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SOLUTIONS BOOK

CLASS 9

Science · Exploration

CHAPTER 8

Journey Inside the Atom

Complete Questions and Activities Solutions

In-text Questions | Revise, Reflect, Refine | The Journey Beyond

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Every question is followed by its answer. Question numbers above are clickable and the PDF bookmarks panel lets you jump to any exercise set or question. Figures are reproduced from the NCERT textbook (© NCERT) for educational use.

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8.1

CLASS 9 SCIENCE · CHAPTER 8

In-text Questions

Solutions · 35 questions

Directions (Questions 1–35): These are the questions that appear inside the chapter (Think It Over, Pause and Ponder, Ready to Go Beyond, Think as a Scientist, What if … and the questions asked in the text), numbered in the order in which they appear. Open-ended questions are given model answers based on the chapter.

QUESTION 1 *Opening picture · p. 140*

Take a closer look at the picture given above. What do you observe? Do you notice that both living beings, like us, and non-living things, like a house, are ultimately composed of atoms?

ANSWER

The picture shows two chains that start from familiar things and end at the same place in the centre: **atoms**.

a What the picture shows

	Living being	Non-living thing
Starts from	Human body	House
Then	Organ → tissue → cell	Room → wall → brick
Made of	Protein	Silicates
Ends in	**Atoms** (C, H, O, N, P …)	**Atoms** (Si, O …)

Both chains end in atoms. Atoms are so tiny that they cannot be seen with the naked eye.

Therefore, yes: both living beings and non-living things are ultimately composed of atoms.

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QUESTION 2 *Think It Over · p. 140*

(i) Are atoms the smallest indivisible particles? (ii) Why do electrons not fall into the nucleus even though they are attracted to protons in it? (iii) Why did scientists keep modifying atomic models?

ANSWER

These three questions are answered step by step in the chapter. Here is a short answer to each.

i Are atoms indivisible?

No. Some elements emit radiation (radioactivity), which showed that atoms are made of smaller particles. Thomson discovered the electron (1897), Rutherford the proton and Chadwick the neutron (1932).

ii Why do electrons not fall into the nucleus?

In Rutherford’s model an orbiting electron is constantly accelerating, so it should lose energy and spiral into the nucleus. Bohr explained that electrons move only in fixed shells (stationary states) with a definite energy and **do not lose energy** while in them, so they do not collapse into the nucleus.

iii Why were atomic models modified?

Model	Could explain	Could not explain
Dalton (1808)	Atoms as the building blocks of matter	That atoms contain smaller particles
Thomson (1897)	Electrons in a neutral atom	Gold foil experiment results
Rutherford (1911)	Gold foil results; a small dense nucleus	Stability of the atom
Bohr (1913)	Stability of the atom	Later found to have limitations too

Therefore, models were modified whenever new experiments gave evidence that the existing model could not explain.

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QUESTION 3 *After Dalton's theory · p. 141*

What are atoms made up of? What would atoms look like if we could see them? What makes the atoms of one element different from the atoms of another element?

ANSWER

Dalton's theory raised these three questions. The rest of the chapter answers them.

a What are atoms made up of?

Atoms are made of three subatomic particles: **electrons**, **protons** and **neutrons**. Protons and neutrons are in the nucleus; electrons move around it.

b What would atoms look like?

An atom has a tiny, dense, positively charged nucleus at the centre, with electrons moving around it in shells (Bohr's model); most of the atom is empty space. Atoms do not show any colour; the colours in diagrams are only for illustration.

c What makes one element different from another?

Atoms of different elements differ in the number of protons (and electrons). The number of protons is the **atomic number** (Z), which determines the identity of the element.

Therefore, atoms are made of electrons, protons and neutrons, and the atomic number makes one element different from another.

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QUESTION 4 *Pause and Ponder 1 · p. 143*

Suppose you made up your own ‘atom’, as Thomson described, using clay for the positive charge and small beads for the electrons spread through it. What will happen if: (i) the positive charge on the clay is lesser than the total negative charge of the beads? (ii) by mistake, the clay itself carries a bit of negative charge? Would your model still represent a neutral atom?

ANSWER

An atom is neutral only when its total positive charge equals its total negative charge. In Thomson’s model the clay supplies the positive charge and the beads the negative charge.

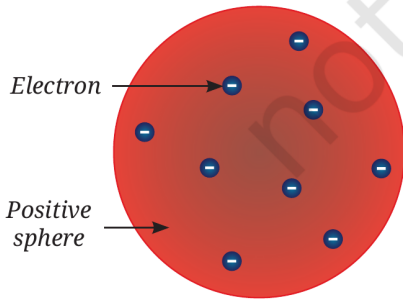


Fig. 8.2: Thomson’s model of an atom

i Positive charge less than the negative charge

The negative charge of the beads would be more than the positive charge of the clay, so the model would carry a **net negative charge**. It would not be neutral.

ii Clay carrying a bit of negative charge

Then the “positive sphere” would not be fully positive and the clay and the beads would both be negative. The model would be negatively charged, so it would **not** represent a neutral atom.

Therefore, the model represents a neutral atom only if the positive charge of the clay exactly balances the negative charge of the beads.

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QUESTION 5 *Pause and Ponder 2 · p. 143*

Could an orange or a lemon, which also contain seeds inside soft pulp, be a good comparison? In what ways does it match Thomson’s idea and where does it fall short?

ANSWER

An orange or a lemon is similar to the watermelon picture used in the chapter: seeds spread through soft pulp.

a Where the comparison matches

- The pulp is like the positively charged sphere and the seeds are like the electrons.
- The seeds are spread through the pulp, as electrons are spread throughout the positive sphere.

b Where it falls short

- Pulp and seeds carry no electric charge, so the fruit cannot show how positive and negative charges balance.
- An orange has a peel and separate segments, but the positive sphere of the atom is a single sphere.
- Seeds are large compared with the fruit, whereas electrons are extremely tiny.
- The model explains nothing about the gold foil results, which is why Thomson’s model was later replaced.

Therefore, an orange or a lemon is a useful picture of Thomson’s plum pudding idea, but it cannot show charge balance or explain later experiments.

QUESTION 6 *Pause and Ponder 3 · p. 143*

Why did Thomson conclude that electrons are present in all atoms?

ANSWER

Thomson passed a high voltage through a gas at very low pressure in a glass tube and studied the cathode rays (Fig. 8.1).

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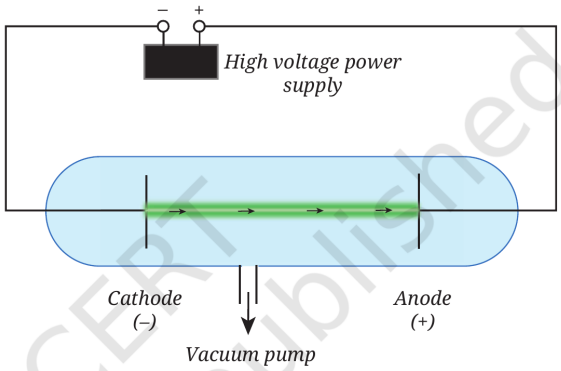


Fig. 8.1: A line diagram of cathode ray tube

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a The evidence

- The cathode rays were streams of negatively charged particles with a much smaller mass than atoms.
- The nature of the cathode rays was **independent of the material of the cathode** and of the gas filled in the tube.

b The conclusion

Whatever the material or the gas, the same negatively charged particles (electrons) were obtained. So electrons must be a fundamental component of all atoms, present in every element.

Therefore, since cathode rays were the same for every cathode material and gas, Thomson concluded that electrons are present in all atoms.

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QUESTION 7 *Ready to Go Beyond · p. 144*

Can you calculate how many atoms would be needed to make a sheet of paper that is 0.1 mm thick, like the one in your textbook?

ANSWER

We stack atoms one above the other until the thickness of the sheet is reached. The number of atoms is the thickness divided by the diameter of one atom.

a Calculation

Diameter of one atom $\approx 10^{-10}$ m

Thickness of sheet = 0.1 mm = 0.1×10^{-3} m = 10^{-4} m

Number of atoms $\approx (10^{-4}\text{ m}) \div (10^{-10}\text{ m}) = 10^{-4-(-10)} = 10^{6}$

Therefore, about 10^6 (one million) atoms must be stacked to make a sheet of paper 0.1 mm thick.

QUESTION 8 *Think as a Scientist · p. 144*

Observe Fig. 8.4 of the gold foil experiment. Predict the observations you would expect if the gold foil in the experiment were made thicker. Also, draw a simple diagram to show the observations you expect.

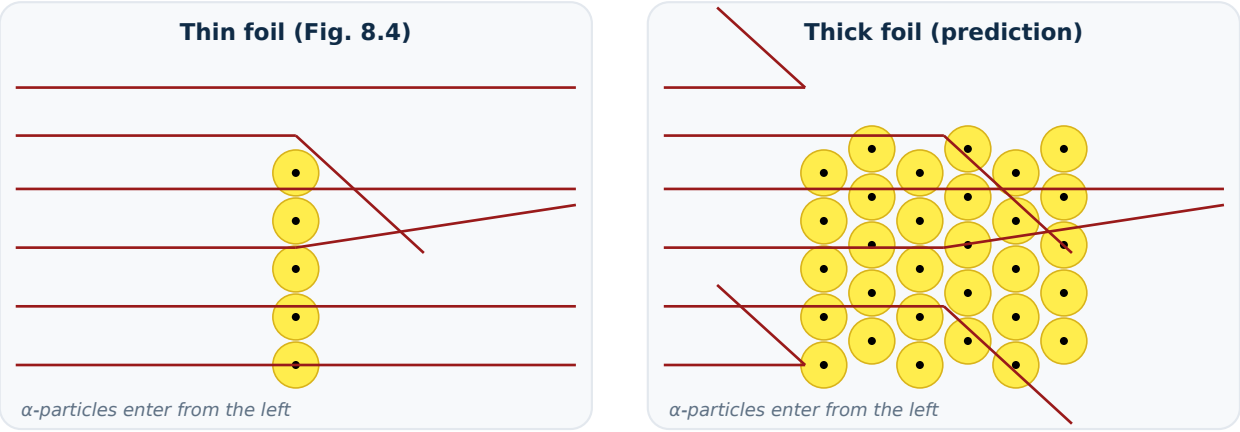
ANSWER

Use the hint: a thicker foil has many more layers of gold atoms, so an α-particle meets many more nuclei on its way.

a Prediction

- Most atoms are empty space, so a good number of α-particles would still pass through.
- But fewer α-particles would pass undeflected, because the chance of coming near a nucleus is higher.
- More α-particles would be deflected, many through large angles, and more would bounce back.

b Diagram



More layers of atoms → more chances of hitting a nucleus → more α-particles scattered (some bounce back)

Therefore, with a thicker foil we expect more scattering: fewer particles pass straight through and more are deflected or bounced back.

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QUESTION 9 *Pause and Ponder 4 · p. 144*

What do you think would happen if α-particles were replaced with negatively charged particles in Rutherford’s gold foil experiment?

ANSWER

α-particles are positively charged and were **repelled** by the positive nucleus. Negatively charged particles would be **attracted** by it.

a What we would expect

- Most particles would still pass through, because most of the atom is empty space.
- Particles passing close to the nucleus would be bent **towards** the nucleus, instead of being pushed away from it.
- The sharp bounce-back caused by repulsion would not be seen in the same way.

Therefore, the pattern of deflection would change: opposite charges attract, so the particles would bend towards the nucleus rather than away from it.

QUESTION 10 *Pause and Ponder 5 · p. 144*

Rutherford found that a few α-particles bounced back sharply. How does this single surprising result completely rule out Thomson’s ‘plum pudding model’ of the atom?

ANSWER

In Thomson’s model the positive charge is spread evenly over the whole atom, so no part of the atom is strongly positive or heavy.

a Why bouncing back rules it out

- With evenly spread positive charge, α-particles were expected to pass straight through or be deflected only slightly.
- To make an α-particle bounce back, there must be a strong repulsive force from a very small, heavy, positively charged region.
- Such a region does not exist in the plum pudding model.

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Therefore, a few α-particles bouncing back show that the positive charge and most of the mass are concentrated in a tiny nucleus, which the plum pudding model cannot explain.

QUESTION 11 *Pause and Ponder 6 · p. 144*

If you could ask Rutherford one question about his work, what would it be?

ANSWER

This is an open question. Two model questions, with the answers that the chapter gives, are shown below.

a Model questions

Question to Rutherford	Answer from the chapter
Why do the electrons orbiting the nucleus not lose energy and fall into it?	Bohr (1913) explained it: electrons move in fixed shells (stationary states) and do not lose energy there.
Is there anything else in the nucleus besides protons?	Yes. Chadwick discovered neutrons in 1932; they add mass without adding charge.

Therefore, a good question points to something the model could not explain; such questions led to Bohr's model and the discovery of the neutron.

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QUESTION 12 *Pause and Ponder 7 · p. 145*

Assertion (A): Rutherford concluded that most of the mass of an atom is concentrated in a small region at the centre called the nucleus. Reason (R): According to Thomson's model, electrons are embedded in a uniformly distributed positive charge sphere. Choose the correct option: (i) Both A and R are true, and R is the correct explanation of A. (ii) Both A and R are true, but R is not the correct explanation of A. (iii) A is true, but R is false. (iv) A is false, but R is true.

ANSWER

Check A and R separately, and then check whether R explains A.

a **Checking the statements**

- **A is true.** Rutherford concluded that the nucleus is dense and contains most of the mass of the atom.
- **R is true.** In Thomson's model electrons are embedded in a uniformly distributed positive sphere.
- **R does not explain A.** A uniformly distributed positive charge is the opposite of a concentrated nucleus; Rutherford's conclusion came from the gold foil experiment.

Correct option: (ii) Both A and R are true, but R is not the correct explanation of A.

QUESTION 13 *Threads of Curiosity · p. 146*

Why are Bohr's shells called K, L, M, N… and not, A, B, C, D?

ANSWER

The naming comes from early X-ray experiments, not from Bohr's own choice.

- The physicist Charles Barkla called the first observed X-ray line K.
- He did not start from A, to leave room for a possible series earlier than the K series. None was ever found.
- Bohr adopted the same notation for atomic shells.

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Therefore, the shells are called K, L, M, N… because Barkla's X-ray lines were named from K, and Bohr kept that notation.

QUESTION 14 *What if … · p. 147*

An atom had no empty space? How would this have affected the size of various objects?

ANSWER

The diameter of an atom is about 10^{-10} m and that of the nucleus is about 10^{-15} m, so the nucleus is about 10^{5} times smaller than the atom. Almost all the volume of an atom is empty space.

a Effect on size

Ratio of diameters = $10^{-10} \div 10^{-15} = 10^{5}$

Length of an object would become 10^{5} times smaller

Example: a 1.5 m tall person would be about $1.5 \div 10^{5}$ m = 1.5×10^{-5} m ≈ 0.015 mm

Their volume would shrink by $(10^{5})^{3} = 10^{15}$ times, while their mass would stay almost the same, so objects would be unimaginably dense.

Therefore, if atoms had no empty space, all objects would be about 100 000 times smaller in length (and extremely dense).

QUESTION 15 *Threads of Curiosity · p. 147*

You may wonder that since all the protons with like charges are squished together in a nucleus why do they not push each other away?

ANSWER

Every proton repels every other proton because they all carry positive charge. Neutrons keep the nucleus together.

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a Role of neutrons

- Neutrons are neutral. By coming in between the protons they increase the distance between them and reduce the repulsion.
- They also strengthen the **nuclear force** that binds all the particles of the nucleus together.

b Why heavier atoms need more neutrons

Atom	Protons	Neutrons
Carbon	6	6
Oxygen	8	8
Iron	26	30
Uranium	92	146

Therefore, neutrons reduce the repulsion between protons and strengthen the nuclear force, so heavier atoms need many more neutrons.

QUESTION 16 *India's Scientific Contributions · p. 148*

Research and explore more about Dhruva!

ANSWER

This is a research task. The points below come from the chapter and show what to look for.



Fig. 8.8: Bhabha Atomic Research Centre

a What the chapter tells us

- Dhruva is a reactor at the Bhabha Atomic Research Centre (BARC), Mumbai.
- BARC uses reactors such as Dhruva for advanced **neutron-scattering** experiments.

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- These experiments have given insights into materials such as superconductors, battery electrodes and drug molecules.
- This helps develop better medicines, energy storage and industrial alloys.

b Points to research further

- What is a research reactor and how does it produce neutrons?
- How does neutron scattering reveal the arrangement of atoms in a material?

Therefore, neutrons from reactors such as Dhruva help scientists study materials, which supports medicine, energy storage and industry.

QUESTION 17 *Pause and Ponder 8 · p. 149*

Imagine you are a scientist who has discovered a new element. Name this element after yourself and justify that the symbol you have chosen follows the IUPAC rules.

ANSWER

Model answer with an imaginary scientist named Ravi. Use your own name in the same way.

Name of the element: Ravium
Symbol: Rv

a Why the symbol follows the rules

- The first letter R is written as a capital letter and the second letter v as a small letter.
- The symbol has two letters. “Ra” (the first two letters) is already used for radium, so the first letter R and another letter v of the name are used, as in Cl for chlorine and Zn for zinc.
- The name and symbol would be approved by IUPAC before being accepted.

Therefore, Rv (Ravium) follows the rules: capital first letter, small second letter, and letters taken from the name.

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QUESTION 18 *Pause and Ponder 9 · p. 149*

What problems could arise if every scientist used different symbols for the same element?

ANSWER

Symbols are a common language of science. Different symbols for the same element would break that language.

a **Problems**

- Scientists in different countries could not understand each other's results and formulae.
- The same element might be mistaken for different elements, or two elements for one, causing errors in experiments.
- Students would have to learn many symbols for one element.

Internationally recognised symbols approved by IUPAC allow scientists worldwide to communicate clearly, regardless of language barriers.

Therefore, a single set of symbols is needed so that everyone in the world can communicate clearly.

QUESTION 19 *Think about it · p. 150*

Can you now say that elements with different atomic numbers are distinct from each other, and the atomic number uniquely identifies an element? Observe Fig. 8.10. How many neutrons and protons are present in a lithium atom, and what is its atomic number?

ANSWER

The atomic number is the number of protons in the nucleus. Two atoms with different numbers of protons are atoms of different elements.

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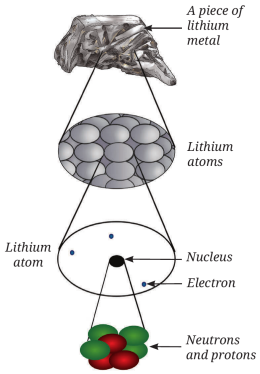


Fig. 8.10: Neutrons and protons in the nucleus

a Lithium (Fig. 8.10 and Table 8.3)

Protons = 3

Neutrons = 4

Atomic number Z = number of protons = 3

Mass number A = 3 + 4 = 7

Therefore, yes, the atomic number uniquely identifies an element. Lithium has 3 protons and 4 neutrons, and its atomic number is 3.

QUESTION 20 *Pause and Ponder 10 · p. 150*

An atom with an atomic number of 26 has 56 nucleons. Find out its number of electrons, protons and neutrons.

ANSWER

Atomic number = number of protons = number of electrons (neutral atom). Nucleons = protons + neutrons = mass number.

Protons = atomic number = 26

Electrons = protons = 26

Neutrons = mass number − protons = 56 − 26 = 30

Therefore, the atom has 26 electrons, 26 protons and 30 neutrons (it is iron).

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QUESTION 21 *Pause and Ponder 11 · p. 150*

The nucleus of an atom contains 20 protons. If its mass number is 41, find the number of neutrons in it.

ANSWER

Mass number = protons + neutrons
Neutrons = 41 − 20 = 21

Therefore, the nucleus contains 21 neutrons.

QUESTION 22 *Pause and Ponder 12 · p. 150*

An atom has 18 neutrons and an atomic number of 17. What is its mass number?

ANSWER

Protons = atomic number = 17
Mass number = protons + neutrons = 17 + 18 = 35

Therefore, the mass number is 35 (the atom is chlorine-35).

QUESTION 23 *Pause and Ponder 13 · p. 150*

An atom ^{23}A has 11 electrons. Find the number of neutrons in it.

ANSWER

The atom is neutral, so the number of protons equals the number of electrons.

Protons = electrons = 11, so atomic number = 11
Mass number = 23
Neutrons = 23 − 11 = 12

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Therefore, the atom has 12 neutrons (it is sodium).

QUESTION 24 *Think about it · p. 151*

Helium contains two protons in its nucleus and two electrons. In which way will the two electrons be arranged in its atomic shell?

ANSWER

Electrons fill the shells in order, starting from the shell closest to the nucleus (K).

K-shell can hold $2 \times 1^2 = 2$ electrons
Helium has 2 electrons → both go into the K-shell
Electronic configuration of helium = 2

Therefore, both electrons of helium are in the K-shell, which is then complete, so helium is stable and largely unreactive.

QUESTION 25 *Pause and Ponder 14 · p. 152*

Identify the number of electrons in the outermost shell of the following elements: (i) ^{12}C (atomic number 6) (ii) ^{19}F (atomic number 9) (iii) ^{28}Si (atomic number 14)

ANSWER

Number of electrons = atomic number. Fill the shells K (2), L (8), M (18 maximum) in order; the last shell holds the outermost electrons.

Element	Electrons	Configuration	Outermost shell electrons
(i) Carbon-12	6	2, 4	**4**
(ii) Fluorine-19	9	2, 7	**7**
(iii) Silicon-28	14	2, 8, 4	**4**

Therefore, the outermost shell has 4 electrons in carbon, 7 in fluorine and 4 in silicon.

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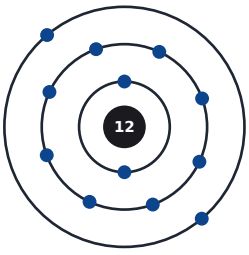
QUESTION 26 *Pause and Ponder 15 · p. 152*

Write the electronic configuration of the elements having atomic numbers 12, 16 and 18.

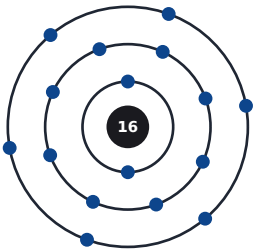
ANSWER

The number of electrons equals the atomic number. The K-shell takes 2, the L-shell 8, and the remaining electrons go to the M-shell.

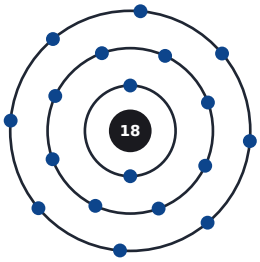
Z = 12 (magnesium): 12 = 2 + 8 + 2 → 2, 8, 2
Z = 16 (sulfur): 16 = 2 + 8 + 6 → 2, 8, 6
Z = 18 (argon): 18 = 2 + 8 + 8 → 2, 8, 8



Mg (Z = 12)
Electrons: 2, 8, 2



S (Z = 16)
Electrons: 2, 8, 6



Ar (Z = 18)
Electrons: 2, 8, 8

Therefore, the configurations are 2, 8, 2 (Z = 12), 2, 8, 6 (Z = 16) and 2, 8, 8 (Z = 18).

QUESTION 27 *Pause and Ponder 16 · p. 152*

Solve this riddle: I am an atom with a mass number of 23 and 11 protons. I am a soft metal and react vigorously with water. Who am I and how many neutrons do I have? You can also create one such riddle.

ANSWER

11 protons means atomic number 11, which is sodium (Na); sodium is a soft metal that reacts vigorously with water.

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Neutrons = mass number − protons = 23 − 11 = 12
Electronic configuration = 2, 8, 1

a A riddle of your own (model)

“I am an atom with 17 protons and 18 neutrons. My mass number is 35 and I need one more electron to complete my octet. Who am I?” Answer: **chlorine** (17 protons, configuration 2, 8, 7; mass number 17 + 18 = 35).

Therefore, I am sodium and I have 12 neutrons.

QUESTION 28 *Think about it · p. 153*

In NH_3 (ammonia) and $MgCl_2$ (magnesium chloride), what will be the combining capacities of nitrogen and magnesium respectively?

ANSWER

The combining capacity of an element is the number of hydrogen or chlorine atoms with which one of its atoms combines (both hydrogen and chlorine have combining capacity one).

Compound	Atoms combined with	Combining capacity
NH_3	One N atom combines with 3 H atoms	**Nitrogen = 3**
$MgCl_2$	One Mg atom combines with 2 Cl atoms	**Magnesium = 2**

Therefore, the combining capacity of nitrogen is 3 and that of magnesium is 2.

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QUESTION 29 *Think about it · p. 153*

Can you predict what happens to the atoms that already have eight electrons in their outermost shell (except the elements with one shell only, where only two electrons are possible)? Will they still try to lose or gain electrons?

ANSWER

An outermost shell with eight electrons is a complete octet (two electrons for helium).

- Atoms with a complete octet are largely **unreactive and more stable**.
- They have no need to lose, gain or share electrons, so their valency is zero.
- Examples: neon (2, 8) and argon (2, 8, 8), and helium (2).

Therefore, no: atoms with a complete octet do not try to lose or gain electrons.

QUESTION 30 *Think about it · p. 153*

Examine Table 8.4. Add one more column to it, and write down the common valency of each element.

ANSWER

Valency is the number of electrons gained, lost or shared to complete the octet. Atoms with fewer than four valence electrons lose them; with more than four they gain; carbon and silicon (four) share. Atoms with a full shell have valency 0.

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Element	Symbol	Configuration (K, L, M)	Valency
Hydrogen	H	1	1
Helium	He	2	0
Lithium	Li	2, 1	1
Beryllium	Be	2, 2	2
Boron	B	2, 3	3
Carbon	C	2, 4	4
Nitrogen	N	2, 5	3
Oxygen	O	2, 6	2
Fluorine	F	2, 7	1
Neon	Ne	2, 8	0
Sodium	Na	2, 8, 1	1
Magnesium	Mg	2, 8, 2	2
Aluminium	Al	2, 8, 3	3
Silicon	Si	2, 8, 4	4
Phosphorus	P	2, 8, 5	3
Sulfur	S	2, 8, 6	2
Chlorine	Cl	2, 8, 7	1
Argon	Ar	2, 8, 8	0

Therefore, the valencies of the first eighteen elements are 1, 0, 1, 2, 3, 4, 3, 2, 1, 0, 1, 2, 3, 4, 3, 2, 1, 0 in that order.

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QUESTION 31 *Think about it · p. 153–154*

Can you say the same regarding the number of neutrons too? Scientists have observed that atoms of the same element can have different numbers of neutrons. What effect does this difference have on the properties of the atom?

ANSWER

The number of protons and electrons is the same for all atoms of an element, but the number of neutrons can differ. Such atoms are isotopes.

a Effect on properties

Property	Effect of different neutrons	Reason
Chemical properties	Same	Same number of electrons and the same electronic configuration (same valence electrons)
Physical properties	Different	Different masses, e.g. different boiling and melting points

Example: carbon-12, carbon-13 and carbon-14 each have six protons and six electrons but 6, 7 and 8 neutrons.

Therefore, no: the number of neutrons can differ; this does not change the chemical properties but does change the physical properties.

QUESTION 32 *Think about it · p. 154*

Naturally occurring hydrogen is a mixture of protium, deuterium and tritium (Fig. 8.12). All of these contain one proton each, whereas deuterium contains one neutron, and tritium contains two neutrons. Can you guess how many electrons each of these isotopes have?

ANSWER

Each atom is neutral, so the number of electrons equals the number of protons, which is 1 in all three.

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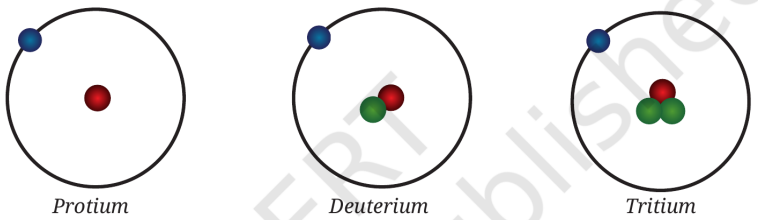


Fig. 8.12: Schematic representation of isotopes of hydrogen

Isotope	Protons	Neutrons	Electrons	Mass number
Protium	1	0	**1**	1
Deuterium	1	1	**1**	2
Tritium	1	2	**1**	3

Therefore, each of the three isotopes of hydrogen has one electron.

QUESTION 33 *Pause and Ponder 17 · p. 156*

Two different atoms have 11 protons each, but one has 12 neutrons, and the other has 13 neutrons. How do their atomic numbers and mass numbers compare? Are they the same element or different elements?

ANSWER

	Atom 1	Atom 2
Protons (atomic number)	11	11
Neutrons	12	13
Mass number = p + n	11 + 12 = 23	11 + 13 = 24

The atomic numbers are the **same** (11) and the mass numbers are **different** (23 and 24). The atomic number identifies the element, so both are atoms of the same element, sodium.

Therefore, they are the same element with different mass numbers; such atoms are called isotopes.

NCERT ARCHIVE

QUESTION 34 *Pause and Ponder 18 · p. 156*

If a 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 the bromine atom.

ANSWER

The average atomic mass is the weighted average: multiply the mass of each isotope by its percent abundance and add.

Average atomic mass = 79 × (49.7 ÷ 100) + 81 × (50.3 ÷ 100)
= 79 × 0.497 + 81 × 0.503
= 39.263 + 40.743
= 80.006 u ≈ 80 u

Check: the answer lies between 79 and 81, and it is very close to 80 because the two isotopes are almost equally abundant.

Therefore, the average atomic mass of bromine is about 80 u.

QUESTION 35 *Think about it · p. 156*

What if two atoms have the same mass number but different atomic numbers? What are such atoms called?

ANSWER

Calcium (Z = 20), potassium (Z = 19) and argon (Z = 18) each have a mass number of 40.

Element	Atomic number (protons)	Neutrons	Mass number
Calcium	20	20	40
Potassium	19	21	40
Argon	18	22	40

Their atoms have the same total number of nucleons (40) but a different number of protons, so they are atoms of different elements.

NCERT ARCHIVE

Therefore, atoms of different elements with the same mass number but different atomic numbers are called isobars.

NCERT ARCHIVE

8.2

CLASS 9 SCIENCE · CHAPTER 8

Revise, Reflect, Refine

Solutions · 15 questions

Directions (Questions 1–15): These are the end-of-chapter questions. Wherever the question asks for a reason or an explanation, the reason is given step by step.

QUESTION 1 *Revise, Reflect, Refine*

Choose the correct options and explain the reason for the correct and incorrect options in the context of Ernest Rutherford's gold foil experiment: (i) The experiment clearly showed the existence of neutrons in the nucleus. (ii) The results disproved the plum pudding model and led to the idea of a nucleus at the centre of the atom. (iii) The large deflection of a few alpha particles indicated that most of the mass of the atom and positive charge are packed into a tiny centre. (iv) The way alpha particles were deflected showed that electrons move around the nucleus.

ANSWER

Correct options: **(ii)** and **(iii)**. Reasons for all four are given below.

Option	Correct?	Reason
(i)	Incorrect	Neutrons were discovered by Chadwick in 1932. The experiment used α-particles to probe the positive charge and did not show neutrons.
(ii)	**Correct**	Thomson's model expected only slight deflections. Sharp deflections and bounce-backs disproved it and led to the idea of a nucleus.
(iii)	**Correct**	Only a very small, heavy, positively charged centre can deflect α-particles by large angles, so the positive charge and most of the mass are packed into a tiny centre.
(iv)	Incorrect	Electrons are far too light to deflect α-particles. The deflections were caused by the nucleus; electrons moving around the nucleus was part of Rutherford's model, not a result of the deflection.

Therefore, options (ii) and (iii) are correct; (i) and (iv) are incorrect.

NCERT ARCHIVE

QUESTION 2 *Revise, Reflect, Refine*

Which of the following statements are correct or incorrect according to the Bohr's atomic model? Give a reason for each statement. (i) Electrons lose energy while moving in fixed orbits and slowly fall into the nucleus. (ii) Electrons can exist anywhere around the nucleus with no fixed energy. (iii) Electrons revolve around the nucleus in orbits of fixed energy without losing energy. (iv) Electrons can be found between energy levels as they move around the nucleus.

ANSWER

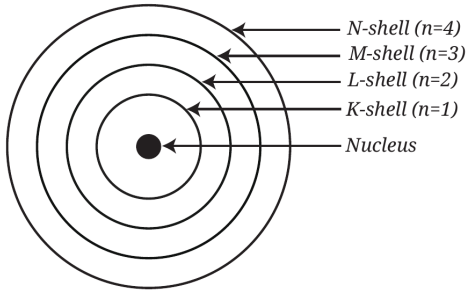


Fig. 8.7: Energy levels in an atom

No.	Verdict	Reason
(i)	Incorrect	In a stationary state (fixed orbit) the energy of an electron remains constant, so it does not lose energy or fall into the nucleus.
(ii)	Incorrect	Electrons move only in fixed shells, and each shell has a definite energy.
(iii)	**Correct**	This is Bohr's postulate: electrons revolve in orbits of fixed energy without losing energy.
(iv)	Incorrect	Electrons can revolve only in the allowed shells and not in between them; they change shell only by absorbing or releasing a fixed amount of energy.

Therefore, only statement (iii) is correct according to Bohr's model.

NCERT ARCHIVE

QUESTION 3 *Revise, Reflect, Refine*

The composition of the nuclei of three atomic species X, Y, and Z are given as follows. X: 18 protons, 19 neutrons. Y: 17 protons, 18 neutrons. Z: 17 protons, 20 neutrons. Explain the relation between the following: (i) Y and Z (ii) Z and X

ANSWER

Mass number = number of protons + number of neutrons.

Species	Protons (Z)	Neutrons	Mass number (A)
X	18	19	18 + 19 = 37
Y	17	18	17 + 18 = 35
Z	17	20	17 + 20 = 37

i Y and Z

Same atomic number (17), different mass numbers (35 and 37). They are atoms of the same element (chlorine), so Y and Z are **isotopes**.

ii Z and X

Same mass number (37), different atomic numbers (17 and 18). They are atoms of different elements (chlorine and argon), so Z and X are **isobars**.

Therefore, Y and Z are isotopes, and Z and X are isobars.

NCERT ARCHIVE

QUESTION 4 *Revise, Reflect, Refine*

What conclusion did Rutherford draw about the position and characteristics of the atom's positively charged part based on the few alpha particles that bounced back or were deflected at large angles in the gold foil experiment?

ANSWER

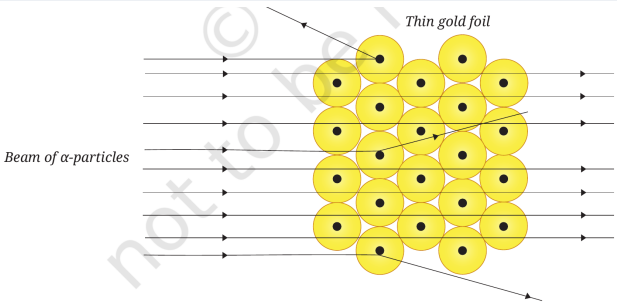


Fig. 8.4: Schematic view of the gold foil experiment

Most α-particles passed through, but a few were sharply deflected or bounced back, which could happen only if they met a strong positive force at a very small place.

a Rutherford's conclusions

- The positive charge is **not spread** throughout the atom. It is concentrated in an extremely small region at the centre, the **nucleus**.
- The nucleus is **dense** and contains all the positive charge and most of the mass of the atom.
- Most of the atom is empty space, as most α-particles passed without any deflection.

Therefore, the positively charged part of the atom is a tiny, dense nucleus at the centre of the atom.

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QUESTION 5 *Revise, Reflect, Refine*

Explain and arrange the following statements in the correct chronological order to show how atomic models have evolved over time. (i) Bohr's model proposed that electrons move in fixed orbits around the nucleus, each with a definite energy. (ii) Thomson's model depicted the atom as a 'plum pudding' with electrons embedded in a sphere of positive charge. (iii) Rutherford's model proposed that atoms have a dense central nucleus. (iv) Dalton's model described atoms as indivisible particles.

ANSWER

Correct order: **(iv) → (ii) → (iii) → (i)**, that is Dalton, Thomson, Rutherford, Bohr.

Order	Model	Year	Idea
1	Dalton (iv)	1808	Atoms are indivisible particles
2	Thomson (ii)	1897	Plum pudding: electrons embedded in a positive sphere
3	Rutherford (iii)	1911	Dense central nucleus; electrons revolve around it
4	Bohr (i)	1913	Electrons move in fixed orbits of definite energy

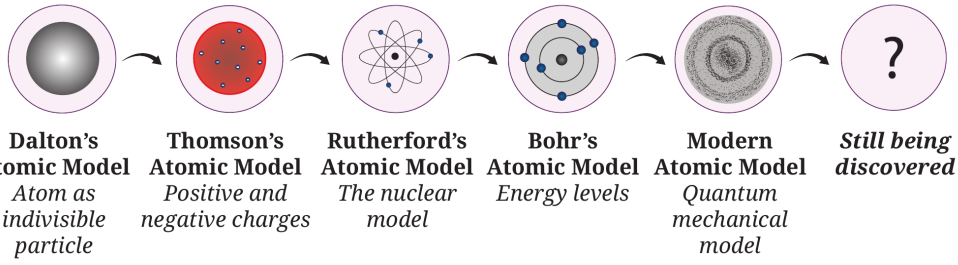


Fig. 8.16: Journey of the development of atomic models

Therefore, the chronological order is (iv), (ii), (iii), (i).

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QUESTION 6 *Revise, Reflect, Refine*

Electrons move around the nucleus in orbits. Why do they not fly away from the atom? Explain what keeps them attracted to the nucleus.

ANSWER

Electrons are negatively charged and the nucleus is positively charged, because it contains the protons.

- Opposite charges attract. The **electrostatic force of attraction** between the positive nucleus and the negative electrons keeps the electrons around the nucleus, so they do not fly away.
- The electrons do not fall into the nucleus either, because in Bohr's model they move in stationary states (fixed shells of definite energy) and do not lose energy there.

Therefore, the force of attraction between the positively charged nucleus and the negatively charged electrons keeps the electrons in the atom.

QUESTION 7 *Revise, Reflect, Refine*

Assertion (A): The discovery of subatomic particles helped in understanding the atomic structure. Reason (R): The number of electrons is equal to the number of protons in an atom. Choose the correct option: (i) Both A and R are true, and R is the correct explanation of A. (ii) Both A and R are true, but R is not the correct explanation of A. (iii) A is true, but R is false. (iv) A is false, but R is true.

ANSWER

- **A is true.** The discovery of the electron, proton and neutron showed what atoms are made of and how they are arranged.
- **R is true.** An atom is electrically neutral, so the number of electrons equals the number of protons.
- **R does not explain A.** Equality of electrons and protons is a property of the atom; it does not explain how discovering the particles helped us understand atomic structure.

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Correct option: (ii) Both A and R are true, but R is not the correct explanation of A.

QUESTION 8 *Revise, Reflect, Refine*

Magnesium is essential for many biological processes, including muscle contraction. For an atom of magnesium with a mass number of 24 and atomic number 12, determine the number of (i) protons, (ii) neutrons, (iii) electrons, and also illustrate the arrangement of electrons in a magnesium atom.

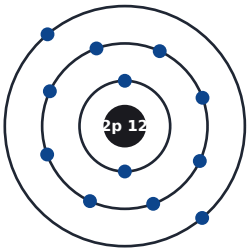
ANSWER

(i) Protons = atomic number = 12

(ii) Neutrons = mass number − protons = 24 − 12 = 12

(iii) Electrons = protons = 12

Arrangement: K = 2, L = 8, M = 2 (2, 8, 2)



Magnesium (Mg)
Electrons: 2, 8, 2

Therefore, magnesium has 12 protons, 12 neutrons and 12 electrons arranged as 2, 8, 2.

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QUESTION 9 *Revise, Reflect, Refine*

Find the following information for the elements shown in Fig. 8.17: (i) Name of the element (ii) Symbol (iii) Total number of electrons (iv) Number of valence electrons (v) Valency of the element (vi) Number of protons (vii) Atomic number

ANSWER

Count the electrons in each diagram (i, iii). The number of protons equals the number of electrons and is the atomic number (vi, vii). Valence = number of valence electrons (iv); Valency (v) is the number of electrons gained, lost or shared.

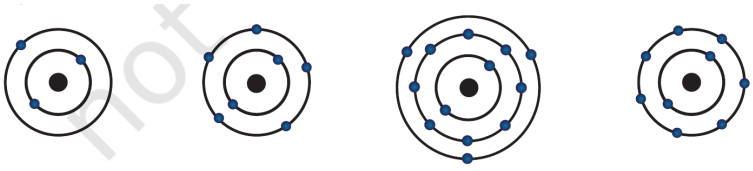


Fig. 8.17

Fig.	Name	Symbol	Total e⁻	Config.	Valence	Valency	Protons=Z
(a)	Lithium	Li	3	2, 1	1	1	3
(b)	Nitrogen	N	7	2, 5	5	3	7
(c)	Aluminium	Al	13	2, 8, 3	3	3	13
(d)	Fluorine	F	9	2, 7	7	1	9

- Valency: Li loses 1 electron (1); N gains 3 to complete the octet (3); Al loses 3 electrons (3); F gains 1 (1).

Therefore, the elements are (a) lithium, (b) nitrogen, (c) aluminium and (d) fluorine, with the values given in the table.

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QUESTION 10 *Revise, Reflect, Refine*

Both Rutherford’s and Bohr’s models have electrons orbiting the nucleus. Why did Rutherford’s model fail to explain atomic stability, while Bohr’s model succeeded?

ANSWER

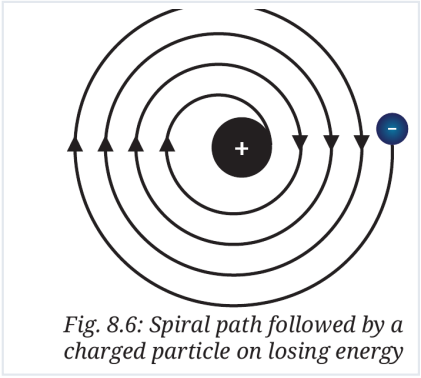


Fig. 8.6: Spiral path followed by a charged particle on losing energy

a Why Rutherford’s model failed

An electron moving in a circle keeps changing direction, so it is accelerating. An accelerating charged electron should lose energy, spiral inward and fall into the nucleus. Atoms would collapse, but atoms are actually stable.

b Why Bohr’s model succeeded

Bohr introduced **stationary states** as a postulate: electrons move only in fixed orbits (shells), each with a definite energy, and an electron in such an orbit does not lose energy. So the electrons do not spiral into the nucleus.

Therefore, Rutherford’s model predicted that electrons would lose energy and collapse into the nucleus, while Bohr’s stationary states keep the energy of the electron constant.

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QUESTION 11 *Revise, Reflect, Refine*

An atom ^{70}X has 31 electrons. How many neutrons are there in its nucleus?

ANSWER

Electrons = protons = 31, so atomic number = 31
Mass number = 70
Neutrons = 70 − 31 = 39

Therefore, the nucleus has 39 neutrons (the element is gallium).

QUESTION 12 *Revise, Reflect, Refine*

An atom has 79 protons and a mass number of 197. Calculate (i) the number of neutrons, and (ii) the number of electrons.

ANSWER

(i) Neutrons = mass number − protons = 197 − 79 = 118
(ii) Electrons = protons = 79 (the atom is neutral)

Therefore, the atom has 118 neutrons and 79 electrons (it is gold).

QUESTION 13 *Revise, Reflect, Refine*

Complete the Table 8.5.

ANSWER

Use: atomic number = protons = electrons, and mass number = protons + neutrons. Find the element name from Table 8.2/8.4.

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Atomic number	Mass number	Neutrons	Protons	Electrons	Element
5	**11**	6	**5**	**5**	**Boron**
7	14	**7**	**7**	7	Nitrogen
12	24	**12**	12	**12**	**Magnesium**
15	**31**	16	**15**	**15**	**Phosphorus**
1	1	0	**1**	**1**	**Hydrogen**

Row 1: A = 5 + 6 = 11
Row 2: Z = 7 (7 electrons), neutrons = 14 − 7 = 7
Row 3: Z = 12, neutrons = 24 − 12 = 12
Row 4: A = 15 + 16 = 31
Row 5: protons = A − neutrons = 1 − 0 = 1

Therefore, the completed values are those shown in bold: boron, nitrogen, magnesium, phosphorus and hydrogen.

QUESTION 14 *Revise, Reflect, Refine*

Aman was discussing the structure of atom with his classmates. During the discussion, he learnt that an element X has a mass number of 35 and contains 18 neutrons. Based on this information, answer the following questions: (i) How many electrons and protons does element X have? (ii) What is its atomic number? (iii) Identify the element X. (iv) Write its electronic configuration. (v) How many valence electrons does it have? (vi) What will be the mass number if two neutrons are added to its nucleus? (vii) What will be the relation of X with the new atom?

ANSWER

(i) Protons = A − neutrons = 35 − 18 = 17; electrons = protons = 17
(ii) Atomic number = number of protons = 17
(iii) Z = 17 is chlorine (Cl); X is chlorine-35
(iv) 17 electrons: K = 2, L = 8, M = 7 → 2, 8, 7
(v) Valence electrons = electrons in the outermost shell = 7
(vi) New mass number = 17 + (18 + 2) = 37
(vii) Same atomic number (17), different mass number (35 and 37)

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Therefore, X is chlorine-35 with 17 protons and 17 electrons, configuration 2, 8, 7, and 7 valence electrons; the new atom (chlorine-37) is an isotope of X.

QUESTION 15 *Revise, Reflect, Refine*

In an atom, there are 12 protons and 12 neutrons in the nucleus. Now, imagine that all the electrons are replaced with some hypothetical particles that have the same charge as electrons but are 500 times heavier. What effect will this replacement have on the atom's: (i) Atomic number (ii) Atomic mass (iii) Mass number (iv) Overall charge

ANSWER

The nucleus (12 protons, 12 neutrons) is not changed. Only the particles moving around it are replaced.

Quantity	Effect	Reason
(i) Atomic number	**No change** (12)	It is the number of protons, and the nucleus is unchanged.
(ii) Atomic mass	**Increases**	Electrons normally have negligible mass, but each new particle is 500 times heavier, so 12 of them add noticeable mass.
(iii) Mass number	**No change** (24)	It counts only protons and neutrons: 12 + 12 = 24.
(iv) Overall charge	**No change** (neutral)	The new particles have the same charge as electrons, so 12 negative charges still balance 12 protons.

Estimate for (ii): an electron is about 1/1836 of the mass of a proton, so each new particle is about 500 ÷ 1836 ≈ 0.27 of a proton mass; 12 of them add about 12 × 0.27 ≈ 3 u to the mass of about 24 u.

Therefore, atomic number, mass number and overall charge stay the same, while the atomic mass increases (by about 3 u).

NCERT ARCHIVE

8.3

CLASS 9 SCIENCE · CHAPTER 8

The Journey Beyond

Solutions · 7 questions

Directions (Questions 1–7): These are the activities and the closing question of The Journey Beyond. Model answers and worked examples are given; use your own examples wherever the task asks you to create or research something.

QUESTION 1 *The Journey Beyond · p. 161*

Create an ‘Atomic Prediction Board’ game based on atomic number, mass number, number of electrons, protons, neutrons and valency. Students may predict elements using atomic clues.

ANSWER

Model clue cards for the game. Each card gives clues and the players predict the element.

Clue card	Working	Element
Mass number 12 and 6 neutrons	Protons = 12 − 6 = 6, Z = 6	**Carbon** (C)
17 electrons and mass number 35	Z = 17, neutrons = 35 − 17 = 18	**Chlorine** (Cl)
Mass number 27 and 14 neutrons	Protons = 27 − 14 = 13, configuration 2, 8, 3, valency 3	**Aluminium** (Al)
Two shells, 6 valence electrons, valency 2	Configuration 2, 6, so 8 electrons, Z = 8	**Oxygen** (O)
Configuration 2, 8, 8 and 22 neutrons	Z = 18, mass number = 18 + 22 = 40, valency 0	**Argon** (Ar)

Therefore, atomic number, mass number, electrons, protons, neutrons and valency give enough clues to identify an element.

NCERT ARCHIVE

QUESTION 2 *The Journey Beyond · p. 161*

Prepare a report on how the properties of atoms impact us in everyday life across fields, such as healthcare, energy, agriculture and technology.

ANSWER

A model outline using examples from the chapter.

Field	Property of atoms used	Example
Healthcare	Radioactive isotopes	Cobalt-60 in radiation treatment for cancer; iodine-131 to treat goitre and thyroid cancer
Energy	Splitting of uranium atoms by neutrons	Uranium-235 as fuel in a nuclear power plant to generate electricity
Agriculture and medicine	Peaceful uses of atomic energy	Work started by Homi J. Bhabha to generate electricity, support agriculture and advanced medical treatments
Technology	Neutron scattering	BARC studies superconductors, battery electrodes and drug molecules
Archaeology and geology	Radioactive carbon-14	Determining the age of ancient fossils and artefacts

Therefore, a good report names the field, the property of atoms used, and a real example, as in the table.

QUESTION 3 *The Journey Beyond · p. 161*

Create a role-play, stage play or story about the ‘Journey Inside the Atom’, and the scientists who discovered and contributed to the identification of atomic structure.

ANSWER

A scene plan for a role-play. Each scientist speaks one key idea from the chapter.

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Scene	Scientist	Key idea to present
1	Acharya Kanada; Leucippus and Democritus	Matter divided again and again reaches smallest particles: *parmanus* / *atomos*
2	John Dalton (1808)	Atoms are indivisible building blocks of matter
3	J. J. Thomson (1897)	Cathode rays show electrons; plum pudding model
4	Rutherford, Geiger and Marsden (1911)	Gold foil experiment shows the nucleus
5	Niels Bohr (1913)	Electrons in fixed shells; atoms are stable
6	James Chadwick (1932)	Discovery of the neutron explains the mass of the atom

Therefore, presenting the scientists in order of time shows how each model grew from the previous one.

QUESTION 4 *The Journey Beyond · p. 161*

Use selected software or digital tools and try to create animations or simulations of various atomic models, and share them in the class.

ANSWER

Steps to follow, using the simulations named in the chapter.

- Open the Rutherford scattering simulation (https://phet.colorado.edu/en/simulations/rutherford-scattering) and compare how α-particles move for the plum pudding atom and for the Rutherford atom.
- Open the Isotopes and Atomic Mass simulation (https://phet.colorado.edu/en/simulations/isotopes-and-atomic-mass) and compare isotopes of the same element.
- Make your own short animation of the models in order: Dalton, Thomson, Rutherford, Bohr (Fig. 8.16).
- Share it in class and explain what each model could and could not explain.

Therefore, simulations let us see how α-particles scatter and how isotopes differ, which helps us understand the models.

NCERT ARCHIVE

QUESTION 5 *The Journey Beyond · p. 161*

Watch a film or documentary about the structure of the atom and write a report answering the following questions: Which film or documentary did you watch, and what was its main idea or topic? What did the film or documentary teach you about the structure of the atom and the atomic model(s)? Which scientists were mentioned in the film or documentary, and what were their contributions? What part of the film or documentary did you find most interesting, and what question do you still have?

ANSWER

The film is your own choice, so this is a report format with guidance on how to answer each part using the chapter.

Question	How to answer
Which film, and what is its main idea?	Write the title and one sentence on the main idea (for example, how our idea of the atom changed over time).
What did it teach about atomic structure and models?	Compare with the chapter: nucleus with protons and neutrons, electrons in shells, Thomson, Rutherford and Bohr models.
Which scientists, and what contributions?	Thomson: electron; Rutherford: nucleus and proton; Chadwick: neutron; Bohr: shells.
Most interesting part and your question?	Give your own view. Example question: Is it possible to completely understand everything inside an atom?

Therefore, a good report names the film, links it to the chapter's models and scientists, and ends with your own question.

QUESTION 6 *The Journey Beyond · p. 161*

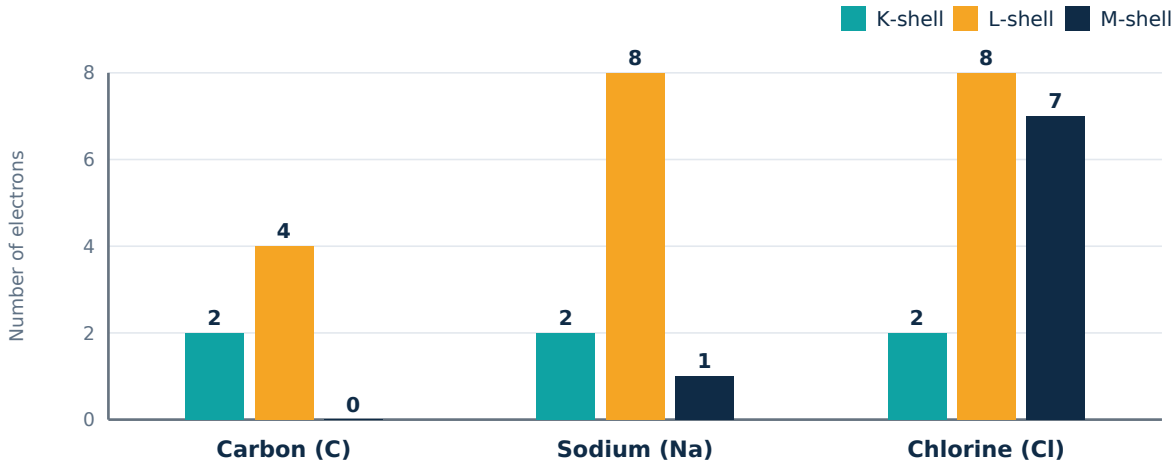
Draw a bar graph showing the number of electrons in each energy level for any three elements.

ANSWER

Three elements are chosen: carbon (2, 4), sodium (2, 8, 1) and chlorine (2, 8, 7).

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Element	K-shell	L-shell	M-shell
Carbon (Z = 6)	2	4	0
Sodium (Z = 11)	2	8	1
Chlorine (Z = 17)	2	8	7



Therefore, the K-shell holds 2 electrons in each atom, and the L-shell holds 8 once it is full, as in sodium and chlorine.

QUESTION 7 *The Quest Continues … · p. 161*

Is it possible to completely understand everything that happens inside an atom?

ANSWER

This is an open question. The chapter suggests that our understanding is still growing.

- The structure of the atom is still being explored (Fig. 8.16 ends with “Still being discovered”).
- Even Bohr’s model was found not to be entirely correct; today electrons are described as ‘electron clouds’ around the nucleus, where we can predict regions in which they are most likely to be, not exactly where they are.
- Each model explained some observations and left new questions, which led to the next model.

Therefore, we do not yet fully understand everything inside the atom; the exploration is far from over, and exciting discoveries still lie ahead.

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