6. Nuclear Chemistry
The branch of Chemistry that deals with the changes that occur in atomic nuclei is called nuclear chemistry.

7. Environmental Chemistry
The branch of Chemistry that deals with the chemicals and toxic substances that pollute the environment and their adverse effect on human beings is called environmental chemistry.

8. Analytical Chemistry
The branch of Chemistry that deals with the methods and instruments that determine the composition of matter is called Analytical Chemistry.

Differentiation between branches of Chemistry
Acetic acid chemical formula: CH_3COOH
Source: Vinegar which contain 5% acetic acid.
Smell: Vinegar like smell
Use: Used to flavor food.
Let's see how various types of studies on this compound can help us to differentiate between the above mentioned eight branches of chemistry.

1. Explanation of conversion of acetic acid from solid to liquid and liquid to gaseous state and vice versa, the application of laws and theories to understand its structure is ***physical chemistry***.
2. Since acetic acid is a carbon compound, the study of its methods of preparation and study of its physical and chemical properties is a part of ***organic chemistry***.
3. The component elements of acetic acid are carbon, hydrogen and oxygen. The study of its component elements is included in ***inorganic chemistry***.
4. The study of all the chemical reactions that acetic acid undergoes in the bodies of human beings is called ***biochemistry***.
5. Use of technology and ways to obtain acetic acid on the large scale is a part of ***industrial chemistry***.
6. The study of radioactive radiation or neutron on this compound is a part of ***nuclear chemistry***.
7. The study of any adverse effects of the compound or the compounds that are derived from it, on the human is part of ***environmental chemistry***.
8. The methods and instruments used to determine its percentage composition, melting and boiling points etc is ***analytical chemistry***.

Example 1.4: Determining formula mass

1. Sodium Chloride, also called table salt is used to flavor food, preserve meat, and in the preparation of large number of compounds. Determine its formula mass.

Solution

Formula mass of NaCl = 1 (atomic mass of Na) + 1 (atomic mass of Cl)
= 1 x 23 + 1 x 35.5
= 58.5 amu

2. Milk of magnesia which contains $Mg(OH)_2$ is used to treat acidity. Determine its formula mass.

Solution

Formula mass of $Mg(OH)_2$ = 24 + 16 x 2 + 1 x 2
= 24 + 32 + 2
= 58 amu

SELF ASSESSMENT EXERCISE 1.4

1. Potassium Chlorate ($KClO_3$) is used commonly for the laboratory preparation of O gas. Calculate its formula mass.

Solution

Formula mass of $KCLO_3$ = 39 + 35.5 + 3 x 16
= 39 + 35.5 + 48
= 122.5 amu

2. When baking soda, $NaHCO_3$ is heated, carbon dioxide is released, which is responsible for the rising of cookies and bread. Determine the formula masses of baking soda and carbon dioxide.

Solution

Formula mass of $NaHCO_3$ = 23 + 1 + 12 + 3 x 16
= 23 + 1 + 12 + 48
= 84 amu

Formula mass of CO_2 = 12 + 2 x 16
= 12 + 32
= 44 amu

3. Following compounds are used as fertilizers. Determine their formula masses.
(i) Urea, $(NH_2)_2CO$
(ii) Ammonium nitrate, NH_4NO_3

Solution

Formula mass of urea = 2 [14 + 2(1)] + 12 + 16
= 2(14) + 4(1) + 12 + 16
= 28 + 4 + 12 + 16
= 60 amu

Formula mass of ammonium nitrate = 14 + 4(1) + 14 + 3(16)
= 14 + 4 + 14 +48
= 80 amu

(b) Mass of H_2O_2 = 30 g
Molar mass of H_2O_2 = 34 g/ mol
Number of moles = $\frac{mass\ of\ H_2O_2}{molar\ mass\ of\ H_2O_2}$

= $\frac{30}{34}$

= 0.88 mol

2) A spoon of table salt, NaCl contains 12.5 grams of this salt. Calculate the number of moles it contains.

Solution
Mass of NaCl = 12.5 g
Molar mass of NaCl = 23 + 35.5 =58.5 g

Number of moles = $\frac{mass\ of\ NaCl}{molar\ mass\ of\ NaCl}$

= $\frac{12.5}{58.5}$

= 0.21 mol

3) Before the digestive systems X-rayed, people are required to swallow suspensions of barium sulphate ($BaSO_4$). Calculate mass of one mole of $BaSO_4$.

Solution
Mass of one mole of $BaSO_4$ = 137 + 32 + 4(16) = 233g

2. Mole-Particles Calculations

Example 1.10: Calculating the number of atoms in given moles

1) Zn is a silvery metal that is used to galvanize steel to prevent corrosion. How many atoms are there in 1.25 moles of Zn?

Solution
1 mole of Zn contains = 6.022×10^{23} atoms
Number of atoms **= No. of moles x Avogadro's number**
1.25 moles of Zn contain = $1.25 \times 6.022 \times 10^{23}$
= 7.53×10^{23} Zn atoms

2) A thin foil of Aluminum (Al) is used as wrapper in food industries. How many atoms are present in a foil that contains 0.2 moles of Aluminium?

Solution
1 mole of Al contains = 6.022×10^{23} atoms
Number of atoms **= No. of moles x Avogadro's number**
0.2 moles of Al contain = $0.2 \times 6.022 \times 10^{23}$
= 1.2044×10^{23} Zn atoms

Example 1.11: Calculating the number of molecules in given moles of a substance

1) Methane (CH_4) is the major component of natural gas. How many molecules are present in 0.5 moles of a pure sample of methane?

Solution

1 mole of CH_4 contains = 6.022×10^{23} molecules
Number of moles = 0.5 moles
Number of molecules =?
Number of molecules = No. of moles x Avogadro's number
So, 0.5 moles of CH_4 will contain= $0.5 \times 6.022 \times 10^{23}$
= 3.011×10^{23} molecules

2) At high temperature hydrogen sulphide (H_2S) gas given off by a volcano is oxidized by air to sulphur dioxide (SO_2). Sulphur dioxide reacts with water to form acid rain. How many molecules are there in 0.25 moles of SO_2?

Solution

1 mole of SO_2 contains = 6.022×10^{23} molecules
Number of moles = 0.25 moles
Number of molecules =?
Number of molecules = No. of moles x Avogadro's number
So, 0.25 moles of SO_2 will contain= $0.25 \times 6.022 \times 10^{23}$
= 1.505×10^{23} SO_2 molecules

Example 1.12: Calculating the number of moles in given number of atoms

Titanium is corrosion resistant metal that is used in rockets, aircrafts and jet engines. Calculate the number of moles of this metal in a sample containing 3.011×10^{23} Ti atoms.

Solution

1 mole of an element contains 6.022×10^{23} atoms.
Number of atoms =3.011×10^{23}
Number of moles =?

$$Number\ of\ moles = \frac{Number\ of\ atoms}{6.022\ x\ 10\text{^}23}$$

= $3.011 \times 10^{23} / 6.022 \times 10^{23}$

= 0.5 moles of Ti

Some Important Points:-

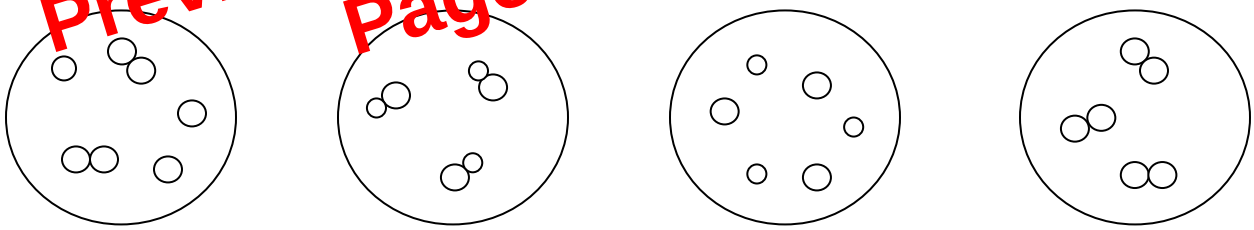
- Volume of an object determines the volume of the liquid it displaces, when submerged in the liquid.
- Elements are the building blocks of all the substances that make up all the living and non-living things.
- Only noble gases exist as monoatomic molecules, other substances exist as polyatomic molecules.
- Water cover 70% of the earth's crust.
- Garlic contains more than 200 compounds. It lowers the chances of getting stomach cancer, prevents heart disease and stroke.
- Entire physical world is made up of mixture of elements and compounds. Most of its components are made up of molecules.
- Quantitative information about atomic masses came from the work of Dalton, Gay Lussac, Lavoisier, Avogadro and Berzelius.
- Glucose ($C_6H_{12}O_6$) is known as blood sugar.
- Milk of magnesia which contains $Mg(OH)_2$ is used to treat acidity.
- Potassium Chlorate ($KClO_3$) is used commonly for the laboratory preparation of O gas.
- Elements have atoms of same sizes and compounds have atoms of different sizes.
- All compounds are molecules; not all molecules are compounds.

Exercise

1. Encircle the correct answer:-

(i) Which of the following lists contains only elements?
(a) Air, water, oxygen (b) Hydrogen, oxygen, brass
(c) Air, water, fire, earth (d) Calcium, sulphur, carbon

(ii) The diagrams below represent particles in four substances, which box represent the particles in nitrogen.



(a) (b) (c) (d)

(iii) What is the formula mass of $CuSO_4.5H_2O$. (Atomic masses: Cu=63.5, S=32, O=16, H=1)
(a) 159.5 (b) 185.5 (c) 249.5 (d) 149.5

(iv) A compound with chemical formula Na_2CX_3 has formula mass 106 amu. Atomic mass of the element X is:
(a) 106 (b) 23 (c) 12 (d) 16

(v) How many moles of molecules are there in 16 g oxygen?
(a) 1 (b) 0.5 (c) 0.1 (d) 0.05

(vi) What is the mass of 4 moles of hydrogen gas?
(a) 8.064 g (b) 4.032 g (c) 1 g (d) 1.008 g

(vii) What is the mass of carbon present in 44 g of carbon dioxide?
(a) 12 g (b) 6 g (c) 24 g (d) 44 g

(vi) What is the number of molecules in 9.0 g of steam?

Ans: Mass in grams = 9.0 g steam (H_2O)

Molar mass of H_2O = 2(1) + 16

= 18 g

Number of molecules = ?

$$Number\ of\ molecules = \frac{mass\ of\ H_2O}{molar\ mass\ of\ H_2O}\ x\ 6.022\ x\ 10^{23}$$

$$Number\ of\ molecules = \frac{9\ g}{18\ g}\ x\ 6.022\ x\ 10^{23}$$

$$Number\ of\ molecules = \ 3.011\ x\ 10^{23}$$

(vii) What are the molar masses of uranium-238 and uranium-235?

Ans: The molar masses of U-238 is 238 g and U-235 is 235 g respectively, because atomic mass of any element expressed in grams is its molar mass.

(viii) Why one mole of hydrogen molecules and one mole of H-atoms have different masses?

Ans: One mole of hydrogen molecules and one mole of H-atoms have different masses because there are two H-atoms present in one molecule of hydrogen (H_2). Hydrogen molecule is diatomic in nature.

Atomic mass of H-atom = 1.008 amu

1 mole of H-atom = 1.008 g

Molecular mass of H_2 = 2 x 1.008

= 2.016 amu

1 mole of H_2 = 2.016 g

3. Define ion, molecular ion, formula unit, free radical, atomic number, mass number, atomic mass unit?

Ans: See Notes, Pages 6, 7, 10, 12, and 13.

4. Differentiate between (a) atom and ion, (b) molecular ion and free radical?

Ans: Difference between an atom and an ion:-

Atom	Ion
It is the smallest particle of an element.	It is the smallest particle of an ionic substance.
It may or may not have independent existence.	It cannot exist independently and is surrounded by oppositely charged ions.
It is a neutral particle.	It has either positive or negative charge on it.

Difference between molecular ion and free radical:-

Molecular Ion	Free Radical
It is formed by gain or loss of electrons by a molecule.	It is an atom or group of atoms having an unpaired electron.
It has positive or negative charge on it.	It is electrically neutral.
Molecular ions are short lived species and only exist at high temperature.	Sun light may produce free radicals.
Molecular ions do not form ionic compounds.	It have tendency to complete its octet by gaining or losing electrons.
Examples: O_2^+, N_2^+ or N_2^-	Examples: $\dot{H}$, $:\ddot{\underset{\cdot\cdot}{Cl}}\cdot$