THREE HOURS

A list of constants is enclosed.

UNIVERSITY OF MANCHESTER

General Physics - SNSF

22nd May 1997, 2.00 p.m. - 5.00 p.m.

THREE HOUR CANDIDATES
Answer **ALL** questions

TWO HOUR CANDIDATES
(Maths/Physics and Chemistry/Physics)
Answer questions 1-10 inclusive

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

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1. The phase velocity of waves on deep water is $\sqrt{(g\lambda/2\pi)}$ for wavelength λ. At what speed is energy transported in a deep ocean by waves with $\lambda = 500$ m?

2. A bullet travelling horizontally strikes a large block of wood, suspended by thin wires, and remains stuck in it. The impact causes the block to swing upward to a height of 20 cm. If the bullet has a mass of 10 g and the block's mass is 4 kg, what was the speed of the bullet immediately before impact?

3. Calculate the average separation of the conduction electrons in potassium (body centred cubic, density = 860 kg m^{-3}, A = 39).

4. A singly charged ion of atomic hydrogen is accelerated from rest through a potential difference of 100 V and then enters a magnetic field with magnitude 0.15 T perpendicular to the path of the ion. Determine the radius of the ion's subsequent motion.

5. A gas container is divided into two equal parts by a removable partition. One part contains 1 mole of argon and the other 1 mole of nitrogen, both at 300 K. Determine the change in entropy that occurs when the two gases are fully mixed after the partition has been suddenly removed. Assume both gases are ideal.

6. A particle moves in one dimension in the potential

$$
\begin{aligned}
V(x) &= \infty & -\infty < x < 0 \\
&= 0 & 0 < x < a \\
&= V_0 > 0 & a < x < \infty
\end{aligned}
$$

Sketch the wave functions of the first and second excited states, assuming that they are bound.

7. A mixture of petrol vapour and air is drawn into an engine at 110°C. The mixture is compressed in a cylinder with a volume compression ratio of 10. What is the temperature attained by the mixture at maximum compression before ignition? (Assume the ratio of specific heats for the mixture C_p/C_v is 1.35. State any further assumptions you make.)

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8. A photon of energy 1000 MeV collides with a stationary proton and is scattered through an angle of 90^0. Calculate its energy after scattering.

9. The maximum possible thermal efficiency of a reversible heat engine whose exhaust reservoir is at a temperature $T_c = 150$ K is 40%. If T_c remains constant, by how much must the temperature, T_H, of the hot reservoir be changed to increase the efficiency to 50 %?

10. Estimate the zero point energy in units of eV for an electron confined by high potential walls to a cube of side 10^{-10} m.

11. Calculate the radius of the geostationary orbit around the Earth. Why is this an important orbit?

12. Light of wavelength 581.0 nm in air is incident upon a block of glass of refractive index equal to 1.5. Determine (a) the speed (b) the frequency and (c) the wavelength of the light within the glass block.

13. Write down the expression for the displacement current density in a vacuum. Show for a parallel plate capacitor with vacuum between its plates, that the current flowing into the capacitor is equal to its displacement current between the plates.

14. A plane parallel, monochromatic light source with wavelength 650 nm is used to illuminate two slits of equal width whose centres are separated by a distance of 0.15 cm. The fifth order of interference is the first order not observed. How wide is each slit?

15. A spherical satellite is in an orbit around the Earth such that it is in view of the Sun at all times. Assuming that the satellite behaves as a black body at uniform temperature calculate this temperature. You may neglect radiation coming from the Earth.

(The solar flux above the Earth's atmosphere is 1372 Wm^{-2}).