

substance: Mn₃O₄

property: magnetic properties

Mn₃O₄ is ferrimagnetic below T_C . Easy directions of magnetization are [100] and [010]. Hard axis is [001] [60D, 74J].

Curie temperature

T_C	41.8(1) K	T_C is depressed by the addition of Zn	60D
	41 K		74J
	43 K		71B1
	54.4 K		75K

susceptibility

See Fig. 1.

Two different magnetic structures have been proposed at 4.2 K [71B2, 74J] with the magnetic unit cell being twice the size of the chemical cell. The magnetic ordering of [74J] is shown in Fig. 2.

magnetic moments per ion and direction cosines

((α_1 , α_2 , α_3) referred to (a , b , c) ($|b| = 2a$, from [74J], for ion numbering, see Fig. 2)

Type of site	Ion no.	p_A	$T = 4.7$ K		
		μ_B	α_1	α_2	α_3
A	1, 2, 3, 4, 5, 6, 7, 8	4.34(10)	0.00(15)	1.00	0.00(15)
B	9, 10, 13, 14,	3.64(8)	− 0.09(5)	− 0.38(2)	− 0.92(1)
	11, 12, 15, 16,	3.64(8)	0.09(5)	− 0.38(2)	0.92(1)
B'	17, 20, 21, 24,	3.25(6)	0.00(6)	− 0.33(2)	− 0.94(1)
	18, 19, 22, 23	3.25(6)	0.00(6)	− 0.33(2)	0.94(1)
Type of site	Ion no.	p_A	$T = 29$ K		
		μ_B	α_1	α_2	α_3
A	1, 2, 3, 4, 5, 6, 7, 8	3.78(12)	0.00(12)	1.00	0.00(12)
B	9, 10, 13, 14,	3.05(8)	− 0.12(7)	− 0.40(3)	− 0.91(1)
	11, 12, 15, 16,	3.05(8)	0.12(7)	− 0.40(3)	0.91(1)
B'	17, 20, 21, 24,	3.17(8)	0.00(4)	− 0.25(3)	− 0.97(1)
	18, 19, 22, 23	3.17(8)	0.00(4)	− 0.25(3)	0.97(1)

At 32.8 K [74J], 35 K [71B2] a phase transition to a new magnetic structure occurs. The transition appears to be a first order modulation of the cell doubling; evolution of the magnetic structure continues until at 39.4 K the magnetic and b.c. tetragonal chemical cells coincide.

Magnetic anisotropy persists above T_C up to ≈ 100 K, above which it is isotropic. The magnetic data at high temperature are consistent with the formula $\text{Mn}_{\text{tet}}^{2+}(\text{Mn}_{\text{oct}}^{3+})_2\text{O}_4$.

At higher temperatures a Curie-Weiss law is obeyed approximately (Fig. 1) with $\Theta_p = -564$ K and $p_{\text{eff}} = 5.27 \mu_B$ [71B2]. More accurate fit obtained with a Néel function: $\chi^{-1} = T/C + \chi_0^{-1} - \sigma/(T-\Theta)$:

C_m	10.71(7) $\text{cm}^3 \text{ K mol}^{-1}$	74N
	6.4 $\text{cm}^3 \text{ K mol}^{-1}$	75K
χ_0^{-1}	53(2) mol cm^{-3}	74N
	36 mol cm^{-3}	75K
σ	1250(50) mol K cm^{-3}	74N
	600 mol K cm^{-3}	75K
Θ	40(5) K	74N
	44 K	75K

References:

- 60D Dwight, K., Menyuk, N.: Phys. Rev. 119 (1960) 1470.
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- 74J Jensen, C. B., Nielsen, O. V.: J. Phys. C7 (1974) 409.
- 74N Nogues, M., Poix, P.: Solid State Commun. 15 (1974) 463.
- 75K Kheer, H. V., Boda, M. G., Bhaduri, A., Biswas, A. B.: J. Inorg. Nucl. Chem. (USSR) 37 (1975) 1605.

Fig. 1.

Mn_3O_4 ceramic. Inverse specific magnetic susceptibility vs. temperature. Solid line shows best fit to Curie-Weiss law using parameters in text. χ in CGS-emu [71B2].

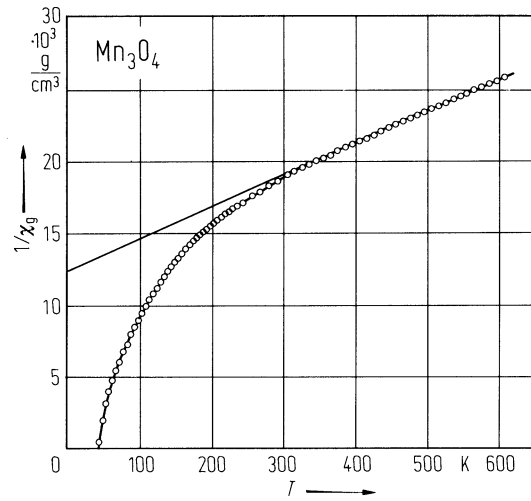


Fig. 2.

Mn_3O_4 . Magnetic structure at 4.7 K. For magnetic moment magnitudes and direction cosines, see the tables. Squares: tetragonal site, open circles: octahedral site, double arrow: moment in the plane, \rightarrow : moment directed upwards, \dashrightarrow moment directed downwards [74J]. x refers to the value of x in tetragonal unit cell.

