HONG KONG ADVANCED LEVEL EXAMINATION
AL PHYSICS
1990 Structural Question

7. (a) (i) Explain what is meant by 'parking orbits' for satellites. (2 marks)

(ii) If the radius of the Earth is 6 400 km, and the acceleration due to gravity at the Earth's surface is 10 m/s^2, find the height of a satellite which is in a 'parking orbit'. Assume the Earth to be a sphere of uniform density. (4 marks)

(b) Nowadays, worldwide telecommunication is possible using electromagnetic waves of frequencies

(i) 3 - 30 MHz, and

(ii) 3 - 30 GHz.

Describe, with the aid of diagrams, how this is possible for each of the frequency ranges listed. (5 marks)

8. A cylinder fitted with a piston contains 0.1 mol of a monatomic gas at a pressure of 10^5 Pa and a temperature of 300 K. The gas is

(i) first heated at constant pressure to 400 K, and then
(ii) compressed isothermally to its initial volume, and finally
(iii) cooled at constant volume to its initial temperature.

Molar gas constant = 8.31 $J\ K^{-1}\ mol^{-1}$.

(a) Find the initial volume of the gas and determine its volume after process (i) is completed. (2 marks)

(b) Hence sketch the above changes on the following *p*-*V* diagram, inserting all the initial and final pressure and volume values for each of the processes (i), (ii) and (iii). (4 marks)

(c) What is the change in internal energy of the gas in process (i)? (3 marks)

(d) Hence determine the heat input to the cylinder in process (i). (3 marks)

(e) What does the area bounded by the curves sketched in part (b) represent? (1 mark)

9.

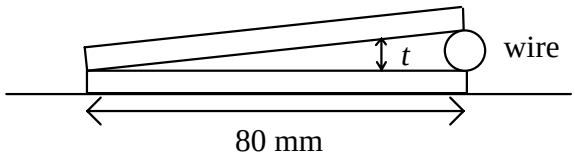

Figure 9.1

To measure the diameter of a metal wire, the wire is placed between two flat parallel-sided glass plates as shown in Figure 9.1, forming a wedge-shaped air film of length 80 mm. The plates are illuminated normally from above by sodium light of wavelength λ and interference fringes are observed from above.

(a) Draw a labelled diagram of a suitable experimental arrangement which includes the apparatus of Figure 9.1 to measure the separation between adjacent fringes. (3 marks)

(b) Briefly explain the formation of the fringes and hence write down in terms of λ and t, the condition for a bright fringe to be produced at a particular point where the separation of the plates is t (see Figure 9.1) (3 marks)

(c) In this experiment, the wavelength of the light is 600 nm, and the fringes are found to have a separation of 0.16 mm. Calculate the diameter of the wire. (4 marks)

(d) If the space in the wedge is filled with water of refractive index 1.33, what will happen to the fringe pattern observed? Explain your answer briefly. (2 marks)

10.

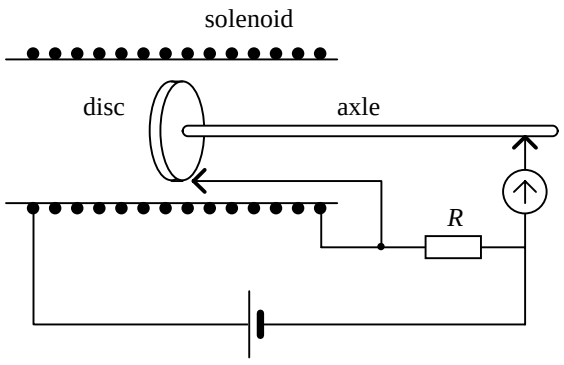

Figure 10.1

Figure 10.1 shows a long uniformly-wound solenoid with a small brass disc mounted inside so that its plane is perpendicular to the magnetic field inside the coil. The disc spins on an axle which lies along the axis of the solenoid, which is connected in series with a d.c. power supply and a resistor of resistance *R*. One end of the resistor is connected to the rim of the disc and the other is connected to the axle via a centre-zero galvanometer.

(a) The solenoid, of length *l*, has *N* turns and carries a current *I*. What is the magnetic flux density inside the solenoid? (1 mark)

(b) The radius of the brass disc is *r* and the radius of the axle is *s*. If the brass disc rotates at a rate of *f* revolutions per second, obtain an expression for the e.m.f. generated between the axle and the rim of the disc. (4 marks)

(c) As the rate of rotation of the disc is increased, it is possible that the galvanometer deflection may change direction. Explain why. (2 marks)

(d) When the galvanometer registers no deflection, $f = f_0$. Find an expression for the resistance of the resistor *R*. (3 marks)

11. (a) Draw a diagram of a circuit you could use to find the input voltage V_i/output voltage V_o characteristic of an NPN transistor in the common-emitter configuration. (3 marks)

(b)

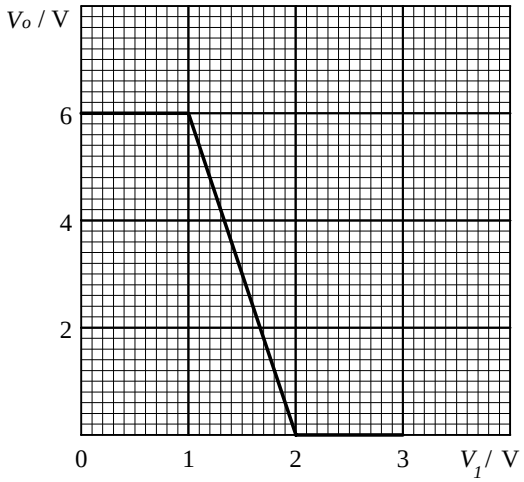

Figure 11.1

The results obtained are shown in Figure 11.1. Suppose the circuit in this experiment is to be used as an alternating voltage amplifier. The input voltage must first be fixed at a suitable value. Use the graph in Figure 11.1 to

(i) choose the most suitable value for this fixed input voltage, giving an explanation, and (2 marks)

(ii) determine the voltage amplification. (2 marks)

(c) A sinusoidal voltage of amplitude 0.4 V is now superimposed on the fixed input voltage. The input and output voltages are then observed on a CRO set in AC mode. The input voltage is shown in Figure 11.2. On the same diagram, sketch the corresponding variations in output voltage as observed on the CRO. (2 marks)

(d) If the amplitude of the superimposed sinusoidal voltage is increased to 1.5 V (Figure 11.3), sketch on the same diagram the corresponding variations in output voltage, as observed on the CRO. (3 marks)

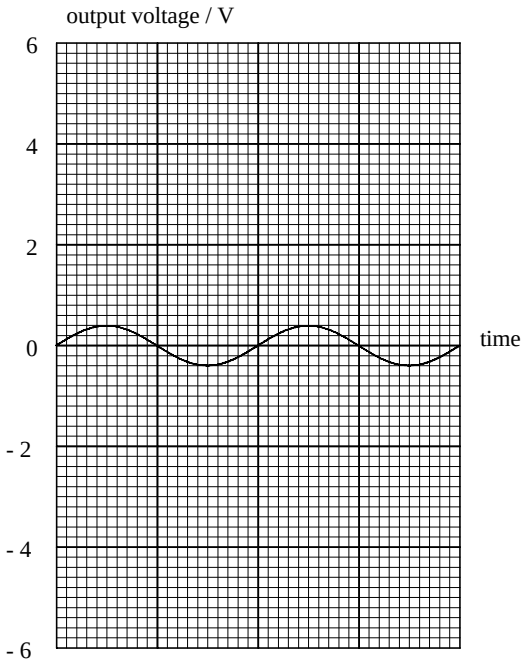

Figure 11.2

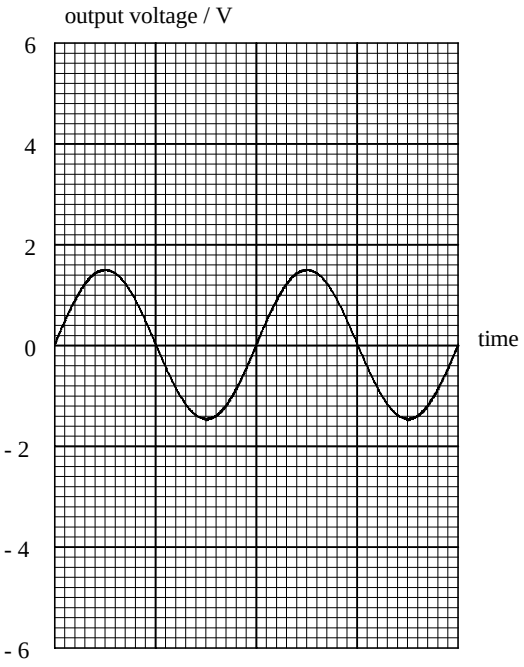

Figure 11.3

12.

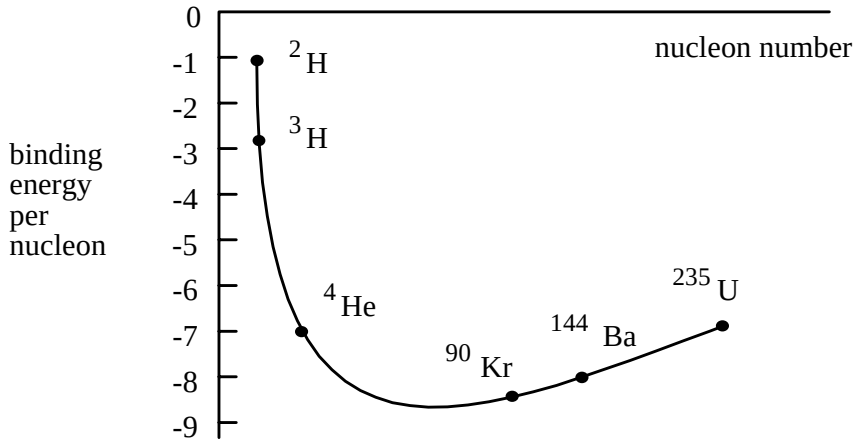

Figure 12.1

Figure 12.1 shows the variation of the average binding energy per nucleon with nucleon number.

(a) Explain why the nuclear binding energy is negative. (2 marks)

(b) Consider the following 2 nuclear reactions:

Fission reaction $^{235}_{92}\mathrm{U} + {}^{1}_{0}\mathrm{n} \longrightarrow {}^{144}_{56}\mathrm{Ba} + {}^{90}_{36}\mathrm{Kr} + 2{}^{1}_{0}\mathrm{n}$

Fusion reaction $^{2}_{1}\mathrm{H} + {}^{2}_{1}\mathrm{H} \longrightarrow {}^{3}_{2}\mathrm{He} + {}^{1}_{0}\mathrm{n}$

(i) Explain, with reference to Figure 12.1, why these two reactions are possible. (2 marks)

(ii) Which reaction process is currently being used in power generating stations and why is the other, at present, not practical? (3 marks)

In answering the following questions, you should refer to the fission reaction described in (b) above.

(c) What is the significance of the two neutrons produced in the fission reaction? (2 marks)

(d) Make a rough estimate of the energy (in MeV) released in the fission of a uranium-235 nucleus. (2 marks)

(Binding energy of $^{235}_{92}\mathrm{U}$ = -7.50 MeV/nucleon
Binding energy of $^{144}_{56}\mathrm{Ba}$ = -8.30 MeV/nucleon
Binding energy of $^{90}_{36}\mathrm{Kr}$ = -8.65 MeV/nucleon)

(e) Mention TWO differences between the fission of a nucleus and the spontaneous decay of a radioactive nuclide. (3 marks)

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