Chapter: 01

Fundamentals of Chemistry

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Exercise MCQs

1. Industrial chemistry deals with the manufacturing of compounds:

   (A) In the laboratory
   (B) On micro scale
   (C) On commercial scale
   (D) On economic scale

2. Which one of the following compounds can be separated by physical means?

   (A) Mixture
   (B) Element
   (C) Compound
   (D) Radical

3. The most abundant element occurring in the oceans is:

   (A) Oxygen
   (B) Hydrogen
   (C) Nitrogen
   (D) Silicon

4. Which one of the following elements is found in most abundance in the Earth's crust?

   (A) Oxygen
   (B) Aluminium
   (C) Silicon
   (D) Iron

5. The third abundant gas found in the Earth's atmosphere is:

   (A) Carbon monoxide
   (B) Oxygen
   (C) Nitrogen
   (D) Argon

6. One amu (atomic mass unit) equivalent to:

   (A) 1.66×10^{-24} mg
   (B) 1.66×10^{-24} g
   (C) 1.66×10^{-24} kg
   (D) 1.66×10^{-23} g

7. Which one of the following molecules is not tri-atomic?

   (A) H_2
   (B) O_3
   (C) H_2O
   (D) CO_2

8. The mass of one molecule of water is:

Ⓐ 18 amu
Ⓑ 18 g
Ⓒ 18 mg
Ⓓ 18 kg

9. The molar mass of H_2SO_4 is:

Ⓐ 98 g
Ⓑ 98 amu
Ⓒ 9.8 g
Ⓓ 9.8 amu

10. Which one of the following is molecular mass of O_2 in amu?

Ⓐ 32 amu
Ⓑ 53.12×10^{-24} amu
Ⓒ 1.92×10^{-25} amu
Ⓓ 192.64×10^{-25} amu

11. How many number of moles are equivalent to 8 grams of CO_2?

Ⓐ 0.15
Ⓑ 0.18
Ⓒ 0.21
Ⓓ 0.24

12. Which one of the following pairs has the same number of ions?

Ⓐ 1mole of NaCl and 1 mole of $MgCl_2$
Ⓑ 1/2 mole of NaCl and 1/2 mole of $MgCl_2$
Ⓒ 1/2 mole of NaCl and 1/3 mole of $MgCl_2$
Ⓓ 1/3 mole of NaCl and 1/2 mole of $MgCl_2$

13. Which one of the following pairs has the same mass?

Ⓐ 1 mole of CO and 1 mole of N_2
Ⓑ 1 mole of CO and 1 mole of CO_2
Ⓒ 1 mole of O_2 and 1 mole of N_2
Ⓓ 1 mole of O_2 and 1 mole of CO_2

ANSWER KEY:

1	Ⓒ	8	Ⓐ
2	Ⓐ	9	Ⓐ
3	Ⓐ	10	Ⓐ
4	Ⓐ	11	Ⓑ
5	Ⓓ	12	Ⓒ
6	Ⓑ	13	Ⓐ
7	Ⓐ		

Exercise Short Questions Answers

Q 1: Define industrial chemistry and analytical chemistry.

Ans: Industrial Chemistry:

The branch of chemistry that deals with the manufacturing of chemical compounds on commercial scale is called industrial chemistry. It deals with the manufacturing of fertilizers, textile, soap, agricultural products, paints, paper etc.

Analytical Chemistry:

It is the branch of chemistry which deals with the separation and analysis of a sample to identify its components. The separation is carried out prior to qualitative and quantitative analysis. Different techniques and instruments used for analysis are also studied in this branch.

Q 2: How can you differentiate between organic and inorganic chemistry? OR Define organic and inorganic chemistry.

Ans: The difference between organic and inorganic chemistry is:

Organic Chemistry	Inorganic Chemistry
Organic chemistry is the study of covalent compounds of carbon and hydrogen (hydrocarbons) and their derivatives.	Inorganic chemistry deals with the study of all elements and their compounds except those of compounds of carbon and hydrogen (hydrocarbons) and their derivatives.

Q 3: Give the scope of biochemistry.

Ans: The scope of biochemistry is very vast. Its applications are in the fields of medicines, food science and agriculture etc.

Q 4: How does Homogeneous mixture differ from heterogeneous mixture?

Ans: The difference between Homogeneous mixture and heterogeneous mixture is:

Homogeneous mixture	Heterogeneous mixture
Mixtures having uniform composition throughout are called homogeneous mixtures e.g. air.	Heterogeneous mixture is that in which composition is not uniform throughout e.g. soil.

Q 5: What is the relative atomic mass? How is it related to gram? OR Define relative atomic mass based on C-12 scale.

Ans: The relative atomic mass of an element is the average mass of atoms of that element as compared to $\frac{1}{12th}$ the mass of one atom of carbon-12 isotope. Its unit is called atomic mass unit with symbol "amu". One atomic mass unit is $\frac{1}{12th}$ the mass of one atom of carbon-12th. When this atomic mass unit is expressed in grams, it is equivalent to:

$$\mathbf{1\ amu = 1.66\times10^{-24}\ g}$$

Q 6: Define empirical formula with an example.

Ans: The type of formula which shows the simplest whole number ratio of atoms present in a compound is called empirical formula. e.g. glucose ($C_6H_{12}O_6$) has simplest ratio 1:2:1 of carbon, hydrogen and oxygen respectively. Hence its empirical formula is CH_2O.

Q 7: State three reasons why do you think air is a mixture and water a compound?

Ans: Three reasons in which air is a mixture and water a compound are:

- Water is a compound because it is formed by chemical combination of hydrogen and oxygen whereas air is formed by simple mixing of different gases.
- Water has fixed ratio between masses of hydrogen and oxygen, whereas in air ratio between masses of component gases is not fixed.
- Water has definite melting and boiling points whereas air does not have any fixed melting and boiling point.

Q 8: Explain why hydrogen and oxygen are considered elements whereas water a compound.

Ans: Hydrogen and oxygen are elements because in these substances same type of atoms with same atomic number are present whereas water is made up of hydrogen and oxygen atoms having different atomic numbers. Hydrogen and oxygen cannot be decomposed into simpler substances by chemical means whereas water can be decomposed into hydrogen and oxygen by electrolysis.

Q 9: What is the significance of the symbol of an element?

Ans: Symbol is the international recognition of an element. With the help of symbol scientists form the formulae of different compounds. Symbol also helps to write and understand chemical equation for different chemical reactions. The periodic table is based on symbols of different elements. We should say without symbols Chemistry would not be easy to understand.

Q 10: State the reason Soft drink is a mixture and water is a compound.

Ans: Soft drink (Cold drink) is a true solution of sugar and water in which CO_2 is dissolved through pressure. We can separate these components by physical methods. It does not have definite melting and boiling point. Therefore cold drink is a mixture, whereas water is formed by chemical combination of hydrogen and oxygen.

$$2H_2 + O_2 \longrightarrow 2H_2O$$

We cannot separate these two gases by physical methods. It has definite freezing and boiling points. Therefore water is a compound.

Q 11: Classify the following into element, compound or mixture.

(i) He and H_2 (ii) CO and Co (iii) Water and Milk
(iv) Gold and Brass (v) Iron and Steel

Ans:

Element	Compound	Mixture
He, Co, Gold and Iron	H_2, CO, Water	Milk, Brass and Steel

Q 12: Define atomic mass unit. Why is it needed?

Ans: The unit for relative atomic mass is called atomic mass unit. Its symbol is "amu". One atomic mass unit is $\frac{1}{12th}$ the mass of one atom of carbon-12th. The mass of an atom is too small to be determined practically. So to determine the atomic mass of various elements atomic mass unit is needed.

Q13: State the nature and name of the substance formed by combining the following:

(i) Zinc + Copper (ii) Water + Sugar
(iii) Aluminium + Sulphur (iv) Iron + Chromium + Nickel

Ans:

Substance	Nature	Name
(i) Zinc + Copper	Alloy (mixture)	Brass
(ii) Water + Sugar	Solution (mixture)	Aqueous solution of sugar
(iii) Aluminium + Sulphur	Compound	Aluminium sulphide
(iv) Iron + Chromium + Nickel	Alloy (mixture)	Nichrome

Q 14: Differentiate between molecular mass and formula mass. Which of the following have molecular formula? H_2O, NaCl, KI, H_2SO_4.

Ans: Molecular mass:

The sum of atomic masses of all the atoms present in one molecule of a molecular substance is called molecular mass. e.g. molecular mass of water is 18 amu. Whereas Formula mass is the sum of atomic masses of all atoms present in one formula unit of a substance is called formula mass. e.g. formula mass of sodium chloride is 58.5 amu.

H_2O and H_2SO_4 are molecular formulae of molecular compounds water and sulphuric acid respectively.

Q 15: Which one has more atoms: 10g of Al or 10g of Fe?

Ans:

1. Given mass of Al = 10 g

Molar mass of Al = 27 $gmol^{-1}$

No. of atoms in 10 g of Al = No. of moles $\times N_A$

$$\text{No. of atoms in 10 g of Al} = \frac{\text{Given mass}}{\text{Molar mass}} \times N_A$$

$$\text{No. of atoms in 10 g of Al} = \frac{10\ g}{27\ gmol^{-1}} \times 6.02 \times 10^{23}\ \text{atoms}$$

No. of atoms in 10 g of Al = 2.23×10^{23} atoms

2. Given mass of Fe = 10 g

Molar mass of Fe = 56 $gmol^{-1}$

$$\text{No. of atoms in 10 g of Fe} = \frac{10\ g}{56\ gmol^{-1}} \times 6.02 \times 10^{23}\ \text{atoms}$$

No. of atoms in 10 g of Fe = 1.115×10^{23} atoms

Therefore 10 g of Al contains more atoms as compared to 10g of Fe.

Q 16: Which one has more molecules: 9g of water or 9g of sugar ($C_{12}H_{22}O_{11}$).
OR (Find out the molecules in 9 gram of water.)

Ans:

1. Given mass of water (H_2O) = 9 g

Molar mass of water (H_2O) = 18 $gmol^{-1}$

No. of molecules in 9 g of water = $\frac{\text{Mass of water}}{\text{Molar mass}} \times N_A$

No. of molecules in 9 g of water = $\frac{9}{18} \times 6.02 \times 10^{23}$ molecules

No. of molecules in 9 g of water = 3.01×10^{23} molecules

2. Given mass of sugar = 9 g

Molar mass of sugar ($C_{12}H_{22}O_{11}$) = 342 $gmol^{-1}$

No. of molecules in 9 g of sugar = $\frac{9}{342} \times 6.02 \times 10^{23}$ molecules

No. of molecules in 9 g of sugar = 1.584×10^{22} molecules

Therefore 9 g of water contains more molecules than 9g of sugar.

Q 17: Which one has more formula units: 1g of NaCl or Ig of KCl.

Ans:

1. Given mass of NaCl = 1 g

Formula mass of NaCl = 58.5 $gmol^{-1}$

No. of formula units in 1g of NaCl = $\frac{\text{Given mass}}{\text{Formula mass}} \times N_A$

No. of formula units in 1g of NaCl = $\frac{1}{58.5} \times 6.02 \times 10^{23}$

No. of formula units in 1g of NaCl = 1.029×10^{22} Formula units (particles)

2. Given mass of KCI = 1g

Formula mass of KCI = 74.5 $gmol^{-1}$

No. of formula units in 1g of KCI = $\frac{1}{74.5} \times 6.02 \times 10^{23}$

No. of formula units in 1g of KCI = 8.080×10^{21} Formula units (particles)

Therefore 1g of NaCI contains more formula units than 1g of KCI.

Q18: Differentiate between homoatomic and heteroatomic molecules with examples.

Ans: Difference between homoatomic and heteroatomic molecules:

Homogeneous molecules	Heterogeneous molecules
A molecule containing same type of atoms is called homoatomic molecule. e.g. Hydrogen (H_2), Oxygen (O_2), Ozone (0_3) and sulphur (S_8) are homoatomic molecules.	A molecule consisting of different types of atoms is called Heteroatomic molecule. e.g. NH_3, H_2O and CO_2 are heteroatomic molecules.

Q19: In which one of the following the number of hydrogen atoms is more? 2 moles of HCI or 1 mole of NH3.

[Hint: 1 mole of a substance contains as much number of moles of atoms as are in 1 molecule of a substance].

Ans:

No. of moles of hydrogen in 1 mole of HCI = 1 mole

No. of moles of hydrogen in 2 moles of HCI = 2 moles

Whereas no. of moles of hydrogen in 1 mole of NH_3 = 3 moles

Hence 1 mole of NH_3 contains 3 moles of hydrogen and will have more hydrogen atoms than 2 moles of hydrogen present in 2 moles of HCI.

Chapter: 01

Fundamentals of Chemistry

Q 1: Define Chemistry. Give its importance in daily life.

Ans: The branch of science which deals with the composition, structure, properties, and reactions of matter is called chemistry. It touches almost every aspect of our life.

Importance:

The development of science and technology has provided us a lot of facilities in daily life e.g. petrochemical products, medicines and drugs, soap, detergents, paper, plastics, paints, pigments, insecticides and pesticides etc play a very important role in our daily life and all these substances are fruits of the efforts of chemists. The development of chemical industry has also generated toxic wastes, contaminated water and polluted air around us. On the other hand, chemistry also provides knowledge and techniques to improve our health and environment and to explore and conserve the natural resources.

Q 2: Describe the various branches of Chemistry.

Ans: Branches of Chemistry:

Chemistry is divided into following main branches.

1. **Physical Chemistry:**

Physical Chemistry is defined as the branch of chemistry that deals with the relationship between the composition and physical properties of matter along with the changes in them.

2. **Application:**

The properties such as structure of atoms or formation of molecules, behavior of gases, liquids and solids and the study of the effect of temperature or radiation on matter, all are studied under this branch.

3. **Organic Chemistry:**

Organic Chemistry is the study of covalent compounds of carbon and hydrogen (hydrocarbons) and their derivatives.

Scope of this branch covers petroleum, petrochemicals and pharmaceutical industries.

4. **Inorganic Chemistry:**

Inorganic chemistry deals with the study of all elements and their compounds except those compounds of carbon and hydrogen, hydrocarbons and their derivatives.

It has **applications** in every aspect of the chemical industry such as glass, cement, ceramics and metallurgy (extraction of metals from ores).

5. Biochemistry:

It is the branch of chemistry in which we study the structure, composition, and chemical reactions of substances found in living organisms. It covers all chemical reactions taking place in living organisms.

Applications of biochemistry are in the fields of medicine, food science and agriculture etc.

6. Industrial Chemistry:

The branch of chemistry that deals with the manufacturing of chemical compounds on commercial scale is called industrial chemistry.

Applications: It deals with the manufacturing of basic chemicals such as oxygen, chlorine, ammonia, caustic soda, nitric acid and sulphuric acid. These chemicals provide the raw materials for many other industries such as fertilizers, soap, textiles, agricultural products, paints and paper etc.

7. Nuclear Chemistry:

Nuclear Chemistry is the branch of chemistry that deals with the radioactivity, nuclear processes and properties.

The main concern of this branch is with the energy of the atom and its uses in daily life.

8. Application:

It has vast applications in medical treatment (radiotherapy), preservation of food and generation of electrical power through nuclear reactors, etc.

9. Environmental Chemistry:

It is the branch of chemistry in which we study about components of the environment and the effects of human activities on the environment.

10. Applications:

Environmental chemistry is related to other branches like biology, geology, ecology, soil and water chemistry, mathematics and engineering. The knowledge of chemical processes taking place in the environment is necessary for its improvement and protection against pollution.

11. Analytical Chemistry:

Analytical chemistry is the branch of chemistry that deals with the separation and analysis of a sample to identify its components.

The separation is carried out prior to qualitative and quantitative analysis.

(a) Qualitative analysis provides the identity of a substance (Composition of chemical species).

(b) Quantitative analysis determines the amount of each component present in the sample. Hence, in this branch different techniques and instruments used for analysis are studied.

The scope of this branch covers food, water, environmental and clinical analysis.

Q 3: Define Matter, Substance, Physical Properties, and Chemical Properties.

Ans: Matter, Substance, Physical Properties, and Chemical Properties:

1. Matter:

Matter is simply defined as anything that has mass and occupies space. Our bodies as well as all the things around us are examples of matter can exist in any of three physical states; solid, liquid or gas.

2. Substance:

A piece of matter in pure form is termed as substance. Every substance has a fixed composition and specific properties or characteristics.

3. Physical Properties:

The properties that are associated with the physical state of a matter are called physical properties; like colour, smell, taste, hardness, the shape of crystal, solubility, melting or boiling points etc. For example when ice is heated, it melts to form water. When water is further heated, it boils to give steam. In this entire process only the physical state of water changes whereas its chemical composition remains the same.

4. Chemical Properties:

The chemical properties depend upon the composition of the substance. When a substance undergoes a chemical change, its composition changes and a new substance is formed. For example, decomposition of water is a chemical change as it produces hydrogen and oxygen gases.

Q 4: Define element and classify the elements with examples.

Ans: Element:

Element is a substance made up of the same type of atoms, having same atomic number and it cannot be decomposed into simple substances by ordinary chemical means. It means that each element is made up of unique type of atoms that have very specific properties.

Explanation:

In the early ages, only nine elements (carbon, gold, silver, tin, mercury, lead, copper, iron, and sulphur) were known. At that time it was considered that elements were the substances that could not be broken down into simpler units

by ordinary chemical processes. Until the end of nineteenth century sixty-three elements had been discovered. Now 118 elements have been discovered, out of which 92 are naturally occurring elements.

Classification of Elements:

On the basis of their properties, elements are divided into metals, non-metals, and metalloids.

Metals:

An element which can lose electron easily, form positive ions, and are good conductor of heat and electricity are called metals e.g. sodium, copper, zinc, gold etc. About 80 percent of the elements are metals.

Non-Metals:

Elements which can gain electrons to form negative ions and are non-conductor of heat and electricity are called non-metals e.g. nitrogen, oxygen, carbon, sulphur etc.

Metalloids or Semi-Metals:

Elements which have properties of both metals and non-metals are called metalloids or semi metals e.g. germanium, arsenic, antimony, etc.

Physical States of Elements:

Elements may be solids, liquids or gases. Majority of the elements exist as solids e.g. sodium, copper, zinc, gold etc. There are very few elements which occur in liquid state e.g. mercury (metal) and bromine (non-metal). A few elements exist as gases e.g. nitrogen, oxygen, chlorine and hydrogen.

Q 5: Describe the occurrences of some major elements.

Ans: Occurrence:

Elements occur in nature in free or combined form. All the naturally occurring elements found in the world have different percentages in the earth's crust, oceans and atmosphere. Table shows natural occurrence in percentage by weight of some abundant elements around us.

It shows concentrations of these major elements found in the three main systems of our environment.

Natural Occurrences by Weight % of Some Major Elements

Crust of Earth		Oceans		Atmosphere	
Oxygen	47%	Oxygen	86%	Nitrogen	78%

Silicon	28%	Hydrogen	11%	Oxygen	21%
Aluminiu	7.8%	Chlorine	1.8%	Argon	0.9%

Q 6: Define valency. Write a detailed note on the concept of valency.

Ans: Valency is the unique property of an element. It is combining the capacity of an element with other elements. It depends upon the number of electrons in the outermost shell.

Valency in Covalent Compounds:

In simple covalent compounds, valency is the number of hydrogen atoms which combine with one atom of that element or a number of bonds formed by one atom of that element e.g. valency of C, O, N, and C is 1,2,3 and 4 respectively. Different number of atoms of hydrogen combines with one atom of these elements to form compounds like HCl, H2O, NH3, and CH4 respectively.

Valency in Ionic Compounds:

In simple ionic compounds, valency is the number of electrons gained or lost by an atom of an element to complete its octet. Elements having less than four electrons in their valence shell; prefer to lose the electrons to complete their octet. For example, atoms of Na, Mg, and Al have 1,2 and 3 electrons in their valence shells respectively. They lose these electrons to have valency of 1,2 and 3 respectively. On the other hand, elements having five or more than five electrons in their valence shell, gain electrons to complete their octet. For example, N, O, and C have 5,6, and 7 electrons in their valence shells respectively. They gain 3, 2, and 1 electron respectively to complete their octet. Hence they show valency of 3, 2, and 1 respectively.

Variable Valency:

Some elements show more than one valency, i.e., they have variable valency. For example, in ferrous sulphate (FeSO4) the valency of iron is 2. In ferric sulphate (Fe2(SO4)3) the valency of iron is 3. Generally, the Latin or Greek name for the element (e.g., Ferrum) is modified to end in '**ous**' for the lower valency (e.g., Ferrous) and to end in '**ic**' for the higher valency (e.g., Ferric).

Some Elements and Radicals with their symbols and common valencies

Element / Radica	Symbol	Valency	Element / Radical	Symbol	Valency
Sodium	Na	1+	Hydrogen	H	1+

Potassium	K	1+	Chlorine	Cl	1-
Silver	Ag	1+	Bromine	Br	1-
Magnesium	Mg	2+	Iodine	I	1-
Calcium	Ca	2+	Oxygen	O	2-
Barium	Ba	2+	Sulphur	S	2-
Zinc	Zn	2+	Nitrogen	N	3-
Copper	Cu	1+ , 2+	Phosphorus	P	3,5
Mercury	Hg	1+ , 2+	Boron	B	3
Iron	Fe	2+ , 3+	Arsenic	As	3
Aluminium	Al	3+	Carbon	C	4
Chromium	Cr	3+	Carbonate	CO^{2-}_4	2-
Ammonium	NH^{+}_4	1+	Sulphate	SO^{2-}_4	2-
Hydronium	H_3O^{+}	1+	Sulphite	SO^{2-}_3	2-
Hydroxide	OH^{-}	1-	Thiosulphate	$S_2O^{2-}_3$	2-
Cyanide	CN^{-}	1-	Nitride	N^{3-}	3-
Bisulphate	HSO_4	1-	Phosphate	PO^{3-}_4	3-
Bicarbonate	HCO^{-}_3	1-			

Q 7: Define Compound. How is it classified?

Ans: Compound:

Compound is a substance made up of two or more elements chemically combined together in a fixed ratio by mass.

Explanation:

As a result of combination, elements lose their own properties and produce new substances (compounds) that have entirely different properties. Compounds cannot be broken down into their constituent elements by simple physical methods. For example, carbon dioxide is formed when elements of carbon and oxygen combine chemically in a fixed ratio of 12:32 or 3:8 by mass. Similarly

water is a compound formed by a chemical combination between hydrogen and oxygen in a fixed ratio of 1:8 by mass.

Classification of Compounds:

Compounds can be classified as ionic or covalent.

Ionic Compounds:

Ionic compounds do not exist in independent molecular form. They form a three-dimensional crystal lattice, in which each ion is surrounded by oppositely charged ions. These oppositely charged ions attract each other very strongly; as a result ionic compounds have high melting and boiling points. These compounds are represented by formula units e.g. NaCl, KBr, CuSO4.

Covalent Compounds:

The covalent compounds mostly exist in molecular form. A molecule is a true representative of the covalent compound and its formula is called a molecular formula e.g. H2O, HCl, H2SO4, CH4.

Some common Compounds with their Formulae

Compound	Chemical Formula
Water	H_2O
Sodium chloride (Common salt)	NaCl
Silicon dioxide (Sand)	SiO_2
Sodium hydroxide (Caustic Soda)	NaOH
Sodium carbonate (Washing Soda)	$Na_2CO_3.10H_2O$
Calcium oxide (Quick Lime)	CaO
Calcium carbonate (Lime Stone)	$CaCO_3$
Sugar	$C_{12}H_{22}O_{11}$
Sulphuric acid	H_2SO_4
Ammonia	NH_3

Q 8: Define Mixture. How is it classified?

Ans: Mixture:

When two or more elements or compounds mix-up physically without any fixed ratio, they form a mixture. On mixing up, the component substances retain their

own chemical identities and properties. The mixture can be separated into parent components by physical methods such as distillation, filtration, evaporation, crystallization, or magnetization.

Classification:

1. Homogeneous Mixture:

Mixtures that have uniform composition throughout are called homogeneous mixtures e.g. air, gasoline, and ice cream.

2. Heterogeneous Mixture:

Heterogeneous mixtures are those in which composition is not uniform throughout e.g. soil, rock, and wood.

Q 9: What is relative atomic mass and atomic mass unit?

Ans: Relative Atomic Mass:

The relative atomic mass of an element is the average masses of an atom of that element as compared to 1/12th (one twelfth) the mass of an atom of carbon-12 isotope.

Explanation:

As we know that the mass of an atom is too small to be determined practically. However, certain instruments enable us to determine the ratio of the atomic masses of various elements to that of carbon-12 atoms. This ratio is known as the relative atomic mass of the element.

Example:

The relative atomic mass of Hydrogen (H) is 1.008 amu and that of Oxygen (O) is 15.9994.

Atomic Mass Unit:

One atomic mass unit is 1/12th the mass of one atom of carbon-12.

Explanation:

Based on carbon-12 standard, the mass of an atom of carbon is 12, and 1/12th of it comes to be one. When we compare the atomic masses of other elements with carbon-12 atoms, they are expressed as relative atomic masses of those elements. The unit for relative atomic masses is called "atomic mass unit" with the symbol "amu". When the atomic mass unit is expressed in grams, it is

$$1 \text{ amu} = 1.66 \times 10^{-24} \text{g}$$

Examples:

Mass of a proton = 1.0073 amu or 1.672×10^{-24}g

Mass of a neutron = 1.0087 amu or 1.674×10^{-24}g

Mass of a electron = 5.486×10^{-4} amu or 9.106×10^{-28}g

Q 10: List five characteristics by which compounds can be distinguished from mixtures.

Ans: Difference between a Compound and a Mixture is:

Compound	Mixture
It is formed by a chemical combination of atoms of elements.	Mixture is formed by the simple mixing up of the substances.
The constituents lose their identity and form a new substance having entirely different properties from them.	Mixture shows the properties of the constituents.
Compounds always have fixed composition by mass.	Mixtures do not have a fixed composition.
The components cannot be separated by physical means.	The components can be separated by simple physical methods.
Every compound is represented by a chemical formula.	It consists of two or more components and does not have any chemical formula.
Compounds have homogeneous composition.	They may be homogeneous or heterogeneous in composition.
Compounds have sharp and fixed melting points.	Mixtures do not have sharp and fixed melting points.

Q 11: What do you know about atomic number and mass number? Explain them with examples.

Ans: Atomic number:

The atomic number of an element is equal to the number of protons present in the nucleus of its atoms. It is represented by the symbol 'Z'.

As all atoms of an element have the same number of protons in their nuclei, they have the same atomic number.

Each element has a specific atomic number and is termed as its identification number also.

Examples:

All hydrogen atoms have 1 proton, their atomic number Z = 1.

All carbon atoms have 6 proton, their atomic number Z = 6.

All oxygen atoms have 8 proton, their atomic number Z = 8.

All Sulphur atoms have 16 proton, their atomic number Z = 16.

Mass number:

The mass number is the sum of number of protons and neutrons present in the nucleus of an atom. It is represented by symbol 'A'.
It is calculated as A=Z+n, where n is the number of neutrons. Each proton and neutron has 1amu mass.

Examples:

Hydrogen atom has one proton and no neutron in its nucleus, its mass number A=1+0=1.
Carbon atom has 6 protons and 6 neutrons, hence its mass number A= 6+ 6 = 12.
Atomic numbers and mass numbers of a few elements are given in the following table.

Some elements along with their atomic and mass numbers

Element	Number of Protons	Number of Neutrons	Atomic Number Z	Mass Number A
Hydrogen	1	0	1	1
Carbon	6	6	6	12
Nitrogen	7	7	7	14
Oxygen	8	8	8	16
Fluorine	9	10	9	19
Sodium	11	12	11	23
Magnesium	12	12	12	24
Potassium	19	20	19	39
Calcium	20	20	20	40

Q 12: How to write a Chemical Formula? Explain with examples.

Ans: Compounds are represented by chemical formulae as elements are represented by symbols. Chemical formulae of compounds are written keeping the following steps in consideration.

- Symbols of two elements are written side-by-side, in the order of positive ion first and negative ion later.
- The valency of each ion is written on the right top corner of its symbol, e.g. Na^{+},Ca^{2+}, Cl^{-} and O^{2-}
- This valency of each ion is brought to the lower right corner of other ion by cross- exchange method, e.g.
- If the valencies are same, they are offset and are not written in the chemical formula. But if they are different, they are indicated as such at the same position, e.g. in case of sodium chloride both the valencies are offset and formula is written as NaCl, whereas, calcium chloride is represented by the formula $CaCl_2$.
- If an ion is a combination of two or more atoms which is called radical, bearing a net charge on it, e.g. SO_4^{2-} (sulphate) and PO_4^{3-} (phosphate), then the net charge represents the valency of the radical. The chemical formula of such compounds is written as explained in (iii) and (iv) for example, chemical formula of aluminium sulphate is written as $Al_2(SO_4)_3$ and that of calcium phosphate as $Ca_3(PO_4)_2$.

Q 13: Describe the significance of chemical formula.

Ans: The significance of chemical formula is:

- It represents the name of the substance e.g. H_2O (water).
- It tells the name of the elements present in the compound.
- It is in fact one molecule or formula unit of the compound.
- It indicates the mass of the compound in amu or grams.
- It also represents one mole of the molecules in the balanced chemical equation.

Q 14: Define Empirical Formula. Explain it with examples.

Ans: Empirical formula:

It is the formula, which shows the simplest whole number ratio of atoms present in a compound.

Explanation:

The empirical formula of a compound is determined by knowing the percentage composition of a compound.

Empirical Formula of Covalent Compounds:

The covalent compound silica (sand) has the simplest ratio of 1:2 of silicon and oxygen respectively. Therefore, its empirical formula is SiO_2. Similarly, glucose has the simplest ratio 1:2:1 of carbon, hydrogen, and oxygen respectively. Hence its empirical formula is CH_2O.

Empirical Formula of Ionic Compounds:

Ionic compounds exist in three dimensional network forms. Each ion is surrounded by oppositely charged ions in such a way to form electrically neutral compound. Therefore, the simplest unit taken as a representative of an ionic compound is called **formula unit**. It is defined as the simplest whole number ratio of ions, as present in the ionic compound.

In other words, ionic compounds have only empirical formulae. For example, formula unit of common salt consists of one Na^+ and one CI^- ion and its empirical formula is NaCl. Similarly, the formula unit of potassium bromide is KBr, which is also its empirical formula.

Q 15: Define Molecular Formula. Explain it with examples.

Ans: Molecular Formula:

Molecules are formed by the combination of atoms. The formula which shows actual number of atoms of each element present in a molecule of that compound is called molecular formula. The molecular formula is derived from the empirical formula by the following relationship:

$$\text{Molecular formula} = (\text{Empirical formula})_n$$

Where n is 1,2,3 and so on.

For example, the molecular formula of benzene is C_6H_6 which is derived from its empirical formula CH where the value of n is 6.

The molecular formula of a compound may be the same or a multiple of the empirical formula. A few compounds having different empirical and molecular formulae are shown in the following Table.

Some Compounds with their Empirical and Molecular Formulae

Compound	Empirical Formula	Molecular Formula
Hydrogen peroxide	HO	H_2O_2
benzene	CH	C_6H_6
glucose	CH_2O	$C_6H_{12}O_6$

Some compounds may have the same empirical and molecular formula e.g. water (H_2O), hydrochloric acid (HCl), etc.

Q 16: Define Molecular Mass and Formula Mass. Give examples.

Ans: Molecular Mass:

The sum of atomic masses of all the atoms present in one molecule of a molecular substance is called molecular mass.

Examples:

- The molecular mass of water (H_2O) is 18 amu.
- The molecular mass of chlorine (Cl_2) is 71amu.
- The molecular mass of Carbon dioxide (CO_2) is 44 amu.

Formula Mass:

The sum of atomic masses of all the atoms present in one formula unit of a substance is called formula mass.

Examples:

- The formula mass of sodium chloride is 58.5 amu.
- Formula mass of $CaCO_3$ is 100 amu.

Q 17: Write a note on the following Chemical Species.

1) **Ions (Cations and Anions)**
2) **Molecular Ions**
3) **Free Radicals**

Ans:

1. Ions:

Ion is an atom or group of atoms having a charge on it. The charge may be positive or negative. There are two types of ions i.e. cations and anions.

Cations:

An atom or group of atoms having positive charge on it is called cation.

Formation:

The cations are formed when an atom loses electrons from its outermost shell. For example, Na^+, K^+ is cations. The following equations show the formation of cations from atoms.

Atoms		Cations
H	$\longrightarrow$	$H^+ + Ie^-$
Na	$\longrightarrow$	$Na^+ + Ie^-$
Ca	$\longrightarrow$	$Ca^{2+} + 2e^-$

Anions:

An atom or a group of atoms that has a negative charge on it is called an anion.

Formation:

Anion is formed by the gain or addition of electrons to an atom.

For example, CI^- and O^{2-}. The following examples show the formation of an anion by the addition of electrons to an atom.

Atoms			Anions
Cl	+	Ie^- $\longrightarrow$	Cl^-
O	+	$2e^-$ $\longrightarrow$	O^{2-}

2. **Molecular Ion:**

Molecular ion or radical is specie having positive or negative charge on it. When a molecule loses or gains an electron, it forms a **molecular ion.** Hence, like other ions they can be **cationic** molecular ions (if they carry positive charge) or **anionic** molecular ions (if they carry negative charge). Cationic molecular ions are more abundant than anionic molecular ions.

Formation:

When gases are bombarded with high-energy electrons in a discharge tube, they ionize to give molecular ions.

Examples:

CH_4 , He^+ , N_2^+.

3. **Free Radicals:**

Free radicals are atoms or group of atoms possessing an odd number of (unpaired) electrons. It is represented by putting a dot over the symbol of an element e.g. H*, Cl*, H_3C*.

Formation:

Free radicals are generated by the homolytic (equal) breakage of the bond between two atoms when they absorb heat or light energy. A free radical is an extremely reactive species as it has the tendency to complete its octet.

Molecules		Free radicals
Cl_2	sunlight →	$2Cl^*$
CH_2	sunlight →	$H_3C^* + H^*$

Q 18: Differentiate between atoms and ions.

Ans: Difference between atoms and ions is:

Atom	Ion
It is the smallest particle of an element.	It is the smallest unit of an ionic compound.
It can or cannot exist independently and can take part in a chemical reaction.	It cannot exist independently and is surrounded by oppositely charged ions.
It is electrically neutral.	It has a net charge (either negative or positive) on it.

Q 19: Differentiate between molecule and molecular ion.

Ans: Difference between Molecule and Molecular Ion is:

Molecule	Molecular Ion
It is the smallest particle of an element or a compound which can exist independently and shows all the properties of that compound.	It is formed by the gain or loss of electrons by a molecule.
It is always neutral.	It can have a negative or positive charge.
It is formed by the combination of ato	It is formed by the ionization of a molecule.
It is a stable unit.	It is reactive specie.

Q 20: Differentiate between ions and free radicals.

Ans: Difference between ions and free radicals is:

Ions	Free Radicals
These are the atoms which bear some charge.	These are the atoms that have odd number of electrons.
They exist in solution or in crystal lattice.	They can exist in solutions as well in the air.
Their formation is not affected by the presence of light.	They may form in the presence of light.

Q 21: Define Molecule. Write down its types.

Ans: A molecule is formed by the chemical combination of atoms. It is the smallest unit of a substance. It shows all the properties of the substance and can exist independently.

Types of Molecules:

1. Monoatomic Molecule:

A molecule consisting of only one atom is called monoatomic molecule.

Examples:

The inert gases helium, neon and argon all exist independently in atomic form.

2. Diatomic Molecule:

A molecule consisting of two atoms is called diatomic molecule.

Examples:

Hydrogen gas (H_2), oxygen (O_2), chlorine (Cl_2) and hydrogen chloride (HCl).

3. Triatomic Molecule:

A molecule consisting of three atoms is called triatomic molecule.

Examples:

Water (H_2O), Carbon dioxide (CO_2) .

4. Polyatomic Molecule:

A molecule consisting of many atoms is called polyatomic molecule.

Examples:

Methane (CH_4), Sulphuric Acid (H_2SO_4) and glucose ($C_6H_{12}O_6$).

5. Homoatomic Molecule:

A molecule containing same type of atoms is called homoatomic molecule.

Examples:

Hydrogen (H_2), Ozone (O_3), Sulphur (S_8)

6. Heteroatomic Molecule:

A molecule consisting of different kinds of atoms is called heteroatomic molecule.

Examples:

Carbon dioxide (CO_2), Water (H_2O), Ammonia (NH_3).

Q 22: Write a note on the following Chemical Species.

1) **Gram Atomic Mass**
2) **Gram Molecular Mass**
3) **Gram Formula Mass**

Ans:

1. Gram Atomic Mass:

The atomic mass of an element expressed in grams is called gram atomic mass or gram atom. It is also called a mole. e.g.

1 gram atom of hydrogen = 1.008 g = 1 mol of hydrogen
1 gram atom of carbon = 12.0 g = 1 mol of carbon

It means that 1 gram atom of different elements has different masses.

2. Gram Molecular Mass:

The molecular mass of a compound expressed in grams is called gram molecular mass or gram molecule. It is also called a mole. e.g.

1 gram molecule of H_2 = 2.0 g = 1 mol of hydrogen
1 gram molecule of H_2O = 18.0 g = 1 mol of water
1 gram molecule of H_2SO_4 = 98.0 g = 1 mol of Sulphuric acid

3. Gram Formula Mass:

The formula mass of an ionic compound expressed in grams is called gram formula mass or gram formula. This is also called a mole. e.g.

1 gram formula of NaCl = 58.5 g = 1 mol of sodium chloride
1 gram formula of $CaCO_3$ = 100g = 1 mol of calcium carbonate

Q 23: What is Avogadro's Number? Explain with examples.

Ans: Avogadro's number:

The number of particles in one mole of a substance is called Avogadro's number. The value of this number is $\mathbf{6.02\times10^{23}}$. It is represented as $\mathbf{N_A}$.

Explanation:

In chemistry we deal with substances which are composed of atoms, molecules or formula units. The counting of these particles is not possible for the chemists. The concept of Avogadro's number facilitated the counting of particles contained in the given mass of a substance. Avogadro's number is a collection of 6.02 x10^{23} particles. It is represented by symbol 'N_A'. Hence, the 6.02 ×10^{23} number of atoms, molecules or formula units is called Avogadro's number that is equivalent to one 'mole' of respective substance.

In simple words 6.02 ×10^{23} particles are equal to one mole as twelve eggs are equal to one dozen. The following examples show the relationship between Avogadro's number and the mole of a substance.

Examples:

- 6.02 × 10^{23} atoms of carbon are equivalent to one mole of carbon.
- 6.02 × 10^{23} molecules of H_2O are equivalent to one mole of water.

- 6.02×10^{23} formula units of NaCl are equivalent to one mole of sodium chloride.
- Thus, 6.02×10^{23} atoms of elements or 6.02×10^{23} molecules of molecular compounds or 6.02×10^{23} formula units of ionic compounds are equivalent to 1 mole.

For further explanation about number of atoms in molecular compounds or number of ions in ionic compounds, following two examples are given:

One molecule of water is made up of 2 atoms of hydrogen and 1 atom of oxygen, hence $2 \times 6.02 \times 10^{23}$ atoms of hydrogen and 6.02×10^{23} atoms of oxygen constitute one mole of water.

One formula unit of sodium chloride consists of one sodium ion and one chloride ion. So, there are 6.02×10^{23} number of Na^+ ions and 6.02×10^{23} CI^- ions in one mole of sodium chloride. Thus, the total number of ions in 1 mole of NaCl is 12.04×10^{23} or 1.204×10^{24}.

Q 24: Mole is SI unit for the amount of a substance. Define it with examples.

Ans: Mole (Chemist secret unit):

A mole is defined as the amount (mass) of a substance that contains 6.02×10^{23} number of particles (atoms, molecules or formula units). It is abbreviated as 'mol'.

It establishes a link between the mass of a substance and number of particles.

Explanation:

We know that a substance may be an element or a compound (molecular or ionic). Mass of a substance is either one of the following: atomic mass, molecular mass or formula mass. These masses are expressed in atomic mass units (amu). But when these masses are expressed in grams, they are called as molar masses. Scientists have agreed that Avogadro's number of particles is present in one molar mass of a substance.

Quantitative definition of mole:

The atomic mass, molecular mass or formula mass of a substance expressed in grams is called mole.

Examples:

Atomic mass of carbon expressed as 12g	=	1 mole of Carbon
Molecular mass of H_2O expressed as 18g	=	1 mole of water
Molecular mass of H_2SO_4 expressed as 98g	=	1 mole of H_2SO_4
Formula mass of NaCl expressed as 58.5g	=	1 mole of NaCl

Relationship between Mole and Mass:

$$\text{Number of moles} = \frac{\text{Known mass of a substance}}{\text{Molar mass of the substance}}$$

OR Mass of substance (g) = number of moles × molar mass

Relationship between Mole and Number of Particles:

$$\text{Number of moles} = \frac{\text{Given number of particles}}{\text{Avogadro's number}}$$

$$\text{Number of moles} = \frac{\text{Given number of particles}}{6.02\times 10^{23}}$$

OR Given number of particles = number of moles × 6.02×10^{23}

Q 25: Differentiate between the following with examples.

1. **Molecule and gram molecule**
2. **Atom and gram atom**
3. **Molecular mass and molar mass**
4. **Chemical formula and gram formula**

Ans:

1. **Molecule:**

A molecule is formed by the chemical combination of atoms. It is the smallest unit of a substance.

Examples:

H_2O, CO_2

Gram Molecule:

The molecular mass of a compound expressed in grams is called gram molecular mass or gram molecule.

Example:

1 gram molecule of water = 18.0 g
1 gram molecule of water = 1 mol of water

2. **Atom:**

It is the smallest particle of an element. It can or cannot exist independently and can take part in a chemical reaction. It is electrically neutral.

Examples:

K , Na , He , Ne etc.

Gram Atom:

The atomic mass of an element expressed in grams is called gram atomic mass or gram atom. It is also called a mole.

Example:

1 gram atom of Hydrogen = 1.008 g
1 gram atom of Hydrogen = 1 mol of Hydrogen

3. Molar mass:

The sum of atomic masses of all the atoms present in one molecule of a molecular substance is called molecular mass.

Examples:

The molecular mass of water (H_2O) is 18 amu.

Molar Mass:

The mass of 1 mole of a substance is called molar mass.

Example:

The molar mass of water (H_2O) is 18 g/mol.

4. Chemical Formula:

Compounds are represented by the Chemical formula. Chemical formula shows types of elements and number of atoms of each element present in it.

Examples:

Chemical formula of benzene is C_6H_6.

Gram Formula:

The formula mass of an ionic compound expressed in grams is called gram formula mass or gram formula. This is also called a mole.

Example:

1 gram Formula of NaCl = 58.5 g
1 gram Formula of NaCl = 1 mol of sodium chloride