LEACHING OF COPPER FROM MATTE - LEACHES 3 AND 6

PREDICTED VS. MEASURED EXTRACTIONS
****

COMPONENT 1

TIME	POTL	MEAS	CALC
6.	486.	.2590	.2291
15.	486.	.3160	.3087
30.	484.	.3670	.3590
60.	483.	.4200	.4207
120.	479.	.4860	.4973
180.	478.	.5250	.5480
240.	476.	.5600	.5855
360.	473.	.6300	.6385
6.	582.	.4480	.4674
15.	573.	.5620	.5880
30.	564.	.6560	.6688
60.	558.	.7320	.7510
120.	550.	.8360	.8267
180.	547.	.8980	.8660
240.	546.	.9190	.8924
300.	544.	.9600	.9119
360.	544.	.9600	.9267
420.	543.	.9670	.9384

SUM OF SQUARED ERRORS = 1.0E-02

RATE CONSTANT VALUES :
****

	1'ST CONSTANT	2'ND CONSTANT
ALLOY	: 2.048E-08	.00000
TROILITE	: 1.030E-15	.02700
CU,FE-S	: 5.575E-08	.00000

LEACHING OF COPPER FROM MATTE - LEACH 7 - REDOX POTENTIAL

PREDICTED VS. MEASURED EXTRACTIONS
****

COMPONENT 1

TIME	POTL	MEAS	CALC
6.	587.	.4360	.4374
16.	576.	.5360	.5339
30.	568.	.6040	.6018
60.	560.	.6700	.6756
120.	556.	.7490	.7504
182.	552.	.8000	.7945
240.	552.	.8150	.8235
300.	548.	.8440	.8460
360.	547.	.8650	.8636
420.	546.	.8870	.8782

SUM OF SQUARED ERRORS = 2.3E-04

RATE CONSTANT VALUES :
****

	1'ST CONSTANT	2'ND CONSTANT
ALLOY	: 3.241E-08	.00000
TROILITE	: 5.466E-16	.02700
CU,FE-S	: 1.756E-07	.00000

LEACHING OF COPPER FROM MATTE - LEACH 7 -MATTE POTENTIAL

PREDICTED VS. MEASURED EXTRACTIONS
****

COMPONENT 1

TIME	POTL	MEAS	CALC
6.	447.	.4360	.3848
16.	450.	.5360	.4643
30.	454.	.6040	.5434
60.	457.	.6700	.6461
120.	471.	.7490	.7546
182.	466.	.8000	.8159
240.	455.	.8150	.8535
300.	446.	.8440	.8821
360.	436.	.8650	.9041
420.	434.	.8870	.9214

SUM.OF SQUARED ERRORS = 1.8E-02

RATE CONSTANT VALUES :
****

	1'ST CONSTANT	2'ND CONSTANT
ALLOY	: 3.988E-08	.00000
TROILITE	: 2.654E-09	.00000
CU,FE-S	: 4.545E-06	.00000

LEACHING OF COPPER FROM MATTE - LEACH 8 - REDOX POTENTIAL

PREDICTED VS. MEASURED EXTRACTIONS
****

COMPONENT 1

TIME	POTL	MEAS	CALC
6.	579.	.3870	.3791
15.	571.	.4780	.4758
30.	563.	.5560	.5577
60.	556.	.6190	.6414
120.	550.	.6990	.7233
180.	546.	.7540	.7693
240.	544.	.7990	.8003
360.	540.	.8750	.8418
420.	538.	.8910	.8567

SUM OF SQUARED ERRORS = 3.7E-03

RATE CONSTANT VALUES :
****

	1'ST CONSTANT	2'ND CONSTANT
ALLOY	: 3.089E-08	.00000
TROILITE	: 5.555E-16	.02700
CU,FE-S	: 1.079E-07	.00000

LEACHING OF COPPER FROM MATTE - LEACH 8 - MATTE POTENTIAL

PREDICTED VS. MEASURED EXTRACTIONS
****

COMPONENT 1

TIME	POTL	MEAS	CALC
6.	497.	.3870	.3816
15.	496.	.4780	.4510
30.	493.	.5560	.5333
60.	487.	.6190	.6300
120.	475.	.6990	.7271
180.	463.	.7540	.7790
240.	454.	.7990	.8117
360.	441.	.8750	.8530
420.	438.	.8910	.8677

SUM OF SQUARED ERRORS = 4.0E-03

RATE CONSTANT VALUES :
****

	1'ST CONSTANT	2'ND CONSTANT
ALLOY	: 3.341E-08	.00000
TROILITE	: 6.479E-12	.01200
CU,FE-S	: 5.701E-06	.00000

LEACHING OF COPPER FROM MATTE - LEACH 8 - RESIDUE POTENTIAL

PREDICTED VS. MEASURED EXTRACTIONS
****

COMPONENT 1

TIME	POTL	MEAS	CALC
6.	498.	.3870	.3897
15.	493.	.4780	.4655
30.	478.	.5560	.5482
60.	455.	.6190	.6358
120.	436.	.6990	.7222
180.	424.	.7540	.7711
240.	417.	.7990	.8036
360.	409.	.8750	.8474
420.	407.	.8910	.8634

SUM OF SQUARED ERRORS = 2.9E-03

RATE CONSTANT VALUES :
****

		1'ST CONSTANT	2'ND CONSTANT
ALLOY	:	3.211E-08	.00000
TROILITE	:	3.353E-11	.00900
CU,FE-S	:	5.701E-06	.00000

LEACHING OF COPPER FROM MATTE - LEACH 9

PREDICTED VS. MEASURED EXTRACTIONS
****

COMPONENT 1

TIME	POTL	MEAS	CALC
12.	593.	.2310	.1955
30.	581.	.2620	.2509
63.	571.	.3000	.3072
122.	566.	.3550	.3676
180.	563.	.4020	.4078
240.	561.	.4330	.4385
307.	560.	.4580	.4650
368.	559.	.4810	.4845

SUM OF SQUARED ERRORS = 1.7E-03

RATE CONSTANT VALUES :
****

	1'ST CONSTANT	2'ND CONSTANT
ALLOY	: 2.655E-09	.00000
TROILITE	: 4.112E-17	.03020
CU,FE-S	: 1.189E-13	.00000

LEACHING OF COPPER FROM MATTE - LEACH 10

PREDICTED VS. MEASURED EXTRACTIONS
****

COMPONENT 1

TIME	POTL	MEAS	CALC
6.	640.	.1330	.0745
15.	620.	.1460	.1090
31.	600.	.1610	.1378
61.	580.	.1870	.1632
119.	571.	.2000	.1910
173.	566.	.2070	.2097
242.	565.	.2170	.2296
305.	563.	.2120	.2454
380.	562.	.2140	.2618

SUM OF SQUARED ERRORS = 9.5E-03

RATE CONSTANT VALUES :
****

	1'ST CONSTANT	2'ND CONSTANT
ALLOY	: 1.920E-10	.00000
TROILITE	: 1.547E-18	.03290
CU,FE-S	: 1.695E-18	.00000

LEACHING OF COPPER FROM MATTE - LEACH 11

PREDICTED VS. MEASURED EXTRACTIONS
****

COMPONENT 1

TIME	POTL	MEAS	CALC
15.	598.	.1650	.1214
30.	576.	.1750	.1561
60.	555.	.2030	.1864
120.	540.	.2230	.2162
180.	535.	.2400	.2358
240.	532.	.2490	.2517
300.	531.	.2580	.2655
362.	530.	.2530	.2785
440.	529.	.2600	.2932

SUM OF SQUARED ERRORS = 4.4E-03

RATE CONSTANT VALUES :
****

	1'ST CONSTANT	2'ND CONSTANT
ALLOY	: 2.323E-10	.00000
TROILITE	: 5.394E-18	.03260
CU,FE-S	: 6.466E-18	.00000

LEACHING OF COBALT FROM MATTE - LEACHES 3, 5 AND 6

PREDICTED VS. MEASURED EXTRACTIONS
****

COMPONENT 1

TIME	POTL	MEAS	CALC
6.	486.	.1180	.1082
15.	486.	.2380	.2206
30.	484.	.3430	.3437
60.	483.	.4720	.4832
120.	479.	.5770	.6075
180.	478.	.6490	.6668
240.	476.	.6970	.7037
360.	473.	.7620	.7482
6.	517.	.1520	.1226
15.	516.	.2550	.2526
30.	514.	.3980	.3965
60.	511.	.5420	.5560
129.	506.	.6930	.6982
180.	505.	.7410	.7451
240.	504.	.7890	.7799
300.	503.	.8130	.8030
360.	503.	.8370	.8202
420.	502.	.8610	.8338
6.	582.	.2680	.2962
15.	573.	.4410	.4420
30.	564.	.5940	.5822
60.	558.	.7190	.7215
120.	550.	.8290	.8241
180.	547.	.8800	.8635
240.	546.	.8660	.8842
300.	544.	.8880	.8963
360.	544.	.9320	.9040
420.	543.	.9460	.9094

SUM OF SQUARED ERRORS = 8.1E-03

RATE CONSTANT VALUES :
****

	1'ST CONSTANT	2'ND CONSTANT
ALLOY :	1.951E-08	.00000
TROILITE :	7.551E-16	.02350

LEACHING OF COBALT FROM MATTE - LEACH 7 -REDOX POTENTIAL

PREDICTED VS. MEASURED EXTRACTIONS
****

COMPONENT 1

TIME	POTL	MEAS	CALC
6.	587.	.2360	.2268
16.	576.	.4080	.4042
30.	568.	.5260	.5303
60.	560.	.6270	.6440
120.	556.	.7140	.7268
182.	552.	.7610	.7661
240.	552.	.7850	.7904
300.	548.	.8160	.8089
360.	547.	.8320	.8232
420.	546.	.8630	.8349

SUM OF SQUARED ERRORS = 1.5E-03

RATE CONSTANT VALUES :
****

	1'ST CONSTANT	2'ND CONSTANT
ALLOY	: 3.803E-08	.00000
TROILITE	: 2.380E-16	.02350

LEACHING OF COBALT FROM MATTE - LEACH 7 -MATTE POTENTIAL

PREDICTED VS. MEASURED EXTRACTIONS
****

COMPONENT 1

TIME	POTL	MEAS	CALC
6.	447.	.2360	.2373
16.	450.	.4080	.4101
30.	454.	.5260	.5206
60.	457.	.6270	.6259
120.	471.	.7140	.7150
182.	466.	.7610	.7635
240.	455.	.7850	.7940
300.	446.	.8160	.8170
360.	436.	.8320	.8347
420.	434.	.8630	.8488

SUM OF SQUARED ERRORS = 3.4E-04

RATE CONSTANT VALUES :
****

	1'ST CONSTANT	2'ND CONSTANT
ALLOY :	5.914E-08	.00000
TROILITE :	1.300E-10	.00000

LEACHING OF COBALT FROM MATTE - LEACH 8 -REDOX POTENTIAL

PREDICTED VS. MEASURED EXTRACTIONS
****

COMPONENT 1

TIME	POTL	MEAS	CALC
6.	579.	.2950	.2639
15.	571.	.4280	.4348
30.	563.	.5400	.5650
60.	556.	.6450	.[illegible]640
120.	550.	.7220	.[illegible]65
180.	546.	.7790	.7719
240.	544.	.8000	.7960
300.	543.	.8070	.8140
360.	540.	.8490	.8280
420.	538.	.8700	.8392

SUM OF SQUARED ERRORS = 3.7E-03

RATE CONSTANT VALUES :
****

	1'ST CONSTANT	2'ND CONSTANT
ALLOY	: 5.069E-08	.00000
TROILITE	: 2.876E-16	.02350

LEACHING OF COBALT FROM MATTE - LEACH 8 -REDOX POTENTIAL

PREDICTED VS. MEASURED EXTRACTIONS
****

COMPONENT 1

TIME	POTL	MEAS	CALC
6.	579.	.2950	.2639
15.	571.	.4280	.4348
30.	563.	.5400	.5650
60.	556.	.6450	.6640
120.	550.	.7220	.7365
180.	546.	.7790	.7719
240.	544.	.8000	.7960
300.	543.	.8070	.8140
360.	540.	.8490	.8280
420.	538.	.8700	.8392

SUM OF SQUARED ERRORS = 3.7E-03

RATE CONSTANT VALUES :
****

	1'ST CONSTANT	2'ND CONSTANT
ALLOY :	5.069E-08	.00000
TROILITE :	2.876E-16	.02350

LEACHING OF COBALT FROM MATTE - LEACH 8 - MATTE POTENTIAL

PREDICTED VS. MEASURED EXTRACTIONS
****

COMPONENT 1

TIME	POTL	MEAS	CALC
6.	497.	.2950	.2828
15.	496.	.4280	.4409
30.	493.	.5400	.5473
60.	487.	.6450	.6406
120.	475.	.7220	.7242
180.	463.	.7790	.7710
240.	454.	.8000	.8021
300.	450.	.8070	.8246
360.	441.	.8490	.8419
420.	438.	.8700	.8555

SUM OF SQUARED ERRORS = 1.0E-03

RATE CONSTANT VALUES :
****

	1'ST CONSTANT	2'ND CONSTANT
ALLOY :	8.140E-08	.00000
TROILITE :	1.405E-10	.00000

LEACHING OF COBALT FROM MATTE - LEACH 8 - RESIDUE POTENTIAL

PREDICTED VS. MEASURED EXTRACTIONS
****

COMPONENT 1

TIME	POTL	MEAS	CALC
6.	498.	.2950	.2828
15.	493.	.4280	.4409
30.	478.	.5400	.5473
60.	455.	.6450	.6406
120.	436.	.7220	.7242
180.	424.	.7790	.7710
240.	417.	.8000	.8021
300.	413.	.8070	.8246
360.	409.	.8490	.8419
420.	407.	.8700	.8555

SUM OF SQUARED ERRORS = 1.0E-03

RATE CONSTANT VALUES :
****

	1'ST CONSTANT	2'ND CONSTANT
ALLOY	: 8.140E-08	.00000
TROILITE	: 1.405E-10	.00000

LEACHING OF COBALT FROM MATTE - LEACH 9

PREDICTED VS. MEASURED EXTRACTIONS
****

COMPONENT 1

TIME	POTL	MEAS	CALC
12.	593.	.0590	.0779
30.	581.	.1470	.1494
63.	571.	.2350	.2455
122.	566.	.3660	.3624
180.	563.	.4500	.4408
240.	561.	.5040	.4994
307.	560.	.5530	.5475
368.	559.	.5730	.5809

SUM OF SQUARED ERRORS = 6.9E-04

RATE CONSTANT VALUES :
****

	1'ST CONSTANT	2'ND CONSTANT
ALLOY :	4.050E-09	.00000
TROILITE :	7.142E-18	.02620

LEACHING OF COBALT FROM MATTE - LEACH 10

PREDICTED VS. MEASURED EXTRACTIONS
****

COMPONENT 1

TIME	POTL	MEAS	CALC
6.	640.	.0000	.0065
15.	620.	.0040	.0114
31.	600.	.0060	.0175
61.	580.	.0260	.0259
119.	571.	.0440	.0396
173.	566.	.0610	.0512
242.	565.	.0730	.0654
305.	563.	.0690	.0777
380.	562.	.0910	.0918

SUM OF SQUARED ERRORS = 4.8E-04

RATE CONSTANT VALUES :
****

	1'ST CONSTANT	2'ND CONSTANT
ALLOY	: 1.654E-10	.00000
TROILITE	: 1.836E-19	.02860

LEACHING OF COBALT FROM MATTE - LEACH 11

PREDICTED VS. MEASURED EXTRACTIONS
****

COMPONENT 1

TIME	POTL	MEAS	CALC
15.	598.	.0000	.0106
30.	576.	.0040	.0175
60.	555.	.0170	.0286
120.	540.	.0370	.0477
180.	535.	.0730	.0650
240.	532.	.0900	.0812
300.	531.	.1130	.0965
362.	530.	.1030	.1114
440.	529.	.1220	.1292

SUM OF SQUARED ERRORS = 1.1E-03

RATE CONSTANT VALUES :
****

	1'ST CONSTANT	2'ND CONSTANT
ALLOY	: 2.889E-10	.00000
TROILITE	: 3.515E-19	.02830

LEACHING OF IRON FROM MATTE - LEACHES 3 TO 6

PREDICTED VS. MEASURED EXTRACTIONS
****

COMPONENT 1

TIME	POTL	MEAS	CALC
30.	484.	.1220	.1651
60.	483.	.2160	.2597
120.	479.	.3720	.3840
180.	478.	.4670	.4630
240.	476.	.5530	.5192
360.	473.	.6200	.5949
6.	517.	.0710	.0696
15.	516.	.1330	.1464
30.	514.	.2230	.2400
60.	511.	.3570	.3639
129.	506.	.5240	.5120
180.	505.	.5840	.5748
240.	504.	.6330	.6274
300.	503.	.6910	.6664
360.	503.	.7200	.6972
420.	502.	.7440	.7220
6.	551.	.1380	.1078
15.	545.	.2350	.2201
30.	541.	.3340	.3409
60.	537.	.4580	.4753
120.	533.	.5720	.6050
180.	530.	.6390	.6740
240.	528.	.6910	.7192
300.	527.	.7270	.7516
6.	582.	.2820	.2370
15.	573.	.3900	.3657
30.	564.	.4810	.4785
60.	558.	.5730	.5906
120.	550.	.6830	.6939
180.	547.	.7460	.7479
240.	546.	.7820	.7832
300.	544.	.8210	.8083
420.	544.	.8570	.8413

SUM OF SQUARED ERRORS = 1.7E-02

RATE CONSTANT VALUES :
****

	1'ST CONSTANT	2'ND CONSTANT
ALLOY	: 1.833E-06	.00000
TROILITE	: 3.865E-12	.01900
CU,FE-S	: 1.829E-08	.00000

LEACHING OF IRON FROM MATTE - LEACH 7 - REDOX POTENTIAL

PREDICTED VS. MEASURED EXTRACTIONS
****

COMPONENT 1

TIME	POTL	MEAS	CALC
6.	587.	.2070	.1827
16.	576.	.3140	.2984
30.	568.	.3960	.3915
60.	560.	.4940	.4996
120.	556.	.5940	.6096
182.	552.	.6620	.6736
240.	552.	.6980	.7145
300.	548.	.7390	.7452
360.	547.	.7760	.7685
420.	546.	.8030	.7871

SUM OF SQUARED ERRORS = 1.9E-03

RATE CONSTANT VALUES :
****

	1'ST CONSTANT	2'ND CONSTANT
ALLOY	: 2.900E-06	.00000
TROILITE	: 2.290E-12	.01900
CU,FE-S	: 5.760E-08	.00000

LEACHING OF IRON FROM MATTE - LEACH 7 - MATTE POTENTIAL

PREDICTED VS. MEASURED EXTRACTIONS
****

COMPONENT 1

TIME	POTL	MEAS	CALC
6.	447.	.2070	.1109
16.	450.	.3140	.2261
30.	454.	.3960	.3379
60.	457.	.4940	.4815
120.	471.	.5940	.6230
182.	466.	.6620	.7005
240.	455.	.6980	.7471
300.	446.	.7390	.7810
360.	436.	.7760	.8060
420.	434.	.8030	.8250

SUM OF SQUARED ERRORS = 2.8E-02

RATE CONSTANT VALUES :
****

	1'ST CONSTANT	2'ND CONSTANT
ALLOY	: 3.569E-06	.00000
TROILITE	: 1.180E-07	.00000
CU,FE-S	: 1.491E-06	.00000

LEACHING OF IRON FROM MATTE - LEACH 8 - REDOX POTENTIAL

PREDICTED VS. MEASURED EXTRACTIONS
****

COMPONENT 1

TIME	POTL	MEAS	CALC
6.	579.	.2250	.1745
15.	571.	.3250	.2897
30.	563.	.4120	.3997
60.	556.	.4920	.5147
120.	550.	.5950	.6265
180.	546.	.6650	.6877
240.	544.	.7110	.7284
300.	543.	.7560	.7583
360.	540.	.7930	.7807
42(.	538.	.8090	.7982

SUM OF SQUARED ERRORS = 6.5E-03

RATE CONSTANT VALUES :
****

	1'ST CONCTANT	2'ND CONSTANT
ALLOY	: 2.765E-06	.00000
TROILITE	: 2.803E-12	.01900
CU,FE-S	: 3.539E-08	.00000

LEACHING OF IRON FROM MATTE - LEACH 8 - MATTE POTENTIAL

PREDICTED VS. MEASURED EXTRACTIONS
****

COMPONENT 1

TIME	POTL	MEAS	CALC
6.	497.	.2250	.1400
15.	496.	.3250	.2717
30.	493.	.4120	.4053
60.	487.	.4920	.5375
120.	475.	.5950	.6479
180.	463.	.6650	.6990
240.	454.	.7110	.7288
300.	450.	.7560	.7498
360.	441.	.7930	.7649
420.	438.	.8090	.7765

SUM OF SQUARED ERRORS = 1.8E-02

RATE CONSTANT VALUES :
****

	1'ST CONSTANT	2'ND CONSTANT
ALLOY	: 2.990E-06	.00000
TROILITE	: 1.129E-12	.02400
CU,FE-S	: 1.870E-06	.00000

LEACHING OF IRON FROM MATTE - LEACH 8 - RESIDUE POTENTIAL

PREDICTED VS. MEASURED EXTRACTIONS
****

COMPONENT 1

TIME	POTL	MEAS	CALC
6.	498.	.2250	.1548
15.	493.	.3250	.2950
30.	478.	.4120	.4227
60.	455.	.4920	.5365
120.	436.	.5950	.6338
180.	424.	.6650	.6849
240.	417.	.7110	.7186
300.	413.	.7560	.7436
360.	409.	.7930	.7631
420.	407.	.8090	.7789

SUM OF SQUARED ERRORS = 1.2E-02

RATE CONSTANT VALUES :
****

	1'ST CONSTANT	2'ND CONSTANT
ALLOY	: 2.874E-06	.00000
TROILITE	: 2.384E-10	.01350
CU,FE-S	: 1.870E-06	.00000

LEACHING OF IRON FROM MATTE - LEACH 9

PREDICTED VS. MEASURED EXTRACTIONS
****

COMPONENT 1

TIME	POTL	MEAS	CALC
12.	593.	.1560	.0894
30.	581.	.2280	.1499
63.	571.	.2830	.2267
122.	566.	.3470	.3198
180.	563.	.3800	.3838
240.	561.	.4080	.4331
307.	560.	.4340	.4762
368.	559.	.4430	.5081

SUM OF SQUARED ERRORS = 2.1E-02

RATE CONSTANT VALUES :
****

	1'ST CONSTANT	2'ND CONSTANT
ALLOY	: 2.377E-07	.00000
TROILITE	: 1.322E-13	.02120
CU,FE-S	: 3.900E-14	.00000

LEACHING OF IRON FROM MATTE - LEACH 1C

PREDICTED VS. MEASURED EXTRACTIONS
****

COMPONENT 1

TIME	POTL	MEAS	CALC
6.	640.	.0000	.0161
15.	620.	.0070	.0285
31.	600.	.0370	.0424
61.	580.	.0770	.0591
119.	571.	.1080	.0823
173.	566.	.1140	.1005
242.	565.	.1280	.1215
305.	563.	.1300	.1393
380.	562.	.1390	.1590

SUM OF SQUARED ERRORS = 2.4E-03

RATE CONSTANT VALUES :
****

	1'ST CONSTANT	2'ND CONSTANT
ALLOY	: 1.719E-08	.00000
TROILITE	: 6.365E-15	.02310
CU,FE-S	: 5.560E-19	.00000

LEACHING OF IRON FROM MATTE - LEACH 11

PREDICTED VS. MEASURED EXTRACTIONS
****

COMPONENT 1

TIME	POTL	MEAS	CALC
15.	598.	.0010	.0377
30.	576.	.0290	.0566
60.	555.	.0650	.0798
120.	540.	.1250	.1102
180.	535.	.1510	.1341
240.	532.	.1710	.1550
300.	531.	.1840	.1743
362.	530.	.1930	.1928
440.	529.	.1970	.2146

SUM OF SQUARED ERRORS = 3.5E-03

RATE CONSTANT VALUES :
****

	1'ST CONSTANT	2'ND CONSTANT
ALLOY	: 2.079E-08	.00000
TROILITE	: 1.830E-14	.02290
CU,FE-S	: 2.121E-18	.00000

PREDICTED VS. MEASURED EXTRACTIONS
****

COMPONENT 1

TIME	POTL	MEAS	CALC
12.	593.	.1170	.1016
30.	581.	.2160	.2067
63.	571.	.3360	.3375
122.	566.	.4660	.4785
180.	563.	.5600	.5630
240.	561.	.6230	.6213
307.	560.	.6660	.6666
368.	559.	.7010	.6965

SUM OF SQUARED ERRORS = 5.1E-04

RATE CONSTANT VALUES :
****

	1'ST CONSTANT	2'ND CONSTANT
ALLOY	: 8.205E-08	.00000
TROILITE	: 2.044E-15	.02120

LEACHING OF NICKEL FROM MATTE - LEACH 9 (X=0.50 : EX ALLOY)

PREDICTED VS. MEASURED EXTRACTIONS
****

COMPONENT 1

TIME	POTL	MEAS	CALC
12.	593.	.1170	.1042
30.	581.	.2160	.2084
63.	571.	.3360	.3368
122.	566.	.4660	.4771
180.	563.	.5600	.5624
240.	561.	.6230	.6213
307.	560.	.6660	.6675
368.	559.	.7010	.6961

SUM OF SQUARED ERRORS = 3.8E-04

RATE CONSTANT VALUES :
****

	1'ST CONSTANT	2'ND CONSTANT
ALLOY	: 3.563E-08	.00000
TROILITE	: 1.958E-15	.02120

LEACHING OF NICKEL FROM MATTE - LEACH 9 (X=0.40 : EX ALLOY)

PREDICTED VS. MEASURED EXTRACTIONS
****

COMPONENT 1

TIME	POTL	MEAS	CALC
12.	593.	.1170	.1071
30.	581.	.2160	.2095
63.	571.	.3360	.3353
122.	566.	.4660	.4762
180.	563.	.5600	.5621
240.	561.	.6230	.6222
307.	560.	.6660	.6684
368.	559.	.7010	.6954

SUM OF SQUARED ERRORS = 2.9E-04

RATE CONSTANT VALUES :
****

	1'ST CONSTANT	2'ND CONSTANT
ALLOY	: 1.534E-08	.00000
TROILITE	: 1.882E-15	.02120

LEACHING OF NICKEL FROM MATTE - LEACH 9 (X=0.30 : EX ALLOY)

PREDICTED VS. MEASURED EXTRACTIONS
****

COMPONENT 1

TIME	POTL	MEAS	CALC
12.	593.	.1170	.1099
30.	581.	.2160	.2113
63.	571.	.3360	.3342
122.	566.	.4660	.4746
180.	563.	.5600	.5607
240.	561.	.6230	.6240
307.	560.	.6660	.6681
368.	559.	.7010	.6955

SUM OF SQUARED ERRORS = 1.9E-04

RATE CONSTANT VALUES :
****

	1'ST CONSTANT	2'ND CONSTANT
ALLOY :	6.611E-09	.00000
TROILITE :	1.813E-15	.02120

LEACHING OF NICKEL FROM MATTE - LEACH 9 (X=0.20 : EX ALLOY)

PREDICTED VS. MEASURED EXTRACTIONS
****

COMPONENT 1

TIME	POTL	MEAS	CALC
12.	593.	.1170	.1134
30.	581.	.2160	.2129
63.	571.	.3360	.3325
122.	566.	.4660	.4726
180.	563.	.5600	.5592
240.	561.	.6230	.6262
307.	560.	.6660	.6678
368.	559.	.7010	.6960

SUM OF SQUARED ERRORS = 1.2E-04

RATE CONSTANT VALUES :
****

	1'ST CONSTANT	2'ND CONSTANT
ALLOY	: 2.858E-09	.00000
TROILITE	: 1.738E-15	.02120

LEACHING OF NICKEL FROM MATTE - LEACH 9 (X=0.10 : EX ALLOY)

PREDICTED VS. MEASURED EXTRACTIONS
****

COMPONENT 1

TIME	POTL	MEAS	CALC
12.	593.	.1170	.1152
30.	581.	.2160	.2151
63.	571.	.3360	.3302
122.	566.	.4660	.4719
180.	563.	.5600	.5588
240.	561.	.6230	.6268
307.	560.	.6660	.6688
368.	559.	.7010	.6955

SUM OF SQUARED ERRORS = 1.3E-04

RATE CONSTANT VALUES :
****

	1'ST CONSTANT	2'ND CONSTANT
ALLOY	: 1.241E-09	.00000
TROILITE	: 1.666E-15	.02120

LEACHING OF NICKEL FROM MATTE - LEACH 9 (X=0.05 : EX ALLOY)

PREDICTED VS. MEASURED EXTRACTIONS
****

COMPONENT 1

TIME	POTL	MEAS	CALC
12.	593.	.1170	.1161
30.	581.	.2160	.2158
63.	571.	.3360	.3290
122.	566.	.4660	.4717
180.	563.	.5600	.5587
240.	561.	.6230	.6272
307.	560.	.6660	.6696
368.	559.	.7010	.6948

SUM OF SQUARED ERRORS = 1.5E-04

RATE CONSTANT VALUES :
****

	1'ST CONSTANT	2'ND CONSTANT
ALLOY	: 8.174E-10	.00000
TROILITE	: 1.627E-15	.02120

NICKEL LEACHING - LEACHES 7 AND 8 (X=2/3 EX ALLOY)

PREDICTED VS. MEASURED EXTRACTIONS
****

COMPONENT 1

TIME	POTL	MEAS	CALC
6.	587.	.3480	.3438
16.	576.	.5320	.5361
30.	568.	.6540	.6353
60.	560.	.7410	.7165
120.	556.	.7960	.7850
182.	552.	.8280	.8253
240.	552.	.8440	.8512
300.	548.	.8630	.8706
360.	547.	.8750	.8854
420.	546.	.8910	.8973
6.	579.	.3340	.3346
15.	571.	.4980	.5124
30.	563.	.6230	.6214
60.	556.	.7100	.7019
120.	550.	.7670	.7708
180.	546.	.8060	.8106
240.	544.	.8270	.8379
300.	543.	.8630	.8582
360.	540.	.8660	.8737
420.	538.	.8790	.8860

SUM OF SQUARED ERRORS = 1.9E-03

RATE CONSTANT VALUES :
****

	1'ST CONSTANT	2'ND CONSTANT
ALLOY	: 1.737E-06	.00000
TROILITE	: 3.743E-14	.01900

NICKEL LEACHING - LEACHES 7 AND 8 (X=0.6 EX ALLOY)

PREDICTED VS. MEASURED EXTRACTIONS
****

COMPONENT 1

TIME	POTL	MEAS	CALC
6.	587.	.3480	.3422
16.	576.	.5320	.5361
30.	568.	.6540	.6373
60.	560.	.7410	.7173
120.	556.	.7960	.7846
182.	552.	.8280	.8250
240.	552.	.8440	.8509
300.	548.	.8630	.8703
360.	547.	.8750	.8851
420.	546.	.8910	.8970
6.	579.	.3340	.3331
15.	571.	.4980	.5122
30.	563.	.6230	.6235
60.	556.	.7100	.7027
120.	550.	.7670	.7704
180.	546.	.8060	.8103
240.	544.	.8270	.8376
300.	543.	.8630	.8579
360.	540.	.8660	.8734
420.	538.	.8790	.8857

SUM OF SQUARED ERRORS = 1.8E-03

RATE CONSTANT VALUES :
****

	1'ST CONSTANT	2'ND CONSTANT
ALLOY	: 9.733E-07	.00000
TROILITE	: 3.732E-14	.01900

NICKEL LEACHING - LEACHES 7 AND 8 (X=0.5 EX ALLOY)

PREDICTED VS. MEASURED EXTRACTIONS
****

COMPONENT 1

TIME	POTL	MEAS	CALC
6.	587.	.3480	.3400
16.	576.	.5320	.5365
30.	568.	.6540	.6404
60.	560.	.7410	.7182
120.	556.	.7960	.7841
182.	552.	.8280	.8245
240.	552.	.8440	.8504
300.	548.	.8630	.8699
360.	547.	.8750	.8847
420.	546.	.8910	.8966
6.	579.	.3340	.3308
15.	571.	.4980	.5121
30.	563.	.6230	.6266
60.	556.	.7100	.7037
120.	550.	.7670	.7699
180.	546.	.8060	.8097
240.	544.	.8270	.8371
300.	543.	.8630	.8574
360.	540.	.8660	.8730
420.	538.	.8790	.8853

SUM OF SQUARED ERRORS = 1.7E-03

RATE CONSTANT VALUES :
****

	1'ST CONSTANT	2'ND CONSTANT
ALLOY	: 4.106E-07	.00000
TROILITE	: 3.716E-14	.01900

NICKEL LEACHING - LEACHES 7 AND 8 (X=0.5 EX ALLOY)

PREDICTED VS. MEASURED EXTRACTIONS
****

COMPONENT 1

TIME	POTL	MEAS	CALC
6.	587.	.3480	.3400
16.	576.	.5320	.5365
30.	568.	.6540	.6404
60.	560.	.7410	.7182
120.	556.	.7960	.7841
182.	552.	.8280	.8245
240.	552.	.8440	.8504
300.	548.	.8630	.8699
360.	547.	.8750	.8847
420.	546.	.8910	.8966
6.	579.	.3340	.3308
15.	571.	.4980	.5121
30.	563.	.6230	.6266
60.	556.	.7100	.7037
120.	550.	.7670	.7699
180.	546.	.8060	.8097
240.	544.	.8270	.8371
300.	543.	.8630	.8574
360.	540.	.8660	.8730
420.	538.	.8790	.8853

SUM OF SQUARED ERRORS = 1.7E-03

RATE CONSTANT VALUES :
****

	1'ST CONSTANT	2'ND CONSTANT
ALLOY :	4.106E-07	.00000
TROILITE :	3.716E-14	.01900

NICKEL LEACHING - LEACHES 7 AND 8 (X=0.4 EX ALLOY)

PREDICTED VS. MEASURED EXTRACTIONS
****

COMPONENT 1

TIME	POTL	MEAS	CALC
6.	587.	.3480	.3378
16.	576.	.5320	.5372
30.	568.	.6540	.6433
60.	560.	.7410	.7186
120.	556.	.7960	.7836
182.	552.	.8280	.8240
240.	552.	.8440	.8500
300.	548.	.8630	.8695
360.	547.	.8750	.8843
420.	546.	.8910	.8963
6.	579.	.3340	.3287
15.	571.	.4980	.5125
30.	563.	.6230	.6296
60.	556.	.7100	.7040
120.	550.	.7670	.7694
180.	546.	.8060	.8093
240.	544.	.8270	.8367
300.	543.	.8630	.8570
360.	540.	.8660	.8726
420.	538.	.8790	.8849

SUM OF SQUARED ERRORS = 1.7E-03

RATE CONSTANT VALUES :
****

	1'ST CONSTANT	2'ND CONSTANT
ALLOY :	1.741E-07	.00000
TROILITE :	3.702E-14	.01900

NICKEL LEACHING - LEACHES 7 AND 8 (X=0.3 EX ALLOY)

PREDICTED VS. MEASURED EXTRACTIONS
****

COMPONENT 1

TIME	POTL	MEAS	CALC
6.	587.	.3480	.3367
16.	576.	.5320	.5371
30.	568.	.6540	.6463
60.	560.	.7410	.7182
120.	556.	.7960	.7833
182.	552.	.8280	.8237
240.	552.	.8440	.8497
300.	548.	.8630	.8692
360.	547.	.8750	.8841
420.	546.	.8910	.8960
6.	579.	.3340	.3276
15.	571.	.4980	.5130
30.	563.	.6230	.6325
60.	556.	.7100	.7037
120.	550.	.7670	.7691
180.	546.	.8060	.8090
240.	544.	.8270	.8364
300.	543.	.8630	.8568
360.	540.	.8660	.8723
420.	538.	.8790	.8846

SUM OF SQUARED ERRORS = 1.7E-03

RATE CONSTANT VALUES :
****

	1'ST CONSTANT	2'ND CONSTANT
ALLOY	: 7.423E-08	.00000
TROILITE	: 3.692E-14	.01900

NICKEL LEACHING - LEACHES 7 AND 8 (X=0.2 EX ALLOY)

PREDICTED VS. MEASURED EXTRACTIONS
****

COMPONENT 1

TIME	POTL	MEAS	CALC
6.	587.	.3480	.3348
16.	576.	.5320	.5378
30.	568.	.6540	.6502
60.	560.	.7410	.7178
120.	556.	.7960	.7828
182.	552.	.8280	.8233
240.	552.	.8440	.8493
300.	548.	.8630	.8688
360.	547.	.8750	.8837
420.	546.	.8910	.8957
6.	579.	.3340	.3258
15.	571.	.4980	.5130
30.	563.	.6230	.6365
60.	556.	.7100	.7033
120.	550.	.7670	.7686
180.	546.	.8060	.8085
240.	544.	.8270	.8360
300.	543.	.8630	.8564
360.	540.	.8660	.8719
420.	538.	.8790	.8843

SUM OF SQUARED ERRORS = 1.8E-03

RATE CONSTANT VALUES :
****

	1'ST CONSTANT	2'ND CONSTANT
ALLOY	: 3.187E-08	.00000
TROILITE	: 3.678E-14	.01900

NICKEL LEACHING - LEACHES 7 AND 8 (X=0.1 EX ALLOY)

PREDICTED VS. MEASURED EXTRACTIONS
****

COMPONENT 1

TIME	POTL	MEAS	CALC
6.	587.	.3480	.3332
16.	576.	.5320	.5389
30.	568.	.6540	.6553
60.	560.	.7410	.7172
120.	556.	.7960	.7822
182.	552.	.8280	.8227
240.	552.	.8440	.8487
300.	548.	.8630	.8683
360.	547.	.8750	.8832
420.	546.	.8910	.8952
6.	579.	.3340	.3242
15.	571.	.4980	.5134
30.	563.	.6230	.6417
60.	556.	.7100	.7028
120.	550.	.7670	.7680
180.	546.	.8060	.8079
240.	544.	.8270	.8354
300.	543.	.8630	.8558
360.	540.	.8660	.8714
420.	538.	.8790	.8838

SUM OF SQUARED ERRORS = 2.1E-03

RATE CONSTANT VALUES :
****

	1'ST CONSTANT	2'ND CONSTANT
ALLOY	: 1.372E-08	.00000
TROILITE	: 3.659E-14	.01900

NICKEL LEACHING - LEACHES 7 AND 8 (X=0.1 EX ALLOY)

PREDICTED VS. MEASURED EXTRACTIONS
****

COMPONENT 1

TIME	POTL	MEAS	CALC
6.	587.	.3480	.3332
16.	576.	.5320	.5389
30.	568.	.6540	.6553
60.	560.	.7410	.7172
120.	556.	.7960	.7822
182.	552.	.8280	.8227
240.	552.	.8440	.8487
300.	548.	.8630	.8683
360.	547.	.8750	.8832
420.	546.	.8910	.8952
6.	579.	.3340	.3242
15.	571.	.4980	.5134
30.	563.	.6230	.6417
60.	556.	.7100	.7028
120.	550.	.7670	.7680
180.	546.	.8060	.8079
240.	544.	.8270	.8354
300.	543.	.8630	.8558
360.	540.	.8660	.8714
420.	538.	.8790	.8838

SUM OF SQUARED ERRORS = 2.1E-03

RATE CONSTANT VALUES :
****

	1'ST CONSTANT	2'ND CONSTANT
ALLOY	: 1.372E-08	.00000
TROILITE	: 3.659E-14	.01900

NICKEL LEACHING - LEACHES 7 AND 8 (X=.05 EX ALLOY)

PREDICTED VS. MEASURED EXTRACTIONS
****

COMPONENT 1

TIME	POTL	MEAS	CALC
6.	587.	.3480	.3329
16.	576.	.5320	.5400
30.	568.	.6540	.6578
60.	560.	.7410	.7169
120.	556.	.7960	.7818
182.	552.	.8280	.8223
240.	552.	.8440	.8484
300.	548.	.8630	.8680
360.	547.	.8750	.8829
420.	546.	.8910	.8949
6.	579.	.3340	.3239
15.	571.	.4980	.5141
30.	563.	.6230	.6442
60.	556.	.7100	.7024
120.	550.	.7670	.7676
180.	546.	.8060	.8075
240.	544.	.8270	.8350
300.	543.	.8630	.8555
360.	540.	.8660	.8711
420.	538.	.8790	.8835

SUM OF SQUARED ERRORS = 2.3E-03

RATE CONSTANT VALUES :
****

	1'ST CONSTANT	2'ND CONSTANT
ALLOY :	9.029E-09	.00000
TROILITE :	3.647E-14	.01900

LEACHING OF COPPER FROM MATTE - LEACH 9 (X=0.5)

PREDICTED VS. MEASURED EXTRACTIONS
****

COMPONENT 1

TIME	POTL	MEAS	CALC
12.	593.	.2310	.1955
30.	581.	.2620	.2509
63.	571.	.3000	.3072
122.	566.	.3550	.3676
180.	563.	.4020	.4078
240.	561.	.4330	.4385
307.	560.	.4580	.4650
368.	559.	.4810	.4845

SUM OF SQUARED ERRORS = 1.7E-03

RATE CONSTANT VALUES :
****

	1'ST CONSTANT	2'ND CONSTANT
ALLOY	: 2.655E-09	.00000
TROILITE	: 4.113E-17	.03020
CU,FE-S	: 3.606E-14	.00000

LEACHING OF COPPER FROM MATTE - LEACH 9 (X=0.25)

PREDICTED VS. MEASURED EXTRACTIONS
****

COMPONENT I

TIME	POTL	MEAS	CALC
12.	593.	.2310	.1954
30.	581.	.2620	.2509
63.	571.	.3000	.3072
122.	566.	.3550	.3676
180.	563.	.4020	.4078
240.	561.	.4330	.4385
307.	560.	.4580	.4650
368.	559.	.4810	.4844

SUM OF SQUARED ERRORS = 1.7E-03

RATE CONSTANT VALUES :
****

	1'ST CONSTANT	2'ND CONSTANT
ALLOY	: 2.655E-09	.00000
TROILITE	: 4.113E-17	.03020
CU,FE-S	: 5.057E-15	.00000

LEACHING OF COPPER FROM MATTE - LEACH 9 (X=0.1)

PREDICTED VS. MEASURED EXTRACTIONS
****

COMPONENT 1

TIME	POTL	MEAS	CALC
12.	593.	.2310	.1955
30.	581.	.2620	.2509
63.	571.	.3000	.3072
122.	566.	.3550	.3676
180.	563.	.4020	.4078
240.	561.	.4330	.4385
307.	560.	.4580	.4650
368.	559.	.4810	.4845

SUM OF SQUARED ERRORS = 1.7E-03

RATE CONSTANT VALUES :
****

	1'ST CONSTANT	2'ND CONSTANT
ALLOY	: 2.655E-09	.00000
TROILITE	: 4.115E-17	.03020
CU,FE-S	: 1.416E-15	.00000

LEACHING OF COPPER FROM MATTE - LEACHES 7 AND 8 (X = 2/3)

PREDICTED VS. MEASURED EXTRACTIONS
****

COMPONENT 1

TIME	POTL	MEAS	CALC
6.	579.	.3870	.3926
15.	571.	.4780	.4791
30.	563.	.5560	.5557
60.	556.	.6190	.6359
120.	550.	.6990	.7194
180.	546.	.7540	.7678
240.	544.	.7990	.8010
360.	540.	.8750	.8458
420.	538.	.8910	.8618
6.	587.	.4360	.4368
16.	576.	.5360	.5281
30.	568.	.6040	.5935
60.	560.	.6700	.6683
120.	556.	.7490	.7475
182.	552.	.8000	.7948
240.	552.	.8150	.8260
300.	548.	.8440	.8502
360.	547.	.8650	.8691
420.	546.	.8870	.8847

SUM OF SQUARED ERRORS 3.0E-03

RATE CONSTANT VALUES :
****

	1'ST CONSTANT	2'ND CONSTANT
ALLOY	: 2.191E-09	.00000
TROILITE	: 6.057E-16	.02700
CU,FE-S	: 1.671E-07	.00000

LEACHING OF COPPER FROM MATTE - LEACHES 7 AND 8 (X=0.5)

PREDICTED VS. MEASURED EXTRACTIONS
****

COMPONENT 1

TIME	POTL	MEAS	CALC
6.	579.	.3870	.3925
15.	571.	.4780	.4793
30.	563.	.5560	.5565
60.	556.	.6190	.6365
120.	550.	.6990	.7192
180.	546.	.7540	.7675
240.	544.	.7990	.8007
360.	540.	.8750	.8455
420.	538.	.8910	.8616
6.	587.	.4360	.4367
16.	576.	.5360	.5283
30.	568.	.6040	.5943
60.	560.	.6700	.6689
120.	556.	.7490	.7474
182.	552.	.8000	.7945
240.	552.	.8150	.8258
300.	548.	.8440	.8500
360.	547.	.8650	.8689
420.	546.	.8870	.8845

SUM OF SQUARED ERRORS = 3.0E-03

RATE CONSTANT VALUES :
****

		1'ST CONSTANT	2'ND CONSTANT
ALLOY	:	2.191E-09	.00000
TROILITE	:	6.046E-16	.02700
CU,FE-S	:	2.642E-08	.00000

LEACHING OF COPPER FROM MATTE - LEACHES 7 AND 8 (X=0.25)

PREDICTED VS. MEASURED EXTRACTIONS
****

COMPONENT 1

TIME	POTL	MEAS	CALC
6.	579.	.3870	.3906
15.	571.	.4780	.4805
30.	563.	.5560	.5585
60.	556.	.6190	.6374
120.	550.	.6990	.7187
180.	546.	.7540	.7670
240.	544.	.7990	.8002
360.	540.	.8750	.8451
420.	538.	.8910	.8611
6.	587.	.4360	.4347
16.	576.	.5360	.5294
30.	568.	.6040	.5963
60.	560.	.6700	.6698
120.	556.	.7490	.7468
182.	552.	.8000	.7940
240.	552.	.8150	.8253
300.	548.	.8440	.8496
360.	547.	.8650	.8685
420.	546.	.8870	.8841

SUM OF SQUARED ERRORS = 3.0E-03

RATE CONSTANT VALUES :
****

	1'ST CONSTANT	2'ND CONSTANT
ALLOY	: 2.191E-09	.00000
TROILITE	: 6.025E-16	.02700
CU,FE-S	: 1.744E-09	.00000

LEACHING OF COPPER FROM MATTE - LEACHES 7 AND 8 (X=0.1)

PREDICTED VS. MEASURED EXTRACTIONS
****

COMPONENT 1

TIME	POTL	MEAS	CALC
6.	579.	.3870	.3892
15.	571.	.4780	.4837
30.	563.	.5560	.5610
60.	556.	.6190	.6369
120.	550.	.6990	.7179
180.	546.	.7540	.7663
240.	544.	.7990	.7995
360.	540.	.8750	.8444
420.	538.	.8910	.8605
6.	587.	.4360	.4331
16.	576.	.5360	.5326
30.	568.	.6040	.5988
60.	560.	.6700	.6692
120.	556.	.7490	.7461
182.	552.	.8000	.7933
240.	552.	.8150	.8246
300.	548.	.8440	.8489
360.	547.	.8650	.8679
420.	546.	.8870	.8835

SUM OF SQUARED ERRORS = 3.0E-03

RATE CONSTANT VALUES :
****

	1'ST CONSTANT	2'ND CONSTANT
ALLOY	: 2.191E-09	.00000
TROILITE	: 5.995E-16	.02700
CU,FE-S	: 3.850E-10	.00000

APPENDIX X

Computer programmes:

1) For calculation of solution redox potentials - POTL.FR

2) For fitting the electrochemical measurements to the leaching model theory - EIFIT.FR

3) For calculating exact phase compositions in the matte, and per cent distribution of metals in the various phases - FRNFIT.FR

POTL. FR

NOTE:
Some subroutines called by this programme are also used in the leaching model, and are listed in Appendix VIII.

```
C**********************************************************************
C                                                                    *
C     COMPUTER PROGRAM FOR THE CALCULATION OF REDOX POTENTIAL        *
C     IN CONCENTRATED FERRIC-FERROUS SULPHATE SOLUTION.              *
C                                                                    *
C**********************************************************************
C
C     COMPONENTS AND COMPLEXES ARE ASSIGNED THE FOLLOWING SUBSCRIPTS
C
C     (1) = FE(3+)
C     (2) = H(+)
C     (3) = SO4(2-)
C     (4) = FE(2+)
C     (5) = NOT USED
C     (6) = NOT USED
C     (7) = FE.H.SO4.SO4
C     (8) = FE.H.SO4(2+)
C     (9) = FE.SO4.SO4(-)
C    (10) = FE.SO4(+)
C    (11) = H.SO4(-)
C    (12) = FE.SO4
C    (13) = FE.H.SO4(+)
C
C
C
      REAL K(14),C(6),E(6),X(20),Y(20),XD(6),XX(6),XE(6),XF(6),DXD(6)
      REAL KK(14),YY(50),P(50),AO(20),U(20),DU(20),PLJ(50)
      REAL SXX(20),XST(50,20),KST(50,7),MISC(50,2)
      INTEGER N(20)
      REAL ACL
      REAL D1E(14),KS(14),SK(14)
      REAL D2E(14),DE2(14,14),DE(50,14)
      DATA NSP,NRX,EPS/20,7,0.0005/
      DATA (N(I),AO(I),U(I),DU(I),I=1,20)/
     1     3,9,70.0,.02   , 1,9,350.,.0130,-2,4,00.0,.022 ,
     2     2,6,53.6,.02   , 2,6,52.0,.02  , 1,4,50.1,.022 ,
     3     0,0,00.0,.00   , 2,8,36.2,.02  ,-1,8,50.0,.02  ,
     4     1,8,50.0,.02   ,-1,4,50.0,.02  , 0,0,00.0,.00  ,
     5     1,4,50.0,.02   , 0,0,00.0,.00  ,-1,4,50.0,.02  ,
     6     2,4,80.0,.02   , 1,4,50.0,.02  , 4,0,00.0,.02  ,
     7     0,0,00.0,.00   , 0,0,00.0,.00  /
      ITER=0
      IIMAX=0
      ACCEPT "MODE (-1=CONC ONLY;0=HARD COPY;1=SCREEN ONLY;2=ABS.;3=REGRESS) ? ",MODE
      ACCEPT "TYPE (0=ACTIVITIES;1=COMPLEXED CONCS;2=TOTAL CONCS)? ",NTYP
      ACCEPT "REDOX COUPLE (OXIDISED,REDUCED SPECIES) ? : ",IOX,IRD
    1 OPEN 2,"PDATA"
      READ FREE (2) BETA
      IF (MODE.LT.3) READ FREE (2) NSET,T
      IF (MODE.GE.3) READ FREE (2) NSET,T,MAXIT,NOPT,ESP
      CALL DEHUC (T,AAO,SBO)
      T=T+273.15
      CALL KEULM (T,KK,NTYP)
      IF (NSET.LT.0) READ FREE (2) (KK(J),J=1,NRX)
      IF (NSET.LT.0) NSET=-NSET
      ACCEPT "K'S ? ",M
      IF (M.LT.0) OPEN 4,"F1"
      IF (M.LT.0) READ BINARY (4) IIMAX,((XST(II,I),I=1,NSP),II=1,IIMAX)
      IF (M.LT.0) CLOSE 4
      IF (M.LT.0) M=-M-1
      IF (M.GT.0) READ FREE (11) (I,KK(I),J=1,M)
      DO 20 J=1,NRX
```

```
      SK(J)=KK(J)
      IF (KK(J).GE.0.) GO TO 20
      SK(J)=0.
      KK(J)=-KK(J)
   20 CONTINUE
    2 IF (MODE.LE.1) OPEN 3,"POUT"
      J=4
      IF (MODE.LE.1) WRITE (3,1007) J
      IF (MODE.LE.1) OPEN 4,"OUTP"
      J=7
      IF (MODE.LE.1) WRITE (4,1007) J
      IF (MODE.LE.0) OPEN 12,"@LPT",ATT="P"
      IF (MODE.LE.0) WRITE (12,1999)
      IF (MODE.LE.0) WRITE (12,2003)
      IF (MODE.LE.0) WRITE (12,2004)
      BIAS=0.
      ESD=0.
      S1=0.
      S2=0.
      S3=0.
      S4=0.
      DO 21 J=1,NRX
      D1E(J)=0.
   21 D2E(J)=0.
      IF (MODE.LE.1) WRITE (10,1000)
      IF (MODE.LE.1) WRITE (10,1001)
      II=0
      DO 39 ISET=1,NSET
      READ FREE (2) NR,TR,NDAT
      CALL REFER (NR,TR,PR,KCL)
      DO 39 IDAT=1,NDAT
      II=II+1
      KOUNT=0
      READ FREE (2) P(II),(C(I),I=1,6)
      P(II)=P(II)+PR
      TAUMAX=0.
      DO 3 I=1,6
      UXD(I)=0.
      TAUMAX=TAUMAX+C(I)*N(I)**2
      X(I)=C(I)
      XH(I)=0.
      IF (IIMAX.GT.0) X(I)=XST(II,I)
    3 XF(I)=C(I)
      DO 4 I=7,NSP
      X(I)=0.
      IF (IIMAX.GT.0) X(I)=XST(II,I)
    4 CONTINUE
      NKK=0
      NKJ=1
    5 TAU=0.
      DO 6 I=1,NSP
    6 TAU=TAU+X(I)*N(I)**2
      IF (TAU.GT.TAUMAX) TAU=TAUMAX
      IF (NTYP.EQ.0) CALL KHSO4 (T,TAU,K(5))
      TAU=SQRT(TAU)
      UNC=X(7)+X(12)+X(14)+X(19)+X(20)
      AA=AA0-BETA*UNC
      IF (AA.LT.0.0025) AA=0.0025
      BB=BB0*(AA/AA0)**(1./3.)
   42 DO 7 I=1,NSP
      Y(I)=1.0
      IF (NTYP.EQ.0) Y(I)=10**(-AA*N(I)*N(I)*TAU/(1.+A0(I)*BB*TAU))
    7 CONTINUE
```

```
      K( 1)=KK( 1)/Y(7)*Y(1)*Y(2)*Y(3)**2
      K( 2)=KK( 2)/Y(8)*Y(1)*Y(2)*Y(3)
      K( 3)=KK( 3)/Y(9)*Y(1)*Y(3)**2
      K( 4)=KK( 4)/Y(10)*Y(1)*Y(3)
      IF (NTYP.GT.0) K(5)=KK(5)
      K( 6)=KK( 6)/Y(12)*Y(3)*Y(4)
      K( 7)=KK( 7)/Y(13)*Y(2)*Y(3)*Y(4)
      K( 8)=KK( 8)/Y(14)*Y(3)*Y(5)
      K( 9)=KK( 9)/Y(15)*Y(3)*Y(6)
      K(10)=KK(10)/Y(16)/Y(2)*Y(1)
      K(11)=KK(11)/Y(17)/Y(2)*Y(4)
      K(12)=KK(12)/Y(18)*(Y(1)/Y(2))**2
      K(13)=KK(13)/Y(19)*Y(2)*Y(3)*Y(6)
      K(14)=KK(14)/Y(20)*Y(1)*Y(6)*Y(3)**2
    8 XD(1)=1.+K(1)*X(2)*X(3)**2+K(2)*X(2)*X(3)+K(3)*X(3)**2+K(4)*X(3)
     1       +K(10)/X(2)+2*K(12)*X(1)/X(2)**2+K(14)*X(6)*X(3)**2
      DXD(1)=2*K(12  X(2)**2
      XD(2)=1.+K(1)*X(1)*X(3)**2+K(2)*X(1)*X(3)+K(5)*X(3)+K(7)*X(3)*X(4)
     1       +K(13)*X(3)*X(6)
      XD(3)=1.+2*K(1)*X(1)*X(2)*X(3)+K(2)*X(1)*X(2)+2*K(3)*X(1)*X(3)
     1       +K(4)*X(1)+K(5)*X(2)+K(6)*X(4)+K(7)*X(2)*X(4)
     2       +K(8)*X(5)+K(9)*X(6)+K(13)*X(2)*X(6)+2*K(14)*X(1)*X(3)*X(6)
      DXD(3)=2*(K(1)*X(1)*X(2)+K(3)*X(1)+K(14)*X(1)*X(6))
      XD(4)=1.+K(6)*X(3)+K(7)*X(2)*X(3)
     1       +K(11)/X(2)
      XD(5)=1.+K(8)*X(3)
      XD(6)=1.+K(9)*X(3)+K(13)*X(2)*X(3)+K(14)*X(1)*X(3)**2
      NER=0
      XX(2)=X(16)+X(17)+2*X(18)
      DO 9 I=1,6
      E(I)=X(I)*XD(I)-C(I)-XX(I)
      IF (ABS(E(I)).LE.(EPS*C(I))) GO TO 9
      NER=NER+1
      XE(I)=-E(I)/(XD(I)+X(I)*DXD(I))
      IF ((XE(I)*XF(I)).LT.0.) XF(I)=-XF(I)/2
      IF ((XE(I)/XF(I)).GT.1.) XE(I)= XF(I)
      IF ((X(I)+XE(I)).LT.0.)  XE(I)=-X(I)
      IF ((X(I)+XE(I)).GT.C(I)) XE(I)=C(I)-X(I)
      X(I)=X(I)+XE(I)
    9 CONTINUE
      X( 7)= K( 1)*X(1)*X(2)*X(3)**2
      X( 8)= K( 2)*X(1)*X(2)*X(3)
      X( 9)= K( 3)*X(1)*X(3)**2
      X(10)= K( 4)*X(1)*X(3)
      X(11)= K( 5)*X(2)*X(3)
      X(12)= K( 6)*X(4)*X(3)
      X(13)= K( 7)*X(4)*X(2)*X(3)
      X(14)= K( 8)*X(3)*X(5)
      X(15)= K( 9)*X(3)*X(6)
      X(16)= K(10)*X(1)/X(2)
      X(17)= K(11)*X(4)/X(2)
      X(18)= K(12)*(X(1)/X(2))**2
      X(19)= K(13)*X(2)*X(3)*X(6)
      X(20)= K(14)*X(3)*X(6)**2
      IF (NER.EQ.0.AND.KOUNT.GT.0) GO TO 10
      KOUNT=KOUNT+1
      IF (KOUNT.LE.10000) GO TO 5
      IF (MODE.LE.1) WRITE (10,1004)
   10 PLJ(II)=0.
      IF (MODE.LE.1) WRITE (10,1002) (X(I),I=1,4),(Y(I),I=1,4),TAU
      IF (MODE.LE.0) WRITE (12,2005) II,(X(I),I=1,4),(X(I),I=7,13)
      IF (MODE.LT.0) GO TO 12
      IF (KCL.LT.0.) GO TO 51
```

```
      PL1=-KCL*(73.52*(1.+.0193*(TR-25.))-76.35*(1.+.0202*(TR-25.)))
      PL2=-KCL*(73.52*(1.+.0193*(TR-25.))+76.35*(1.+.0202*(TR-25.)))
      PL3= 0.
      PL4= KCL*(73.52*(1.+.0193*(TR-25.))+76.35*(1.+.0202*(TR-25.)))
      DO 11 I=1,NSP
      IF (N(I).EQ.0) GO TO 11
      PL1=PL1+U(I)*(1.+DU(I)*(TR-25.))/N(I)*X(I)*ABS(N(I))
      PL2=PL2+U(I)*(1.+DU(I)*(TR-25.))*X(I)*ABS(N(I))
      PL3=PL3+U(I)*(1.+DU(I)*(TR-25.))*X(I)*ABS(N(I))
   11 CONTINUE
      PLJ(II)=0.08617*T*PL1/PL2*ALOG(PL3/PL4)
   51 TAU=TAU*TAU/2
      IF (NKJ.EQ.1) MISC(II,1)=TAU
      IF (NKJ.EQ.1) MISC(II,2)=X(1)*Y(1)
      YY(II)=ALOG(Y(IRD)*X(IRD)/Y(IOX)/X(IOX))
      IF (MODE.LT.3) S1=S1+(P(II)+PLJ(II))
      IF (MODE.LT.3) S2=S2+(P(II)+PLJ(II))**2
      IF (MODE.LT.3) S3=S3+YY(II)
      IF (MODE.LT.3) S4=S4+(P(II)+PLJ(II))*YY(II)
      E0=771.+1.19*(T-298.15)
      EI=E0-0.08617*T*YY(II)-P(II)-PLJ(II)
      BIAS=BIAS+EI
      IF (MODE.LT.3) ESQ=ESQ+EI**2
      IF (MODE.LT.3) GO TO 12
      IF (NKJ.EQ.1) GO TO 36
      KK(NKK)=SKK
      DO 35 I=1,NSP
   35 X(I)=SXX(I)
   36 GO TO (27,28,29) NKJ
   27 EM=EI
      ESQ=ESQ+EI**2
      S1=S1+(P(II)+PLJ(II))
      S2=S2+(P(II)+PLJ(II))**2
      S3=S3+YY(II)
      S4=S4+(P(II)+PLJ(II))*YY(II)
      DO 37 I=1,NSP
   37 SXX(I)=X(I)
      GO TO 30
   28 EL=EI
      GO TO 30
   29 EU=EI
   30 IF (NKJ.GT.1) GO TO 31
      NKK=NKK+1
      IF (NKK.GT.NKX) GO TO 12
      DE(II,NKK)=0.
      IF (SK(NKK).EQ.0.) GO TO 30
      SKK=KK(NKK)
   31 DO 40 I=1,6
   40 XF(I)=C(I)
      GO TO (32,33,34) NKJ
   32 NKJ=2
      KK(NKK)=KK(NKK)*(1.-ESP)
      GO TO 5
   33 IF (NOPT.GT.0) GO TO 38
      EU=2*EM-EL
      GO TO 34
   38 NKJ=3
      KK(NKK)=KK(NKK)*(1.+ESP)
      GO TO 5
   34 DL=(EM-EL)/KK(NKK)/ESP
      DH=(EU-EM)/KK(NKK)/ESP
      DI=(DL+DH)/2
      DE(II,NKK)=DI
```

```
      D2=(DH-DL)/KK(NKK)/ESP
      IF (NOPT.LT.2) D2=0.
      DE2(NKK,NKK)=DE2(NKK,NKK)+2*D2
      D1E(NKK)=D1E(NKK)+2*EH*D1
      D2E(NKK)=D2E(NKK)+2*(D1**2+D2)
      NKJ=1
      GO TO 30
12    DO 39 I=1,7
      IF (NTYP.GT.0) GO TO 39
      IF (KK(I).EQ.0.) GO TO 39
      IF (K(I).EQ.0.) GO TO 39
      KST(II,I)=ALOG10(K(I)/KK(I))
39    CONTINUE
      CLOSE 2
      IIMAX=II
      BIAS=BIAS/IIMAX
      DO 41 J=1,NRX
      DO 41 L=1,NRX
      IF (L.NE.J) DE2(J,L)=0.
      DO 41 II=1,IIMAX
41    DE2(J,L)=DE2(J,L)+2*DE(II,J)*DE(II,L)
      T1=T-273.15
      IF (MODE.LE.0) WRITE (12,2006) T1
      IF (MODE.LE.0) WRITE (12,2007) (I,KK(I),I=1,NRX)
      IF (MODE.LT.0) GO TO 14
      IF (MODE.EQ.0) WRITE (12,1999)
      IF (MODE.EQ.0) WRITE (12,2000)
      IF (MODE.EQ.0) WRITE (12,2001)
      B=(B1*B3-IIMAX*B4)/(B1**2-IIMAX*B2)
      A=(B3-B*B1)/IIMAX
      B=1/B
      A=-A*B
      IF (MODE.LE.1) WRITE (10,1003)
      ER1=0.
      ER2=0.
      ER3=0.
      E1R=0.
      E2R=0.
      DO 13 II=1,IIMAX
      POTL=A+B*YY(II)
      PPP=P(II)+PLJ(II)
      PTL=E0-8.3144*T/96.487*YY(II)
      PPL=PTL-BIAS
      E1R=E1R+(POTL-PPP)**2
      E2R=E2R+(PPL-PPP)**2
      IF (ABS(POTL-PPP).GT.ER1) ER1=ABS(POTL-PPP)
      IF (ABS(PPL-PPP).GT.ER2) ER2=ABS(PPL-PPP)
      IF (ABS(PTL-PPP).GT.ER3) ER3=ABS(PTL-PPP)
      IF (MODE.LE.1) WRITE (3,1008) YY(II),PPP,POTL,PPL,PTL
      IF (MODE.LE.1) WRITE (4,2011) MISC(II,1),(KST(II,I),I=1,7)
      IF (MODE.LE.1) WRITE (10,1005) PPP,POTL,PPL,PTL
      IF (MODE.LE.0) WRITE (12,2002) II,P(II),PLJ(II),PPP,YY(II),POTL,PPL,PTL,MISC(II,1)
13    CONTINUE
      IF (MODE.LE.0) ESD=SQRT(ESQ/IIMAX)
      IF (MODE.LE.0) E1R=SQRT(E1R/IIMAX)
      IF (MODE.LE.0) E2R=SQRT(E2R/IIMAX)
      IF (MODE.LE.1) CLOSE 3
      B1=-8.3144*T/96.487
      EA=E0-BIAS
      IF (MODE.LE.0) WRITE (12,2012) A,B,E1R,ER1,EA,B1,E2R,ER2,E0,B1,ESD,ER3
      A=A-E0
      B=B1/B
      IF (MODE.LE.1) WRITE (10,1006) A,B
```

```
      IF (MODE.LE.1) GO TO 14
      IF (MODE.LT.3) WRITE (10,1009) ESQ,A,B
      IF (MODE.LT.3) GO TO 18
      CALL KSTEP (SK,D1E,DE2,KS,ESP)
      TEST=0.
      NTEST=0
      DO 15 J=1,NRX
      IF (SK(J).EQ.0.) GO TO 15
      IF (KK(J).EQ.0..AND.KS(J).LT.0.) GO TO 22
      IF (ABS(KS(J)/KK(J)).LE.ABS(TEST)) GO TO 22
      TEST=KS(J)/KK(J)
      NTEST=J
   22 IF ((KS(J)*SK(J)).LT.0.) SK(J)=-SK(J)/2
      IF ((KS(J)/SK(J)).GT.1.) KS(J)= SK(J)
   15 CONTINUE
 9999 FORMAT (1X,"ERR =",F6.1,5X,"A =",F6.1,5X,"B =",F6.2,10X,
     1           "TEST =",F10.4,3X,"(",I2,")")
      QSE=SQRT(ESQ/IIMAX)
      WRITE (10,9999) QSE,A,B,TEST,NTEST
      IF (ABS(TEST).GT.(ESP/10)) GO TO 16
      MODE=0
      GO TO 19
   16 DO 17 J=1,NRX
      IF (SK(J).EQ.0.) GO TO 17
      KK(J)=KK(J)+KS(J)
      IF (KK(J).GE.0.) GO TO 17
      KK(J)=0.
   17 CONTINUE
      ITER=ITER+1
      IF (ITER.LE.MAXIT) GO TO 19
      MODE=0
      GO TO 19
   18 READ FREE (11) MODE
      IF (MODE.GT.0) GO TO 1
      IF (MODE.EQ.0) GO TO 14
      IF (MODE.EQ.-1) MODE=0
      IF (MODE.EQ.0) GO TO 19
      MODE=-MODE
      READ FREE (11) M
      IF (M.GT.0) READ FREE (11) (I,KK(I),J=1,M)
   19 OPEN 2,"PDATA"
      READ FREE (2) BETA
      READ FREE (2) NSET,T
      IF (MODE.LT.3) READ FREE (2) NSET,T,MAXIT,NOPT,ESP
      IF (MODE.GE.3) READ FREE (2) (DUMMY,J=1,NRX)
      IF (NSET.LT.0) READ FREE (2) NSET=-NSET
      IF (NSET.LT.0) NSET=-NSET
      T=T+273.15
      IF (MODE.NE.3) GO TO 2
      DO 50 I=1,NSP
   50 SK(J)=KK(J)
      GO TO 2
   14 CLOSE 4
      OPEN 4,"F1"
      WRITE BINARY (4) IIMAX,((XST(II,I),I=1,NSP),II=1 IIMAX)
      CLOSE 4
      STOP
 1000 FORMAT (///,5X,27HUNCOMPLEXED CONCENTRATIONS ,12X,
     1       21HACTIVITY COEFFICIENTS,10X,3HTAU,/,5X, 26(1H*),13X,21(1H*)
     2       ,10X,3(1H*),/)
 1001 FORMAT (   4X,6HFE(3+),5X,4HH(+),4X,7HSO4(2-),4X,6HFE(2+),
     1           2X,6HFE(3+),2X,4HH(+),1X,7HSO4(2-),1X,6HFE(2+),/)
 1002 FORMAT (4F10.6,4F7.3,F10.2)
 1003 FORMAT (//,34HCALCULATED VS. MEASURED POTENTIALS,/,34(1H*),//,
```

```
        8HMEASURED,5X,9HSTR. LINE,5X,11HNERNST EQN.,5X,11HNERNST EQN.,/
     1  ,27X,11H EMPIRICAL ,5X,11HTHEORETTCAL,/)
     2
 1004 FORMAT (23HMAX ITERATIONS EXCEEDED)
 1005 FORMAT (F6.1,F14.1,F15.1,F14.1,F14.1)
 1006 FORMAT (//,18HNERNST INTERCEPT =,F10.2,//,
              18HNERNST SLOPE     =,F10.2)
     1
 1007 FORMAT (I2," 0 0")
 1008 FORMAT (F10.4,4F10.2)
 1009 FORMAY (/,5HESO =,1PE10.3,5X,3HA =,0PF6.1,5X,3HB =,0PF6.2)
 1010 FORMAT (8F10.7)
 1999 FORMAT (1H1,/////)
 2000 FORMAT (1H0,50HPREDICTED AND CALCULATED SOLUTION REDOX POTENTIALS
               ,/,1X,50(1H*))
     1
 2001 FORMAT (1H0,"POINT",2X," MEASURED ",2X ," LIQ. JN. ",2X," CORRECTED",
              2X,"LN(ACT. RATIO)",2X," BEST LINE ",2X,"NERNST EQN.",
     1        2X,"NERNST EQN.",4X,"IONIC",/,
     2        73X,"(EMPIRICAL) (THEORETICAL)  STRENGTH",/)
     3
 2002 FORMAT (1H ,I4,F10.0,F11.0,F14.0,F14.3,F14.0,F13.0,F13.0,F12.2)
 2003 FORMAT (1H0,40HCONCENTRATIONS IN SOLUTION, GMOLES/LITRE,/,
               1X,40(1H*))
     1
 2004 FORMAT (1H0,5HPOINT,5X,6HFE(3+),7X,2HH+,6X,7HSO4(2-),5X,
               6HFE(2+),2X,9HFEHSO4SO4,1X,10HFEHSO4(2+),2X,
     1         9HFESO4SO4-,5X,6HFESO4+,6X,5HHSO4-,6X,
     2         5HFESO4,4X,7HFEHSO4+,/)
     3
 2005 FORMAT (1H ,I5,11F11.4)
 2006 FORMAT (1H0,36HVALUES OF EQUILIBRIUM CONSTANTS USED,/,
              1H ,36(1H*),/,1H0,13HTEMPERATURE :,F4.0,5HDEG C,/)
     1
 2007 FORMAY (1H ,8HREACTION,I3,2H :,1PE12.3)
 2008 FORMAT (1H0,"SUM OF SQUARED DIFFERENCES    :",F5.0)
 2011 FORMAT (8F9.3)
 2012 FORMAT (//," EQUATIONS FITTED TO THE EXPERIMENTAL RESULTS :",
            //,34X,"INTERCEPT,",5X,"  SLOPE,   ",5X,"AVE. ERROR",5X,"MAX. ERROR",
     1       /,34X,"MILLIVOLTS",5X,"MILLIVOLTS",5X,"MILLIVOLTS",5X,"MILLIVOLTS",
     2      //," BEST STRAIGHT LINE              :",F12.1,F15.2,F14.1,F15.1,
     3      //," EMPIRICAL NERNST EQUATION   :",F12.1,F15.2,F14.1,F15.1,
     4      //," THEORETICAL NERNST EQUATION :",F12.1,F15.2,F14.1,F15.1)
     4
      END
```

```
      PARAMETER NT=2,ND=25
      SUBROUTINE REFER (II,TR,PR,KCL)
      REAL T(NT,ND),P(NT,ND),KCL
      INTEGER N(NT)/16,25/
      DATA (T(1,J),P(1,J),J=1,16)/
     1        0,.2601,  5,.2568, 10,.2536, 15,.2503, 20,.2471,
     2       25,.2438, 30,.2405, 35,.2373, 40,.2340, 45,.2308,
     3       50,.2275, 60,.2199, 70,.2124, 80,.2047, 90,.1967,
     4      100,.1885/
      DATA (T(2,J),P(2,J),J=1,25)/
     1        0,.2365,  5,.2340, 10,.2314, 15,.2285, 20,.2256,
     2       25,.2224, 30,.2192, 35,.2157, 38,.2136, 40,.2121,
     3       45,.2083, 50,.2044, 55,.2004, 60,.1963, 70,.1878,
     4       80,.1787, 90,.1695, 95,.1651,125,.1330,150,.1032,
     5      175,.0708,200,.0348,225,-.0051,250,-.054,275,-.09/
      I=ABS(II)
      IF (I.LT.1) GO TO 3
      IF (I.GT.2) GO TO 3
      IF (I.EQ.1) KCL=4.2
      IF (I.EQ.2) KCL=3.0
      NN=N(I)
      DO 1 J=1,NN
        IF (TR.LE.T(I,J)) GO TO 2
    1   CONTINUE
    2 PR=P(I,J-1)+(TR-T(I,J-1))*(P(I,J)-P(I,J-1))/(T(I,J)-T(I,J-1))
      PR=PR*100.
      GO TO 4
    3 PR=0.
      KCL=0.0
    4 IF (II.GE.0) GO TO 5
      KCL=-1.0
    5 RETURN
      END
```

```
      SUBROUTINE MATRX (SK,DE2,D1E,D2E,DE,NK,M,N)
      REAL SK(N),D2E(N,N),D1E(N),DE2(N,N),DE(N)
      INTEGER NK(N)
      DO 1 J=1,N
      DE(J)=0.
      DO 1 L=1,N
    1 D2E(J,L)=0.
      NKJ=0
      NKK=0
      DO 2 J=1,N
      IF (DE2(J,J).NE.0.) NKJ=NKJ+1
      IF (DE2(J,J).EQ.0.) NKK=NKK+1
      IF (DE2(J,J).NE.0.) NK(NKJ)=NKK
    2 CONTINUE
      M=N-NKK
      DO 3 J=1,M
      NJ=NK(J)
      DE(J)=D1E(NJ+J)
      DO 3 L=1,M
      NL=NK(L)
    3 D2E(J,L)=DE2(J+NJ,L+NL)
      RETURN
      END
```

```
      SUBROUTINE MATRX (SK,DE2,D1E,D2E,DE,NK,M,N)
      REAL SK(N),D2E(N,N),D1E(N),DE2(N,N),DE(N)
      INTEGER NK(N)
      DO 1 J=1,N
      DE(J)=0.
      DO 1 L=1,N
    1 D2E(J,L)=0.
      NKJ=0
      NKK=0
      DO 2 J=1,N
      IF (DE2(J,J).NE.0.) NKJ=NKJ+1
      IF (DE2(J,J).EQ.0.) NKK=NKK+1
      IF (DE2(J,J).NE.0.) NK(NKJ)=NKK
    2 CONTINUE
      M=N-NKK
      DO 3 J=1,M
      NJ=NK(J)
      DE(J)=D1E(NJ+J)
      DO 3 L=1,M
      NL=NK(L)
    3 D2E(J,L)=DE2(J+NJ,L+NL)
      RETURN
      END
```

```
      SUBROUTINE GAUSS (D2E,D1E,M,DK,ND,W,N)
      REAL D2E(N,N),D1E(N),DK(N),W(N)
      INTEGER ND(N)
      DO 1 J=1,M
      DK(J)=-D1E(J)
    1 ND(J)=J
      DO 8 I=1,M
      TEST=0.
      NTST=0
      DO 2 J=I,M
      IF (ABS(D2E(J,I)).LE.ABS(TEST)) GO TO 2
      TEST=D2E(J,I)
      NTST=J
    2 CONTINUE
      IF (NTST.EQ.I) GO TO 4
      DO 3 J=1,M
      W(J)=D2E(I,J)
      D2E(I,J)=D2E(NTST,J)
    3 D2E(NTST,J)=W(J)
      NW=ND(I)
      ND(I)=ND(NTST)
      ND(NTST)=NW
      WK=DK(I)
      DK(I)=DK(NTST)
      DK(NTST)=WK
    4 DK(I)=DK(I)/D2E(I,I)
      DO 5 J=M,I,-1
    5 D2E(I,J)=D2E(I,J)/D2E(I,I)
      I1=I+1
      IF (I1.GT.M) GO TO 8
      DO 6 L=I1,M
      DK(L)=DK(L)-DK(I)*D2E(L,I)
      DO 6 J=M,I,-1
    6 D2E(L,J)=D2E(L,J)-D2E(I,J)*D2E(L,I)
    8 CONTINUE
      DO 9 I=M,2,-1
      DO 9 J=M,I,-1
    9 DK(I-1)=DK(I-1)-D2E(I-1,J)*DK(J)
      RETURN
      END
```

```
      PARAMETER NRX=14
      SUBROUTINE KSTEP (SK,D1E,DE2,KS,ESP)
      INTEGER NK(NRX),ND(NRX)
      REAL DE2(NRX,NRX),D2E(NRX,NRX),D2(NRX,NRX)
      REAL D1E(NRX),SK(NRX),KS(NRX),DE(NRX)
      REAL W(NRX),R(NRX),E(NRX)
      CALL MATRX (SK,DE2,D1E,D2E,DE,NK,MRX,NRX)
      MODE=1
    1 DO 2 J=1,MRX
      DO 2 L=1,MRX
    2 D2(J,L)=D2E(J,L)
      GO TO (3,7) MODE
    3 CALL GAUSS (D2,DE,MRX,KS,ND,W,NRX)
    4 DO 5 J=1,MRX
    5 R(J)=DE(J)
      DO 6 J=1,MRX
      DO 6 L=1,MRX
    6 R(J)=R(J)+D2E(J,L)*KS(L)
      MODE=2
      GO TO 1
    7 CALL GAUSS (D2,R,MRX,E,ND,W,NRX)
      DO 8 J=1,MRX
    8 KS(J)=KS(J)+E(J)
      NTEST=0
      DO 9 J=1,MRX
      IF (ABS(E(J)).GT.ABS(ESP*KS(J))) NTEST=NTEST+1
    9 CONTINUE
      IF (NTEST.GT.0) GO TO 4
      CALL KEXTR (KS,NK,W,MRX,NRX)
      RETURN
      END
```

```
      SUBROUTINE KEXTR (DK,NK,W,M,N)
      REAL DK(N),W(N)
      INTEGER NK(N)
      DO 1 J=1,M
    1 W(J)=DK(J.
      DO 2 J=1,N
    2 DK(J)=0.
      DO 3 J=1,M
      I=NK(J)
    3 DK(I+J)=W(J)
      RETURN
      END
```

AOS FORTRAN 5, VERSION 6.15 == WEDNESDAY, JANUARY 19, 1983 12:33:42 PM

EIFIT.FR

```
C********************************************************************
C                                                                   *
C      COMPUTER PROGRAM FOR FITTING THE LEACHING MODEL PREDICTION   *
C      TO THE ELECTROCHEMICAL MEASUREMENT DATA                      *
C                                                                   *
C********************************************************************
C
C
C
C
       REAL V(20),E(20),I(20),I0,II,K
       REAL I1,K1(4,3),K2(4,3),AK(3)
       INTEGER NK(4)
       READ FREE (11) (AK(J),J=1,3)
       READ FREE (11) (NK(J),J=1,4)
       DO 1 M=1,4
       LL=NK(M)
       READ FREE (11) (K1(M,L),K2(M,L),L=1,LL)
     1 CONTINUE
       READ FREE (11) N,(V(J),I(J),J=1,N),R,ELJ1,ELJ2,I0,K,A,EPS,MAX
       READ FREE (11) EHI,ELO
       DO 2 J=1,N
       E(J)=V(J)-R*I(J)+ELJ1
     2 CONTINUE
       SK=K/10.
       SI=I0/10.
       KOUNT=0
       NA=0
       SA=A
     3 ESQ=0.
```

```
      D1K=0.
      D2K=0.
      D1I=0.
      D2I=0.
      DO 4 J=1,N
      II=I0*EXP(K*E(J))
      EJ=II-I(J)
      DK1=II*E(J)
      DK2=II*E(J)**2
      DI1=EXP(K*E(J))
      ESQ=ESQ+EJ**2
      D1K=D1K+2*EJ*DK1
      D2K=D2K+2*(DK1**2+EJ*DK2)
      D1I=D1I+2*EJ*DI1
    4 D2I=D2I+2*DI1**2
      IF (ABS(D1I).LT.ABS(EPS*D2I)) GO TO 5
      GO TO 6
    5 IF (ABS(D1K).LT.ABS(EPS*D2K)) GO TO 7
    6 DK=-D1K/ABS(D2K)
      DI=-D1I/ABS(D2I)
      IF ((DK*SK).LT.0.) SK=-SK/2
      IF ((DI*SI).LT.0.) SI=-SI/2
      IF ((DK/SK).GT.1.) DK= SK
      IF ((DI/SI).GT.1.) DI= SI
      K=K+DK
      I0=I0+DI
      SK=DK
      SI=DI
      KOUNT=KOUNT+1
```

```
      IF (KOUNT.LE.MAX) GO TO 3
      WRITE (10,1004)
    7 IF (NA.NE.0) OPEN 12,"@LPT",ATT="P"
      IF (NA.NE.0) WRITE (12,2000)
      IF (NA.NE.0) WRITE (10,1000)
      IF (NA.NE.0) OPEN 2,"OUT"
      IF (NA.NE.0) WRITE (2,1001)
      ERS=0.
      D1E=0.
      D2E=0.
      DO 9 J=1,N
      II=I0*EXP(K*E(J))
      I1=0.
      D1=0.
      DO 8 M=1,4
      LL=NK(M)
      DO 8 L=1,LL
      D1=D1+3216233.33*AK(L)*K1(M,L)*EXP(K2(M,L)*(E(J)-ELJ2))
    8 I1=I1+3216233.33*AK(L)*A*K1(M,L)*EXP(K2(M,L)*(E(J)-ELJ2))
      IF (NA.NE.0) WRITE (10,1002) E(J),I(J),II,I1
      IF (NA.NE.0) WRITE (12,2001) E(J),I(J),II,I1
      IF (NA.NE.0) [illegible]E (2,1002) E(J),I(J),II,I1
      IF (E(J).LT.E[illegible]) GO TO 9
      IF (E(J).GT.EHI) GO TO 9
      ERS=ERS+(I1-I(J))**2
      D1E=D1E+2*(I1-I(J))*D1
      D2E=D2E+2*D1**2
    9 CONTINUE
      IF (NA.NE.0) GO TO 11
      IF (ABS(D1E/D2E).LT.(ERS*EPS)) GO TO 10
      DA=-D1E/D2E
      IF (ABS(DA).LT.(0.001*A)) GO TO 10
      IF ((DA*SA).LT.0.) SA=-SA/2
      IF ((DA/SA).GT.1.) DA= SA
```

```
      A=A+DA
      SA=DA
      KOUNT=KOUNT+1
      IF (KOUNT.LE.MAX) GO TO 7
      WRITE (10,1004)
      GO TO 11
 10   NA=1
      GO TO 7
 11   WRITE (10,1003) ESQ,ERS,IO,K
      WRITE (12,2002) A,IO,K
      WRITE (10,1005) A
      CLOSE 2
      STOP
 1000 FORMAT (///,29HPREDICTED VS MEASURED RESULTS,/,29(1H*),///,
     1            10HPOTENTIAL,,10X,32HCURRENT DENSITY, MILLIAMPS/SQ.CM,
     2        /,10HMILLIVOLTS,/,20X,8HMEASURED,14X,10HCALCULATED,
     3        12X,8HMODELLED,//)
 1001 FORMAT (5H3 0 0)
 1002 FORMAT (F7.0,F19.1,F23.1,F20.1)
 1003 FORMAT (///,5HESQ =,2F10.2,///,5HIO  =,1PE12.3,//,5HK   =,1PE12.3)
 1004 FORMAT (23HMAX ITERATIONS EXCEEDED)
 1005 FORMAT (/,6HAREA =,F10.1,2X,"SQUARE CENTIMETERS")
 2000 FORMAT (1H0,29HPREDICTED VS MEASURED RESULTS,/,1X,29(1H*),/,
     1       1H0,10HPOTENTIAL,,14X,24HCURRENT, MILLIAMPS/SQ.CM,/,
     2       1H ,10HMILLIVOLTS,/,
     3       1H ,20X,8HMEASURED,14X,10HCALCULATED,12X,8HMODELLED,//)
 2001 FORMAT (1H ,F7.0,F19.1,F23.1,F20.1)
 2002 FORMAT (1H0,"AREA          = ",F10.1,2X,"SQUARE CENTIMETERS",/,
     1       1H0,"CONSTANT IO = ",1PE12.3,/,
```

```
    2          1H0,"CONSTANT   K = ",1PE12.3,/,
    3          1H0,"CURRENT = 10*EXP(K*POTENTIAL)")
                END
```

FRNFIT.FR

```
C*********************************************************************
C                                                                    *
C      COMPUTER PROGRAM FOR THE CALCULATION OF THE COMPOSITI. OF     *
C      THE INDIVIDUAL PHASES IN THE MATTE, AND THE DISTRIBUTION      *
C      OF THE NICKEL, COPPER, COBALT AND IRON BETWEEN THE PHASES     *
C      FOR EACH PARTICLE SIZE FRACTION USED.                         *
C                                                                    *
C*********************************************************************
C
C
C
C
      PARAMETER N=6
      REAL A(N),T(N),S(N),F(N),M(N)
      OPEN 2, "FRNDAT"
      READ FREE (2) NF,(F(I),A(I),T(I),S(I),M(I),I=1,NF)
      READ FREE (2) DA,DT,DS,DM
      READ FREE (2) X,XMAX,XMIN,DXM
      READ FREE (2) Y,YMAX,YMIN,DYM
      READ FREE (2) Z,ZMAX,ZMIN,DZM
      READ FREE (2) W,WMAX,WMIN,DWM
      READ FREE (2) EPS
      CLOSE 2
      D2X=0.
      D2Y=0.
      D2Z=0.
      D2W=0.
      DO 1 I=1,NF
      SUM=A(I)*DA+T(I)*DT+S(I)*DS+M(I)*DM
      A(I)=A(I)*DA/SUM
```

```
      T(I)=T(I)*DT/SUM
      S(I)=S(I)*DS/SUM
      M(I)=M(I)*DM/SUM
      D2X=D2X+2*A(I)**2
      D2Y=D2Y+2*T(I)**2
      D2W=D2W+2*M(I)**2
    1 D2Z=D2Z+2*S(I)**2
      KOUNT=0
      K=0
      NN=1
    2 ESQ=0.
      DEX=0.
      DEY=0.
      DEZ=0.
      DEW=0.
      DO 3 I=1,NF
      E=F(I)-A(I)*X-T(I)*Y-S(I)*Z-M(I)*W
      ESQ=ESQ+E*E
      DEX=DEX-2*A(I)*E
      DEY=DEY-2*T(I)*E
      DEW=DEW-2*M(I)*E
    3 DEZ=DEZ-2*S(I)*E
      DX=DEX/D2X
      DY=DEY/D2Y
      DZ=DEZ/D2Z
      DW=DEW/D2W
      IF (ABS(DX).GT.DXM) DX=DX*ABS(DXM/DX)
      IF (ABS(DY).GT.DYM) DY=DY*ABS(DYM/DY)
      IF (ABS(DZ).GT.DZM) DZ=DZ*ABS(DZM/DZ)
```

```
      IF (ABS(DW).GT.DWM) DW=DW*ABS(DWM/DW)
      IF ((X-DX).LT.XMIN) DX=X-XMIN
      IF ((X-DX).GT.XMAX) DX=XMAX-X
      IF ((Y-DY).LT.YMIN) DY=Y-YMIN
      IF ((Y-DY).GT.YMAX) DY=YMAX-Y
      IF ((Z-DZ).LT.ZMIN) DZ=Z-ZMIN
      IF ((Z-DZ).GT.ZMAX) DZ=ZMAX-Z
      IF ((W-DW).LT.WMIN) DW=W-WMIN
      IF ((W-DW).GT.WMAX) DW=WMAX-W
      IF (ABS(DX).GT.EPS.AND.DXM.NE.0.) GO TO 4
      IF (ABS(DY).GT.EPS.AND.DYM.NE.0.) GO TO 4
      IF (ABS(DZ).GT.EPS.AND.DZM.NE.0.) GO TO 4
      IF (ABS(DW).GT.EPS.AND.DWM.NE.0.) GO TO 4
      GO TO 5
    4 X=X-DX/NN
      Y=Y-DY/NN
      Z=Z-DZ/NN
      W=W-DW/NN
      KOUNT=KOUNT+1
      K=K+1
      IF (K.LT.100) GO TO 2
      NN=NN*2
      K=1
      IF (KOUNT.LT.1000) GO TO 2
      WRITE (10,1001)
 1001 FORMAT (22HSOLUTION NOT CONVERGED)
    5 WRITE (10,1002) X,Y,Z,W,ESQ
 1002 FORMAT (///,18HPHASE COMPOSITIONS,/,18(1H*),//,
     1               3HX =,F10.3,/,3HY =,F10.3,/,3HZ =,F10.3,/,
     2               3HW =,F10.3,//,5HESQ =,1PE10.3)
 1003 FORMAT (//,27HCALCULATED FRN COMPOSITIONS,/,27(1H*),//,
     1           3HFRN,8X,10HMASS % (C),5X,10HMASS % (M),/)
 1004 FORMAT (//33HPERCENTAGE DISTRIBUTION IN PHASES,/,33(1H*),//,
     1          9X, 9H    ALLOY,6X,9H TROILITE,6X,9H SULPHIDE,
```

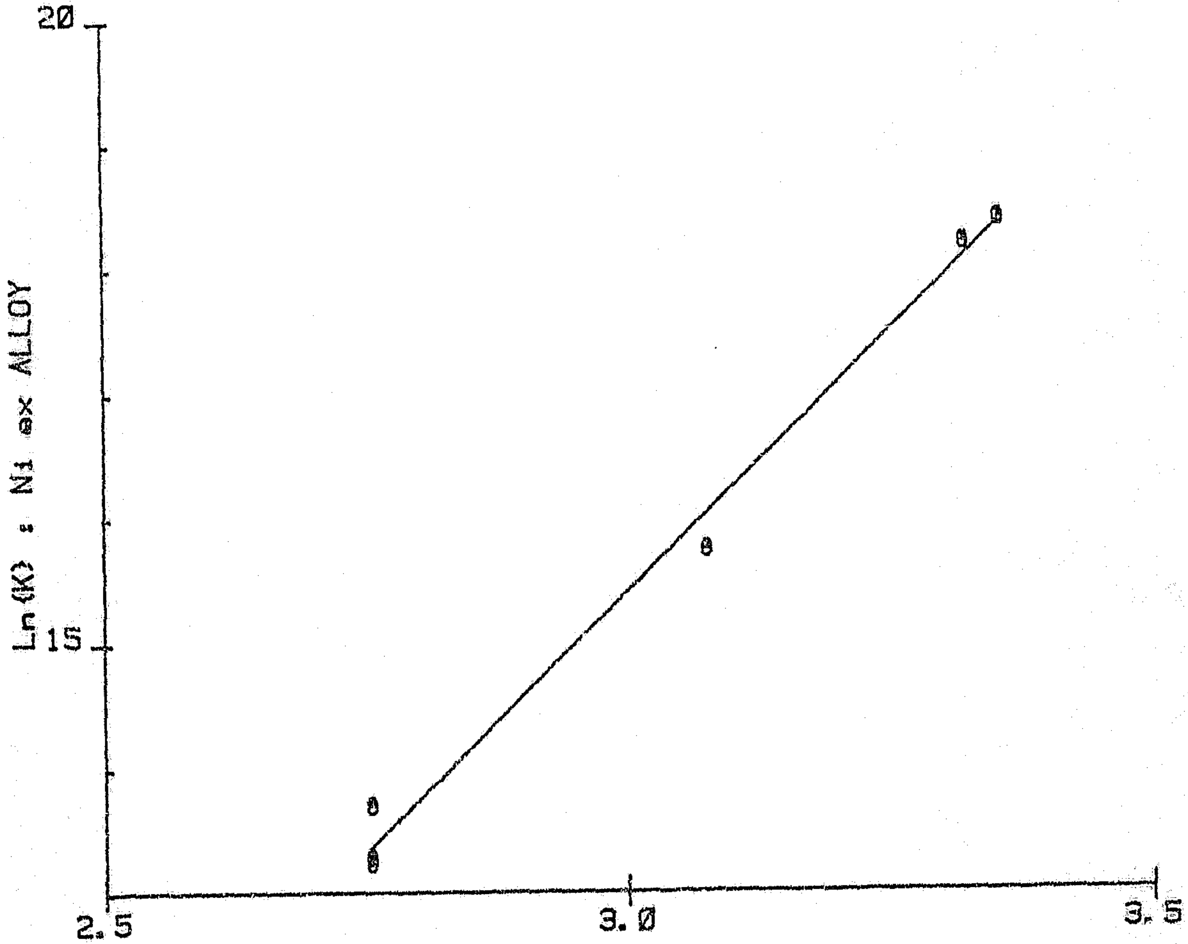
```
     2              6X,9HMAGNETITE,/)
1005 FORMAT (I3,4F15.2)
     WRITE (10,1003)
     DO 6 I=1,NF
     E=A(I)*X+T(I)*Y+S(I)*Z+M(I)*W
     WRITE (10,1005) I,E,F(I)
   6 CONTINUE
     WRITE (10,1004)
     DO 7 I=1,NF
     E=A(I)*X+T(I)*Y+S(I)*Z+M(I)*W
     PX=100*A(I)*X/E
     PY=100*T(I)*Y/E
     PZ=100*S(I)*Z/E
     PW=100*M(I)*W/E
     WRITE (10,1005) I,PX,PY,PZ,PW
   7 CONTINUE
     STOP
     END
```

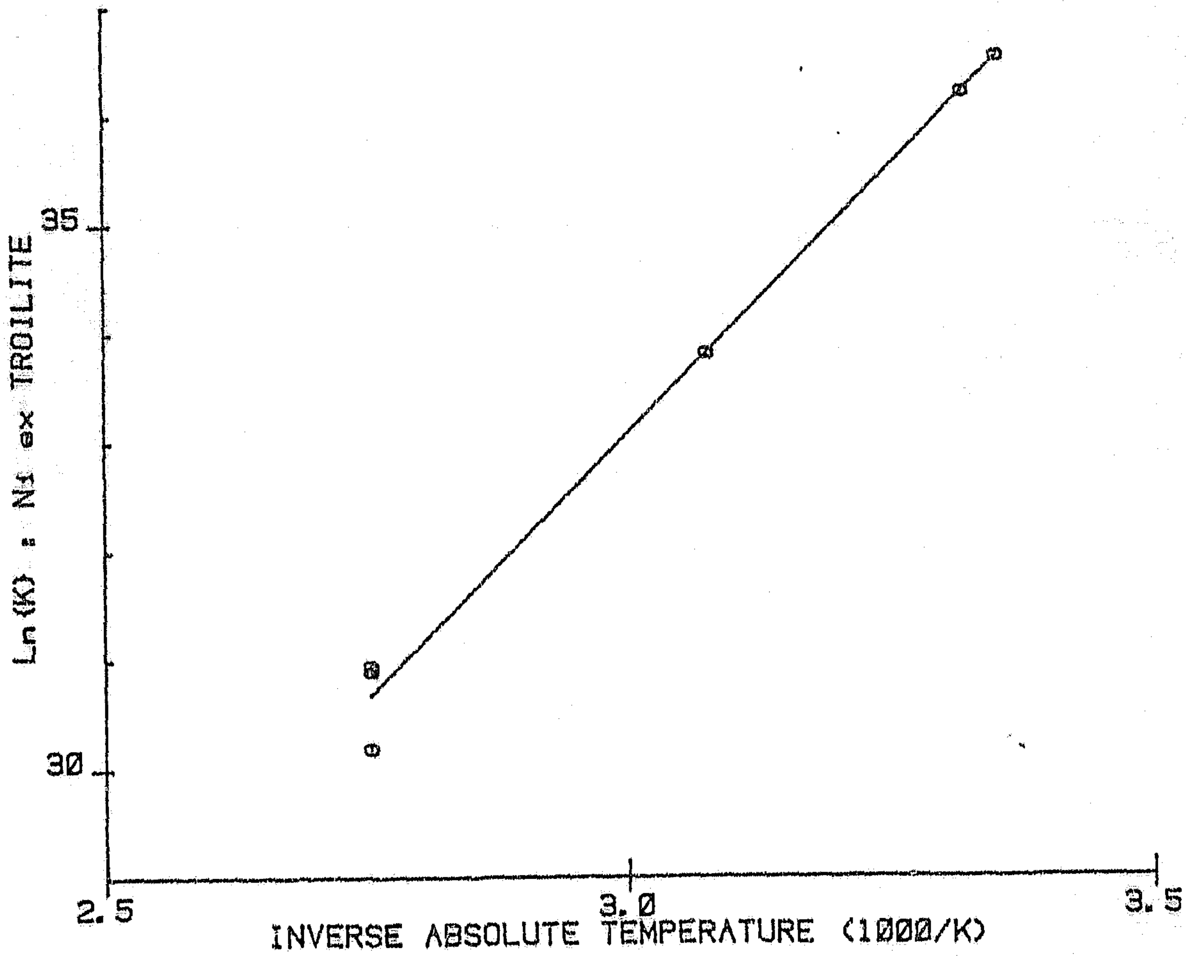
```
     2               6X,9HMAGNETITE,/)
1005 FORMAT (I3,4F15.2)
     WRITE (10,1003)
     DO 6 I=1,NF
     E=A(I)*X+T(I)*Y+S(I)*Z+M(I)*W
     WRITE (10,1005) I,E,F(I)
   6 CONTINUE
     WRITE (10,1004)
     DO 7 I=1,NF
     E=A(I)*X+T(I)*Y+S(I)*Z+M(I)*W
     PX=100*A(I)*X/E
     PY=100*T(I)*Y/E
     PZ=100*S(I)*Z/E
     PW=100*M(I)*W/E
     WRITE (10,1005) I,PX,PY,PZ,PW
   7 CONTINUE
     STOP
     END
```

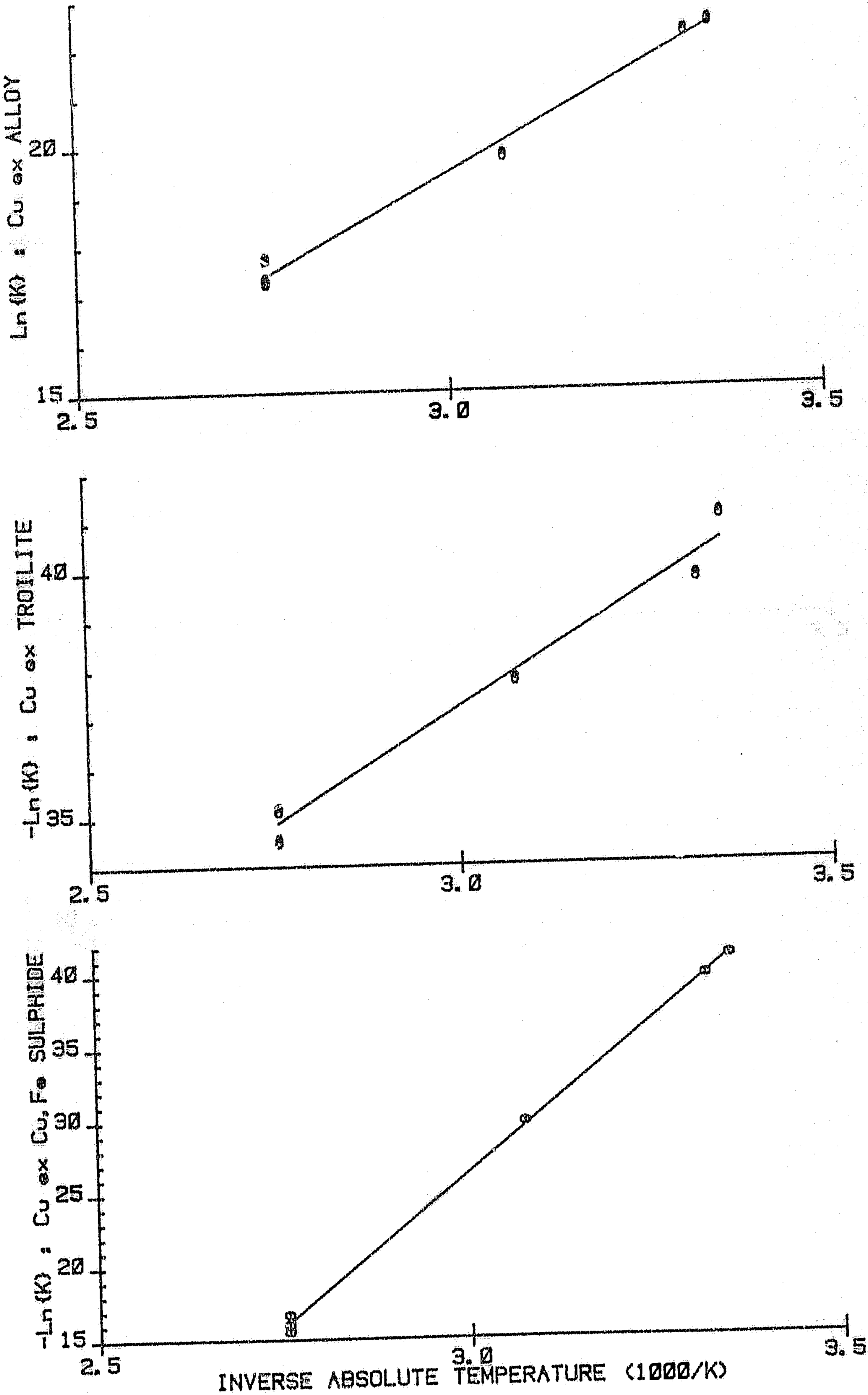
```
     2              6X,9HMAGNETITE,/)
1005 FORMAT (I3,4F15.2)
     WRITE (10,1003)
     DO 6 I=1,NF
     E=A(I)*X+T(I)*Y+S(I)*Z+M(I)*W
     WRITE (10,1005) I,E,F(I)
   6 CONTINUE
     WRITE (10,1004)
     DO 7 I=1,NF
     E=A(I)*X+T(I)*Y+S(I)*Z+M(I)*W
     PX=100*A(I)*X/E
     PY=100*T(I)*Y/E
     PZ=100*S(I)*Z/E
     PW=100*M(I)*W/E
     WRITE (10,1005) I,PX,PY,PZ,PW
   7 CONTINUE
     STOP
     END
```

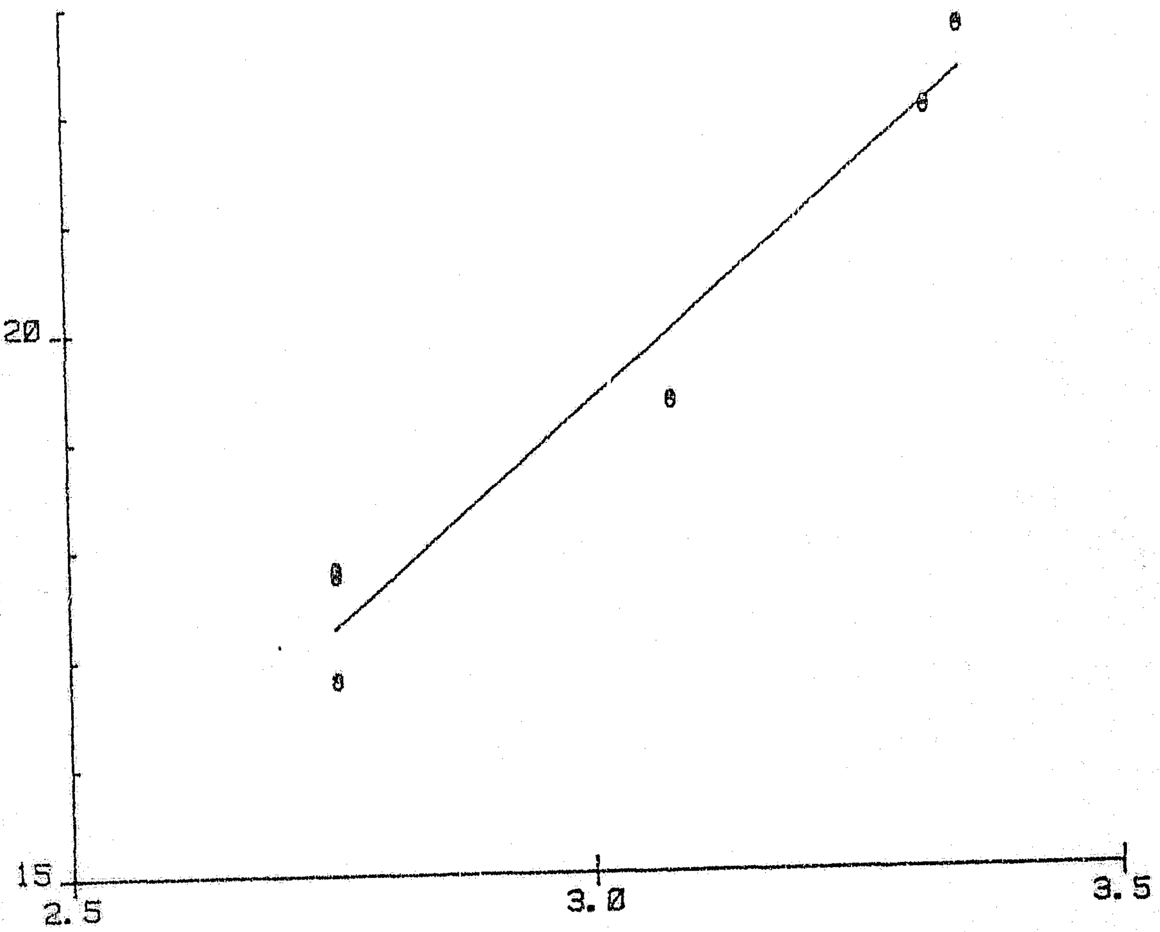
APPENDIX XI

Graphs showing the effect of temperature on the leaching rate constant

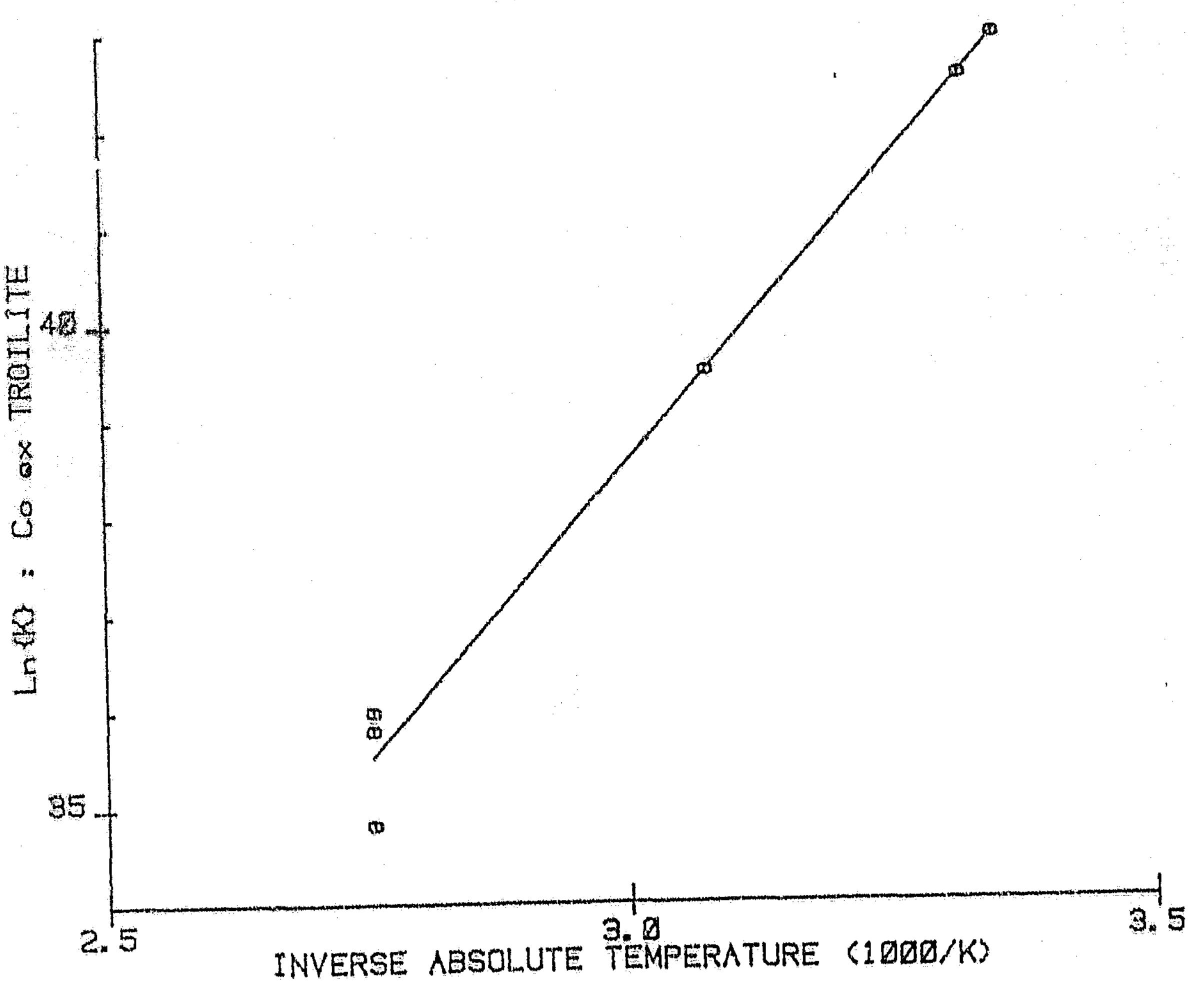

20
15
Ln(K) : Ni ex ALLOY
2.5
3.0
3.5


35
30
Ln(K) : Ni ex TROILITE
2.5
3.0
3.5
INVERSE ABSOLUTE TEMPERATURE (1000/K)

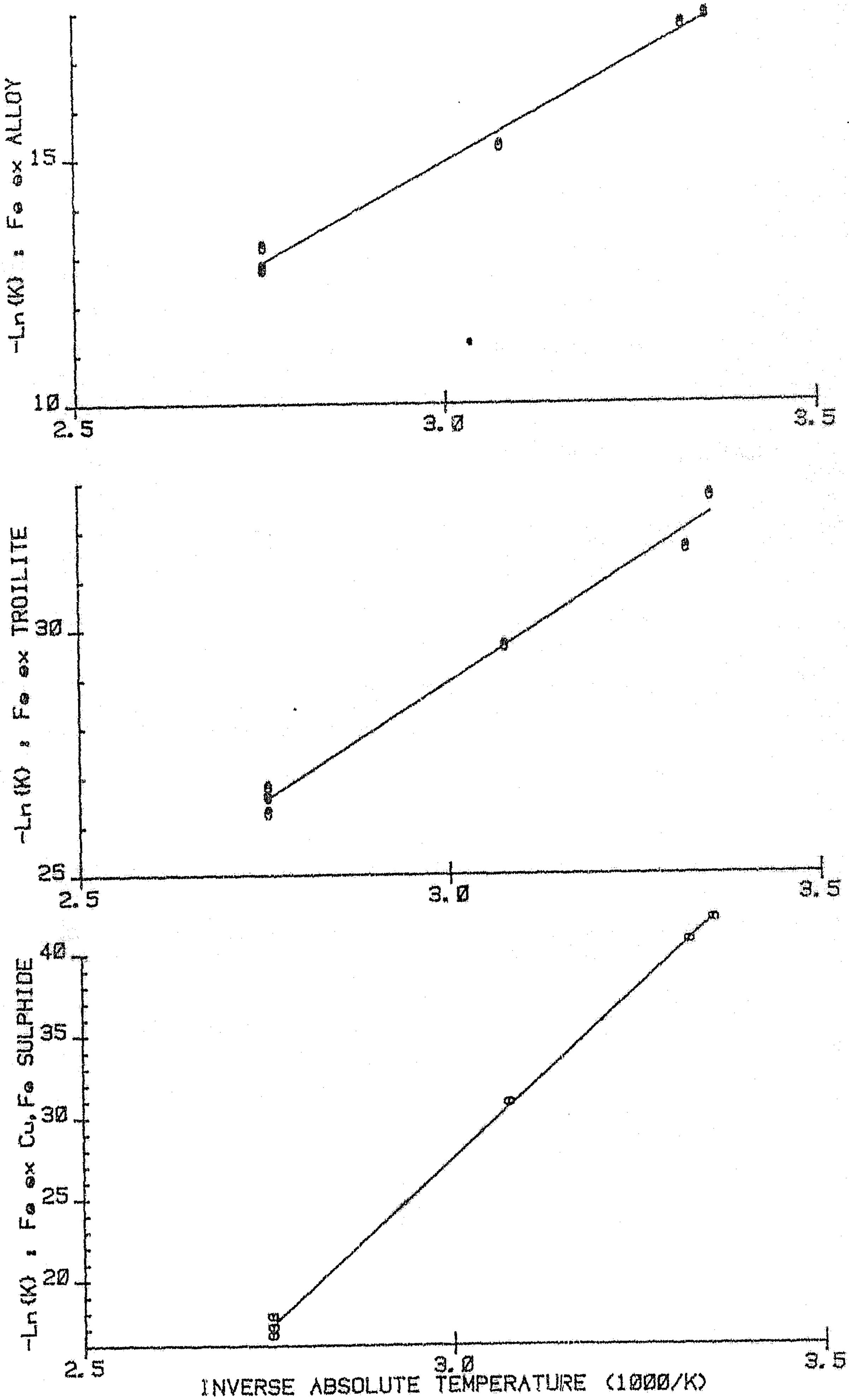

Ln(K) : Cu ex ALLOY
20
15
2.5
3.0
3.5
-Ln(K) : Cu ex TROILITE
40
35
2.5
3.0
3.5
-Ln(K) : Cu ex Cu, Fe SULPHIDE
40
35
30
25
20
15
2.5
3.0
3.5
INVERSE ABSOLUTE TEMPERATURE (1000/K)



Ln(K) : Co ex ALLOY
20
15
2.5
3.0
3.5



Ln(K) : Co ex TROILITE
40
35
2.5
3.0
3.5
INVERSE ABSOLUTE TEMPERATURE (1000/K)


-Ln(K) : Fe ex ALLOY
15
10
2.5
3.0
3.5
-Ln(K) : Fe ex TROILITE
30
25
2.5
3.0
3.5
-Ln(K) : Fe ex Cu,Fe SULPHIDE
40
35
30
25
20
2.5
3.0
3.5
INVERSE ABSOLUTE TEMPERATURE (1000/K)

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