Relative formula mass and percentage by mass

Worked solutions

GCSE science calculations

This topic online

1 Yeast in bread dough at a bakery makes carbon dioxide, CO_2. The bubbles of gas make the bread rise.

Relative atomic masses (A_r): C = 12, O = 16

Calculate the relative formula mass (M_r) of carbon dioxide. (1 mark)

Mr = add up the Ar of every atom in the formula

CO2: 1 x C and 2 x O

Mr = 12 + (2 x 16)

44

2 Sodium carbonate, Na_2CO_3, is sold as washing soda for softening hard water.

Relative atomic masses (A_r): Na = 23, C = 12, O = 16

Calculate the relative formula mass (M_r) of sodium carbonate. (2 marks)

Mr = add up the Ar of every atom in the formula

Na2CO3: 2 x Na, 1 x C, 3 x O

Mr = (2 x 23) + 12 + (3 x 16)

Mr = 46 + 12 + 48

106

3 Mr Hughes spreads calcium hydroxide, $Ca(OH)_2$, on his allotment to make the soil less acidic.

Relative atomic masses (A_r): Ca = 40, O = 16, H = 1

Calculate the relative formula mass (M_r) of calcium hydroxide. (2 marks)

The 2 outside the bracket doubles everything inside

Ca(OH)2: 1 x Ca, 2 x O, 2 x H

Mr = 40 + 2 x (16 + 1)

Mr = 40 + 34

74

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4 Ammonium sulfate, $(NH_4)_2SO_4$, is a fertiliser used by farmers in Lincolnshire.

Relative atomic masses (A_r): N = 14, H = 1, S = 32, O = 16

Calculate the relative formula mass (M_r) of ammonium sulfate.

(2 marks)

The 2 outside the bracket doubles N and H4

(NH4)2SO4: 2 x N, 8 x H, 1 x S, 4 x O

$M_r = 2 \times (14 + 4 \times 1) + 32 + (4 \times 16)$

$M_r = 36 + 32 + 64$

132

5 Ammonium nitrate, NH_4NO_3, is a fertiliser that adds nitrogen to soil.

Relative atomic masses (A_r): N = 14, H = 1, O = 16

Calculate the percentage by mass of nitrogen in ammonium nitrate.

(3 marks)

First find Mr

$M_r = 14 + (4 \times 1) + 14 + (3 \times 16) = 80$

There are 2 N atoms in the formula

mass of N = $2 \times 14 = 28$

% by mass = (Ar x number of atoms) ÷ Mr x 100

$\%\ N = \frac{28}{80} \times 100$

35%

6 Glucose, $C_6H_{12}O_6$, is made in leaves by photosynthesis.

Relative atomic masses (A_r): C = 12, H = 1, O = 16

Calculate the percentage by mass of oxygen in glucose.

Give your answer to 3 significant figures.

(3 marks)

First find Mr

$M_r = (6 \times 12) + (12 \times 1) + (6 \times 16)$

$M_r = 72 + 12 + 96 = 180$

There are 6 O atoms in the formula

mass of O = $6 \times 16 = 96$

$\%\ O = \frac{96}{180} \times 100$

$\%\ O = 53.33...\%$

53.3%

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7 A garden centre sells a 2.5 kg bag of pure calcium carbonate, $CaCO_3$.

Relative atomic masses (A_r): Ca = 40, C = 12, O = 16

Calculate the mass of calcium in the bag, in grams. (3 marks)

Convert kg to g: 1 kg = 1000 g

$2.5\ kg = 2.5 \times 1000 = 2500\ g$

Find M_r

$M_r = 40 + 12 + (3 \times 16) = 100$

$\text{Mass of Ca} = \frac{\text{Ar of Ca}}{M_r} \times \text{mass of compound}$

$\text{mass of Ca} = \frac{40}{100} \times 2500$

1000 g

8 A sample of bauxite ore has a mass of 1.20 kg. The sample contains 0.51 kg of aluminium oxide, Al_2O_3. The rest of the ore is other rock.

Relative atomic masses (A_r): Al = 27, O = 16

Calculate the mass of aluminium in the sample, in grams. (3 marks)

Use 0.51 kg: only the aluminium oxide contains aluminium, not the whole 1.20 kg of ore

Convert kg to g

$0.51\ kg = 0.51 \times 1000 = 510\ g$

$M_r = (2 \times 27) + (3 \times 16) = 102$

$\text{mass of Al in formula} = 2 \times 27 = 54$

$\text{mass of Al} = \frac{54}{102} \times 510$

270 g

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9 Chen tests a white solid with the formula XCl_2, where X is a metal. The relative formula mass (M_r) of XCl_2 is 95.

Relative atomic mass (A_r): Cl = 35.5

Calculate the relative atomic mass of X. (2 marks)

Mr = Ar of X + Ar of the two Cl atoms

$95 = X + (2 \times 35.5)$

$95 = X + 71$

$X = 95 - 71$

24

10 A dietitian at a hospital in Leeds advises that an adult should eat no more than 2.4 g of sodium a day. Most of this sodium comes from salt, sodium chloride, NaCl.

Relative atomic masses (A_r): Na = 23, Cl = 35.5

Calculate the mass of sodium chloride that contains 2.4 g of sodium. Show your working. (3 marks)

Mr = add up the Ar of every atom in the formula

$Mr = 23 + 35.5 = 58.5$

$\text{Mass of Na} = \frac{23}{58.5} \times \text{mass of NaCl}$

$2.4 = \frac{23}{58.5} \times m$

Rearrange: multiply by 58.5, divide by 23

$m = 2.4 \times 58.5 \div 23$

$m = 6.104...\ g$

6.1 g

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11 A farm shop sells two nitrogen fertilisers. Both come in 25 kg bags.

- Urea, $CO(NH_2)_2$
- Ammonium sulfate, $(NH_4)_2SO_4$

Relative atomic masses (A_r): C = 12, O = 16, N = 14, H = 1, S = 32

a. Calculate the percentage by mass of nitrogen in urea. Give your answer to 3 significant figures.

b. Calculate the percentage by mass of nitrogen in ammonium sulfate. Give your answer to 3 significant figures.

c. Which fertiliser gives more nitrogen per bag?

Show your working. (5 marks)

The 25 kg bag mass is not needed: percentage by mass does not depend on how much you have

a)

$$M_r = 12 + 16 + 2 \times (14 + 2 \times 1) = 60$$

$$\text{mass of N} = 2 \times 14 = 28$$

$$\%\,N = \frac{28}{60} \times 100$$

$$\%\,N = 46.66...\%$$

46.7%

b)

$$M_r = 2 \times (14 + 4 \times 1) + 32 + (4 \times 16) = 132$$

$$\text{mass of N} = 2 \times 14 = 28$$

$$\%\,N = \frac{28}{132} \times 100$$

$$\%\,N = 21.21...\%$$

21.2%

c)

Same bag mass, and 46.7% > 21.2%

urea

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12 A blast furnace is loaded with 3.0 tonnes of iron ore. 80% of the ore by mass is iron(III) oxide, Fe_2O_3.

Relative atomic masses (A_r): Fe = 56, O = 16

1 tonne = 1000 kg

Calculate the maximum mass of iron that could be extracted from the ore, in kg. Show your working. (4 marks)

Only 80% of the ore is iron(III) oxide

mass of Fe_2O_3 = $0.80 \times 3.0 = 2.4$ tonnes

Convert tonnes to kg

2.4 tonnes = $2.4 \times 1000 = 2400$ kg

$M_r = (2 \times 56) + (3 \times 16) = 160$

mass of Fe in formula = $2 \times 56 = 112$

$$\text{mass of Fe} = \frac{112}{160} \times 2400$$

1680 kg

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