5 In an experiment, 10.0 cm^3 of 0.200 mol dm^{-3} solution of acidified potassium manganate(VII) was made up to 250 cm^3. 25.0 cm^3 of this diluted solution was then titrated with 34.50 cm^3 of hydrogen peroxide solution.

(a) Calculate the concentration of hydrogen peroxide solution. **[2]**

Oxidation: $H_2O_2 \rightarrow O_2 + 2\,H^+ + 2e$ ---- (1)
Reduction: $MnO_4^- + 8\,H^+ + 5e \rightarrow Mn^{2+} + 4\,H_2O$ ---- (2)

Overall: *(1) x 5 + (2) x 2*

$5\ H_2O_2\ (aq) + 2\ MnO_4^-(aq) + 6\ H^+\ (aq) \rightarrow 5\ O_2\ (g) + 2\ Mn^{2+}\ (aq) + 8\ H_2O\ (l)$

$5\,H_2O_2 \equiv 2\,MnO_4^-$

No. of mol of MnO_4^- in <u>250 cm³</u> $= 0.200 \times \frac{10.0}{1000} = 2.00 \times 10^{-3}$ **[1/2]**

No. of mol of MnO_4^- in <u>25.0 cm³</u> $= 2.00 \times 10^{-3} \times \frac{25.0}{250} = 2.00 \times 10^{-4}$ **[1/2]**

No. of mol of H_2O_2 in 34.50cm³ $= 2.00 \times 10^{-4} \times \frac{5}{2} = 5.00 \times 10^{-4}$ **[1/2]**

$[H_2O_2] = n/v = \frac{5.00\times10^{-4}}{34.50/1000} =$ **$\underline{1.45 \times 10^{-2}\ mol\ dm^{-3}}$** **[1/2]**

(b) Determine the volume strength of the hydrogen peroxide solution **[2]**

Recall: Use the decomposition equation not the oxidation half equation of H_2O_2 in c(i)

Decomposition of H_2O_2:

$2\,H_2O_2\ (aq) \rightarrow 2H_2O\ (l) + O_2\ (g)$

$2\,H_2O_2 \equiv O_2$

No. of mol of H_2O_2 in 1 dm^3 of 1.45×10^{-2} mol dm^{-3} $H_2O_2 = 1.45 \times 10^{-2}$ **[1/2]**

No. of mol of O_2 produced by 1 dm^3 of $H_2O_2 = 1.45 \times 10^{-2} \times \frac{1}{2} = 0.00725$ **[1/2]**

Volume of O_2 produced by 1 dm^3 of a 1.45×10^{-2}mol dm^{-3} H_2O_2 at s.t.p.

$= 0.00725 \times 22.4$

$= 0.0162\ dm^3$ **[1/2]**

Volume strength of H_2O_2 $= \frac{\text{Volume of } O_2 \text{ produced}}{\text{Volume of } H_2O_2 \text{ solution}} = \frac{0.0162}{1} =$ **<u>0.0162 (no units)</u>**

[1/2]

[Total : 4 marks]

6 Pyrolusite is a mineral, which contains manganese dioxide. It is used for the large scale production of potassium manganate(VII). The process involves two steps:

Step 1
The pyrolusite is reacted with potassium hydroxide and heated in the presence of oxygen to form potassium manganate(VI) and water.

Step 2
Potassium manganate(VI) is then electrolytically oxidized to potassium manganate(VII).

To determine the percentage composition of manganese dioxide, a sample of pyrolusite that weighed 2.50 g was treated according to Step 1 and 2. The potassium manganate(VII) formed required 24.00 cm^3 of 4.80 mol dm^{-3} of iron (II) sulfate solution for complete reaction.

(a) Write the balanced equation for the formation of potassium manganate(VI) from manganese dioxide.

[1]

$MnO_2 + 2OH^- + \frac{1}{2}O_2 \rightarrow MnO_4^{2-} + H_2O$ **[1]**

(b) Write the balanced equation for the reaction of potassium manganate(VII) with iron (II) sulfate.

[1]

$MnO_4^- + 5Fe^{2+} + 8H^+ \rightarrow Mn^{2+} + 5Fe^{3+} + 4H_2O$**[1]**

(c) Calculate the percentage composition of manganese dioxide in pyrolusite.
(Ans: 80.0%)

[3]

No. of moles of Fe^{2+} = 4.80 x 0.024 = 0.115 **[1/2]**

$MnO_4^- \equiv 5Fe^{2+}$

No of moles of MnO_4^- = $\frac{1}{5} \times 0.115 = 0.0230$ **[1/2]**

$MnO_4^- \equiv MnO_4^{2-} \equiv MnO_2$

No of moles of MnO_2 = 0.0230 **[1/2]**

Mass of MnO_2 = 0.0230 x (54.9 + 2 x 16) = 2.00 g **[1/2]**

Percentage composition = $\frac{2}{2.5} \times 100\%$ **[1/2]** = <u>**80.0%**</u> **[1/2]**

(d) Is it possible to use iron (II) chloride in place of iron (II) sulfate for the determination of potassium manganate (VII)? Justify your answer. **[1]**

No. Because the chloride ions will be **oxidised** by potassium manganate(VII).**[1]**

[Total: 6 marks]