Date : May 2, 2008   MAJOR   Time: 3.30 – 5.30 pm

Venue: VI LT1   Max Marks : 50

ASL 850 Numerical Modelling of Atmospheric Processes

1. A balloon filled with helium is required to carry an instrument payload of 100 kg to an altitude where the pressure is 12 hPa and temperature is 230K. Balloons are available of non-stretch polythene with a thickness of 25 μm and density $10^3 kg/m^3$. [$1 \mu m = 10^{-6} m$] What approximate radius of ballon is needed? (10)

2. If the total potential energy of the atmosphere is (5)

$$E = \frac{c_p}{g(1+\kappa)\, p_0^{\kappa}} \int_0^{\infty} \left(\overline{p^{1+\kappa}}\right) d\theta ;$$

c_p = sp. heat of air at constant pressure; g = accⁿ due to gravity; $\kappa = R/c_p$, R = gas const.

and its minimum potential energy is given as

$$E_{min} = \frac{c_p}{g(1+\kappa)\, p_0^{\kappa}} \int_0^{\infty} (\overline{p})^{1+\kappa} d\theta ,$$

then, obtain the expression for total available potential energy $E_A = E - E_{min}$, assuming $1+\kappa > 1$, $\left(\overline{p^{1+\kappa}}\right) > (\overline{p})^{1+\kappa}$ and $\overline{p'} = 0$.

3. Suppose 1-kg parcel of dry air is is rising at a constant vertical velocity. If the parcel is heated by radiation at a rate 0.1 W/kg, what must be the speed of rise of the parcel in order to maintain it at a constant temperature? (5)

4. Two equal air masses mix at constant pressure. Their temperatures and water vapour pressures are as follows, (7)

Parcel 1 : $T_1 = 23.8°C$, $e_1 = 25.5$ hPa,

Parcel 2 : $T_2 = -6.4°C$, $e_2 = 2.1$ hPa.

(a) Determine the relative humidities of both air masses.

(b) Determine whether this mixture results in fog.

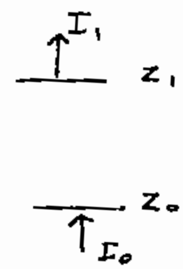
5. Assuming the sun overhead and a uniform Temperature atmosphere, for a distribution of number density n of ozone molecules as a function of pressure p given by $n = n_0 p^{3/2}$, show that the heating rate h by absorption of solar radiation is of the form (7)

$$\frac{h}{h_m} = \left(\frac{p}{p_m}\right)^{\frac{1}{2}} \exp\left\{-\frac{1}{3}\left(\frac{p}{p_m}\right)^{\frac{3}{2}} - 1\right\}$$

where p_m is the level of maximum heating h_m. Assume a single absorption coefficient independent of wavelength within the ozone band.

6. Given (6)

$$I_1 = I_0\, \tau(z_0, z_1) + \int_{\tau(z_0,z_1)}^{1} B(z)\, d\tau(z, z_1) \qquad (A1)$$



for a thick slab between levels z_0 and z_1 with radiant energy I_0 incident vertically upwards at z_0 and I_1 is the intensity leaving the top of the slab at z_1, show that I_1 can be written as

$$I_1 = \{I_0 - B(z_0)\}\, \tau(z_0, z_1) + B(z_1) + \int_{z_1}^{z_0} \tau(z, z_1) \frac{dB(z)}{dz}\, dz. \qquad (A2)$$

Write the first eqn. given above in the flux form and obtain the expression for heating rate $(\rho C_p \frac{dT}{dt})$ at level z_1.

7. Submit Assignment

(10)