3. Atoms and Molecules

Assess Yourself

1. Question

Which unit is used to measure the atomic radius? Convert it into metre.

Answer

Fermi unit is used to measure the atomic radius.

1 fermi = 10^{-15}m

2. Question

Name the smallest particle of an element that can retain all the chemical properties.

Answer

An atom is the smallest particle of an element that can retain all the chemical properties. It is the indivisible unit of matter that can exist independently. It is building block of matter.

3. Question

Why is it not possible to see an atom with the unaided eyes?

Answer

It is not possible to see an atom with the unaided eyes because it is very small, it is smaller than anything that we can imagine or compare with.

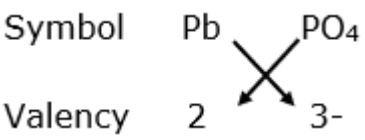
4. Question

Write the formula of lead phosphate.

Answer

Lead phosphate:

By applying criss-cross method:



Chemical formula: $Pb_3(PO_4)_2$

5. Question

What is meant by the valency of an element?

Answer

The combining power or capacity of an element is known as valency. It can be used to find out how the atoms of an element will combine with the atoms of another element to form a chemical compound.

6. Question

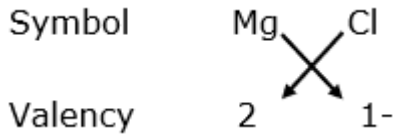
What helps in determining the formula of an ionic compound?

Answer

Valency helps in determining the formula of an ionic compound. Valency can be used to find out how the atoms of an element will combine with the atoms of another element to form a compound.

For example: Magnesium chloride

By applying criss-cross method:



Formula: $MgCl_2$

Thus, the formula for magnesium chloride is $MgCl_2$.

7. Question

What is meant by molar mass?

Answer

Molar mass is the mass of one mole of any substance. One mole of any species (atoms, molecules, ions or particles) is that quantity in number having a mass equal to its atomic or molecules mass in grams.

Molar mass is represented by "M"

$$Number\ of\ moles\ (n) = \frac{Given\ mass\ (m)}{Molar\ mass\ (M)}$$

We can write,

Molar mass (M) = mass (m) × Number of moles(n)

8. Question

What is meant by the law of conservation of mass? If 12 g of C is burnt in the presence of O_2, how much CO_2 will be formed?

[Atomic mass of C = 12 u, O = 16 u]

Answer

Law of conservation of mass: This law states that "atoms are neither created nor destroyed in a chemical reaction".

This means that the total mass of the products formed in chemical reaction must be equal to the mass of reactants consumed.

Carbon + oxygen → CO_2

Mass of carbon = 12g

Mass of oxygen = 32g

Mass of CO_2 =?

According to the law of conservation of mass,

Sum of masses of reactants = Sum of masses of of products

Hence, 12g + 32g = 44g

Thus, the amount of CO_2 formed is 44g.

9. Question

Calculate the formula mass of $CuSO_4.5H_2O$.

[Atomic mass of Cu = 63.5 u, S = 32 u, O = 16 u, H = 1 u]

Answer

Formula unit mass of $CuSO_4.5H_2O$:

Atomic mass of Cu + Atomic mass of S + (4× atomic mass of O) + 5 (2× atomic mass of H + atomic mass of O)

63.5 u + 32 u + 4× 16u + 5 (2 × 1 u + 16 u)

63.5 u + 32 u + 64 u + 90 u

249.5 u

Thus, the formula unit mass of $CuSO_4.5H_2O$ is 249.5 u

10. Question

Calculate the number of moles in 52 g of He.

[Atomic mass of He = 4 u]

Answer

Given:

Mass of He (m) = 52g

Atomic mass of He = 4u

Molar mass of He (M) = 4g/mol

To calculate the number of moles, we will apply the formula given below:

$$Number\ of\ moles = \frac{Given\ mass\ (m)}{Molar\ mass\ (M)}$$

$$Number\ of\ moles = \frac{52g}{4g/mol}$$

Number of moles = 13

Thus, the number of moles in 52 g of He is 13.

11. Question

Convert 12.044×10^{23} number of He atoms into number of moles.

Answer

We know, 1 mole = 6.022×10^{23}(N_a = Avogadro's number)

$$The\ number\ of\ moles = \frac{Given\ number\ of\ atoms}{Avogadro's\ number}$$

$$Number\ of\ moles = \frac{12.044 \times 10^{23}}{6.022 \times 10^{23}}$$

Number of moles = 2

Thus, number of moles of He is 2.

12. Question

Calculate the mass of 0.5 mole of N_2 gas.

[Atomic mass of N = 14 u]

Answer

Given:

Number of moles = 0.5

Atomic mass of N = 14 u

Atomic mass of N_2 = 2 × Atomic mass of N

= 2 × 14 u

= 28 u

Molar mass of N_2 = 28g/mol

To calculate the mass, apply the formula:

$$Number\ of\ moles\ (n) = \frac{Mass\ (m)}{Molar\ mass\ (M)}$$

We can write:

Mass (m) = Number of moles (n) × Molar mass (M)

Mass = 0.5 mol × 28g/mol

Mass = 14g

Thus, the mass of 0.5 mole of N_2 gas is 14g

13. Question

Calculate the mass of 0.5 mole of N atoms.

Answer

Given:

Number of moles = 0.5

Atomic mass of N = 14 u

Molar mass of N = 14g/mol

To calculate the mass, apply the formula:

$$Number\ of\ moles\ (n) = \frac{Mass\ (m)}{Molar\ mass\ (M)}$$

We can write:

Mass(m) = Number of moles (n) × Molar mass (M)

Mass = 0.5 mol × 14g/mol

Mass = 7g

Thus, the mass of 0.5 mole of Natoms is 7g.

14. Question

Calculate the mass of 3.011×10^{23} atoms of nitrogen.

Answer

First we will convert 3.011×10^{23} number of nitrogen atoms into number of moles:

We know, 1 mole = 6.022×10^{23}(N_a = Avogadro's number)

$$The\ number\ of\ moles = \frac{Given\ number\ of\ atoms}{Avogadro's\ number}$$

$$Number\ of\ moles = \frac{3.011 \times 10^{23}}{6.022 \times 10^{23}}$$

Number of moles = 0.5

Now, to calculate mass, apply the formula:

$$Number\ of\ moles\ (n) = \frac{Mass\ (m)}{Molar\ mass\ (M)}$$

We can write:

Mass(m) = Number of moles (n) × Molar mass of nitrogen (M)

Mass = 0.5 mol × 14g/mol

Mass = 7g

Thus, the mass of 3.011×10^{23} atoms of nitrogen is 7g

15. Question

Calculate the mass of 6.022×10^{23} N_2 molecules.

Answer

We know, 1 mole = 6.022×10^{23}

Now, to calculate mass, apply the formula:

$$Number\ of\ moles\ (n) = \frac{Mass\ (m)}{Molar\ mass\ (M)}$$

We can write:

Mass(m) = Number of moles (n) × Molar mass of N_2 (M)

Mass = 1 mol × 28g/mol

Mass = 28g

Thus, the mass of 6.022×10^{23} atoms of nitrogen is 28g

16. Question

Give postulates of Dalton's atomic theory.

Answer

Postulates of Dalton's atomic theory are:

i. All mater is made up of very tiny particles called atoms.

ii. Atoms are indivisible particles.

iii. They cannot be created or destroyed in a chemical reaction.

iv. Atoms of a given element are identical in mass and chemical properties.

v. Atoms of different elements have different masses and chemical properties.

vi. Atoms combine in the ratio of small whole numbers to form compounds.

17. Question

Write the chemical formula using criss-cross method:

(a) Ammonium sulphate

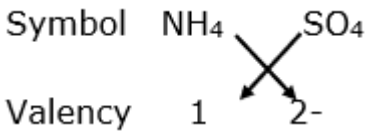
(b) Magnesium bicarbonate

(c) Barium nitrate

Answer

a) Ammonium sulphate:

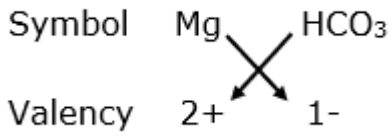
By applying criss-cross method:



Chemical formula: $(NH_4)_2SO_4$

b) Magnesium bicarbonate:

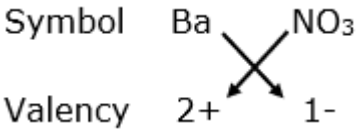
By applying criss-cross method:



Chemical formula: $Mg(HCO_3)_2$

c) Barium nitrate:

By applying criss-cross method:



Chemical formula: $Ba(NO_3)_2$

18. Question

(a) Define the term 'molecular mass'.

(b) Determine the molecular mass of $ZnSO_4$.

[Atomic mass of Zn = 65 u, S = 32 u, O = 16 u]

Answer

a) Molecular mass: The molecular mass of a substance is the sum of atomic masses of all the atoms in a molecule of the substance.

i. It is used for those substances whose constituent particles are molecules.

ii. The molecular mass remains the same even if millions of molecules are added.

iii. For example: The molecular mass of H_2O = 2 × Atomic mass of hydrogen + Atomic mass of oxygen

= 2 + 16 = 18u

b) Molecular mass of $ZnSO_4$:

Atomic mass of Zn + Atomic mass of S + 4× atomic mass of O

65 u + 32 u + 4× 16u

65 u + 32 u + 64 u

161 u

Thus, the molecular mass of $ZnSO_4$ is 161u

19. Question

With the help of example, explain the law of conservation of mass.

Answer

Law of conservation of mass: This law of states that "atoms are neither created nor destroyed in chemical reaction". During a chemical reaction, the sum of the masses of the reactants and products remains unchanged. This is known as the law of conservation of mass.

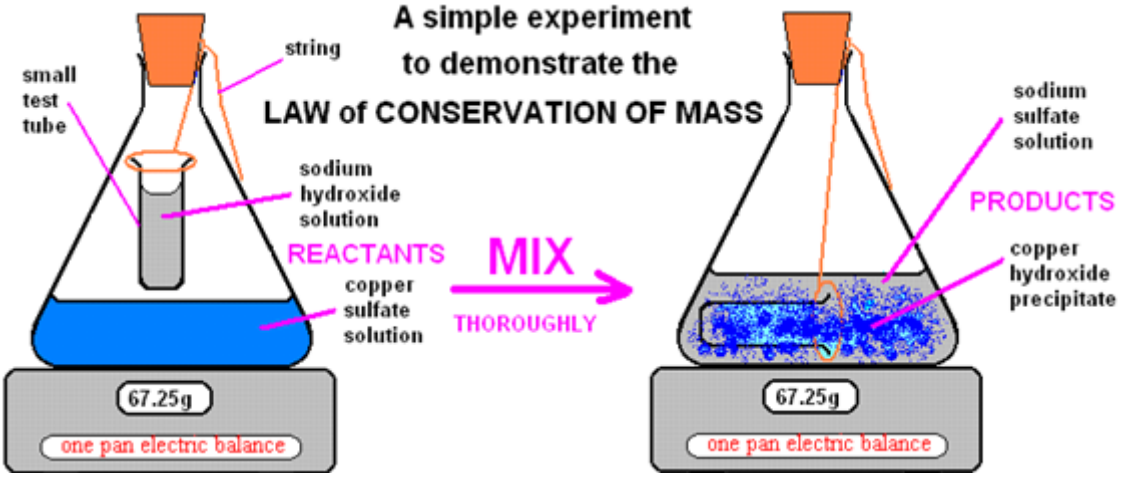
This means that the total mass of the products formed in chemical reaction must be equal to the mass of reactants consumed.

For example:

$CaCO_3 \rightarrow CaO + CO_2$

100g 56g 44g

Sum of masses of reactants = Sum of masses of products



20. Question

Calculate:

(a) The number of moles of Sulphur (S_8) present in 16 g of solid sulphur.

(b) the mass of 10 moles of sodium sulphite (Na_2SO_3).

(c) the number of atoms in 11.5 g of Na.

[atomic mass: Na = 23u; S = 32u, O = 16u, $N_A = 6.022 \times 10^{23}\ mol^{-1}$]

Answer

a) Given:

Mass of sulphur (m) = 16g

Atomic mass of sulphur (S_8) = 8 × 32u = 256 u

Molar mass of S_8 (M) = 256g/mol

To calculate the number of moles, we will apply the formula given below:

$$Number\ of\ moles = \frac{Given\ mass\ (m)}{Molar\ mass\ (M)}$$

$$Number\ of\ moles = \frac{16g}{256g/mol}$$

Number of moles = 0.0625

Thus, the number of moles in 16 g of solid sulphur is 0.0625.

b) Given:

Number of moles = 10

Molecular mass of sodium sulphite (Na_2SO_3) = 2 × Atomic mass of Na + atomic mass of sulphur + 3 × Atomic mass of O

= 2 × 23 u + 32 u + 48 u

= 126 u

Molar mass of Na_2SO_3 = 126g/mol

To calculate the mass, apply the formula:

$$Number\ of\ moles = \frac{Mass\ (m)}{Molar\ mass\ (M)}$$

We can write:

Mass = Number of moles × Molar mass

Mass = 10 mol × 126g/mol

Mass = 1260g

Thus, the mass of sodium sulphite is 1260g.

c) Given:

Mass of Na (m) = 11.5g

Atomic mass of sulphur = 23u

Molar mass of sulphur (M) = 23g/mol

To calculate the number of moles, we will apply the formula given below:

$$Number\ of\ moles = \frac{Given\ mass\ (m)}{Molar\ mass\ (M)}$$

$$Number\ of\ moles = \frac{11.5g}{23g/mol}$$

Number of moles = 0.5

We know, 1 mole = 6.022×10^{23}(N_a = Avogadro's number)

$$The\ number\ of\ moles = \frac{Number\ of\ atoms}{Avogadro's\ number}$$

We can write, number of atoms = Number of moles × N_a

Number of atoms = $0.5 \times 6.022 \times 10^{23}$

Number of atoms = 3.022×10^{23}

Thus, the number of atoms in 11.5 g of Na is 3.022×10^{23}

21. Question

Calculate:

(a) the mass of 1.0505×10^{23} molecules of carbon dioxide (CO_2).

(b) the number of molecules of 0.25 moles of NH_3,

(c) the formula unit mass of Na_2SO_3.

[Atomic mass: Na = 23 u, S = 32 u, O = 16 u, H = 1 u, $N_A = 6.022 \times 10^{23}\ mol^{-1}$]

Answer

(a) First we will convert 1.0505×10^{23} molecules of carbon dioxide (CO_2) into number of moles:

We know, 1 mole = 6.022×10^{23}(N_a = Avogadro's number)

$$The\ number\ of\ moles = \frac{Given\ number\ of\ molecules}{Avogadro's\ number}$$

$$Number\ of\ moles = \frac{1.0505 \times 10^{23}}{6.022 \times 10^{23}}$$

Number of moles = 0.17

Now, to calculate mass, apply the formula:

$$Number\ of\ moles\ (n) = \frac{Mass\ (m)}{Molar\ mass\ (M)}$$

We can write:

Mass(m) = Number of moles (n) × Molar mass of CO_2 (M)

Mass = 0.17 mol × 44g/mol

Mass = 7.48g

Thus, the mass of 1.0505×10^{23} molecule of CO_2 is 7.48g.

(b) Given: Number of moles = 0.25

We know, 1 mole = 6.022×10^{23}(N_a = Avogadro's number)

$$The\ number\ of\ moles = \frac{Number\ of\ molecules}{Avogadro's\ number}$$

We can write:

Number of molecules = Number of moles (n) × N_a

Number of molecules = 0.25mol × 6.022×10^{23}

Number of molecules = 1.5×10^{23}

Thus, the number of molecules of 0.25 moles of NH_3 is 1.5×10^{23}

(c) Formula unit mass of Na_2SO_3 :

2 × Atomic mass of Na + Atomic mass of sulphur + 3 × Atomic mass of O

= 2 × 23 u + 32 u + 3 × 16 u

= 126 u

Thus, the formula unit mass of Na_2SO_3 is 126 u

22. Question

What is meant by the term 'mole'? Calculate the number of moles in

(a) 3.011×10^{23} atoms of C

(b) 32 g of oxygen gas

[$N_A = 6.022 \times 10^{23}$ mol^{-1}, At. mass of O = 16 u and C = 12 u]

Answer

Mole: One mole of any species (Atoms, molecules, ions or particles) is that quantity in number having a mass equal to its atomic or molecules mass in grams.

(a) We will convert 1.0505×10^{23} atoms of C into number of moles:

We know, 1 mole = 6.022×10^{23}(N_a = Avogadro's number)

$$The\ number\ of\ moles = \frac{Given\ number\ of\ atoms}{Avogadro's\ number}$$

$$Number\ of\ moles = \frac{3.011 \times 10^{23}}{6.022 \times 10^{23}}$$

Number of moles = 0.5

Thus, the number of moles in 3.011×10^{23} atoms of C is 0.5.

(b) Given mass: 32g

Molar mass of oxygen gas (O_2) = 2 × atomic mass of oxygen = 2 × 16 u = 32g /mol

To calculate the number of moles, we will apply the formula given below:

$$Number\ of\ moles\ (n) = \frac{Given\ mass\ (m)}{Molar\ mass\ (M)}$$

$$Number\ of\ moles\ (n) = \frac{32g}{32g/mol}$$

Number of mole = 1

Thus, the number of mole in 32 g of oxygen gas is 1.

23. Question

(a) Calculate the number of moles in 112 g of iron.

(b) Calculate the mass of 0.5 mole of sugar ($C_{12}H_{22}O_{11}$).

[Atomic mass of Fe = 56 u, C = 12 u, H = 1 u, O = 16 u]

Answer

(a) Given mass: 112g

Molar mass of iron (Fe) = 56 g/mol

To calculate the number of moles, we will apply the formula given below:

$$Number\ of\ moles\ (n) = \frac{Given\ mass\ (m)}{Molar\ mass\ (M)}$$

$$Number\ of\ moles\ (n) = \frac{112g}{56g/mol}$$

Number of moles = 2

Thus, the number of moles in 112 g of iron is 2

(b) Given: Number of moles = 0.5

Molar mass of $C_{12}H_{22}O_{11}$ = 12 × atomic mass of C + 22 × atomic mass of H + 11 × atomic mass of O

= 12 × 12 + 22 × 1 u + 11 × 16 u = 342 u or 342 g/mol

Now, to calculate mass, apply the formula:

$$Number\ of\ moles\ (n) = \frac{Mass\ (m)}{Molar\ mass\ (M)}$$

We can write:

Mass(m) = Number of moles (n) × Molar mass of $C_{12}H_{22}O_{11}$ (M)

Mass = 0.5 mol × 342g/mol

Mass = 171g

Thus, the mass of 0.5 mole of sugar ($C_{12}H_{22}O_{11}$) is 171g.

24. Question

Define the following terms

(a) Atom

(b) Molecule

(c) Avogadro's number

(d) Valency

(e) Molar mass

Answer

(a) Atom:

i. The building blocks of all matter are atoms. Atoms are very small.

ii. They are smaller than anything we can imagine or compare with.

(b) Molecule:

i. A molecule is general a group of two or more atoms that are chemically bonded together. They are tightly held together by attractive forces.

ii. A molecule can be defined as the smallest particles of an element or a compound that is capable of an independent existence.

iii. A molecule shows all the properties of a particular substance.

iv. Atoms of the same element or different element join together to form molecules.

(c) Avogadro's number:

i. Avogadro's number is the number of particles (atoms, ions or ions) present in one mole of any substance is fixed with a value of 6.022×10^{23}.

ii. This is an experimentally obtained value.

(d) Valency:

i. The combining power or capacity of an element is known as valency.

ii. Valency can be used to find out how the atoms of an element will combine with the atoms of another element to form a chemical compound.

(e) Molar mass:

Molar mass is the mass of one mole of any substance. One mole of any species (atoms, molecules, ions or particles) is that quantity in number having a mass equal to its atomic or molecules mass in grams.

Molar mass is represented by "M"

$$Number\ of\ moles\ (n) = \frac{Given\ mass\ (m)}{Molar\ mass\ (M)}$$

We can write,

Molar mass (M) = mass (m) × Number of moles(n)