Answer on Question #62346, Chemistry / General Chemistry

A 33.153 mg sample of a chemical known to contain only carbon, hydrogen, sulfur, and oxygen is put into a combustion analysis apparatus, yielding 59.060 mg of carbon dioxide and 24.176 mg of water. In another experiment, 47.029 mg of the compound is reacted with excess oxygen to produce 20.326 mg of sulfur dioxide. Add subscripts below to correctly identify the empirical formula of this compound (use this order of elements: CHSO).

Solution:

1) Get grams of each element:
Carbon: 59.060·mg x (12.011(g/mol) / 44.009(g/mol)) = 16.119 mg of C in 33.153 mg sample
Hydrogen: 24.176 mg x (2.016 / 18.015) = 2.075 mg of H in 33.153 mg sample
Oxygen: we leave this to later
Sulfur: 20.326 mg x (32.066 / 64.066) = 11.041 mg of S in 47.029 mg sample

2) Let us determine the percent composition:
Carbon: 16.119 mg / 33.153 mg = 48.62%
Hydrogen: 2.075 mg / 33.153 mg = 6.26%
Sulfur: 11.041 mg / 47.029 mg = 23.48%
Oxygen: 100% - (48.62% + 6.26% +23.48%) = 21.64%

3) Assume 100 mg of compound present. Therefore:
Carbon: 48.62 mg
Hydrogen: 6.26 mg
Sulfur: 23.48 mg
Oxygen: 21.64 mg

4) Calculate moles:
Carbon: $48.62 \cdot 10^{-3}$ g / 12.011 g/mol = $4.048 \cdot 10^{-3}$ mol
Hydrogen: $6.26 \cdot 10^{-3}$ g / 1.008 g/mol = $6.21 \cdot 10^{-3}$ mol
Sulfur: $23.48 \cdot 10^{-3}$ g / 32.066 g/mol =$0.73 \cdot 10^{-3}$ mol
Oxygen: $21.64 \cdot 10^{-3}$ g / 16.00 g/mol = $1.353 \cdot 10^{-3}$ mol

5) Look for smallest, whole-number ratio:
Carbon: = $4.048 \cdot 10^{-3}$ mol / $0.73 \cdot 10^{-3}$ mol = 6
Hydrogen: = $6.21 \cdot 10^{-3}$ mol / $0.73 \cdot 10^{-3}$ mol = 9
Sulfur: =$0.73 \cdot 10^{-3}$ mol / $0.73 \cdot 10^{-3}$ mol = 1
Oxygen: $1.353 \cdot 10^{-3}$ mol / $0.73 \cdot 10^{-3}$ mol = 2

C: 6
H: 9
S: 1
O: 2

The empirical formula is $C_6H_9SO_2$

Answer: $C_6H_9SO_2$