physical sciences data 10

phase diagrams

a literature source book

Part A

jaime wisniak

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Department of Chemical Engineering
Ben-Gurion University of the Negev, Beer-Sheva, Israel

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יש דבר שיאמר ראה זה חדש
הוא כבר היה לעולמים אשר היה מלפנינו:

קהלת, א, י

**THERE IS A THING WHEREOF IT MAY BE SAID,
SEE, THIS IS NEW ; BUT IT HATH BEEN ALREADY
OF OLD TIME, WHICH WAS BEFORE US.**

Ecclesiastes 1:10

TO

Anita, Daniel, Debora and Ariel Wisniak

PREFACE

The advent of both new materials of construction and the energy crisis has focused an increasing attention on the subject of phase equilibrium. Almost every branch of industry and technology makes extensive use of multicomponent alloys and other composite materials. Numerous aspects of applied science such as industrial metallurgy, physics of metals, geology and crystallization deal with artificial or natural multicomponent multiphase systems.

It is well known that pure materials, or their mixtures, may exist in various states of aggregation and several crystalline forms, many of them with significantly different physical properties.

Phase diagrams, in general, help in determining the necessary and optimum conditions for the preparation, separation and purification of certain phases. Information regarding equilibrium among several possible phases helps give insight into the pressure, temperature, and composition conditions that determine the existence, co-existence, transformation or interaction of the various phases of the system.

This book is intended to provide a quick and organised reference source for the data published on phase diagrams between 1900 and 1980. The information reported here has been gathered mainly from Chemical Abstracts and allied publications in Chemistry, Chemical Engineering and Materials Engineering. Over 22,000 references have been scrutinized and of these about 18,000 found to contain pertinent material. The systems covered include organic and inorganic materials. This reference source should be particularly useful for people working in chemical engineering, materials and metallurgical engineering, and process design.

We would like to express our deepest thanks to the Ben-Gurion University of the Negev for providing encouragement and generous assistance, to the Computer Center for their technical help and, in particular, to my assistants Yehudit Reizner and Moshe Golden, who performed long tedious hours of computer work in handling the vast amount of data.

JAIME WISNIAK

Beer-Sheva, Israel, January 1981

באר-שבע, שבט תשמ"א

GUIDE TO TABLES

The sequence of systems in the Tables is based on the empirical convention used in Chemical Abstracts. The compounds are arranged in order of increasing C and H, with the remaining elements in alphabetical order. For a given leading compound, the binaries are reported first, followed by ternary, quaternary, etc. systems. A particular system may be reached through any of its components.

All references are provided with their Chemical Abstract number. This should prove useful for journals that are difficult to obtain.

This book is divided into two parts. Part A contains compounds from A to H_2NiO_2 and Part B, compounds from H_2O to Z, and the references.

AG SILVER

AG CL	SILVER CHLORIDE	136
AG CL BI BI CL3	SILVER CHLORIDE BISMUTH BISMUTH(III) CHLORIDE	14505
AG CL CL2 PB PB	SILVER CHLORIDE LEAD(II) CHLORIDE LEAD	11252,15893
AG CL CL2 SN SN	SILVER CHLORIDE TIN(II) CHLORIDE TIN(IV)	146
AG CU PD	PALLADIUM SILVER COPPER	11342
AG2 S	SILVER SULFIDE	12152
AG2 S S3 SB2 SB	SILVER SULFIDE ANTIMONY(III) SULFIDE ANTIMONY	8264
AL	ALUMINUM	3331, 6322,11605
AL CU	ALUMINUM COPPER	9550
AL FE	ALUMINUM IRON	2645
AL FE SI	ALUMINUM IRON SILICON	1144, 1145
AL GE	ALUMINUM GERMANIUM	13519
AL IN	ALUMINUM INDIUM	2764
AL MG	ALUMINUM MAGNESIUM	3932,11171,16707
AL MN	ALUMINUM MANGANESE	11606
AL NI SI	ALUMINUM NICKEL SILICON	1145
AL O2 SI	ALUMINUM SILICON DIOXIDE	14862
AL PB	ALUMINUM LEAD	2768
AL PD	ALUMINUM PALLADIUM(1:1)	11341
AS CU	ARSENIC COPPER	9261
AS GA	ARSENIC GALLIUM	11326
AS PB	ARSENIC LEAD	4312
AS S	ARSENIC SULFUR	7965,12660 12659,12663
AS SE	ARSENIC SELENIUM	2175, 7964
AS GA	GALLIUM ARSENIDE	8467
AU	GOLD	6322, 9453
AU CU	GOLD COPPER	10891
AU GE	GOLD GERMANIUM	17378
AU PD	GOLD PALLADIUM	9829

AG SILVER

AU S	GOLD SULFUR	5651
AU SI	GOLD SILICON	8297
AU SN	GOLD TIN	4542
B	BORON	12741
BA	BARIUM	16632
BI	BISMUTH	8469
BI PB S	BISMUTH LEAD SULFUR	3320, 3326
BI S	BISMUTH SULFUR	3320, 3326, 7957
CA	CALCIUM	10877
CD	CADMIUM	2767, 6322,12383
CD CU	CADMIUM COPPER	9024,11624
CD CU SN	CADMIUM COPPER TIN	5236
CD CU ZN	CADMIUM COPPER ZINC	309,11621,11622
CD IN	CADMIUM INDIUM	14466
CD MG	CADMIUM MAGNESIUM	8635
CD S	CADMIUM SULFUR	15739
CD SB	CADMIUM ANTIMONY	1218
CD TI	CADMIUM TITANIUM	12163
CD ZN	CADMIUM ZINC	10351
CD S	CADMIUM SULFIDE	15740
CD SB	CADMIUM ANTIMONIDE	1231
CD TE	CADMIUM TELLURIDE	11312
CE	CERIUM	3512, 5825
CE LA	CERIUM LANTHANUM	16345
CL2 PB	LEAD(II) CHLORIDE	15893
CL2 PB CU	LEAD(II) CHLORIDE COPPER	11251
CO GE	COBALT GERMANIUM	2657
CO SI	COBALT SILICON	9516
CS	CESIUM	5876
CU	COPPER	3355, 4126,16106 3920, 9453
CU FE S	COPPER IRON SULFUR	5854

AG SILVER

CU GE	COPPER GERMANIUM	10866
CU MG	COPPER MAGNESIUM	13934
CU O2	COPPER OXYGEN	8803
CU P	COPPER PHOSPHORUS	10230
CU PB S	COPPER LEAD SULFUR	5855
CU PD	COPPER PALLADIUM	5378
CU S	COPPER SULFUR	5852,16006
CU SE	COPPER SELENIUM	631
CU TE	COPPER TELLURIUM	170
CU TI	COPPER TITANIUM	4440, 4443 4441, 4444
CU ZN	COPPER ZINC	7218,10036
CU	COPPER(II)	15827
CU S	COPPER(II) SULFUR	3107
CU SE	COPPER(II) SELENIUM	3107
DY	DYSPROSIUM	3513, 5825, 5943
DY PD	DYSPROSIUM PALLADIUM	14349,14350
DY RH	DYSPROSIUM RHODIUM	14348
ER	ERBIUM	5231, 5825
EU	EUROPIUM	5825
FE	IRON	5304
FE GE	IRON GERMANIUM	2657
FE S	IRON SULFUR	15208
GA	GALLIUM	6319, 8469,16924 7711,16782
GA IN	GALLIUM INDIUM	16924
GA S	GALLIUM SULFUR	2272,10588
GA ZN	GALLIUM ZINC	10037
GA SB	GALLIUM ANTIMONIDE	5413
GD	GADOLINIUM	7384
GE	GERMANIUM	63, 4126, 8465 4118, 8463
GE MN	GERMANIUM MANGANESE	2657

AG SILVER

GE NI	GERMANIUM NICKEL	2657
GE SI	GERMANIUM SILICON	11986
H2	HYDROGEN	9720
H2 PD	HYDROGEN PALLADIUM	8156,12154
HG	MERCURY	8469
HG PB	MERCURY LEAD	15536
HG TI	MERCURY TITANIUM	12163
IN	INDIUM	2765, 6322
IN SB	INDIUM(III) ANTIMONIDE	8458
LA	LANTHANUM	3514, 5825
LI MG	LITHIUM MAGNESIUM	3948
LU	LUTETIUM	5825
MG	MAGNESIUM	5140,14738
MN	MANGANESE	11605
MN ZN	MANGANESE ZINC	10035
NA	SODIUM	8469,16626
ND	NEODYMIUM	4787, 5825,14706
NI	NICKEL	2190,14781
NI SI	NICKEL SILICON	2190, 9516
O2	OXYGEN	6082
O2 SE	OXYGEN SELENIUM	11407
O2 V	OXYGEN VANADIUM	12335
O5 V2	VANADIUM(V) OXIDE	16432
P	PHOSPHORUS	15854
PB	LEAD	5050, 8469,15893
PB PD	LEAD PALLADIUM	7332
PB S	LEAD SULFUR	3326, 5853
PB SB	LEAD ANTIMONY	1933
PB SE	LEAD SELENIUM	8702
PB SN	LEAD TIN	11382
PB TE	LEAD TELLURIUM	1875,16560
PB ZN	LEAD ZINC	6813,13694 11456,13695
PD	PALLADIUM	13385
PD Y	PALLADIUM YTTRIUM	14351,14510

AG	SILVER	
PD YB	PALLADIUM YTTERBIUM	6343
PD ZR	PALLADIUM ZIRCONIUM	8971
PR	PRASEODYMIUM	3511,14706
PT	PLATINUM	4126
PU	PLUTONIUM	8361,16765
S SB	SULFUR ANTIMONY	1014, 7217 5193,14584
S SE	SULFUR SELENIUM	15675
SB	ANTIMONY	10886,14583
SB SE	ANTIMONY SELENIUM	5193,15151
SB TE	ANTIMONY TELLURIUM	5193,14741
SC	SCANDIUM	5825
SI	SILICON	4118
SM	SAMARIUM	5232, 5825
SN	TIN	15876
SN TE	TIN TELLURIUM	1874
SR	STRONTIUM	6105,16107,16632
TB	TERBIUM	3515
TE	TELLURIUM	2836, 8032,16740
TE TL	TELLURIUM THALLIUM	7959, 7960
TL	THALLIUM	8469
TM	THULIUM	5825
U	URANIUM	2702
Y	YTTRIUM	5232, 5825
YB	YTTERBIUM	5825,11240
ZN	ZINC	63, 469
ZR	ZIRCONIUM	8970
AG AS S2	ARSENIC SILVER SULFIDE	
AG S2 SB	SILVER ANTIMONY SULFIDE	15383
AG B H4	SILVER TETRAFLUOROBORATE	
C5 H10	1-PENTENE	12217
AG BR	SILVER BROMIDE	
AG CL	SILVER CHLORIDE	10114
AG CL AG I	SILVER CHLORIDE SILVER IODIDE	5430, 9632
AG CL AG N O3	SILVER CHLORIDE SILVER NITRATE	8884, 8885

AG BR SILVER BROMIDE

AG CL BR K CL K	SILVER CHLORIDE POTASSIUM BROMIDE POTASSIUM CHLORIDE	11250
AG CL BR LI CL LI	SILVER CHLORIDE LITHIUM BROMIDE LITHIUM CHLORIDE	1546
AG CL BR NA CL NA	SILVER CHLORIDE SODIUM BROMIDE SODIUM CHLORIDE	3871
AG CL BR TL CL TL	SILVER CHLORIDE THALLIUM(I) BROMIDE THALLIUM(I) CHLORIDE	547
AG F BR NA F NA	SILVER FLUORIDE SODIUM BROMIDE SODIUM FLUORIDE	16135
AG I	SILVER IODIDE	10114
AG I BR K CL K	SILVER IODIDE POTASSIUM BROMIDE POTASSIUM CHLORIDE	11250
AG I H NA O	SILVER IODIDE SODIUM HYDROXIDE	10975
AG N O3 BR CS	SILVER NITRATE CESIUM BROMIDE	4906
AG N O3 BR LI	SILVER NITRATE LITHIUM BROMIDE	4906
AG N O3 BR NA N NA O3	SILVER NITRATE SODIUM BROMIDE SODIUM NITRATE	17006
AG N O3 BR RB	SILVER NITRATE RUBIDIUM BROMIDE	4906
AG N O3 CL K K N O3	SILVER NITRATE POTASSIUM CHLORIDE POTASSIUM NITRATE	8886
AG N O3 CS N O3	SILVER NITRATE CESIUM NITRATE	4906
AG N O3 H2 O H3 N	SILVER NITRATE WATER AMMONIA	15122
AG N O3 LI N O3	SILVER NITRATE LITHIUM NITRATE	4906
AG N O3 N O3 RB	SILVER NITRATE RUBIDIUM NITRATE	4906
AG2 MO O4 BR NA MO NA2 O4	SILVER MOLYBDATE SODIUM BROMIDE SODIUM MOLYBDATE	14234
AG2 O4 S BR TL O4 S TL2	SILVER SULFATE THALLIUM(I) BROMIDE THALLIUM(I) SULFATE	3870
AG2 SE	SILVER SELENIDE	1881, 2155
AG2 TE	SILVER TELLURIDE	1881, 6987
AL BR3	ALUMINUM BROMIDE	7241
AL CL3	ALUMINUM CHLORIDE	11746
BR CS BR TL	CESIUM BROMIDE THALLIUM(I) BROMIDE	3796
BR CU	CUPROUS BROMIDE	5021, 6848, 6849
BR K	POTASSIUM BROMIDE	13274,17178
BR K H2 O	POTASSIUM BROMIDE WATER	8544,15122

AG BR	**SILVER BROMIDE**	
BR LI	LITHIUM BROMIDE	13283,15693
BR NA	SODIUM BROMIDE	13283,14242 14234,17178
BR RB	RUBIDIUM BROMIDE	13274
BR TL BR2 CD	THALLIUM(I) BROMIDE CADMIUM BROMIDE	3797
BR2 CD	CADMIUM BROMIDE	17003
BR2 MN	MANGANESE BROMIDE	13685
BR3 GA	GALLIUM BROMIDE	10096
BR3 IN	INDIUM(III) BROMIDE	4068
BR3 ND	NEODYMIUM BROMIDE	10106
BR3 PR	PRASEODYMIUM BROMIDE	10106
BR4 TE	TELLURIUM TETRABROMIDE	13117
CL NA	SODIUM CHLORIDE	14221
CL NA K N 03	SODIUM CHLORIDE POTASSIUM NITRATE	3865
H2 O H3 N	WATER AMMONIA	15122
K2 MO 04	POTASSIUM MOLYBDATE	14234
LI2 MO 04	LITHIUM MOLYBDATE	14234
MO NA2 04	SODIUM MOLYBDATE	14234
AG BR 03	**SILVER BROMATE**	
BR NA 03 H2 O	SODIUM BROMATE WATER	12502
AG CL	**SILVER CHLORIDE**	
AG	SILVER	136
AG	SILVER	14505
BI BI CL3	BISMUTH BISMUTH(III) CHLORIDE	
AG	SILVER	11252,15893
CL2 PB PB	LEAD(II) CHLORIDE LEAD	
AG	SILVER	146
CL2 SN SN	TIN(II) CHLORIDE TIN(IV)	
AG BR AG I	SILVER BROMIDE SILVER IODIDE	5430
AG BR AG N 03	SILVER BROMIDE SILVER NITRATE	8884, 8885
AG BR BR K CL K	SILVER BROMIDE POTASSIUM BROMIDE POTASSIUM CHLORIDE	11250
AG BR BR LI CL LI	SILVER BROMIDE LITHIUM BROMIDE LITHIUM CHLORIDE	1546
AG BR BR NA CL NA	SILVER BROMIDE SODIUM BROMIDE SODIUM CHLORIDE	3871
AG BR BR2 PB CL2 PB	SILVER BROMIDE LEAD(II) BROMIDE LEAD(II) CHLORIDE	11279

AG CL SILVER CHLORIDE

AG I CL K I K	SILVER IODIDE POTASSIUM CHLORIDE POTASSIUM IODIDE	12754,12759
AG I CL2 HG HG I2	SILVER IODIDE MERCURIC CHLORIDE MERCURIC IODIDE	1585
AG N O3	SILVER NITRATE	6718
AG N O3 CL K K N O3	SILVER NITRATE POTASSIUM CHLORIDE POTASSIUM NITRATE	8886
AG N O3 CL LI LI N O3	SILVER NITRATE LITHIUM CHLORIDE LITHIUM NITRATE	17008
AG N O3 CL NA N NA O3	SILVER NITRATE SODIUM CHLORIDE SODIUM NITRATE	17007
AG N O3 CL RB N O3 RB	SILVER NITRATE RUBIDIUM CHLORIDE RUBIDIUM NITRATE	14236
AG2 CR O4 CL LI CR LI2 O4	SILVER CHROMATE LITHIUM CHLORIDE LITHIUM CHROMATE	8806
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AG2 O4 S CD CL2 CD O4 S	SILVER SULFATE CADMIUM CHLORIDE CADMIUM SULFATE	3867
AG2 O4 S CL LI LI2 O4 S	SILVER SULFATE LITHIUM CHLORIDE LITHIUM SULFATE	8743, 8805
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AG2 O4 S CL2 PB O4 PB S	SILVER SULFATE LEAD(II) CHLORIDE LEAD(II) SULFATE	5364
AG2 O4 S LI2 O4 S	SILVER SULFATE LITHIUM SULFATE	8743
AG2 O4 W CL LI LI2 O4 W	SILVER TUNGSTATE LITHIUM CHLORIDE LITHIUM TUNGSTATE	8810
AG2 S	SILVER SULFIDE	1879,15659
AG2 S CL CU CU2 S	SILVER SULFIDE CUPROUS CHLORIDE CUPROUS SULFIDE	15891
AG2 S CL2 PB PB S	SILVER SULFIDE LEAD(II) CHLORIDE LEAD(II) SULFIDE	15908
AG2 SE	SILVER SELENIDE	1881, 2155
AG2 TE	SILVER TELLURIDE	1881, 2124
AL BR3	ALUMINUM BROMIDE	11746
AL CL3	ALUMINUM CHLORIDE	7241
B F4 TL	THALLIUM(I) TETRAFLUOROBORATE	5783
BE CL2	BERYLLIUM CHLORIDE	13517
BI CL3	BISMUTH(III) CHLORIDE	3067
BR K	POTASSIUM BROMIDE	16607
C H4 O CL CS H2 O	METHANOL CESIUM CHLORIDE WATER	3536