InkChemistry

ANSWER BOOK

Empirical and molecular formulae

Amount of substance · Unit C02

AQA 3.1.2.4 · OCR A 2.1.3

16 questions · 51 marks

NAVY EDITION

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SECTION A · Short, 1 to 2 marks

A1 EM-Q10

B1 the oxygen in the carbon dioxide and water comes partly from the oxygen gas used for burning, not only from the sample. **B1** so the mass of oxygen in the sample is the mass of the sample minus the masses of carbon and hydrogen. [2]

A2 EM-Q11

B1 1.33 is one and a third, so both numbers are multiplied by 3, giving 3.00 : 3.99. **B1** the empirical formula is C_3H_4; rounding 1.33 to 1 would discard a third of the hydrogen. [2]

A3 EM-Q19

B1 ethyl ethanoate, because 100 °C is above its boiling point so all of the injected liquid becomes vapour. **B1** butanoic acid boils above 100 °C, so it would not all vaporise and the volume measured would not correspond to the mass injected. [2]

SECTION B · Standard, 3 to 5 marks

B1 EM-Q5

M1 in 100 g: C 82.8 ÷ 12.0 = 6.90 and H 17.2 ÷ 1.0 = 17.2. **M1** dividing by 6.90 gives 1 : 2.49, which is doubled to 2 : 5, so the empirical formula is C_2H_5; reject CH_2 or CH_3 from rounding 2.49. **M1** the empirical formula mass is 29.0, and 58.0 ÷ 29.0 = 2. **A1** the molecular formula is C_4H_{10}; allow error carried forward from a wrong empirical formula. [4]

B2 EM-Q7

M1 mass of C = 0.264 × 12.0 ÷ 44.0 = 0.0720 g and mass of H = 0.108 × 2.0 ÷ 18.0 = 0.0120 g. **M1** mass of O = 0.180 - 0.0720 - 0.0120 = 0.0960 g. **M1** moles: C 0.00600, H 0.0120, O 0.00600, a ratio of 1 : 2 : 1. **A1** the empirical formula is CH_2O. [4]

B3 EM-Q15

M1 in 100 g: C 48.6 ÷ 12.0 = 4.05; H 8.1 ÷ 1.0 = 8.1; O 43.2 ÷ 16.0 = 2.70. **M1** dividing by 2.70 gives C 1.5, H 3.0, O 1.0, and doubling clears the half: 3 : 6 : 2. **A1** the empirical formula is $C_3H_6O_2$; reject C_2H_3O or any formula from rounding 1.5. **A1** empirical formula mass = 74.0, equal to Mr, so the molecular formula is also $C_3H_6O_2$. [4]

B4 EM-Q2

B1 the empirical formula of glucose is CH_2O. **B1** the empirical formula of ethane is CH_3. **B1** the empirical formula of butane is C_2H_5. [3]

B5 EM-Q3

M1 n(Mg) = 1.20 ÷ 24.3 = 0.0494 mol and n(O) = 0.80 ÷ 16.0 = 0.0500 mol. **M1** dividing by the smaller amount gives Mg : O = 1 : 1.01. **A1** the empirical formula is MgO. [3]

B6 EM-Q4

M1 in 100 g: C 52.2 ÷ 12.0 = 4.35; H 13.0 ÷ 1.0 = 13.0; O 34.8 ÷ 16.0 = 2.175. **M1** dividing by 2.175 gives C 2.00, H 5.98, O 1.00. **A1** the empirical formula is C_2H_6O. [3]

B7 EM-Q6

M1 Fe 70.0 ÷ 55.8 = 1.254 and O 30.0 ÷ 16.0 = 1.875. **M1** dividing by 1.254 gives 1 : 1.50, which is multiplied by 2 to give 2 : 3. **A1** the empirical formula is Fe_2O_3. [3]

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B8 EM-Q9

B1 the drying agent, such as anhydrous calcium chloride, absorbs only water. **B1** soda lime absorbs carbon dioxide but also absorbs water. **B1** with soda lime first, its mass gain would include the water, so the mass of carbon would be too high and the mass of hydrogen too low. [3]

B9 EM-Q12

B1 any compound C_nH_{2n}, for example ethene, C_2H_4. **B1** a second example, such as propene, C_3H_6, or cyclohexane, C_6H_{12}. **B1** measure the relative molecular mass, for example from the molecular ion peak in a mass spectrum, and divide it by 14.0 to find the molecular formula. [3]

B10 EM-Q13

B1 the empirical formula, CH_2O, gives only the simplest ratio of atoms. **B1** the molecular formula, $C_2H_4O_2$, gives the actual number of atoms of each element in one molecule. **B1** the structural formula, CH_3COOH, also shows how the atoms are arranged, which separates it from isomers such as methyl methanoate. [3]

B11 EM-Q14

B1 2.40 is 0.40 from a whole number, far more than the variation expected from experimental error. **B1** 2.40 is two and two fifths, so multiplying by 5 gives 5 : 12. **B1** the empirical formula is C_5H_{12}, pentane, so the student's rounding is not justified. [3]

B12 EM-Q18

B1 some carbon leaves as carbon monoxide or stays as soot, and is not absorbed by the soda lime. **B1** the mass of carbon dioxide, and so the mass of carbon calculated, is too low. **B1** oxygen is found by difference, so the mass of oxygen comes out too high by the same amount. [3]

SECTION C · Long, 6 marks or more

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C1 EM-Q16 **Indicative content** [6]

B1 a weighed, dry sample is burned in a stream of excess oxygen, so that all its carbon forms carbon dioxide and all its hydrogen forms water. **B1** hot copper(II) oxide downstream of the sample oxidises any carbon monoxide to carbon dioxide, so that no carbon escapes unmeasured. **B1** the gases pass first through a weighed tube of anhydrous calcium chloride, which absorbs only water, then through a weighed tube of soda lime. **B1** soda lime absorbs carbon dioxide and water, so it must come second or its gain in mass would include water and the carbon would be too high. **B1** mass of carbon = gain of the soda lime × 12.0 ÷ 44.0, mass of hydrogen = gain of the calcium chloride × 2.0 ÷ 18.0, and oxygen is the sample mass minus both. **B1** each mass is divided by its Ar and by the smallest result to give the simplest whole-number ratio, which is the empirical formula.

Levels

Level 3 (5–6 marks) combustion in excess oxygen, the copper(II) oxide to convert carbon monoxide, the absorbers in the correct order with the reason the order matters, oxygen found by difference and the conversion of the three masses to the simplest ratio are all present; each stage is linked to why the result can be trusted.

Level 2 (3–4 marks) the two absorbers are named and their gains give carbon and hydrogen, with oxygen by difference; the order of the absorbers is not justified, the copper(II) oxide is absent, or the ratio is not completed.

Level 1 (1–2 marks) the compound is burned and the products absorbed, typically with the alkali first so that it takes up the water too, and the calculation is not set out.

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