THREE HOURS OR TWO HOURS

A list of constants is enclosed.

UNIVERSITY OF MANCHESTER

General Physics (snsf)

29th May 2003, 9.45 a.m. - 12.45 a.m.

THREE HOUR CANDIDATES

Answer as many questions as you can.
All questions have equal weight.
Marks will be awarded for your **THIRTEEN** best answers.

TWO HOUR CANDIDATES
(Maths/Physics and Physics with Business and Management)

Answer as many questions as you can from questions 1-10 inclusive.
All questions have equal weight.
Marks will be awarded for your **NINE** best answers.

Electronic calculators may be used, provided that they cannot store text.

The numbers are given as a guide to the relative weights of the different parts of
each question.

PC3010 June 2003 continued...

1. A piece of space debris, initially at rest, falls radially towards the Moon. It is initially at twice the Moon's radius from the centre of the Moon. Estimate the velocity of the debris when it hits the Moon's surface.

   The mass and radius of the Moon are 7.4×10^{22} kg and 1.74×10^6 m respectively.

2. Given that the ionization energy of hydrogen is 13.6 eV, calculate the wavelength of radiation needed to excite an electron from the $n = 3$ to the $n = 4$ orbit of hydrogen.

3. A piston-cylinder system is used to slowly compress a mass of gas from 0.4 m^3 to 0.25 m^3 at a constant pressure of 1 atmosphere. It is found that the internal energy decreases by 25 kJ during the process. Calculate the amount of heat transferred to or from the gas during the compression.

4. The upthrust force F on an aeroplane wing of fixed cross-sectional shape is proportional to the length l of the wing. Use a simple dimensional argument to show how it depends on the width of the wing d, the density of air ρ, and the velocity of the aeroplane v.

5. Estimate the molar heat capacity of argon gas at constant pressure. Comment on any difference between your estimate and the measured value of 21.13 J K^{-1} at room temperature and pressure.

6. The group velocity of waves in a medium is found to be twice the phase velocity. Find the relation between the angular frequency ω and the wave number k in the medium.

7. A long bar magnet is bent into the form of a closed ring. If the intensity of magnetisation is $\mathbf{M}$, and ignoring any end effects due to the join, find the magnetic field $\mathbf{H}$ and the induction $\mathbf{B}$ (a) inside the material of the magnet, and (b) just outside.

8. A laser emits light at a wavelength of 500 nm through a circular aperture of diameter 5 cm. What is the linear diameter of the beam, between points of zero intensity, at the distance of the Moon? [The Earth-Moon distance is 400,000 km]

PC3010

PC3010 June 2003 continued...

9. A particle with mass 10 eV and a photon are produced simultaneously in a galaxy $150,000$ light years away. The energy for both particles is 10 MeV. Estimate the difference in arrival time between the two particles.

10. Draw a clearly labelled graph indicating the main features of the dependence of the average binding energy per nucleon of the stable nuclei as a function of their mass number.

11. A standard 35 mm colour slide has a picture of dimension 24 mm $\times$ 36 mm. What focal length would a projection lens have to have to project a 2.4 m $\times$ 3.6 m image of this picture on a lecture theatre screen 10 m from the lens?

12. The single-particle partition function of a certain type of ideal gas, of volume V at temperature T and consisting of N indistinguishable particles, is

$$Z_1 = bVT^3 \ ,$$

where b is a constant. Write down the Helmholtz free energy of the gas, if N is sufficiently large that it can be assumed that $\ln N! = N \ln N - N$.

13. The magnitude of the total angular momentum of a particle is given by $\mid \mathbf{L} \mid = \sqrt{6}\hbar$. Determine the possible values that could be obtained in a measurement of the z-component of $\mathbf{L}$.

PC3010 June 2003 continued. . .

14.
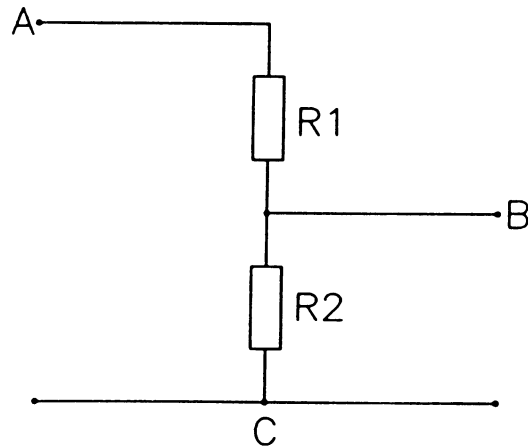
The voltage divider above consists of resistors $R1$ and $R2$ and has input terminals AC and output terminals BC. (a) What resistance would the circuit present to a voltage generator connected across AC? (b) What source resistance would the divider circuit present to another circuit connected across BC, when the divider circuit is used to drive the second circuit?

15. A radioactive source yields 676 counts in one minute. In a similar experiment, conducted precisely one year later, it yields 400 counts. Calculate the value and error of the inverse lifetime $\lambda = \tau^{-1}$, and hence the value and error of the lifetime τ.

———————————