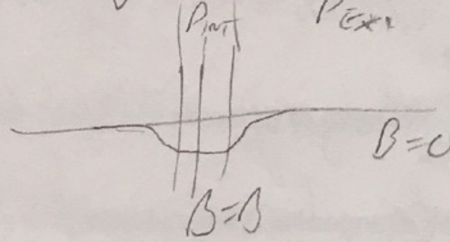
① 2 POINTS - GOOD CLEAR ANSWER, MAYBE A NICE SKETCH
NO WAFFLING,

1 POINT - GENERAL CONCEPT CORRECT, BUT UNCLEAR

0 POINT - MISSING OR INCORRECT

(a) velocity low enough and sufficient size scale
so as to move magnetic field around
without destroying it.
Maybe discussion of magnetic reynolds number?

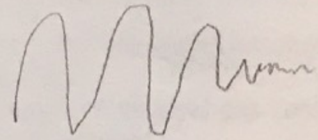
(b) $P_{EXT} = P_{INT} + \frac{B^2}{8\pi}$



As B^2 is always +ve, $P_{INT} < P_{EXT}$
hence $\rho_{int} < \rho_{ext}$
and we see deeper down, where it is
hotter and more dense

(c) Measure of total solar power over all →
($J s^{-1}$) incident on $1 m^2$ at 1 AU. So
overall $W m^{-2}$

(d) ~~periodic~~ pulsations of changing frequency or amplitude, or of finite lifetime

e.g. 

(e) use of wave equations to infer, unobservable plasma parameters, by studying changes in the time ~~&~~ or frequency domain.

2 (a)

$P \propto 1/V$ $\quad P = k_1 \cancel{V} / V$ — ①

$V \propto T$ $\quad V = k_2 T$ — ②

$P \propto T$ $\quad P = k_3 T$ — ③

– 1 point

$1 \times 2 \times 3 \longrightarrow P^2 V = k_1 k_2 k_3 \cancel{T} T^2 / V$

$$P^2 V^2 = k_4 \, T^2$$

$$PV = k_5 T$$

– 1 point

As K_5 is proportional to the 'fixed amount of gas'

$$K_5 = R N_{moles} = K_B N_{particles}$$

where k_B is Boltzmann constant

$$PV = K_B N T$$

$$P = k_B \frac{N}{V} T$$

$$= k_B n T$$

– 2 points

And where a gas, mostly hydrogen, is fully ionized

$$n = 2 n_e$$

$$\Rightarrow P = 2 k_B n_e T$$

– 1 point

2(b)

$$P_{th} = 2 n_e k_B T$$

$$P_m = B^2/8\pi$$

$$\Rightarrow \beta = \frac{2 n_e k_B T \; 8\pi}{B^2} \qquad — ①$$

where ~~thermal pressure~~ mass density is mostly governed by proton — ①

$$\beta = 2 \frac{\rho}{m_p} k_B T \, 8\pi / B^2$$

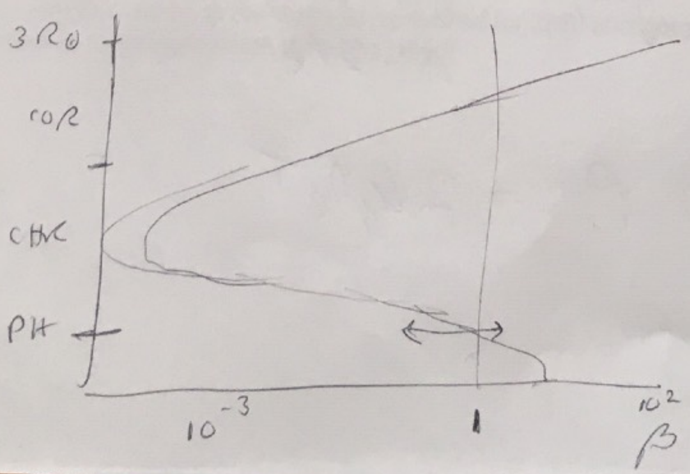
$$= \frac{(16\pi)(1.4\times10^{-16})}{1.7\times10^{-24}} \frac{\rho T}{B^2}$$

$$\sim 50 \times 10^{-16+24} \, \rho T / B^2$$

$$\sim 10^{10} \frac{\rho T}{2 B^2} \qquad — ①$$

(c) substitute for ρ, T at low limits of β to calculate B

(d)



Shape ①
Heights ②
Axes ②

Assume ρ exponential
Assume B drops at [illegible] concerned
Assume T minim through the 1MK corona

3(a) $c_s^2 = \frac{\partial P}{\partial \rho}$ and $P = k\rho^\gamma$

$$c_s^2 = \frac{\partial P}{\partial \rho} = k\gamma\rho^{\gamma-1} \quad \text{——— (2)}$$

$$= (k\rho^\gamma)\rho^{-1}\gamma \quad \text{——— (2)}$$

$$= \gamma P \rho^{-1} \quad \text{——— (1)}$$

(b) $c_s^2 = \gamma P \rho^{-1}$

$$= \gamma (n k_B T)(mn^{-1})$$

$$= \gamma k_B T m^{-1} \quad \text{——— (2)}$$

so $c_s \sim T^{1/2}$

$$c_s^2 = \left(\frac{5}{3}\right)\left(\frac{(1.4 \times 10^{-16})(5.8 \times 10^3)}{1.7 \times 10^{-24}}\right) \quad \text{— (2)}$$

$$= \left(\frac{5}{3}\right)\left(\frac{1.4}{1.7}\right)(5.8) \times 10^{-16+3+24}$$

$$= 8 \times 10^{11} = 80 \times 10^{10}$$

$c_s \sim 9 \times 10^5 \text{ cm s}^{-1} \sim 9 \text{ km s}^{-1}$ — (1)

(c) $\beta = \dfrac{2c_s^2}{\gamma c_A^2}$

$$c_A^2 = \frac{2c_s^2}{\gamma\beta} = \frac{2\gamma P\rho^{-1}}{\gamma 8\pi P/B^2} \quad \text{——} \quad ②$$

$$= \frac{2B^2}{8\pi\rho} \quad \text{——} \quad ②$$

$$= \frac{B^2}{4\pi\rho}$$

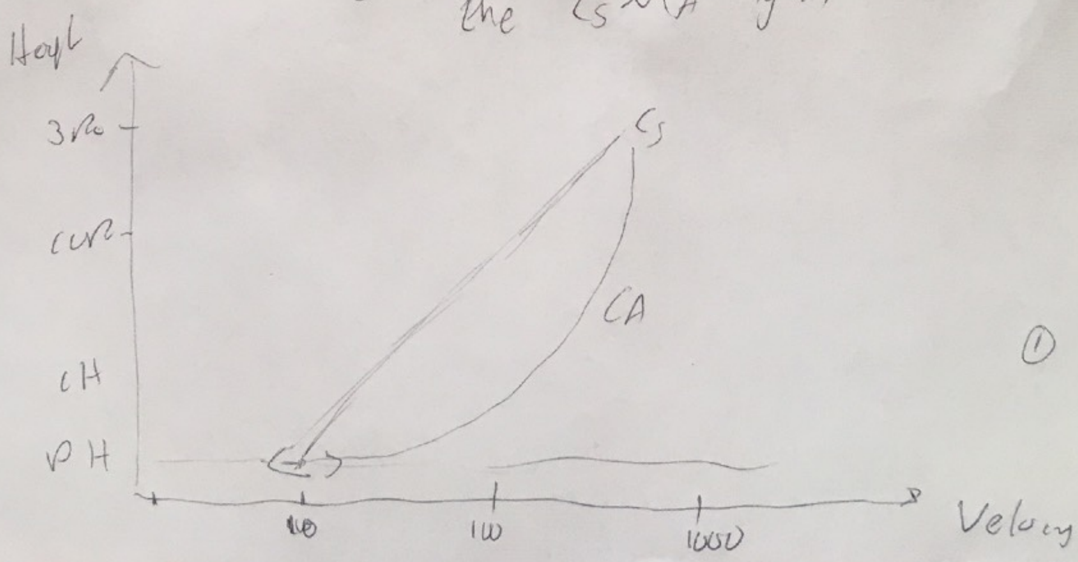
$$c_A = \sqrt{\frac{B^2}{4\pi\rho}} \quad \text{——} \quad ①$$

(d) Several Approaches — As $c_s \sim T^{1/2}$
$c_s \sim 200$ km s^{-1} at $T \sim 10^6$

Generous grading

② And As $c_A \sim B\rho^{-1/2}$
and B falls off but ρ falls faster
with height
$c_A \uparrow \sim 800$ km s^{-1} at 10^6

OR — As β drops to $\beta \ll 1$
but then increases close to $\beta \sim 1$
② the $c_s \sim c_A$ again



①