ATMO 451a/551a **Hour Exam – Closed Notes** Fall 2001

Instructions: ATMO 451a: Please work any 3 of the following 6 problems.
ATMO 551a: Please work any 4 of the following 6 problems.

1. Given that the population of Earth is currently 6.175 billion people and that the global increase (i.e. birth rate minus death rate) is currently 2.4 people per second, estimate the global population in 2006 (5 years from now).

2. Figure 2.2 (following) shows a plot of the average pressure and temperature as a function of altitude.

   a) What fraction of the total mass of the atmosphere is in the troposphere?

   b) What fraction of the total mass of the atmosphere is in the stratosphere?

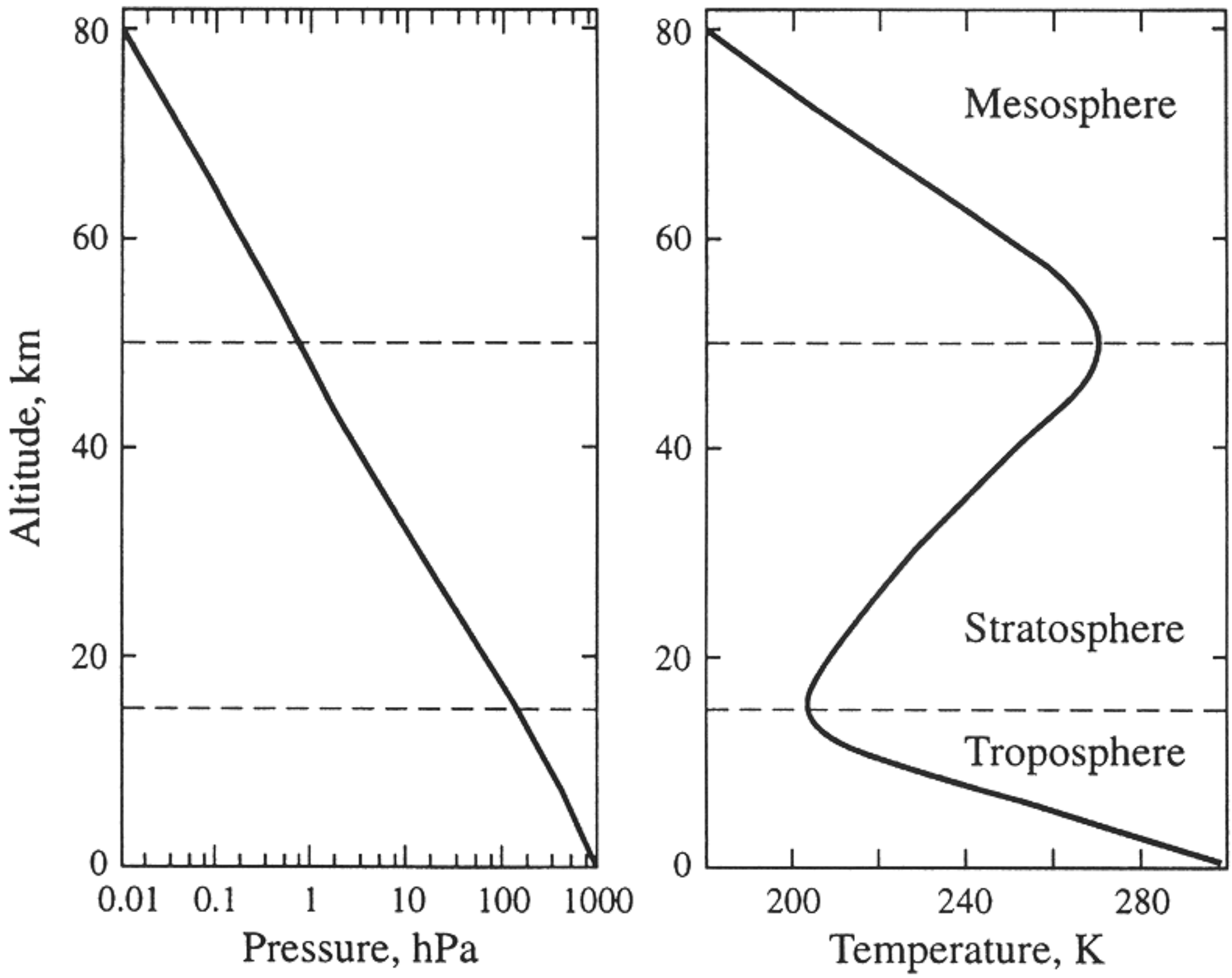


Fig. 2-2 Mean pressure and temperature versus altitude at 30° N, March.

3. Starting with the hydrostatic equation and the gas law, derive an expression for the pressure scale height of water vapor. Compute a numerical value for this scale height in the lower stratosphere (see Figure 2.2 above).

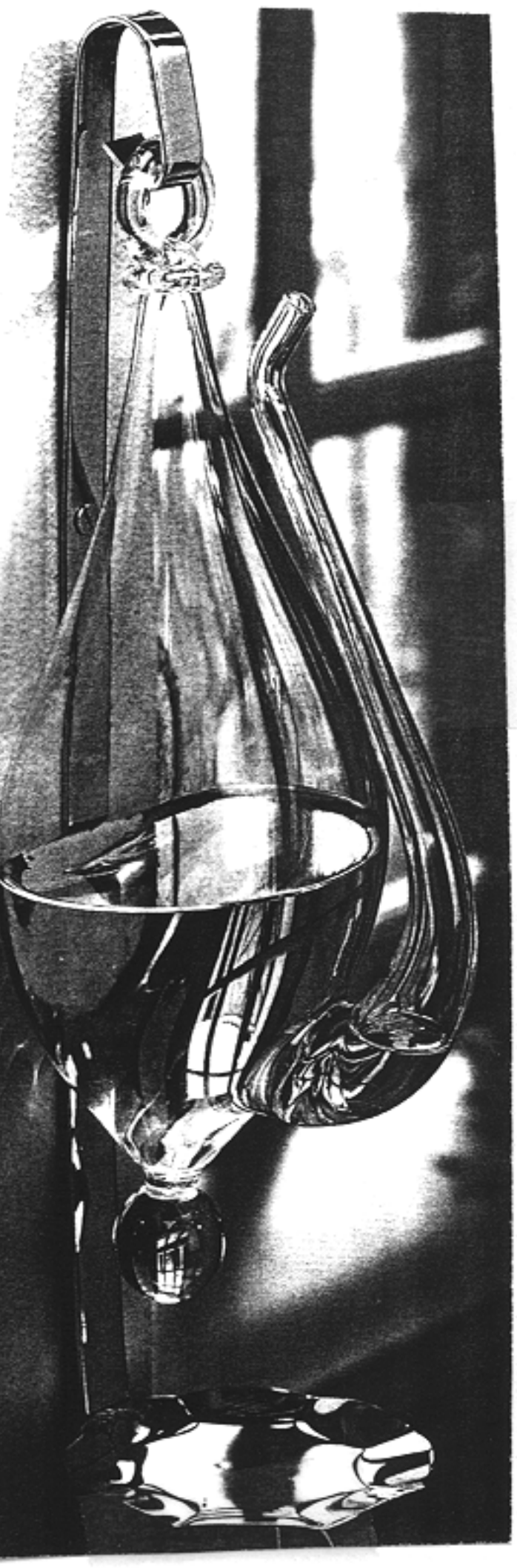
4. Suppose a hollow spherical bubble with radius, a, is completely submerged in a glass of water. Integrate the pressure force over the surface of the bubble, and show that the total force upward (the buoyant force) is given by

$$F_b = \tfrac{4}{3}\pi a^3 \rho_w g$$

where ρ_w is the mass density of water and g is the acceleration of gravity.

5. From careful measurements of the radio refractive index, the GPS/MET satellite obtains accurate values of n, the number density of air molecules, as a function of atmospheric depth, Z. Show explicitly how such measurements can be used to determine both the atmospheric pressure, p, and temperature, T, as a function of Z.

6. Consider a "weatherglass" like that shown in the following figure. Suppose the volume of air in the large bulb is 500 cm^3 and that the water level in the spout is the same as the level in the bulb. What will happen to the water levels if the temperature of the large bulb increases by 3°C while the outside pressure remains constant? You can assume that the cross-sectional areas of the spout and bulb are 1.0 cm^2 and 100 cm^2, respectively.



Some Constants

Constant	Value	Description
G	$= 6.67\times10^{-11}$ Nt m^2/kg^2	Univeral Constant of Gravitation
g_0	$= 980.6$ cm/sec^2	
R_E	$= 6371$ km	Average radius of Earth
M_E	$= 6.0\times10^{27}$ gm	Mass of Earth
N_A	$= 6.02\times10^{23}$ molecules mole^{-1}	Avogadro's number
R	$= 8.314\times10^{7}$ erg °K^{-1} mole^{-1}	Universal Gas Constant
	$= 8.314$ J °K^{-1} mole^{-1}	
k	$= 1.38\times10^{-16}$ erg °K^{-1}	Boltzmann's Constant
	$= 1.38\times10^{-23}$ J °K^{-1}	
$\rho_{dry\ air}$	$= 1.3\times10^{-3}$ gm cm^{-3} at STP	
	$= 1.3$ kg m^{-3} at STP	
ρ_{water}	$= 1$ gm cm^{-3}	
	$= 1000$ kg m^{-3}	
$p_{sea\ level}$	$= 1013$ mb $= 1.013\times10^{6}$ dynes/cm^2	

Some Gases

Gas	Molecular Weight
Nitrogen (N_2)	28
Oxygen (O_2)	32
Argon (A)	40
Water Vapor (H_2O)	18
Carbon Dioxide (CO_2)	44
Hydrogen (H_2)	2