Units in magnetism

Table A.1: Units in the SI system and the cgs system. The abbreviations are m=metre, g=gramme, N=Newton, J=Joule, T=Tesla, G=Gauss, A=Amp, Oe=Oersted, Wb=Weber, Mx=Maxwell. The term emu is short for 'electromagnetic unit' and is not a unit in the conventional sense. It is sometimes used as a magnetic moment (1 emu = 1 erg G^{-1}) and sometimes takes the dimensions of volume (1 emu = 1 cm^3).

Quantity	symbol		SI unit		cgs unit
Length	x	10^{-2}	m	$=1$	cm
Mass	m	10^{-3}	kg	$=1$	g
Force	F	10^{-5}	N	$=1$	dyne
Energy	E	10^{-7}	J	$=1$	erg
Magnetic induction	$\mathbf{B}$	10^{-4}	T	$=1$	G
Magnetic field strength	$\mathbf{H}$	$10^3/4\pi$	$A\,m^{-1}$	$=1$	Oe
Magnetic moment	$\boldsymbol{\mu}$	10^{-3}	$J\,T^{-1}$ or $A\,m^2$	$=1$	erg G^{-1} or emu
Magnetization (= moment per volume)	$\mathbf{M}$	10^3	$A\,m^{-1}$ or $J\,T^{-1}\,m^{-3}$	$=1$	Oe or emu cm^{-3}
Magnetic susceptibility	χ	4π	$\times 1$	$=1$	emu cm^{-3} or emu cm^{-3} Oe^{-1}
Molar susceptibility	χ_m	$4\pi \times 10^{-6}$	$m^3\,mol^{-1}$	$=1$	emu mol^{-1} or emu mol^{-1} Oe^{-1}
Mass susceptibility	χ_g	$4\pi \times 10^{-3}$	$m^3\,kg^{-1}$	$=1$	emu g^{-1} or emu g^{-1} Oe^{-1}
Magnetic flux	ϕ	10^{-8}	Tm^2 or Wb	$=1$	G cm^2 or Mx
Demagnetization factor	N		$0 < \mathsf{N} < 1$		$0 < \mathsf{N} < 4\pi$

Though not an SI unit, the Bohr magneton $\mu_B = 9.274 \times 10^{-24}$ J T^{-1} is a useful measure of magnetic moment since it corresponds to the magnetic moment of a 1s electron in hydrogen. For a paramagnet, the molar susceptibility χ_m is given by Curie's law which is in SI units

$$\chi_m = \frac{\mu_0 N_A \mu_{\text{eff}}^2 \mu_B^2}{3k_B T} \tag{A.1}$$

where N_A is Avogadro's number. Hence $\chi_m T$ is independent of temperature and this can be related to the effective moment. Hence by rearranging equation A.1, one has $\mu_{\text{eff}} = [3k_B/\mu_0 N_A \mu_B^2]^{1/2}\sqrt{\chi_m T}$, so that

$$\mu_{\text{eff}} = 797.8\sqrt{\chi_m^{\text{SI}} T} \approx 800\sqrt{\chi_m^{\text{SI}} T} \qquad \text{(SI)} \tag{A.2}$$

$$\mu_{\text{eff}} = 2.827\sqrt{\chi_m^{\text{cgs}} T} \approx \sqrt{8\chi_m^{\text{cgs}} T} \qquad \text{(cgs)} \tag{A.3}$$

where μ_{eff} is measured in Bohr magnetons per formula unit, χ_m^{SI} is measured in m^3 mol^{-1}, and χ_m^{cgs} is measured in emu mol^{-1}. These numerical relationships can be useful for extracting effective moments from graphs of $\chi_m T$ against T.

Adapted and updated from part of Appendix A of *Magnetism in Condensed Matter*, by Stephen Blundell, Oxford University Press 2001.