RAJARATA UNIVERSITY OF SRI LANKA
FACULTY OF APPLIED SCIENCES

B.Sc. (General) Degree
Third Year – Semester I Examination – March/April 2014

PHY 3301 – ATMOSPHERIC PHYSICS

Answer **Six** Questions Only Time allowed: 3 hours

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1. (a). Explain why the ozone layer is confined to stratosphere. Why does the temperature increase with the height in the stratosphere? *(35 marks)*

(b). Name three manmade chemicals that contribute to the destruction of the ozone layer. In what way do humans affect the ozone concentration in the atmosphere? *(30 marks)*

(c). Explain the mechanism of the "*atmospheric greenhouse effect*" and how it warms the surface of the Earth. Give two examples for "*greenhouse gases*". *(35 marks)*

2. (a). What is it meant by "*temperature inversion*" in atmosphere? Give one consequence of it.

(25 marks)

(b). Explain the idea of an air parcel used in the atmospheric studies. Give three assumptions made for such a parcel. *(25 marks)*

(c). What is it meant by stability of a parcel of air with respective to its vertical movement and describe the nature of the atmosphere when

(i) Actual laps rate $\Gamma < \Gamma_d$
(ii) Actual laps rate $\Gamma = \Gamma_d$
(iii) Actual laps rate $\Gamma > \Gamma_d$ Where Γ_d is the dry adiabatic laps rate.

(50 marks)

3. (a). Define *Geopotential* (ϕ) for a unit mass of air at a height from the sea level at any point in the Earth's atmosphere. Explain what is meant by the *geopotential height.* *(25 marks)*

Contd.

(b). Starting with the hydrostatic equation and the ideal gas law show that the geopotential thickness of an isothermal atmospheric layer between pressure levels P_1 and P_2 can be expressed as

$\Delta Z = (Z_2 - Z_1) = (R_d T_v / g_o) \int_{P2}^{P1} (\frac{dp}{p})$. Here the symbols have their usual meanings.

(50 marks)

(c).The thickness of the 1000 hPa to 500 hPa atmospheric layer is predicted to increase from 5230 m to 5650 m at a given station. Assuming that the laps rate remains constant, estimate the change in the surface temperature. (Given $R_d/g_o = 29.3$)

(25 marks)

4. (a). Consider a volume V of moist air at temperature T and total pressure P. The density of moist air can be written as $\rho = \rho_d' + \rho_v'$

Where ρ_d' = the partial density of dry air

ρ_v' = the partial density of moist air

Write down an expression for partial pressures exerted by the water vapour (e) and dry air (P_d) in terms of ρ_d' , ρ_v', T, R_v and R_d where R_v - the gas constant for 1 Kg of water vapour and R_d - the gas constant for 1 Kg of dry air. *(30 marks)*

(b).Using Dalton's Law of partial pressures write down an expression for total pressure P of the moist air using expressions obtained in part (a) above.

(30 marks)

(c). Obtain the expression $P=\rho R_d T_V$, from the results obtained in part (b) above. Where

$$T_V = \frac{T}{\left[1-\frac{e}{P}(1-\varepsilon)\right]} \quad \text{and} \quad \varepsilon = R_d/R_V$$

(40 marks)

5. (a) What is an adiabatic process and give one example for it?

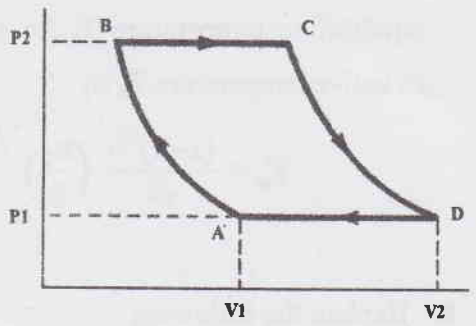
(25 marks)

(b) State briefly the 1st law of thermodynamics with its differential form.

(25 marks)

Contd.

(c) An ideal gas is carried through a thermodynamic cycle consisting of two isobaric and two isothermal processes as shown in Figure.



Show that the net work done on the gas in the entire cycle is given by

$$W_{net} = -P_1 (V_2 - V_1) \ln \left(\frac{P2}{P1}\right)$$

(50 marks)

6. (a). What is it meant by planetary albedo? List three factors which affect the albedo and explain how humans can affect land surface albedos. *(25 marks)*

(b). State, giving mathematical expressions, the following radiation laws.

(i) Planck's law (II) Stefan-Boltzman Law *(25 marks)*

(c).The sun with radius R_s of 7×10^8 m emits radiation as a black body of 5780 K temperature. If the distance between the sun and the earth is approximately 1.5×10^{11} m, estimate the solar constant of the earth. *(Stefan's constant $\sigma = 5.7 \times 10^{-8}$ W m^{-2} K^{-4})*

(50 marks)

7. (a). Define the inverse square law used in atmospheric radiation and explain why this concept is important.

(25 marks)

(b). Energy transfer in the atmosphere involves radiation in two distinct bands of wavelengths. List these two distinct bands of wavelengths and name the sources from where these radiations originate.

(25 marks)

Contd.

(c). Nearly all of the Sun's radiation is emitted from the outmost visible layer which has a mean radius R_s of 7 x 10^8 m and a temperature, T_s of 5780 K. Show that the radiative equilibrium temperature T_e for a planet with a distance R from the sun is related to the radiative temperature T_s by

$$T_e = \frac{(1-\alpha)^{1/4}}{\sqrt{2}} \left(\frac{R_S}{R}\right)^{1/2} T_S \qquad \textit{(50 marks)}$$

8. Explain the following

(a). A parcel of air cools when it is lifted. Dry air parcels cool more rapidly than moist parcels. *(25 marks)*

(b) Pressure in the atmosphere increases approximately exponentially with height, where as the pressure in the ocean increases approximately linearly with depth. *(25 marks)*

(c).What happens when the wind pushes a moist air mass against a mountain? *(25 marks)*

(d).The gas constant for moist air is greater than that for dry air. *(25 marks)*

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