The concentration of the atmospheric pollutant sulfur dioxide (SO2) can be found by bubbling air through a dilute KMnO4(aq) solution of known concentration.

 5SO2(g) + 2MnO4-(aq) + 2H2O(l) -----> 5SO42-(aq) + 2Mn2+(aq) + 4H+(aq)

The concentration of the remaining KMnO4(aq) can be found by titration with standardised oxalic acid. This allows the amount of KMnO4 reacting with sulfur dioxide to be found and thus its concentration in the air sample can be calculated. In such a procedure, 43.9 m3 of SO2 polluted air was bubbled through 215.0 mL of 5.007 x 10-3 mol L-1 KMnO4(aq). The unreacted KMnO4 was acidified and diluted to a volume of 250.0 mL. 20.00 mL samples of this KMnO4 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 SO2(g) in ppm if the air has a density of 1.18 kg m-3

[12 marks]

Before Bubbling

**E**

**D**

**C**

**B**

**A**

Density of air = 1.18 kg m-3

Oxalic acid

V= 38.50 mL

c = 2.194 x 10-3M

 20 mL

 250 mL

Acidified and transferred

KMnO4

V= 215.0 mL

c = 5.007 x 10-3 mol L-1

Some KMnO4 reacts

Some KMnO4 remains

air (containing SO2) bubbled through.

Volume = 43.9 m3

After Bubbling

Before Bubbling

n(KMnO4) = cV = 0.2150 x 5.007 x 10-3 = 1.0765 x 10-3 **(1 mark)**

After Bubbling

**A:** n(oxalic acid) = cV = 0.3850 x 2.194 x 10-3 = 8.4469 x 10-5 **(1 mark)**

Titration reaction:

2MnO4-(aq) + 6H+(aq) + 5H2C2O4(aq) -----> 2Mn2+(aq) + 8H2O(l) + 10CO2(g) **(2 marks)**

**B:** n(KMnO4) = (2/5) x n(oxalic acid) = (2/5) x 8.4469 x 10-5 = 3.3788 x 10-5 **(1 mark)**

**C:** c(KMnO4) = n/V = 3.3788 x 10-5 / 0.020 = 1.6894 x 10-3M = c(KMnO4) at **D**

 **(1 mark)**

**D:** n(KMnO4) = cV = 1.6894 x 10-3 x 0.250 = 4.2235 x 10-4 = n(KMnO4) at **E (1 mark)**

Moles of SO2 reacting

n(KMnO4)reacting with SO2 = n(KMnO4)Before Bubbling - n(KMnO4)After Bubbling

 = 1.0765 x 10-3 - 4.2235 x 10-4 = 6.5416 x 10-4 **(1 mark)**

n(SO2) = (5/2) x n(KMnO4)reacting with SO2 = (5/2) x 6.5416 x 10-4 = 1.6354 x 10-3

 **(1 mark)**

m(SO2) = n x M = 1.6354 x 10-3 x 64.07 = 1.0478 x 10-1 g = 104.78 mg **(1 mark)**

This mass is contained in 43.9 m3 of air

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

c(SO2)ppm = m(SO2)mg / mass(air)kg = 104.78 / 51.802 = **2.02 ppm** **(1M]**