

**HONG KONG ADVANCED LEVEL EXAMINATION**  
**AL PHYSICS**  
**1987 Structural Question**

1. A spring of force constant 135 N/m is suspended vertically with its top end rigidly clamped. A mass of 0.15 kg is attached to the lower end of the unextended spring and then released. The system then oscillates - the oscillations slowly dying away until the mass achieves static equilibrium.
- (a) Calculate the frequency of the oscillations. (2 marks)
- (b) When the mass has achieved static equilibrium, calculate the energy stored in the extended spring. (3 marks)
- (c) Calculate the change in the gravitational potential energy of the mass from the beginning to the end of the motion. Why is this answer different from the answer to (b) above? (2 marks)
- (d) Using a suitable sketch graph, describe how the amplitude of the oscillations varies with time. (3 marks)

2. [ In this question, you may assume that

the density of water in liquid state at 100 °C	= 1 000 kg/m <sup>3</sup>
the relative molecular mass of water	= 18
Avogadro constant	= 6 × 10 <sup>23</sup> mol <sup>-1</sup>

In your calculations, show your reasoning and explain why approximations made.]

When 1 kg of water is changed from liquid state to gaseous state at temperature 100 °C and pressure 10<sup>5</sup> Pa, its volume increases by 1.67 m<sup>3</sup>. At this temperature and pressure, estimate

- (a) the average separation between water vapour molecules, (4 marks)
- (b) the diameter of a water molecule, (4 marks)
- (c) the mean free path of water vapour molecules, (4 marks)
- (d) the r.m.s. speed of water vapour molecules. (2 marks)

3.

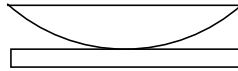


Figure 1

A student tests the grinding of a lens surface by observing the appearance of Newton's rings. The lens is placed in contact with a flat glass plate (as shown in Figure 1), and light from a sodium discharge lamp is shone on the lens from above.

- (a) If the rings are to be observed also from above, draw a labelled diagram of the experimental arrangement he should use to view the Newton's rings. (4 marks)
- (b) How can he tell whether or not the ground lens surface is perfectly spherical? (1 mark)
- (c) In observing Newton's rings using reflected light, the central region is dark when the thickness of the air film at the centre is zero. Briefly account for this. (2 marks)
- (d) Draw a diagram showing the path of the rays which destructively interfere to form a dark ring. (3 marks)
- (e) If the student now replaces the lens by another plano-convex lens of shorter focal length, describe and explain the changes in the fringe pattern observed. (3 marks)

4.

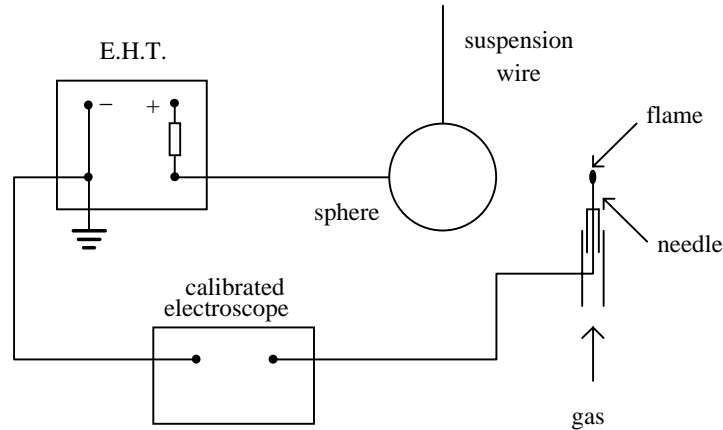


Figure 2

A student uses a flame probe to investigate the variations in potential in the region around a positively charged sphere. The probe, in the form of a small gas flame at the point of a needle, is connected to an electroscope calibrated to measure potentials.

- (a) Briefly explain why the electroscope reading is a measure of the potential at the point where the probe is situated. (5 marks)
- (b) The experiment has to be performed with the charged sphere remote from the floor and neighbouring walls. Explain briefly why. (2 marks)
- (c)

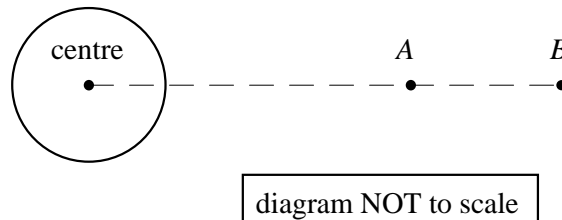


Figure 3

The student measures the potential at points *A* and *B* (see Figure 3), which are 1 cm apart. He finds that the potentials at *A* and *B* are 450 V and 400 V respectively. Give an estimate of the electric field in the region between *A* and *B*. In what direction does it act? (3 marks)

5. A student wishes to construct a simple microammeter to measure small direct electric currents. A horse-shoe magnet with curved pole pieces is available and a light framework, or former, upon which to wind a coil. In addition there is a choice of two fibres, *A* and *B*, to suspend the coil, and a choice of two insulated conducting wires, *C* and *D*, from which to wind the coil.

The fibres *A* and *B* are of equal length but *A* can reliably support double the load of *B*. The restoring torque provided by *A* is double that of *B* for the same angle of twist.

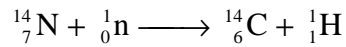
There is an effectively unlimited supply of wires *C* and *D*, which are made from the same material. The area of cross-section of wire *C* is double that of wire *D*.

- (a) The student tries to compare the four possible combinations of wires and fibres and draws up the following table:

Combination of fibre and wire		maximum	corresponding	torsional	current
Fibre	Wire	no. of turns in coil	internal resistance of coil	constant of suspension	sensitivity
<i>A</i>	<i>C</i>	<i>N</i>	<i>R</i>	<i>c</i>	<i>s</i>
<i>A</i>	<i>D</i>	_____	_____	_____	_____
<i>B</i>	<i>C</i>	_____	_____	_____	_____
<i>B</i>	<i>D</i>	_____	_____	_____	_____

- (i) Fill in the blanks in the above table.
- (ii) Given that the resistance of the suspension fibres is negligible, use the completed table to decide which of the four choices is the best one. Explain your answer briefly. (8 marks)
- (b) Draw a sketch, in the space provided, showing the internal structure of the microammeter. (4 marks)
- (c) List the features that would be necessary to ensure that the deflection is proportional to the current. (2 marks)

6. Carbon 14 is produced in the natural environment from the bombardment of nitrogen atoms in the atmosphere by neutrons according to the following reaction:



- (a) Carbon 14 is radioactive and undergoes  $\beta$ -decay with a half life of 5760 years. Write down the corresponding reaction equation representing the decay of carbon 14. (1 mark)
- (b) Measurement of the activity of carbon 14 is by means of the 'liquid scintillation counting' technique. The sample is first dissolved in an organic solvent and then mixed with a scintillation liquid. Low-energy beta-particles are emitted and excite the liquid scintillant which gives out light photons. These photons are counted by a detector and recorded. Explain why this method is to be preferred to a normal direct measurement technique. (2 marks)
- (c) Carbon 14 can be used to measure the approximate age of archaeological wood samples. For this purpose it may be assumed that the proportion of carbon 14 in the natural carbon of living wood is everywhere and at all times the same and that it begins to change only after death. Suppose a piece of timber has been recovered from an excavation, and from which 10 g of carbon is prepared. Determine the number of carbon 14 atoms originally present in the sample, given that the ratio of carbon 14 to natural carbon is  $1.25 \times 10^{-12}$ .
- ( Relative atomic mass of natural carbon = 12  
Avogadro constant =  $6 \times 10^{23} \text{ mol}^{-1}$ ) (2 marks)
- (d) If the activity of the sample is found to be  $19 \times 10^{-12} \text{ Ci}$  (1 Ci corresponds to  $3.7 \times 10^{10}$  disintegrations per second), estimate
- (i) the number of carbon 14 atoms in the timber, and
- (ii) the age of the sample in years,
- given that the half-life of carbon 14 is 5760 years. (4 marks)
- (e) List TWO advantages which make carbon 14 a suitable nuclide for dating archaeological samples. (2 marks)