OCR
RECOGNISING ACHIEVEMENT

ADVANCED GCE UNIT **2825/05**

PHYSICS A

Telecommunications

THURSDAY 21 JUNE 2007

Afternoon

Time: 1 hour 30 minutes

Additional materials: Electronic calculator.

Candidate Name

Centre Number

Candidate Number

INSTRUCTIONS TO CANDIDATES

- Write your name, Centre Number and Candidate Number in the boxes above.
- Answer **all** the questions.
- Use blue or black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure you know what you have to do before starting your answer.
- Do **not** write in the bar code.
- Do **not** write outside the box bordering each page.
- WRITE YOUR ANSWER TO EACH QUESTION IN THE SPACE PROVIDED. ANSWERS WRITTEN ELSEWHERE WILL NOT BE MARKED.

INFORMATION FOR CANDIDATES

- The number of marks for each question is given in brackets [ ] at the end of each question or part question.
- The total number of marks for this paper is 90.
- You may use an electronic calculator.
- You are advised to show all the steps in any calculations.
- The first five questions concern Telecommunications. The last question concerns general physics.

FOR EXAMINER'S USE

Qu.	Max.	Mark
1	15	
2	17	
3	15	
4	17	
5	6	
6	20	
TOTAL	90	

This document consists of **18** printed pages and **2** blank pages.

SP (MML 13180 3/06) T24046/5

Data

speed of light in free space,	$c = 3.00 \times 10^{8}\ \mathrm{m\,s^{-1}}$
permeability of free space,	$\mu_0 = 4\pi \times 10^{-7}\ \mathrm{H\,m^{-1}}$
permittivity of free space,	$\epsilon_0 = 8.85 \times 10^{-12}\ \mathrm{F\,m^{-1}}$
elementary charge,	$e = 1.60 \times 10^{-19}\ \mathrm{C}$
the Planck constant,	$h = 6.63 \times 10^{-34}\ \mathrm{J\,s}$
unified atomic mass constant,	$u = 1.66 \times 10^{-27}\ \mathrm{kg}$
rest mass of electron,	$m_e = 9.11 \times 10^{-31}\ \mathrm{kg}$
rest mass of proton,	$m_p = 1.67 \times 10^{-27}\ \mathrm{kg}$
molar gas constant,	$R = 8.31\ \mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant,	$N_A = 6.02 \times 10^{23}\ \mathrm{mol^{-1}}$
gravitational constant,	$G = 6.67 \times 10^{-11}\ \mathrm{N\,m^{2}\,kg^{-2}}$
acceleration of free fall,	$g = 9.81\ \mathrm{m\,s^{-2}}$

Formulae

uniformly accelerated motion,	$s = ut + \frac{1}{2}at^2$
	$v^2 = u^2 + 2as$
refractive index,	$n = \frac{1}{\sin C}$
capacitors in series,	$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \ldots$
capacitors in parallel,	$C = C_1 + C_2 + \ldots$
capacitor discharge,	$x = x_0 e^{-t/CR}$
pressure of an ideal gas,	$p = \frac{1}{3}\frac{Nm}{V}<c^2>$
radioactive decay,	$x = x_0 e^{-\lambda t}$
	$t_{\frac{1}{2}} = \frac{0.693}{\lambda}$
critical density of matter in the Universe,	$\rho_0 = \frac{3H_0^2}{8\pi G}$
relativity factor,	$= \sqrt{(1 - \frac{v^2}{c^2})}$
current,	$I = nAve$
nuclear radius,	$r = r_0 A^{1/3}$
sound intensity level,	$= 10 \lg \left(\frac{I}{I_0}\right)$

Answer **all** the questions.

1 Fig. 1.1 shows the frequency spectrum of the signal from a radio transmitter.

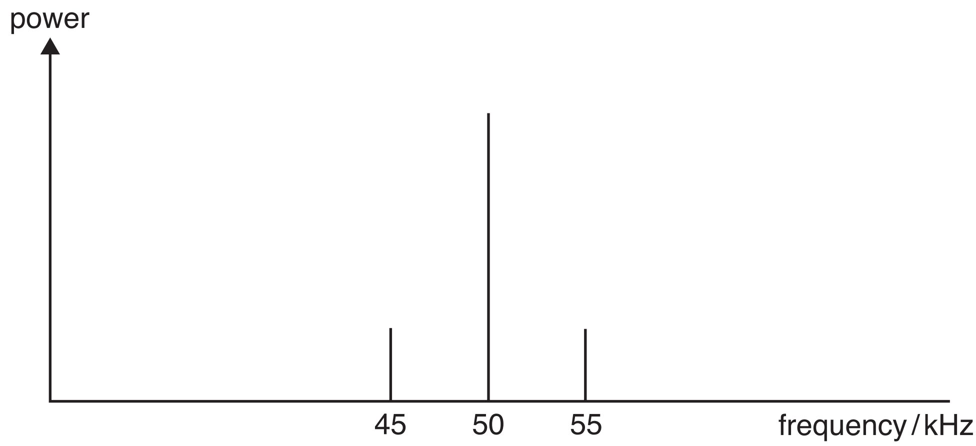

Fig. 1.1

(a) State the full name of the type of modulation shown in Fig. 1.1.

.... [1]

(b) Explain why it is unlikely that anyone is listening to this broadcast.

....

....

....

.... [2]

(c) State the bandwidth of the signal shown in Fig. 1.1 and give a suitable unit for your answer.

bandwidth = ... unit .... [2]

(d) State the name and frequency range of the radio waveband which accommodates this signal.

waveband .... from .... kHz to .... kHz [2]

(e) On the axes of Fig. 1.2, sketch a graph of the radio signal of Fig. 1.1 as a function of time.

Numerical values of signal voltage are **not** required.

Use the space below to show the calculations. [5]

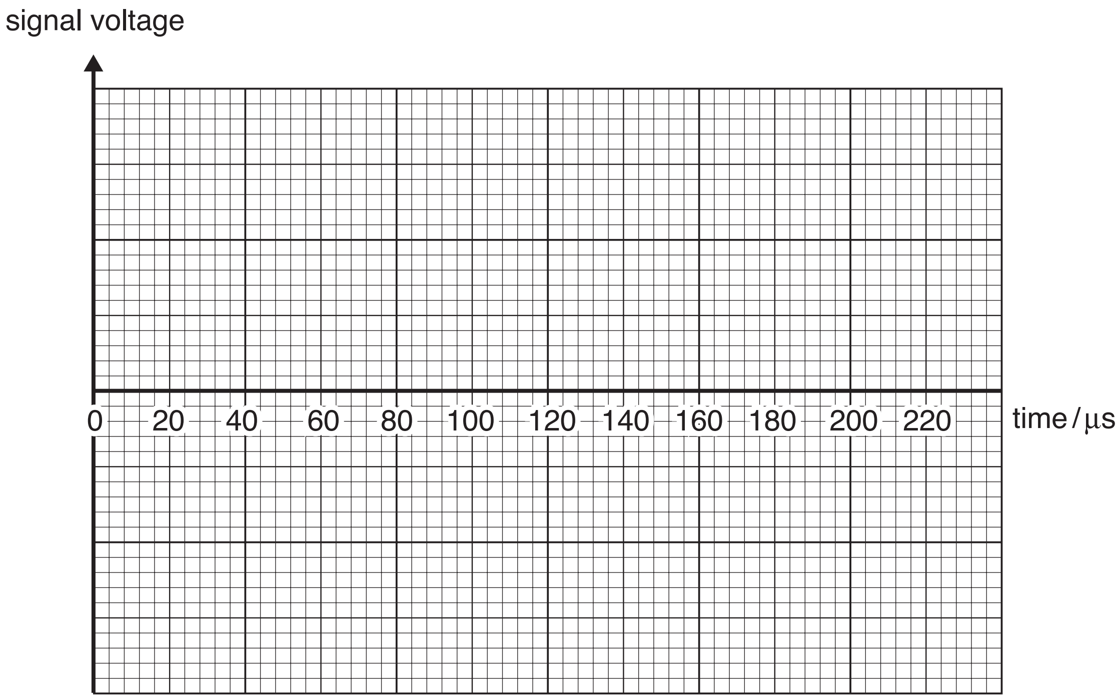

Fig. 1.2

(f) On the axes of Fig. 1.3, sketch the frequency spectrum of a radio broadcast from the same transmitter as Fig. 1.1 to which people might be listening.

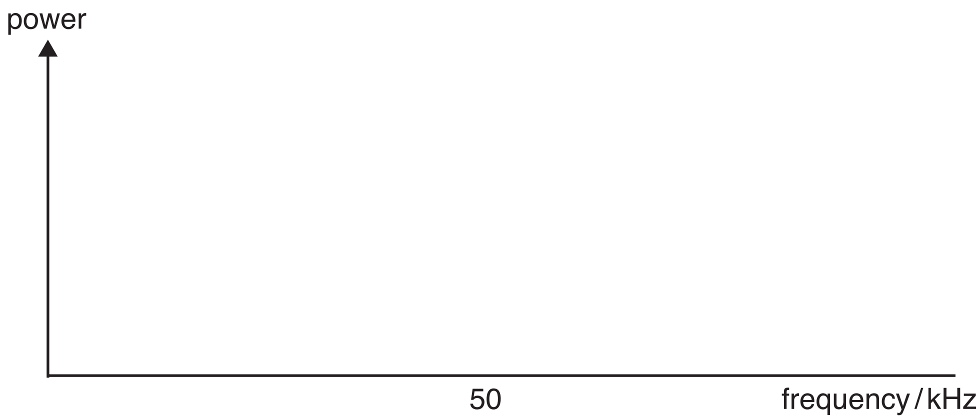

Fig. 1.3

Explain your answer.

....

....

.... [3]

[Total: 15]

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2 Fig. 2.1 shows a system where a TV cable company is transmitting TV signals through an optic fibre cable to a receiving station.

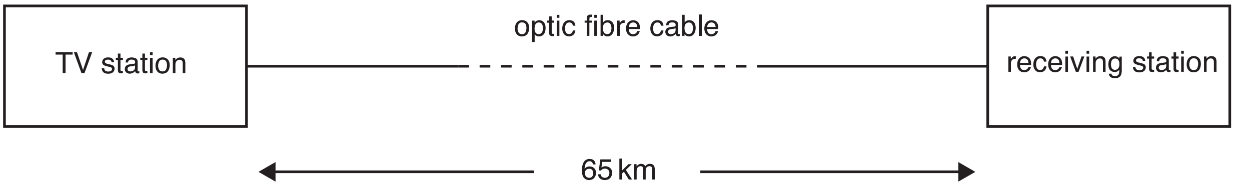

Fig. 2.1

The optic fibre cable is a monomode cable of length 65 km. There are no amplifiers between the two stations. The attenuation of the cable is 0.32 dB km^{-1}. The noise power at the receiving station is 0.24 μW. The signal-to-noise ratio at the receiving end is 28 dB.

(a) **(i)** State what is meant by *signal-to-noise ratio*.

....

.... [1]

(ii) State and explain how this ratio changes along the length of the fibre.

....

.... [2]

(b) **(i)** Show that the signal power at the receiving end of the optic fibre is about 150 μW.

[3]

(ii) Calculate the attenuation in the cable.

attenuation = ... dB [2]

(iii) Calculate the signal power input to the cable.

input signal power = ... W [2]

(c) **(i)** State the type of device used by the TV company to produce the light for the fibre.

.... [1]

(ii) Explain why this type of device is used.

....

.... [1]

(d) The TV company could transmit their signals in analogue or in digital format.

(i) Explain what is meant by

1 an *analogue* signal ....

....

2 a *digital* signal...

.... [2]

(ii) Explain **three** advantages of using digital signal transfer.

1. ....

....

2. ....

....

3. ....

.... [3]

[Total: 17]

3 Fig. 3.1 shows a satellite in geostationary orbit around the Earth. The satellite is broadcasting TV signals into a footprint of diameter 1200 km.

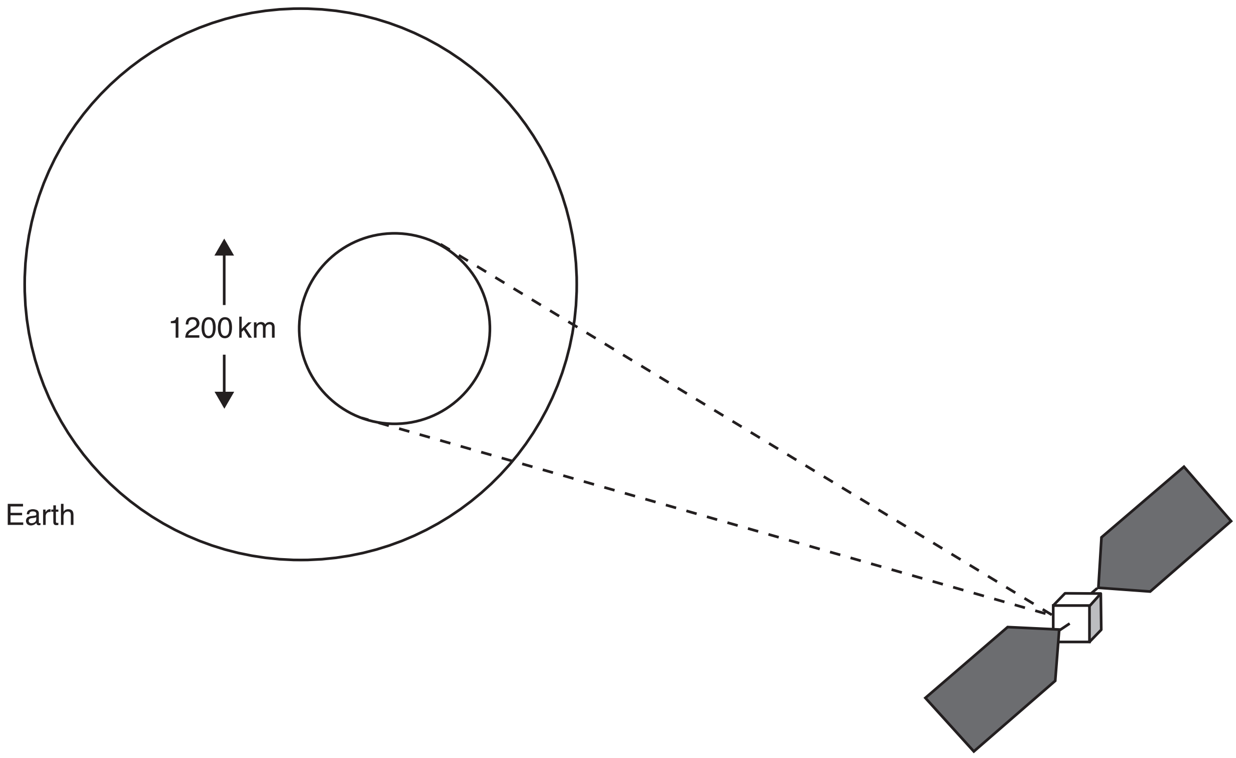

Fig. 3.1

(a) On Fig. 3.1, indicate the position of the North Pole of the Earth. [1]

(b) The satellite carries both batteries and solar panels. Explain why.

....

.... [2]

(c) The solar panels have a total area of 4.5 m^2 and produce a maximum output power of 1080 W.

The intensity of sunlight is 1.6 kW m^{-2}.

Calculate the percentage efficiency of the solar panels in converting sunlight to electricity.

efficiency = ... % [3]

(d) The satellite transmits a power of 750 W back to the Earth. 90% of this power is concentrated in the footprint of diameter 1200 km. Calculate the maximum power which can be received on Earth by a satellite dish of diameter 1.1 m. Assume power is uniformly distributed within the footprint.

power = ... W [4]

(e) Explain, quoting typical frequencies in your answer, how the TV signal gets from the TV station on Earth to the satellite dish of the viewer.

....

....

....

....

....

.... [3]

(f) Explain the advantage in broadcasting TV signals by satellite instead of by terrestrial transmissions from dipole aerials.

....

....

....

.... [2]

[Total: 15]

4 It is required to set up an optic fibre system capable of communicating speech from one room to another room a few metres away. The optic fibre has already been laid between the two rooms. You have available a microphone, which produces a maximum output of ± 30 mV, dual ± 15 V power supplies, a loudspeaker and a range of standard electronic components.

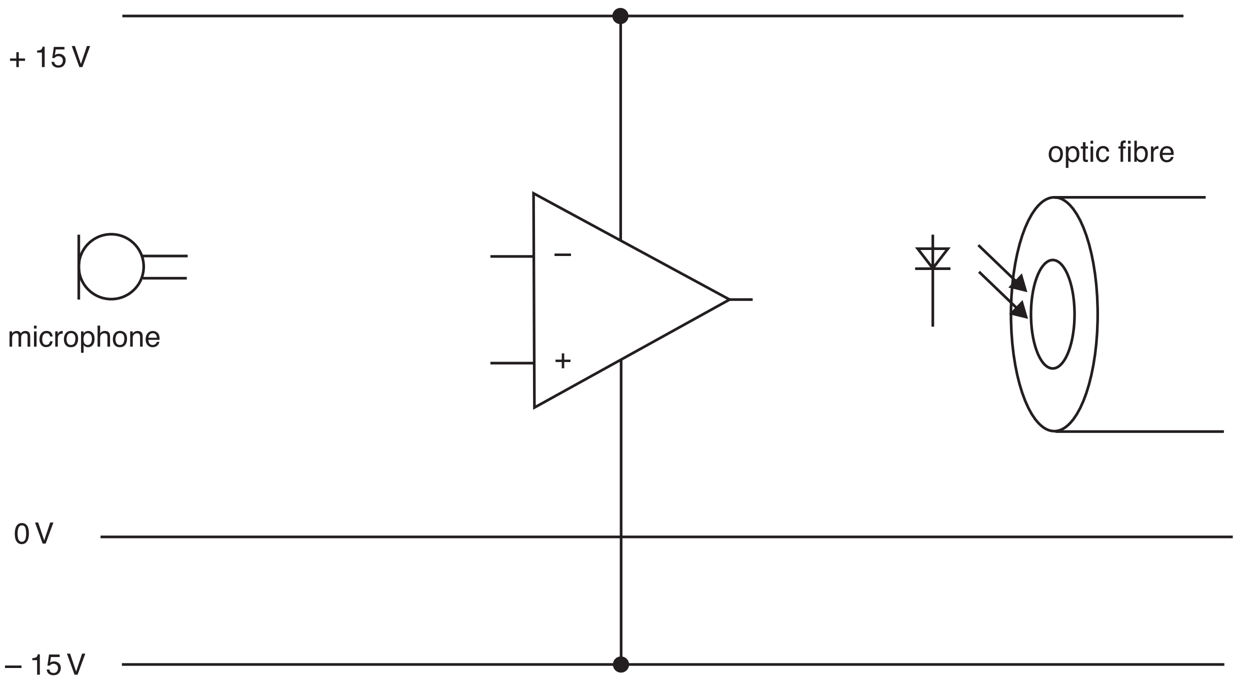

Fig. 4.1

(a) (i) On Fig. 4.1 complete the op-amp circuit diagram showing how the input to the optic fibre is produced. [4]

(ii) Calculate the maximum possible gain for the op-amp.

maximum gain = ... [1]

(iii) Label all resistors with appropriate values. Use the space below for your calculations and assume the LED current is not more than 10 mA.

[3]

(iv) Outline how your transmission system operates.

....

....

.... [2]

(b) Fig. 4.2 shows part of the circuit required at the receiving end of the fibre.

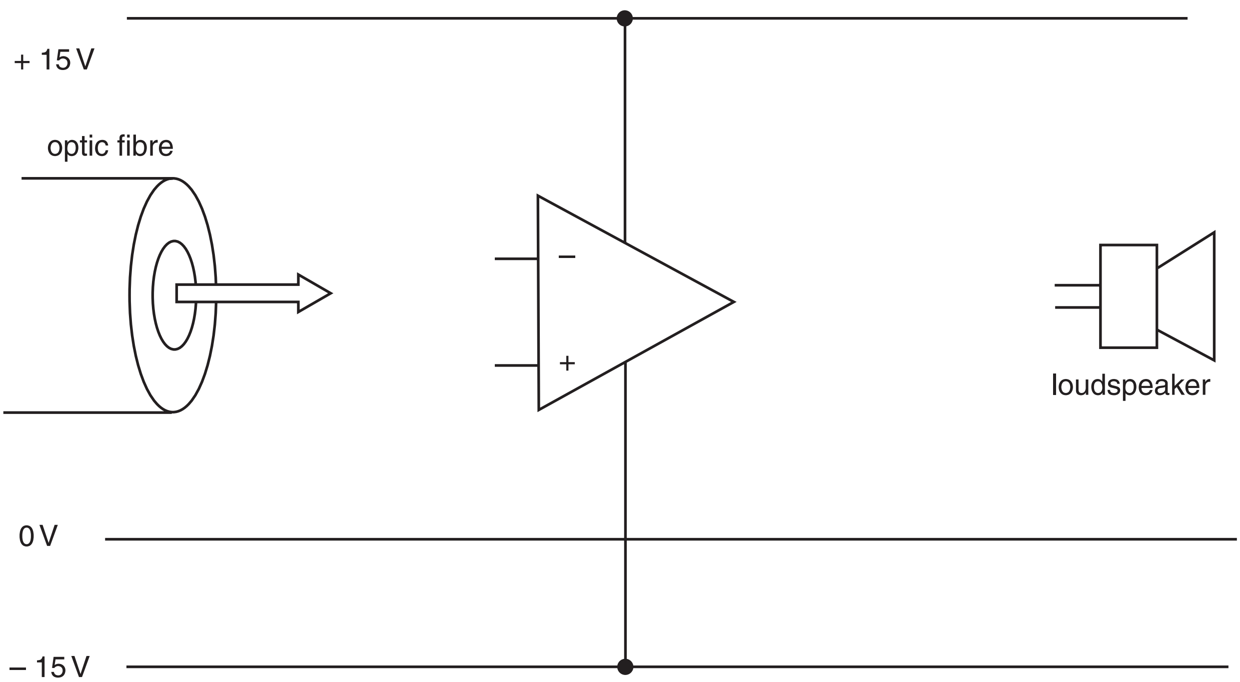

Fig. 4.2

(i) Draw on Fig. 4.2 the circuit required. The amplifier you draw should have a voltage gain of about 500. [5]

(ii) Explain how your receiver system operates.

....

....

....

.... [2]

[Total: 17]

5 There are three different ways in which electromagnetic waves may be propagated from a transmitting aerial to a receiving aerial. The mode of propagation depends on the transmission frequency. For each of the waves listed below, state their range of frequencies and describe the means by which they are propagated.

Surface waves

....

....

....

....

Sky waves

....

....

....

....

Space waves

....

....

....

.... [6]

[Total: 6]

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6 The suspension system for road vehicles can be modelled using springs and masses. The natural frequency of oscillation *f* for a mass *m* supported by a spring is given by

$$f = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$$

where *k* is the spring constant.

(a) (i) A spring is found to compress by 40 mm when loaded with a mass of 5000 kg. Show that the spring constant *k* is $1.2 \times 10^{6}\,\mathrm{N\,m^{-1}}$.

[2]

(ii) A 5000 kg mass is supported by four such springs as shown in Fig. 6.1.

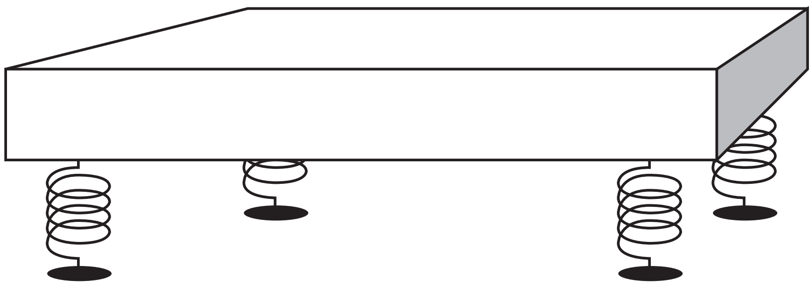

Fig. 6.1

Calculate the natural frequency of oscillation of the mass.

natural frequency = ... Hz [2]

(b) The suspension systems of large lorries require springs made from rods which may be several centimetres thick. Steel rod of this diameter would snap if bent into shape at room temperature. To prevent this the rod is 'hot-coiled': it is heated from 20 °C to 1000 °C before being wound into a spring.

The method of heating is electrical, using a supply of 50 V, which passes a current of 12 000 A through the steel rod. Large contacts at each end of the rod are necessary and these are water-cooled (see Fig. 6.2).

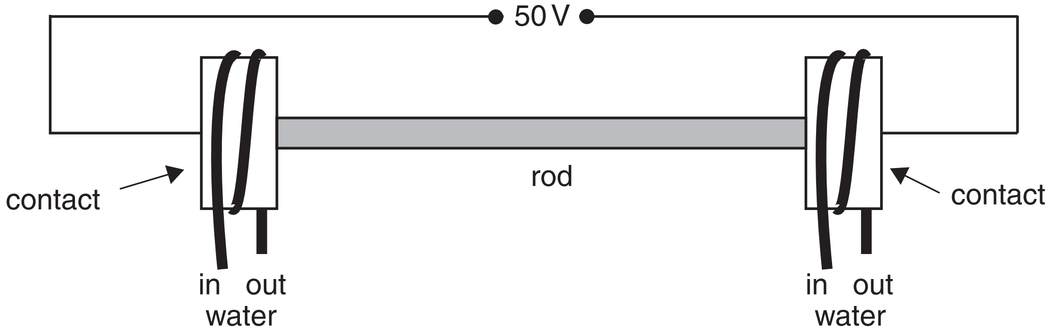

Fig. 6.2

(i) Calculate the resistance of the rod, assuming that the voltage across it is 50 V.

resistance = ... Ω [1]

(ii) Show that the electrical power generated in the rod is 600 kW.

[1]

The mass of the rod is 15 kg.

The specific heat capacity of steel is 420 J kg^{-1} K^{-1}.

(iii) Calculate the energy required to heat the rod from 20 °C to 1000 °C.

energy = ... J [2]

(iv) Calculate the minimum time required to heat the rod to 1000 °C.

minimum time = ... s [2]

(c) In practice the time taken to reach 1000 °C is greater than the value found in **(b)(iv)**. Consequently, the total energy supplied is found to vary according to the time taken for the heating process. The relationship between the energy supplied and time taken is shown in Fig. 6.3.

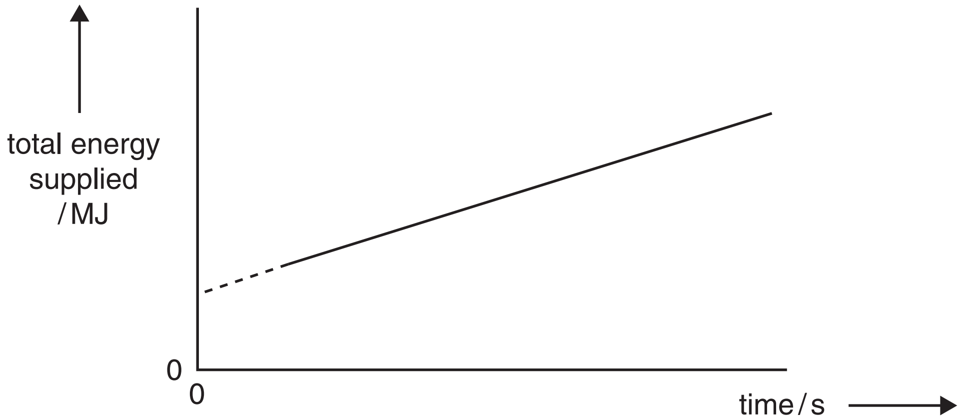

Fig. 6.3

Discuss **two** ways in which energy is lost from the rod during heating and explain the trend shown by the graph in Fig. 6.3.

....

....

....

....

....

.... [3]

(d) A spring is made from a steel rod of the same length but with **twice** the radius.

Suggest, **with reasons**, how the following will change.

(i) The resistance of the rod.

....

....

....

.... [2]

(ii) The time taken to heat the rod from 20 °C to 1000 °C, using the same voltage across the rod.

....

....

....

....

.... [3]

(iii) The natural frequency of the mass-spring system in **(a)**.

....

....

....

.... [2]

[Total: 20]

END OF QUESTION PAPER

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