Class:9th

Subject: Chemistry

Chapter 2: Atomic Structure

Exercise MCQs:

(i) How many electrons can be accommodated at the most in the third shell of the elements?

(a) 8

(b) 18 ✅

(c) 10

(d) 32

(ii) What information was obtained from discharge tube experiments?

(a) Structure of atom was discovered.

(b) Neutrons and protons were discovered.

(c) Electrons and protons were discovered. ✅

(d) Presence of nucleus in an atom was discovered.

(iii) Why have isotopes not been shown in the periodic table?

(a) Periodic table cannot accommodate a large number of isotopes of different elements.

(b) Some of the isotopes are unstable and they give rise to different elements

(c) All the isotopes have same atomic number; so there is no need to give them separate places. ✅

(d) Isotopes do not show periodic behavior.

(iv) Which particle is present in different number in the isotopes?

(a) Electron

(b) Neutron ✅

(c) Proton

(d) Both neutron and electron

(v) In which isotope of oxygen there are the equal number of protons, electrons and neutrons?

(a) "O

(b) ^{16}O ✅

(c) ^{18}O

(d) None of these

(vi) What will be the relative atomic mass of nitrogen given the abundances of its two isotopes, ^{14}N and ^{15}N are 99.64 and 0.35 respectively?

(a) 14.0210 ✅

(b) 14.0021

(c) 14.2100

(d) 14.1200

(vii) How is radiocarbon dating useful for archeologists?

(a) It helps determine the age of organic matter. ✅

(b) It helps determine the composition of matter.

(c) It helps determine the usefulness of matter.

(d) It helps determine whether the matter is radioactive or not.

(viii) What does keep the particles present in the nucleus intact?

(a) Particles are held together by strong nuclear force. ✅

(b) Particles are held together by weak nuclear force.

(c) Particles are held together by electrostatic force.

(d) Particles are held together by dipolar force.

(ix) How do electrons keep themselves away from the oppositely charged nucleus?

(a) By keeping themselves stationary

(b) By revolving around the nucleus ✅

(c) Due to their wave-like nature

(d) A magnetic field around the nucleus keeps them away

(x) Rubidium consists of two isotopes Rb^{85} and Rb^{87}. The percent abundance of the light isotope is 72.2%. What is the percent abundance of the heavier isotope?

(a) 15%

(b) 27.8% ✅

(c) 37%

(d) 72%

Important MCQs:

1. The idea of atom was first proposed by:

(a) John Dalton

(b) J.J. Thomson

(c) Rutherford

(**d**) Democritus ✅

2. Evidence for the existence of atoms was provided by:

(a) J.J. Thomson

(b) Rutherford

(**c**) John Dalton ✅

(d) Goldstein

3. A proton is how many times heavier than an electron?

(a) 1000 times

(b) 2000 times

(c) 1836 times ✅

(d) 500 times

4. The negative particles in a discharge tube were detected by their:

(a) Glow on the anode

(b) Deflection towards the positive plate ✅

(c) Color change

(d) Sound waves

5. Cathode rays were studied in detail by:

(a) J.J. Thomson ✅

(b) Rutherford

(c) Goldstein

(d) Democritus

6. Cathode rays bend towards the:

(a) Negative plate

(b) Positive plate ✅

(c) Neutral plate

(d) Anode

7. The negatively charged particles in an atom are called:

(a) Protons

(b) Neutrons

(c) Electrons ✅

(d) Ions

8. The scientist who discovered canal rays was:

(a) Rutherford

(b) Thomson

(c) E. Goldstein ✅

(d) Dalton

9. Anode rays are also known as:

(a) Cathode rays

(b) Canal rays ✅

(c) Proton rays

(d) Neutron beams

10. The presence of hydrogen nucleus in other

elements was proven by:

(a) Goldstein

(b) Rutherford ✅

(c) Thomson

(d) Chadwick

11. The neutron was discovered in:

(a) 1911

(b) 1933 ✅

(c) 1897

(d) 1800

12. The particle that has no charge is called:

(a) Electron

(b) Proton

(c) Neutron ✅

(d) Ion

13. Neutrons and protons are found in the:

(a) Electron shell

(b) Nucleus ✅

(c) Cathode

(d) Orbit

14. The nucleus of an atom was discovered by:

(a) J.J. Thomson

(b) Rutherford ✅

(c) Goldstein

(d) Democritus

15. Protons and neutrons are held together by:

(a) Magnetic force

(b) Nuclear force ✅

(c) Electrostatic force

(d) Gravitational force

16. Bohr's atomic model was proposed in the year:

(a) 1911

(b) 1913 ✅

(c) 1926

(d) 1932

17. In Bohr's model, the fixed paths in which

electrons revolve are called:

(a) Orbitals

(b) Electrons

(c) Orbits or shells ✅

(d) Waves

18. The energy of the electron is minimum when it is:

(a) In outer shell

(b) In excited state

(c) Near the nucleus ✅

(d) Outside the atom

19. The ground state of an atom refers to:

(a) Highest energy level

(b) State of ionization

(c) State near the nucleus with minimum energy ✅

(d) When atom is neutral

20. The shell nearest to the nucleus is called:

(a) L shell

(b) M shell

(c) K shell ✅

(d) N shell

21. The second shell (L shell) can accommodate how many electrons at maximum?

(a) 2

(b) 8 ✅

(c) 18

(d) 32

22. The formula used to calculate maximum electrons in a shell is:

(a) 2n

(b) n^2

(c) $2n^2$ ✅

(d) n + 2

23. How many sub-shells are in the third shell (n = 3)?

(a) 1

(b) 2

(c) 3 ✅

(d) 4

24. The maximum number of electrons a p-sub-shell can hold is:

(a) 2

(b) 4

(c) 6 ✅

(d) 8

25. The fourth shell has how many types of sub-shells?

(a) 2

(b) 3

(c) 4 ✅

(d) 5

26. The fundamental particles in atoms include:

(a) Proton and Neutron

(b) Electron and Proton

(c) Electron, Proton and Neutron ✅

(d) Only Electron

27. The number of protons in an atom is called:

(a) Mass number

(b) Atomic number ✅

(c) Neutron number

(d) Charge number

28. Atomic number is represented by the symbol:

(a) A

(b) N

(c) Z ✅

(d) P

29. Mass number is the total number of:

(a) Electrons and neutrons

(b) Protons and neutrons ✅

(c) Protons and electrons

(d) Neutrons only

30. If an element has atomic number 17 and mass

number 35, then number of neutrons is:

(a) 35

(b) 18

(c) 17

(d) 18 ✅ (Since 35 – 17 = 18)

31. Isotopes of an element have:

(a) Different number of protons

(b) Same number of neutrons

(c) Same number of protons ✅

(d) Different atomic numbers

32. Which isotope of hydrogen contains one proton and no neutron?

(a) Tritium

(b) Deuterium

(c) Protium ✅

(d) Isotope-3

33. The mass number of Carbon-14 isotope is:

(a) 12

(b) 14 ✅

(c) 13

(d) 6

34. Tritium is:

(a) A noble gas

(b) A stable isotope

(c) A radioactive isotope ✅

(d) A metal

35. Which isotope is used in radiocarbon dating?

(a) C-13

(b) C-12

(c) C-14 ✅

(d) C-16

36. The chemical properties of isotopes are:

(a) Very different

(b) Similar ✅

(c) Opposite

(d) Unpredictable

37. The physical properties of isotopes are:

(a) Same

(b) Always constant

(c) Different ✅

(d) Undefined

38. Which radioactive isotope is used in medical imaging?

(a) Uranium-235

(b) Carbon-14

(c) Technetium-99m ✅

(d) Plutonium-239

39. The unit used for relative atomic mass is:

(a) Kilogram

(b) Mole

(c) Gram

(d) amu ✅

40. 1 atomic mass unit (amu) is equal to:

(a) 1.67377×10^{-24} g

(b) 1.67377×10^{-10} kg

(c) 1.67377×10^{-27} kg ✅

(d) 1.67377×10^{-23} g

41. Isotopes differ in:

(a) Number of electrons

(b) Number of protons

(c) Number of nuclei

(d) Number of neutrons ✅

42. The process of emission of radiation by unstable nuclei is called:

(a) Ionization

(b) Radiation

(c) Emission

(d) Radioactivity ✅

43. Ionizing radiation can:

(a) Break atoms

(b) Create atoms

(c) Add protons to nucleus

(d) Remove electrons from atoms ✅

44. Which formula is used to calculate relative atomic mass from isotopes?

(a) m × p

(b) m + p

(c) $m_1p_1 + m_2p_2 + \ldots \div 100$ ✅

(d) p/m × 100

Exercise Short Questions:

i. Why is it said that almost all the mass of an atom is concentrated in its nucleus?

Because the nucleus contains protons and neutrons, which have significant mass, while electrons are very light and contribute almost nothing to the atom's total mass. Therefore, nearly all the mass of an atom is concentrated in its small, dense nucleus.

ii. Why are elements different from one another?

Elements differ from one another because they have different atomic numbers (i.e., different

numbers of protons in their nuclei). The number of protons determines the identity and properties of each element.

iii. How many neutrons are present in $^{210}Bi_{83}$?

Solution:

Mass number = 210

Atomic number (Bi) = 83

Number of neutrons = Mass number − Atomic number

= 210 − 83

= 127 neutrons

Final Answer: ⇒ 127 neutrons are present in $^{210}Bi_{83}$.

iv. Why is tritium ($_1{}^3H$) a radioactive element?

Tritium has 1 proton and 2 neutrons, making its nucleus unstable. Due to this instability, it emits beta radiation to become stable. This radioactive behavior classifies it as a radioactive isotope of hydrogen.

v. How can an atom absorb and evolve energy?

An atom can absorb energy when its electrons move from a lower energy level to a higher energy level (excited state).

It can evolve (release) energy when electrons fall back from a higher energy level to a lower one, usually in the form of light or heat. This is the principle behind atomic spectra.

Important Short Questions:

1. What information was obtained from discharge tube experiments?

Discharge tube experiments revealed that atoms consist of smaller subatomic particles: negatively charged electrons and positively charged protons.

2. What are cathode rays and what type of charge do they carry?

Cathode rays are streams of negatively charged particles (electrons) that move from the cathode to the anode in a discharge tube.

3. Who discovered the proton and how was it discovered?

E. Goldstein discovered protons in 1886 during discharge tube experiments using a perforated cathode. He observed positively charged rays (canal rays) moving toward the cathode.

4. When and by whom was the neutron discovered? What is its charge and mass?

The neutron was discovered in 1933 by James Chadwick. It carries no charge and has a mass almost equal to that of a proton.

5. What is the difference between cathode rays and anode rays?

Cathode rays are negatively charged electrons, while anode rays (canal rays) are positively charged particles (ions) that move in the opposite direction in the discharge tube.

6. Why is it said that almost all the mass of an atom is concentrated in its nucleus?

Because the nucleus contains protons and neutrons,

which are much heavier than electrons, almost all the mass of an atom resides in the nucleus.

7. What was the contribution of J.J. Thomson in the discovery of electron?

J.J. Thomson studied cathode rays and found that they are negatively charged particles. He measured their charge-to-mass ratio and proved they are present in all atoms.

8. What are fundamental particles of an atom? Name them.

The fundamental particles of an atom are electrons, protons, and neutrons.

9. What conclusion did Rutherford draw from his gold foil experiment?

Rutherford concluded that atoms have a small, dense, positively charged nucleus where most of the atom's mass is concentrated.

10. Why are atoms of different elements different from each other?

Atoms differ due to the different number of protons,

neutrons, and electrons they contain, which gives each element its unique properties.

11. What is meant by an orbit or shell in Bohr's atomic model?

In Bohr's model, an orbit or shell is a specific circular path around the nucleus in which electrons revolve with fixed energy.

12. Define ground state of an atom.

The ground state is the lowest energy state of an atom where the electron is present in the orbit closest to the nucleus.

13. What is meant by energy levels?

Energy levels are fixed energy states associated with the electrons in an atom's shells. Each shell has a specific energy.

14. How are shells and sub-shells represented?

Shells are represented by letters K, L, M, N or by numbers 1, 2, 3, 4. Sub-shells are denoted as s, p, d, and f.

15. What is the maximum number of electrons that

can be accommodated in the M shell?

The M shell (n = 3) can accommodate a maximum of 18 electrons using the formula $2n^2$.

16. Name the sub-shells present in the third shell.

The third shell (n = 3) contains three sub-shells: s, p, and d.

17. What is the formula to calculate maximum number of electrons in a shell?

The formula is $2n^2$, where n is the number of the shell.

18. Define atomic number. How is it represented?

Atomic number is the number of protons in the nucleus of an atom. It is represented by the symbol Z.

19. What is mass number? Which particles contribute to it?

Mass number is the total number of protons and neutrons in an atom. Protons and neutrons contribute to the mass number.

20. How can the number of neutrons in an atom be calculated?

The number of neutrons (N) is calculated using the formula:

$N = A - Z$,

where A is the mass number and Z is the atomic number.

21. What are isotopes? Give an example.

Atoms of the same element having the same atomic number but different mass numbers due to a different number of neutrons are called isotopes.

Example: Hydrogen has three isotopes – ^{1}H (Protium), ^{2}H (Deuterium), and ^{3}H (Tritium).

22. Which isotope of hydrogen is radioactive?

Tritium (^{3}H) is the radioactive isotope of hydrogen.

23. Why do isotopes of an element have almost the same chemical properties?

Chemical properties depend on the number of electrons, and isotopes of an element have the

same number of electrons, so they show almost the same chemical behavior.

24. What is radioactive decay?

Radioactive decay is the process where an unstable radioactive isotope emits radiation and transforms into another element, which may be stable or radioactive.

25. List two applications of radioactive isotopes.

Used in medical imaging to diagnose diseases (e.g., Technetium-99m).

Used in radiocarbon dating to find the age of archaeological objects.

26. What is ionization caused by radiation?

Ionization is the process where radiation emitted from a radioactive source removes electrons from atoms, converting them into positively charged ions.

27. Define relative atomic mass.

Relative atomic mass is the weighted average mass of the isotopes of an element compared to 1/12th the mass of carbon-12 isotope.

28. What is the unit used to express relative atomic mass?

Relative atomic mass is expressed in atomic mass units (amu), where 1 amu equals one-twelfth the mass of a carbon-12 atom.

29. How is the relative atomic mass of an element calculated from isotopes?

It is calculated by taking the sum of the products of each isotope's relative isotopic mass and its percent abundance, divided by 100.

30. Give an example of calculating relative atomic mass using isotopic masses and abundances.

If an element has two isotopes with masses 10 amu and 11 amu and abundances 75% and 25%, relative atomic mass = (10 × 75 + 11 × 25) / 100 = 10.25 amu.

3. Constructed Response Questions:

i. Why does the energy of electron increase as we move from first shell to second shell?

As we move from the first shell to the second shell, the distance between the electron and the nucleus increases. Since electrons are negatively charged and the nucleus is positively charged, more energy is required to keep electrons at greater distances. Therefore, electrons in higher shells possess more energy than those in inner shells.

ii. Why is it needed to lower the pressure of the gas inside the discharge tube?

Lowering the pressure inside the discharge tube is necessary because at high pressure, gas atoms are too close together and collisions between them prevent free movement of electrons. At low pressure (around 0.01 mmHg), the gas becomes partially ionized and free electrons can accelerate, allowing visible discharge and the production of cathode rays.

iii. What is the classical concept of an electron? How has this concept changed with time?

Classical Concept:

Electrons were once considered to be tiny,

indivisible particles orbiting the nucleus in fixed circular paths like planets around the sun (Bohr model).

Modern Concept:

With the development of quantum mechanics, electrons are now viewed as wave-particles that occupy regions called orbitals, not fixed paths. Their exact position cannot be predicted, only the probability of finding them in a certain region.

iv. Why are the nuclei of the radioactive elements unstable?

Radioactive nuclei are unstable because they contain an imbalance between protons and neutrons, or they have too many nucleons (protons + neutrons). The nuclear forces are not strong enough to hold such large or imbalanced nuclei together, so they decay by emitting radiation to become stable.

v. During discharge tube experiments, how did scientists conclude that the same type of electrons and protons are present in all elements?

In discharge tube experiments, when different gases were used and different materials were applied for electrodes, the same type of cathode rays (electrons) and positive rays (protons) were produced each time. This proved that electrons and protons are fundamental particles that are common to all atoms of all elements.

4. Descriptive Questions:

i. Explain the structure of a hydrogen atom.

The hydrogen atom is the simplest atom in nature. It consists of:

- One proton in the nucleus, which carries a positive charge (+1).
- One electron, which revolves around the nucleus in a circular orbit.

The electron is negatively charged (−1) and is attracted to the proton due to electrostatic force. Since hydrogen has only one electron, its electronic configuration is $1s^1$. There are no

neutrons in the most common isotope of hydrogen (^1H).

ii. How does the theory of atomic structure explain the ionization of atoms by a radioactive isotope?

According to atomic structure theory, atoms contain electrons in defined energy levels. When a radioactive isotope decays, it emits alpha, beta, or gamma radiation, which carries energy.

This radiation can knock electrons out of other atoms, causing ionization — the atom loses an electron and becomes a positively charged ion. The theory explains this as a result of energy absorption causing electron ejection from the atom's shell.

iii. What is radioactivity? Explain any three applications of radioactive isotopes.

Radioactivity is a process in which unstable atomic nuclei spontaneously decay, emitting alpha, beta, or gamma radiation to become stable.

Applications of radioactive isotopes:

1. Medicine:

Isotopes like Cobalt-60 are used in cancer treatment (radiotherapy), and Iodine-131 is used to diagnose and treat thyroid diseases.

2. Agriculture:

Radioactive isotopes are used to kill pests and bacteria in crops and to increase shelf life of food products by sterilization.

3. Industry:

Used to detect leaks in pipelines and to measure the thickness of materials like paper and metal sheets.

iv. Find out the relative atomic mass of mercury from the following data.

We use the formula:

Relative Atomic Mass = $(m_1p_1 + m_2p_2 + m_3p_3 + ... + m_np_n) / 100$

Where:

- m = isotopic mass (mass number)
- p = relative abundance (%)

Given data:

Isotope	Mass No.	Abundance (%)
196Hg	196	0.0146
198Hg	198	10.02
199Hg	199	16.34
200Hg	200	23.13
201Hg	201	13.22
202Hg	202	29.80
204Hg	204	6.85

Calculation:

Relative Atomic Mass =

(196 × 0.0146 + 198 × 10.02 + 199 × 16.34 + 200 × 23.13 + 201 × 13.22 + 202 × 29.80 + 204 × 6.85) / 100

= (2.8616 + 1983.96 + 3251.66 + 4626 + 2657.22 + 6019.6 + 1398.6) / 100

= 19939.96 / 100

= 199.40 (amu)

Final Answer: The relative atomic mass of mercury is approximately 199.40 amu.

Important Long Questions:

Q1: Explain Bohr's Atomic Model for the hydrogen atom. Describe the concept of orbits and energy levels in this model.

In 1913, the Danish physicist Niels Bohr proposed a model for the hydrogen atom to explain how electrons are arranged and how atoms emit light. Bohr's atomic model was a significant improvement over earlier models because it introduced the idea of fixed energy levels.

According to Bohr's model:

The electron revolves around the nucleus of the atom in specific circular paths called orbits or shells.

- Each orbit corresponds to a fixed energy level, meaning the electron has a definite and constant energy when it is in that orbit.

- The orbits are numbered as n = 1, 2, 3, ..., where n is called the principal quantum number.
- The orbit closest to the nucleus (n=1) is called the first shell or K shell and has the lowest energy, known as the ground state of the atom.
- Orbits that are further away from the nucleus (n=2, 3, etc.) have higher energy levels. The electron can only occupy these discrete energy levels, not the space between them.
- When an electron absorbs energy, it can jump from a lower energy orbit to a higher one (excited state). When it returns to a lower energy orbit, it emits energy in the form of light.
- This explained the emission spectrum of hydrogen, where specific colors (wavelengths) correspond to electrons falling between energy levels.

In summary, Bohr's model introduced the idea that electrons move in fixed orbits with fixed energies, and these orbits correspond to quantized energy levels.

Q2: What are shells and sub-shells according to Bohr's model? How are the sub-shells arranged in different shells?

In Bohr's atomic model:

- The fixed orbits in which electrons revolve are called shells or energy levels.
- Each shell is identified by a principal quantum number n = 1, 2, 3, ...
- The shells are also given letter names starting from the closest shell to the nucleus:
- K shell (n=1)
- L shell (n=2)
- M shell (n=3)
- N shell (n=4), and so on.

Sub-shells or orbitals are smaller divisions within

each shell where electrons can be found. The number of sub-shells in each shell equals the value of n for that shell:

- For the first shell (n=1), there is 1 sub-shell called the s sub-shell.
- For the second shell (n=2), there are 2 sub-shells: s and p.
- For the third shell (n=3), there are 3 sub-shells: s, p, and d.
- For the fourth shell (n=4), there are 4 sub-shells: s, p, d, and f.

Each sub-shell can hold a fixed maximum number of electrons:

- s sub-shell can hold 2 electrons.
- p sub-shell can hold 6 electrons.
- d sub-shell can hold 10 electrons.
- f sub-shell can hold 14 electrons.

For example:

- The first shell (K) has only the s sub-shell and

can hold up to 2 electrons.

- The second shell (L) has s and p sub-shells and can hold up to 8 electrons (2 in s, 6 in p).
- The third shell (M) has s, p, and d sub-shells and can hold up to 18 electrons in total.

This arrangement explains how electrons fill the atom's shells and sub-shells in a structured way, giving rise to the atom's chemical properties.

Q3: Define atomic number and mass number. How do they help in identifying an element? Explain with examples.

Atomic Number (Z):

The atomic number of an element is the number of protons present in the nucleus of each atom of that element. It is represented by the symbol Z. Since an atom is electrically neutral, the number of electrons in the atom is also equal to the atomic number. The atomic number is unique for each element and acts as the identity of that element. This means no two different elements can have the same atomic

number.

For example,

- The atomic number of oxygen (O) is 8, which means every oxygen atom has 8 protons in its nucleus and 8 electrons revolving around it.
- The atomic number of carbon (C) is 6, meaning every carbon atom has 6 protons and 6 electrons.

Mass Number (A):

The mass number of an atom is the total number of protons and neutrons present in its nucleus. It is represented by the symbol A. Since the mass of an electron is very small compared to protons and neutrons, it is not counted in the mass number. The mass number gives an idea about the total mass of the nucleus.

For example,

- An oxygen atom with 8 protons and 8 neutrons will have a mass number of 16 (8 + 8 = 16).
- A carbon atom with 6 protons and 6 neutrons

will have a mass number of 12 (6 + 6 = 12).

How do they help in identifying an element?

- The atomic number identifies the element because it tells the number of protons in its atoms, which determines its chemical properties.
- The mass number helps distinguish between different isotopes of the same element (atoms with the same atomic number but different numbers of neutrons).

The element's symbol is often written with the mass number as a superscript and the atomic number as a subscript on the left side, for example:

- Oxygen: ${}^{16}_{8}O$
- Carbon: ${}^{12}_{6}C$

This notation provides a clear representation of the element's identity and the composition of its nucleus.

Q4: Explain the relationship between protons, electrons, and neutrons in an atom. Why is the atomic number unique for each element?

Relationship between protons, electrons, and neutrons:

- An atom is made up of three fundamental particles: protons, electrons, and neutrons.
- The protons and neutrons are located in the nucleus at the center of the atom, while electrons revolve around the nucleus in shells or energy levels.
- The number of protons in the nucleus defines the atomic number (Z) and is fixed for each element.
- Since atoms are electrically neutral, the number of electrons outside the nucleus is always equal to the number of protons. This balance keeps the overall charge zero.
- The neutrons have no electric charge and provide stability to the nucleus by reducing the

repulsive forces between positively charged protons. The number of neutrons can vary in atoms of the same element, giving rise to isotopes.

Why is the atomic number unique for each element?

- The atomic number is the number of protons in the nucleus. Since the chemical behavior of an element depends on the number of protons and electrons (which are equal in a neutral atom), no two different elements can have the same atomic number.
- Changing the number of protons changes the element entirely. For example, an atom with 6 protons is carbon, but if it has 7 protons, it becomes nitrogen.
- Therefore, the atomic number acts as a unique identifier for each element and determines the element's position in the periodic table.

Q5: What are isotopes? Explain with examples. How do isotopes of the same element differ in physical and chemical properties?

Isotopes are atoms of the same element that have the same number of protons (atomic number) but different numbers of neutrons. Because the atomic number is the same, isotopes belong to the same element but have different mass numbers.

Example:

Carbon has three main isotopes:

- Carbon-12 (6 protons and 6 neutrons)
- Carbon-13 (6 protons and 7 neutrons)
- Carbon-14 (6 protons and 8 neutrons)

All these isotopes are carbon but have different masses because of different numbers of neutrons.

Difference in physical properties:

Isotopes differ in their physical properties because physical properties depend on mass. For example, melting points, boiling points, densities, and rates of diffusion can vary between isotopes.

Similarity in chemical properties:

However, isotopes have nearly identical chemical

properties because chemical behavior depends mainly on the number of electrons and the electronic configuration, which remains the same for isotopes of an element. Since isotopes have the same number of protons and electrons, their chemical reactions are generally the same.

Q6: Describe the isotopes of hydrogen and carbon. How do their masses differ? Why do isotopes have the same chemical properties?

Isotopes of Hydrogen:

- **Protium** (Hydrogen-1): 1 proton, 0 neutrons (mass number = 1)
- **Deuterium** (Hydrogen-2): 1 proton, 1 neutron (mass number = 2)
- **Tritium** (Hydrogen-3): 1 proton, 2 neutrons (mass number = 3)
- **Isotopes** of Carbon:
- **Carbon**-12: 6 protons, 6 neutrons (mass number = 12)
- **Carbon**-13: 6 protons, 7 neutrons (mass

number = 13)

- **Carbon**-14: 6 protons, 8 neutrons (mass number = 14)

Difference in masses:

The mass difference between isotopes arises from the different numbers of neutrons in the nucleus. For example, Hydrogen-1 has a mass of about 1 atomic mass unit (amu), while Tritium has a mass of about 3 amu.

Why isotopes have the same chemical properties:

Chemical properties depend on electron arrangement, which is determined by the atomic number (number of protons). Since isotopes have the same number of protons and electrons, they behave the same chemically.

Q7: What is radioactivity? How does it relate to radioactive isotopes?

Radioactivity is the spontaneous emission of particles or energy from the unstable nucleus of certain atoms. This emission can be in the form of

alpha particles, beta particles, or gamma rays. It occurs when an atomic nucleus seeks to become more stable.

Relation to radioactive isotopes:

- Radioactive isotopes (also called radioisotopes) are isotopes with unstable nuclei that undergo radioactive decay to achieve stability. For example, Carbon-14 is a radioactive isotope of carbon that decays over time, emitting radiation.
- Radioactivity is a property of certain isotopes whose nuclei have excess energy or imbalance in protons and neutrons, making them unstable.

Q8: What is Relative Atomic Mass? Explain the atomic mass scale adopted in 1961 and the role of carbon-12 in it

Relative Atomic Mass (RAM) of an element is the average mass of one atom of that element compared to one-twelfth the mass of a carbon-12 atom. It is a dimensionless quantity that shows how heavy an atom is compared to the standard

reference atom.

Atomic Mass Scale Adopted in 1961:

- Before 1961, chemists used different reference scales to compare atomic masses, which caused confusion. To standardize this, in 1961, chemists agreed to use the isotope carbon-12 (^{12}C) as the reference standard.
- The mass of one atom of carbon-12 was exactly assigned a value of 12 atomic mass units (amu).
- One atomic mass unit (1 amu) is defined as one-twelfth the mass of a carbon-12 atom.
- This scale allowed chemists to measure the relative masses of other atoms accurately and consistently.
- Role of Carbon-12:
- Carbon-12 isotope is chosen because it is stable and abundant.
- It serves as a universal reference for comparing the masses of all atoms.

- Using carbon-12, the relative atomic mass of any element is calculated by comparing its atom's mass to 1/12th of the carbon-12 atom's mass.
- **For example,** hydrogen-1 has a relative atomic mass of about 1.007 amu, meaning it is roughly one-twelfth as heavy as carbon-12.

Note:

This chapter is designed to provide a solid foundation of knowledge, with the goal of deepening understanding and encouraging further exploration of the subject. The content has been

carefully selected to support effective learning and inspire students to engage with the topic more deeply.

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Purpose: To contribute to education by offering insightful, valuable content that enhances learning and understanding.

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