Appendix 1. Chemical Reactions
Chemical reactions Stoichiometry

$$FeSO_4 + \mathbf{2}FeCl_3 + \mathbf{8}NH_4OH \rightarrow Fe_3O_4 + (NH_4)_2SO_4 + \mathbf{6}NH_4Cl + \mathbf{4}H_2O$$

The product of Fe_3O_4 to get a result of 7 grams. Then the first thing calculate the molar value of Fe_3O_4 :

a. Calculate the mol of Fe_3O_4

$$mol = \frac{m}{Mr}$$

Mr Fe_3O_4 = 232 gram

Therfore, mol of Fe_3O_4 to get 7 grams of product are

$$mol = \frac{7}{232} = \mathbf{0,0320\ mol}$$

b. Calculate the mol of $FeSO_4$

mol $FeSO_4$ = Coefficient value of $FeSO_4$ x mol of Fe_3O_4

mol $FeSO_4$ = 1 x 0,032 = **0,0320 mol**

c. Calculate the mol of $FeCl_3$

mol $FeCl_3$ = Coefficient value of $FeCl_3$ x mol of Fe_3O_4

mol $FeCl_3$ = 2 x 0,032 = **0,064 mol**

d. Calculate the mass of $FeSO_4$ to get 7 grams of Fe_3O_4

$$Massa\ FeSO_4 = mol\ FeSO_4 \text{ x Mr } FeSO_4.7H2O$$

$$Massa\ FeSO_4 = 0{,}0320\ x\ 278 = \mathbf{8,896\ gram}$$

e. Calculate the mass of iron sand (Fe_2O_3) to get 7 grams of Fe_3O_4

Based on the mol of Fe_2O_3 *n*= 0,0320 mol. Then the determination of the mass of the sand is multiplied by the number of mol Fe_2O_3 assuming that the content of Fe_2O_3 are 81,69%. Then the calculation is:

$$Massa\ of\ iron\ sand = mol\ Fe_2O_3 \text{ x Mr } Fe_2O_3$$

$$= (0{,}032x\ 100/81{,}69)\ x\ 160 = \mathbf{6,27\ gram}$$

f. Calculate the mol of $FeCl_3$

$$Fe_2O_3 : FeCl_3 = (0{,}039) : (81{,}69\%\ x\ 0{,}039\ x\ 2)$$

$$\text{mol of } FeCl_3 = \mathbf{0{,}064\ mol}$$

g. Calculate the mol of HCl

Coefficient HCl : Coefficient Fe_2O_3= 6 : 1

$$mol\ HCl = \frac{coef.HCl}{coef.Fe_2O_3} x\ mol\ Fe_2O_3$$

$$mol\ HCl = \frac{6}{1} x\ 0{,}032\ mol = \mathbf{0,192\ mol}$$

h. Calculate the volume of HCl

$$mol = volume\ x\ molaritas$$

$$volume = \frac{mol}{Molaritas}$$

$$volume = \frac{0{,}192}{12{,}063} = 0{,}0159l = \mathbf{15,9\ ml}$$

i. The sedimentation reaction of iron salts in a NH_4OH25% solution

$FeSO_4$ + **2**$FeCl_3$ + **8**NH_4OH → Fe_3O_4 + $(NH_4)_2SO_4$ + **6**NH_4Cl + **4**H_2O

mol of $FeCl_3$ = **0,064 mol**

j. Calculate the mass of iron salt

$$mass\ of\ FeCl_3 = mol\ FeCl_3\ x\ Mr\ FeCl_3$$

$$mass\ of\ FeCl_3 = 0{,}064x\ 162{,}5 \frac{gr}{mol} = \mathbf{10,4\ gram}$$

k. Calculate the mol of NH_4OH

Coefficietnt of NH_4OH : Coefficient of $FeCl_3$ = 8 : 2

$$Mol\ NH_4OH = \frac{coef.NH_4OH}{coef.FeCl_3} x\ mol\ FeCl_3$$

$$mol\ NH_4OH = \frac{8}{2} x 0{,}064 = \mathbf{0,256\ mol}$$

l. Calculate the volume of NH_4OH

$$\text{Volume } NH_4OH = \frac{mol\ NH_4OH}{Molaritas\ NH_4OH}$$

$$\text{Volume } NH_4OH = \frac{0{,}4256}{6{,}64285} = 0{,}038537\ l = \mathbf{38,537\ ml}$$

m. Calculate the mol of NH_4OH

Coefficient of NH_4OH : coefficient of $FeSO_4$ = 8 : 1

$$Mol\ NH_4OH = \frac{coef.\ NH_4OH}{coef.FeSO_4} x\ mol\ FeCl_2$$

$$mol\ NH_4OH = \frac{8}{1} x 0{,}032 = \mathbf{0,256\ mol}$$

Appendix 2. Calculation of lattice parameters
The calculation of the width of the mesh uses the Bragg equation.

$$n\lambda = 2dsin\theta$$

$$d = \frac{n\lambda}{2sin\theta}$$

In determining the value of a lattice parameter for a cubic crystal structure using the following equation.

$$a = d_{hkl}\sqrt{h^2 + k^2 + l^2}$$

Table 1. Calculation of lattice parameters pH 9

$\lambda(\text{Å})$	2θ	θ	$sin\theta$	h	k	l	d_{hkl}	a
1,5406	21,16978	10,58489	0,183692	1	1	1	4,193429626	7,26323317
1,5406	30,10588	15,05294	0,259711	2	2	0	2,96598423	8,389070249
1,5406	35,47378	17,73689	0,304646	3	3	1	2,528505421	11,02149961
1,5406	36,58537	18,29269	0,313871	2	2	2	2,454191092	8,501567326
1,5406	43,13566	21,56783	0,367602	4	0	0	2,095470251	8,381881005
1,5406	53,38174	26,69087	0,449177	4	2	2	1,714915557	8,401336133
1,5406	57,03821	28,51911	0,477452	5	1	1	1,613356671	8,383247176
1,5406	62,62215	31,31108	0,519684	4	4	0	1,482246148	8,384850422
Average lattice parameters								8,590835636

Table 2. Calculation of lattice parameters pH 9

$\lambda(\text{Å})$	2θ	θ	$sin\theta$	h	k	l	d_{hkl}	a
1,5406	30,18307	15,09154	0,260362	2	2	0	2,958575	8,368113
1,5406	35,55026	17,77513	0,305282	3	3	1	2,523241	10,99855
1,5406	43,20692	21,60346	0,368181	4	0	0	2,092179	8,368717
1,5406	53,52965	26,76483	0,450329	4	2	2	1,710525	8,379829
1,5406	57,13702	28,56851	0,478209	5	1	1	1,610801	8,369968
1,5406	62,7346	31,3673	0,520522	4	4	0	1,479859	8,371349
Average lattice parameters								8,809421

Table 3. Calculation of lattice parameters pH 11

$\lambda(\text{Å})$	2θ	θ	$sin\theta$	h	k	l	d_{hkl}	a
1,5406	30,20171	15,10086	0,260519	2	2	0	2,956791	8,363068
1,5406	35,56887	17,78444	0,305437	3	3	1	2,521963	10,99298
1,5406	43,22874	21,61437	0,368358	4	0	0	2,091174	8,364695
1,5406	53,62985	26,81493	0,45111	4	2	2	1,707566	8,365329
1,5406	57,16377	28,58189	0,478414	5	1	1	1,610111	8,366382
1,5406	62,7863	31,39315	0,520908	4	4	0	1,478765	8,365159
Average lattice parameters								8,802936

Appendix 3. Calculation of crystal size
Calculation of crystal size using the Debye-Scherrer equation

$$D = \frac{K\,\lambda}{B\cos\theta}$$

Description:

D = crystal size

K = Scherrer constant (0.9)

λ = X-ray wavelength (0.15406 A)

B = FWHM, width half the peak of the maximum wave (from XRD data analysis using ORIGIN)

θ = Wave angle

Table 1. Calculation of crystal size pH 9

2θ	**FWHM**	**Crystal size (nm)**
21,16978	1,28658	6,281622987
30,10588	0,3888	21,15888226
35,47378	0,34179	24,40317954
36,58537	1,03568	8,078862761
43,13566	0,36138	23,63828135
53,38174	0,63003	14,11324781
57,03821	0,4132	21,88138845
62,62215	0,38045	24,44090914
Average crystal size		17,99954679

Table 2. Calculation of crystal size pH 10

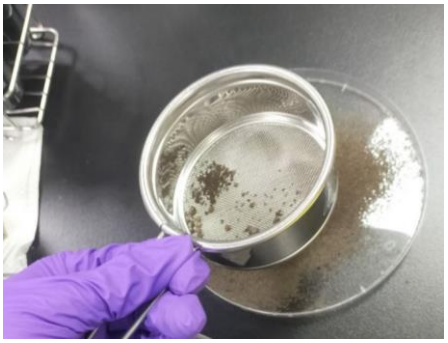
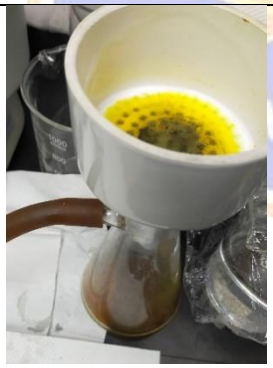
2θ	**FWHM**	**Crystal size (nm)**
30,18307	0,34555	22,19736445
35,55026	0,40577	18,64367621
43,20692	0,44156	16,72759422
53,52965	1,50559	4,711214456
57,13702	0,53386	13,06904342
62,7346	0,53044	12,78790319

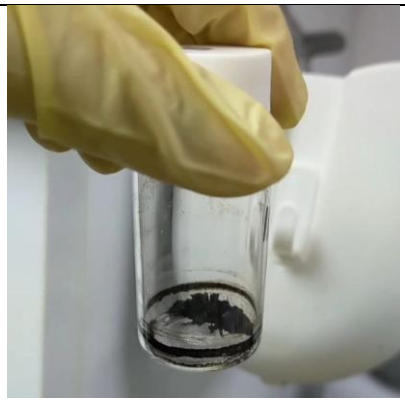
Average crystal size	14,68946599

Table 3. Calculation of crystal size pH 11

2θ	**FWHM**	**Crystal size (nm)**
30,20171	0,52463	15,68425
35,56887	0,556	15,00536
43,22874	0,53856	15,86666
53,62985	0,9272	9,600388
57,16377	0,66634	13,57683
62,7863	0,75178	12,3795
Average crystal size		13,6855

Appendix 4. Research Documentations

Documentation of Experiments in the Laboratory	
	
Filtering Tianyar iron sand	Cleans the iron sand from the sink using ultrasonic waves
	
Extracting iron sand samples using permanent magnets	Weighing the iron sand to synthesize
	
Filters iron sand solutions using paper and vacuum filters	Deposits formed after the synthesis process

	
Magnetite powder after drying in the oven	XRD characterization tool
	
SEM-EDS characterization tool	