HONG KONG ADVANCED LEVEL EXAMINATION
AL PHYSICS
1987 Essay Type Question

1. (a) Write down Newton's second law of motion. Apply it to the situation where a body, initially at rest, is subject to a constant force, and describe the subsequent motion. (2 marks)

   (b) Clearly distinguish between the properties 'mass' and 'weight' of a body and explain why a passenger sometimes has the feeling of 'weightlessness' in a lift. (5 marks)

   (c) Without giving any mathematical derivations, explain how it is possible for a body to move with constant speed in a horizontal circular path. (2 marks)

   (d) Describe an experiment to demonstrate the relation between the angular velocity of the body in (c) and the radius of the path, for a constant acting force, explaining any source of error. (7 marks)

2. (a) Qualitatively compare the molecular/atomic models for

      (i) a gas and

      (ii) a solid

      with particular reference to the forces exerted by the molecules/atoms, and the effects of an increase in temperature. (8 marks)

   (b) Briefly describe the origins of the following binding forces in solids:

      (i) ionic (electrostatic) binding,

      (ii) metallic binding and

      (iii) covalent binding.

      (4 marks)

   (c) Glass reinforced plastic (fibre glass) is made up of glass fibres embedded in plastic material. Explain its mechanical advantages over conventional metals. (4 marks)

3. Both light and sound can be considered as wave propagations of energy.

   (a) Carefully compare the main characteristics of such waves and their propagation. (10 marks)

(b) Distinguish between

(i) refraction and

(ii) diffraction

for a sound wave, giving one practical example of each. (4 marks)

(c) Briefly explain why diffraction is more difficult to observe in 'everyday life' for light rather than sound. (2 marks)

4. (a) Describe the phenomenon of electromagnetic induction under the following conditions:

(i) physical movement is involved;

(ii) no physical movement is involved.

(3 marks)

(b) Describe the analogous resulting effects when a battery is connected in turn across circuits consisting of

(i) an inductor and resistor in series, and

(ii) an uncharged capacitor and resistor, in series.

A full mathematical analysis is only expected for (ii). (9 marks)

(c) A fully-charged capacitor is suddenly connected across a coil of large inductance. Explain, qualitatively, the waveform you would expect to observe in an oscilloscope connected across the coil, and how the stored energy changes with time. (4 marks)

5. (a) Account for the exponential time decay of a radioactive isotope. (3 marks)

(b) Uranium 238 decays to Uranium 234 as follows:

$$^{238}_{92}\mathrm{U} \xrightarrow{\alpha} \mathrm{Th} \xrightarrow{\beta} \mathrm{Pa} \xrightarrow{\beta} {}^{234}\mathrm{U},$$

where α and β represent accompanying α-, β-particle emissions. Determine the missing atomic number and mass number values, giving explanations of your choices. (3 marks)

(c) Natural radium is known to emit α-particles and β-particles and also γ-photons. Explain how you would verify this experimentally using a method based upon absorption. (5 marks)

(d) Mention the most important factors which determine the dangerousness of a sealed radioactive source, used externally, and the main precautions to be taken when using it. (5 marks)

6. (a) An alternating current $I = I_0 \sin \omega t$ flows in the following circuits:

(i) an inductance L and resistance R connected in series,

(ii) a capacitance C and resistance R connected in series.

In each case, determine from first principles the reactance and the phase relation between the voltage across the reactive element and the current. (4 marks)

(b) Hence, using a phasor diagram, obtain an expression for the impedance of a circuit consisting of an inductance L, a capacitance C and a resistance R connected in series with an a.c. source. (2 marks)

(c) For the circuit of (b) the current is a maximum at the resonant frequency ω_0. Show that the power taken by such a circuit drops by 50% of that taken at resonance when the frequency is changed to ω, where

$$\omega L - \frac{1}{\omega C} = R$$ (3 marks)

(d) By writing ω as $(\omega_0 + \Delta\omega)$ show that $\Delta\omega \sim R/(2L)$. (You may consider $\Delta\omega << \omega_0$.) (3 marks)

(e) The 'sharpness' of the resonance is given by $Q = \omega_0/(2\ \Delta\omega)$ and it is usual for $Q \sim 30$.

(i) Show that at resonance the r.m.s. voltage across the capacitor C will be $Q \times$ r.m.s. voltage across the whole circuit.

(ii) Explain how this is possible.

(4 marks)

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