
- Energy is emitted when an electron jumps from a higher energy level to a lower energy level.
- Electrons can move from a lower energy level to higher energy level if it is supplied energy.
- **Atomic number** is equal to the number of protons in the nucleus of an atom. It is denoted by '**Z**'. It is also equal to the number of electrons in case of a neutral atom.
- **Mass number** is equal to the sum of total number of protons and neutrons. It is denoted by '**A**'. $A = n_N + n_P$
- Representation of an atom ${}^{A}_{Z}E$, e.g. ${}^{12}_{6}C$ where mass number (A) = 12, atomic number (Z) = 6.
- Distribution of electrons in the various energy levels is done in accordance with **Bohr's Bury Scheme**, it states that the outermost shell of an atom cannot accommodate more than 8 electrons, even if has a capacity for accomodating more electrons.
- The outermost energy level of an atomota element is called **valence shell**.
- Each shell can have maximum number of electrons equal to $2n^2$ where 'n' represents the number of the shell.
- Valence shell cannot have more than **8** electrons.
- **Penultimate shell** (last but one) cannot have more than **18** electrons.
- Valence electrons are the electrons present in the outermost (last) shell of an element.
- Valency is determined with the help of valence electrons.
- **Valency** is as the number of electrons lost or gained or shared for achieving 8 electrons in its outermost shell or nearest noble gas configration.

(Z) Atomic Number	Element 'X'	Atomic mass 'A'	E	P	N	Distribution of electrons (Electronic configuration)					
						K	L	M	N	Valence electrons	Valency
1	**Hydrogen**	1	1	1	0	1				1	**1**
2	**Helium**	4	2	2	2	2				2	**Zero**
3	**Lithium**	7	3	3	4	2,	1			1	**1**
4	**Beryllium**	9	4	4	5	2,	2			2	**2**
5	**Boron**	11	5	5	6	2,	3			3	**3**
6	**Carbon**	12	6	6	6	2,	4			4	**4**
7	**Nitrogen**	14	7	7	7	2,	5			5	**3, 5**
8	**Oxygen**	16	8	8	8	2,	6			6	**2**
9	**Fluorine**	19	9	9	10	2,	7			7	**1**
10	**Neon**	20	10	10	10	2,	8			8	**0**
11	**Sodium**	23	11	11	12	2,	8,	1		1	**1**
12	**Magnesium**	24	12	12	12	2,	8,	2		2	**2**
13	**Aluminium**	27	13	13	14	2,	8,	3		3	**3**
14	**Silicon**	28	14	14	14	2,	8,	4		4	**4**
15	**Phosphorus**	31	15	15	16	2,	8,	5		5	**3, 5**
16	**Sulphur**	32	16	16	16	2,	8	6		6	**2, 4, 6**
17	**Chlorine**	35	17	17	18	2,	8,	7		7	**1**
18	**Argon**	40	18	18	22	2,	8,	8		8	**0**
19	**Potassium**	39	19	19	20	2,	8,	8,	1	1	**1**
20	**Calcium**	40	20	20	20	2,	8,	8,	2	2	**2**

- **Isotopes** are the atoms of some element having different mass number but same atomic number, e.g. $^{35}_{17}Cl$ and $^{37}_{17}Cl$.
- **Isobars** are those species which have the same mass number but different atomic number, e.g. $^{40}_{20}Ca$, and $^{40}_{18}Ar$.

1. Charged Particles in Matter, The Structure of an Atom

Cathode rays: When high voltage is passed through a discharge tube at low pressure a greenish glow is observed moving from cathode to anode. These rays are called cathode rays.

- In an electric field, cathode rays are directed towards the +ve terminal, it shows that they consist of negatively charged particles called **electrons**.

Canal rays: (Anode rays) when perforated cathode was used in discharge tube and high voltage was passed at a very low pressure, after the greenish glow ceases, pinkish glow was observed to move from anode to cathode, passing through the hole of a cathode. These rays are called canal rays.

- Canal rays consist of positively charged particles called **protons**.

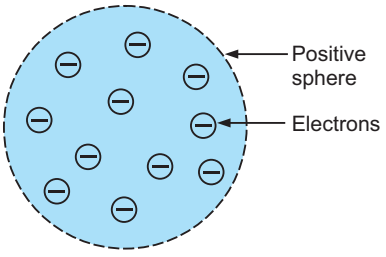
Neutrons: James Chadwick discovered neutrons.

- These are neutral subatomic particles.
- Their mass is nearly equal to that of proton.
- They are present in the nucleus denoted by ${}_0^1n$
- The mass of an atom is equal to the mass of protons as well as neutrons present in the nucleus because electrons have negligible mass.

Structure of Atom: J.J. Thomson proposed the first model for the structure of an atom.

Thomson Model of Atom

- An atom consists of a positively charged sphere and the electrons are embedded in it.
- The negative and positive charges are equal in magnitude. Therefore an atom as a whole is electrically neutral.
- *Achievement:* Thomson's model explained that atoms are electrically neutral.
- *Drawbacks:* It could not explain the stability of the atoms. Also the results of the experiments carried out by other scientists could not be explained by this model.



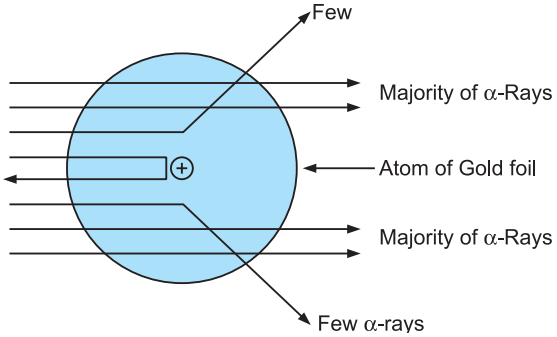
J.J. Thomson's Model of Atom

Rutherford's Model of Atom

- Rutherford took a very thin sheet of gold metal foil which was about 1000 atoms thick.
- He bombarded gold foil with α-rays.
- α-rays are positively charged helium nuclei with mass 4 *u*, the fast moving α-particles have a considerable amount of energy.

Observation:

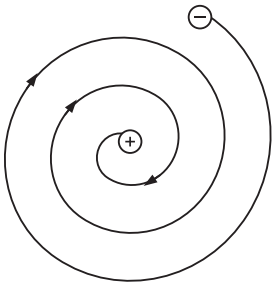
- Most of the α-particles passed through gold foil passed undeflected.



Rutherford's α-ray scattering experiment

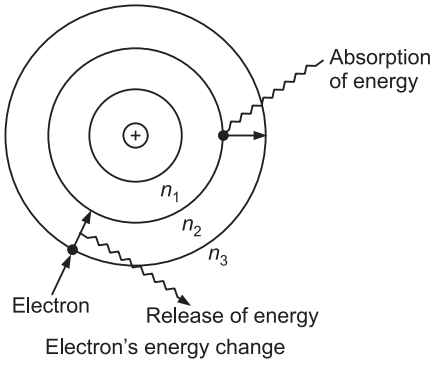
Conclusion:

- An Atom consists of predominantly empty space as most of the α-particles passed through gold foil undeflected.
- Atoms contains centrally placed positively charged nucleus (carrying positively charged particles), because few α-particles suffered deflection and a very few, i.e. only one in 12000 get bounced back.
- Since a minute fraction of α-particles suffered deflections and very few bounced back, this lead to the conclusion that most of the space occupied by nucleus is negligible as compared to this empty space. The size of nucleus was about $\frac{1}{100,000}$ of the size of atom.
- Whole mass of an atom is concentrated in the nucleus.
- Electrons revolve around the nucleus in well defined orbits.
- *Drawbacks:* Maxwell proved that whenever a charged particle revolves, under forces of attraction, it continuously loses energy. Its path will become smaller and smaller and ultimately it will fall into nucleus and atom will collapse which actually does not happen. It means that there is something wrong with Rutherford model of Atom.


Maxwell experiment

Bohr's Model of Atom

- Electrons revolve in certain special orbits known as discrete orbits of electrons.
- These orbits are associated with fixed amount of energy and are called energy levels.
- As long as electrons revolve in the same energy level, it does not radiate energy.
- Electrons radiate energy when an electron jumps from a higher energy level to a lower energy level. Supply of energy to electrons will excite the electrons to higher energy level.



Electron's energy change

Exercise 4.1

I. Very Short Answer Type Questions (1 Mark)

1. Name three subatomic particles present in an atom. [*DOE*]
2. Name the negatively charged particles present in all the atoms of all the elements.[*DOE*]
3. Which part of the atom was discovered by Rutherford's alpha particle scattering experiment? [*DOE*]
4. What are Canal rays? [*NCERT*] [*CBSE* 2010]
5. If an atom contains one electron and one proton, will it carry any charge or not? [*NCERT*]
6. Why is an atom neutral inspite of the presence of charged particles in it? [*DOE*]
7. How does a proton differ from an electron? [*DOE*]
8. Helium atom has atomic mass of $4u$ and has 2 protons in its nucleus. How many neutrons does it have? [*NCERT*]
9. Who discovered electrons? [*CBSE* 2010]
10. What is a proton? Who discovered it? [*CBSE* 2015]
11. What was the main drawback of Rutherford's model of atom? [*CBSE* 2016]
12. Name an element which does not have any neutron.

II. Short Answer Type Questions–I (2 Marks)

13. Mention any two points which Rutherford put forward to explain the nuclear model of an atom. [*CBSE* 2010]
14. Compare the properties of electrons, protons and neutrons.
15. What are the limitations of J.J. Thomson's model of the atom? [*NCERT*]
16. What are the limitations of Rutherford's model of atom? [*NCERT*]

III. Short Answer Type Questions–II (3 Marks)

17. Describe Thomson's model of atom. Which subatomic particle was not present in Thomson's model of Atom?
18. Describe Rutherford's model of atom.
19. Describe Bohr's model of atom. [*NCERT*]

IV. Long Answer Type Question (5 Marks)

20. Compare all the proposed models of an atom given in this chapter. [*NCERT*]

Answers 4.1

1. Electrons, protons and neutrons
2. Electrons
3. Nucleus
4. Canal rays are the rays emitted in a discharge tube when a very high voltage is passed at a very low pressure. These rays consist of positively charged particles.
5. It will not carry any charge because positively charged protons are equal to the negatively charged electrons.
6. It is because the number of negatively charged particles, i.e. electrons is equal to the number of positively charged particles, i.e. protons.
7. Proton is positively charged whereas an electron is negatively charged.
8. It has 2 neutrons: Number of neutrons = Mass Number (or Atomic mass) – Atomic No. = 4 – 2 = 2
9. J.J. Thomson
10. Proton is a positively charged particle, mass is nearly equal to the mass of one hydrogen atom. It was discovered by E.Goldstein.
11. Ernest Rutherford could not explain the stability of an atom.
12. Hydrogen
13. (*i*) Most part of an atom is hollow.
    (*ii*) The centre of an atom is heavy and is positively charged where almost whole of the mass of an atom is concentrated.
14.

Electrons	Protons	Neutrons
It is negatively charged.	It is positively charged.	It does not have any charge.
Its mass is 9.1×10^{-31} kg.	Its mass is 1.67×10^{-27} kg.	Its mass is 1.675×10^{-27} kg.

15. The results of the experiments carried out by other scientists could not be explained by this model.
16. Maxwell proved that whenever a charged particle revolves under the force of attraction, it continuously lose energy. Its path will become smaller and smaller and ultimately it will fall into the nucleus and atom will collapse which actually does not happen. It means that there is something wrong with Rutherford's model of Atom.
17. **Thomson's Model of Atom:**
    - An atom consists of a positively charged sphere and electrons are embedded in it.
    - The negative and positive charges are equal in magnitude. Therefore an atom as a whole is electrically neutral.
    - *Achievement:* Thomson's model explained that atoms are electrically neutral. Neutron was not present in Thomson model of atom.
18. **Rutherford's Model of Atom**
    - Rutherford took a very thin sheet of gold metal foil which was about 1000 atoms thick.
    - He bombarded gold foil with α-rays.
    - α-rays are positively charged helium nuclei with mass 4 *u*, the fast moving α-particles have a considerable amount of energy.

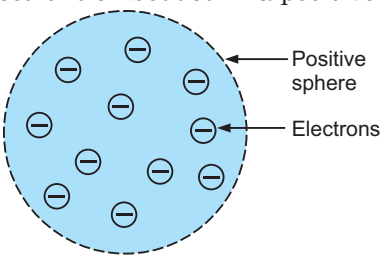
    Observation:
    - Most of the α-particles passed through gold foil undeflected.
    - Some particles are deflected by larger angles.
    - Very few came back in the same direction.

19. Bohr's Model of Atom

- Electrons revolve in certain special orbits known as discrete orbits or electrons.
- These orbits are associated with fixed amount of energy and these are called energy levels.
- As long as electrons revolve in the same energy level, it does not radiate energy.
- Electrons radiate energy when electrons jump from a higher energy level to a lower energy level. Supply of energy to electrons will excite the electrons to higher energy level.

20. Thomson's Model

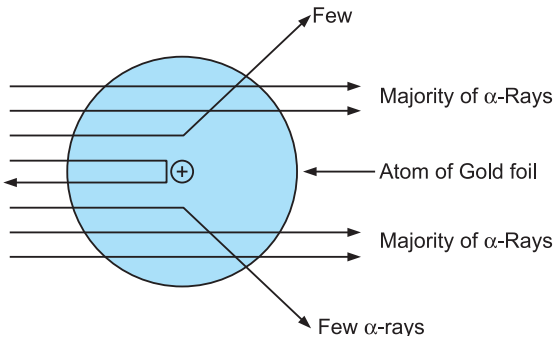
- An atom consists of a positively charged sphere and the electrons are embedded in it.
- The negative and positive charges are equal in magnitude. Therefore an atom on the whole is electrically neutral.
- An atom is depicted as electrons embedded in a positively charged sphere.



J.J. Thomson's Model of Atom

Rutherford's Model

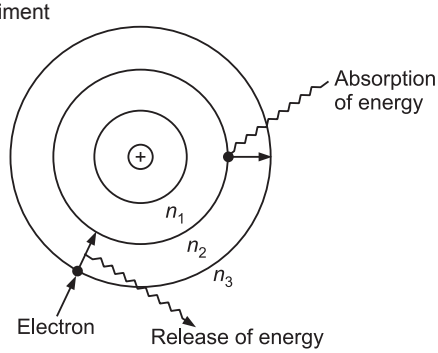
- An atom consists of predominantly empty space with a positively charged centre nucleus.
- Space occupied by the nucleus is negligible.
- Electrons revolve in a well defined orbits around the nuclear α-rays.



Rutherford's α-ray scattering experiment

Bohr's Model

- An atom consists of protons, neutrons and electrons.
- Protons and neutrons are present in the centre called nucleus.
- Orbits in which electrons are revolving are associated with a fixed amount of energy.



Bohr's Model of Atom

2. Distribution of Electrons in Shells, Valency, Atomic Number, Mass Number, Isotopes and Isobars

Bohr's Bury Scheme

- Each shell can have maximum number of electrons equal to $2n^2$, where 'n' is the shell number.
- The outermost shell cannot have more than 8 electrons.
- The last but one shell (penultimate) shell cannot have more than 18 electrons.
- Each shell is a filled up in the stepwise manner.

Valency

It is equal to the number of electrons lost or gained or shared between atoms of an element to become stable.

- **Valence electrons:** The electrons present in the outermost shell are called valence electrons.
- **Valence Shell:** The outermost electronic shell is called valence shell.
- **Electronic Configuration:** The distribution of electrons in various energy levels according to Bohr's Bury Scheme is called electronic configuration.

Atomic Number (Z)

It is equal to the number of protons (P). It is also equal to the number of electrons (E) in a neutral atom, *i.e.*, Z = P = E.

Mass Number (A)

It is equal to the sum of number of protons (P) and neutrons (N) present in an atom, *i.e.* A = P + N = E + N.

Isotopes

Atoms of the same element with different mass number but same atomic number are called isotopes, e.g. ${}^{12}_{6}C$, ${}^{13}_{6}C$, ${}^{14}_{6}C$.

They differ in the number of neutrons. They differ in physical properties but have the same chemical properties.

Applications of Isotopes:

(*i*) U-235 is used as a nuclear fuel in nuclear reactors.

(*ii*) Co-60 is used in the treatment of cancer.

(*iii*) Na-24 is used to detect blood clot.

(*iv*) I-131 is used in the treatment of goitre.

(*v*) Heavy water containing an isotope of hydrogen is used in nuclear reactors as a coolant and in some reactors as a moderator.

(*vi*) ${}^{14}_{6}C$ is used in determining the age of old fossils.

Isobars

These are the atoms of different elements having same mass number but different atomic numbers.

- They differ in the number of electrons, protons and neutrons.
- They differ in chemical properties due to different atomic numbers.

Isotones have same number of neutrons, e.g. ${}^{14}_{6}C$ and ${}^{16}_{8}O$.

Exercise 4.2

I. Very Short Answer Type Questions (1 Mark)

1. The total number of electrons in Nitrogen is 7. What is its valency? [*DOE*]
2. What name is given to the pair of atoms: $^{14}_{7}N$ and $^{15}_{7}N$? [*DOE*]
3. Oxygen has 8 protons and 8 neutrons whereas sulphur has 16 protons and 16 neutrons. What is the mass number of oxygen and sulphur.
4. The atomic number of neon is 10. Write its electronic configuration. [*CBSE* 2010]
5. What happens to the element 'Z' if it can gain three electrons? [*CBSE* 2010]
6. Helium has 2 electrons in its valence shell but its valency is not 2. Explain [*CBSE* 2016]
7. According to Bohr Bury Scheme what is the maximum number of electrons present in M-shell of an atom? [*CBSE* 2016]
8. In the notation $^{14}_{7}N$, what do the numbers 14 and 7 denote? [*CBSE* 2010]
9. If Mg^{2+} has 12 protons and 12 neutrons, what is its atomic number and mass number? [*CBSE* 2010] **[HOTS]**
10. What is the difference between Na atom and Na^{+} ion in terms of number of electrons? [*CBSE* 2010]
11. Why are the shells in which electrons revolve are called energy levels?
12. Why is Co-60 used in the treatment of cancer? **[HOTS]**
13. Which isotope is used to find the age of a mummy?
14. Which isotope is used as a fuel in Nuclear reactors?
15. What is the formula of the compound when 'X' with atomic number 12 combines with an element with atomic number 17? **[HOTS]**
16. An ion of an element has 3 units positive charge. Mass number of the atom is 27 and the number of the neutrons is 14. What is the number of electrons in this ion? **[HOTS]**
17. In a sample of ethanoate ($CH_3COOC_2H_5$), the oxygen atoms have the same number of electrons but different number of neutrons. What is a relationship between two atoms of oxygen? **[HOTS]**
18. Elements with valency equal to one are
    (*a*) always metals (*b*) always metalloids
    (*c*) either metals or non-metals (*d*) always non-metals
    [*NCERT Exemplar*] **[HOTS]**
19. Which of the following statement is always correct?
    (*a*) An atom has equal number of electrons and protons.
    (*b*) An atom has equal number of electrons and neutrons.
    (*c*) An atom has equal number of protons and neutrons.
    (*d*) An atom has equal number of electrons, protons and neutrons. [*NCERT Exemplar*]
20. Will ^{35}Cl and ^{37}Cl have different valencies? Justify your answer. [*NCERT Exemplar*] **[HOTS]**
21. Why did Rutherford select a gold foil for his α–ray scattering experiment? [*NCERT Exemplar*]
22. One electron is present in the outermost shell of the atom of an element X. What would be the nature and value of charge on the ion formed, if this electron is removed from the outermost shell? [*NCERT Exemplar*]
23. In the atom of an element X, 6 electrons are present in the outermost shell. If it acquires noble gas configuration by accepting requisite number of electrons, what would be the charge on the ion so formed? [*NCERT Exemplar*]

II. Short Answer Type Questions–I (2 Marks)

24. For the symbol H,D and T tabulate three sub-atomic particles found in each of them. [*NCERT*]

25. Write the electronic configuration of any one pair of isotopes and isobars. [*NCERT*]

26. Summarise the rules for writing of distribution of electrons in various shells for the first eighteen elements. [*NCERT*]

27. Define valency by taking the examples of silicon and oxygen. [*NCERT*]

28. Na^+ ion has completely filled K and L shells. Explain. [*NCERT*]

29. If bromine atom is available in the form of, say, two isotopes $^{79}_{35}Br$ (49.7%) and $^{81}_{35}Br$ (50.3%). Calculate the average atomic mass of bromine (Br) atom. [*NCERT*]

30. The average atomic mass of a sample of an element X is 16.2 *u*. What is the percentage of isotopes $^{16}_{8}X$ and $^{18}_{8}X$ in the given sample? [*NCERT*] **[HOTS]**

31. If Z = 3, what would be the valency of the element? Also, name that element. [*NCERT*]

32. Composition of the nuclei of two atomic species X and Y are given as under

Nuclei	X	Y
Protons	6	6
Neutrons	6	8

Give the mass numbers of X and Y. What is the relation between the two species? [*NCERT*]

33. The following data represents the distribution of electrons, protons and neutrons in atoms of the elements: A, B, C, D: [*CBSE* 2011]

Elements	Protons	Neutrons	Electrons
A	19	21	19
B	17	18	17
C	17	20	17
D	18	22	18

Answer the following questions:

(*a*) Describe the electronic configuration of B.

(*b*) Is element 'B' a metal or a non-metal, why?

(*c*) Which two elements are pair of Isotopes?

(*d*) Which two elements are pair of Isobars?

34. (*a*) What is the similarity in the electronic structure of the following set of elements?

(*i*) Lithium (*ii*) Sodium (*iii*) Potassium

(*b*) Which of the above element is most reactive and why? [*CBSE* 2011] **[HOTS]**

35. An atom of an element has two electrons in its outermost 'M' shell, state the (*a*) electronic configuration, (*b*) Atomic number, (*c*) Number of protons, (*d*) Valency of this element [*CBSE* 2010] **[HOTS]**

36. In response to a question, a student stated that in an atom, the number of protons is greater than the number of neutrons, which in turn is greater than the number of electrons. Do you agree with the statement? Justify your answer.

37. Show diagrammatically the electron distributions in a sodium atom and a sodium ion. Give their atomic numbers. [*NCERT Exemplar*]

38. In the Gold foil experiment of Geiger and Marsden, that paved way for Rutherford's model of an atom, ~ 1.00% of the α-particles were found to deflect at an angles > 50°. If one mole of α-particles were bombarded on the gold foil, compute the number of α-particles that would deflect at an angle less than 50°. [*NCERT Exemplar*] **[HOTS]**

39. Find the electron distribution for the element that has atomic number 20 and write its valency. [*CBSE* 2010]

40. If number of electrons in an atom is 8 and number of protons is also 8, then (*i*) what is the atomic number of the atom? (*ii*) What is the charge on the atom? [*NCERT*]

III. Short Answer Type Questions–II (3 Marks)

41. Write the distribution of electrons in an atom of element whose atomic number is 18. What is special about the outermost shell of an atom in this element?

42. How will you find out the valency of chlorine, sulphur and magnesium atoms? [*NCERT*]

43. Explain with examples: (*i*) Atomic number, (*ii*) Mass number, (*iii*) Isotopes, (*iv*) Isobars. Give any two uses of isotopes. [*NCERT*]

44. State the observations in α-particle scattering experiment that led to Rutherford making the following conclusions:

(*a*) Most of the space in an atom is empty.

(*b*) Almost whole of the mass of atom is concentrated in its centre.

(*c*) Centre is positively charged. **[*CBSE* 2012]**

45. The number of electrons, protons and neutrons of 5 elements are given below:

Element	A	B	C	D	E
Electron	4	18	17	11	17
Protons	6	18	17	9	17
Neutrons	6	22	20	10	18

(*a*) Which of them is a cation? (*b*) Which of them is an anion?

(*c*) Which is an atom of inert gas? **[HOTS]**

46. Fill in the blanks

Element	Atomic Number	P	E	N	Mass Number
Na^+	11	11	–	12	23
Ca^{2+}	20	20	18	–	40
Oxygen	8	8	–	8	16

[*CBSE* 2014]

47. In the following table, the mass number and atomic number of certain elements are given.

Elements	A	B	C	D	E	F	G	H
Mass No.	2	3	3	6	9	11	19	23
Atomic No.	1	1	2	3	4	5	9	11

(*a*) How many neutrons are present in 'F'?

(*b*) Which atoms are the isotopes of the same element?

(*c*) Which atom will form single positive charged ion?

(*d*) Which is an atom of inert gas?

(*e*) Which will form single negative charged ion?

(*f*) Which one of these have 11 electrons?

48. (*a*) Calculate the average atomic mass of chlorine if it exists in two isotopes $^{35}_{17}Cl$ (75%) and $^{37}_{17}Cl$ (25%). [*CBSE* 2015]

(*b*) Write the main drawback of Rutherford model of atom.

IV. Long Answer Type Question (5 Marks)

49. Complete the following table.

Atomic Number	Mass Number	Number of Neutrons	Number of Protons	Number of Electrons	Name of the Atomic Species
9	-	10	-	-	-
16	32	-	-	-	Sulphur
-	24	-	12	-	-
-	2	-	1	-	-
-	1	0	1	0	-

Answers 4.2

1. Its electronic configuration is 2, 5. It can gain 3 electrons to become stable, therefore its valency is 3.

2. Isotopes

3. Mass number of Oxygen = 8 + 8 = 16
Mass number of Sulphur = 16 + 16 = 32

4. 2, 8

5. It will acquire three units of negative charge, i.e. Z^{3-} ion will be formed.

6. Its K shell is fully filled. It can neither lose nor gain or share electrons, so its valency is zero.

7. It is equal to $2n^2 = 2 \times 3^2 = 2 \times 9 = 18$ electrons if it is not a valence shell.

8. 14 denotes mass number, 7 denotes atomic number.

9. Atomic number = 12
Mass number = 12 + 12 = 24

10. Na atom has 11 electrons whereas Na^+ ion has 10 electrons.

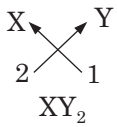
11. It is because each shell is associated with a fixed amount of energy, therefore called as energy levels.

12. It is because it gives out Υ-radiations which have higher energy and it can kill abnormal cancerous cells.

13. $^{14}_{6}C$ is used to determine the age of fossils like mummy.

14. U – 235

15. X(12) 2, 8, 2 Valency = 2
Y(17) 2, 8 7 Valency = 1



XY_2

XY_2 is the formula of the compound.

16. Number of protons = Mass Number – No. of neutrons = 27 – 14 = 13
Number of electron = 13 – 3 = 10

Since it has three units positive charge, therefore the number of protons will be three times more than the number of electrons.

17. These are isotopes because isotopes differ in the number of neutrons.

18. (*c*) They can be either metals or non-metals because metals can lose 1 electron whereas non-metals can gain one electron. Both have valency equal to 1.

19. (*a*) An atom is neutral due to the presence of equal number of electrons and protons.

20. No, both will have the same valency because they have the same atomic number, i.e. same number of valence electrons.

21. It is because very thin sheet of gold metal foil having 1000 atoms can be made out of it because it is highly malleable.

22. It will have unit one positive charge.

23. It will have two units of negative charge.

24.

$^{1}_{1}H$	$^{2}_{1}H(D)$	$^{3}_{1}H(T)$
E =1	E = 1	E = 1
P = 1	P = 1	P = 1
N = 0	N = 1	N = 2

25. $^{35}_{17}Cl$ and $^{37}_{17}Cl$ has the electronic configuration: 2, 8, 7

$^{40}_{18}Ar$ has electronic configuration: 2, 8, 8

$^{40}_{20}Ca$ has electronic configuration: 2, 8, 8, 2

26. Rules for writing of distribution of electrons in various shells for the first 18 elements are as follows:

- Each shell can have maximum number of electrons equal to $2n^2$, where 'n' is shell number.
- The outermost shell (penultimate shell) cannot have more than 8 electrons.
- Each shell is filled up in the step wise manner.

27. Si(14): 2, 8, 4. It can share 4 electrons to become stable, $\therefore$ its valency is 4.
O(8): 2, 6. It can gain 2 electrons to become stable, so its valency is 2.

28. Na^+ ion has $11 - 1 = 10$ electrons
Its electronic configuration is 2, 8
Its K and L shell are full.

29. Average atomic mass of Br:

$$= \frac{79 \times 49.7 + 81 \times 50.3}{100} = \frac{3926.3 + 4074.3}{100} = \frac{8000.6}{100} = 80.00$$

30. Let percentage of $^{16}_{8}X$ be 'x'.

Percentage of $^{16}_{8}X$ will be $100 - x$.

$$\text{Average Atomic mass} = \frac{x \times 16 + (100 - x)\,18}{100}$$

$$16.2 = \frac{16x + 1800 - 18x}{100}$$

$$16x + 1800 - 18x = 1620$$

$$-2x = -180$$

$$x = 90$$

$^{16}_{8}X$ is 90% and $^{16}_{8}X$ is 10%.

31. The name of element is Lithium.

Its electronic configuration is 2, 1 and its

Valency = 1

32. X has mass number 12,

Y has mass number 14.

These two species are isotopes.

33. (*a*) 2, 8, 7.

(*b*) Non-metal, because it can gain 1 electron to become stable.

(*c*) *B* and *C* are isotopes because their atomic numbers are the same, the number of neutrons is different.

(*d*) *A* and *D* are Isobars because mass numbers are same, atomic numbers are different.

34. (*a*) (*i*) Li (3) the 2, 1:

(*ii*) Na (11) the 2, 8, 1:

(*iii*) K (19) 2, 8, 8, 1:

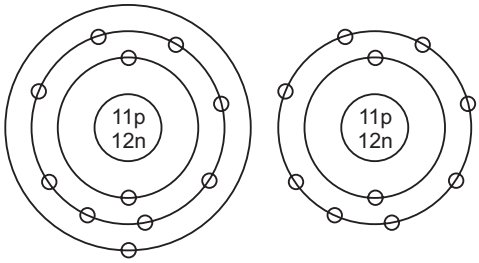
They have the same number of valence electrons.

(*b*) K is most reactive because it is larger in size and it can lose its electrons easily.

35. (*a*) 2, 8, 2 (*b*) 2 + 8 + 2 = 12 (*c*) 12 (*d*) 2

36. No, it is not possible because an atom on the whole is electrically neutral, it must have equal number of electrons and protons. Protons can be more than neutrons only in case of one element, i.e. hydrogen which has one proton but no neutrons.

37.



Na(11): 2, 8, 1 Na^{+}(11): 2, 8

Atomic number of Na^{+} ion remains 11 which is equal to the number of protons and not equal to the number of electrons in the case of ion.

38. No. of α-particle deflected at angle > 50° = 1%

No. of α-particle deflected at angle < 50° = 99%

Total number of particles:

= 1 mole = 6.022×10^{23}

No. of α-particle deflected at angle < 50°

$$= \frac{99 \times 6.022 \times 10^{23}}{100} = 5.96 \times 10^{23} \propto\text{-particles}$$

39. Electrons distribution is: 2, 8, 8, 2 and Valency = 2

40. (*i*) Atomic number of electrons = 8

(*ii*) No charge, ∵ No. of protons (P) = No. of protons (E)

41. 2, 8, 8

Its outermost shell is fully filled, i.e. its octet is complete.

42. Cl (17): 2, 8, 7. Its valency is 1 ∵ it can gain one electron to become stable.

S(16): 2, 8, 6. Its valency is 2, ∵ it can gain 2 electrons to become stable. Mg(12): 2, 8, 2 and its valency is to 2, ∵ it can lose 2 electrons to become stable.

43. (*i*) **Atomic number** is equal to the number of protons present in the nucleus of an atom. It is denoted by '**Z**'. It is also equal to the number of electrons in case of a neutral gaseous atom. *e.g.* $^{40}_{20}Ca$ has atomic number (Z) = 20.

(*ii*) **Mass number** is equal to the sum of the total number of protons and neutrons. It is denoted by '**A**'. $A = n_N + n_P$

For example an element 'Cl' has:

$n_N = 18$

$n_P = 17 \quad \therefore \quad n_E = 17$

$\because \quad Z = n_A \Rightarrow 17$

$\because \quad A = n_N + n_P \Rightarrow 18 + 17 = 35$

(*iii*) **Isotopes** are the atoms of the same element having different mass numbers but same atomic number, e.g. $^{35}_{17}Cl$ and $^{37}_{17}Cl$.

(*iv*) **Isobars** are those species which have the same mass number but different atomic numbers, e.g. $^{40}_{20}Ca$, and $^{40}_{18}Ar$.

Uses of Isotopes:

- *As a nuclear fuel:* An isotope of uranium (U-235) is used as a nuclear fuel.
- *In medical field:* An isotope of cobalt (Co-60) is used in the treatment of cancer.

44. (*a*) Most of the α-rays passed through it undeviated.

(*b*) Very few rays bounced back in the same path.

(*c*) Some rays will be deviated by larger angles.

45. (*a*) 'A' is a cation because the number of protons is more than the number of electrons.

(*b*) 'D' is an anion because the number of electrons is more than the number of protons.

(*c*) 'B' is an inert gas because it has 8 electrons in its valence shell.

46.

Element	Atomic Number	P	E	N	Mass Number
Na^+	11	11	10	12	23
Ca^{2+}	20	20	18	20	40
Oxygen	8	8	8	8	16

47. (*a*) 6 (*b*) A and B (*c*) D and H (*d*) C

(*e*) G (*f*) H

48. (*a*) Average atomic mass of Cl

$$= \frac{35 \times 75 + 37 \times 25}{100} = \frac{2625 + 925}{100} = \frac{3550}{100} = 35.5$$

(*b*) Any particle in circular orbit will undergo acceleration. During acceleration, charged particle radiates energy and finally fall into the nucleus, i.e. atoms should be highly unstable whereas atoms are quite stable. It means that there is something wrong in Rutherford model of an atom.

49.

Atomic Number	Mass Number	Number of Neutrons	Number of Protons	Number of Electrons	Name of the Atomic Species
9	19	10	9	9	Fluorine
16	32	16	16	16	Sulphur
12	24	12	12	12	Magnesium
1	2	1	1	1	Deuterium
1	1	0	1	0	H^+

Value Based Questions

1. People of village Malasia were suffering from goitre. Dr. Chitranjan told the villagers to take iodised common salt, instead of a normal common salt. Villagers followed his advice and there are no fresh case of goitre in the village.
   (*i*) What values are associated with Dr. Chitranjan?
   (*ii*) Deficiency of which element causes goitre?
   (*iii*) It atomic number of Iodine in 53, what will be its electronic configuration?
2. Ashok's father is suffering from high blood pressure. Ashok advised his father to take less common salt. His father followed his advice and his blood pressure is now under control.
   (*i*) What values are associated with Ashok?
   (*ii*) What are the elements present in common salt?
   (*iii*) Write the electronic configuration of both the elements.

Answers

1. (*i*) He is a helpful person and is concerned about the health of villagers.
   (*ii*) Iodine
   (*iii*) 2, 8, 18, 18, 7
2. (*i*) He is concerned about the health of his father and has sound knowledge of science.
   (*ii*) Na and Cl
   (*iii*) Na (11): 2, 8,1
   Cl (17): 2, 8, 7

IMPORTANT FORMULAE

1. Maximum number of electrons = $2n^2$ where 'n' is the orbit number or energy level.
2. Atomic number (Z) = Number of protons present.
3. Mass number (A) = Number of protons + Number of neutrons
4. Number of electrons = Number of protons in a neutral atom

COMMON ERRORS

Errors	Corrections
• Children do not learn the atomic number of elements.	☞ It is most important for IX as well as X grade-students. Learn atomic number of atleast first 20 elements.
• Children write electronic configuration of K(19) and Ca(20) incorrectly. K (19) 2, 8, 8, 1 and not 2, 8, 9 Ca (20) 2, 8, 8, 2 and not 2, 8, 10	☞ It is because last shell cannot have more than 8 electrons.
• Children calculate the valency of some elements incorrectly.	☞ If valence electrons are 1, 2, 3, 4, then valency is equal to 1, 2, 3, 4. If valence electrons are 5, 6, 7, then valency is 3, 2, 1. If valence electrons are 8, then valency is zero. He (helium) has 2 valence electrons but its valency is zero because its valence shell, i.e. first shell is fully filled.
• Children do not make proper diagrams.	☞ Diagram of Thomson, Rutherford and Bohr's model of atom must be made properly with correct labeling using a pencil.
• Children write wrong atomic number of ions.	☞ Atomic number of ions is same as that of elements because atomic number is equal to the number of protons and not electrons in ions, e.g. Na^+ has atomic number 11 and not 10.
• Children calculate wrong number of electrons in ions.	☞ Positive ions (cations) are formed by loss of electrons. They have protons more than electrons. Negative ions (Anions) are formed by gain of electrons. They have more number of electrons than protons.
• Children do not know the meaning of Isotopes, Isobars, Isoelectronic species, Isotones.	☞ Iso means the same, Isotopes have same atomic number, Isobars have same mass number, Iso–electronic have same number of electrons and Isotones have same number of neutrons.
• Children generally get confused with mass number and atomic mass.	☞ Mass number is equal to the total number of protons and neutrons. It is always in whole number. Atomic mass is the mass of protons and neutrons. It can be in fractions also, e.g. Isotopes of Cl have mass number 35, 37 respectively but its atomic mass is 35.5 *u*.

REVISION CHART