King's College London

UNIVERSITY OF LONDON

This paper is part of an examination of the College counting towards the award of a degree. Examinations are governed by the College Regulations under the authority of the Academic Board.

B.Sc. EXAMINATION

CP/1020 Basic Physics 2

Summer 1999

Time allowed: THREE Hours

**Candidates must answer SIX parts of SECTION A,
and TWO questions from SECTION B.**

The approximate mark for each part of a question is indicated in square brackets.

Separate answer books must be used for each Section of the paper.

**You must not use your own calculator for this paper.
Where necessary, a College Calculator will have been supplied.**

TURN OVER WHEN INSTRUCTED

Acceleration due to gravity at surface of the Earth = 9.8 m s^{-2}

Section A - Answer **SIX** parts of this section

1.1) Explain the importance of an internationally-agreed system of units in scientific investigations. What are the principles by which the fundamental SI units of mass, length and time are established?

[7 marks]

1.2) What is meant by the term *error* associated with experimental measurements? Explain briefly, without detailed analysis, how errors of measurement can be estimated. How would a result *R* with associated error *e* be written conventionally?

[7 marks]

1.3) A piece of lead of mass 150 g is heated to 85°C and is then dropped into a calorimeter containing 400 g of water at 21°C. Determine the final temperature of the lead and water. (Assume that no heat is lost from the system and that the heat capacity of the calorimeter can be neglected. The specific heat capacities of lead and water are 0.128 kJ kg^{-1} K^{-1} and 4.18 kJ kg^{-1} K^{-1} respectively.)

[7 marks]

1.4) Describe how sound waves propagate through a material and explain the meaning of the *intensity* of sound waves. The intensity of a sound wave corresponding to the threshold of hearing is conventionally taken to be 10^{-12} W m^{-2}, while the intensity of sound associated with normal conversation is 10^{-6} W m^{-2}. What is the difference, expressed in decibels, between the two sound levels?

[7 marks]

1.5) What is meant by a totally inelastic collision? During an ice-dance routine, a skater moving in a straight line with a velocity of 25 km h^{-1} picks up his stationary partner, whose mass is 75% of his own. What is the velocity of the pair immediately after the manoeuvre if they continue to move along the same linear path?

[7 marks]

1.6) Draw labelled diagrams to illustrate the three types of lever, and obtain expressions for the mechanical advantage in each case. A person holds a ball of mass 1 kg in the palm of an upturned hand, with the lower arm horizontal and the elbow close to the body. If the ball is 30 cm from the elbow, determine the force exerted by the vertical biceps muscle to maintain the arm position, assuming that the muscle tendon is attached to the lower arm at a point 5 cm from the elbow.

[7 marks]

1.7) What is meant by the *surface tension* of a liquid? Describe, with the aid of a diagram, what happens when a capillary tube is partially immersed in water. Indicate the forces acting to maintain equilibrium of the water within the capillary. (A detailed analysis is not required.)

[7 marks]

1.8) Carefully distinguish between the three characteristics of radiation measured in *roentgens*, *grays* and *sieverts*, and explain the relationships between them.

[7 marks]

SEE NEXT PAGE

Section B - Answer **TWO** questions from this section

2) Explain the meaning of viscosity applied to fluid flow, and show how the *coefficient of viscosity* is defined. Explain what is meant by a *Newtonian fluid.*

[10 marks]

Draw a labelled diagram to illustrate how a Newtonian fluid behaves when flowing along a pipe of circular cross section under conditions of (a) streamlined and (b) turbulent flow. The rate at which fluid flows along such a pipe in a streamlined manner is given by

$$V = \frac{\pi P a^4}{8\eta l}.$$

Carefully explain the meaning of each term in this equation.

[8 marks]

In the human circulatory system, blood takes 1.5 s to pass through a capillary of length 1.5 mm and diameter 6 μm. If the pressure drop between the ends of the capillary is 4 kPa, determine the coefficient of viscosity of blood. You may assume that the blood behaves as a Newtonian fluid.

[12 marks]

3) What is meant by (a) the conservation of energy and (b) the conservation of linear momentum?

[8 marks]

A pendulum bob of mass 0.5 kg is released from a position where the string which links it to a rigid support is horizontal. If the string has a length of 1.2 m, what is the speed of the bob when the string becomes vertical? (Neglect effects of air resistance.)

[10 marks]

As the string becomes vertical, the bob collides with a stationary mass of 1.0 kg which is free to move on a smooth, horizontal surface. Determine the speed of the 1.0 kg mass after the collision, deriving any equations you need. (Neglect effects of friction.)

[12 marks]

SEE NEXT PAGE

4) Give a description of the phenomenon of natural radioactivity, indicating the meaning of the terms *decay constant* and *half-life*.

[10 marks]

Describe the structure and method of operation of a Geiger counter used to monitor ionising radiation. Include in your answer any limitations on the use of the instrument.

[10 marks]

A sample of ^{128}I, a radionuclide used as a medical tracer, has an initial activity of 392 Bq. After 30 minutes, the activity has fallen to 160 Bq. Use these data to determine the decay constant and half-life of ^{128}I.

[10 marks]

5) What is meant by thermal equilibrium?

[3 marks]

Describe the construction and use of
(a) a mercury-in-glass thermometer and
(b) a thermocouple,
giving the advantages and disadvantages of each in measuring temperature.

[9 marks]

Give an account of the physical processes involved in the following mechanisms of heat transfer: (a) conduction; (b) convection; (c) radiation.

[12 marks]

A cylindrical copper rod of length 0.9 m and radius 1.0 cm is insulated to prevent heat loss through its curved surface. One of the exposed flat ends is maintained at a temperature of 100°C, while the other is kept at 0°C. Determine the rate at which heat energy is conducted along the rod. (Thermal conductivity of copper = 401 W m^{-1} K^{-1}.)

[6 marks]

FINAL PAGE