



RAJARATA UNIVERSITY OF SRI LANKA

FACULTY OF APPLIED SCIENCES

B.Sc. (General) Degree in Applied Sciences
Third Year - Semester I Examination - September/October 2014

PHY 3301 –ATMOSPHERIC PHYSICS

Answer all six (06) questions

Time allowed: 3 hours

1. Earth's atmosphere is believed to be formed due to volcanic outgassing, which contained gasses like CO_2 , H_2O , NH_3 , SO_2 and H_2 . However, the atmosphere did not contain oxygen (O_2) gas.
 - I. What are the major processes that produce oxygen gas in the atmosphere?
 - II. Explain the reasons for the temperature decrease with increasing altitude in the troposphere (lowest layer of the atmosphere).
 - III. In the stratosphere, the temperature exhibits a threefold increment; the temperature does not change with the altitude in the lowest part, and the temperature increases at different rates in the middle and the upper parts. Giving appropriate chemical reactions, explain the reasons for these variations.
 - IV. Explain why most commercial aircrafts *cruise* at altitudes of 9 - 12 km (lower stratosphere).
 - V. Explain,
 - i) The temperature variation in the thermosphere with respect to increasing altitude
 - ii) Formation of the ionosphere.

(20 Points)

2. During a clear night, the surface of the earth - loses F_{IR} amount of energy per unit area, through net infrared emission. If this loss of energy is transferred immediately to the atmosphere above;

Show that the atmospheric temperature above the earth's surface is,

$$T_R = T_i e^{-\Delta t/t_r}$$

where, $t_r^{-1} = \frac{F_{IR} R_d}{\Delta z C_p P}$ with R_d - gas constant, Δz - height of the atmosphere, C_p -

heat capacity at constant pressure, P - atmospheric pressure, T_i - initial temperature and Δt - time difference. (Hint: Energy absorbed by the atmosphere is $Q = mC_p \frac{dT}{dt}$ and the ideal gas law is $P = \rho R_d T$.)

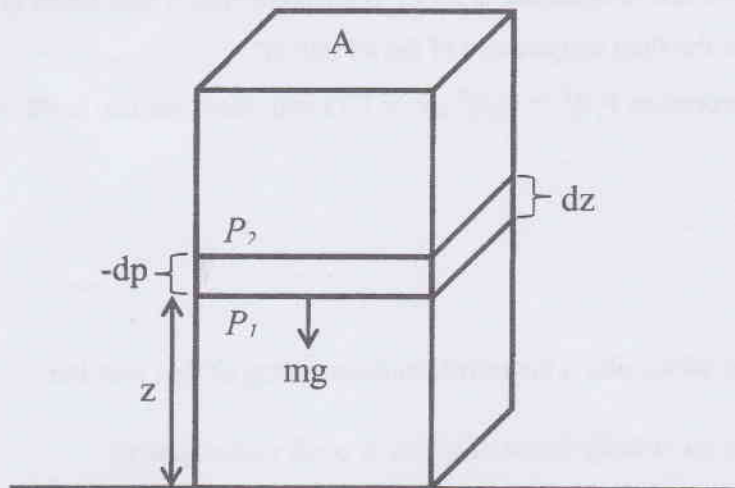
(15 Points)

3. Clouds in the earth's atmosphere are formed due to adiabatic expansion of rising air parcels.

- I. What is homogeneous nucleation?
- II. Explain why it is not possible to form clouds by homogeneous nucleation.
- III. Briefly explain the formation of clouds in earth's atmosphere.
- IV. Clouds are made up of water droplets and ice. Explain why all clouds cannot produce precipitation.

(15 Points)

4. Consider a thin horizontal slab of air with thickness dz , weight mg and area A above the ground as shown in the following diagram.



If the density of the air is ρ and pressure above and below the air slab are P_2 and P_1 respectively,

- I. Considering Hydrostatic equilibrium, show that

$$\frac{dp}{dz} = -\rho g$$

- II. Using the equation in *part I* and the ideal gas law ($PV = nRT$), show that,

$$P_2 = P_1 e^{(-\frac{z}{H})}$$

Where, $H = \frac{RT}{gM}$ with R – universal gas constant and M – molar mass.

- III. Plot the variation of pressure with height z across the air slab.
- IV. Calculate the pressure at 5 km above the ground, if the surface pressure and temperature are 100 kPa and 300 K respectively. Assume that the average molar mass of air is equal to 28.97 g/mol.

(20 Points)

5. During the cloud formation, an air parcel rapidly expands adiabatically, whose initial pressure is 10^5 Pa and temperature is 22°C , to a volume that is four times of its original volume. What is the final temperature of the air parcel?

(For adiabatic processes $P_1 V_1^\gamma = P_2 V_2^\gamma$, $\gamma = 1.33$ and Ideal gas law is $PV = Nk_B T$)

(15 Points)

6. The atmospheric winds play a major role in determining earth's weather.

- I. What are the driving forces of winds in earth's atmosphere?
- II. If a low-pressure zone is developed at the Bay of Bengal, in which direction will the wind blow (clockwise or anti-clockwise)? Explain your answer.
- III. If a low-pressure zone is developed closer to New Zealand, in which direction will the wind blow? Explain your answer.
- IV. Explain why low-pressure zones in the earth have more rain whereas high-pressure zones produce desert areas.
- V. Geostrophical winds blow parallel to isobars making circular wind patterns in the upper atmosphere. Explain why these geostrophical winds can only be observed at the upper atmosphere?

(15 Points)