Structure of the Atom

Multiple Choice Questions

1. Which of the following correctly represent the electronic distribution in the Mg atom?

(a) 3, 8, 1
(b) 2, 8, 2
(c) 1, 8, 3
(d) 8, 2, 2

Ans. (b) 2, 8, 2

Explanation: The first shell can have at the most two electrons in it. Hence option 'b' is correct.

2. Rutherford's 'alpha (α) particles scattering experiment' resulted in to discovery of

(a) Electron
(b) Proton
(c) Nucleus in the atom
(d) Atomic mass

Ans. (c) Nucleus in the atom

Explanation: The observation that some alpha particles returned on their original path showed the presence of nucleus in the centre of an atom.

3. The number of electrons in an element X is 15 and the number of neutrons is 16. Which of the following is the correct representation of the element?

(a) ${}^{31}_{15}\mathrm{X}$
(b) ${}^{31}_{16}\mathrm{X}$
(c) ${}^{16}_{15}\mathrm{X}$
(d) ${}^{15}_{16}\mathrm{X}$

Ans. (a) ${}^{31}_{15}\mathrm{X}$

Explanation: Atomic number (no. of electrons) is written in subscript, while mass number is written in superscript; before the symbol of element.

4. Dalton's atomic theory successfully explained

(i) Law of conservation of mass
(ii) Law of constant composition
(iii) Law of radioactivity
(iv) Law of multiple proportion
(a) (i), (ii) and (iii)
(b) (i), (iii) and (iv)
(c) (ii), (iii) and (iv)
(d) (i), (ii) and (iv)

Ans. (d) (i), (ii) and (iv)

Explanation: Dalton's theory explained the law of conservation of mass, law of constant composition and law of multiple proportions. But the theory did not talk about law of ratio activity.

5. Which of the following statements about Rutherford's model of atom are correct?
(i) considered the nucleus as positively charged
(ii) established that the α–particles are four times as heavy as a hydrogen atom
(iii) can be compared to solar system
(iv) was in agreement with Thomson's model
(a) (i) and (iii)
(b) (ii) and (iii)
(c) (i) and (iv)
(d) only (i)

Ans. (a) (i) and (iii)
Explanation: Alpha particles are positively charged and hence were deflected by the nucleus. This showed that nucleus is positively charged. Rutherford also postulated that electrons are arranged around the nucleus; the way planets are arranged around the sun.

6. Which of the following are true for an element?
(i) Atomic number = number of protons + number of electrons
(ii) Mass number = number of protons + number of neutrons
(iii) Atomic mass = number of protons = number of neutrons
(iv) Atomic number = number of protons = number of electrons
(a) (i) and (ii)
(b) (i) and (iii)
(c) (ii) and (iii)
(d) (ii) and (iv)

Ans. (d) (ii) and (iv)
Explanation: Atomic number = number of protons = number of electrons. Since electron has negligible mass; so, masses of protons and neutrons are taken into account for mass number.

7. In the Thomson's model of atom, which of the following statements are correct?
(i) the mass of the atom is assumed to be uniformly distributed over the atom
(ii) the positive charge is assumed to be uniformly distributed over the atom
(iii) the electrons are uniformly distributed in the positively charged sphere
(iv) the electrons attract each other to stabilize the atom
(a) (i), (ii) and (iii)
(b) (i) and (iii)
(c) (i) and (iv)
(d) (i), (iii) and (iv)

Ans. (a) (i), (ii) and (iii)
Explanation: Thomson proposed that negatively charge electrons are stabilized by positively charged nucleus. Hence, option (iv) is not correct. Rest of the options are correct.

8. **Rutherford's α–particle scattering experiment showed that**
(i) electrons have negative charge
(ii) the mass and positive charge of the atom is concentrated in the nucleus
(iii) neutron exists in the nucleus
(iv) most of the space in atom is empty
Which of the above statements are correct?
(a) (i) and (iii)
(b) (ii) and (iv)
(c) (i) and (iv)
(d) (iii) and (iv)

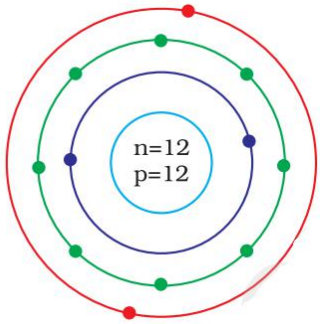
Ans. **(b)** (ii) and (iv)

9. **The ion of an element has 3 positive charges. Mass number of the atom is 27 and the number of neutrons is 14. What is the number of electrons in the ion?**
(a) 13
(b) 10
(c) 14
(d) 16

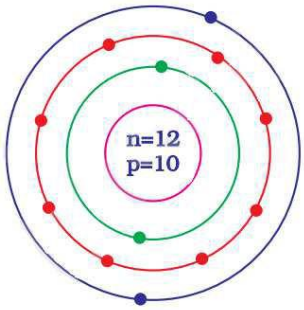
Ans. **(b)** 10
Explanation: Mass number = 27 and number of neutrons = 14
Hence, number of electrons in atom = 27 – 14 = 13
Now, ion has 3 positively charges, so number of electrons in the ion = 13 – 3 = 10

10. **Identify the Mg^{2+} ion from the Fig.4.1 where, n and p represent the number of neutrons and protons respectively**

(a)



(b)



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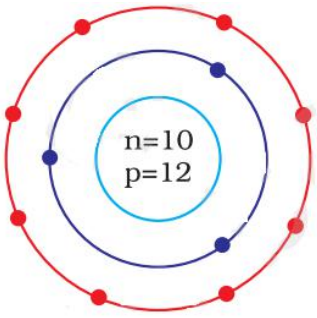
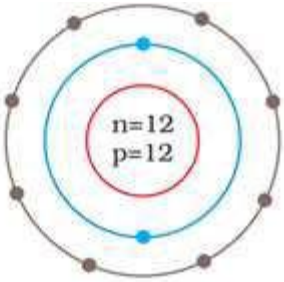


(d)



Ans. **(d)**
Explanation: Electronic configuration of Mg atom is: 2, 8, 2
So, electronic configuration of Mg^{2+} ion is; 2, 8.

11. **In a sample of ethyl ethanoate (CH3COOC2H5) the two oxygen atoms have the same number of electrons but different number of neutrons. Which of the following is the correct reason for it?**
(a) One of the oxygen atoms has gained electrons
(b) One of the oxygen atoms has gained two neutrons
(c) The two oxygen atoms are isotopes
(d) The two oxygen atoms are isobars.

Ans. **(c)** The two oxygen atoms are isotopes
Explanation: Isotopes are elements with same atomic number but different mass numbers. The different in mass number is because of different number of neutrons in them.

12. **Elements with valency 1 are**
(a) always metals
(b) always metalloids
(c) either metals or non-metals
(d) always non-metals

Ans. **(c)** either metals or non-metals
Explanation: If an element show positive valency then it is a metal; otherwise it is a non-metal.

13. **The first model of an atom was given by**
(a) N. Bohr
(b) E. Goldstein
(c) Rutherford

(d) J.J. Thomson

Ans. **(d)** J.J. Thomson

14. **An atom with 3 protons and 4 neutrons will have a valency of**

(a) 3
(b) 7
(c) 1
(d) 4

Ans. **(c)** 1

Explanation: Electronic configuration of this element: 2, 1
Since number of electron in outermost shell is 1, hence valency is 1.

15. **The electron distribution in an aluminium atom is**

(a) 2, 8, 3
(b) 2, 8, 2
(c) 8, 2, 3
(d) 2, 3, 8

Ans. **(a)** 2, 8, 3

Explanation: Atomic number of aluminium is 13 and the first shell can have at the most two electrons in it only. Hence option (a) is correct.

16. **Which of the following in Fig. 4.2 do not represent Bohr's model of an atom correctly?**

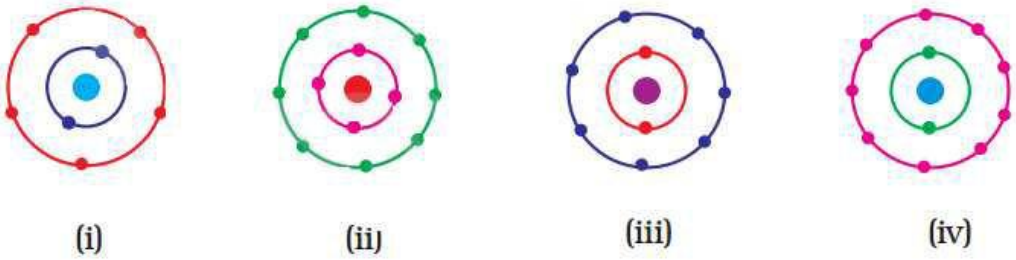


Fig. 4.2

(a) (i) and (ii)
(b) (ii) and (iii)
(c) (ii) and (iv)
(d) (i) and (iv)

Ans. **(c)** (ii) and (iv)

Explanation: The second shell cannot have more than 88 electrons and first shell cannot have more than 2 electrons.

17. **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.

Ans. **(a)** An atom has equal number of electrons and protons.

18. Atomic models have been improved over the years. Arrange the following atomic models in the order of their chronological order

(i) Rutherford's atomic model
(ii) Thomson's atomic model
(iii) Bohr's atomic model
(a) (i), (ii) and (iii)
(b) (ii), (iii) and (i)
(c) (ii), (i) and (iii)
(d) (iii), (ii) and (i)

Ans. **(c)** (ii), (i) and (iii)

Structure of the Atom

Short Answer Questions

19. Is it possible for the atom of an element to have one electron, one proton and no neutron. If so, name the element.

Ans. Yes, it is true for hydrogen atom which is represented as $^{1}_{1}H$

20. Write any two observations which support the fact that atoms are divisible.

Ans. Discovery of electrons and protons

21. Will ^{35}Cl and ^{37}Cl have different valencies? Justify your answer.

Ans. They are isotopes. Isotopes have same number of electrons in them. Hence, their valencies do not differ.

22. Why did Rutherford select a gold foil in his α–ray scattering experiment?

Ans. Gold is highly malleable. Hence, it can be made into very thin sheet. Rutherford wanted a metal sheet which could be as thin as possible. So, he selected gold foil for his alpha-ray scattering experiment.

23. Find out the valency of the atoms represented by the Fig. 4.3 (a) and (b).

Fig. 4.3

Ans. Atom 'a' has zero valency; while atom 'b' has a valency of 1.

24. One electron is present in the outer most 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 outer most shell?

Ans. Single and positive charge (+1).

25. Write down the electron distribution of chlorine atom. How many electrons are there in the L shell? (Atomic number of chlorine is 17).

Ans. 2, 8, 7. The L shell has eight electrons

26. 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, then what would be the charge on the ion so formed?

Ans. This element needs to gain two electrons in order to acquire noble gas configuration. So, the charge on ion would be – 2.

27. What information do you get from the Fig. 4.4 about the atomic number, mass number and valency of atoms X, Y and Z? Give your answer in a tabular form.

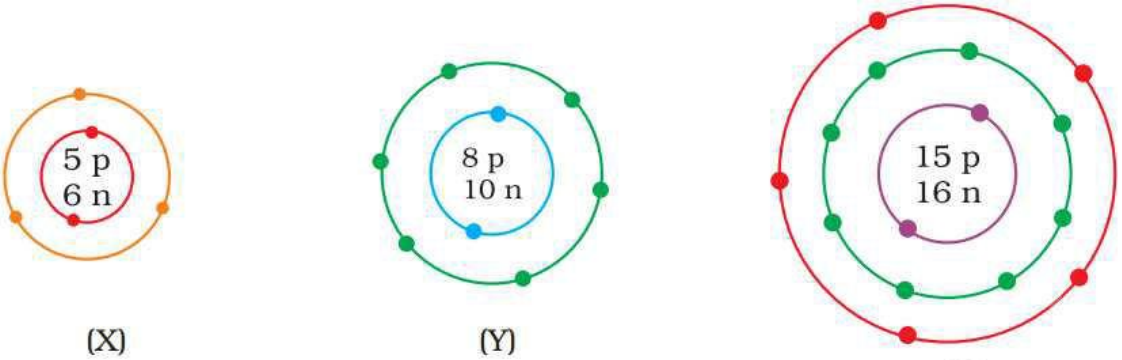


Fig. 4.4

Ans.

	Atomic No.	Mass no.	Valency
X	5	11	3
Y	8	18	2
Z	15	31	3, 5

28. 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.

Ans. Student is giving wrong statement. Number of protons can never be more than that of neutrons. It can be equal to or less than the number of neutrons. Number of electrons and protons is always equal in an atom.

29. Calculate the number of neutrons present in the nucleus of an element X which is represented as ${}^{31}_{15}X$.

Ans. Mass number = No. of protons + No. of neutrons = 31

$\therefore$ Number of neutrons = 31 – number of protons

= 31 – 15 = 16

30. Match the names of the Scientists given in column A with their contributions towards the understanding of the atomic structure as given in column B

Column A	Column B
(a) Ernest Rutherford	(i) Indivisibility of atoms
(b) J.J. Thomson	(ii) Stationary orbits
(c) Dalton	(iii) Concept of nucleus
(d) Neils Bohr	(iv) Discovery of electrons
(e) James Chadwick	(v) Atomic number
(f) E. Goldstein	(vi) Neutron
(g) Mosley	(vii) Canal rays

Ans. (a) (iii)
(b) (iv)
(c) (i)
(d) (ii)
(e) (vi)
(f) (vii)
(g) (v)

31. The atomic number of calcium and argon are 20 and 18 respectively, but the mass number of both these elements is 40. What is the name given to such a pair of elements?

Ans. Elements with same mass number and different atomic numbers are called isobars.

32. Complete the Table 4.1 on the basis of information available in the symbols given below

(a) $^{35}_{17}CI$

(b) $^{12}_{6}C$

(c) $^{81}_{35}Br$

Element	n_p	n_n

Ans.

Element	n_p	n_n
CI	17	18
C	6	6
Br	35	46

33. Helium atom has 2 electrons in its valence shell but its valency is not 2, Explain.

Ans. Helium atom has 2 electrons in its outermost shell and its duplet is complete. Hence the valency is zero.

34. Fill in the blanks in the following statements

(a) Rutherford's α-particle scattering experiment led to the discovery of the _____.

Ans. atomic nucleus

(b) Isotopes have same _____ but different _____.

Ans. atomic number, mass number

(c) Neon and chlorine have atomic numbers 10 and 17 respectively. Their valencies will be _____ and _____ respectively.

Ans. 0 and 1.

(d) The electronic configuration of silicon is _____ and that of Sulphur is _____.

Ans. Silicon—2, 8, 4, Sulphur— 2, 8, 6

35. An element X has a mass number 4 and atomic number 2. Write the valency of this element?

Ans. Valency is zero as K shell is completely filled.

Structure of the Atom

Long Answer Questions

36. Why do Helium, Neon and Argon have a zero valency?

Ans. Helium has two electrons in its only energy shell, while Argon and Neon have 8 electrons in their valence shells. As these have maximum number of electrons in their valence shells, they do not have any tendency to combine with other elements. Hence, they have a valency equal to zero.

37. The ratio of the radii of hydrogen atom and its nucleus is ~ 10^5. Assuming the atom and the nucleus to be spherical, (i) what will be the ratio of their sizes? (ii) If atom is represented by planet earth 'R_e' = 6.4 ×10^6 m, estimate the size of the nucleus.

Ans. (i) Volume of the sphere $= \frac{4}{3}\pi r^3$

Let R be the radius of the atom and r be that of the nucleus.

$\Rightarrow R=10^5 r$

Volume of the atom $= \frac{4}{3}\pi R^3 = \frac{4}{3}\pi(10^5 r)^3 \quad (\because R=10^5 r)$

$= \frac{4}{3}\pi r^3 \times 10^{15}$

Volume of the nucleus $= \frac{4}{3}\pi r^3$

Ratio of the size of atom to that of nucleus $= \frac{\frac{4}{3}\times 10^{15}\times \pi r^3}{\frac{4}{3}\pi r^3} = 10^{15}$

(ii) If the atom is represented by the planet earth $(R_e = 6.4\times 10^6 \text{ m})$ then the radius of the nucleus would be $r_n = \frac{R_e}{10^5}$

$r_n = \frac{6.4\times 10^6 m}{10^5}$

$= 6.4\times 10m$

= 64 m.

38. Enlist the conclusions drawn by Rutherford from his α-ray scattering experiment

Ans. Rutherford concluded from the α-particle scattering experiment that–

(i) Most of the space inside the atom is empty because most of the α-particles passed through the gold foil without getting deflected.

(ii) Very few particles were deflected from their path, indicating that the positive charge of the atom occupies very little space.

(iii) A very small fraction of α-particles were deflected by 180^o, indicating that all the positive charges and mass of the gold atom were concentrated in a very small volume within the atom.
From the data he also calculated that the radius of the nucleus is about 10^5 times less than the radius of the atom.

39. In what way is the Rutherford's atomic model different from that of Thomson's atomic model?

Ans. Rutherford proposed a model in which electrons revolve around the nucleus in well-defined orbits. There is a positively charged centre in an atom called the nucleus. He also proposed that the size of the nucleus is very small as compared to the size of the atom and nearly all the mass of an atom is centred in the nucleus. Whereas, Thomson proposed the model of an atom to be similar to a christmas pudding. The electrons are studded like currants in a positively charged sphere like christmas pudding and the mass of the atom was supposed to be uniformly distributed.

40. What were the drawbacks of Rutherford's model of an atom?

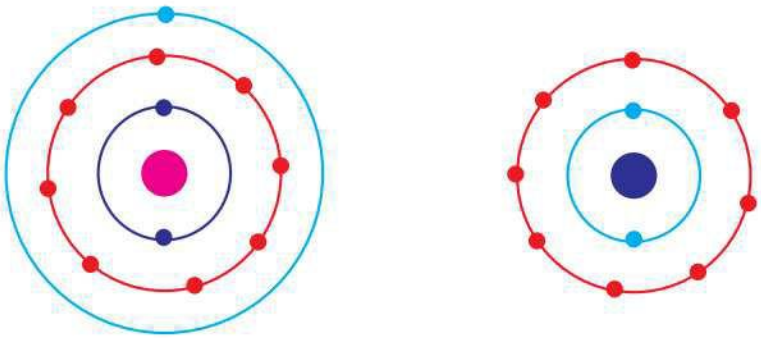
Ans. The orbital revolution of the electron is not expected to be stable. Any particle in a circular orbit would undergo a acceleration and the charged particles would radiate energy. Thus, the revolving electron would lose energy and finally fall into the nucleus. If this were so, the atom should be highly unstable and hence matter would not exist in the form that we know.

41. What are the postulates of Bohr's model of an atom?

Ans. The postulates put forth by Neils Bohr's about the model of an atom:
(i) Only certain special orbits known as discrete orbits of electrons, are allowed inside the atom.
(ii) While revolving in discrete orbits the electrons do not radiate energy.
These orbits are called energy levels. Energy levels in an atom are shown by circles.
These orbits are represented by the letters K, L, M, N, … or the numbers, n = 1, 2, 3, 4, ….

42. Show diagramatically the electron distributions in a sodium atom and a sodium ion and also give their atomic number.

Ans.



Sodium atom Sodium ion

Since the atomic number of sodium atom is 11, it has 11 electrons. A positively charged sodium ion (Na^+) is formed by the removal of one electron from a sodium atom. So, a sodium ion has 11–1 = 10 electrons in it. Thus, electronic distribution of sodium ion will be 2, 8. The atomic number of an element is equal to the number of protons in its atom. Since, sodium atom and sodium ion contain the same number of protons, therefore, the atomic number of both is 11.

43. In the Gold foil experiment of Geiger and Marsden, that paved the way for Rutherford's model of an atom, ~ 1.00% of the α-particles were found to deflect at angles > 50^0. If one mole of α-particles were bombarded on the gold foil, compute the number of α-particles that would deflect at angles less than 50^0.

Ans. % of α-particles deflected more than 50^0 =1% of α-particles.

% of α-particles deflected less than 50^0 =100–1 = 99%

Number of α-particles bombarded = 1 mole $= 6.022 \times 10^{23}$ particles

Number of particles that deflected at an angles less than 50^0

$$= \frac{99}{100} \times 6.022 \times 10^{23}$$

$$= \frac{596.178}{100} \times 10^{23}$$

$$= 5.96 \times 10^{23}$$