KEY

1 - Moles and mass calculations

1. **Symbols**

Prerequisite: common chemical names.

(a) State the symbols used to represent

i. molar mass

i. M

ii. relative molecular mass

ii. M_r

iii. mass of a sample

iii. m

iv. number of moles of a sample

iv. n

v. Avogadro's number

IN GERMAN CHEMISTRY LITERATURE, THE AVOGADRO NUMBER IS KNOWN ALSO AS THE LOSCHMIDT CONSTANT.

v. L OR N_A

vi. relative atomic mass

vi. A_r

(b) State the symbols used to represent

i. molar mass of ammonia

i. M_{NH_3}

ii. relative molecular mass of C_6H_6

ii. $M_{r(C_6H_6)}$

iii. mass of water

iii. m_{H_2O}

iv. number of moles of ethanol

iv. $n_{CH_3CH_2OH}$

v. relative molecular mass of sodium

v. $A_{r\,(Na)}$

2. Calculating molar mass

Calculate the molar mass for the following. Report units and give your answers to 4 significant figures.

(a) Sulphuric acid

(a) 98.08 g/mol

H_2SO_4 : $M_{H_2SO_4} = 2M_H + M_S + 4M_O$
$= 2(1.008) + 32.065 + (16.00)4 = 98.08$ g/mol

(b) $HCl_{(aq)}$

(b) 36.46 g/mol

HCl : $M_{HCl} = M_H + M_{Cl}$
$= 1.008 + 35.453 = 36.46$ g/mol

(c) $^{2}H^{35}Cl_{(aq)}$

THESE ARE NOW EXACT MASSES INSTEAD OF A MIXTURE OF ISOTOPES AT NATURAL ABUNDANCES.

(c) 37.00 g/mol

(d) $CuSO_{4(s)}$

(d) 159.6 g/mol

$M_{CuSO_4} = M_{Cu} + M_S + 4M_O$
$= 63.546 + 32.065 + 4(16.00) = 159.6$ g/mol

(e) $CuSO_4 \cdot 5H_2O_{(s)}$

(e) 249.7 g/mol

$M_{CuSO_4 \cdot 5H_2O} = M_{CuSO_4} + 5M_{H_2O} = 159.6 + 5(18.00)$
$= 249.7$ g/mol

3. Mole conversions

Give your answers to appropriate number of significant figures.

(a) **Without using a calculator**, determine the **number** of particles of a compound **X** in:

i. 6.02×10^{23} molecules of **X**

$\frac{6.02\times10^{23}}{L} = \frac{6.02\times10^{23}}{6.02\times10^{23}} = 1.00$

i. 1.00 mol

ii. 6.02×10^{25} molecules of **X**

$\frac{6.02\times10^{25}}{6.02\times10^{23}} = 1.00\times10^{25-23}$

ii. 1.00×10^{2} mol

iii. 1.20×10^{15} molecules of **X**

$\frac{1.20\times10^{15}}{L} = \frac{12.0\times10^{14}}{6.02\times10^{23}}$

iii. 2.00×10^{-9} mol

(b) **Without using a calculator**, determine the **moles** of a compound **X** in:

i. 1.00 mol

i. 6.02×10^{23}

ii. 1.00×10^3 mol

$(6.02\times10^{23}) \times 10^{3} = 6.02\times10^{23+3}$

ii. 6.02×10^{26}

iii. 5.00×10^3 mol

$(5.00\times10^{3}) \times (6.02\times10^{23}) = 30.10\times10^{26}$

iii. 3.010×10^{27}

iv. 5.00×10^{-3} mol

iv. 3.010×10^{21}

$(5.00\times10^{-3}) \times (6.02\times10^{23})$

$= 30.10\times10^{23-3} = 30.10\times10^{20}$

v. 0.200 mmol

v. 1.20×10^{20}

0.200×10^{-3} mol $\times$ 6.02×10^{23}

$= 1.20\times10^{20}$ (23 - 3)

4. **Moles ⟶ mass**

Give your answers to appropriate number of significant figures.

(a) i. Deduce the molar mass of $CaCO_{3(s)}$.

i. 100.1 g/mol

$M_{CaCO_3} = M_{Ca} + M_C + 3M_O$
$= 100.1$ g/mol

ii. Deduce the mass contained in 2.00 mol of $CaCO_{3(s)}$.

ii. 200.2 g

2.00 mol × 100.1 g/mol = 200.2 g/mol

iii. Deduce the ~~number of moles~~ MASS contained in 0.250 mol of $CaCO_{3(s)}$.

iii. 25.00 g

0.250 mol × 100.1 g/mol

(b) Deduce the mass, in g, in:

i. 8.00 mol copper powder.

i. 508 g

$M_{Cu} = 63.55$ g/mol
$m = n \times M = 8.00$ mol × 63.55 g/mol = 508 g.

ii. 5.00 mol $ZnO_{(s)}$

ii. 407 g

$m = n \times M$
$= 5.00 \text{ mol} \times (65.409 + 16.00) \text{ g/mol}$
$= 407 \text{ g}$

iii. 5.00 ~~kg~~ mmol $H_2O_{(g)}$

iii. 9.00×10^{-2} g

$n = 5.00 \times 10^{-3}$ mol
$m = n \times M = (5.00 \times 10^{-3}) \text{ mol} \times 18.00 \text{ g/mol}$
$= 90.0 \times 10^{-3}$ g

5. **Mass ⟶ moles**

Give your answers to appropriate number of significant figures.

(a) i. Deduce the molar mass of $CaCO_{3(s)}$.

i. 100.1 g/mol

SAME AS ABOVE : 100.1 g/mol

ii. Deduce the number of moles contained in 200.2 g of $CaCO_{3(s)}$.

ii. 2.000 mol

$n = \frac{m}{M} = \frac{200.2 \text{ g}}{100.1 \text{ g/mol}} = 2.000 \text{ mol}$

iii. Deduce the number of moles contained in 5.00 g of $CaCO_{3(s)}$.

iii. 0.0500 mol.

$n = \frac{m}{M} = \frac{5.00\ g}{100.1\ g/mol}$

(b) Deduce the number of moles in:

i. 8.00 g sodium hydroxide powder.

i. 0.200 mol

$n = \frac{m}{M_{NaOH}} = \frac{8.00\ g}{40.0\ g/mol} = 0.200\ mol$

ii. 5.00 g $CuSO_4 \cdot 5H_2O_{(s)}$

ii. 0.0200 mol

$n = \frac{m}{M_{CuSO_4 \cdot 5H_2O}} = \frac{5.00\ g}{250.0\ g/mol} = 0.0200\ mol$

iii. 5.00 kg $H_{2(g)}$

iii. 2500 mol.

$n = \frac{5000\ g}{M_{H_2}} = \frac{5000\ g}{2\ g/mol} = 2500\ mol$

iv. 0.360 mg $NH_{3(l)}$

iv. 0.020×10^{-3} mol

OR 0.020×10^{-3} ×100 ÷100 $= 2.0 \times 10^{-5}$ m

$n = \frac{m}{M_{NH_3}} = \frac{0.360 \times 10^{-3}}{18} = 0.020 \times 10^{-3}$ mol.