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AMOUNT OF SUBSTANCE

THE MOLE

pair

2

dozen

12

score

20

gross

144

mole

602204500000000000000000

6.02×10^{23}



MOLES

**1 mole of H₂O molecules has mass 18.0 g
(M_r of H₂O = 18.0)**

**1 mole of C atoms has mass 12.0 g
(M_r of C = 12.0)**

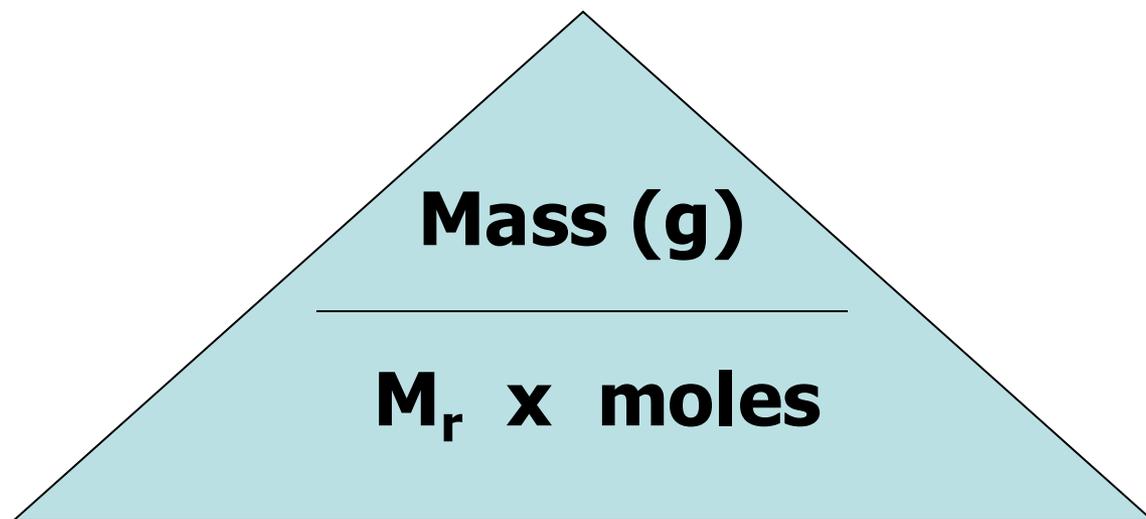
THIS IS NOT A COINCIDENCE!

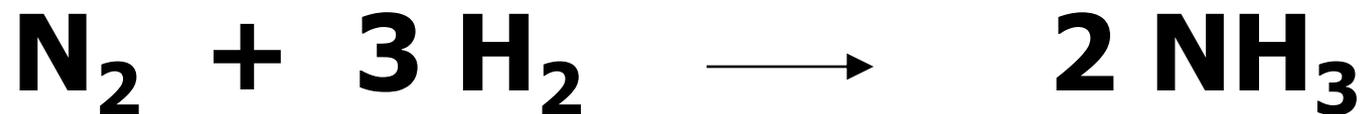
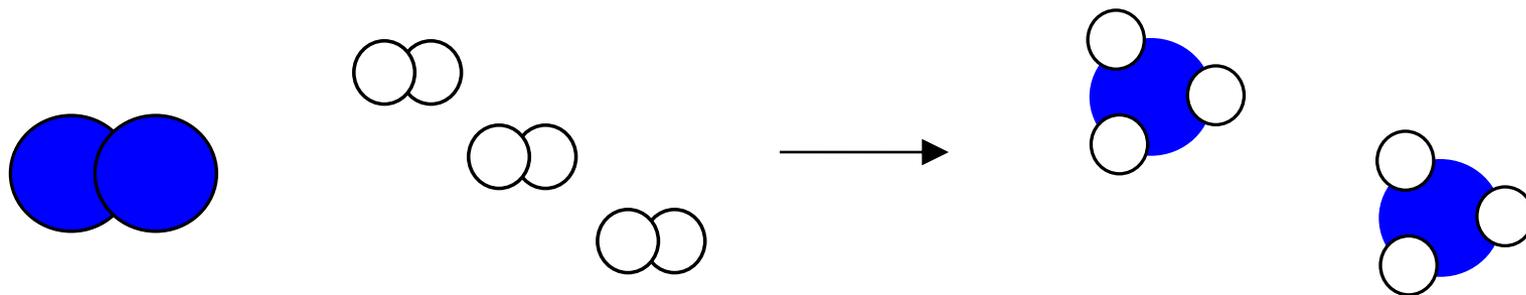
**Chemists have worked how many particles
are in the M_r in grams of any substance –
this number is the mole (6.02 x 10²³)**

MOLES

$$\text{Mass (g)} = M_r \times \text{moles}$$

Remember **"Mr Moles"**





1 mole

3 moles

2 moles

10 moles

30 moles

20 moles

2 moles

6 moles

4 moles

0.5 moles

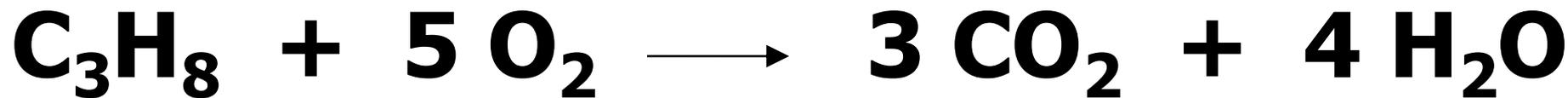
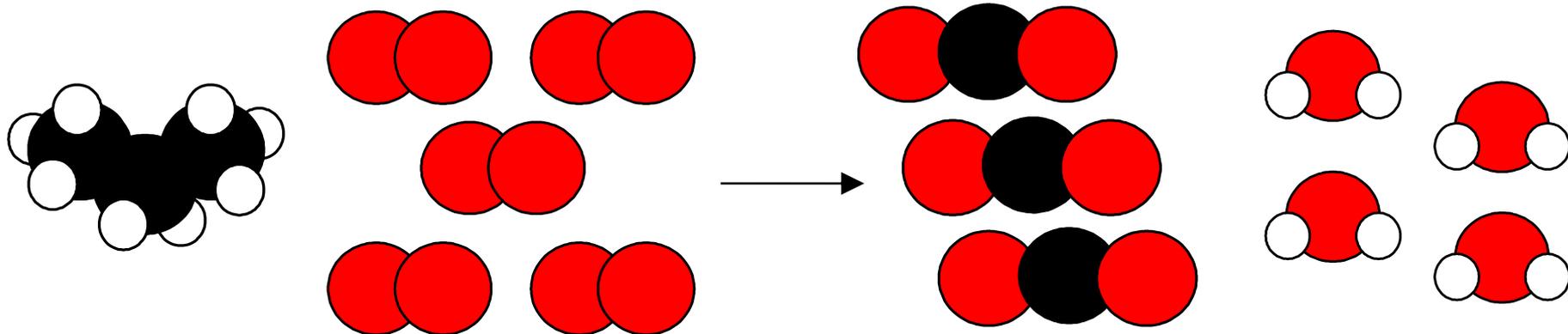
1.5 moles

1.0 moles

4 moles

12 moles

8 moles



1 molecule

5 molecules

3 molecules

4 molecules

10 moles

50 moles

30 moles

40 moles

2 moles

10 moles

6 moles

8 moles

0.5 moles

2.5 moles

1.5 moles

2 moles

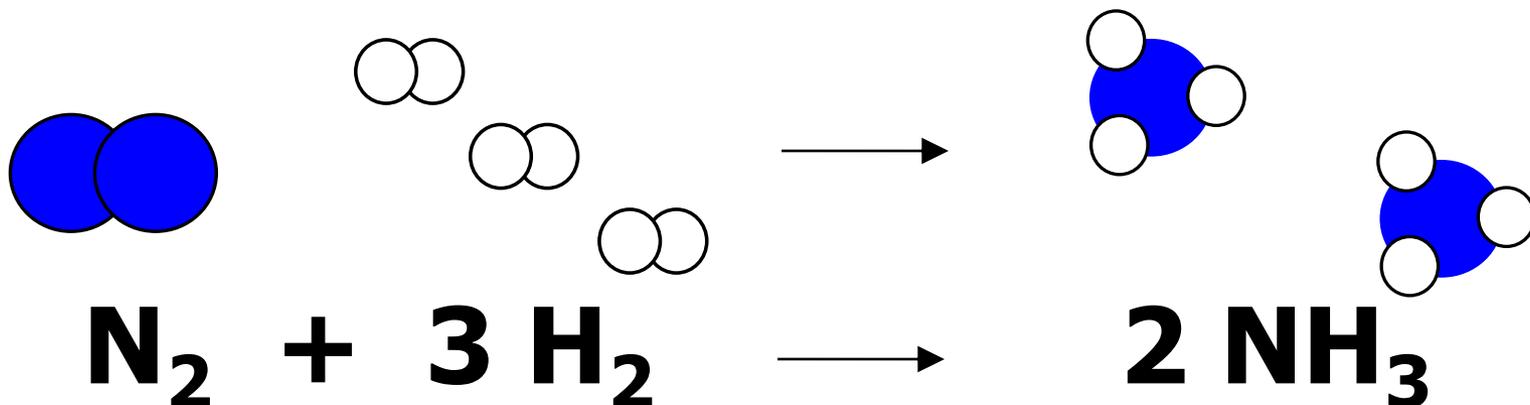
0.03 moles

0.15 moles

0.09 moles

0.12 moles

LIMITING REAGENTS



START

3 moles

3 moles

3 moles of N_2 needs 9 moles of H_2 for it all to react

\therefore there is not enough H_2 so the amount that reacts is limited by moles H_2

\therefore H_2 is **limiting reagent** (and N_2 is in **excess**)

\therefore so only 1 mole of N_2 can react (and 2 moles of N_2 is left over)

CHANGES

-1 mole

-3 moles

+2 moles

END

$3-1 =$

2 moles

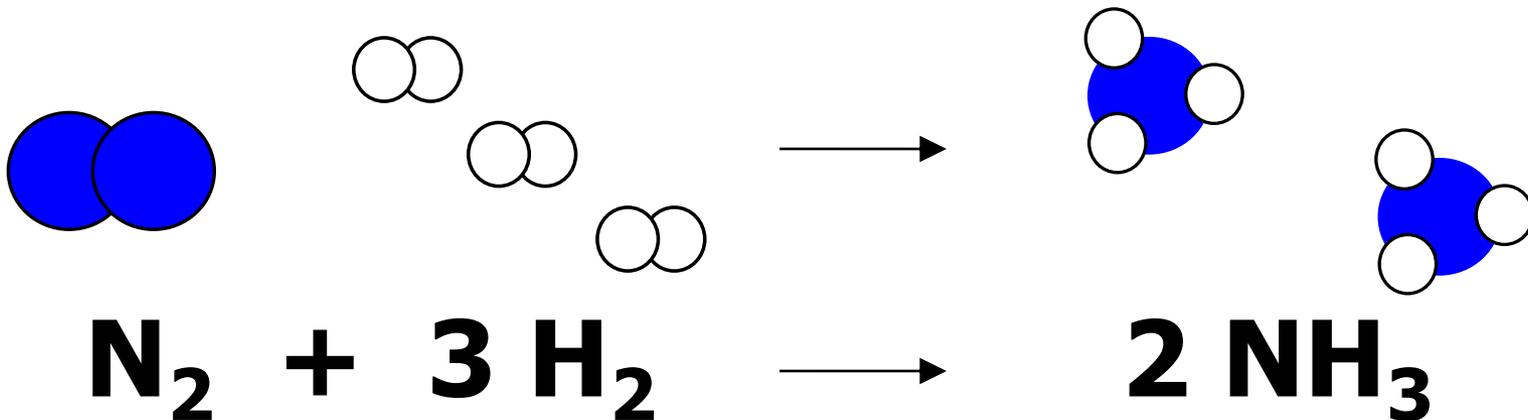
$3-3 =$

0 moles

$0+2 =$

2 moles

LIMITING REAGENTS



START

1 mole

10 moles

1 mole of N_2 needs 3 moles of H_2 for it all to react

\therefore there is more than enough H_2 not all of the H_2 reacts

\therefore N_2 is **limiting reagent** (and H_2 is in **excess**)

so only 3 mole of H_2 can react (and 7 moles of H_2 is left over)

CHANGES

-1 mole

-3 moles

+2 moles

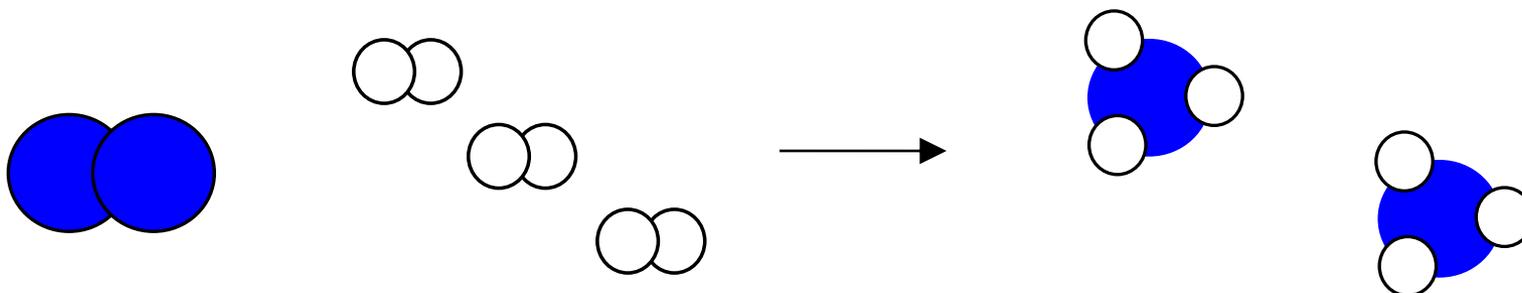
END

1-1 =
0 moles

10-3 =
7 moles

0+2 =
2 moles

LIMITING REAGENTS



START

12 moles 24 moles

12 moles of N_2 needs 36 moles of H_2 for it all to react

\therefore there is not enough H_2 so the amount that reacts is limited by moles H_2

\therefore H_2 is **limiting reagent** (and N_2 is in **excess**)

\therefore so only 8 moles of N_2 can react (and 4 moles of N_2 is left over)

CHANGES

-8 mole

-24 moles

+16 moles

END

12-8 =

24-24 =

0+16 =

4 moles

0 moles

16 moles

LIMITING REAGENTS



START

10 moles 8 moles

10 moles of SO_2 needs 5 moles of O_2 for it all to react

\therefore there is more than enough O_2

\therefore SO_2 is **limiting reagent** (and O_2 is in **excess**)

\therefore so only 5 moles of O_2 can react (and 3 moles of O_2 is left over)

CHANGES

-10 mole

-5 moles

+10 moles

END

10-10 =

0 moles

8-5 =

3 moles

0+16 =

10 moles

IDEAL GAS EQUATION

$$PV = nRT$$

P = Pressure (Pa)

V = Volume (m³)

n = number of moles

R = Gas Constant (8.31 J mol⁻¹ K⁻¹)

T = Temperature (K)

Pressure units

$$1\text{kPa} = 1\,000\text{ Pa}$$

$$\text{kPa} \times 10^3 = \text{Pa}$$

$$1\text{MPa} = 1\,000\,000\text{ Pa}$$

$$\text{MPa} \times 10^6 = \text{Pa}$$

Temperature units

$$T(\text{K}) = 273 + T(^{\circ}\text{C})$$

Volume units

$$1\text{ dm}^3 = 10^{-3}\text{ m}^3$$

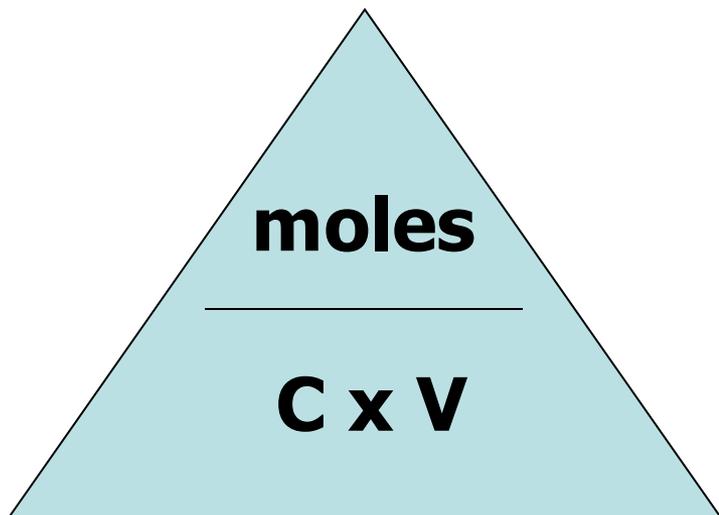
$$\frac{\text{dm}^3}{10^3} = \text{m}^3$$

$$1\text{ cm}^3 = 10^{-6}\text{ m}^3$$

$$\frac{\text{cm}^3}{10^6} = \text{m}^3$$

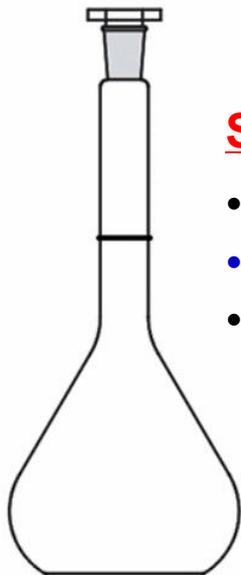
SOLUTIONS

$$\text{concentration (mol dm}^{-3}\text{)} = \frac{\text{moles}}{\text{volume (dm}^3\text{)}}$$



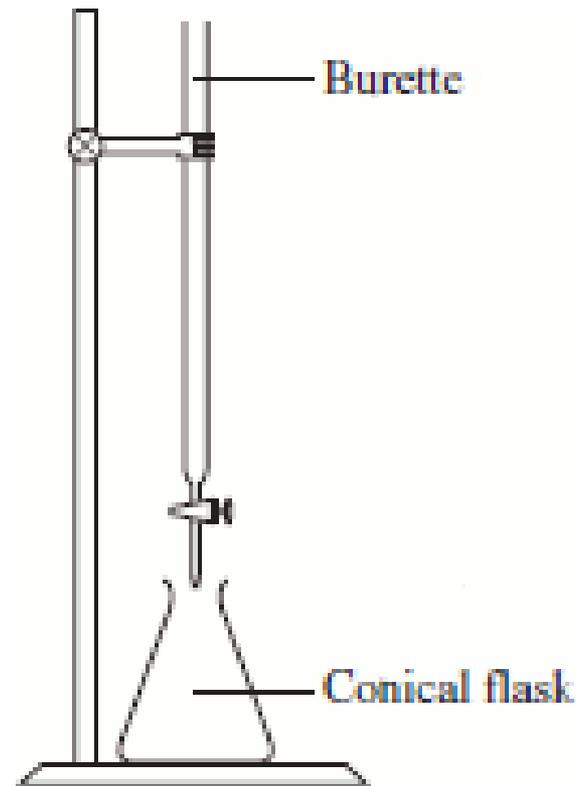
BACK TITRATIONS

Used to analyse insoluble bases (we have to work backwards).



STEP 1

- place sample in volumetric flask
- **add excess acid/base**
- make up to 250 cm³



STEP 2

- remove 25 cm³ by pipette
- titrate excess acid/base against solution of known concentration
- repeat titration to get concordant results

BACK TITRATIONS

Used to analyse insoluble acids/bases (we have to work backwards).

Imagine that we are trying to find out how many moles of CaCO_3 we have (let's call it x moles).

We add 10.0 moles of HCl (an excess). The excess HCl is made into a 250 cm³ stock solution and then 25 cm³ portions of it require 0.40 moles of NaOH for neutralisation.



$$x \quad 10.0$$

$$10.0 \text{ added} - 4.0 \text{ left over} \\ = 6.0 \text{ reacted with } \text{CaCO}_3$$

$$3.0$$

left over



$$0.40 \quad 0.40 \quad \text{per titration}$$

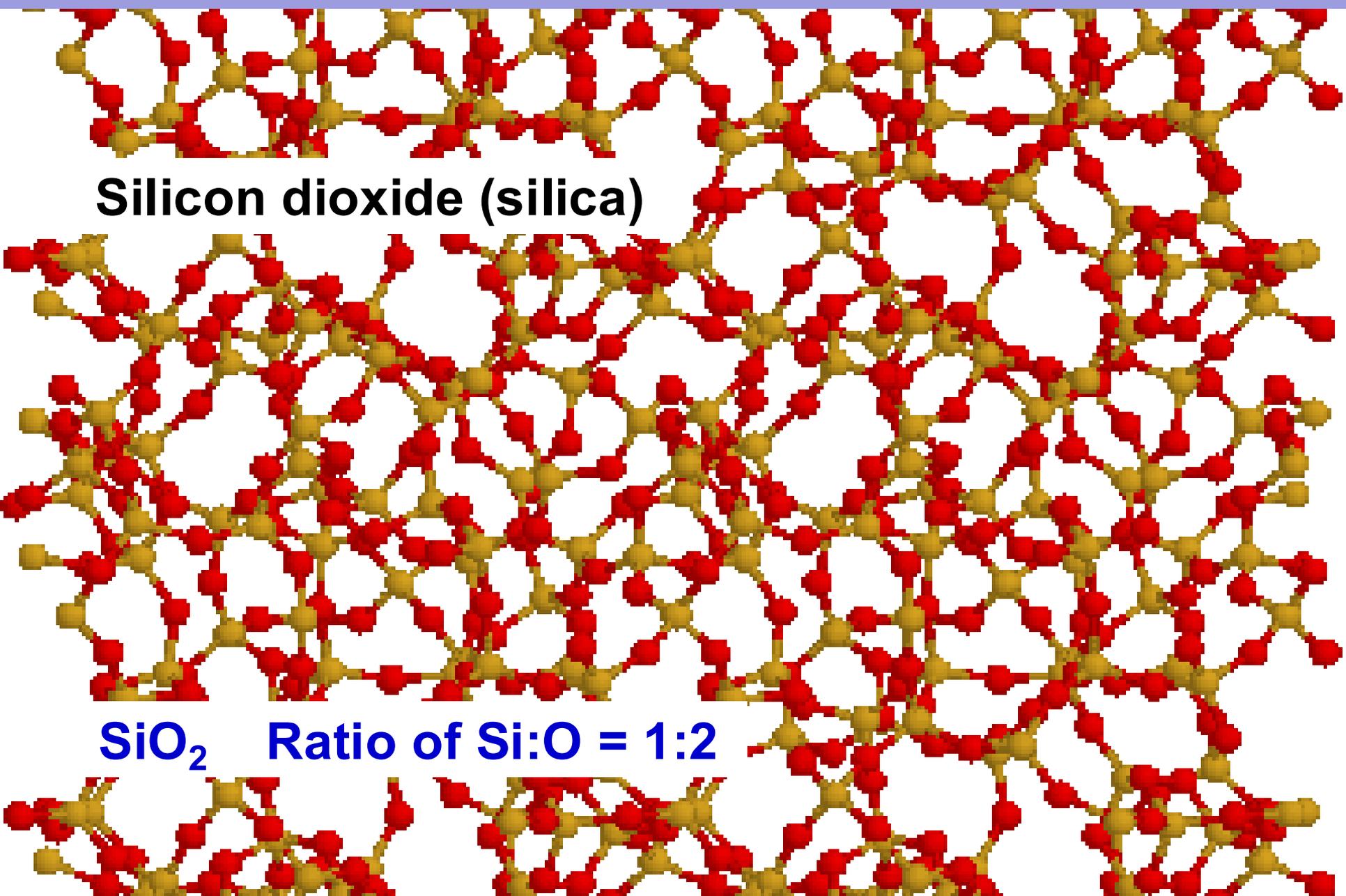
$$4.0 \text{ in whole stock solution}$$

\therefore there are 10 x 0.40 moles (= 4.0 moles) of left over HCl in the stock solution

\therefore 6.0 moles (10.0 – 4.0 moles) of HCl reacted with the CaCO_3

\therefore there must have been 3.0 moles of CaCO_3 (i.e. $x = 3.0$) in the first place (remember that 2 moles of HCl reacts with 1 mole of CaCO_3).

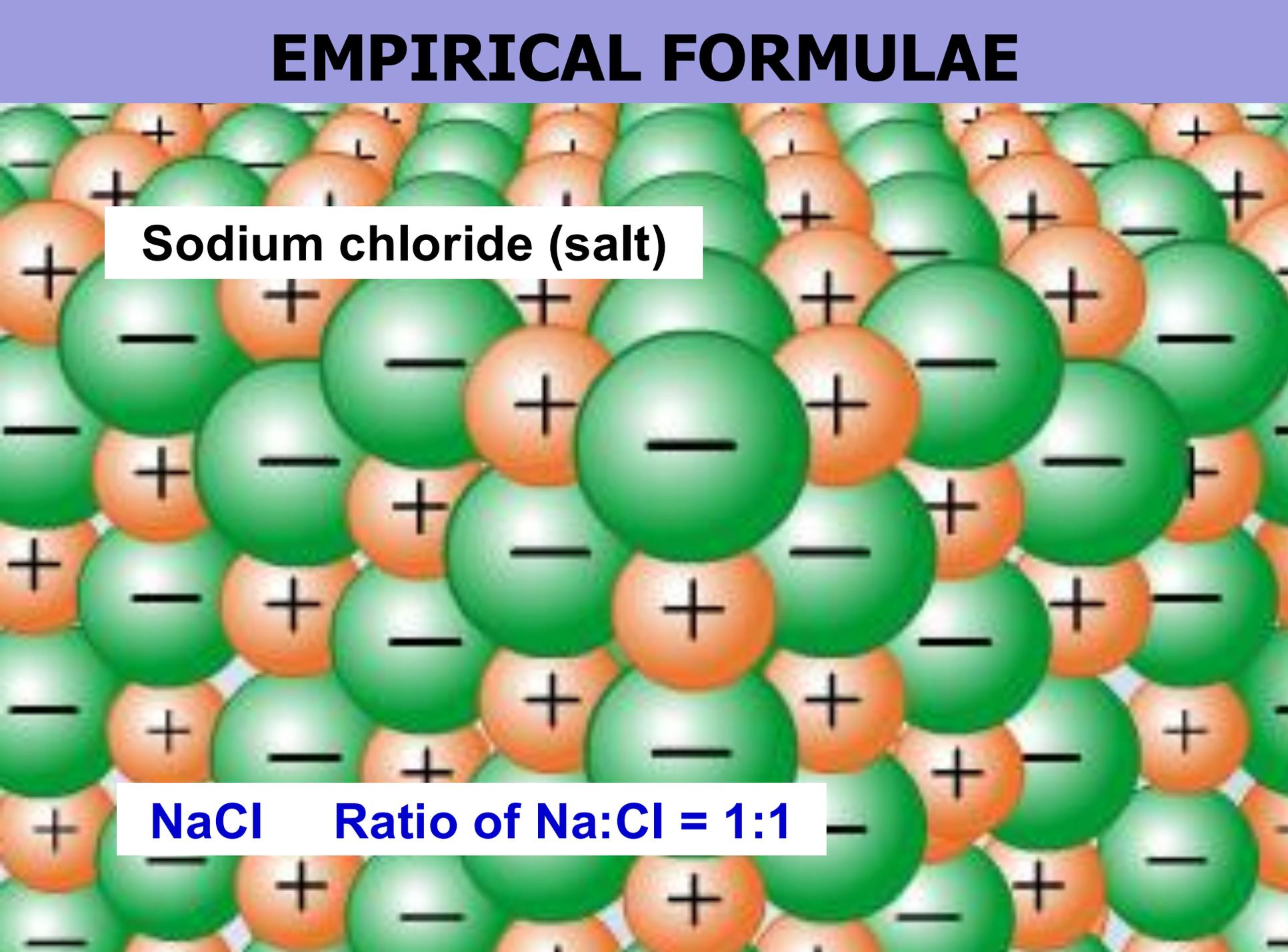
EMPIRICAL FORMULAE

A ball-and-stick model of a silica network. The structure consists of a continuous 3D lattice of silicon (Si) and oxygen (O) atoms. Silicon atoms are represented by yellow spheres, and oxygen atoms are represented by red spheres. Each silicon atom is tetrahedrally coordinated to four oxygen atoms, and each oxygen atom is bridged between two silicon atoms, forming a continuous network of SiO4 tetrahedra.

Silicon dioxide (silica)

SiO_2 Ratio of Si:O = 1:2

EMPIRICAL FORMULAE



Sodium chloride (salt)

NaCl **Ratio of Na:Cl = 1:1**

EMPIRICAL FORMULAE

- **All substances have an empirical formula**
- **It gives the simplest ratio of atoms/ions of each element in a substance**
- **For most substances it is the ONLY formula (substances made of molecules also have a second formula – the molecular formula)**

EMPIRICAL FORMULAE

Water

Empirical formula = H_2O Ratio of H:O = 2:1

Molecular formula = H_2O In one molecule: 2H & 1O atoms

EMPIRICAL FORMULAE

Benzene

Empirical formula = CH Ratio of C:H = 1:1

Molecular formula = C₆H₆ In one molecule: 6C & 6H atoms