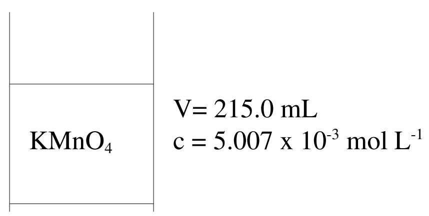
The concentration of the atmospheric pollutant sulfur dioxide (SO_2) can be found by bubbling air through a dilute $KMnO_4(aq)$ solution of known concentration.

$$5SO_2(g) + 2MnO_4^-(aq) + 2H_2O(l) \text{ -----> } 5SO_4^{2-}(aq) + 2Mn^{2+}(aq) + 4H^+(aq)$$

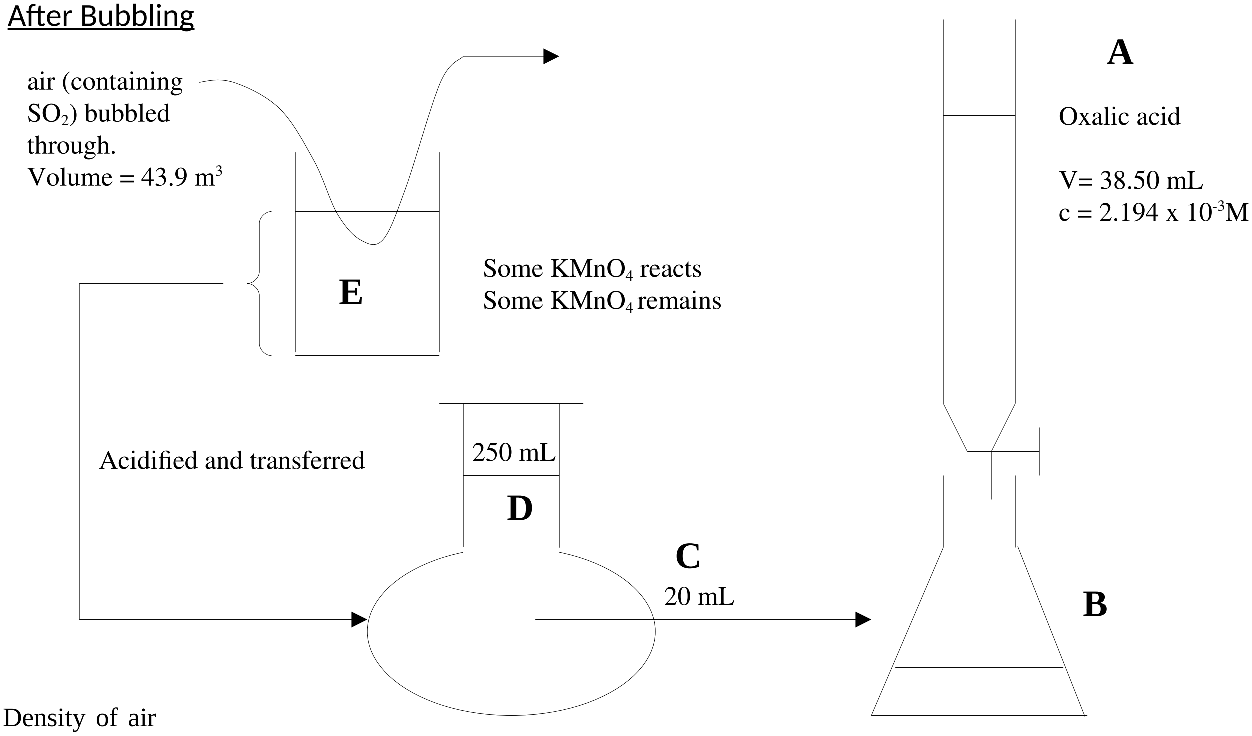
The concentration of the remaining $KMnO_4(aq)$ can be found by titration with standardised oxalic acid. This allows the amount of $KMnO_4$ reacting with sulfur dioxide to be found and thus its concentration in the air sample can be calculated. In such a procedure, 43.9 m^3 of SO_2 polluted air was bubbled through 215.0 mL of 5.007 x 10^{-3} mol L^{-1} $KMnO_4(aq)$. The unreacted $KMnO_4$ was acidified and diluted to a volume of 250.0 mL. 20.00 mL samples of this $KMnO_4$ solution were titrated to equivalence with 38.50 mL of 2.194 x 10^{-3} mol L^{-1} oxalic acid solution. What is the concentration of the pollutant $SO_2(g)$ in ppm if the air has a density of 1.18 kg m^{-3}

[12 marks]

Before Bubbling



After Bubbling



Density of air = 1.18 kg m^{-3}

<u>Before Bubbling</u>

$n(KMnO_4) = cV = 0.2150 \times 5.007 \times 10^{-3} = 1.0765 \times 10^{-3}$ **(1 mark)**

<u>After Bubbling</u>

A: n(oxalic acid) = $cV = 0.3850 \times 2.194 \times 10^{-3} = 8.4469 \times 10^{-5}$ **(1 mark)**

Titration reaction:

$2MnO_4^-(aq) + 6H^+(aq) + 5H_2C_2O_4(aq) \text{----->} 2Mn^{2+}(aq) + 8H_2O(l) + 10CO_2(g)$ **(2 marks)**

B: $n(KMnO_4)$ = (2/5) x n(oxalic acid) = $(2/5) \times 8.4469 \times 10^{-5} = 3.3788 \times 10^{-5}$ **(1 mark)**

C: $c(KMnO_4) = n/V = 3.3788 \times 10^{-5} / 0.020 = 1.6894 \times 10^{-3}M = c(KMnO_4)$ at **D**

(1 mark)

D: $n(KMnO_4) = cV = 1.6894 \times 10^{-3} \times 0.250 = 4.2235 \times 10^{-4} = n(KMnO_4)$ at **E (1 mark)**

<u>Moles of SO_2 reacting</u>

$n(KMnO_4)_{\text{reacting with SO2}} = n(KMnO_4)_{\text{Before Bubbling}} - n(KMnO_4)_{\text{After Bubbling}}$

$= 1.0765 \times 10^{-3} - 4.2235 \times 10^{-4} = 6.5416 \times 10^{-4}$ **(1 mark)**

$n(SO_2) = (5/2) \times n(KMnO_4)_{\text{reacting with SO2}} = (5/2) \times 6.5416 \times 10^{-4} = 1.6354 \times 10^{-3}$

(1 mark)

$m(SO_2) = n \times M = 1.6354 \times 10^{-3} \times 64.07 = 1.0478 \times 10^{-1}$ g = 104.78 mg **(1 mark)**

This mass is contained in 43.9 m^3 of air

mass(air) = density(air) x V = 1.18 x 43.9 = 51.802 kg **(1 mark)**

$c(SO_2)_{ppm} = m(SO_2)_{mg} / \text{mass(air)}_{kg}$ = 104.78 / 51.802 = **<u>2.02 ppm</u>** **(1M]**