

UNIVERSITIES OF MANCHESTER LIVERPOOL
LEEDS SHEFFIELD AND BIRMINGHAM

JOINT MATRICULATION BOARD

GENERAL CERTIFICATE OF EDUCATION

PHYSICS—Paper I

ADVANCED

Monday 31 May 1965 2-5

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 , the density of mercury is 13.6 gm. cm.^3 , and one calorie is equivalent to 4.2joules.

Mathematical tables are supplied.

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SECTION (1)

Answer six questions from this section.

1. State the principle of the conservation of linear momentum and show how it follows from Newton's laws of motion.

A stationary radioactive nucleus of mass 210 units disintegrates into an alpha particle of mass 4 units and a residual nucleus of mass 206 units. If the kinetic energy of the alpha particle is E , calculate the kinetic energy of the residual nucleus.

2. Explain in terms of the kinetic theory of matter (a) what happens when a vessel, closed and evacuated, is half-filled with water, the temperature being maintained constant; (b) the effect of subsequently raising the temperature.

3. Calculate the pressure in mm. of mercury exerted by hydrogen gas if the number of molecules per cm.³ is 6.80×10^{15} and the root mean square speed of the molecules is 1.90×10^5 cm.sec.⁻¹. Comment on the effect of a pressure of this magnitude (a) above the mercury in a barometer tube; (b) in a cathode ray tube.

(Avogadro's Number = 6.02×10^{23} . Molecular weight of hydrogen = 2.02.)

4. Draw a diagram to show the passage of three rays from a non-axial point on an object through a compound microscope, consisting of two thin lenses, which is so adjusted that an observer sees the image at his near point. Mark the positions of the principal foci of both lenses and distinguish between rays and construction lines.

5. A plane wave-front of monochromatic light is incident normally on one face of a glass prism, of refracting angle 30° , and is transmitted. Using Huygens' construction trace the course of the wave-front. Explain your diagram and find the angle through which the wave-front is deviated.

(Refractive index of glass = 1.5.)

6. A two-metre potentiometer wire is used in an experiment to determine the internal resistance of a voltaic cell. The e.m.f. of the cell is balanced by the fall of potential along 90.6 cm. of wire. When a standard resistance of 100 ohm is connected across the cell the balance length is found to be 75.5 cm. Draw a labelled circuit diagram and calculate, from first principles, the internal resistance of the cell.

How may the accuracy of this determination be improved? Assume that other electrical components are available if required.

7. A filament lamp of negligible inductance is found to glow when connected in series with a capacitor across an alternating voltage supply of negligible impedance. Explain what will happen to the brightness of the lamp if the frequency of the supply is doubled. Show how a second capacitor can be included in the circuit so as to increase the brightness of the lamp.

What is the advantage of using a capacitor rather than a resistor to control the brightness of a lamp operated on an alternating voltage power supply?

8. Copper is an element of *atomic weight* 63.5 and *atomic number* 29. It has two naturally occurring *isotopes* of *mass numbers* 63 and 65. Give the meanings of the terms printed in italics and estimate the relative abundance of each isotope.

SECTION (2)

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

Answer three questions from this section.

9. In an experiment to measure Young's modulus for steel a wire is suspended vertically and loaded at the free end. In such an experiment, (a) why is the wire long and thin, (b) why is a second steel wire suspended adjacent to the first?

Sketch the graph you would expect to obtain in such an experiment showing the relation between the applied load and the extension of the wire. Show how it is possible to use the graph to determine (a) Young's modulus for the wire, (b) the work done in stretching the wire.

If Young's modulus for steel is 2.00×10^{12} dyne cm^{-2} , calculate the work done in stretching a steel wire 100 cm. in length and of cross-sectional area 0.030 cm^2 when a load of 10 kgm. wt. is slowly applied without the elastic limit being reached.

10. What do you understand by the First and Second Laws of Thermodynamics?

Why cannot all the heat energy taken in by a heat engine be converted into work?

A locomotive engine uses 500 kgm. of fuel per hour when hauling a train at 84 km.p.h., the effective load being 1,800 kgm.wt. What is the efficiency of the engine?

(Calorific value of fuel = $7,200 \text{ cal.gm}^{-1}$)

11. Write down an expression for the speed of sound in an ideal gas. Give a consistent set of units for the quantities involved.

Discuss the effect of changes of pressure and temperature on the speed of sound in air.

Describe an experimental method for finding a *reliable* value for the speed of sound in free air.

12. What is *black body radiation*?

Using the same axes sketch graphs, one in each instance, to illustrate the distribution of energy in the spectrum of radiation emanating from (a) a black body at $1,000^\circ \text{K}$., (b) a black body at $2,000^\circ \text{K}$. and (c) a source other than a black body at $1,000^\circ \text{K}$. Point out any special features of the graphs.

Indicate briefly how the relative intensities needed to draw one of these graphs could be determined.

13. Explain the special features that are necessary in a moving coil galvanometer intended for ballistic use.

A ballistic galvanometer is connected in series with a search coil and the secondary winding of a mutual inductance. When a current is reversed in the primary winding of the inductance a charge of 90 microcoulombs flows through the galvanometer. After switching off the primary current the search coil (which has 200 turns of mean diameter 1.00 cm.) is placed in and perpendicular to a magnetic field. The deflection of the galvanometer caused by the rapid removal of the search coil from the magnetic field is the same as was observed when the primary current was reversed. The total resistance of the galvanometer circuit is 250 ohms. Calculate the magnetic induction (flux density) of the magnetic field. Draw a complete circuit diagram of the arrangement.

(Candidates using the c.g.s. system of units may assume that 1 coulomb = 10^{-1} e.m.u. of charge and 1 ohm = 10^9 e.m.u. of resistance.)

14. Draw a sketch to show the essential parts of a cathode ray oscillograph having electrostatic deflection.

With the help of your sketch explain how in a cathode ray oscillograph:

- (a) the electrons are produced,
- (b) the electrons are focussed,
- (c) the spot is made visible,
- (d) the brightness of the spot is controlled.

What is meant by stating that a cathode ray oscillograph is fitted with a linear time base of variable frequency.