BOARD OF STUDIES
NEW SOUTH WALES

HIGHER SCHOOL CERTIFICATE EXAMINATION

1999

COSMOLOGY

DISTINCTION COURSE

MODULES 1, 2 AND 3

(60 Marks)

Time allowed—One hour
(Plus 5 minutes reading time)

DIRECTIONS TO CANDIDATES

- A data sheet is attached to this paper.
- Board-approved calculators may be used.
- Answer each section in a SEPARATE Answer Booklet.

SECTION I (8 marks)

- Attempt FOUR questions.
- Each question is worth 2 marks.
- Allow about 8 minutes for this Section.

SECTION II (12 marks)

- Attempt BOTH questions.
- Each question is worth 6 marks.
- Allow about 12 minutes for this Section.

SECTION III (40 marks)

- Attempt BOTH questions.
- Each question is worth 20 marks.
- Allow about 40 minutes for this Section.

SECTION I

(8 Marks)

Attempt FOUR questions.

Each question is worth 2 marks.

QUESTION 1

(a) Briefly explain what is meant by the term *homogeneous universe* in cosmology.

(b) On what scale size does our Universe seem homogeneous?

QUESTION 2

Where would you locate an ultraviolet telescope? State the range of wavelengths it would observe.

QUESTION 3

State FOUR pieces of information that might be obtained from the optical spectrum of a celestial object.

QUESTION 4

What key observations did Edwin Hubble make that changed our concept of the size of the Universe?

QUESTION 5

State the function of, and describe, an objective prism.

QUESTION 6

Outline the main concepts assumed in a theistic model of our Universe.

SECTION II

(12 Marks)

Attempt BOTH questions.

Each question is worth 6 marks.

QUESTION 7

(a) Discuss the stellar magnitude scale, and explain the meaning of the terms:

(i) *apparent magnitude*;

(ii) *Absolute Magnitude* (in astronomy).

(b) Calculate the distance to a quasar of apparent magnitude 13 and Absolute Magnitude –26·4.

QUESTION 8

The Universe is observable at many wavelengths. List some of the objects that emit millimetre waves, and describe the astrophysical quantities that may be measured from observations of such millimetre waves.

Please turn over

SECTION III

(40 Marks)

Attempt BOTH questions.

Each question is worth 20 marks.

Answer each question in a SEPARATE Writing Booklet.

QUESTION 9

After Copernicus' death in 1543, the year his model of the Universe was published, there was a period of more than 100 years before this new model supplanted the Ptolemaic model. Discuss why general acceptance of Copernicus' model took so long.

QUESTION 10

Instruments such as FLAIR and 2dF make the international Anglo-Australian Telescope and the UK-Schmidt Telescope more productive.

(a) Discuss the design and operation of these instruments.

(b) Describe the information that these instruments provide about the Universe, and explain why the telescopes are now considered more productive than they were as conventional optical telescopes.

End of paper

Cosmology Distinction Course

Physical Constants and Conversion Factors

Recommended values

Abstracted from the consistent set of constants in CODATA Bull. No. 63 (1986) by the Royal Society, the Institute of Physics, and the Royal Society of Chemistry.

The number in parenthesis after each value is the estimated uncertainty (standard deviation) of the last digit quoted.

speed of light in a vacuum	c	$2{\cdot}997\,924\,58 \times 10^{8}$ m s^{-1} (exact)
permeability of a vacuum	μ_0	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of a vacuum, $\left[\mu_0 c^2\right]^{-1}$	ϵ_0	$8{\cdot}854\,187\,817\ldots \times 10^{-12}$ F m^{-1}
elementary charge (of proton)	e	$1{\cdot}602\,177\,33(49) \times 10^{-19}$ C
gravitational constant	G	$6{\cdot}672\,59(85) \times 10^{-11}$ N m^2 kg^{-2}
Planck constant	h	$6{\cdot}626\,0755(40) \times 10^{-34}$ J s
Avogadro constant	N_A	$6{\cdot}022\,1367(36) \times 10^{23}$ mol^{-1}
molar gas constant	R	$8{\cdot}314\,510(70)$ J K^{-1} mol^{-1}
Boltzmann constant	k	$1{\cdot}380\,658(12) \times 10^{-23}$ J K^{-1}
unified atomic mass constant	m_u	$1{\cdot}660\,5402(10) \times 10^{-27}$ kg
rest mass of electron	m_e	$9{\cdot}109\,3897(54) \times 10^{-31}$ kg

SI secondary units

astronomical unit	AU	$1{\cdot}495\,978 \times 10^{11}$ m
parsec	pc	$3{\cdot}0856 \times 10^{16}$ m = 3·262 ly
Gregorian calendar year	y	365·2425 days = 31 556 952 s
jansky	Jy	10^{-26} W m^{-2} Hz^{-1}

Indicative values

earth mass	$5{\cdot}977 \times 10^{24}$ kg
solar mass, $M_\odot$	$1{\cdot}989 \times 10^{30}$ kg
galaxy mass	$10^{11}\ M_\odot$
Hubble constant, H_0	$100\ h$ km s^{-1} Mpc^{-1} (typically h ranges from 1 to 0·5)

Conversion factors

distance (light-year)	ly	$9{\cdot}460 \times 10^{15}$ m = 63 240 AU
energy (erg)	erg	10^{-7} J
magnetic field (gauss)	G	10^{-4} T
wavelength (angstrom)	Å	10^{-10} m