

# Counting atoms with the mole

Chemistry grades 9-10 (GCSE · IGCSE · O Level · Class 9-10) · Worksheet answers

Compare your working with these answers, not only your final numbers. Check that you used the molar mass of the whole particle, followed the units through each step and gave answers to a sensible number of significant figures.

**Level:** Chemistry grades 9-10 (GCSE · IGCSE · O Level · Class 9-10) · **Curriculum:** HS-PS1-7, GCSE C3

## Problem 1 Mole and Avogadro

- $6.02 \times 10^{23}$  per mole.
- $6.02 \times 10^{23}$  atoms.
- $2 \times 6.02 \times 10^{23} = 1.204 \times 10^{24} \approx 1.20 \times 10^{24}$  atoms.

**$6.02 \times 10^{23}$  per mol;  $1.20 \times 10^{24}$  atoms in 2 mol.**

## Problem 2 Mass of one mole of atoms

- The molar mass in g/mol equals the relative atomic mass in grams.

**C 12 g, Mg 24 g, S 32 g, Cu 63.5 g.**

## Problem 3 Relative formula masses

- $12 + 2 \times 16 = 44$ .
- $23 + 16 + 1 = 40$ .
- $40 + 12 + 3 \times 16 = 100$ .
- $2 \times 1 + 32 + 4 \times 16 = 98$ .

**44, 40, 100 and 98.**

## Problem 4 Moles of water

- $\text{H}_2\text{O}: 2 \times 1 + 16 = 18 \text{ g/mol}$ .
- $n = 36 \div 18 = 2.0 \text{ mol}$ .

**2.0 mol**

## Problem 5 Mass from moles

- $m = n \times M$ .
- $m = 0.50 \times 58.5 = 29.25 \text{ g}$ , which is 29.3 g to 3 significant figures.

**29.3 g**

**Problem 6 Reading the balances**

1.  $\text{H}_2\text{O}$ : 18 g/mol.  $\text{CO}_2$ : 44 g/mol.  $\text{NaCl}$ : 58.5 g/mol.
2. Each sample is  $18.0 \div 18 = 1.00$ ,  $44.0 \div 44 = 1.00$  and  $58.5 \div 58.5 = 1.00$  mol.
3. Each contains  $6.02 \times 10^{23}$  particles (molecules or formula units).

**1.00 mol each,  $6.02 \times 10^{23}$  particles each.**

**Problem 7 Atoms from moles**

1.  $N = n \times 6.02 \times 10^{23} = 0.20 \times 6.02 \times 10^{23} = 1.204 \times 10^{23}$ .

**$1.20 \times 10^{23}$  atoms**

**Problem 8 Brackets in formulae**

1.  $40 + 2 \times 17 = 74$ .
2.  $2 \times 27 + 3 \times (32 + 64) = 54 + 288 = 342$ .
3.  $2 \times (14 + 4) + 12 + 48 = 36 + 60 = 96$ .
4.  $24 + 2 \times (14 + 48) = 24 + 124 = 148$ .

**74, 342, 96 and 148.**

**Problem 9 Moles from mass**

1.  $M = 44$ .  $n = 4.4 \div 44 = 0.10$  mol.
2.  $M = 98$ .  $n = 49 \div 98 = 0.50$  mol.
3.  $M = 27$ .  $n = 2.7 \div 27 = 0.10$  mol.

**0.10 mol, 0.50 mol, 0.10 mol**

**Problem 10 Mass from moles, harder**

1.  $M = 100$ .  $m = 0.25 \times 100 = 25$  g.
2.  $M = 18$ .  $m = 3.0 \times 18 = 54$  g.
3.  $M = 56$ .  $m = 0.10 \times 56 = 5.6$  g.

**25 g, 54 g, 5.6 g**

**Problem 11 Molecules in a raindrop**

1.  $n = 0.050 \div 18 = 0.002778$  mol, which is  $2.78 \times 10^{-3}$  mol.
2.  $N = 0.002778 \times 6.02 \times 10^{23} = 1.67 \times 10^{21}$ .

**$2.78 \times 10^{-3}$  mol;  $1.67 \times 10^{21}$  molecules**

**Problem 12 Atoms in methane**

1.  $N = 0.40 \times 6.02 \times 10^{23} = 2.408 \times 10^{23} \approx 2.41 \times 10^{23}$  molecules.
2. 1 carbon and 4 hydrogen atoms = 5 atoms.
3.  $0.40 \times 5 \times 6.02 \times 10^{23} = 1.204 \times 10^{24} \approx 1.20 \times 10^{24}$  atoms.

**$1.20 \times 10^{24}$  atoms**

### Problem 13 Mass against moles

- 12 g.
- Gradient =  $20 \text{ g} \div 0.50 \text{ mol} = 40 \text{ g/mol}$ , which is the molar mass.
- $M(\text{NaOH}) = 23 + 16 + 1 = 40 \text{ g/mol}$ , which matches.

**12 g; gradient 40 g/mol.**

### Problem 14 A tablet of paracetamol

- 500 mg = 0.500 g.
- $8 \times 12 + 9 \times 1 + 14 + 2 \times 16 = 96 + 9 + 14 + 32 = 151 \text{ g/mol}$ .
- $n = 0.500 \div 151 = 0.00331 \text{ mol} = 3.31 \times 10^{-3} \text{ mol}$ .

**$3.31 \times 10^{-3} \text{ mol}$**

### Problem 15 Spot the errors

- Wrong: oxygen gas is  $\text{O}_2$ , so  $M = 32 \text{ g/mol}$ .
- Wrong: there are two OH groups, so  $M_r = 40 + 2 \times 17 = 74$ .
- Wrong:  $0.50 \text{ mol}$  is  $0.50 \times 6.02 \times 10^{23} = 3.01 \times 10^{23}$  particles.
- Wrong:  $n = m \div M$ .

**32 g/mol; 74;  $3.01 \times 10^{23}$ ;  $n = m \div M$**

### Problem 16 Magnesium or aluminium

- Mg:  $10 \div 24 = 0.417 \text{ mol}$ . Al:  $10 \div 27 = 0.370 \text{ mol}$ .
- Mg:  $0.4167 \times 6.02 \times 10^{23} = 2.51 \times 10^{23}$ . Al:  $0.3704 \times 6.02 \times 10^{23} = 2.23 \times 10^{23}$ .
- Magnesium has more atoms:  $0.4167 \div 0.3704 = 1.125$ , so 12.5 % more.

**Magnesium has 12.5 % more atoms.**

### Problem 17 Iron in haematite

- $112 \div 160 \times 100 = 70.0 \%$ .
- $0.700 \times 2.50 \text{ kg} = 1.75 \text{ kg}$ .
- $n = 160 \div 160 = 1.00 \text{ mol}$ .

**70.0 % iron; 1.75 kg; 1.00 mol**

### Problem 18 Ions in a solution

- Each formula unit gives 2  $\text{Al}^{3+}$  and 3  $\text{SO}_4^{2-}$ .
- $\text{Al}^{3+}$ :  $2 \times 0.20 = 0.40 \text{ mol}$ .  $\text{SO}_4^{2-}$ :  $3 \times 0.20 = 0.60 \text{ mol}$ .
- Total =  $1.00 \text{ mol}$  of ions =  $6.02 \times 10^{23}$  ions.

**0.40 mol, 0.60 mol;  $6.02 \times 10^{23}$  ions**

**Problem 19 Mass of one particle**

1.  $18 \div 6.02 \times 10^{23} = 2.99 \times 10^{-23} \text{ g}$ .
  2.  $12 \div 6.02 \times 10^{23} = 1.99 \times 10^{-23} \text{ g}$ .
  3.  $n = 1.00 \div 12 = 0.0833 \text{ mol}$ , so  $N = 0.0833 \times 6.02 \times 10^{23} = 5.02 \times 10^{22} \text{ atoms}$ .
- $2.99 \times 10^{-23} \text{ g}$ ;  $1.99 \times 10^{-23} \text{ g}$ ;  $5.02 \times 10^{22} \text{ atoms}$**

**Problem 20 Baking soda**

1.  $23 + 1 + 12 + 3 \times 16 = 84 \text{ g/mol}$ .
  2.  $n = 8.4 \div 84 = 0.10 \text{ mol}$ .
  3. One  $\text{Na}^+$  per formula unit:  $0.10 \times 6.02 \times 10^{23} = 6.02 \times 10^{22}$ .
  4. Three O per formula unit:  $0.30 \text{ mol of O atoms} = 0.30 \times 6.02 \times 10^{23} = 1.81 \times 10^{23}$ .
- $84 \text{ g/mol}$ ;  $0.10 \text{ mol}$ ;  $6.02 \times 10^{22} \text{ Na}^+$ ;  $1.81 \times 10^{23} \text{ O atoms}$**