

Numerical Questions

Q1: The mass of five moles of an element (x) is 60 grams. Calculate the molar mass of this element. Name the element.

Solution:

Given moles = 5 moles

Given mass = 60g

Molar mass = ?

$$\text{Molar mass} = \frac{\text{mass}}{\text{no. of moles}} = \frac{60\text{g}}{5\text{mole}} = (12\text{g/mole})$$

The molar mass of the element (x) = 12g/mole

The name of the element (x) = Carbon

Q2: Calculate the molecular / formula masses of the following compounds: [Atomic masses = C = 12, K = 39, Cr = 52, Al = 27, H = 1, O = 16] (a) $\text{C}_2\text{H}_5\text{OH}$ (b) Al_2O_3 (c) $\text{K}_2\text{Cr}_2\text{O}_7$

Solution:

$$\text{C}_2\text{H}_5\text{OH} / \text{C}_2\text{H}_6\text{O} \Rightarrow (12 \times 2) + (1 \times 6) + (16 \times 1) = 24 + 6 + 16 = \boxed{46 \text{ amu}}$$

$$\text{Al}_2\text{O}_3 = (27 \times 2) + (16 \times 3) = 54 + 48 \Rightarrow \boxed{102 \text{ amu}}$$

$$\text{K}_2\text{Cr}_2\text{O}_7 = (39 \times 2) + (52 \times 2) + (16 \times 7) = 78 + 104 + 112 = \boxed{294 \text{ amu}}$$

Q3: Calculate the mass in grams of:

(a) 7.75 moles Al_2O_3 (b) 15 moles H_2SO_4

(c) 1×10^{25} molecules of water

Atomic masses [S = 32, Al = 27, H = 1, O = 16]

Solution:

(a) Mass of 7.75 moles of Al_2O_3

$$\Rightarrow \text{Molar mass of } \text{Al}_2\text{O}_3 = (27 \times 2) + (16 \times 3)$$

$$= 54 + 48 = 102\text{g/mole}$$

Mass of Al_2O_3

$$= n_{\text{Al}_2\text{O}_3} \times \text{molar mass of } \text{Al}_2\text{O}_3$$

$$= 7.75 \text{ mol} \times 102\text{g/mol}$$

$$= 790.5 \text{ grams}$$

(b) Mass of 15 moles of H_2SO_4 :

$$\text{Molar mass of } \text{H}_2\text{SO}_4 = 2 + 32 + 64 = (98\text{g/mol})$$

$$\begin{aligned}\text{Mass of H}_2\text{SO}_4 &= n_{\text{H}_2\text{SO}_4} \times \text{molar mass of H}_2\text{SO}_4 \\ &= 15 \text{ mol} \times 98 \text{ g/mol} = \boxed{1470 \text{ grams}}\end{aligned}$$

(c) 1×10^{25} molecules of H_2O :

First we find out the number of moles of water

$$n = \frac{\text{number of water molecules}}{N_A}$$

$$n = \frac{1 \times 10^{25} \text{ molecules}}{6.023 \times 10^{23} \text{ molecule / mole}}$$

$$n = 0.1660 \times 10^{25-23} = 0.1660 \times 10^2 \text{ mole} \Rightarrow \boxed{16.6 \text{ moles}}$$

$$\text{Mass of H}_2\text{O} = n \times \text{molar mass}$$

$$16.6 \text{ mol} \times 18 \text{ g/mol} = \boxed{298.8 \text{ grams}}$$

Q4: How many moles [formula units] are present in each of the following samples? Atomic masses [H=1, C=12, O=16, Na=23, Mg=24, S=32, Cl=35.5, Ca=40]

(a) 30g MgS

(b) 75g Ca

(c) 8.85kg CO_2

(d) 40dm³ of O_2 at STP

(e) 7.5×10^{20} molecules C_6H_6

(f) 40 grams NaCl

Solution:

(a) 30g MgS $\rightarrow$ Molar mass of MgS = 24+32 = (56g/mole)

$$n_{\text{MgS}} = \frac{\text{mass of MgS}}{\text{molar mass of MgS}} = \frac{30\text{g}}{56 \text{ g/mol}} = \boxed{0.535 \text{ moles}}$$

(b) 75 grams Ca $\rightarrow$ Molar mass of Ca = (40g/mole)

$$n_{\text{Ca}} = \frac{\text{mass of Ca}}{\text{Molar mass of Ca}} = \frac{75\text{g}}{40 \text{ g/mol}} = \boxed{1.875 \text{ moles}}$$

(c) 8.85 kg CO_2 = $8.85 \times 1000 \Rightarrow 8850\text{g}$ of CO_2

$$n_{\text{CO}_2} = \frac{\text{mass of CO}_2}{\text{molar mass of CO}_2} = \frac{8850\text{g}}{44 \text{ g/mol}} = \boxed{201.13 \text{ moles}}$$

(d) 40dm³ O_2 at STP:

$$\text{Volume of O}_2 \text{ gas} = 40\text{dm}^3$$

$$\text{Molar volume of gas at STP} = 22.4\text{dm}^3$$

$$n_{\text{O}_2} = \frac{\text{volume of O}_2}{\text{molar volume}} = \frac{40\text{dm}^3}{22.4\text{dm}^3 / \text{mole}} = \boxed{1.785 \text{ moles}}$$

(e) 7.5×10^{20} molecules of C_6H_6 (Benzene)

$$\text{Number of benzene molecules} = 7.5 \times 10^{20}$$

$$n_{C_6H_6} = \frac{\text{no. of molecules}}{N_A} = \frac{7.5 \times 10^{20} \text{ molecules}}{6.023 \times 10^{23} \text{ molecules / mole}}$$

$$n = 1.245 \times 10^{-3} \text{ mole}$$

$$n = 1.245 \times 10^{-3} \text{ mole}$$

$$(n = 0.001245 \text{ mole})$$

(f) 40 grams NaCl = Molar mass of NaCl = 23 + 35.5 = (58.5g/mol)

$$n_{NaCl} = \frac{\text{mass of NaCl}}{\text{molar mass of NaCl}}$$

$$n = \frac{40g}{58.5g / \text{mol}} = \boxed{0.683 \text{ moles}}$$

Q5: Calculate the mass of Mg-metal required to consume 2560 grams of CO₂ in the reaction. Atomic masses [C=12, Mg=24, O=16]

Solution:



(Mass = ?) (2560g)

First we find out the number of moles of CO₂

$$n_{CO_2} = \frac{\text{mass of CO}_2}{\text{molar mass of CO}_2} = \frac{2560g}{44g / \text{mol}} = (58.18 \text{ moles})$$

From the balance equation it is clear that,

1 mole CO₂ needs = 2 moles Mg

58.18 moles CO₂ will need = 2 x 58.18 = (116.36 moles)

Now we will convert the moles into mass.

$$\begin{aligned} \text{Mass of Mg} &= n \times \text{molar mass} \\ &= 116.36 \text{ mol} \times 24g/\text{mol} \\ &= (2792.64 \text{ grams}) \end{aligned}$$

Descriptive Questions

Q1: (a) Define and explain mole and Avogadro's number with examples.

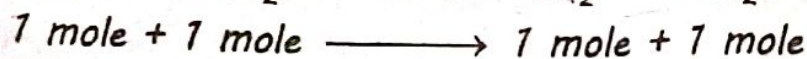
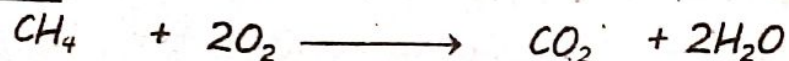
Ans: Please see question number 3.

(b) Given the equation



How can this equation be read in terms of particles, moles and masses?

Solution:



16 grams + 64 grams $\longrightarrow$ 44 grams + 36 grams

$6.023 \times 10^{23} + 2(6.023 \times 10^{23}) \rightarrow 6.023 \times 10^{23} + 2(6.023 \times 10^{23})$

In terms of Mole:

1 mole methane gas react with two moles of oxygen gas, produces 1 mole of CO_2 gas and 2 moles of water.

In terms of Masses:

16 grams CH_4 gas react with 64 grams oxygen gas, produces 44g CO_2 and 36 grams of water.

In terms of particles, Avogadro number CH_4 molecules react with two Avogadro's number of oxygen molecules, produces Avogadro's number of CO_2 molecules and two Avogadro's number of water molecules.

(c) Define molar volume of a gas. What will be the volume of 60 grams of NH_3 at STP? Atomic masses [H=1 and N=14]

Ans: Molar Volume:

The volume of one mole of a gas is called its molar volume. One mole of any gas has a volume of 22.4 dm^3 at STP.

Volume of 60 grams of NH_3 :

$$\text{Number of moles of } \text{NH}_3 = \frac{60\text{g}}{17\text{g/mol}} = \boxed{3.52 \text{ mole}}$$

1 mole of NH_3 at STP has a volume = 22.4 dm^3

3.52 moles NH_3 will have a volume = $3.52 \text{ mol} \times 22.4 \text{ dm}^3/\text{mol}$
 $= (78.85 \text{ dm}^3)$

OR volume = $n \times \text{molar volume}$

$$= 3.52 \times 22.4 = 78.85 \text{ dm}^3$$

Q2: (a) What do you mean by percentage composition of a compound?
 How the percentage of an element is calculated in a compound?

(b) Calculate the percentage composition of each element in the following compounds. Atomic mass [Al=27, K=39, Mg=24, Mn=55, Na=23, O=16 and S=32].

(i) MgSO_4 (ii) KMnO_4 (iii) NaAl(SO)_2

Ans. (a) Percentage Composition:

"The percent by mass of an element in a compound is called its percentage composition." Formula used to calculate the percentage of an element in a compound is given below:

$$\text{Percentage of an element} = \frac{\text{mass of an element in compound}}{\text{total mass of the compound}}$$

(b) Molar mass of $\text{MgSO}_4 = 24 + 32 + 64 = 120 \text{ g/mole}$

$$\% \text{ Mg} = \frac{\text{mass of Mg}}{\text{molar mass of MgSO}_4} \times 100$$

$$\% \text{ Mg} = \frac{24}{120} \times 100 = \frac{2400}{120} = \boxed{20\%}$$

$$\% \text{ S} = \frac{32}{120} \times 100 = \frac{3200}{120} = \boxed{26.67\%}$$

$$\% \text{ O} = \frac{64}{120} \times 100 = \frac{6400}{120} = \boxed{53.33\%}$$

(ii) Molar mass of $\text{KMnO}_4 = 39 + 55 + 64 = 158 \text{ g/mole}$

$$\% \text{ K} = \frac{39}{158} \times 100 = \frac{3900}{158} = \boxed{24.68\%}$$

$$\% \text{ Mn} = \frac{55}{158} \times 100 = \frac{5500}{158} = \boxed{34.81\%}$$

$$\% \text{ O} = \frac{64}{158} \times 100 = \frac{6400}{158} = \boxed{40.51\%}$$

(iii) Molar mass of $\text{NaAl(SO}_4)_2 = 23 + 27 + 64 + 128 = 242 \text{ g/mol}$

$$\% \text{ Na} = \frac{23}{242} \times 100 \Rightarrow \frac{2300}{242} \Rightarrow (9.50\%)$$

$$\% \text{ Al} = \frac{27}{242} \times 100 \Rightarrow \frac{2700}{242} \Rightarrow (11.16\%)$$

$$\% \text{ S} = \frac{64}{242} \times 100 \Rightarrow \frac{6400}{242} \Rightarrow (26.45\%)$$

$$\% \text{ O} = \frac{128}{242} \times 100 \Rightarrow \frac{12800}{242} \Rightarrow (52.89\%)$$

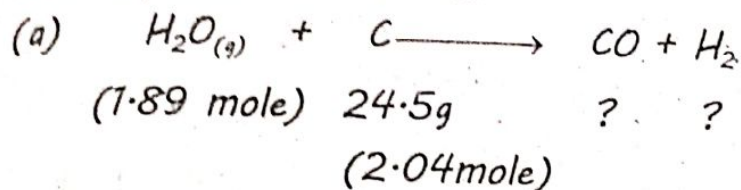
Q3: When steam is passed through red hot carbon a mixture of H_2 and CO gases called water gas is formed. $H_2O_{(g)} + C_{(s)} \rightarrow CO + H_2$

(a) Which is the limiting reagent if 24.5 gram of carbon is mixed with 1.89 moles of water vapours?

(b) Calculate the amount (grams) of the excess reagent left unreacted.

Solution:

Given equation is as under:



$$\text{Number of moles of Carbon} = \frac{24.5g}{12g \cdot mol^{-1}} \Rightarrow (2.04 \text{ moles})$$

From the balance chemical equation it is clear that;

1 mole carbon gives = 1 mole H_2/CO i.e. products

2.04 moles of carbon will give = 2.04 moles products

Similarly

1 mole H_2O gives = 1 mole CO/H_2 (products)

1.89 moles water will give = 1.89 moles products

As water gives the least number of moles of products so it is a limiting reagent.

(b) As limiting reagent control the amount of products formation so only 1.89 moles of carbon will react with 1.89 moles of water because these are in 1:1 ratio in the balance equation.

1 mole H_2O require $\Rightarrow$ 1 mole carbon

1.89 mole H_2O will require = 1.89 mole carbon

Un-reacted moles of C = available moles - used moles

$$= 2.04 \text{ moles} - 1.89 \text{ moles}$$

$$= (0.15 \text{ moles})$$

Mass of un-reacted carbon = moles $\times$ molar mass

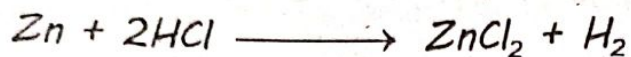
$$= 0.15 \text{ mole} \times 12g/\text{mole} = \span style="border: 1px solid black; padding: 2px;">1.80 \text{ grams}$$

Q4: (a) Calculate the percentage yield, if 6.53 grams of hydrogen gas is produced when 5 moles of Zn is consumed in the reaction.



Solution:

The given reaction is as follow:



(5moles)

(6.53g)

Actual yield of hydrogen gas = 6.53 grams

Given moles of Zn = 5 moles

From the balanced chemical equation it is clear;

1 mole Zn produces = 1 mole H_2

5 moles Zn will produce = 5 moles H_2

Mass of H_2 = moles of hydrogen $\times$ molar mass of H_2

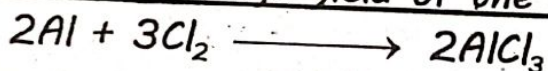
Mass of H_2 = 5 mole $\times$ 2g/mole = 10 grams

So theoretical yield of H_2 = 10 grams

$$\% \text{ yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100$$

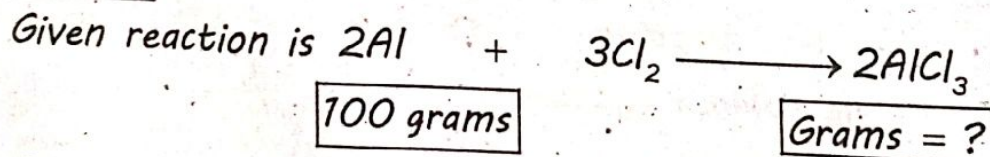
$$\% \text{ yield} = \frac{6.53}{10} \times 100 = \frac{653}{10} = \text{65.3\%}$$

(b) The percentage yield of the following reaction is 85%



How many grams of AlCl_3 will be actually obtained from 100 grams aluminium metal?

Solution:



100 grams

Grams = ?

Given mass of aluminium metal = 100 grams

$$n_{\text{Al}} = \frac{\text{mass of Al}}{\text{molar mass of Al}} = \frac{100\text{g}}{27\text{g/mol}} = \text{3.70 moles}$$

From the balanced equation it is clear that;

2 moles Al give = 2 moles AlCl_3

1 mole Al will give = $\frac{2}{2}$ i.e. 1 mole AlCl_3

And 3.70 moles Al will give = $3.70 \text{ moles AlCl}_3$

$$\text{Mass of AlCl}_3 = n_{\text{AlCl}_3} \times \text{molar mass}$$

$$\text{Mass of AlCl}_3 = 3.70 \text{ mole} \times 133.5 \text{ g/mole}$$

$$\text{Mass of AlCl}_3 = 493.95 \text{ grams}$$

So theoretical yield of AlCl_3 is = 493.95 g

Given % yield = 85%

Actual yield = ?

$$\% \text{ yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100$$

$$\text{Actual yield} = \frac{\% \text{ yield} \times \text{theoretical yield}}{100}$$

$$\text{Actual yield} = \frac{85 \times 493.95}{100} = \frac{41985.75}{100} = 419.85 \text{ grams}$$

$$\begin{aligned} \text{AlCl}_3 \\ 27 + (35.5 \times 3) \\ 27 + 106.5 \\ = 133.5 \end{aligned}$$

(c) Given the equation $\text{N}_2 + 3\text{H}_2 \rightarrow 2\text{NH}_3$ at STP. How many moles of ammonia will be formed if 6.3 dm^3 of N_2 gas react with an excess of hydrogen?

Solution:

Given volume of $\text{N}_2 = 6.3 \text{ dm}^3$

$$\begin{aligned} n_{\text{N}_2} &= \frac{\text{volume of N}_2}{\text{molar volume of N}_2} = \frac{6.3 \text{ dm}^3}{22.4 \text{ dm}^3 / \text{mole}} \\ &= 0.28 \text{ moles} \end{aligned}$$

From the balanced chemical equation it is clear that;

1 mole N_2 form = 2 mole NH_3

0.28 mole N_2 will form = $0.28 \times 2 = 0.56 \text{ moles}$

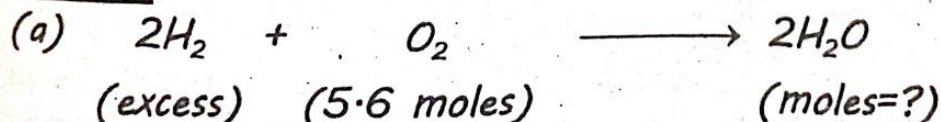
Q5: Given the equation: $2\text{H}_2 + \text{O}_2 \longrightarrow 2\text{H}_2\text{O}$

(a) How many moles of water will be obtained by burning 5.6 moles of O_2 in an excess of H_2 ?

(b) How many moles of oxygen would be needed to react 58.5 grams of H_2 to form water?

(c) How many grams of H_2 would be needed to form 120 grams H_2O ?

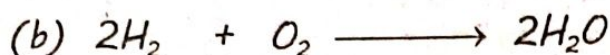
Solution:



From the balanced chemical equation it is clear that;

1 mole oxygen produces = 2 moles H_2O

5.6 moles oxygen will produce = $2 \times 5.6 = 11.2$ moles



(58.5g) (moles=?)

$$n_{H_2} = \frac{\text{mass of } H_2}{\text{molar mass of } H_2}$$

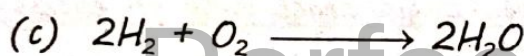
$$\frac{58.5g}{2g / \text{mol}} = 29.25 \text{ moles}$$

From the balanced chemical equation it is clear that;

2 moles hydrogen needs = 1 mole O_2

1 mole hydrogen will need = $\frac{1}{2}$ mole O_2

And 29.25 moles hydrogen will need = $\frac{1}{2} \times 29.25$ moles
= 14.62 moles



(Grams=?)

(120 grams)

$$n_{H_2O} = \frac{\text{mass of } H_2O}{\text{molar mass of } H_2O} = \frac{120 \text{ grams}}{18g / \text{mole}} = 6.66 \text{ moles}$$

From the balanced chemical equation it is clear that;

2 moles water needs = 2 moles H_2

1 mole H_2O will need = $\frac{2}{2}$ i.e. 1 mole H_2

And 6.66 moles H_2O will need = 6.66 moles H_2

Mass of $H_2 = n \times \text{molar mass}$

Mass of $H_2 = 6.66 \text{ mole} \times 2g/\text{mole} = 13.32 \text{ grams}$



How strange is the logic of our mind . . .

We look for compromise when we are wrong

But we look for justice when others are wrong.