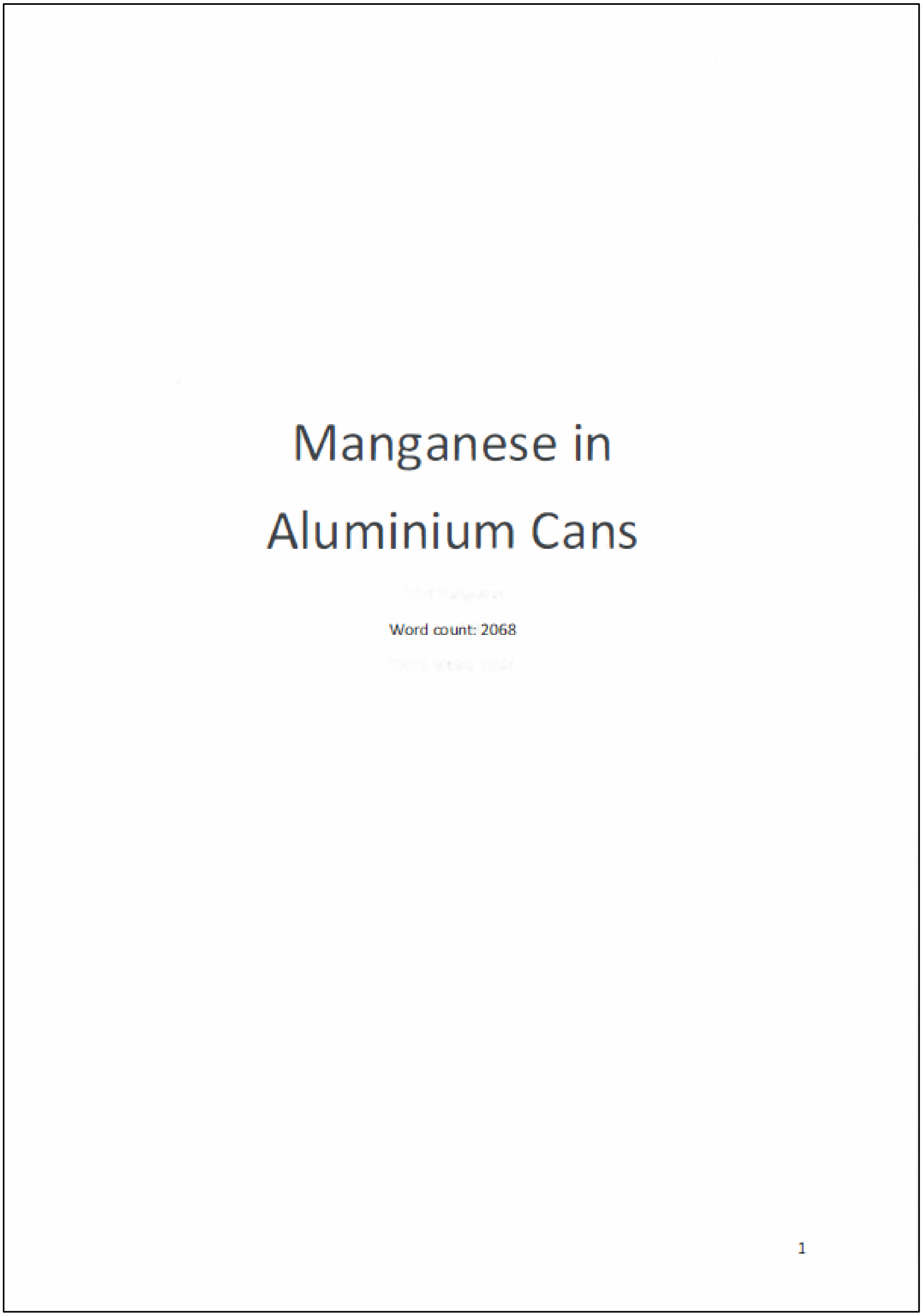
Candidate evidence



Manganese in Aluminium Cans

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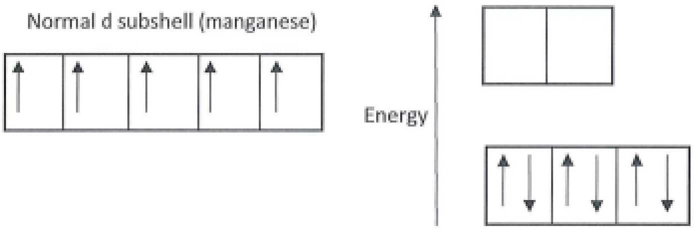
Abstract:

The aim was to find what percentage of aluminium cans is comprised of manganese. We found that about 0.8%-1.0% of the aluminium can is manganese

Underlying Chemistry:

Manganese is a transition metal, this means it is found in the d section of the periodic table. A transition metal is an element with a partly filled d-subshell this means even though zinc is found in the d section of the periodic table it is not a transition metal as it has a full d-subshell. When transition metals are found by themselves they have lone pairs and their electrons are degenerate, meaning the all have the same energy, however when transition metals are bonded with ligands (forming dative covalent bonds) their electrons split in energy levels. Manganese Can be found as permanganate MnO^{-}_{4} as the d orbitals are bonded with oxygen they are no longer degenerate they split.



This gap in the energy levels mean that light can be absorbed the absorbed light will cause electrons to move up a level to an excited state. The complimentary colour of light absorbed is what is seen and this is why transition metals make different colours. Permanganate or MnO^{-}_{4} is a purple colour this mean that green light with wavelength 500nm to 560nm is absorbed. Using E=hlf the energy absorbed can be measured.

Using light 540nm

$f=c/\lambda$

$f=3.0\times10^{8}/540\times10^{-9}$

$f=5.56\times10^{14}$

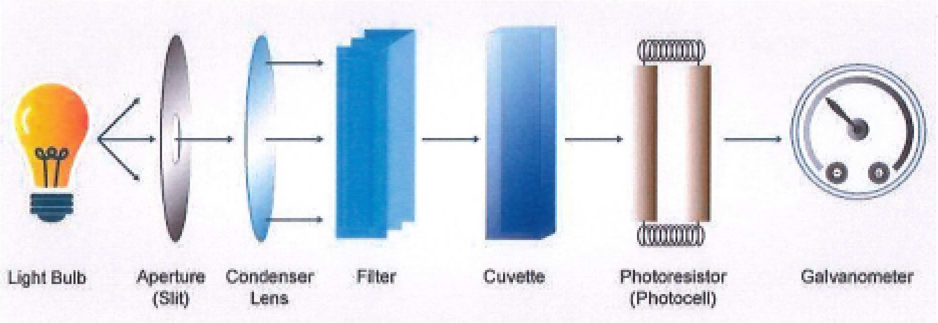
$E=hlf$

$E=6.63\times10^{-34} \times 6.02\times10^{23} \times 5.56 \times10^{14}$

$E=221914J$

$E=222kJ$

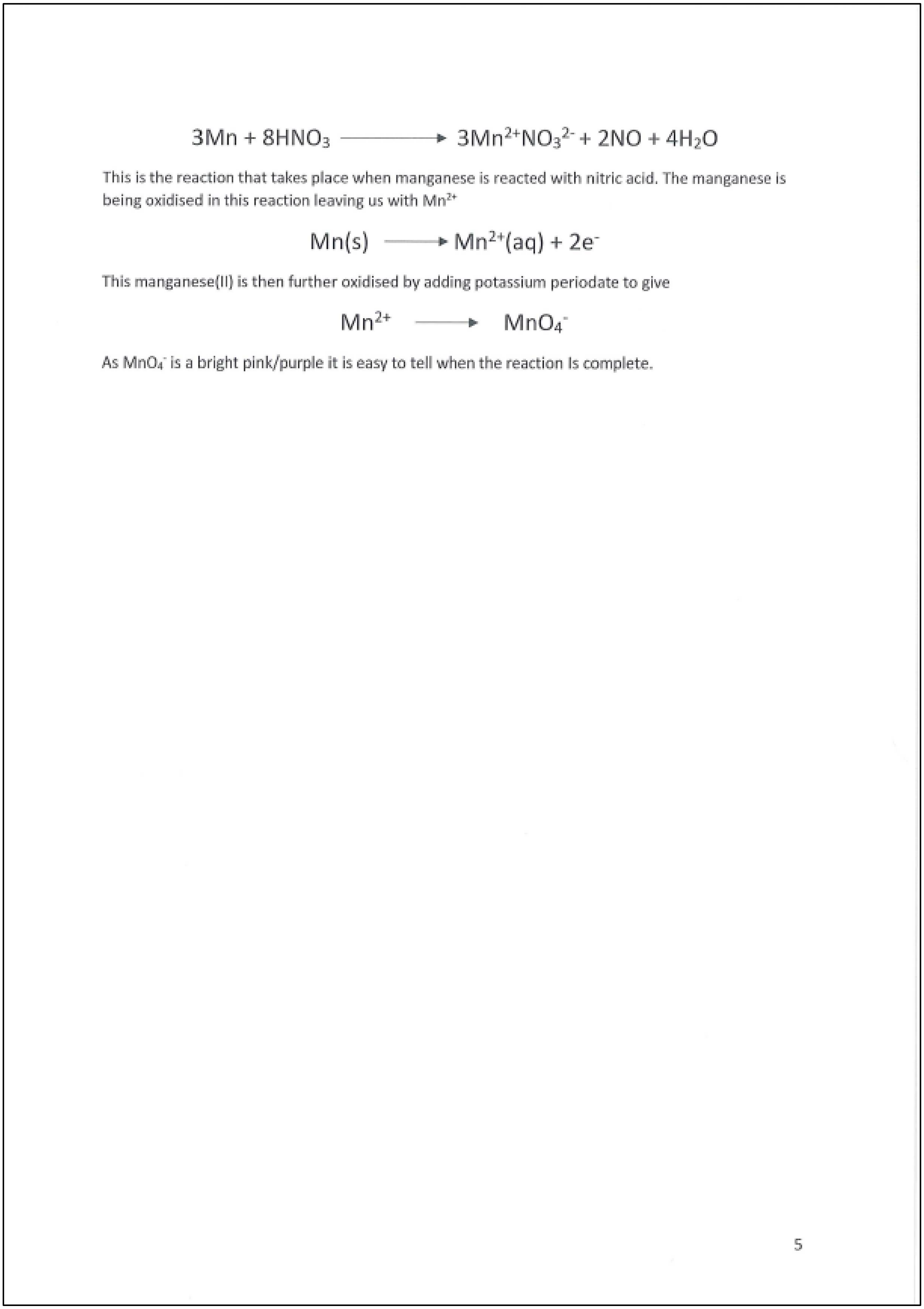
Because light of certain wavelengths is absorbed colorimetry can be used to measure an absorbance. A colorimeter works by shining light through a solution in a cuvette with a filter complimentary to the colour of solution. As permanganate is purple a green filter will be used. When light goes through the solution some is absorbed this is measured and displayed by the colorimeter. This absorption can be used to find the concentration using a calibration curve. A graph of absorption over concentration can be drawn by putting known concentrations of solution. The absorbance over concentration is directly proportional so a straight line should be plotted passing through the origin in ideal conditions.



Another method of determining the concentration would be a titration. If permanganate is reacted with Iron (II) and H^+ it will reduce to form manganese (II) the below equation shows:

$$MnO_4^- + 5Fe^{2+} + 8H^+ \longrightarrow Mn^{2+} + 5Fe^{3+} + 4H_2O$$

As permanganate is a bright purple colour and manganese(II) is a pale pink colour adding 5 iron(II) would start to turn the solution a very pale pink colour as soon as the colour change has happened the amount of Iron(II) added would be recorded and the number of moles would be calculated using n=cv then to find the number of mols of manganese(II) as it is a 5:1 Ratio if number of moles of iron = 0.01 then number of moles of manganese = 0.05 then using m=n x GFM we would find that mass = 0.05 x 54.9 = 2.745 grams. However the method of extracting MnO_4^- that was used made this titration invalid. Nitric acid was used to dissolve the permanganate into a solution but because nitric acid is a stronger oxidising agent than permanganate it ended up reacting with the Iron (II) instead of the permanganate. This meant no colour change was observed and even if one was observed it would be after all the nitric acid was reacted giving a wrong result.



$$3Mn + 8HNO_3 \longrightarrow 3Mn^{2+}NO_3{}^{2-} + 2NO + 4H_2O$$

This is the reaction that takes place when manganese is reacted with nitric acid. The manganese is being oxidised in this reaction leaving us with Mn^{2+}

$$Mn(s) \longrightarrow Mn^{2+}(aq) + 2e^-$$

This manganese(II) is then further oxidised by adding potassium periodate to give

$$Mn^{2+} \longrightarrow MnO_4^-$$

As MnO_4^- is a bright pink/purple it is easy to tell when the reaction Is complete.

Data Collection:

Equipment List:

- Burette
- 50 cm^3 standard flask
- 25 cm^3 standard flask
- Measuring cylinder
- Pipette
- Cuvettes
- Colorimeter
- Stoppers
- Accurate scale
- 250 cm^3 Beaker
- Hot plate
- Thermometer
- Clock Glass
- Anti-bumping granules

Chemical list:

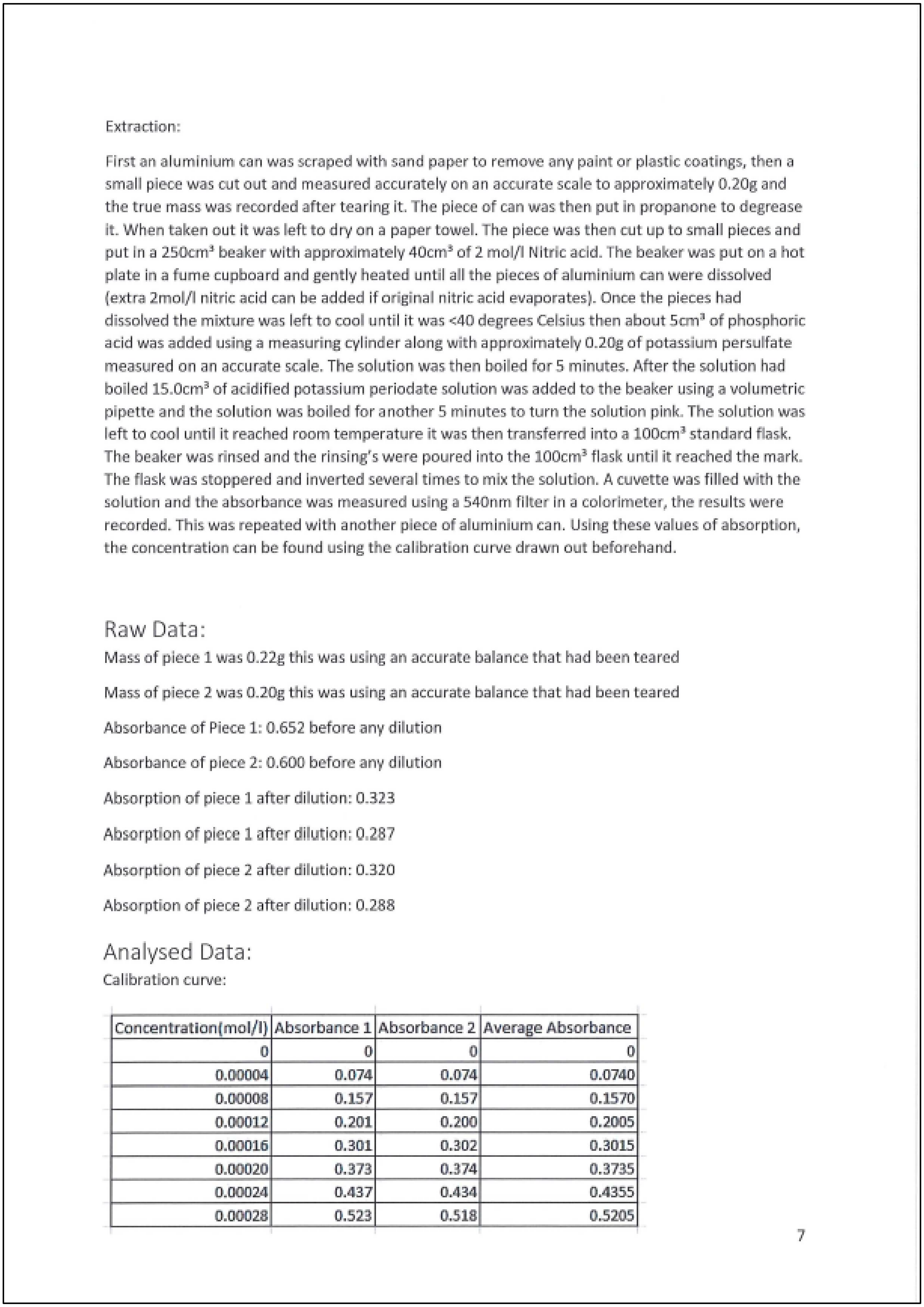
- 0.001 mol l^{-1} potassium permanganate
- 2 mol l^{-1} nitric acid
- Acidified potassium periodate solution
- Potassium persulfate
- Propanone
- Deionised water
- 1 mol l^{-1} sulphuric acid

Safety:

Nitrile gloves were worn along with safety glasses and a lab coat. A risk assessment of all the chemicals being used was completed in case of spillage or accidents.

Procedure calibration curve:

First a burette was rinsed out using 0.001 mol/l acidified potassium permanganate and then filled using the same solution and held on a clamp stand. A 50 cm^3 standard flask was filled using a volumetric pipette with 2.0cm^3 of the permanganate solution then filled to the line using deionised water. The flask was then labelled with its concentration. This was repeated 6 more times using 4.0cm^3, 6.0cm^3, 8.0cm^3, 10.0cm^3, 12.0cm^3 and 14.0cm^3 of permanganate solution each time filling to the line of the 50 cm^3 standard flask with deionised water. All the flasks were stoppered and inverted several times to properly mix the solution. 7 cuvettes were filled with a different concentration of permanganate each with one cuvette filled with water to act as a control. A colorimeter fitted with 540nm filter was used to measure absorbance of each cuvette and results were recorded. A calibration curve was plotted with absorbance over concentration.



Extraction:

First an aluminium can was scraped with sand paper to remove any paint or plastic coatings, then a small piece was cut out and measured accurately on an accurate scale to approximately 0.20g and the true mass was recorded after tearing it. The piece of can was then put in propanone to degrease it. When taken out it was left to dry on a paper towel. The piece was then cut up to small pieces and put in a 250cm^3 beaker with approximately 40cm^3 of 2 mol/l Nitric acid. The beaker was put on a hot plate in a fume cupboard and gently heated until all the pieces of aluminium can were dissolved (extra 2mol/l nitric acid can be added if original nitric acid evaporates). Once the pieces had dissolved the mixture was left to cool until it was <40 degrees Celsius then about 5cm^3 of phosphoric acid was added using a measuring cylinder along with approximately 0.20g of potassium persulfate measured on an accurate scale. The solution was then boiled for 5 minutes. After the solution had boiled 15.0cm^3 of acidified potassium periodate solution was added to the beaker using a volumetric pipette and the solution was boiled for another 5 minutes to turn the solution pink. The solution was left to cool until it reached room temperature it was then transferred into a 100cm^3 standard flask. The beaker was rinsed and the rinsing's were poured into the 100cm^3 flask until it reached the mark. The flask was stoppered and inverted several times to mix the solution. A cuvette was filled with the solution and the absorbance was measured using a 540nm filter in a colorimeter, the results were recorded. This was repeated with another piece of aluminium can. Using these values of absorption, the concentration can be found using the calibration curve drawn out beforehand.

Raw Data:

Mass of piece 1 was 0.22g this was using an accurate balance that had been teared

Mass of piece 2 was 0.20g this was using an accurate balance that had been teared

Absorbance of Piece 1: 0.652 before any dilution

Absorbance of piece 2: 0.600 before any dilution

Absorption of piece 1 after dilution: 0.323

Absorption of piece 1 after dilution: 0.287

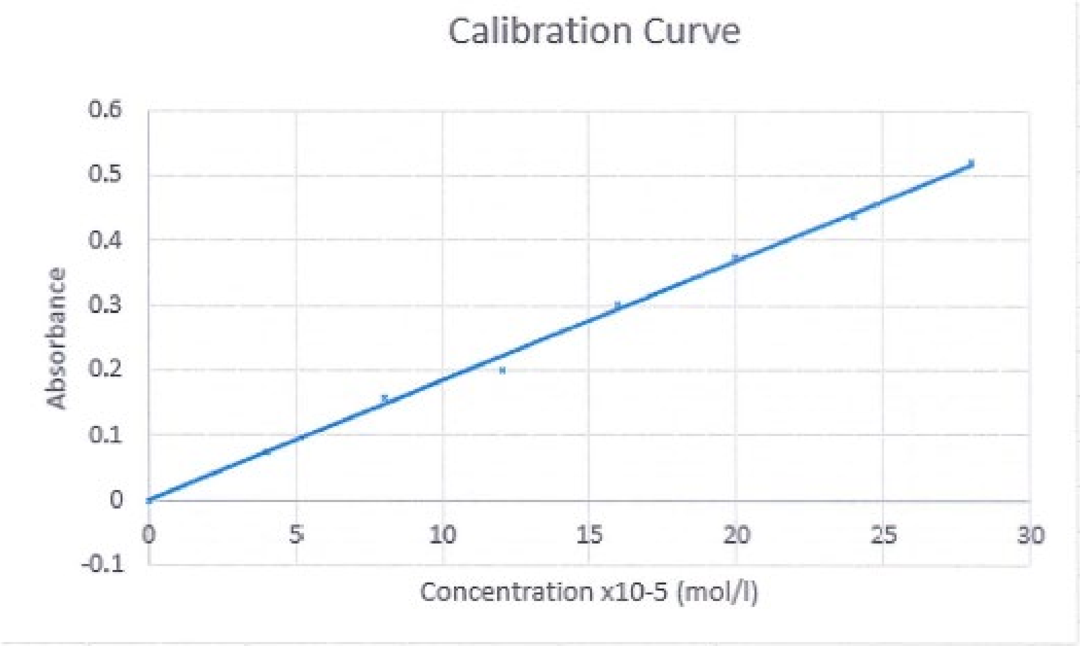
Absorption of piece 2 after dilution: 0.320

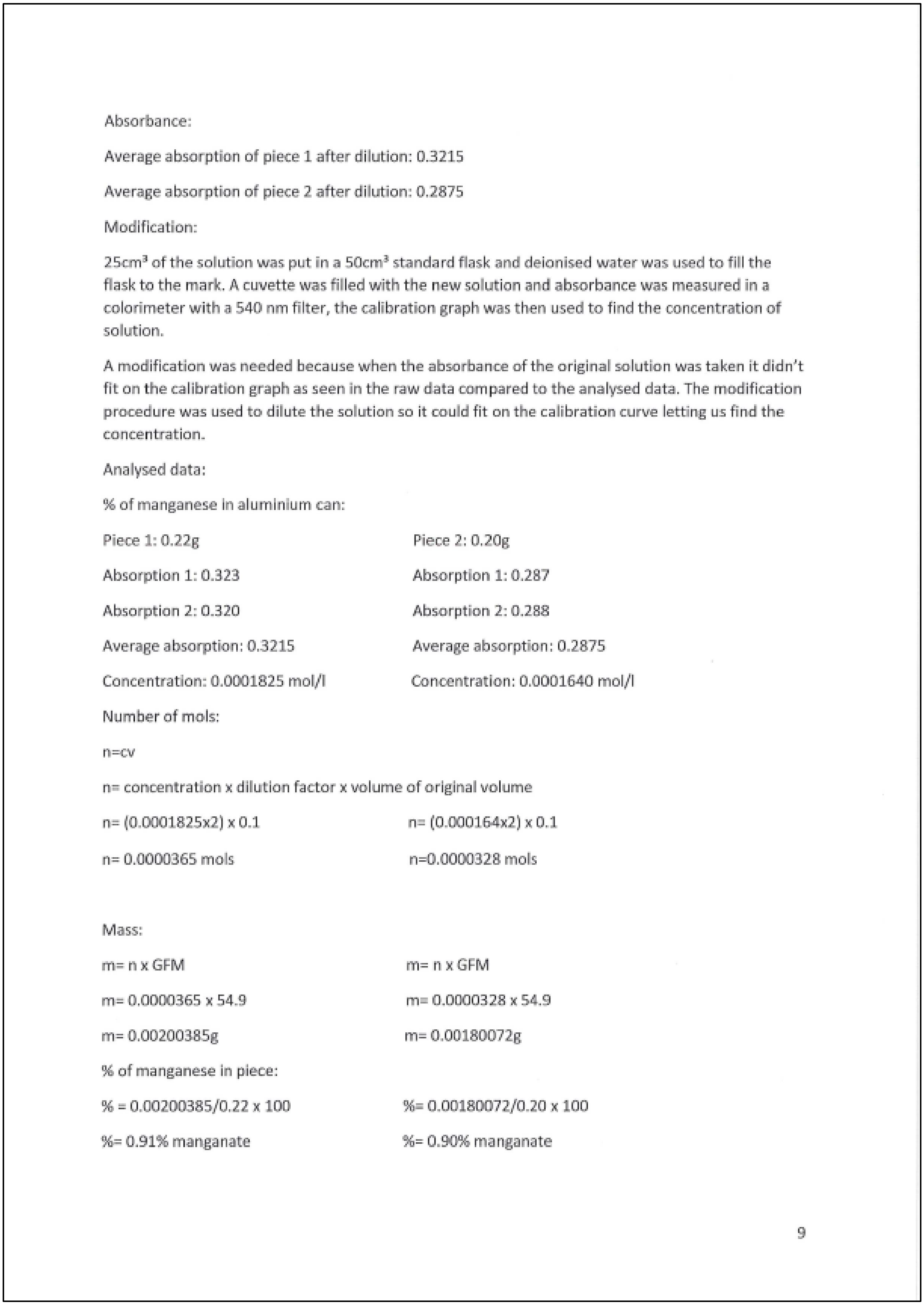
Absorption of piece 2 after dilution: 0.288

Analysed Data:

Calibration curve:

Concentration(mol/l)	Absorbance 1	Absorbance 2	Average Absorbance
0	0	0	0
0.00004	0.074	0.074	0.0740
0.00008	0.157	0.157	0.1570
0.00012	0.201	0.200	0.2005
0.00016	0.301	0.302	0.3015
0.00020	0.373	0.374	0.3735
0.00024	0.437	0.434	0.4355
0.00028	0.523	0.518	0.5205


Calibration Curve
Absorbance
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
0
5
10
15
20
25
30
Concentration x10-5 (mol/l)



Absorbance:

Average absorption of piece 1 after dilution: 0.3215

Average absorption of piece 2 after dilution: 0.2875

Modification:

25cm^3 of the solution was put in a 50cm^3 standard flask and deionised water was used to fill the flask to the mark. A cuvette was filled with the new solution and absorbance was measured in a colorimeter with a 540 nm filter, the calibration graph was then used to find the concentration of solution.

A modification was needed because when the absorbance of the original solution was taken it didn't fit on the calibration graph as seen in the raw data compared to the analysed data. The modification procedure was used to dilute the solution so it could fit on the calibration curve letting us find the concentration.

Analysed data:

% of manganese in aluminium can:

Piece 1: 0.22g	Piece 2: 0.20g
Absorption 1: 0.323	Absorption 1: 0.287
Absorption 2: 0.320	Absorption 2: 0.288
Average absorption: 0.3215	Average absorption: 0.2875
Concentration: 0.0001825 mol/l	Concentration: 0.0001640 mol/l

Number of mols:

n=cv

n= concentration x dilution factor x volume of original volume

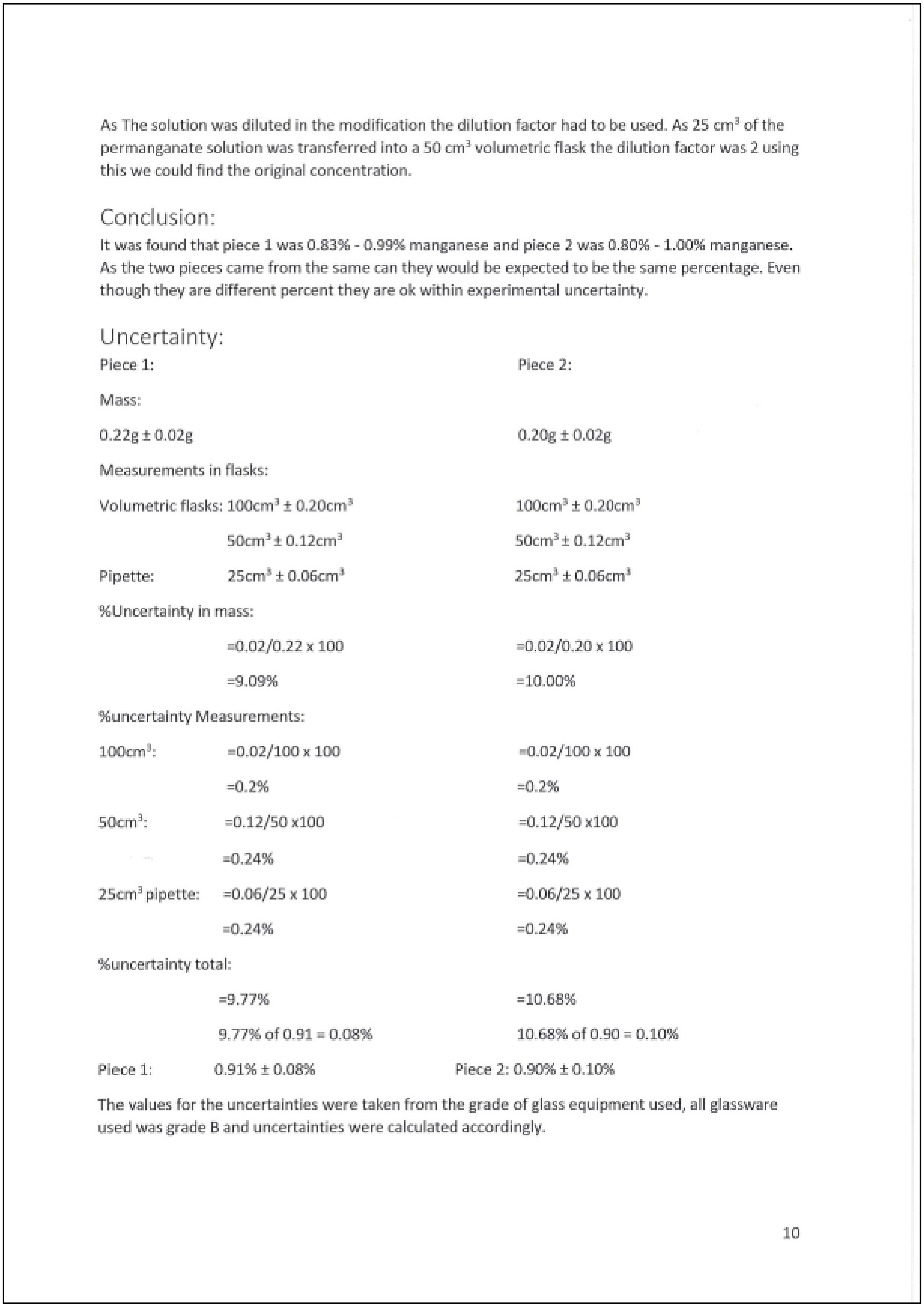
n= (0.0001825x2) x 0.1	n= (0.000164x2) x 0.1
n= 0.0000365 mols	n=0.0000328 mols

Mass:

m= n x GFM	m= n x GFM
m= 0.0000365 x 54.9	m= 0.0000328 x 54.9
m= 0.00200385g	m= 0.00180072g

% of manganese in piece:

% = 0.00200385/0.22 x 100	%= 0.00180072/0.20 x 100
%= 0.91% manganate	%= 0.90% manganate



As The solution was diluted in the modification the dilution factor had to be used. As 25 cm^3 of the permanganate solution was transferred into a 50 cm^3 volumetric flask the dilution factor was 2 using this we could find the original concentration.

Conclusion:

It was found that piece 1 was 0.83% - 0.99% manganese and piece 2 was 0.80% - 1.00% manganese. As the two pieces came from the same can they would be expected to be the same percentage. Even though they are different percent they are ok within experimental uncertainty.

Uncertainty:

	Piece 1:	Piece 2:
Mass:		
	0.22g ± 0.02g	0.20g ± 0.02g
Measurements in flasks:		
Volumetric flasks:	100cm^3 ± 0.20cm^3	100cm^3 ± 0.20cm^3
	50cm^3 ± 0.12cm^3	50cm^3 ± 0.12cm^3
Pipette:	25cm^3 ± 0.06cm^3	25cm^3 ± 0.06cm^3
%Uncertainty in mass:		
	=0.02/0.22 x 100	=0.02/0.20 x 100
	=9.09%	=10.00%
%uncertainty Measurements:		
100cm^3:	=0.02/100 x 100	=0.02/100 x 100
	=0.2%	=0.2%
50cm^3:	=0.12/50 x100	=0.12/50 x100
	=0.24%	=0.24%
25cm^3 pipette:	=0.06/25 x 100	=0.06/25 x 100
	=0.24%	=0.24%
%uncertainty total:		
	=9.77%	=10.68%
	9.77% of 0.91 = 0.08%	10.68% of 0.90 = 0.10%

Piece 1: 0.91% ± 0.08% Piece 2: 0.90% ± 0.10%

The values for the uncertainties were taken from the grade of glass equipment used, all glassware used was grade B and uncertainties were calculated accordingly.

Analysis:

Internet source: (1)

Element	Content (%)
Aluminium / Aluminum , Al	97.8
Manganese, Mn	1.2
Magnesium, Mg	1

The alloy used to make beverage cans is alloy 3004, above is the composition of this alloy. The experimental results disagree with our internet source but not by much.

Evaluation:

Our final percentage of manganese in can did not agree with our internet source. Our findings said that piece 1 was 0.91%±0.08% and piece 2 was 0.90%±0.10% this gave us a range for both percentages with piece 1 having a range of 0.83% - 0.99% and piece 2 having a range of 0.80% - 1.00% these values are very close to our source but not the same. At the start of the experiment the paint coating of the drink can was scraped off before the piece was dissolved, however later on in the experiment it was found that there may have been a layer of plastic coating also on the can, this would make it seem like there was slightly less manganese as the mass of the plastic was counted as the mass of aluminium can. A way to prevent this in future would be to also scrape the inside of the can with sand paper and wash it out with water to make sure there was nothing on the piece.

Another problem that we ran into was Dissolving the pieces of aluminium. It was taking very long to dissolve the pieces that the nitric acid was evaporating before the can would dissolve, a way this could be fixed would be to use a stronger concentration of acid, heat up the mixture more or cut the piece up into smaller bits. The most viable of these options would be to cut the piece up more as a stronger acid could prove to be dangerous if spilt and rising the temperature would evaporate the acid even faster and could also cause spitting so solution could be lost.

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