HONG KONG ADVANCED LEVEL EXAMINATION
AL PHYSICS
1988 Essay Type Question

1. (a) Explain in terms of molecular forces why

   (i) it is possible to 'float' a small steel needle on the surface of water,

   (ii) if part of the needle is inserted vertically into the water some of the water is drawn up around it above the normal water level, and

   (iii) a liquid film always assumes a minimum surface area.

   For (i) and (ii) diagrams should be drawn showing the relevant forces.
   (8 marks)

   (b) Discuss the effect of the spreading of a liquid on a solid surface and give one practical example, each, where

   (i) good spreading,

   (ii) poor spreading

   is important. (3 marks)

   (c) Briefly describe a method for measuring the surface tension of water using the rise of water in a glass capillary tube. Derive any necessary relation and point out necessary experimental precautions. (5 marks)

2. (a) The human eye functions as a converging lens of variable focal length. Explain why the apparent sizes of the Moon and a dollar held at arm's length seem similar. (2 marks)

   (b) When a single converging lens is used as a magnifying glass the viewed image may be formed at

   (i) infinity or

   (ii) the distance of nearest clear vision from the eye.

   Using a ray diagram show which of these arrangements gives the greatest magnification. What is the physical factor limiting the magnification?
   (4 marks)

(c) Show, using a ray diagram, that it is possible to further increase the magnification by using an additional converging lens. (No mathematical treatment involving the lens equation is required.) (3 marks)

(d) Give reasons why the brightness of an image recorded on photographic film in a simple camera is proportional to d^2t / f^2, where d is the aperture diameter, t the time exposure and f the focal length of the converging lens. Hence explain the meaning of f-stop, and its use in photography. (7 marks)

3. (a) A long slinky spring is laid flat on a horizontal table and slightly stretched. Briefly explain how you would produce two transverse pulses moving along the spring in opposite directions from each end, when the amplitudes are

(i) in the same direction and

(ii) in opposite directions.

Draw suitable diagrams showing the propagation of the pulses along the spring, through its centre. (4 marks)

(b) By reference to the results of (a) explain the main effects of the principle of superposition on interfering waves. (2 marks)

(c) Describe, qualitatively, the phenomenon of wave interference and give one example, each, for

(i) sound and

(ii) light,

which may be experienced in daily life. (No mathematical derivations are required.) (5 marks)

(d) Explain clearly the necessary conditions for observable interference to take place between

(i) sound waves and

(ii) light waves,

briefly contrasting any main difficulties encountered in satisfying such conditions. (5 marks)

4. (a) An electrical circuit consists of a resistor connected across the terminals of a battery. By considering the charges moving around the circuit, define the terms

(i) electric field,

(ii) potential difference and

(iii) electromotive force (e.m.f.).

(4 marks)

(b) Explain the mechanism by which heat would be produced in the resistor.

(2 marks)

(c) Obtain an expression for the rate of heat dissipation in the resistor in terms of the electric current and resistance. Explain clearly the differences in computing the rate of heat dissipation in an a.c. circuit which includes a reactive element. (3 marks)

(d) Briefly describe the public electrical power transmission system, usually adopted, from the power station to the domestic consumer. Explain why such a system is used. (4 marks)

(e) By considering the resistance of the transmission cables and of the appliances used locally, explain why the mains voltage varies significantly throughout Hong Kong, and why there are variations at any particular location. (3 marks)

5. (a) Compare the appropriate physical conservation laws which apply to

(i) elastic and

(ii) non-elastic

collisions between a moving non-rotating body and a stationary body.

(3 marks)

(b) Give brief accounts of the following collisions, explaining whether they are elastic or non-elastic:

(i) high energy α-particle scattering by atoms in thin metal foils.

(ii) slow neutron bombardment of ^{235}U atoms.

(iii) high energy electron collisions with gaseous xenon atoms.

(7 marks)

(c) Describe the Franck-Hertz experimental investigation of the effect of varying the electron energy in (iii) and briefly explain the importance of the results.

(6 marks)

6. (a) By considering the uniform motion of a point in a circular path, demonstrate the meaning of simple harmonic motion (S.H.M.), giving a relation between the acceleration and displacement from the equilibrium position for a particle undergoing S.H.M. (3 marks)

(b) Briefly explain how it is possible to set a small object into S.H.M. using a spiral spring. (3 marks)

(c) Atoms of a diatomic molecule (each of mass m) are able to oscillate towards and away from each other in a similar manner to two small objects connected by a spiral spring. Assume that the potential energy of such a system, for an atomic spacing x, is $U = -(a/x) + [b/(2x^2)]$, where a and b are constants.

(i) Obtain an expression for the corresponding force F between the two atoms and determine the equilibrium separation in terms of a and b. Sketch out the variation of F with x, explaining the shape and significant features of your graph.

(ii) Show that for small oscillations about the equilibrium location of the atoms (you may consider one atom to remain stationary and the effective mass of the other atom to be $m/2$), S.H.M. occurs and obtain expressions for

(I) the force constant (force/displacement) and

(II) the oscillation period.

(Hint: use binomial expansion for terms in the force equation.)

(10 marks)

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