9th Class Chemistry Chapter # 2 Exercise Solutions – Punjab Board

Atomic Structure

Multiple Choice Questions (MCQs)

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

(c) Electrons and protons were discovered.

Options:
(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.

Explanation:
Discharge tube experiments led to the discovery of **electrons** by J.J. Thomson and later the **proton** as a positively charged particle, helping build early atomic models.

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

(b) 18

Options:
(a) 8

(b) 18
(c) 10
(d) 32

Explanation:
Maximum number of electrons in any shell = $\mathbf{2n^2}$
For 3rd shell (n = 3):
$2 \times 3^2 = 2 \times 9 =$ **18 electrons**

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

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

Options:
(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.

Explanation:
Since isotopes of the same element have identical atomic numbers, they occupy the same position in the periodic table.

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

(c) Neutron

Options:
(a) Electron
(b) Proton

(c) Neutron
(d) Both neutron and electron

Explanation:
Isotopes differ in the number of **neutrons**, while their number of **protons and electrons** remains the same.

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

(a) ^{16}O

Options:

(a) ^{16}O
(b) ^{17}O

(c) ^{18}O
(d) None of these

Explanation:
Atomic number of oxygen = 8 → protons = electrons = 8
In ^{16}O → neutrons = 16 − 8 = **8**
So, ^{16}O has 8 protons, 8 electrons, and 8 neutrons.

(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

Options:

(a) 14.0210
(b) 14.0021
(c) 14.2100
(d) 14.1200

Explanation:
= (14 × 99.64 + 15 × 0.35) / 100
= (1394.96 + 5.25) / 100 = 1400.21 / 100 = **14.0021**
Close to **14.0210** (minor rounding)

(vii) ^{14}C is useful for:

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

Options:

(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.

Explanation:
^{14}C is used in **radiocarbon dating** to estimate the age of ancient biological materials.

(viii) What keeps the particles present in the nucleus intact?

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

Options:

(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.

Explanation:
The **strong nuclear force** overcomes the repulsion between positively charged protons in the nucleus, holding nucleons together.

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

(b) By revolving around the nucleus

Options:
(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

Explanation:
Electrons **revolve** around the nucleus at high speed. This movement prevents them from collapsing into the nucleus despite the attraction.

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

(b) 27.8%

Options:
(a) 15%

(b) 27.8%
(c) 37%
(d) 72%

Explanation:
Total abundance = 100%
Heavier isotope = 100% − 72.2% = **27.8%**

Short Questions with Answers

i. Why is it said that almost all the mass of an atom is concentrated in its nucleus?
Answer:
Almost all the mass of an atom is concentrated in its nucleus because the nucleus contains **protons and neutrons**, which are **heavy subatomic particles**. Electrons are extremely light and revolve around the nucleus in energy levels, contributing very little to the overall mass of the atom.

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ii. Why are elements different from one another?
Answer:
Elements are different from one another because they have **different atomic numbers**, i.e., different number of **protons** in their nuclei. Since the atomic number defines the identity and chemical behavior of an element, no two different elements have the same atomic number.

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iii. How many neutrons are present in ^{83}Bi (Bismuth)?
Answer:
Bismuth has an atomic number of **83**, which means it has 83 protons. The most common isotope of bismuth is ^{209}Bi.
Neutrons = Mass number − Atomic number = 209 − 83 = **126 neutrons**

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iv. Why is tritium (^{3}H) a radioactive element?
Answer:
Tritium (^{3}H) is a radioactive isotope of hydrogen because it has **one proton and two neutrons**, making its nucleus **unstable**. This instability causes it to **emit beta particles** and transform into a stable form, thus exhibiting radioactivity.

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v. How can an atom absorb and evolve energy?
Answer:
An atom can **absorb energy** when an electron moves from a **lower energy level to a higher one** (excited state). It **evolves or emits energy** when the electron returns from a **higher energy level to a lower one**, usually in the form of **light or electromagnetic radiation**.

Constructed Response Questions

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

Answer:

Electrons in an atom are arranged in energy levels or shells around the nucleus. The **first shell (K-shell)** is closest to the nucleus and has the **lowest energy**. As we move to **outer shells** (like the second or L-shell), the electrons are **farther from the nucleus**, and their energy is **higher**. This is because electrons in outer shells are **less tightly held** by the nucleus due to increased distance and shielding effect. Therefore, **energy increases** as we move from inner to outer shells.

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

Answer:

The pressure of the gas in the discharge tube is **lowered (to about 0.01 atm)** to make it easier for **electrical current to pass** through the gas. At normal pressure, **gas molecules are too close**, causing frequent collisions that **prevent free movement of electrons**. When pressure is reduced, **gas becomes less dense**, allowing electrons to travel freely, strike gas atoms, and produce **visible glow and ionization**, which helps in studying subatomic particles like **electrons**.

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

Answer:

The **classical concept** treated the electron as a **tiny particle** revolving around the nucleus in **fixed circular orbits**, similar to planets around the sun (Bohr's Model). Over time, **modern quantum mechanics** changed this view. Now, the electron is considered to have **both particle and wave-like nature** (wave-particle duality), and its position is described in terms of **probability** in orbitals rather than fixed paths. The **quantum model** provides a more accurate description using **atomic orbitals and energy sublevels**.

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

Answer:

The nuclei of radioactive elements are unstable because they have an **imbalance between the number of protons and neutrons**, or they have **too many nucleons (protons + neutrons)**. This imbalance causes **internal repulsive forces**, especially **electrostatic repulsion between protons**, to become stronger than the **strong nuclear force** that holds the nucleus together. As a result, the nucleus breaks down and emits **radiations (alpha, beta, gamma)** to attain stability — a process known as **radioactive decay**.

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v. During discharge tube experiments, how did the scientists conclude that the same type of electrons and protons are present in all the elements?
Answer:
In discharge tube experiments, when **different gases** were used at low pressure and high voltage, the resulting **cathode rays (electrons)** had the **same properties** regardless of the type of gas or material of electrodes used. This indicated that **electrons are a fundamental part of all atoms**. Later, the discovery of **canal rays (protons)** also showed **similar behavior**. Since these particles were observed in **all elements**, scientists concluded that **electrons and protons are common and universal subatomic particles** present in all atoms.

Descriptive Questions
Investigative Questions

i. Explain the structure of a hydrogen atom.
Answer:
A hydrogen atom is the **simplest atom**. It consists of:

- **1 proton** in the nucleus (positively charged)
- **1 electron** revolving around the nucleus in the first shell (K-shell)

There are **no neutrons** in the most common isotope of hydrogen (^{1}H). The electron is bound to the nucleus by **electrostatic force of attraction**, and its motion in the shell prevents it from collapsing into the nucleus.

Modern model:
The electron in hydrogen exists in a **probability region called orbital**, not a fixed path, as per **quantum mechanics**.

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ii. How does the theory of atomic structure explain the ionization of atoms by a radioactive isotope?
Answer:
According to atomic structure theory, **ionization** occurs when an atom **gains or loses electrons**, forming **ions**.

Radioactive isotopes emit **radiations** (like alpha, beta, or gamma rays) during decay. These high-energy radiations:

- **Knock electrons out** of surrounding atoms
- This results in the **formation of positive ions**

Such interaction between radioactive emissions and atoms leads to **ionization**, which is widely used in detectors and nuclear chemistry.

iii. What is radioactivity? Explain any three applications of radioactive isotopes.
Answer:
Radioactivity is the spontaneous emission of **radiations** (alpha, beta, gamma) from the unstable nuclei of certain elements.

Applications of radioactive isotopes:

1. **Medicine (Radiotherapy):**
   - Isotopes like **Cobalt-60** are used to kill cancer cells through gamma rays.
2. **Agriculture:**
   - **Phosphorus-32** is used to study nutrient uptake in plants and to control pests.
3. **Archaeology (Carbon Dating):**
   - **Carbon-14** is used to determine the age of fossils and ancient artifacts.

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

Isotope	Relative Abundance (%)
196Hg	0.0146%
198Hg	10.02%
199Hg	16.34%
200Hg	23.13%
201Hg	13.22%
202Hg	29.80%

Isotope	Relative Abundance (%)
204Hg	6.85%

Solution:
Use the formula:
Relative Atomic Mass =

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

Step-by-step calculation:

- 196 × 0.0146 = **2.8616**
- 198 × 10.02 = **1983.96**
- 199 × 16.34 = **3252.66**
- 200 × 23.13 = **4626.00**
- 201 × 13.22 = **2656.22**
- 202 × 29.80 = **6019.60**
- 204 × 6.85 = **1397.40**

Add all values:
= 2.8616 + 1983.96 + 3252.66 + 4626.00 + 2656.22 + 6019.60 + 1397.40
= **21938.70**

Now divide by 100:
Relative atomic mass = 21938.70 / 100 = 219.387

Final Answer: 219.39 (approx)

i. How can scientists synthesize elements in the laboratory?
Answer:
Scientists can synthesize elements in the laboratory using **particle accelerators**, also known as **atom smashers**. In this process:

- **Stable elements** are bombarded with **high-energy particles** like **protons, neutrons, or other nuclei**.

- These collisions can **fuse atomic nuclei**, forming **new elements** that may not exist naturally.
- For example, **transuranic elements** (with atomic number > 92) like **plutonium** or **curium** are synthesized this way.

These reactions usually produce **radioactive elements**, and their properties are studied for use in **medicine, energy, and scientific research**.

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ii. A system just like our solar system exists in an atom. Comment on this statement.
Answer:
This statement is based on the **Bohr model of the atom**. In this model:

- The **nucleus** of the atom is like the **sun** at the center.
- The **electrons** revolve around the nucleus in **fixed circular orbits**, just like **planets revolve around the sun**.

While this model helps visualize atomic structure, modern physics shows that:

- Electrons do **not move in fixed paths**.
- Instead, they exist in **probability regions (orbitals)** around the nucleus as per **quantum mechanics**.

So, while the comparison is helpful as a **conceptual model**, the **modern atomic model is more complex** and accurate than the solar system analogy.