Empirical & Molecular Formula

1) An oxide of nitrogen contains 30.45% N and 69.55% O. What is its empirical formula? The molar mass of this oxide is 92 g/mol. What is its molecular formula?

2) A chloride of silicon contains 79.1% chlorine. What is its molecular formula if its molar mass is 269 g/mol?

3) Cortisol is a steroid hormone that is used to reduce inflammation. It has a molar mass of 362.47 g/mol and comprises 69.6% C, 8.34% H, and 22.1% O. What is its molecular formula?

4) Menthol is a substance commonly used in cough drops. It has a molar mass of 156.3 g/mol and comprises 77.4% C, 12.9% H, and 10.2% O. What is its molecular formula?

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Answers

1) An oxide of nitrogen contains 30.45% N and 69.55% O. What is its empirical formula? The molar mass of this oxide is 92 g/mol. What is its molecular formula?

Moles of N = (30.45 g / 14.01 g/mol) = 2.18 moles/2.18 moles = 1

Moles of O = (69.55 g / 16.00 g/mol) = 4.35 moles/ 2.18 moles = 2

Empirical formula = NO_2

Empirical formula mass = (1 × 14.01 g/mol) + (2 × 16.00 g/mol) = 46.01 g/mol

Ratio = Molar mass/ Empirical formula mass = 92 g/mol / 46.01 g/mol ≈ 2.

Molecular formula = $(NO_2)_2 = N_4O_2$

2) A chloride of silicon contains 79.1% chlorine. What is its molecular formula if its molar mass is 269 g/mol?

Moles of Cl = (79.1 g/ 35.45 g/mol) = 2.23 moles/0.744 moles = 3

Moles of Si = ((100 g - 79.1 g)/ 28.09 g/mol) = 0.744 moles/0.744 moles = 1

Empirical formula = $SiCl_3$

Empirical formula mass = (1 × 28.09 g/mol) + (3 × 35.45 g/mol) = 134.44 g/mol

Ratio = 269 g/mol/134.44 g/mol = 2. Molecular formula = $(SiCl_3)_2 = Si_2Cl_6$

3) Cortisol is a steroid hormone that is used to reduce inflammation. It has a molar mass of 362.47 g/mol and comprises 69.6% C, 8.34% H, and 22.1% O. What is its molecular formula?

Moles of C = 69.6 g / 12.01 g/mol = 5.80 moles/1.38 moles = 4.2 x 5 = 21

Moles of H = 8.34 g / 1.01 g/mol = 8.26 moles/1.38 moles = 6 x 5 = 30

Moles of O = 22.1 g / 16.00 g/mol = 1.38 moles/1.38 moles = 1 x 5 = 5

Empirical formula = $C_{21}H_{30}O_5$

Empirical formula mass = (21 × 12.01 g/mol) + (30 × 1.01 g/mol) + (5 × 16.00 g/mol) = 362.51 g/mol

Ratio = 362.47 g/mol /362.51 g/mol = 1. Molecular formula = $C_{21}H_{30}O_5$

4) Menthol is a substance commonly used in cough drops. It has a molar mass of 156.3 g/mol and comprises 77.4% C, 12.9% H, and 10.2% O. What is its molecular formula?

Moles of C = 77.4 g / 12.01 g/mol = 6.45 moles/0.64 moles = 10

Moles of H = 12.9 g / 1.01 g/mol = 12.77 moles/0.64 moles = 20

Moles of O = 10.2 g / 16.00 g/mol = 0.64 moles/0.64 moles = 1

Empirical formula = $C_{10}H_{20}O$

Empirical formula mass = (10 × 12.01 g/mol) + (20 × 1.01 g/mol) + (1 × 16.00 g/mol) = 156.30 g/mol

Ratio = 156.30 g/mol /156.30 g/mol = 1. Molecular formula = $C_{10}H_{20}O$

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