PHYSICS—HIGHER LEVEL

MONDAY, 21st JUNE—MORNING, 9.30 to 12

1971 (LC) A1

Any **six** questions to be answered

1. Answer *eleven* of the following fifteen items (a), (b), (c) . . . etc. Each item carries six marks. *Keep your answers short.*

(a) A constant force acts on a 5 kg mass and reduces its velocity from 9 metres per second to 3 metres per second in 2 seconds. Find the magnitude of the force.

(b) Give an example of the conversion of chemical energy to thermal energy.

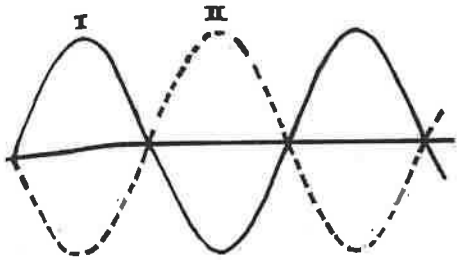
(c) Show how the kinetic theory equation $p = \frac{1}{3}\frac{nm\bar{c}^2}{v}$ is related to Boyle's law.

(d) A particle is projected horizontally at a height of 44·1 metres: show that the time taken to reach the ground is 3 seconds. (Take $g = 9{\cdot}8$ m s^{-2} $= 980$ cm s^{-2}).

(e) Two thin lenses of focal lengths f_1 and f_2 are placed in contact: write down an expression for the focal length f of the combination.

(f) Find the speed of light in glass of refractive index 1·5, given that the speed of light in air is 3×10^8 metres per second.

(g) The diagram represents two wave motions I and II which are the same in every respect except that they are half a wavelength out of phase. What would occur under these conditions?



(h) Show the relative positions of ultraviolet light, visible light, X-rays, in the electromagnetic spectrum. Which has the shortest wavelength?

(i) What does polarisation tell us about the nature of light?

(j) How would you confirm which is the positive pole of a D.C. supply?

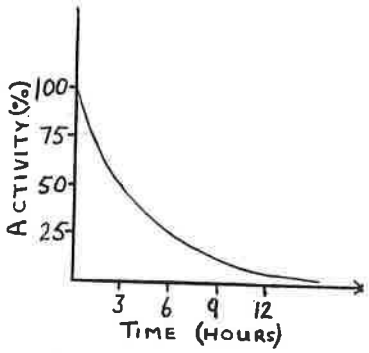
(k) Show with a circuit diagram how a galvanometer (or a milliammeter) may be converted into an ammeter.

(l) What are the carriers of electric current in electrolytes? Name a conducting medium for which Ohm's law does not hold.

(m) A Geiger-Müller tube consists essentially of electrodes and a gas at low pressure. State what happens in the tube when a beta particle enters the tube.

(n) When an atom of uranium $_{92}U^{238}$ emits an alpha particle a new element is formed. Write the atomic number and mass number of this element.

(o) From the accompanying graph write down the half-life of the radioactive element.



(66 marks)

2. Write down the force that is required to keep a body of mass m moving with constant speed v in a circle of radius r. Give an expression to represent Newton's law of gravitation. Hence establish the relationship between the periodic time of a satellite in circular orbit, the mass of the central body and the radius of the orbit.

The periodic time of a satellite which moves round the moon in a circular orbit at a height of 60 km ($6{\cdot}0 \times 10^6$ cm) above the moon's surface is found to be 112 minutes 30 seconds. Find the mass of the moon and the acceleration due to gravity on the moon's surface, assuming the moon to be a sphere of radius 1740 km. (Take $G = 6{\cdot}67 \times 10^{-11}$ SI units $= 6{\cdot}67 \times 10^{-8}$ c.g.s. units. As approximations take $\pi^2 = 9{\cdot}9$ and take $6{\cdot}67 \times 3 = 20$).

(66 marks)

3. State the principles underlying the establishing of a scale of temperature. Define temperature (i) in terms of the gas scale, (ii) in terms of the electrical resistance of a material.

Why is the gas thermometer considered superior to the electrical resistance thermometer as a basis for defining temperature?

Describe how you would show that the highest temperature in the flame of a bunsen burner is of the order of 500 °C.

(66 marks)

4. Summarise the evidence which supports the wave theory of light. Explain briefly how the wave nature of X-rays can be demonstrated using a crystal grating. Why would you expect to encounter difficulty in diffracting X-rays with an optical line grating?

What is the minimum wavelength of X-rays emitted from an X-ray tube operating at 30 kV (30×10^3 volts)?

(Take Planck's constant, $h = 6{\cdot}6 \times 10^{-34}$ Js $= 6{\cdot}6 \times 10^{-27}$ erg s;
speed of light, $c = 3{\cdot}0 \times 10^8$ m s^{-1} $= 3{\cdot}0 \times 10^{10}$ cm s^{-1};
electron charge, $e = 1{\cdot}6 \times 10^{-19}$ $C = 4{\cdot}8 \times 10^{-10}$ e.s.u., 1 e.s.u. $= 300$ volts)

(66 marks)

5. State the factors on which the capacitance (capacity) of a capacitor depends and describe an experiment to show the effect of any *one* of these factors.

Derive the expression

$$\frac{\varepsilon_o A}{d} \text{ (SI units) or } \frac{A}{4\pi d} \text{ (e.g.s. units)}$$

for the capacitance of a parallel plate air capacitor where A is the area of the plate, d the distance between the plates and ε_o the permittivity of a vacuum (or air).

A capacitor in a circuit allows alternating current but not direct current to flow in the circuit: explain. Why would an increase in capacitance allow greater current to flow?

(66 marks)

6. Describe how you would carry out any *two* of the following experiments (i) the measurement of the horizontal component of the earth's magnetic field, (ii) the comparison of two low resistances (other than by the ammeter-voltmeter method), (iii) the measurement of the refractive index of the glass of a prism.

Give the theory associated with *one* of the experiments you have described.

(66 marks

7. Give an account, with the aid of a labelled diagram, of how an A.C. dynamo *or* a transformer operates.

How are the energy losses of a transformer reduced to a minimum?

What is meant by inductance? When a transformer is connected to a D.C. source it blows a fuse but not when connected to an A.C. source of the same voltage: explain.

(66 marks)

8. What is meant by thermionic emission? In what way does it resemble the evaporation which occurs when a liquid is heated?

Draw a characteristic curve for a thermionic diode showing the variation of plate (anode) current with potential for a fixed temperature of the filament. Mention the chief features of the curve.

Indicate how a beam of electrons is controlled in (i) a triode, (ii) a cathode ray tube.

(67 marks)

A3

9. Describe, with the aid of a labelled diagram, a moving-coil ammeter. Outline the theory which shows that the current is proportional to the angle of deflection of the coil.

Indicate how an ammeter may be calibrated by means of electrolysis or otherwise.

How would you measure an ionisation current (i.e. the current which results on the ionisation of a gas)?

(67 marks)

10. (a) "Although radioactivity, fission, fusion, all involve changes in the nucleus these processes differ from one another". Discuss.

Account for the release of energy in fission.

(b) Write a brief note on radioactivation analysis referring in particular to the role of gamma radiation in this method of analysis.

(67 marks)

11. Answer briefly any *two* of the following.

(a) Compare the optical arrangement of a microscope with that of a telescope.

(b) Distinguish (i) between vibrations in strings and in air columns (pipes), (ii) between loudness and pitch of notes.

(c) Outline how the ratio of the charge to mass $\left(\frac{e}{m}\right)$ of the electron may be determined.

(d) Discuss the Compton effect and the conservation laws.

(67 marks)