UNIVERSITY COLLEGE LONDON

University of London

EXAMINATION FOR INTERNAL STUDENTS

For The Following Qualification:-

M.Sci.

Astronomy 4C12: Planetary Atmospheres

COURSE CODE	:	**ASTR4C12**
UNIT VALUE	:	**0.50**
DATE	:	**13-MAY-05**
TIME	:	**10.00**
TIME ALLOWED	:	**2 Hours 30 Minutes**

TURN OVER

Answer THREE questions
The numbers in square brackets indicate the provisional allocation of maximum marks per sub-section of a question.

1.

(a) What is the major source and the major loss of energy which determines the surface temperature of an inactive solar system body with no atmosphere? **[2 marks]**

(b) Briefly describe the difference to this temperature that an atmosphere may provide. **[2 marks]**

(c) What major internal energy source may be important in determining temperature at the bottom of an atmosphere for (i) a terrestrial planet and (ii) a gas giant? **[2 marks]**

(d) What additional sources of energy may be important in a planetary atmosphere? **[6 marks]**

(e) Two new extrasolar planets are discovered at identical distances around their parent stars. The stars have the same intensity. If the albedos of the two planets are 0.4 and 0.3, calculate the ratio of the *equilibrium temperatures* of the planets. **[4 marks]**

(f) Given that the planets in part (e) are gas giants, why might the ratio of their *effective temperatures* be different? **[4 marks]**

2.

(a) Describe briefly each of the five principal circulation systems in planetary atmospheres. **[10 marks]**

(b) Describe the atmospheric motion visible at **(i)** Jupiter and **(ii)** Saturn. **[4 marks]**

(c) In what way, and why, are the motions in (b) different to the basic circulations in (a)? **[2 marks]**

(d) Which circulation systems would you expect to be important in the atmosphere of Saturn's moon Titan? Explain your answer. **[4 marks]**

3.

(a) Classical Chapman theory of the formation of ozone in the stratosphere is based on the balance of five chemical reactions:

(1) $O_2+h\nu_2$	$\Rightarrow$	$O+O$	J_2
(2) $O_3+h\nu_3$	$\Rightarrow$	O_2+O	J_3
(3) $O+O+M$	$\Rightarrow$	O_2+M	k_1
(4) $O+O_2+M$	$\Rightarrow$	O_3+M	k_2
(5) $O+O_3$	$\Rightarrow$	$2O_2$	k_3

where J_2 and J_3 are dissociation rates per molecule per second and k_1, k_2 and k_3 are the reaction rates, and M is an atom or molecule required to satisfy conservation of energy and momentum.

Write down equations giving the rate of change of concentrations of O_2 and O_3. Show that in equilibrium the concentration n_3 of O_3 is proportional to the concentration n_2 of O_2 as follows:

$$n_3^{\,2} = n_2^{\,2}\left(\frac{J_2 k_2 n_M}{J_3 k_3}\right)$$

where n_M is the concentration of species M. Which reactions are neglected to produce the above result?

[12 marks]

(b) Sketch the form of the solution for ozone density with altitude **[2 marks]**

(c) Which planets have an appreciable stratosphere, and why? **[2 marks]**

(d) Large scale volcanic eruptions can increase the amount of dust in the stratosphere for significant periods. What effect might this have on stratospheric temperatures? What latitudinal variations might you expect?

[4 marks]

4.

(a) Name the four main regions of Jupiter's atmosphere and sketch the vertical structure in that atmosphere as a graph of pressure against temperature. **[6 marks]**

(b) Describe the main heating and cooling mechanisms at work, and any clouds, in each layer. **[8 marks]**

(c) Which four diagnostic methods were used to determine this profile? Provide a brief description of each method. **[6 marks]**

5.

(a) Give a detailed comparison of the evolution of the atmospheres of the Earth, Venus and Mars since the formation of the planets 4.6 billion years ago. **[16 marks]**

(b) Why is the atmosphere of Titan said to resemble the Earth's early atmosphere? **[2 marks]**

(c) Why has Titan's atmosphere not evolved beyond its current point? **[2 marks]**