UNIVERSITIES OF MANCHESTER LIVERPOOL
LEEDS SHEFFIELD AND BIRMINGHAM

JOINT MATRICULATION BOARD

GENERAL CERTIFICATE OF EDUCATION

PHYSICS—Paper II

ADVANCED

Tuesday 7 June 1966 9.30-12.30

Careless and untidy work will be penalized.

Answer **nine** *questions including:*
(*a*) **six** *questions from* SECTION (1);
(*b*) **three** *questions from* SECTION (2).

Candidates are advised to spend about 15 minutes on each SECTION (1) *answer and about 30 minutes on each* SECTION (2) *answer.*

Answers to Sections (1) and (2) must be written in different answer-books.

The books must be marked clearly either SECTION (1) *or* SECTION (2) *and handed in to the Supervisor separately.*

Candidates should wherever possible show by their answers that they have seen or themselves performed experiments on the subjects they are discussing.

For full credit it is not sufficient to obtain correct results to numerical questions; the principles involved and their bearing on the question must be clearly stated.

Assume that the acceleration due to gravity is 981 cm. sec.$^{-2}$.

Mathematical tables are supplied.

SECTION (1)

Answer **six** *questions from this section.*

1. How do you account for the sensation of 'weightlessness' experienced by the occupant of a space capsule (*a*) in a circular orbit round the earth, (*b*) in outer space? Give one other instance in which an object would be 'weightless'.

2. A flywheel with an axle $1\cdot0$ cm. in diameter is mounted in frictionless bearings and set in motion by applying a steady tension of 200 gm.wt. to a thin thread wound tightly round the axle. The moment of inertia of the system about its axis of rotation is $5\cdot0\times10^3$ gm. cm.^{2}. Calculate (*a*) the angular acceleration of the flywheel while the thread is being pulled, (*b*) the kinetic energy of the flywheel when 100 cm. of thread has been pulled off the axle, (*c*) the constant retarding couple which must then be applied to bring the flywheel to rest in one complete turn, the tension in the thread having been completely removed.

3. A uniform steel bar of cross-sectional area $1\cdot5$ cm.^{2} and length 100 cm. at 10° C. is heated to 60° C. At this temperature the ends of the bar are fixed to rigid supports. The bar is then allowed to cool to 10° C. Calculate (*a*) the tension in the bar, (*b*) the additional potential energy which is now stored in it.

(Coefficient of linear expansion of steel $= 1\cdot2\times10^{-5}$ deg.$^{-1}$ C.

Young's Modulus for steel $= 2\cdot0\times10^{12}$ dyne cm.$^{-2}$.)

4. State the postulates on which the simple kinetic theory of gases is based. What modifications are made to the postulates in dealing with real gases? How are these modifications represented in van der Waals' equation?

5. Discuss the factors which determine the pitch of the note given by a 'closed' pipe. Explain why the fundamental frequency and the quality of the note from a 'closed' pipe differ from those of the note given under similar conditions by a pipe of the same length which is open at both ends.

6. A parallel beam of monochromatic radiation travelling through glass is incident on the plane boundary between the glass and air. Using Huygens' principle draw diagrams (one in each case) showing successive positions of the wave fronts when the angle of incidence is (*a*) 0°, (*b*) 30°, (*c*) 60°. Indicate clearly and explain the constructions used. (The refractive index of glass for the radiation used is $1\cdot5$.)

7. State with reasons the essential requirement for the resistance of (*a*) an ammeter, (*b*) a voltmeter.

A voltmeter having a resistance of 1,800 ohms is used to measure the potential difference across a 200 ohm resistance which is connected to the terminals of a d.c. power supply having an e.m.f. of 50 volts and an internal resistance of 20 ohms. Determine the percentage change in the potential difference across the 200 ohm resistor as a result of connecting the voltmeter across it.

8. Explain what is meant by the *peak value* and *root mean square value* of an alternating current. Establish the relation between these quantities for a sinusoidal waveform.

What is the r.m.s. value of the alternating current which must pass through a resistor immersed in oil in a calorimeter so that the initial rate of rise of temperature of the oil is three times that produced when a direct current of $2\cdot0$ amp. passes through the resistor under the same conditions?

Turn over

9. Using the information on atomic masses given below, show that a nucleus of uranium 238 can disintegrate with the emission of an alpha particle according to the reaction:

$$_{92}U^{238} \rightarrow {}_{90}Th^{234} + {}_{2}He^{4}.$$

Calculate (*a*) the total energy released in the disintegration, (*b*) the kinetic energy of the alpha particle, the nucleus being at rest before disintegration.

Mass of $U^{238} = 238 \cdot 12492$ a.m.u.

Mass of $Th^{234} = 234 \cdot 11650$ a.m.u.

Mass of $He^{4} = 4 \cdot 00387$ a.m.u.

1 a.m.u. (atomic mass unit) is equivalent to 930 MeV.

SECTION (2)

(Answers to be written in a separate answer-book.)

Answer **three** *questions from this section.*

10. Define *surface tension* and state the unit in which it is usually expressed.

Making reference to your definition, derive an expression for the pressure difference between the inside and outside of a spherical drop of radius *r*.

What is the effect on the surface tension of water of adding a little detergent? How would you attempt to investigate the effect on the surface tension of various concentrations of detergent?

11. The saturation pressure of water vapour is 1·2 cm. of mercury at 14° C. and 2·4 cm. of mercury at 25° C. Describe and explain the experiment you would perform to verify these data.

Explain qualitatively in terms of the kinetic theory of matter (*a*) what is meant by saturation vapour pressure, (*b*) the relative magnitudes of the saturation vapour pressures quoted.

Sketch a graph showing how the saturation pressure of water vapour varies between 0° C. and 110° C.

12. Explain why the velocity of light is difficult to measure by a direct terrestrial method; illustrate your answer with an estimate of the orders of magnitude of the quantities involved in the assessment.

Describe, with the aid of a labelled diagram, Michelson's method for the determination of the velocity of light.

What are the advantages of this method over the earlier one developed by Foucault?

13. Describe, with the aid of a labelled diagram, how the wavelength of monochromatic light may be found using Young's slits. Give the theory of the experiment.

State, and give physical reasons for the features which are common to this method and to **either** the method based on Lloyd's mirror **or** that based on Fresnel's biprism.

In an experiment using Young's slits the distance between the centre of the interference pattern and the tenth bright fringe on either side is 3·44 cm. and the distance between the slits and the screen is 2·00 m. If the wave length of the light used is $5 \cdot 89 \times 10^{-5}$ cm. determine the slit separation.

14. Describe, with the aid of a labelled diagram, a Van de Graaff generator, explaining the physical principles of its action.

The high voltage terminal of such a generator consists of a spherical conducting shell of radius 50 cm. Estimate the maximum potential to which it can be raised in air for which electrical breakdown occurs when the electric intensity exceeds 30,000 volt $cm.^{-1}$.

State **two** ways in which this maximum potential could be increased.

15. Describe an experiment to determine the ratio of the charge to the mass of electrons. Draw labelled diagrams of (*a*) the apparatus, (*b*) any necessary electrical circuits, and show how the result is calculated from the observations.

Two plane metal plates $4 \cdot 0$ cm. long are held horizontally $3 \cdot 0$ cm. apart in a vacuum, one being vertically above the other. The upper plate is at a potential of 300 volts and the lower is earthed. Electrons having a velocity of $1 \cdot 0 \times 10^9$ cm. $sec.^{-1}$ are injected horizontally midway between the plates and in a direction parallel to the $4 \cdot 0$ cm. edge. Calculate the vertical deflection of the electron beam as it emerges from the plates.

(In the c.g.s. system of units the ratio of the charge to mass of the electron is $1 \cdot 8 \times 10^7$ e.m.u. $gm.^{-1}$ and 1 volt $= 10^8$ e.m.u.; in the m.k.s. system of units, the ratio of the charge to the mass of the electron is $1 \cdot 8 \times 10^{11}$ coulomb $kgm.^{-1}$.)