CHAPTER 3

Atoms and Molecules

EXAM DRILL

ANSWERS

1. Aurum

2. MSO_4

3(i) $BaCl_2$

3(ii) A compound made up of two elements is called a binary compound, *e.g.*, water (H_2O).

3(iii) Magnesium bromide

3(iv) CO_3^{2-}

4(i) $CaCl_2$

4(ii) Valency of Na : 1, Valency of sulphide : 2

4(iii) (b)

4(iv) (a)

5. (c) : According to law of conservation of mass, mass of reactants is equal to the mass of products.

$CaCO_{3(s)} \xrightarrow{\Delta} CaO_{(s)} + CO_{2(g)}$

Mass of reactant ($CaCO_3$) = 10 g

Mass of products ($CaO + CO_2$) = $(5.6 + x)$ g

10 g = $(5.6 + x)$ g

$x = 4.4$ g

OR

(a) : One gram atom of magnesium = 24 g

$\because$ 24 g of magnesium = 1 g atom

$\therefore$ 360 g of magnesium = $\frac{1}{24} \times 360$ = 15 g atom

6. (c)

7. (b): In flask *X* :

1 molecule of oxygen (O_2) = 2 atoms of oxygen

1 mole of oxygen gas = 6.022×10^{23} molecules

Or 1 mole of O_2 = $2 \times 6.022 \times 10^{23}$ atoms

$\therefore$ 0.5 mole of O_2 = $2 \times 6.022 \times 10^{23} \times 0.5$

= 6.022×10^{23} atoms

In flask *Y* :

1 molecule of ozone (O_3) = 3 atoms of oxygen

1 mole of ozone gas = 6.022×10^{23} molecules

Or 1 mole of O_3 = $3 \times 6.022 \times 10^{23}$ atoms

$\therefore$ 0.4 mole of ozone gas = $3 \times 6.022 \times 10^{23} \times 0.4$ atoms

= 7.23×10^{23} atoms

$\therefore$ Flask *Y* has greater number of oxygen atoms as compared to flask *X*.

8. (b): Valency of sodium = 1

Valency of phosphorus = 3

Symbol Na P

Valency 1 3

Formula : Na_3P

OR

(c) : Mass of 6.023×10^{23} Mg^{2+} ions = 24 g

$\therefore$ Mass of 3.01×10^{23} Mg^{2+} ions

$= \frac{24}{6.023 \times 10^{23}} \times 3.01 \times 10^{23}$ = 12 g

Similarly, mass of 6.023×10^{23} CO_3^{2-} ions

= $(12 + 3 \times 16)$ = 60 g

Mass of 3.01×10^{23} CO_3^{2-} ions

$= \frac{60}{6.023 \times 10^{23}} \times 3.01 \times 10^{23} = 30$ g

Hence, mass of $MgCO_3$ sample = 12 + 30 = 42 g = 0.042 kg

9. (d)

10. (c)

11. (a): Symbol of tin is Sn.

12. (a): $\frac{\text{Atomic mass of O}}{\text{Atomic mass of C}} = \frac{16}{12} = \frac{4}{3}$

OR

(a) : Volume of 1 mole of water = mass/density

= 18 g/1g/mL = 18 mL

13. (a): % of carbon in the compound = $\frac{12}{106} \times 100$

= 11.32%

14. (a): For universally accepted atomic mass unit in 1961, C–12 was selected as standard. However,the new symbol used is ‘u’(unified mass) in place of amu.

15. Molecular mass of $CaSO_4$ = 1 (Ca) + 1 (S) + 4 (O)

= 1 (40) + 1 (32) + 4 (16)

= 40 + 32 + 64 = 136 u

Also mass of sulphur in $CaSO_4$ = 1 × (32) = 32 u

$\therefore$ Mass percentage of sulphur in $CaSO_4$

$= \frac{32}{136} \times 100 = 23.53\%$

OR

Gram molecular mass (6.022×10^{23} molecules) of $CO_2 = 44$ g

Mass of 10^{21} molecules of $CO_2 = \frac{44}{6.022 \times 10^{23}} \times 10^{21} = 0.073$ g

Mass of CO_2 left $= (0.2 - 0.073) = 0.127$ g

Moles of CO_2 left $= \frac{0.127 \text{ g}}{44 \text{ g}} = 2.88 \times 10^{-3}$

16. (a) K_2SO_4

(b) Molecular mass of $S_8 = 32 \times 8 = 256$ g

256 g of S_8 contain 6.022×10^{23} molecules

64 g of S_8 contains $= \frac{6.022 \times 10^{23} \times 64}{256}$

$= 1.505 \times 10^{23}$ molecules

17. Gram atomic mass of sulphur = 32 g

Mass of one sulphur atom $= \frac{\text{Gram atomic mass}}{6.022 \times 10^{23}}$

$= \frac{32}{6.022 \times 10^{23}} = 5.31 \times 10^{-23}$ g

Molecular mass of $CO_2 = 12 + 2 \times 16 = 44$

Gram molecular mass of $CO_2 = 44$ g

Mass of one molecule of $CO_2 = \frac{\text{Gram molecular mass}}{6.022 \times 10^{23}}$

$= \frac{44}{6.022 \times 10^{23}} = 7.306 \times 10^{-23}$ g

18. Moles of $KClO_3 = \frac{\text{Given mass}}{\text{Molar mass}} = \frac{122.5 \text{ g}}{122.5 \text{ g}} = 1$

(Molar mass of $KClO_3 = 122.5$)

From the formula $KClO_3$, we know that 1 mole of $KClO_3$ contains 1 mole of K atoms, 1 mole of Cl atoms and 3 moles of O atoms.

$\therefore$ Number of atoms of K $= 1 \times 6.022 \times 10^{23}$

Number of atoms of Cl $= 1 \times 6.022 \times 10^{23}$

Number of atoms of O $= 3 \times 6.022 \times 10^{23} = 1.80 \times 10^{24}$

OR

(a) The formula *M*O shows that the valency (charge) of $M = +2$

$\therefore$ Formula of its sulphate

Symbol M SO_4

Charge $+2$ -2

Formula = MSO_4

Formula of its nitrate

Symbol M NO_3

Charge $+2$ -1

Formula = $M(NO_3)_2$

(b) (i) In $MgCO_3$, Mg : C : O = 24 : 12 : 3 × 16

= 24 : 12 : 48 = 2 : 1 : 4

(ii) In HNO_3, H : N : O = 1 : 14 : 3 × 16

= 1 : 14 : 48

(iii) In C_2H_5OH or C_2H_6O, C : H : O

= 2 × 12 : 1 × 6 : 16 = 24 : 6 : 16 = 12 : 3 : 8

19. (a) Molecular mass of HNO_3

= (1 × 1) + (14 × 1) + (16 × 3)

= 1 + 14 + 48 = 63 u

(b) Number of moles of Al = Given mass/Molar mass

= 270 g / 27 g = 10

(molar mass of Al = 27 g)

(c) Mass = Number of moles × Molar mass

= 0.5 × 4 = 2 g

20. (a) (i) Atoms cannot exist independently whereas molecules can exist independently.

(ii) Molecular mass is the sum of masses of the atoms in the molecule whereas formula mass is the sum of atomic masses of all the atoms in a formula unit of an ionic compound.

(b) Symbol NH_4 SO_4

Valency 1 2

Formula = $(NH_4)_2SO_4$

21. (a) It is the mass unit exactly equal to one-twelfth (1/12th) the mass of one atom of carbon-12.

(b) The molecular mass of a substance is the sum of the atomic masses of all atoms in a molecule whereas the mass of 1 mole of any substance is called its molar mass. Molecular mass is measured by amu or u whereas molar mass by g/mol.

(c) Diatomic molecules of a compound : HCl, CO, NO

Triatomic molecules of a compound : CO_2, H_2O, SO_2

22. The exact number of atoms present in 12 g of carbon-12 is called Avogadro's constant.

(b) No. of moles (Ne) $= \frac{m}{M} = \frac{\text{Given mass}}{\text{Molar mass}} = \frac{56}{20} = 2.8$

OR

(i) % composition of B $= \frac{0.096 \times 100}{0.24} = 40\%$

% composition of O $= \frac{0.144}{0.24} \times 100 = 60\%$

(ii) Number of moles of $O_2 = \frac{0.144}{32} = 0.0045$ mole

$= 4.5 \times 10^{-3}$

23. P_4 unit mass = 31 × 4 = 124 g

Molar mass contains Avogadro's number of molecules, 124 g contains 6.022×10^{23} molecules

248 g contains = $2 \times 6.022 \times 10^{23}$ molecules

= 12.044×10^{23} molecules

24. (a) Cation : Mg^{2+}, Anion : CH_3COO^-

(b) The volume occupied by one mole of a gas under standard conditions of temperature and pressure (0°C and 1 atm. pressure) is called molar volume. Its value is 22.4 L at STP.

25. 0.9% mass by mass means 0.9 g NaCl in 100 g of solution

∴ Given mass = 0.9 g

Molar mass of NaCl = 58.5 g mol^{-1}

(i) Number of moles = $\frac{m}{M} = \frac{0.9}{58.5} = 0.015$

(ii) Number of molecules = $n \times N_0$

$= 0.015 \times 6.022 \times 10^{23}$

$= 0.09 \times 10^{23}$ or 9.033×10^{21}

OR

(i) (a) Two atoms of oxygen - 2 O

(b) Diatomic oxygen - O_2 molecule

(c) Triatomic oxygen - O_3 molecule

(d) Two atoms of hydrogen and one atom of oxygen forming one molecule of water (H_2O).

(ii) (a) K_2CO_3 - Potassium carbonate

(b) $CaCl_2$ - Calcium chloride

(iii) $Al_2(SO_4)_3 = 2 \times 27 + 3(32 + 4 \times 16)$

= 54 u + 3(96)

= 54 + 288 = 342 u

∴ Formula unit mass = 342 u.

26. (a) Molecular mass of CO_2 = 44 u

1 mole of CO_2 = 44 g

5 mole of $CO_2 = 5 \times 44 = 220$ g

Molecular mass of H_2S = 34 u

1 mole of H_2S = 34 g

5 mole of $H_2S = 5 \times 34 = 170$ g

Hence, both do not have same mass.

(b) 40 g of Ca = 1 mole

240 g of Ca = $\frac{1}{40} \times 240 = 6$ mole

24 g of Mg = 1 mole

240 g of Mg = $\frac{1}{24} \times 240 = 10$ mole

∴ Molar ratio is 6 : 10 *i.e.*, 3 : 5

27. (i) Atomicity - Number of atoms constituting a molecule,

(ii) Polyatomic element - sulphur (S_8)

Polyatomic ion - NH_4^+, OH^-, SO_4^{2-}

(iii) $CaCl_2$ - atomicity - 3

SO_4^{2-} - atomicity - 5

(iv) (a) Na_2CO_3 - Sodium carbonate

(b) NH_4Cl - Ammonium chloride

(c) ZnO - Zinc oxide

(d) $Al(OH)_3$ - Aluminium hydroxide

28. (a) (i) Symbol Cr SO_4

Charge 3 2

Formula = $Cr_2(SO_4)_3$

(ii) Symbol Pb NO_3

Charge 2 1

$Pb(NO_3)_2$

(b) Significance of mole :

(i) It is SI unit of measurement for amount of substance.

(ii) Mole corresponds to the mass of a substance that contains 6.022×10^{23} particles (atom, molecules, ions) of the substance.

(c) For sodium

m = 100 g

M = 23 g

$n = \frac{m}{M} = \frac{100}{23}$

$N = n \times N_0$

$= \frac{100}{23} \times 6.022 \times 10^{23}$

$= 4.35 \times 6.022 \times 10^{23}$

For iron

m = 100 g

M = 56 g

$n = \frac{m}{M} = \frac{100}{56}$

$N = n \times N_0$

$= \frac{100}{56} \times 6.022 \times 10^{23}$

$= 1.78 \times 6.022 \times 10^{23}$

Hence, 100 g sodium has more number of atoms.

OR

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

(ii) 1 mole = 6.022×10^{23} in number

No. of moles = $\frac{\text{Mass of substance (g)}}{\text{Relative molecular mass}}$

(iii) ∵ 1 mole of oxygen contains 6.022×10^{23} molecules

∴ 0.25 mole of oxygen will contain $6.022 \times 10^{23} \times 0.25$

$= 1.505 \times 10^{23}$ molecules.

29. (a) A group of atoms carrying a charge is known as polyatomic ion.

e.g., PO_4^{3-}, SO_4^{2-}, NH_4^+

(b) Mass of 10 moles of Na_2SO_3

$= 10(23 \times 2 + 32 + 16 \times 3) = 1260$ g

(c) (i) Molar mass of $(NH_4)_2Cr_2O_7$

$= 2 \times (14 + 4 \times 1) + 2 \times 52 + 7 \times 16 = 252$ g

Number of moles of $(NH_4)_2Cr_2O_7 = \frac{\text{given mass}}{\text{molar mass}} = \frac{100}{252}$

$= 0.397$ mol

1 mole of $(NH_4)_2Cr_2O_7$ contains 2 moles of N atoms, 8 moles of H atoms, 2 moles of Cr atoms and 7 moles of O atoms.

Number of moles N atoms $= 2 \times 0.397 = 0.794$ mol

Number of moles H atoms $= 8 \times 0.397 = 3.18$ mol

Number of moles Cr atoms $= 2 \times 0.397 = 0.794$ mol

Number of moles O atoms $= 7 \times 0.397 = 2.78$ mol

(ii) $m = 22$ g, $M = 44$, $n = ?$

$$n = \frac{m}{M} = \frac{22}{44} = \frac{1}{2} = 0.5 \text{ mole}$$

30. (a) Mass of pure gold in the sample $= \frac{1\,g \times 90}{100} = 0.9$ g

Number of atoms of gold = Number of moles of gold × Avogadro's number

$$= \frac{0.9\text{ g} \times 6.022 \times 10^{23}\text{ mol}^{-1}}{197\text{ g/mol}} = 2.75 \times 10^{21}$$

(b) Difference of mass per atom and ion

$=$ Mass of 2 electrons $= 2 \times 9.1 \times 10^{-31}$ kg

So, difference in the masses of 10^3 moles of Mg atoms and ions

$= 10^3 \text{ mol} \times 2 \times 9.1 \times 10^{-31}$ kg

$= 10^3 \times 6.022 \times 10^{23} \times 2 \times 9.1 \times 10^{-31}$ kg

$= 1.1 \times 10^{-3}$ kg

OR

(a) 1 hydrogen gas molecule contains 2 atoms of hydrogen

∴ 1 dozen of H_2 = 24 atoms of H

6.022×10^{23} molecules of H_2 = 1 mole

∴ 12 molecules of $H_2 = \frac{12}{6.022 \times 10^{23}}$ mole of H_2

$= 1.99 \times 10^{-23}$

(b) Hydrogen : Oxygen (by mass)

$$H_2 + \frac{1}{2}O_2 \longrightarrow H_2O$$

∵ 1 mole of H_2 combines with $\frac{1}{2}$ mole of oxygen,

∴ $\frac{12}{6.022 \times 10^{23}}$ mole of H_2 combines $= \frac{1}{2} \times \frac{12}{6.022 \times 10^{23}}$ moles of oxygen.

So, required $O_2 = 0.99 \times 10^{-23}$ moles.

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