Atoms, Molecules and Stoichiometry – 2017

1. 9701/21/M/J/17/No.1

Combustion data can be used to calculate the empirical formula, molecular formula and relative molecular mass of many organic compounds.

(a) Define the term *relative molecular mass*.

....

....

....

.... [2]

(b) **T** is an alcohol, C_xH_yO. A gaseous sample of **T** occupied a volume of 20 cm^3 at 120 °C and 100 kPa.

The sample was completely burned in 200 cm^3 of oxygen (an excess). The final volume, measured under the same conditions as the gaseous sample, was 250 cm^3.

Under these conditions, all water present is vaporised. Removal of the water vapour from the gaseous mixture decreased the volume to 170 cm^3.

Treating the remaining gaseous mixture with concentrated alkali, to absorb carbon dioxide, decreased the volume to 110 cm^3.

The equation for the complete combustion of **T** can be represented as shown.

$$C_xH_yO + zO_2 \rightarrow xCO_2 + \frac{y}{2}H_2O$$

(i) Use the data given to calculate the value of x.

x = ... [1]

(ii) Use the data given to calculate the value of y.

y = ... [1]

If you were unable to calculate values for x and y then use $x = 4$ and $y = 10$ for the remaining parts of this question. These are **not** the correct values.

(iii) Complete the equation for the complete combustion of the alcohol, **T**.

.... + ...O_2 → ....CO_2 + ...H_2O

[1]

(iv) Give the skeletal formulae for two possible structures of **T**.

Name each alcohol.

....	....

[2]

(v) Use the general gas equation to calculate the mass of **T** present in the original 20 cm^3 gaseous sample, which was measured at 120 °C and 100 kPa.

Give your answer to **three** significant figures. Show your working.

mass = ... g [3]

[Total: 10]

2. 9701/22/M/J/17/No.1

The composition of atoms and ions can be determined from knowledge of atomic number, nucleon number and charge.

(a) Complete the table.

atomic number	nucleon number	number of electrons	number of protons	number of neutrons	symbol
3		2			${}^{6}_{3}Li^{+}$
		23	26	32	

[2]

(b) Boron occurs naturally as a mixture of two stable isotopes, ^{10}B and ^{11}B. The relative isotopic masses and percentage abundances are shown.

isotope	relative isotopic mass	abundance / %
^{10}B	10.0129	19.78
^{11}B	to be calculated	80.22

(i) Define the term *relative isotopic mass*.

....

.... [2]

(ii) Calculate the relative isotopic mass of ^{11}B.

Give your answer to **six** significant figures. Show your working.

[2]

[Total: 6]

3. 9701/23/M/J/17/No.1

Combustion data can be used to calculate the empirical formula, molecular formula and relative molecular mass of many organic compounds. Combustion data cannot distinguish between different structural isomers.

(a) Define the term *structural isomers*.

....

....

....

.... [2]

(b) **P** is a hydrocarbon, C_xH_y. A gaseous sample of **P** occupied a volume of 25 cm^3 at 37 °C and 100 kPa.

The sample was completely burned in 200 cm^3 of oxygen (an excess).
The final volume, measured under the same conditions as the gaseous sample (so that the water produced is liquid and its volume can be ignored), was 150 cm^3.

Treating the remaining gaseous mixture with concentrated alkali, to absorb carbon dioxide, decreased the volume to 50 cm^3.

The equation for the complete combustion of **P** can be represented as shown.

$$C_xH_y + (x + \frac{y}{4})O_2 \rightarrow xCO_2 + \frac{y}{2}H_2O$$

(i) Use the data given to calculate the value of x.

x = ... [1]

(ii) Use the data given to calculate the value of $(x + \frac{y}{4})$.

$(x + \frac{y}{4})$ = ... [1]

If you were unable to calculate values in **(b)(i)** and **(b)(ii)** then use the data in this box for the remaining parts of this question. These are **not** the correct values.

$x = 6$ $\quad\quad$ $(x + \frac{y}{4}) = 9$

(iii) Give the molecular formula and the empirical formula of **P**.

molecular formula of **P** ....

empirical formula of **P** ....
[2]

(iv) **P** is unbranched.

Give the skeletal formulae for two possible structures of **P** that are positional isomers of each other.

[2]

(v) Use the general gas equation to calculate the mass of **P** present in the original $25\,cm^3$ gaseous sample, which was measured at 37 °C and 100 kPa.

Give your answer to **three** significant figures.

mass = ... g [3]

[Total: 11]