UNIVERSITY COLLEGE LONDON

University of London

EXAMINATION FOR INTERNAL STUDENTS

For The Following Qualifications:-

B.Sc. *M.Sci.*

Astronomy 2B17: Physics of the Solar System

COURSE CODE	:	**ASTR2B17**
UNIT VALUE	:	**0.50**
DATE	:	**19-MAY-04**
TIME	:	**14.30**
TIME ALLOWED	:	**2 Hours 30 Minutes**

TURN OVER

Answer all SIX questions from section A and THREE questions from Section B.
The numbers in brackets indicate the provisional allocation of marks for each sub-section of the question.

Stefan-Boltzmann constant σ	$= 5.67 \times 10^{-8}$ W m^{-2} K^{-4}
Boltzmann constant k	$= 1.38 \times 10^{-23}$ JK^{-1}
Proton mass m_p	$= 1.67 \times 10^{-27}$ kg
Electron mass m_e	$= 9.11 \times 10^{-31}$ kg
Electron charge q	$= -1.6 \times 10^{-19}$ C
Permeability of free space μ_o	$= 4\pi \times 10^{-7}$ H m^{-1}
Mean Earth-Sun distance (1AU, Astronomical Unit)	$= 150 \times 10^{6}$ km
Sun's radius R_S	$= 6.960 \times 10^{8}$ m
Radius of Earth R_E	$= 6.37 \times 10^{3}$ km
Radius of Mars R_M	$= 3.4 \times 10^{3}$ km
Magnetic field at Earth's surface B_E	$= 31 \times 10^{-6}$ T

Section A

1. Describe what is meant by "primary", "secondary" and "tertiary" crust. List reasons why there are a smaller number of meteor craters observed on the Earth compared with the moon. [8]

2. Explain why the magnetic field of the solar wind is "frozen-in" and why, as a consequence, in the ecliptic plane the mean angle of the interplanetary magnetic field with respect to the Sun-Earth line is around 45°. [6]

3. The simple heat balance equation for the effective temperature of a planet is given by the following equation:

$$T_p^4 = \frac{(R_s^2\, T_s^4)\,(1 - A)}{k \qquad r_p^2}$$

Define all the terms and briefly explain the theory behind the derivation of this equation. Give two examples of planets to illustrate different k values. [6]

4. Explain qualitatively why the adiabatic lapse rate determines the stability of an atmosphere. Account for why the adiabatic lapse rate of Mars should differ from that of Earth. [7]

5. Explain what is meant by the J parameters and how they may help determine the interior composition of a planet [6]

6. Derive an expression for the Larmor radius r for a particle with charge q in a magnetic field B. Calculate the values of r for the following particles using the given parameters:

a) An electron in the solar wind, where B= 6nT and the solar wind temperature = 8.9×10^4K.
b) A 7keV electron travelling with a pitch angle of 60° to the Earth's magnetic field where the field value is 240nT.

[7]

Section B

7. Theories of the formation of the Solar System must account for the observations of geometry, dynamics and chemistry of the Sun and planetary bodies. List 5 observations that must be accounted for. [5]

Explain what the condensation sequence is, giving appropriate examples. [6]

A homogeneous spherical primordial nebula with radius R_0 collapses to form a homogeneous disk-shaped solar system with radius R_1 and depth d. Assume a rigid sphere such that all parts of the sphere rotate about a single axis through its centre with angular speed ω_0, and similarly a rigid disk that rotates with angular speed ω_1 about a single axis through its centre. Determine the moment of inertia of the disk-shaped solar system in terms of its mass M and then determine the moment of inertia of the spherical solar nebula in terms of its mass M.

Show that the ratio of the angular speeds ω_0 / ω_1 is given by:

$$(\omega_0 / \omega_1) = (5/4)(R_1 / R_0)^2$$

[Hint: the moment of inertia of a disk may be determined by considering an elemental ring of radius r, thickness dr and depth d. The moment of inertia of a sphere may be determined by considering an elemental disk of radius r and depth dz that is a distance z from the centre of the sphere.] [9]

8. Sketch and label a diagram of a comet as it nears the Sun. Account for why a comet close to the Sun has a different appearance to when it is in the outer reaches of the solar system. [8]

Briefly explain how the trajectories and periodicity of comets indicate where their origins may lie. [6]

A spacecraft approaches and lands on a comet. The spacecraft uses a spring to lift off from the comet surface. On Earth the spring is able to lift the spacecraft to a height of 3m. What is the largest cometary nucleus that the spacecraft could escape from? (Assume that the ratio of the densities of the Earth to the comet is 5:1.) [6]

9. Explain qualitatively how the radius of a stable orbit for a planetary satellite is restricted by both the Roche Limit and the Instability Limit. Give a simple derivation of the Roche Limit to show that it can be given by the following expression, where C is a constant, and explain all the parameters.

$$r = C\,(\rho_p / \rho_s)^{1/3}\ R_p$$ [9]

Describe the general structure of rings and satellites around the Gas Giants and include an account of how the Roche Limit might influence the geometry and distribution of this matter. [11]

10. Describe how the distribution of sunspots changes during the sunspot cycle. Explain why there is an 11 year and 22 year cycle for sunspots. How it is possible to distinguish a sunspot at the end of the old cycle from one at the beginning of a new cycle? Describe the magnetic field model that accounts for sunspots and the sunspot cycle. [13]

Briefly describe each component of the process that links a coronal mass ejection with the Earth's auroral regions and leads through to the shutdown of the electricity grid in northern Canada. [7]

11. Briefly describe the mechanisms of differentiation in the formation of a planet. [6]

Compare and contrast, with diagrams, the possible internal structures of Earth and Venus. [11]

Give 3 possible reasons why Earth has a magnetic field, while Venus has none. [3]

END OF PAPER