

Landolt-Börnstein

Numerical Data and Functional Relationships in Science and Technology

New Series / Editor in Chief: O. Madelung

Group III: Solid State Physics

Volume 27

Magnetic Properties
of Non-Metallic Inorganic Compounds
Based on Transition Elements

Subvolume j1

Halides I

Editor: H.P.J. Wijn

Contributors:

K. Katsumata, M. Matsuura, H.P.J. Wijn

Springer-Verlag

Berlin Heidelberg New York

London Paris Tokyo

Hong Kong Barcelona Budapest

Table of contents

Magnetic properties of non-metallic inorganic compounds based on transition elements Subvolume j1: Halides I

9	Magnetic properties of halides	1
9.1	MX_2 and $\text{MX}_2 \cdot n\text{H}_2\text{O}$ compounds (M = 3d element, X = halogen element) (K. KATSUMATA)	1
9.1.1	Introduction	1
9.1.1.1	General remarks	1
9.1.1.2	List of frequently used symbols and abbreviations	2
9.1.2	Macroscopic magnetic and related properties of MX_2 compounds	4
9.1.2.1	MF_2 compounds	4
9.1.2.2	MCl_2 compounds	13
9.1.2.3	MBr_2 compounds	20
9.1.2.4	MI_2 compounds	25
9.1.3	Macroscopic magnetic and related properties of $\text{MX}_2 \cdot n\text{H}_2\text{O}$ compounds	28
9.1.4	Microscopic magnetic and related properties of MX_2 and $\text{MX}_2 \cdot n\text{H}_2\text{O}$ compounds	47
9.1.4.1	MX_2 compounds	47
9.1.4.2	$\text{MX}_2 \cdot n\text{H}_2\text{O}$ compounds	54
9.1.5	References for 9.1	56
9.2	$\text{M}_{1-x}\text{M}'_x\text{X}_2$ and $\text{M}_{1-x}\text{M}'_x\text{X}_2 \cdot n\text{H}_2\text{O}$ compounds (M, M' = 3d element, X = halogen element) (K. KATSUMATA)	59
9.2.1	Introduction	59
9.2.1.1	General remarks	59
9.2.1.2	List of frequently used symbols and abbreviations	60
9.2.2	Static magnetic and related properties of $\text{M}_{1-x}\text{M}'_x\text{X}_2$ and $\text{M}_{1-x}\text{M}'_x\text{X}_2 \cdot n\text{H}_2\text{O}$ compounds	61
9.2.2.1	Static magnetic and related properties of $\text{M}_{1-x}\text{M}'_x\text{F}_2$ compounds	61
9.2.2.2	Static magnetic and related properties of $\text{M}_{1-x}\text{M}'_x\text{Cl}_2$ compounds	72
9.2.2.3	Static magnetic and related properties of $\text{Fe}_{1-x}\text{Co}_x\text{Br}_2$ compound	88
9.2.2.4	Static magnetic and related properties of $\text{M}_{1-x}\text{M}'_x\text{X}_2 \cdot n\text{H}_2\text{O}$ compounds	92
9.2.3	Dynamical magnetic and related properties of $\text{M}_{1-x}\text{M}'_x\text{X}_2$ and $\text{M}_{1-x}\text{M}'_x\text{X}_2 \cdot n\text{H}_2\text{O}$ compounds	103
9.2.3.1	Dynamical magnetic and related properties of $\text{M}_{1-x}\text{M}'_x\text{F}_2$ compounds	103
9.2.3.2	Dynamical magnetic and related properties of $\text{M}_{1-x}\text{M}'_x\text{Cl}_2$ compounds	104
9.2.3.3	Dynamical magnetic and related properties of $\text{Fe}_{1-x}\text{Co}_x\text{Br}_2$ compound	110
9.2.3.4	Dynamical magnetic and related properties of $\text{Fe}_{1-x}\text{Co}_x\text{Cl}_2 \cdot 2\text{H}_2\text{O}$ compound	111
9.2.4	References for 9.2	112

9.3	MX_3 compounds ($\text{M} = 3\text{d element}$, $\text{X} = \text{halogen element}$) (K. KATSUMATA)	114
9.3.1	Introduction	114
9.3.1.1	General remarks	114
9.3.1.2	List of frequently used symbols and abbreviations	114
9.3.2	Macroscopic magnetic and related properties of MX_3 compounds	116
9.3.2.1	MF_3 compounds	117
9.3.2.2	MCl_3 compounds	121
9.3.2.3	MBr_3 compounds	128
9.3.2.4	MI_3 compounds	130
9.3.3	Microscopic magnetic and related properties of CrX_3 compounds	132
9.3.4	References for 9.3	134
9.4	MCl_2 -GIC; MCl_3 -GIC ($\text{M} = 3\text{d element}$) (M. MATSUURA)	136
9.4.1	Introduction	136
9.4.1.1	General remarks	136
9.4.1.2	List of frequently used symbols	140
9.4.1.3	List of abbreviations	142
9.4.2	Singly intercalated compounds	144
9.4.2.1	General survey	144
9.4.2.2	CoCl_2 -GIC	148
9.4.2.2.1	Stage 2 CoCl_2 -GIC	148
9.4.2.2.2	Stage n CoCl_2 -GIC ($n \geq 3$)	159
9.4.2.2.3	Stage 1 CoCl_2 -GIC	160
9.4.2.3	NiCl_2 -GIC	163
9.4.2.3.1	Stage 2 NiCl_2 -GIC	163
9.4.2.3.2	Stage n NiCl_2 -GIC ($n \geq 3$)	168
9.4.2.3.3	Stage 1 NiCl_2 -GIC	168
9.4.2.4	MCl_2 -GIC ($\text{M} = \text{Mn, Cu}$)	170
9.4.2.4.1	Stage n MnCl_2 -GIC	170
9.4.2.4.2	Stage n CuCl_2 -GIC	175
9.4.2.5	MCl_3 -GIC ($\text{M} = \text{Cr, Fe}$)	176
9.4.2.5.1	Stage n CrCl_3 -GIC	176
9.4.2.5.2	Stage 1 FeCl_3 -GIC	179
9.4.2.5.3	Stage n FeCl_3 -GIC ($n \geq 2$)	182
9.4.3	Bi-intercalation compounds	184
9.4.3.1	General survey	184
9.4.3.2	$\text{M}'(\text{magnetic})\text{Cl}_n\text{-M}''(\text{nonmagnetic})\text{Cl}_m\text{-GBIC}$ ($\text{M}' = \text{Co, Cr}$, $\text{M}'' = \text{Al, Ga, Cd}$)	186
9.4.3.2.1	$\text{CoCl}_2\text{-GaCl}_3\text{-GBIC}$	186
9.4.3.2.2	$\text{CoCl}_2\text{-AlCl}_3\text{-GBIC}$	186
9.4.3.2.3	$\text{CrCl}_3\text{-AlCl}_3\text{-GBIC}$	186
9.4.3.2.4	$\text{CrCl}_3\text{-CdCl}_2\text{-GBIC}$	186
9.4.3.3	$\text{M}'(\text{magnetic})\text{Cl}_n\text{-M}''(\text{magnetic})\text{Cl}_m\text{-GBIC}$ ($\text{M}', \text{M}'' = \text{Cr, Mn}$, Fe, Co, Ni)	188
9.4.3.3.1	$\text{CoCl}_2\text{-FeCl}_3\text{-GBIC}$	188
9.4.3.3.2	$\text{NiCl}_2\text{-FeCl}_3\text{-GBIC}$	189
9.4.3.3.3	$\text{NiCl}_2\text{-CrCl}_3\text{-GBIC}$	191
9.4.3.3.4	$\text{MnCl}_2\text{-CrCl}_3\text{-GBIC}$	193
9.4.4	Mixed intercalation compounds	193
9.4.4.1	General survey	193

9.4.4.2	Mixed compounds	194
9.4.4.2.1	$\text{Co}_{1-x}\text{Ni}_x\text{Cl}_2\text{-GIC}$	194
9.4.4.2.2	$\text{Co}_{1-x}\text{Mn}_x\text{Cl}_2\text{-GIC}$	196
9.4.4.2.3	$\text{Co}_{1-x}\text{Fe}_x\text{Cl}_2\text{-GIC}$	198
9.4.4.3	Diluted compounds	198
9.4.4.3.1	$\text{Co}_{1-x}\text{Al}_x\text{Cl}_2\text{-GIC}$	198
9.4.4.3.2	$\text{Co}_{1-x}\text{Mg}_x\text{Cl}_2\text{-GIC}$	199
9.4.5	References for 9.4	201
9.5	$\text{MM}'\text{F}_5$ and $\text{MM}'\text{F}_5 \cdot n\text{H}_2\text{O}$ compounds ($\text{M}, \text{M}' = 3\text{d element or Al}; n = 2 \text{ or } 7$) (H.P.J. Wijn)	206
9.5.1	List of symbols and abbreviations	206
9.5.2	$\text{MM}'\text{F}_5$ compounds	206
9.5.3	$\text{MM}'\text{F}_5 \cdot 2\text{H}_2\text{O}$ compounds	213
9.5.3.1	Crystal structure	213
9.5.3.2	Magnetic structures	214
9.5.3.3	Mössbauer data	217
9.5.3.4	Magnetization curves	222
9.5.3.5	Paramagnetic properties	224
9.5.4	$\text{MM}'\text{F}_5 \cdot 7\text{H}_2\text{O}$ compounds	226
9.5.5	References for 9.5	232