4. Atoms and Molecules

Exercises

1 A. Question

Some elements have atomic mass in fractions. It is due to the presence of

A. fractions of protons

B. fractions of neutrons

C. isotopes

D. valence electrons

Answer

The atomic mass of some elements are in fractions because they exist as a mixture of isotopes of different masses. The atomic mass arises in fraction because of this mixture.

$$\text{Mass} = \frac{\text{The total mass of all atoms}}{\text{Number of atoms}}$$

Note- Isotopes are atoms of the same element having a same atomic number but different atomic masses due to the presence of different numbers of neutrons.

Ex- Carbon-12 and Carbon-14 are both isotopes of carbon, one with 6 neutrons and one with 8 neutrons but both have 6 protons.

1 B. Question

Plants in a garden make use of 22.4 liters of carbon dioxide at S T P (Standard temperature and Pressure) The number of molecules of carbon dioxide utilized by the plants is,

A. 6.023×10^{23} molecules

B. 22.4 molecules

C. 6.023×10^{24} atoms

D. 11.2 moles of molecules

Answer

According to Avogadro's law, equal volumes of all gases contain an equal number of molecules at a constant temperature and pressure.

The standard molar volume of a gas is the volume occupied by one mole of any gas at 273 K and 1 atm pressure (STP). It is 22.4 litres. It is the same for all gases. And we know that 6.023×10^{23} molecules are present in one mole of any gas. So the number of molecules of carbon dioxide utilized by the plants will be 6.023×10^{23}.

1 C. Question

The atomic mass of Deuterium, an isotope of hydrogen is 2. The atomic mass of oxygen is 16. Then the molecular mass of heavy water formed is

A. 16

B. 18

C. 20

D. 24

Answer

Deuterium is an isotope of hydrogen which has atomic mass 2u. The formula of heavy water is D_2O. In heavy water, there are 2 deuterium atoms and 1 oxygen atom. So the molecular mass will be $2\times2 + 1\times16 = 20$.

1 D. Question

Some elements can have different valences. It can happen due to the change in

A. number of electrons that participate in a reaction

B. number of neutrons

C. a number of protons

D. atomic mass number

Answer

Valency is defined as the number of electrons that participate in a reaction. It is the number of electrons, an atom of an element can gain or loss in a reaction.

If valence electrons are 4 or less then the valency of an atom is equal to the valence electrons. And if valence electrons are more than 4, the valency is equal to 8 minus the number of electrons in the outer most shell.

For example valency of Magnesium is 2 because it has 2 valence electrons and it can donate two electrons to form a bond. The valency of sulphur is 2 because it has 6 electrons and it can accept or share 2 electrons to form a bond. The valency of carbon is 4 because it has 4 electrons and it can share 4 electrons with other atoms.

Note- Valence electrons are the electrons present in the outermost shell of an atom.

2 A. Question

Give a scientific reason for the following

The Valency of noble gases is zero.

Answer

The valency is the combining power of an element with the other atoms. The valency of noble gases is zero because its combining capacity is zero. These have a complete octet. Complete octet means that the outermost shell has complete 8 electrons. So noble gases cannot gain or lose electrons in a reaction. Hence the valency of noble gases is zero.

2 B. Question

Give a scientific reason for the following

In the atmosphere, Oxygen is available as O_2 but not as O.

Answer

Oxygen has electronic configuration 2, 6. The outer most shell of oxygen has 6 electrons so its valency is 2. It wants to accept two electrons to complete its octet to get stability. So it combines with another oxygen atom to complete its octet. In O_2 molecule, both O atoms have a complete octet. So O_2 is more stable than O atom. Hence Oxygen is available as O_2 in the atmosphere.

3 A. Question

Answer the following

Define:

a) Atomic mass

b) Relative atomic mass

c) Gram molecular mass

d) Mole.

e) Valency of an element

Answer

(a) Atomic mass- Atomic mass is defined as the sum of a number of protons and neutrons normally found in the nucleus of an atom of a given element. It is measured in u (unified mass) or amu (atomic mass unit).

Ex-The atomic mass of Oxygen (O) is 16. It is the sum of 8 protons and 8 neutrons present in its nucleus.

(b) Relative atomic mass- Relative atomic mass (A_r) is a dimensionless quantity. It is defined as the ratio of the average mass of atoms of an element of a given sample to the 1/12 of the atomic mass of a carbon-12 atom.

Ex- Relative atomic mass of Aluminium (Al)

$$= \frac{\text{The average mass of atoms of an element}}{\frac{1}{12} \times \text{Atomic mass of carbon} - 12 \text{ atom}}$$

$$= \frac{27}{\frac{1}{12} \times 12.01}$$

$$= \frac{27 \times 12}{12.01}$$

= 26.98 u

(c) Gram molecular mass- Gram molecular mass of a substance is its relative molecular mass expressed in grams.

Ex- Gram molecular mass of Aluminium (Al) = 26.98g

(d) Mole- A mole of a substance is defined as the amount of substance containing a same number of atoms or molecules as there are atoms in exactly 12g of carbon-12.

(e) Valency of an element- Valency is the combining capacity of an element. It is the number of electrons an atom of an element can gain or loss.

If valence electrons are 4 or less then the valency of an atom is equal to the valence electrons. And if valence electrons are more than 4, the valency is equal to 8 minus the number of electrons in the outer most shell.

Ex- Sodium has electronic configuration 2, 8, 1. So its valency is 1 because it has 1 valence electrons. Oxygen has electronic configuration 2, 6. So its valency is 2 because it has 6 valence electrons.

3 B. Question

Calculate the percentage composition of carbon and Oxygen in CO_2. (given atomic masses : Carbon =12 and oxygen =16)

Answer

The percentage composition of an element in a compound is the mass of an element present in 100g of that compound.

$$\text{The mass percentage of an element} = \frac{\text{Mass of that element in a compound}}{\text{Mass of that compound}} \times 100$$

Now, Total mass of CO_2 = 12 + 2×16 = 44

Percentage composition of carbon in $CO_2 = \frac{12}{44} \times 100$

= 27.27%

Percentage composition of oxygen in CO_2 = $\frac{32}{44} \times 100$

= 72.73%

3 C. Question

A student has a piece of copper sulphate ($CuSO_4$) crystal. Explain the method of calculating the number of $CuSO_4$ molecules in that crystal. (Given atomic masses: Calcium =40, Sulphur = 32 and Oxygen=16)

Answer

First, we calculate the molar mass of copper sulphate ($CuSO_4$) crystal.

Molar mass of $CuSO_4$ = 63 + 32 + 4×16

= 159 g

Now we will calculate the number of moles of copper sulphate ($CuSO_4$)

Number of moles of $CuSO_4$ = $\frac{\text{Given mass of } CuSO_4}{\text{Molar mass of } CuSO_4}$

And we know that 1 mole of $CuSO_4$ = 6.023×10^{23} molecules

Hence, Number of = Number of moles of $CuSO_4 \times 6.023 \times 10^{23}$

molecules of $CuSO_4$

3 D. Question

$$CaCO_3 \xrightarrow{\text{Heat}} CaO + CO_2 \uparrow$$

From the above equation calculate the amount of carbon dioxide in grams liberated by heating 25 g of calcium carbonate.

Answer

From the above equation, one mole of calcium carbonate ($CaCO_3$) produces one mole of carbon dioxide (CO_2).

Molar mass of $CaCO_3$ = 40 + 12 + 3×16

= 100g

Molar mass of CO_2 = 12 + 2×16

= 44g

Number of moles of $CaCO_3$ = $\frac{\text{Given mass}}{\text{Molar mass}}$

= $\frac{25}{100}$

= 0.25 moles

Now, 0.12 moles of $CaCO_3$ produces 0.12 moles of CO_2.

So the amount of carbon dioxide in grams liberated by heating 25 g of calcium carbonate = 0.25×44

= 11 g