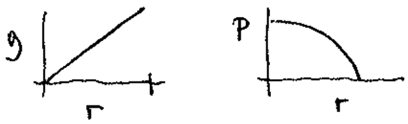
MIDTERM.

1 a) solar photosphere ; carbonaceous (CI) chondrites (2)

b) $t \sim d^2/\kappa \sim 10^2/10^{-6} \sim 10^8$ s $\sim$ 3 years (2)

c)  (2)

d) Mars, Venus, Earth, Titan (2) poorly done

e) $F = k\frac{dT}{dz}$ $\frac{dT}{dz} = \frac{30\times10^{-3}}{3} = 10^{-2}\ \mathrm{K\,m^{-1}} = 10\ \mathrm{K/km}$ (2)

f) incoming radiation short λ, atmosphere transparent poorly done
outgoing re-radiated energy long λ, atmosphere opaque, heat gets trapped (2)

g) $\sigma = E\varepsilon = E\alpha\Delta T = 10^{11}\times 3\times10^{-5}\times 20 = 6\times10^{7} = 60$ MPa (2)

h) lower surface density ; longer orbital periods (2) poorly done

i) $\alpha = \left(\frac{E T_e^3}{3g\Delta\rho(1-\nu^2)}\right)^{1/4}$ $\alpha_{Moon} > \alpha_{Mars}$ => mountains with longer wavelength can still be flexurally-supported on the Moon ($\alpha > \lambda$)
=> Mars more likely to show compensation (2)

j) atmosphere ; surface erosion/deposition (2)

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2 a)  $m = \frac{2}{3}\pi R^3 \rho_e$ (1)

b) $PE = mgh = \frac{2}{3}\pi R^4 \rho_e g$ (1)

c) $KE = \frac{1}{2}\frac{4}{3}\pi r^3 \rho_i v^2 = \frac{2}{3}\pi r^3 \rho_i v^2$ (2)

d) $\cancel{\frac{2}{3}\pi} R^4 \rho_e g = \cancel{\frac{2}{3}\pi} r^3 \rho_i v^2$ $R = \left(r^3 \frac{\rho_i}{\rho_e}\frac{v^2}{g}\right)^{1/4}$ (4)

$r\uparrow$ $R\uparrow$ makes sense $v\uparrow$ $R\uparrow$ makes sense $g\uparrow$ $R\downarrow$ makes sense – more work done against gravity, so crater smaller
$\frac{\rho_i}{\rho_e}\uparrow$ $R\uparrow$ makes sense

e) comet bigger crater (v^2 beats ρ) (1)

f) $v_{esc} = \sqrt{2gR_p}$ $R = \left(r^3 \frac{2gR_p}{g}\right)^{1/4} = (2r^3 R_p)^{1/4}$ (2)

g) $R_p^4 = 2r^3 R_p \Rightarrow r = \frac{R_p}{2^{1/3}}$ (2)

h) Mercury – mantle stripped Mars – hemispheric dichotomy (2)
Earth – Moon formed
Venus – flipped over

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3 a) $g = \frac{GM}{r^2} = G\frac{\frac{4}{3}\pi r^3 \rho}{r^2} = \frac{4}{3}\pi G \rho r$ (2)

b) $\frac{dP}{dr} = -\rho g = -\rho^2 \frac{4}{3}\pi G r \Rightarrow P = -\rho^2 \frac{4}{3}\pi G \frac{r^2}{2} + c$

at $r = R$ $P = 0 \Rightarrow c = \rho^2 \frac{2}{3}\pi G R^2 \Rightarrow P = \frac{2}{3}\pi G \rho^2 (R^2 - r^2)$ (4)

c) $g_0 = \frac{4}{3}\pi G \rho R \Rightarrow P_{cen} = \frac{1}{2} g_0 \rho R$ (2)

d) $g_0 = \frac{4}{3}\pi G \rho R \Rightarrow g_{SE} = 3 g_E = 30\,\mathrm{ms^{-2}}$ (3)

e) $P_{SE} = \frac{1}{2} g_0 \rho R \Rightarrow P_{SE} = 3 \times 1.5 \times 2 = 9 P_E = 2700$ GPa (2)

f) pressures are higher => material is more compressed (bulk modulus)
=> higher density (2) $\boxed{15}$

4 a) $\rho = \frac{P\mu}{RT}$ (1)

b) $\frac{dP}{dz} = -\rho g \Rightarrow \frac{dP}{dz} = -\frac{P\mu}{RT} g \Rightarrow \frac{1}{P} dP = \frac{\mu g}{RT} dz$

$\Rightarrow \ln P = \frac{\mu g z}{RT}$ at $z = 0$ $P = P_0 \Rightarrow P = P_0 \exp\left(-\frac{\mu g}{RT} z\right)$ (4)

c) scale height; distance over which pressure drops to 1/e (2)
of surface value

d) $\rho = \rho_0 \exp\left(-\frac{\mu g}{RT} z\right)$ total column mass $= \int \rho\, dz$

$= \left[\rho_0 \frac{RT}{\mu g} \exp\left(-\frac{\mu g}{RT} z\right)\right]_0^{\infty}$

$= \frac{\rho_0 RT}{\mu g}$ (3)

e) $P_0 = \rho_0 \frac{RT}{\mu} \Rightarrow$ column mass $= \frac{P_0}{g}$ This is weight divided by gravity, (2)
which gives mass (per unit area)

f) $H = \frac{RT}{g\mu}$ Venus has bigger $T \Rightarrow$ bigger H
Mars has lower $g \Rightarrow$ bigger H. (2)

g) temperature was higher (?) (1)

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