LEAVING CERTIFICATE EXAMINATION. 1984

PHYSICS–HIGHER LEVEL

MONDAY, 25 JUNE–MORNING, 9.30 to 12.30

Any six questions to be answered.
All questions carry the same marks.

1. Answer *eleven* of the following items (*a*), (*b*), (*c*), etc. All the items carry the same marks. *Keep your answers short.*

   (*a*) Define potential energy.

   (*b*) A bicycle wheel is turning with an angular velocity of 15 rad s^{-1}. Calculate the velocity of the bicycle if the radius of the wheel is 0·6 m.

   (*c*) A body, travelling at a velocity of 20 m s^{-1}, strikes a second body of mass 2 kg at rest. After the collision both bodies move together with a velocity of 10 m s^{-1}. What was the mass of the first body?

   (*d*) Define specific heat capacity.

   (*e*) In what way does the object lens in an astronomical telescope differ from that in a compound microscope?

   (*f*) Complete the following statement: When white light is passed through a .... or a prism .... occurs.

   (*g*) Fig. 1 shows a positively charged rod held near the plate (cap) of an electroscope. What is the sign of the charge on (i) the leaves, (ii) the inside of the case?

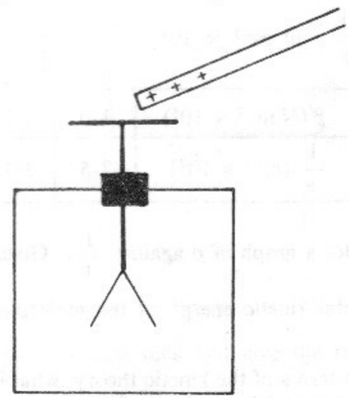

Fig. 1

   (*h*) Write down an expression for the force on a charge q in an electric field of field intensity (strength) E.

4.

(*i*) Fig. 2 shows the relationship between the current (I) flowing in a length of wire and the potential difference (V) between its ends. What may be deduced from the graph about the temperature of the wire?

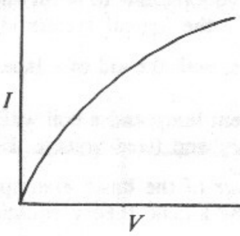

Fig. 2

(*j*) What is the basic principle of moving-coil meters?

(*k*) Why does a charged particle, travelling at right angles to a magnetic field of uniform magnetic flux density, follow a circular path?

(*l*) A capacitor is usually connected in parallel with the output of a diode rectifier. Why?

(*m*) What is (i) magnetic dip, (ii) magnetic declination?

(*n*) Name two of the forces on an oil drop as it moves upwards between the plates in Millikan's oil drop experiment.

(*o*) State how a moving-coil galvanometer may be converted to function as (i) an ammeter, (ii) a voltmeter.

(*p*) Complete the following nuclear reaction:

$$^{3}_{1}H + ^{2}_{1}H \rightarrow ^{4}_{2}He +$$

What name is given to this type of nuclear reaction?

2. State Newton's second law of motion. Hence establish the relationship, force = mass × acceleration.

Fig. 3 shows a spacecraft (S), travelling from the earth to the moon along a line joining their centres. State the two largest forces acting on the spacecraft. Explain, considering only these two forces, how the acceleration of the craft changes, in magnitude and direction, while its engines are switched off.

Calculate how far the craft is from the centre of the earth when its acceleration is zero, given that the distance from the centre of the earth to the centre of the moon is $3{\cdot}8 \times 10^8$ m and that the mass of the earth is 81 times that of the moon.

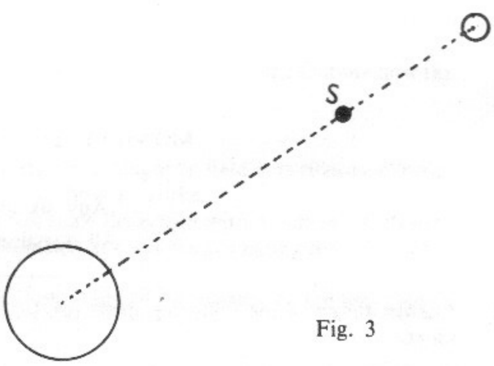

Fig. 3

3. State *four* of the basic assumptions of the kinetic theory of gases.

The volume, v, of a fixed mass of gas at constant temperature was measured for different values of the pressure, p, in the range $1{\cdot}0 \times 10^5$ N m^{-2} to $3{\cdot}0 \times 10^5$ N m^{-2}. The value of $\frac{1}{v}$ was calculated in each case.

The table of results given below shows the values of p, in N m^{-2} × 10^5, and the corresponding values of $\frac{1}{v}$, in m^{-3} × 10^4.

p (N m^{-2} × 10^5)	1·0	1·2	1·4	1·6	1·8	2·0	2·2	2·4	2·6	2·8	3·0
$\frac{1}{v}$ (m^{-3} × 10^4)	2·5	3·1	3·4	4·0	4·5	5·0	5·6	5·9	6·3	6·7	7·7

Plot a graph of p against $\frac{1}{v}$. Given the kinetic theory equation $p = \frac{1}{3}\frac{nm\overline{c^2}}{v}$, calculate, from the graph, the total kinetic energy of the molecules of the gas.

In terms of the kinetic theory, what is the relationship between the temperature of a gas and the average kinetic energy of its molecules?

5. Define temperature on the Celsius scale for a constant volume gas thermometer. Give a thermometric property on which an electrical thermometer may be based.

4. (*a*) **Use ray diagrams to show the formation of (i) a real image by a concave mirror, (ii) a virtual image by a convex mirror. In the case of the convex mirror explain how the position of the image may be determined experimentally and give *two* uses of such a mirror.**

(*b*) **Define refractive index.**
Describe an experiment to measure the refractive index of the glass of a prism.
Indicate how a prism may be used to reflect light through 180°.

5. Answer (*a*) **and** either (*b*) or (*c*).

(*a*) Explain how it may be shown experimentally that light is a transverse, rather than a longitudinal, wave motion.
Outline a terrestrial method for measuring the velocity of light.

(*b*) Fig. 4 shows an apparatus in which sound from a loudspeaker, S, can travel by two separate paths, A and B, to the opening, O. The length of the apparatus may be varied by moving the sliding tube in and out. As the sliding tube is moved, the loudness of the note heard at O increases and decreases. Explain this variation in loudness, given that the loudspeaker emits a continuous note. If the frequency of the note is **2,000 Hz calculate the average distance moved by the sliding tube between successive positions of maximum and minimum loudness.**
(Velocity of sound in air = 340 m s^{-1})

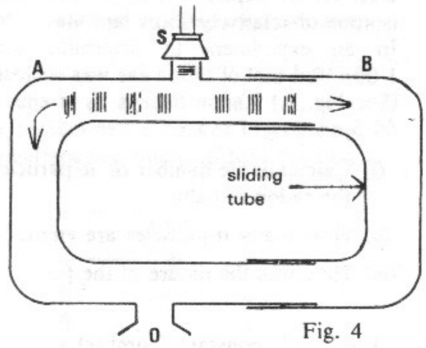

Fig. 4

(*c*) **Describe an experiment to measure the velocity of sound in a gas other than air. Give the theory associated with the experiment.**

6. (*a*) **State Faraday's first law of electrolysis.**
In an experiment to check the accuracy of an ammeter using a copper voltameter the following measurements were noted.

Initial mass of cathode	= 5·424 g
Final mass of cathode	= 5·622 g
Current (read from ammeter)	= 0·52 A
Time for which current flowed	= 20 min.

Draw a labelled circuit diagram for this experiment and calculate the error in the ammeter reading.
(Electrochemical equivalent of copper = 3·3 × 10^{-7} kg C^{-1})

(*b*) State Faraday's law of electromagnetic induction.
Fig. 5 shows a rectangular coil which is free to turn about a vertical axis. The coil, which has an area of 0·1 m^2 and contains 100 turns, is placed with its plane **perpendicular to the horizontal component of the earth's magnetic flux density, B_H. The total magnetic flux linking the coil in this position is given by B_HNA, where A is the area of the coil and N is the number of turns in the coil. The total resistance of the circuit is 110 Ω. When the coil is turned through 90° in 0·2 s an average current of 8 × 10^{-6} A flows through the galvanometer (G). Calculate**

(i) the average induced electromotive force (e.m.f.),

(ii) the value of B_H.

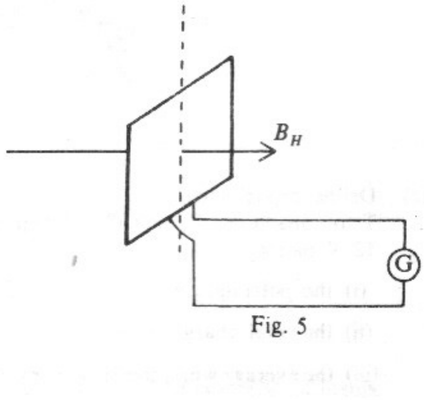

Fig. 5

7. (*a*) **Describe an experiment to compare the electromotive force (e.m.f.) of two cells and give the theory associated with the experiment.**

(*b*) **Describe an experiment to investigate the relationship between the heat produced in a resistor (e.g. a length of wire) and the current flowing through it.**

8. Compare electrons and protons under the following headings: charge, mass, location in the atom.
What are X-rays?
Outline experiments, one in each case, to show that (i) electrons have a wave nature, (ii) X-rays have a wave nature.
What is the relationship between the momentum of an electron and its wavelength, i.e. de Broglie's equation?
In an X-ray tube the potential difference between the electrodes is V. Show that the wavelength, λ_e, of the electrons striking the target is given by

$$\lambda_e = \frac{h}{\sqrt{2Vem}}$$

where h is Planck's constant, m is the mass of an electron and e is the charge on an electron.

9. Explain the terms: radioactivity, half-life.
Describe an experiment to measure the half-life of a radioactive isotope of relatively short half-life.
In an experiment to determine the nature of α-particles, $1{\cdot}09 \times 10^{-5}$ mol of radon gas was enclosed in a thin-walled tube, A. (See Fig. 6.) Radon decays by α emission and has a half-life of 54·5 s.

(i) Calculate the number of α-particles emitted per second from the radon initially.

(ii) How many α-particles are emitted in 54·5 s?

(iii) How was the nature of the gas in the outer tube established?

(Avogadro's constant (number) = $6{\cdot}0 \times 10^{23}$ mol^{-1}; take ln 2 = 0·69.)

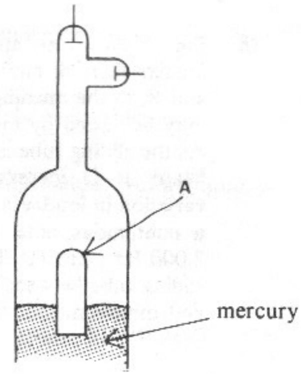

Fig. 6

10. Answer any *two* of the following.

(*a*) Describe a method, giving the relevant theory, of measuring the wavelength of monochromatic light.

(*b*) Define simple harmonic motion.
A spiral spring has a length of 1·0 m. A 0·5 kg mass is attached to the end of the spring and is allowed to hang freely. The length of the spring becomes 1·2 m. The mass is then pulled down a further distance x. (See Fig. 7.)
If the mass is released at this point what is the resultant force acting on it? Show that the mass executes simple harmonic motion and calculate the period of the motion.
(Take g = 10 m s^{-2}.)

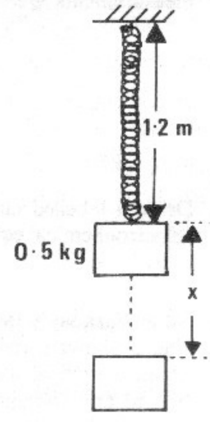

Fig. 7

(*c*) Define capacitance.
Two capacitors, C_1 and C_2, of capacitance 3 μF and 5 μF, respectively, are connected in series with a 12 V battery. Calculate

(i) the potential difference across C_1,

(ii) the total charge on either capacitor,

(iii) the average work done in placing each microcoulomb (μC) of charge on C_1.

(*d*) Write down an expression for Einstein's photoelectric law.
Describe an experiment to investigate the relationship between the current flowing in a photoelectric cell and the intensity of the radiation incident on it.