# 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 1997**

**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) Define each of the following physical quantities and give units in which each is measured: *Force*; *potential energy*; *kinetic energy; work; power.*

[7 marks]

1.2) Draw a diagram to show how a system of two pulley blocks each with two pulley wheels, together with a rope, should be arranged to lift a weight. If the effects of friction and the masses of the pulley blocks may be neglected, what is the mechanical advantage of your arrangement?

[7 marks]

1.3) Draw a labelled diagram of a thermocouple used as a thermometer and briefly explain how it works.

[7 marks]

1.4) The specific heat capacity of mercury is 138 J $kg^{-1}$ $K^{-1}$. How much energy is needed to raise the temperature of 2 g of mercury by 50°C?

[7 marks]

1.5) A drop of water is in equilibrium on a horizontal plate in a normal laboratory environment. Draw a labelled diagram to illustrate the *angle of contact* and the forces acting at the line of contact between the liquid and solid. Obtain an expression for the angle of contact in terms of the forces.

[7marks]

1.6) Explain the terms *exposure*, *absorbed dose* and *dose equivalent* as used in radiation physics. Give units in which each is measured and explain the relationship between them.

[7 marks]

1.7) Give a qualitative explanation of the Doppler effect. Indicate how it can be used in the measurement of blood flow using ultrasound.

[7 marks]

1.8) Radioactive decay can be described in terms of the following relation: $N = N_0 \exp(-\lambda t)$. Explain the significance of this relation, and obtain an expression for the half-life in terms of $\lambda$.

[7 marks]

**SEE NEXT PAGE**

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

2. Define *elastic* and *totally inelastic* collisions. In a one-dimensional elastic collision process between a sphere of mass $m_1$ moving with velocity $v_1$ and a stationary sphere of mass $m_2$, show that the velocities of the two spheres after the collision are, respectively,

$$\frac{m_1 - m_2}{m_1 + m_2} v_1 \text{ and } \frac{2m_1}{m_1 + m_2} v_1 .$$

[15 marks]

Use your results to obtain an expression for the energy lost by the moving particle in terms of its initial energy.

[6 marks]

Hence determine the energy lost in head-on elastic collisions between:

(a) a 6 MeV α-particle and an electron;

(b) a 6keV β-particle and an electron;

(c) a 6 MeV α-particle and a radon nucleus.

(Mass of α-particle = $6.7 \times 10^{-27}$ kg; mass of β-particle = $9.1 \times 10^{-31}$ kg; mass number of radon = 222.)

[9 marks]

3. Give an account of the production and propagation of sound. Include in your discussion the nature of sound waves, the subjective and corresponding objective descriptions of sound and the transmission of sound energy from one medium to another.

[12 marks]

A whisper heard at a distance of 1 m has a sound level of 20 dB. Given that the standard reference intensity for sound is $10^{-12}$ W m$^{-2}$ (corresponding approximately to the limit of human hearing), determine the intensity of the whisper.

[8 marks]

The sound level in front of loudspeakers at some music concerts can reach 120 dB. What is the ratio of the intensity of this sound to that of a pneumatic drill operating at a sound level of 90 dB?

[10 marks]

**SEE NEXT PAGE**

4. Explain what is meant by surface tension? Describe, with appropriate analysis, one method by which surface tension can be measured.

[12marks]

Show that the excess pressure inside a spherical soap bubble over that outside is $4\gamma/R$, where $\gamma$ is the surface tension of the soap solution and $R$ is the radius of the bubble. Two soap bubbles with differing radii are connected by a tube so that the interiors of the bubbles are connected; describe and explain what happens to the bubbles. Determine the pressure inside a spherical soap bubble of radius 2 cm if the atmospheric pressure where the bubble is formed is $9.8 \times 10^4$ Pa. (Surface tension of soap solution = 20 mN $m^{-1}$.)

[12 marks]

Describe the action of a surfactant and explain its significance in the action of the lungs.

[6 marks]

5. Give a critical discussion of the mechanisms by which a body can lose heat.

[15 marks]

How are these mechanisms utilised by mammals in temperature regulation?

[6 marks]

Calculate the rate at which body heat is conducted through a hiker's clothing, given the following data:
body surface area = 1.7 $m^2$;
thickness of clothing = 1.1 cm;
skin temperature = 33°C;
atmospheric temperature = +2°C;
thermal conductivity of clothing = 0.045 W $m^{-1}$ $K^{-1}$.

How much faster would the hiker lose his body heat if his clothes were to become soaked with water?

(Thermal conductivity of water = 0.6 W $m^{-1}$ $K^{-1}$.)

[9 marks]