skip - same for [illegible]

discuss in problems rather than here

HK

C(T) FOR SPIN SYSTEM :

(need for last problem) (9.9)

- N ATOMS, SPIN $\frac{1}{2}$
- KNOWN TO BE FERROMAGNETIC

$\Rightarrow$ LOW T ALL SPINS LINE UP

{ NOTES: (1) RULES FOR ALLOWED SPINS FOR COMBINED SYSTEM

(ATOM = NUCLEUS + e^-) SAME AS FOR SINGLE PARTICLE

spin + orbit

$s = 0, \frac{1}{2}, 1, \frac{3}{2}, \ldots$ ALLOWED S'S

$S_z = -s\hbar \ldots + s\hbar$

$S^2 = s(s+1)\hbar^2$

} often just due to unpaired e^-

TO GET + S_z, just add together

(2) MAGNETIC PROPERTIES OF MATTER

- MOSTLY DUE TO e^-'s (NOT NUCLEAR SPIN)

SPIN + ORBITAL MOTION

(comments were misleading last class)

very small effect (small moment)

COMMENT ON

- ORDER, E, T :

TYPICAL SYSTEM: SMALL E: $\Omega \to 1$

$S \to 0$

$T \to 0$

~ talked about

LARGE E: $\Omega \sim E^f$

(can list, not a calc) $S \sim k f \ln E$

$kT \sim E/f$ (NOT LIMITED BY AVAIL)

$\Rightarrow$ AS T INCR, E INCR, MORE STATES AVAIL, HIGHER $\bar{E}/f$

MORE RANDOM / DISORDERED

** $\Rightarrow$ CAN USE $kT \sim \bar{E}/f$ AS GUIDE : STATES FOR INDIV. DOF. fluctuations

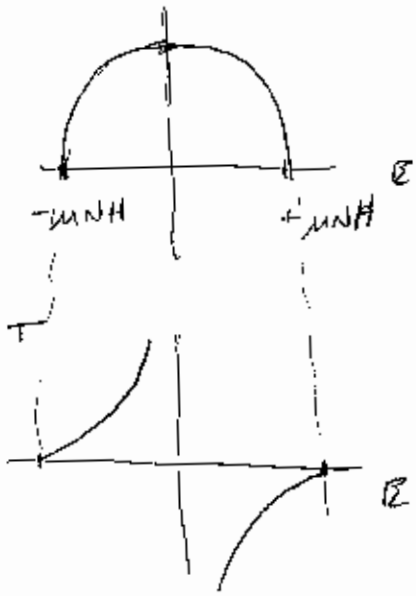
OF ENERGY $\ll kT$ WILL BE EQUALLY OCCUPIED, BUT [illegible] states ab

OCC. OF STATES WITH $E \gtrsim kT$ BECOMES RARE for other

{ ~ have 1000 cm^{-1} per mol., 10, 11 ~ easily avail; but 3000 need to acct for fact that mos

DH

PROB 3.2 SPINS IN H (PICTURE ABOUT SAME AS TYPICAL SYS UNTIL NEAR END



$E \to E_0$

$T \to 0$

SPINS LINE UP $\Rightarrow$ ORDERED

$E \to 0$ $\Rightarrow$ HALF UP, HALF DN

S MAX $\beta \to 0$ $T \to \infty$

$\Rightarrow$ DISORDERED

SPS HAVE SAME SYS, BUT W/OUT EXT MAGN FIELD:
FERROMAGNETISM:

- NO EXTERNAL FIELD, BUT B FROM ONE ATOM AFFECTS SPIN OF OTHER

skip
- MACRO SYSTEM COMPLETELY CHARACTERIZED BY E (OR T) (NO V, ...)
- LOWEST E STATE: ALL LINED UP

(other behavior possible – DEPENDS ON DETAILS)

$E \to E_0$

$T \to 0$ LINE UP $\Omega \to 1$ $S \to 0$

E LARGE (near max)

$T \to \infty$ ~ ALL SPINS AVAIL. (spin $\frac{1}{2}$ ⇒ $S_z = \pm \frac{1}{2}\hbar$)

$\Omega \to 2^N$

$S \to S_{MAX} = k N \ln 2$ (S has a max for spin systems)

$\Rightarrow$ $C(T)$ (don't have to specify $\bar{p}$ or V since system has neither)

MUST SATISFY $\Delta S = S(T_f = \infty) - S(T_i = 0) = \int_{T_i}^{T_f} \frac{dQ}{T}$ $\Rightarrow$

$$\Rightarrow \quad kN \ln 2 = \int_0^\infty \frac{C(T)\, dT}{T}$$

- TRUE REGARDLESS OF FORM OF $C(T)$, DETAILS OF INTERACTIONS
- CONNECTS INFO ON MICRO STRUCTURE TO MACRO OBS. C
- NOTE: $C(T) \to 0$ AS $T \to 0$

  OR WOULDN'T GET FINITE INTEGRAL

WHY? AS $T \to 0$ $E \to E_0$ (GND ST)

REDUCING T CAN'T REDUCE E (OR S) FURTHER

(recall C measures how much of E (and S) chg w/ T)