

HONG KONG ADVANCED LEVEL EXAMINATION
AL PHYSICS
1992 Essay Type Question

1. (a) Explain the meanings of Newton's second and third Laws of Motion. (3 marks)
- (b) Apply these laws to the rapid impact between two bodies, which were initially moving with unequal velocities along the same direction, and show that linear momentum is conserved. Explain whether the total kinetic energy is necessarily conserved, or not. (7 marks)
- (c) Briefly discuss the conservation of energy in regard to
- (i) the results of the Franck-Hertz experiment and
 - (ii) the energy spectrum of the β -particles emitted naturally by some nuclei.
- (No experimental circuit details or theoretical details are expected.) (6 marks)
2. (a) State the main assumptions of Kinetic Theory as applied to ideal gases. (4 marks)
- (b) (i) Explain why the speed of diffusion of a gas is much slower than the average speed of the gas molecules.
- (ii) Distinguish between the average separation of the molecules and their mean free path. (4 marks)
- (c) (i) Briefly describe an experiment for measuring the rate of diffusion of bromine into air and hence show how to estimate the mean free path of bromine molecules. (Random walk statistical rule to be assumed and density of bromine known.)
- (ii) By a consideration of the effect of diffusion on the various constituents of the earth's atmosphere, briefly discuss how you would expect the composition to vary with height. Assume no convection or turbulence. (8 marks)

3. (a) Demonstrate the differences between
- (i) transverse wave propagation,
 - (ii) longitudinal wave propagation,
- by drawing graphical plots showing the corresponding variations of the displacements of the medium particles with distance from the source for times $t = 0, T/4, T/2$ and $3T/4$, where T is the wave period. (8 marks)
- (b) Describe an experiment to show the phase change of the particle oscillations with distance from a sound wave source, and hence explain how you would determine the wave propagation speed. (6 marks)
- (c) How does the propagation of light waves differ from that of sound waves? (2 marks)
4. (a) Give definitions of
- (i) the electric field intensity and
 - (ii) the electric potential,
- and explain the relationship between them with the aid of a diagram showing equi-potential lines. (4 marks)
- (b) Explain the concept of capacitance by considering a small charged metal sphere, assuming the inverse square law for the force between charges. (4 marks)
- (c) Describe how you would experimentally investigate the geometric factors affecting the capacitance of a parallel plate capacitor using a reed switch to convert the stored charge into a current. (There is no need to explain the working of the reed switch.) Suggest two sources of error. (8 marks)
5. By considering the force on free electrons of charge $-e$ moving with a constant velocity v in a path, perpendicular to a uniform magnetic field B ,
- (a) explain the production of an electric field E when an electric current is passed through an n-type semiconductor crystal in a direction perpendicular to a magnetic field B . (5 marks)
 - (b) further, explain the production of another electric field E' in a linear conductor moved perpendicular to the magnetic field B . (4 marks)

- (c) describe an experiment to measure the charge/mass (e/m) ratio for electrons using an electric field and magnetic field perpendicular to each other. (No theory of the production of the magnetic field is expected.) Briefly indicate main difficulties.

(7 marks)

6. (a) Define simple harmonic motion (s.h.m.) and give one example of motion approximating to s.h.m. which may be observed during our daily lives.

(2 marks)

- (b) (i) A long spiral spring of force constant k hangs vertically from a fixed support with a weight of mass m attached to its bottom end. If the weight is pulled downwards and then released show that the subsequent motion is s.h.m., with the displacement from the equilibrium position at any time t given by $x = a \cos \omega_0 t$, where a is a constant and ω_0 the natural angular frequency of oscillation.

- (ii) If the weight now moves in a viscous liquid, there will be an additional retardation force acting of $b \frac{dx}{dt}$, where $\frac{dx}{dt}$ is the instantaneous velocity. Write down the new equation of motion. Assume a solution, $x = Ae^{-\gamma t} \cos \omega t$ and by substitution derive an expression for γ and show that the new angular frequency of oscillation, $\omega = (\omega_0^2 - \gamma^2)^{1/2}$. (Hint: consider particular times $t = 0, \frac{\pi}{2\omega}$.)

(10 marks)

- (c) Now consider the connection of a charged capacitor of capacitance C across a coil of inductance L and resistance R . Show that a similar differential equation holds good for the charge Q on the capacitor, in place of the displacement x in (b)(ii), and hence by analogy determine the corresponding expression for γ , ω and ω_0 . (4 marks)

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