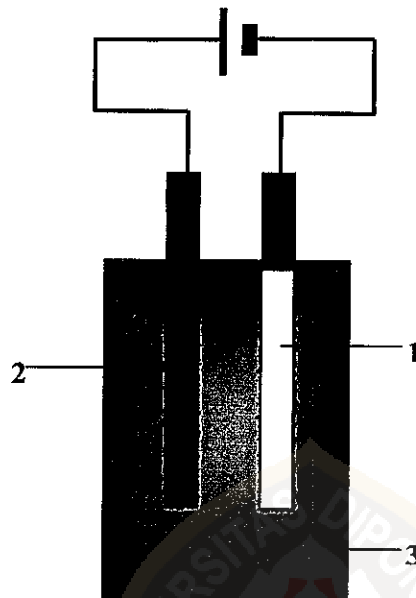


**Lampiran A. Skema sel elektrolisis****Keterangan:**

1. Katode Cu
2. Anode Pb, Cu atau C
3. Larutan Elektrolit  $\text{H}_2\text{Cr}_2\text{O}_7$

**Lampiran B. Difraktogram hasil elektrolisis menggunakan katode tembaga  
dan anode timbal**

\*\*\* Basic Data Process \*\*\*

# Data Information

Group Name : Standard  
Data Name : ayu2  
File Name : ayu2.RAW  
Sample Name : chromium  
Comment :  
Date & Time : 08-31-04 09:59:20

# Measurement Condition

X-ray tube  
target : Cu  
voltage : 40.0 (kV)  
current : 30.0 (mA)  
Slits  
divergence slit : 1.00 (deg)  
scatter slit : 1.00 (deg)  
receiving slit : 0.30 (mm)  
Scanning  
drive axis : Theta-2Theta  
scan range : 5.0000 - 50.0000 (deg)  
scan mode : Continuous Scan  
scan speed : 5.0000 (deg/min)  
sampling pitch : 0.0200 (deg)  
preset time : 0.24 (sec)

# Data Process Condition

Smoothing [ AUTO ]  
smoothing points : 27  
B.G.Subtraction [ AUTO ]  
sampling points : 27  
repeat times : 30  
Kal-a2 Separate [ MANUAL ]  
Kal a2 ratio : 50 (%)  
Peak Search [ AUTO ]  
differential points : 27  
FWHM threshold : 0.050 (deg)  
intensity threshold : 30 (par mil)  
FWHM ratio (n-1)/n : 2  
System error Correction [ NO ]  
Precise peak Correction [ NO ]

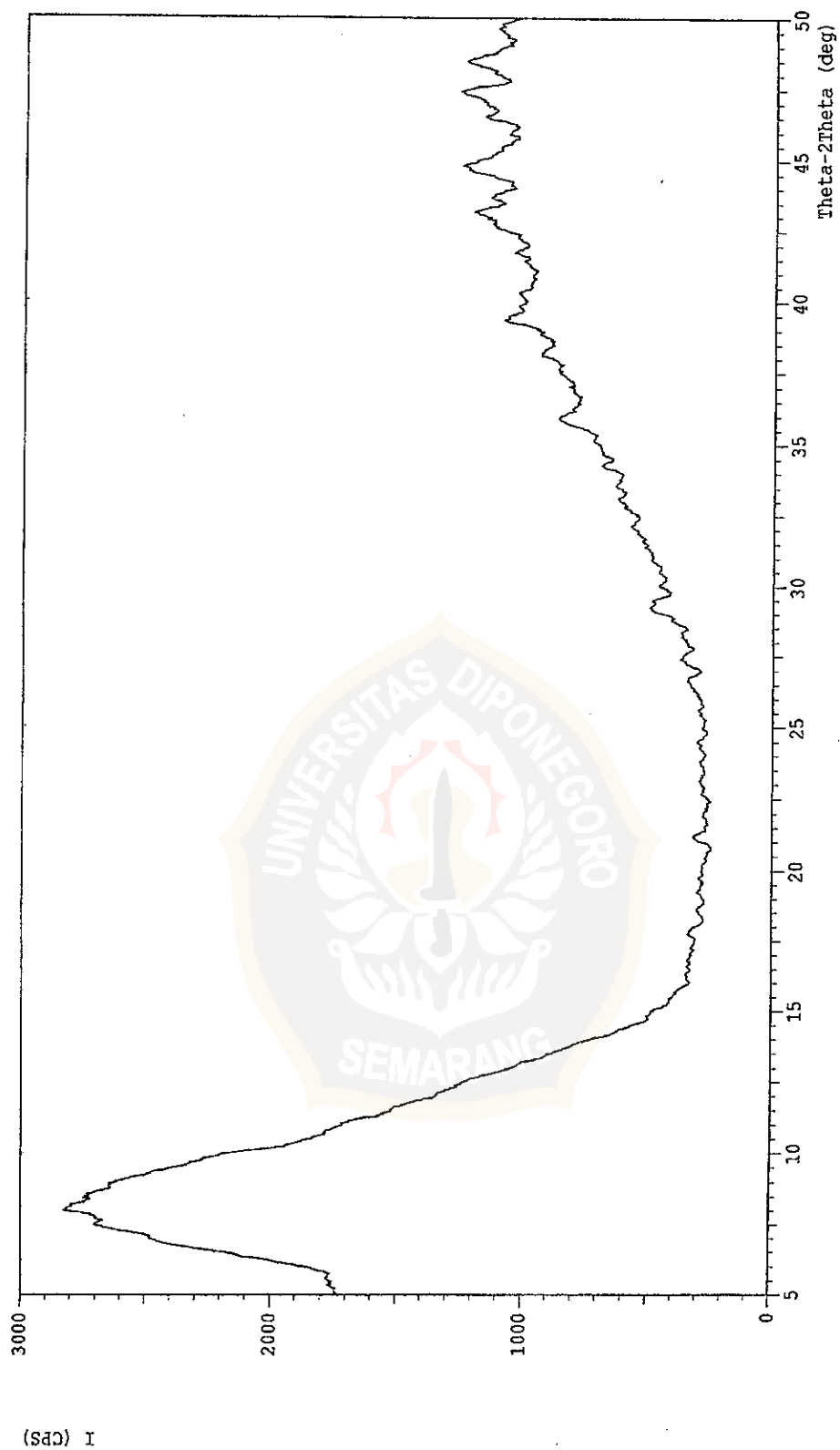
Group Name : Standard  
 Data Name : ayu2  
 File Name : ayu2.PKR  
 Sample Name : chromium  
 Comment : Cu - Pb

# Strongest 3 peaks							
no.	peak no.	2Theta (deg)	d (A)	I/I1	FWHM (deg)	Intensity (Counts)	Integrated Int (Counts)
1	4	8.0200	11.01521	100	0.00000	177	0
2	5	8.5200	10.36987	94	0.00000	167	0
3	6	8.9600	9.86159	90	0.00000	159	0

# Peak Data List							
peak no.	2Theta (deg)	d (A)	I/I1	FWHM (deg)	Intensity (Counts)	Integrated Int (Counts)	
1	5.3400	16.53592	3	0.08000	6	48	
2	6.4600	13.67131	36	0.65340	63	2148	
3	7.5000	11.77772	86	1.86000	152	8817	
4	8.0200	11.01521	100	0.00000	177	0	
5	8.5200	10.36987	94	0.00000	167	0	
6	8.9600	9.86159	90	0.00000	159	0	
7	9.3600	9.44104	77	0.00000	136	0	
8	9.7800	9.03652	65	1.76000	115	7357	
9	11.0200	8.02233	32	0.00000	57	0	
10	11.6600	7.58339	22	0.00000	39	0	
11	12.2200	7.23710	19	0.00000	34	0	
12	12.5800	7.03080	16	0.00000	28	0	
13	13.1800	6.71205	11	0.68000	20	812	
14	13.6000	6.50569	8	0.51000	15	244	
15	13.8800	6.37508	7	0.12000	12	107	
16	15.0200	5.89368	3	0.12000	5	59	
17	17.7900	4.98176	3	0.22000	5	72	
18	19.7350	4.49494	3	0.05000	5	33	
19	21.1666	4.19405	6	0.30670	10	183	
20	22.6650	3.92005	3	0.09000	5	33	
21	23.0400	3.85709	3	0.12000	5	85	
22	24.4950	3.63118	3	0.07000	5	32	
23	26.4700	3.36456	4	0.10000	7	124	
24	27.4066	3.25166	5	0.09330	9	107	
25	29.2783	3.04791	9	0.57670	16	450	
26	30.0125	2.97500	4	0.10500	7	51	
27	30.9000	2.89155	3	0.10000	5	46	
28	32.1133	2.78501	5	0.21330	9	196	
29	32.8075	2.72765	5	0.09500	8	62	
30	33.0450	2.70859	5	0.25000	8	116	
31	34.2500	2.61600	3	0.14000	6	45	
32	35.8650	2.50182	11	0.37000	20	468	
33	37.5100	2.39579	3	0.10000	5	55	
34	38.1450	2.35736	7	0.23000	13	210	
35	38.8633	2.31542	5	0.12670	8	62	
36	39.3800	2.28623	16	0.40000	29	518	
37	39.7400	2.26634	9	0.42000	16	262	
38	40.1700	2.24307	8	0.42000	14	293	
39	41.7400	2.16225	5	0.12000	9	73	
40	42.6000	2.12057	10	0.28000	17	280	
41	43.0950	2.09735	16	0.39000	29	594	
42	43.6700	2.07106	10	0.18000	17	224	
43	44.7400	2.02398	19	0.48000	34	896	
44	45.1400	2.00697	5	0.00000	9	0	
45	46.4950	1.95159	11	0.20000	19	229	

peak no.	2Theta (deg)	d (A)	I/I1	FWHM (deg)	Intensity (Counts)	Integrated Int (Counts)
46	47.0000	1.93179	11	0.24000	19	298
47	47.3500	1.91833	19	0.46000	34	654
48	48.0700	1.89126	7	0.14000	12	105
49	48.4300	1.87804	16	0.36000	29	595
50	48.8400	1.86323	3	0.00000	6	0
51	49.6150	1.83592	6	0.15000	11	172





**Lampiran C. Difraktogram hasil elektrolisis menggunakan katode tembaga  
dan anode tembaga**

\*\*\* Basic Data Process \*\*\*

# Data Infomation

Group Name : Standard  
Data Name : ayu3  
File Name : ayu3.RAW  
Sample Name : crom  
Comment : Cu-Cu  
Date & Time : 09-04-04 11:31:59

# Measurement Condition

X-ray tube  
target : Cu  
voltage : 40.0 (kV)  
current : 30.0 (mA)  
Slits  
divergence slit : 1.00 (deg)  
scatter slit : 1.00 (deg)  
receiving slit : 0.30 (mm)  
Scanning  
drive axis : Theta-2Theta  
scan range : 5.0000 - 90.0000 (deg)  
scan mode : Continuous Scan  
scan speed : 5.0000 (deg/min)  
sampling pitch : 0.0500 (deg)  
preset time : 0.60 (sec)

# Data Process Condition

Smoothing [ AUTO ]  
smoothing points : 11  
B.G.Subtraction [ AUTO ]  
sampling points : 11  
repeat times : 30  
Kal-a2 Separate [ MANUAL ]  
Kal a2 ratio : 50 (%)  
Peak Search [ AUTO ]  
differential points : 11  
FWHM threshold : 0.050 (deg)  
intensity threshold : 30 (par mil)  
FWHM ratio (n-1)/n : 2  
System error Correction [ NO ]  
Precise peak Correction [ NO ]

Group Name : Standard  
 Data Name : ayu3  
 File Name : ayu3.PKR  
 Sample Name : crom  
 Comment : Cu-Cu

## # Strongest 3 peaks

no.	peak no.	2Theta (deg)	d (A)	I/I1	FWHM (deg)	Intensity (Counts)	Integrated Int (Counts)
1	5	8.5000	10.39422	100	0.00000	489	0
2	4	8.0000	11.04270	94	0.00000	462	0
3	3	7.4500	11.85666	83	0.00000	404	0

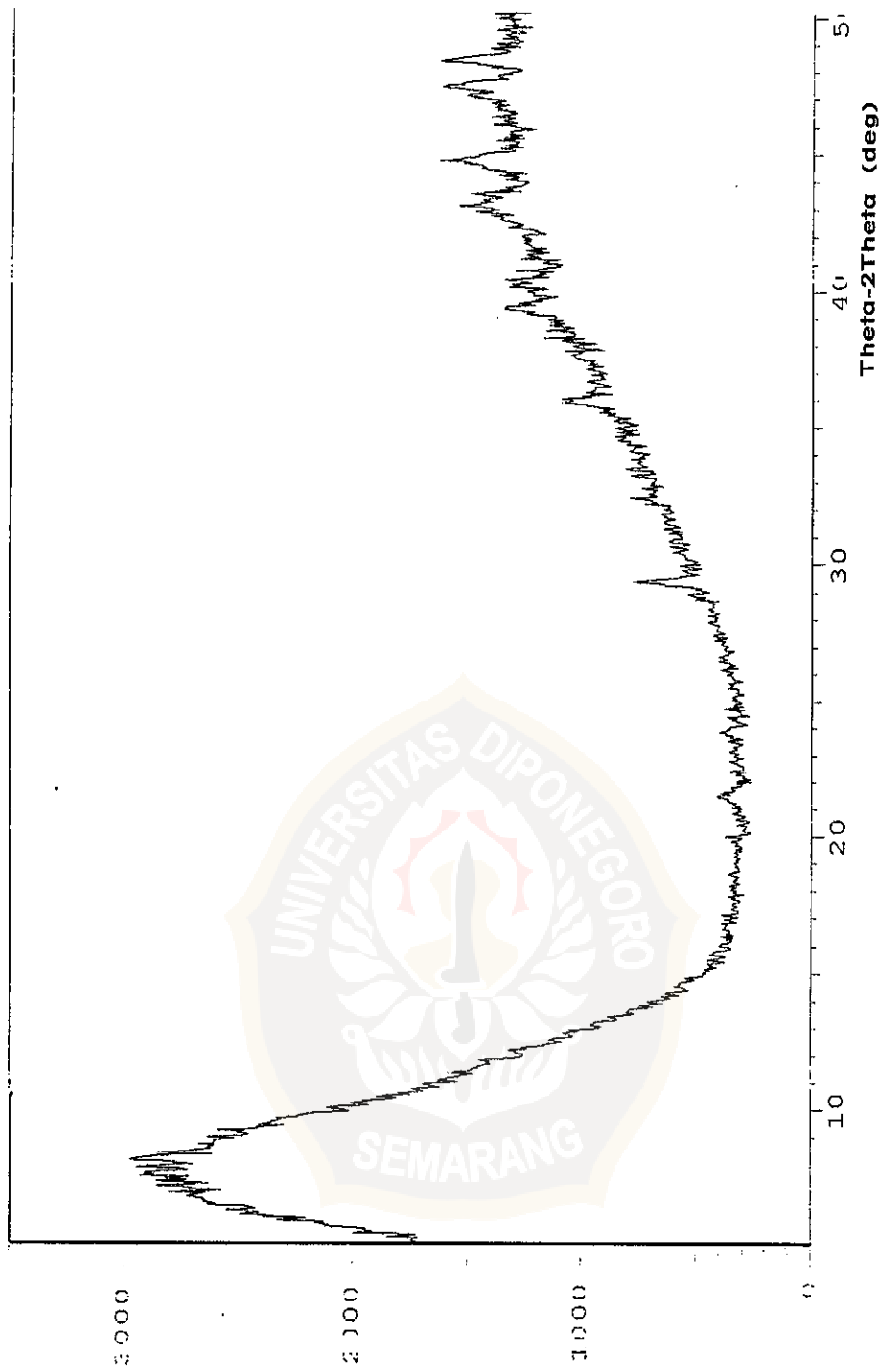
## # Peak Data List

peak no.	2Theta (deg)	d (A)	I/I1	FWHM (deg)	Intensity (Counts)	Integrated Int (Counts)
1	6.5000	13.58727	56	0.96000	273	6403
2	7.0500	12.52845	76	0.00000	373	0
3	7.4500	11.85666	83	0.00000	404	0
4	8.0000	11.04270	94	0.00000	462	0
5	8.5000	10.39422	100	0.00000	489	0
6	9.0500	9.76372	81	0.00000	398	0
7	9.5000	9.30222	72	0.00000	352	0
8	9.8500	8.97245	65	0.00000	317	0
9	10.5000	8.41843	42	0.00000	206	0
10	11.2500	7.85883	27	0.00000	132	0
11	11.8500	7.46223	22	0.00000	108	0
12	12.3500	7.16121	18	0.00000	89	0
13	12.8500	6.88367	11	0.00000	54	0
14	13.3000	6.65176	6	0.00000	29	0
15	13.7500	6.43506	3	0.44000	15	291
16	14.7300	6.00906	3	0.14000	16	55
17	19.8950	4.45916	3	0.16000	15	75
18	21.4966	4.13041	8	0.47330	38	536
19	23.1833	3.83357	3	0.26670	16	146
20	23.8468	3.72839	6	0.33640	30	229
21	26.5822	3.35061	3	0.22440	16	116
22	28.9000	3.08694	4	0.26660	19	156
23	29.4081	3.03475	18	0.30670	90	633
24	32.3897	2.76187	5	0.28710	25	224
25	34.5650	2.59288	5	0.23000	26	160
26	35.4500	2.53015	4	0.31820	18	186
27	35.9734	2.49453	18	0.38030	89	831
28	37.6312	2.38835	7	0.26250	33	209
29	38.3500	2.34523	6	0.42500	28	359
30	38.8000	2.31906	5	0.00000	26	0
31	39.3980	2.28522	21	0.45600	102	1167
32	40.2500	2.23879	17	0.50000	82	842
33	40.7500	2.21247	5	0.16660	25	98
34	41.3330	2.18260	5	0.29390	25	135
35	41.8146	2.15857	7	0.40420	33	246
36	42.5500	2.12295	9	0.52500	42	433
37	43.1000	2.09712	19	1.18000	95	1514
38	44.2500	2.04525	5	0.40000	26	310
39	44.7287	2.02447	24	0.55750	115	1352
40	46.2000	1.96336	6	0.21120	27	180
41	46.7500	1.94154	8	0.44000	40	309
42	47.0500	1.92985	16	0.27340	77	397
43	47.5000	1.91262	26	0.26540	125	956
44	48.4262	1.87818	25	0.37180	124	1037
45	48.9500	1.85930	6	0.27140	29	265

peak no.	2Theta (deg)	d (Å)	I/I1	FWHM (deg)	Intensity (Counts)	Integrated Int (Counts)
46	49.3500	1.84516	3	0.00000	17	0
47	49.5000	1.83992	4	0.00000	18	0
48	50.2000	1.81589	6	0.33760	30	449
49	51.2087	1.78247	4	0.15750	21	106
50	51.8431	1.76214	3	0.32630	17	109
51	52.4000	1.74471	3	0.22500	16	83
52	52.7841	1.73292	9	0.21040	46	244
53	53.8800	1.70023	6	0.21000	28	194
54	54.2000	1.69094	4	0.24540	18	114
55	54.6000	1.67950	5	0.18660	24	107
56	55.0017	1.66818	7	0.28530	33	266
57	55.7950	1.64632	6	0.19000	28	143
58	56.3500	1.63142	8	0.22720	41	167
59	56.7000	1.62217	7	0.52220	33	343
60	57.3712	1.60478	17	0.30370	84	535
61	58.0258	1.58823	7	0.16170	35	198
62	58.7875	1.56945	3	0.17500	16	105
63	59.6131	1.54967	4	0.15960	20	78







(002) 1

Lampiran D. Difraktogram hasil elektrolisis menggunakan katode tembaga  
dan anode karbon

\*\*\* Basic Data Process \*\*\*

```
# Data Information
  Group Name       : Standard
  Data Name        : ayu4
  File Name        : ayu4.RAW
  Sample Name      : crom
  Comment          : Cu-C
  Date & Time      : 09-04-04 11:52:12

# Measurement Condition
  X-ray tube
  target           : Cu
  voltage          : 40.0 (kV)
  current          : 30.0 (mA)
  Slits
  divergence slit  : 1.00 (deg)
  scatter slit     : 1.00 (deg)
  receiving slit   : 0.30 (mm)
  Scanning
  drive axis       : Theta-2Theta
  scan range       : 5.0000 - 90.0000 (deg)
  scan mode        : Continuous Scan
  scan speed       : 5.0000 (deg/min)
  sampling pitch   : 0.0500 (deg)
  preset time      : 0.60 (sec)

# Data Process Condition
  Smoothing        [ AUTO ]
  smoothing points : 11
  B.G.Subtraction  [ AUTO ]
  sampling points  : 11
  repeat times     : 30
  Kal-a2 Separate  [ MANUAL ]
  Kal a2 ratio     : 50 (%)
  Peak Search      [ AUTO ]
  differential points : 11
  FWHM threshold   : 0.050 (deg)
  intensity threshold : 30 (par mil)
  FWHM ratio (n-1)/n : 2
  System error Correction [ NO ]
  Precise peak Correction [ NO ]
```

Group Name : Standard  
 Data Name : ayu4  
 File Name : ayu4.PKR  
 Sample Name : crom  
 Comment : Cu-C

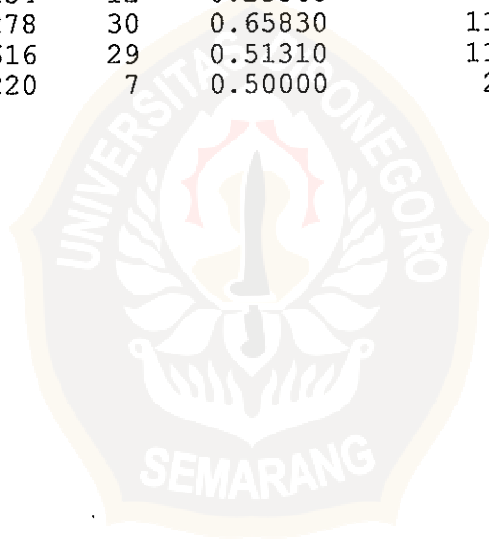
# Strongest 3 peaks

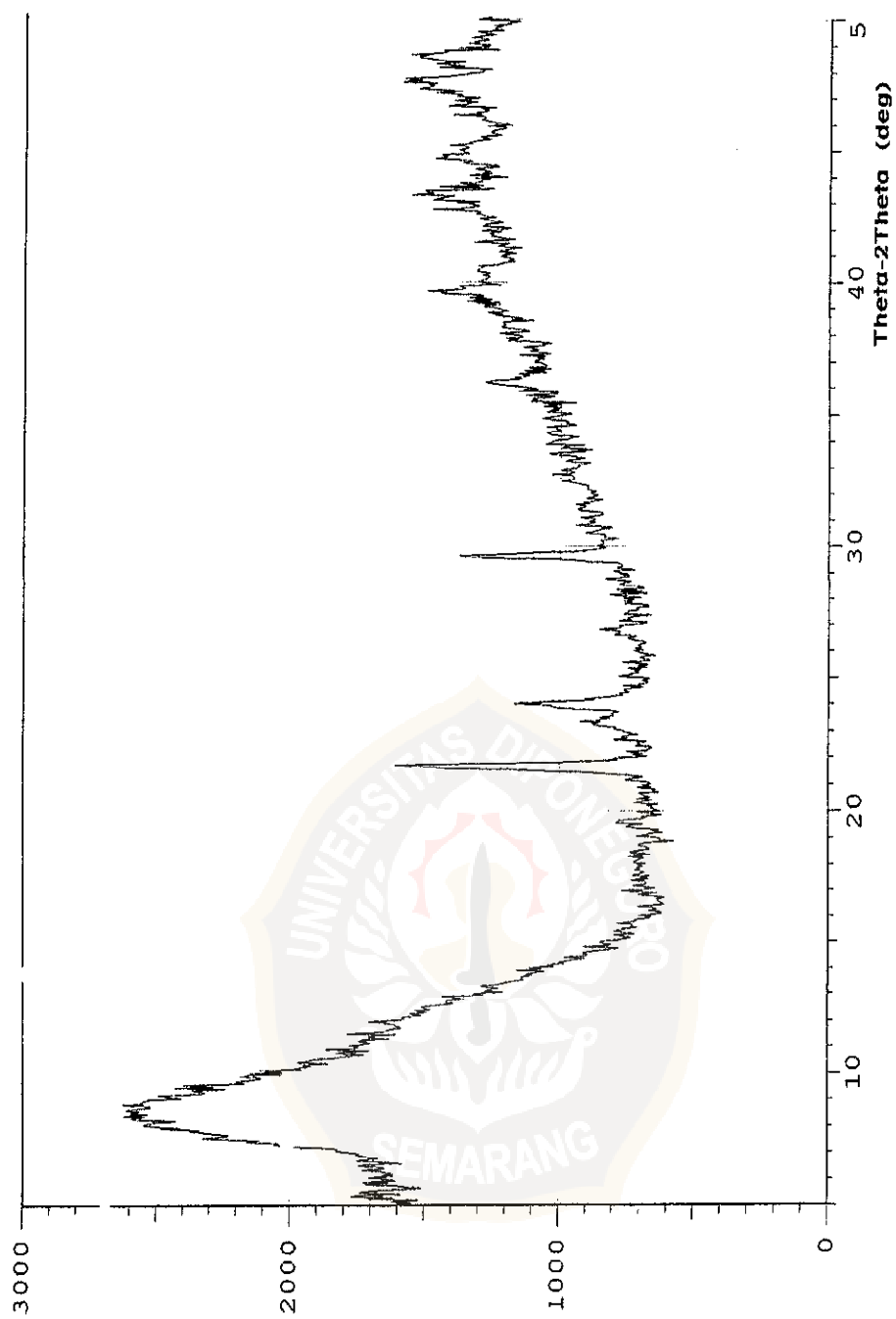
no.	peak no.	2Theta (deg)	d (A)	I/I1	FWHM (deg)	Intensity (Counts)	Integrated Int (Counts)
1	6	8.4500	10.45561	100	0.00000	397	0
2	5	8.1000	10.90660	91	0.00000	360	0
3	7	9.4500	9.35132	78	0.00000	309	0

# Peak Data List

peak no.	2Theta (deg)	d (A)	I/I1	FWHM (deg)	Intensity (Counts)	Integrated Int (Counts)
1	5.3750	16.42833	8	0.21660	32	147
2	5.9260	14.90200	4	0.16210	17	68
3	6.3500	13.90789	5	0.07140	20	39
4	7.3000	12.09995	40	0.45000	157	5458
5	8.1000	10.90660	91	0.00000	360	0
6	8.4500	10.45561	100	0.00000	397	0
7	9.4500	9.35132	78	0.00000	309	0
8	9.9500	8.88250	60	0.00000	239	0
9	10.4000	8.49915	45	0.00000	179	0
10	10.9500	8.07346	35	0.00000	139	0
11	11.4500	7.72200	32	0.00000	127	0
12	11.9500	7.40001	35	0.00000	138	0
13	12.4000	7.13245	28	0.00000	110	0
14	12.8000	6.91045	22	0.00000	88	0
15	13.3000	6.65176	16	0.66660	64	976
16	13.9000	6.36595	10	0.43840	39	385
17	15.7416	5.62510	4	0.28330	14	84
18	16.9500	5.22670	7	0.40900	29	374
19	17.4000	5.09253	6	0.00000	25	0
20	17.7500	4.99289	8	0.00000	30	0
21	18.2500	4.85721	7	0.76660	28	462
22	19.5440	4.53844	11	0.30070	43	270
23	21.1500	4.19731	4	0.32500	14	192
24	21.6394	4.10347	75	0.34810	297	2123
25	22.6500	3.92262	6	0.22860	25	150
26	23.3117	3.81275	19	0.55990	76	869
27	23.9783	3.70824	41	0.42330	162	1413
28	24.5500	3.62317	6	0.20000	25	191
29	25.1281	3.54111	5	0.29380	21	173
30	26.7208	3.33354	11	0.34170	42	385
31	27.9625	3.18827	5	0.07500	13	35
32	28.6719	3.11098	4	0.14380	15	56
33	29.6010	3.01541	50	0.32290	199	1403
34	30.4875	2.92972	6	0.22500	23	141
35	30.9068	2.89092	7	0.25640	29	168
36	31.4835	2.83927	8	0.25290	32	217
37	32.6416	2.74113	8	0.61670	31	357
38	33.4130	2.67959	5	0.14900	19	64
39	33.9097	2.64147	6	0.17290	25	115
40	34.3583	2.60800	6	0.21670	25	150
41	35.5732	2.52167	7	0.29640	27	177
42	36.1792	2.48081	20	0.39490	81	765
43	37.9216	2.37073	10	0.19020	39	157
44	38.2824	2.34921	10	0.38140	38	256
45	38.9000	2.31332	11	0.53340	44	468

peak no.	2Theta (deg)	d (Å)	I/I1	FWHM (deg)	Intensity (Counts)	Integrated Int (Counts)
46	39.1500	2.29913	14	0.00000	54	0
47	39.5982	2.27413	29	0.47350	114	1255
48	40.4000	2.23083	13	0.43760	53	620
49	41.5000	2.17420	4	0.35000	15	228
50	41.9000	2.15437	4	0.00000	16	0
51	42.2000	2.13974	5	0.00000	20	0
52	42.7000	2.11584	15	0.36260	60	557
53	43.2626	2.08962	30	0.48530	120	1062
54	43.7500	2.06746	12	0.15620	46	215
55	44.1000	2.05186	4	0.00000	17	0
56	44.6500	2.02785	20	0.19040	81	409
57	45.1500	2.00655	14	0.43340	54	706
58	46.3000	1.95935	9	0.26260	34	167
59	46.7500	1.94154	12	0.25560	46	284
60	47.4958	1.91278	30	0.65830	118	1565
61	48.4815	1.87616	29	0.51310	116	1149
62	49.1500	1.85220	7	0.50000	26	293





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**Lampiran E. Perbandingan Harga d**

**Tabel 1. Perbandingan Harga d**

d (Å)	h k l	Cu-Pb		Cu-Cu		Cu-C	
		2θ (°)	d (Å)	2θ (°)	d (Å)	2θ (°)	d (Å)
1,83	2 0 0	49,61	1,83	49,50	1,83	-	-
1,87	2 1 1	48,43	1,87	48,42	1,87	48,48	1,87
2,02	1 1 0	44,74	2,02	44,72	2,02	44,65	2,02
2,07	1 1 1	43,67	2,07	-	-	43,75	2,06
2,31	2 0 0	38,86	2,31	38,80	2,31	39,15	2,29



**Lampiran F. Penampakan lapisan krom pada katode  
dengan variasi kuat arus dan anode.**

**Tabel 2. Penampakan lapisan krom pada katode dengan variasi kuat arus dan anode.**

No	Kuat Arus (A)	Cu-Pb	Cu-Cu	Cu-C
1	0,2	Putih mengkilap, melekat kuat	Putih mengkilap, melekat kuat	Putih mengkilap, melekat kuat
2	0,4	Putih mengkilap, melekat kuat	Putih mengkilap, melekat kuat	Putih mengkilap, melekat kuat
3	0,6	Putih mengkilap, melekat kuat	Putih mengkilap, melekat kuat	Putih mengkilap, melekat kuat
4	0,8	Putih mengkilap, melekat kuat	Putih mengkilap, melekat kuat	Putih mengkilap, melekat kuat
5	1,0	Putih mengkilap, melekat kuat	Putih mengkilap, melekat kuat	Putih mengkilap, melekat kuat



**Lampiran G. Berat endapan krom hasil elektrolisis menggunakan katode tembaga dan anode timbal.**

Tabel 3. Berat endapan krom hasil elektrolisis menggunakan katode tembaga dan anode timbal

Arus (A)	$W_{\text{calc}}$ (gram)	$W_{\text{obs}}$ (gram)	$\eta$ (%)
0,2	0,06466	0,0009	1,3900
0,4	0,12932	0,005	3,8660
0,6	0,19398	0,0141	7,2680
0,8	0,25864	0,0218	8,4287
1,0	0,3233	0,0259	8,0100





**Lampiran H. Berat endapan krom hasil elektrolisis menggunakan katode tembaga dan anode tembaga.**

Tabel 4. Berat endapan krom hasil elektrolisis menggunakan katode tembaga dan anode tembaga

Arus (A)	$W_{\text{calc}}$ (gram)	$W_{\text{obs}}$ (gram)	$\eta$ (%)
0,2	0,06466	0,0008	1,2372
0,4	0,12932	0,0030	2,3198
0,6	0,19398	0,0167	8,6090
0,8	0,25864	0,0137	5,2969
1,0	0,3233	0,0284	8,7840



**Lampiran I. Berat endapan krom hasil elektrolisis menggunakan katode tembaga dan anode karbon**

Tabel 5. Berat endapan krom hasil elektrolisis menggunakan katode tembaga dan anode karbon

Arus (A)	$W_{\text{calc}}$ (gram)	$W_{\text{obs}}$ (gram)	$\eta$ (%)
0,2	0,06466	0,0009	1,3900
0,4	0,12932	0,0064	4,9490
0,6	0,19398	0,0121	6,2377
0,8	0,25864	0,0226	8,7380
1,0	0,3233	0,0359	11,1042



**Lampiran J. Perhitungan berat endapan krom hasil elektrolisis.**

Cara perhitungan:

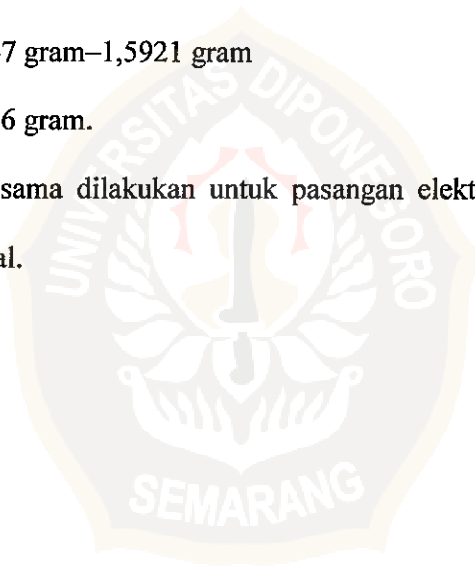
$$\begin{aligned}W_{\text{obs}} &= \text{berat endapan krom} \\ &= (\text{berat katode setelah dielektrolisis}) - (\text{berat katode awal}) \\ &= W_{C_2} - W_{C_1}\end{aligned}$$

Contoh perhitungan:

Berat katode setelah dielektrolisis dengan pasangan elektrode tembaga–karbon pada arus 0,8 A,  $W_{C_2}$  adalah 1,6147 gram dan berat katode awal,  $W_{C_1}$  adalah 1,5921 gram. Maka berat endapan krom yang diperoleh adalah:

$$\begin{aligned}W_{\text{obs}} &= W_{C_2} - W_{C_1} \\ &= 1,6147 \text{ gram} - 1,5921 \text{ gram} \\ &= 0,0226 \text{ gram.}\end{aligned}$$

Perhitungan yang sama dilakukan untuk pasangan elektrode tembaga–tembaga dan tembaga–timbal.



### Lampiran K. Perhitungan berat endapan krom secara teoritis

Cara perhitungan:

$$\begin{aligned}W_{\text{calc}} &= \text{berat teoritis} \\ &= e i t\end{aligned}$$

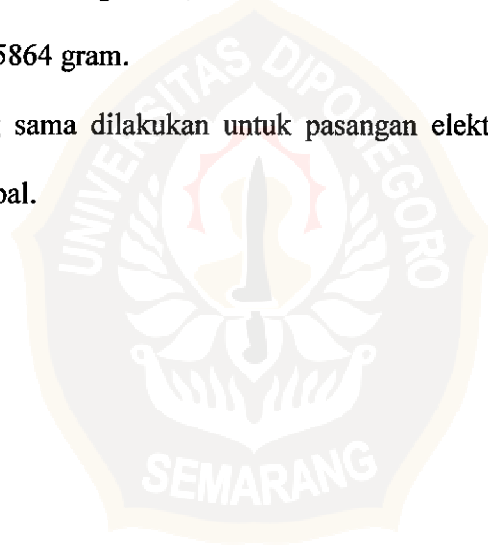
Contoh perhitungan:

Untuk Cr, besar nilai  $e$  adalah  $8,98 \times 10^{-5} \text{ g/C}$  dan  $t$  selama 1 jam adalah 3600 s.

Maka berat teoritis untuk endapan krom hasil elektrolisis dengan pasangan elektrode tembaga–karbon pada arus 0,8 A adalah:

$$\begin{aligned}W_{\text{calc}} &= e i t \\ &= 8,98 \times 10^{-5} \text{ g/C} \times 0,8 \text{ A} \times 3600 \text{ s} \\ &= 0,25864 \text{ gram.}\end{aligned}$$

Perhitungan yang sama dilakukan untuk pasangan elektrode tembaga–tembaga dan tembaga–timbal.



**Lampiran L. Perhitungan efisiensi elektrolisis.**

Cara perhitungan:

$$\begin{aligned}\eta &= \text{efisiensi elektrolisis} \\ &= \frac{W_{obs}}{W_{calc}} \times 100\%\end{aligned}$$

Contoh perhitungan:

Berat endapan krom hasil elektrolisis pasangan elektrode tembaga–karbon pada arus 0,8 A,  $W_{obs}$  adalah 0,0226 gram, Berat teoritis,  $W_{calc}$  adalah 0,25864 gram, maka efisiensi elektrolisis,  $\eta$  adalah:

$$\begin{aligned}\eta &= \text{efisiensi elektrolisis} \\ &= \frac{W_{obs}}{W_{calc}} \times 100\% \\ &= \frac{0,0226}{0,25864} \times 100\% \\ &= 8,7380\%\end{aligned}$$

Perhitungan yang sama dilakukan untuk pasangan elektrode tembaga–tembaga dan tembaga–timbal.

