InkChemistry

ANSWER BOOK

Time-of-flight mass spectrometry and relative atomic mass

Atomic structure · Unit C01

AQA 3.1.1.2 · OCR A 2.1.1

14 questions · 46 marks

NAVY EDITION

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SECTION B · Standard, 3 to 5 marks

B1 TFM-Q1

B1 ionisation first, then acceleration. **B1** ion drift in the flight tube, then detection. **B1** without a vacuum the ions would collide with molecules in the air. **B1** collisions would slow or deflect the ions, so they would arrive at the wrong time or not reach the detector. [4]

B2 TFM-Q10

M1 mass of one ion = 0.0240 kg mol^{-1} ÷ 6.022 × 10^{23} mol^{-1} = 3.985 × 10^{-26} kg. **M1** v = √(2KE/m) = √(2 × 2.00 × 10^{-16} ÷ 3.985 × 10^{-26}) = 1.002 × 10^{5} m s^{-1}. **M1** t = d ÷ v = 1.50 ÷ 1.002 × 10^{5}; error carried forward from the speed. **A1** t = 1.50 × 10^{-5} s, to three significant figures. [4]

B3 TFM-Q16

B1 in electron impact the sample is vaporised, while in electrospray it is dissolved in a volatile solvent. **B1** electron impact knocks an electron off to form X^+, while electrospray adds a proton to form XH^+. **B1** the ion from electron impact has the mass of the particle, Mr, while the ion from electrospray has a mass of Mr + 1. **B1** electron impact often fragments molecules, while electrospray causes little fragmentation, so it is used for large molecules. [4]

B4 TFM-Q19

B1 about 1.1% of carbon atoms are carbon-13, so a few molecules contain one carbon-13 atom and are one unit heavier. **M1** n = (100 × height of M+1 peak) ÷ (1.1 × height of M peak). **M1** n = (100 × 3.41) ÷ (1.1 × 62.0) = 341 ÷ 68.2 = 5.0. **A1** 5 carbon atoms, a whole number, from 5.0. [4]

B5 TFM-Q2

B1 the sample is vaporised, if it is not already a gas. **B1** high-energy electrons from an electron gun knock one electron off each atom, forming 1+ ions. **B1** $Kr(g) + e^- \rightarrow Kr^+(g) + 2e^-$; allow $Kr(g) \rightarrow Kr^+(g) + e^-$. [3]

B6 TFM-Q3

B1 the sample is dissolved in a volatile solvent. **B1** the solution is forced through a fine hollow needle held at a high positive voltage, so each molecule gains a proton. **B1** $X(g) + H^+ \rightarrow XH^+(g)$; reject an equation that removes an electron. [3]

B7 TFM-Q4

B1 the electric field gives every ion with the same charge the same kinetic energy. **B1** since KE = ½mv^2, an ion of smaller mass has a greater speed. **B1** every ion crosses the same length of flight tube, so the lighter ions arrive first; the flight time is proportional to √m. [3]

B8 TFM-Q5

B1 the positive ions hit a negatively charged plate and each gains an electron. **B1** the flow of electrons to the plate produces a current. **B1** the size of the current is proportional to the number of ions arriving, and so to the abundance. [3]

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B9 TFM-Q9

M1 with x as the percentage of boron-10, $10x + 11(100 - x) = 10.8 \times 100$. **M1** $1100 - x = 1080$. **A1** boron-10 is 20% of boron, to two significant figures. [3]

B10 TFM-Q11

M1 at the same kinetic energy and distance, t is proportional to $\sqrt{m}$. **M1** $t = 1.54 \times 10^{-5} \times \sqrt{(81 \div 79)} = 1.54 \times 10^{-5} \times 1.0126$. **A1** $t = 1.56 \times 10^{-5}$ s, to three significant figures. [3]

B11 TFM-Q14

B1 the ion detected is MH^+, so the protein's Mr is 14306 - 1 = 14305. **B1** electron impact would break a molecule this large into many fragments. **B1** electrospray is gentle, so the molecule stays whole and its molecular ion peak is seen. [3]

B12 TFM-Q15

B1 m/z is the mass of an ion divided by its charge. **B1** a $^{32}S^{2+}$ ion, formed when two electrons are removed, has $m/z = 32 \div 2 = 16$. **B1** a 2+ ion gains twice the kinetic energy in the field, so it arrives at the same time as a 1+ ion of mass 16. [3]

B13 TFM-Q17

B1 no bromine atom has a relative mass of 79.9: the isotopes have masses close to 79 and 81. **B1** Ar is the weighted mean mass of the atoms of the element, relative to one twelfth of the mass of a carbon-12 atom. **B1** the two isotopes are almost equally abundant, so the mean lies near 80; the statement is wrong because Ar is an average, not the mass of any one atom. [3]

B14 TFM-Q21

B1 two peaks two units apart in a 1 : 1 ratio show one bromine atom, because bromine-79 and bromine-81 are almost equally abundant. **B1** 122 - 79 = 43 is left for the alkyl group, which is C_3H_7. **B1** the molecular formula is C_3H_7Br. [3]

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