

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

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

- 1.1) Draw a diagram to show how a system of two pulley blocks each with three 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, determine the mechanical advantage of your arrangement. [7 marks]
- 1.2) Define the decibel, the unit used in the measurement of sound levels. The sound level in front of a loudspeaker at a music concert is 110 dB. Given that the standard reference intensity for sound is $10^{-12} \text{ W m}^{-2}$, determine the intensity of sound in front of the loudspeaker. [7 marks]
- 1.3) What is meant by the *surface tension* of a liquid? Explain briefly the role played by surface tension in the action of a surfactant in the human lung. [7 marks]
- 1.4) What is the principle of conservation of mechanical energy? An object is dropped to fall vertically from a height of 2.4 m above the surface of the Earth. What is its speed just before it strikes the surface? (Neglect effects of air resistance.) [7 marks]
- 1.5) Describe briefly the arrangement and behaviour of atoms in
(a) an atomic liquid and
(b) a monatomic gas. [7 marks]
- 1.6) Explain the meaning of each of the following subjective characteristics of sound waves: *pitch*, *quality* and *loudness*. Include a brief description of what is observed in measuring these parameters and mention any relevant objective parameters. [7 marks]
- 1.7) A cylindrical aluminium rod of length 0.8 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 120°C , while the other is kept at 0°C . Determine the rate at which thermal energy is conducted along the rod. (Thermal conductivity of aluminium = $235 \text{ W m}^{-1} \text{ K}^{-1}$.) [7 marks]
- 1.8) How much energy is needed to heat 500 g of water in an insulated container from a temperature of 20°C to a temperature of 95°C ? At the molecular level, how is this energy manifested? (Specific heat capacity of water = $4190 \text{ J kg}^{-1} \text{ K}^{-1}$.) [7 marks]

SEE NEXT PAGE

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

- 2) Describe the three most common kinds of natural radioactivity and explain what causes each of them. What is meant by each 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 ^{123}I , a radionuclide used as a medical tracer, has an initial activity of 407 Bq. After 2 hours, the activity has fallen to 366 Bq. Use these data to determine the decay constant and half-life of ^{123}I .

[10 marks]

- 3) The rate at which a liquid flows along a cylindrical tube is given by Poiseuille's equation:

$$V = \frac{p Pa^4}{8hl}$$

Explain the meaning of each symbol in this equation.

[8 marks]

A hospital drip consists of a plastic reservoir of liquid connected by a wide-bore tube to a horizontal syringe needle of length 5 cm and diameter 0.25 mm. If the liquid surface in the reservoir is 90 cm above the needle, and the viscosity of the liquid is 1.1 mPa s, while its density is 1010 kg m⁻³, determine the rate at which liquid will flow from the needle. (Assume that the free end of the needle is open to the atmosphere.)

[7 marks]

If the needle is replaced by one of the same length, but with a diameter of 0.8 mm, by what factor will the flow rate change?

[5 marks]

Draw a clear, labelled diagram of an Ostwald capillary viscometer; and explain how it is used to determine the viscosity of a liquid.

[10 marks]

- 4) Give a brief description of a transducer which can both generate and detect ultrasound. [10 marks]

Explain how ultrasound can be used:

(a) to measure the depth of tissues in the human body; [5 marks]

(b) to produce an image of tissues in the human body. [5 marks]

What is the importance of impedance matching in these two procedures? [5 marks]

An ultrasound generator/detector placed on a patient's abdomen directs an ultrasound pulse into the abdominal cavity. The detector receives two pulses separated by 0.12 ms. If the speed of ultrasound in tissue is 1500 m s^{-1} , what can be deduced from this information? [5 marks]

- 5) Describe the construction and operation of:
- (a) a mercury-in-glass thermometer; [6 marks]
- (b) any form of electrical thermometer. [6 marks]

Comment on the advantages and disadvantages of the two types of instrument. [5 marks]

Why might two uncalibrated thermometers give different readings when immersed side-by-side in a liquid of uniform temperature? [5 marks]

A thermocouple and a thermistor are used to measure the temperatures of ice, steam and a patient, and gave raw electrical signals as shown in the following table:

	Ice	Patient	Steam
Thermocouple	0 mV	74 mV	200 mV
Thermistor	750 Ω	534 Ω	150 Ω

Determine the temperature of the patient as recorded by each thermometer. [8 marks]