PRACTICAL REPORT: DETERMINATION OF THE IRON(II) CONTENT IN LAWN FERTILISER BY REDOX TITRATION

AIM

To design and carry out a redox titration in order to analyse and determine the iron content (as water-soluble iron(II) ions) of a synthetic fertiliser.

APPARATUS

- 30 g synthetic fertiliser containing (iron(II) ions)
- 100 mL 0.0100 M potassium permanganate solution
- 100 mL 1 M sulphuric acid
- 3 x 250 mL conical flasks
- 2 x Measuring cylinders
- Deionised water
- 50 mL Burette
- Burette stand
- Electronic balance
- Spatula
- White tile

METHOD

1. Accurately weigh out 10.000 g of fertiliser into 3 conical flasks on the electronic balance using a spatula.
2. Measure out 20 mL of sulfuric acid in the measuring cylinder and add to the first flask. Repeat for the other two flasks.
3. Measure 10 mL of deionised water in a measuring cylinder and add to the first flask. Repeat for the other two flasks.
4. Ensure all fertiliser is dissolved in each flask.
5. Rinse the burette with potassium permanganate solution.
6. Fill burette with approximately 40 mL of the potassium permanganate solution.
7. Record the initial burette reading

8. Carefully titrate potassium permanganate solution into the first conical flask until the equivalence point has been reached (a noticeable change in colour should occur at this stage and should occur approximately after 10 mL of solution has been titrated)

9. Stop the discharge from the burette and record the final burette reading

10. Repeat steps 7 – 9 for the remaining two conical flasks.

11. Calculate the average titre and hence calculate n(MnO_4^-),n(Fe^{2+}), m(Fe^{2+}) to calculate the percentage by mass of iron(II) ions in the synthetic fertiliser.

RESULTS

Mass of fertiliser in each flask: 10.000 grams

C($KMnO_4$) = 0.100 M

C(H_2SO_4) = 0.100 M

TABLE 1: Volume of titre during titration of HCl into excess NaOH:

Titration Number:	Initial Burette Reading	Final Burette Reading	Titre Volume
1.	22.72 mL	39.57 mL	11.79 mL
2.	24.58 mL	34.64 mL	10.06 mL
3.	34.63 mL	44.62 mL	9.98 mL

- Average titre of $KMnO_4$ during titration was 10.02 mL
- Shows 0.280% w/w of iron(II) in the synthetic fertiliser

PROCEDURE

1. (a) & (b) & (c) See 'Discussion'

2. Sulfuric acid is added to the fertiliser solution before it is titrated with the potassium permanganate solution because in a redox reaction there needs to be a source of H^+ since redox reactions involve electron transfer.

3. The mass of fertiliser required to reach the end point would be fertiliser

4. (a) An indicator is not required during this titration because when the equivalence point is reached i.e. the reactants have turned into the products, the potassium permanganate solution which is normally purple in colour fully reacts with the iron(II) ions to produce Mn^{2+} ions which changes the colour of the solution from a purple to a pink hence displaying an end point to the reaction.

   (b) When using potassium permanganate solution in the burette, it is necessary to read the burette from the top of the meniscus rather than from the bottom because of the dark colour of the solution sometimes making the bottom hard to see. By reading from the top it keeps readings consistent and accurate.

5. To analyse the concentration of iron(II) must be made up. If a standard solution of the fertiliser was made up in a 250 mL volumetric flask then 125 g of fertiliser would be required to be weighed out and made up into solution to have 0.028 grams of iron(II) ions in each flask. Since this amount is unpractical it is easier to weigh out 10 grams of fertiliser into each conical flask instead of using a standard solution. This still provides 0.028 grams of iron(II) in each conical flask which will result in a titre around 10 mL as required.

6. See ‘Safety’.

7. See ‘Method’.

SAFETY

TABLE 2: Safety requirements:

Material	Hazard	Control
Fertiliser	Harmful if swallowed	Do not ingest
$KMnO_4$	Harmful if swallowed	Do not ingest and wear gloves
H_2SO_4	Corrosive to eyes and skin	Wear lab coat, safety glasses and gloves. Keep lid on bottle when not in use.

Safe working practices

- Wear safety glasses, gloves and lab coat throughout prac
- Leave lid on chemicals when not in use
- Clean any spills immediately

SOURCES OF UNCERTAINTY AND ERRORS

Sources of uncertainty:

- Electronic balance $\pm$0.001 g
- Burette $\pm$0.02 mL

Sources of error:

- Accurately weighing the amount of fertiliser in each flask
- Rinsing the burette thoroughly with potassium permanganate solution to rid of foreign substances
- Stopping the titration as soon as the end point is reached and a change of colour is evident
- Making sure all the iron(II) ions have dissolved in solution
- Accurately calculating unknown quantities.

CALCULATIONS

$$Average\ titre = \frac{10.06+9.98}{2}$$
$$= 10.02mL$$

$$n(MnO_4{}^-) = C \times V$$
$$= 0.0100 \times 0.01002$$
$$= 1.00 \times 10^{-4}\ mol$$

$$n(Fe^{2+}) = 5 \times n(MnO_4{}^-)$$
$$= 5.01 \times 10^{-4}\ mol$$

$$m(Fe^{2+}) = n \times M$$
$$= 5.01 \times 10^4 \times 55.9$$
$$= 2.80 \times 10^{-2}$$

Procedure Calculations

$$n(MnO_4{}^-) = C \times V$$
$$= 0.1 \times 0.01$$
$$= 0.0001\ mol$$

$$n(Fe^{2+}) = 5 \times (MnO_4{}^-)$$
$$= 0.0001 \times 5$$
$$= 0.0005\ mol$$

$$m(Fe^{2+}) = n \times M$$
$$= 0.0005 \times 55.85$$
$$= 0.0279\ grams$$

$$m(fertiliser) for\ 0.028g\ Fe^{2+}$$
$$= \frac{0.028 \times 100}{0.28}$$
$$= 10\ grams$$

$$\%\ w/w\ of\ Fe^{2+}\ in\ fertiliser\ = \frac{2.80 \times 10^{-2}}{10.000} \times 100$$
$$= 0.280\ \%\ \text{w/w}$$

DISCUSSION

- During this redox titration, iron(II) ions in the synthetic fertiliser are oxidised to form iron(III) ions according to the following equation:

$$Fe^{2+}{}_{(aq)} \rightarrow Fe^{3+}{}_{(aq)} + e^-$$

- Additionally, manganate ions from the potassium permanganate solution are reduced by the iron(II) according to this equation:

$$MnO_4{}^-{}_{(aq)} + 8H^+{}_{(aq)} + 5e^- \rightarrow Mn^{2+}_{(aq)} + 4H_2O_{(l)}$$

- The overall redox reaction that occurs is:

$$5Fe^{2+}{}_{(aq)} + MnO_4{}^-{}_{(aq)} + 8H^+{}_{(aq)} \rightarrow 5Fe^{3+}{}_{(aq)} + Mn^{2+}_{(aq)} + 4H_2O_{(l)}$$

- It can be proved that this is a redox reaction through the use of oxidation numbers being applied to the overall equation:

  As a reactant, iron is assigned the oxidation number of +2 and manganese is given the oxidation number of +7 whereas on the products side, iron is assigned the oxidation number +3 and manganese is assigned +2.

  Since iron undertakes an increase in oxidation number, oxidation is said to have undergone oxidation and since manganese undertakes a decrease in oxidation number it is said to have undergone reduction, hence this reaction is a redox reaction.

- The average titre obtained is found using only the two concordant results of 10.06 mL and 9.98 mL in order to increase the accuracy of the results. If the titre of 11.79 mL had of been included in calculations then the %w/w of Fe^{2+} would have been significantly higher.

- In comparison to the specifications of the synthetic fertiliser used, the result obtained was very close to the specified result. The specification of 0.282 w/w of Fe^{2+} was slightly higher than the analysed percentage of 0.280% w/w. The slight difference may be accounted for by the sources of uncertainty and error as aforementioned.

- The addition of iron(II) into fertiliser is essential for plant growth. Along with other nutrients, it provides plants with the nutrition they require. During this exercise, the content of water-soluble iron(II) was analysed.

QUESTIONS

1. Calculate the iron content in the fertiliser.

   The iron content in the fertiliser analysed was 0.280% w/w

2. If the fertiliser contained other chemicals that can be oxidised by permanganate ions how would this affect the calculated %w/w?

   If the fertiliser contained other chemicals that can be oxidised by permanganate ions then the overall calculation of the %w/w of iron would be greater.

CONCLUSION

This practical was a success as the purpose was achieved, "To design and carry out a redox titration in order to analyse and determine the iron content (as water-soluble iron(II) ions) of a synthetic fertiliser." The analysed percentage by mass of iron(II) compared strongly to the synthetic fertilisers specification; the specification being 0.282% w/w and the analysed amount being 0.280% w/w. This indicates that the method developed and the redox titration carried out was exceptionally accurate with the slight difference in results being accountable through the sources of uncertainty and error as aforementioned. This activity demonstrated how with knowledge of redox reactions and redox titrations, an experiment can be designed and carried out in order to analyse and determine the iron(II) content of fertiliser. Overall, the presence of iron(II) in fertiliser helps maintain a plants health and aid growth.