OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced GCE

PHYSICS A **2825/03**

Materials

Thursday **27 JUNE 2002** Morning 1 hour 30 minutes

Candidates answer on the question paper.
Additional materials:
Electronic calculator

Candidate Name	Centre Number	Candidate Number

TIME 1 hour 30 minutes

INSTRUCTIONS TO CANDIDATES

- Write your name in the space above.
- Write your Centre number and Candidate number in the boxes above.
- Answer **all** the questions.
- Write your answers in the spaces on the question paper.
- Read each question carefully and make sure you know what you have to do before starting your answer.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets [ ] at the end of each question or part question.
- You may use an electronic calculator.
- You are advised to show all the steps in any calculations.

FOR EXAMINER'S USE		
Qu.	**Max.**	**Mark**
1	9	
2	10	
3	10	
4	12	
5	9	
6	9	
7	11	
8	20	
TOTAL	90	

This question paper consists of 19 printed pages and 1 blank page.

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,
$$s = ut + \tfrac{1}{2}at^2$$
$$v^2 = u^2 + 2as$$

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,
$$p = \tfrac{1}{3}\frac{Nm}{V}<c^2>$$

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 **(a)** Fig. 1.1 shows a two-dimensional view of part of a perfect cubic crystal. The circles represent atoms. The arrows labelled **F** represent forces to be applied to this section of crystal.

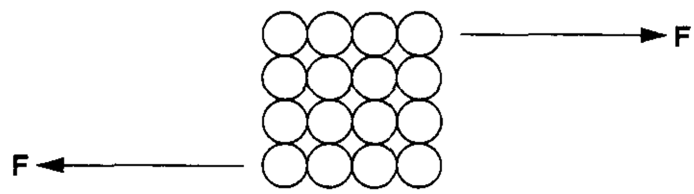

Fig. 1.1

Draw diagrams to show the new arrangement of the atoms in Fig. 1.1 when

(i) the forces **F** are small and the crystal is deformed elastically

[2]

(ii) the forces **F** are large and the crystal is deformed plastically.

[3]

(b) Two apparently identical thin rods, A and B, are shown in Fig. 1.2. A and B are made of the same crystalline material and have the same dimensions. Forces are used to stretch both rods by the same amount. Fig. 1.3 shows A and B when the forces are removed. A has returned to its original length, but B has remained stretched.

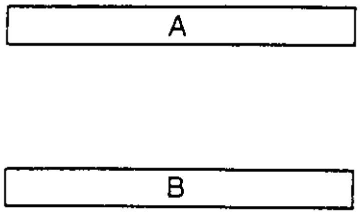

Fig. 1.2

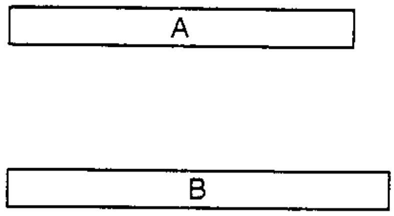

Fig. 1.3

(i) Describe the behaviour of the atoms in rod A, during this process.

....

....

....[2]

(ii) Suggest why rod B remains stretched.

....

....

....

....[2]

[Total : 9]

2 Fig. 2.1 shows a rectangular slab of copper. A uniform magnetic field acts perpendicular to the face ABCD.

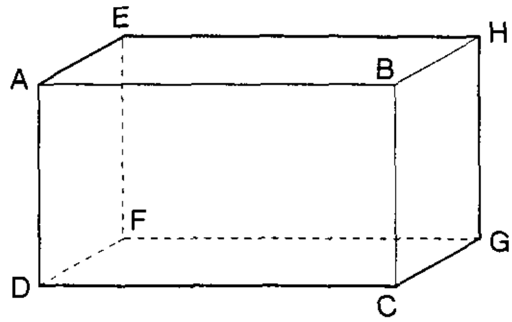

Fig. 2.1

(a) On Fig. 2.1, draw suitable circuits connected to the slab which will allow a Hall voltage to be set up and measured. [2]

(b) In Fig. 2.1, AD = 20 mm and AE = 1.0 mm. A current of 12 A enters at face ADFE and leaves at face BCGH. The concentration of free electrons in copper is $8.7 \times 10^{28}\,m^{-3}$. Calculate the drift velocity of free electrons in the slab.

drift velocity = ... $m\,s^{-1}$ [3]

(c) The Hall voltage measured across the copper slab is 1.5 μV.
Calculate the flux density of the magnetic field.

flux density = ... T [3]

(d) In practical Hall probes used to measure magnetic flux density, a slab of semiconductor is used rather than one of copper. Explain why.

....

....

....[2]

[Total : 10]

For Examiner's Use

3 (a) Individual iron atoms behave as magnetic dipoles. Explain what is meant by a *magnetic dipole*.

....

....[1]

(b) In terms of the behaviour of magnetic dipoles, describe what happens when

(i) an unmagnetised iron bar is placed in a magnetic field,

....

....

....[2]

(ii) a magnetised iron bar is heated to the Curie temperature of the iron.

....

....[1]

(c) Fig. 3.1 shows the hysteresis loop of a magnetic material.

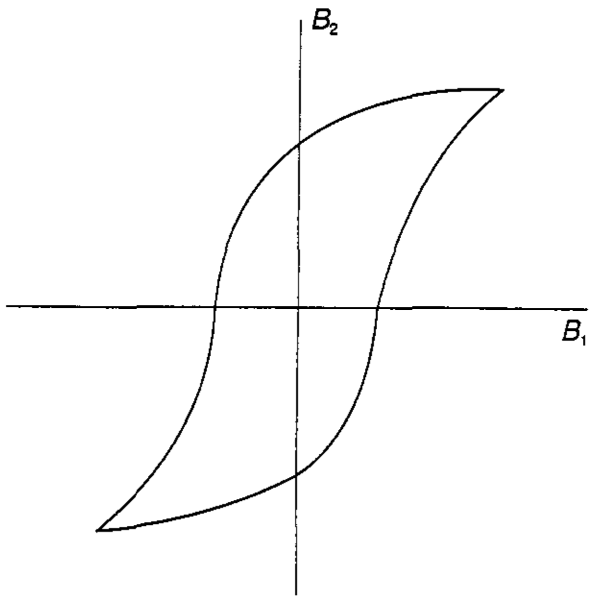

Fig. 3.1

(i) State what is represented by

1. B_1 ....

2. B_2 ....

[2]

For Examiner's Use

(ii) Explain why the material would be suitable, when magnetised, for use as a permanent magnet.

....

....

....[2]

(iii) Suggest **two** reasons why the material would be unsuitable for use as the core of a transformer.

1. ....

....

2. ....

....[2]

[Total : 10]

For Examiner's Use

4 (a) The primary coil of a transformer is connected to a low voltage a.c. source. A resistor is connected to the secondary coil. Measurements are to be carried out to determine the efficiency of the transformer.

(i) Draw a diagram of the circuit required, including the necessary meters.

[3]

(ii) With reference to the circuit you have drawn, explain how the efficiency of the transformer may be calculated.

....

....

....

....

....[3]

(b) (i) Identify **one** reason for the inefficiency of a transformer.

....[1]

(ii) State Faraday's law of electromagnetic induction.

....

....[1]

(iii) State and explain how the efficiency of a transformer depends on the frequency of the voltage supply.

....

....

....

....

....[3]

For Examiner's Use

(iv) State **one** desirable property of a material for use in the core of a transformer designed to operate at high frequencies.

....

....[1]

[Total : 12]

5 (a) The superconducting transition temperature of mercury is 4.2 K.

(i) Explain what is meant by *superconducting transition temperature*.

....

....[1]

(ii) On the axes of Fig. 5.1 sketch a graph to show the variation with temperature of the resistivity of mercury in the range 0–10 K. [3]

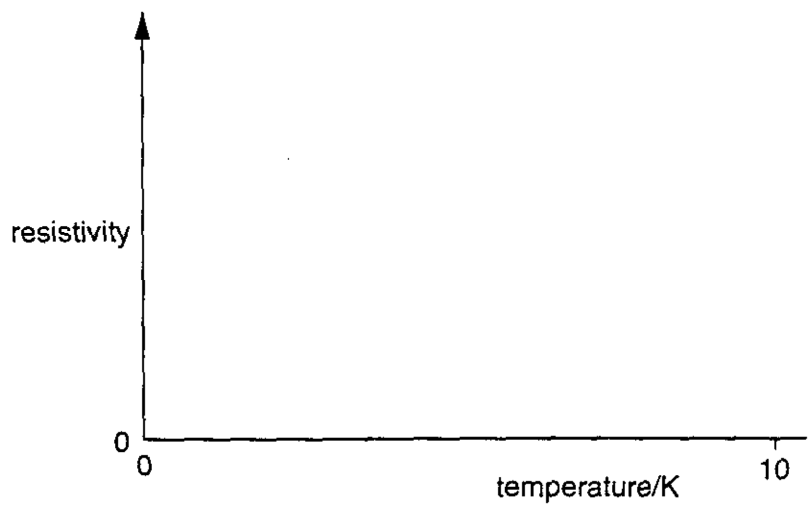

Fig. 5.1

(b) Superconducting materials are used in the production of very strong magnetic fields.

(i) Outline how these materials are used to produce a very strong magnetic field.

....

....

....[2]

(ii) State **two** advantages of the use of these materials.

....

....

....[2]

(iii) State **one** problem with the use of these materials in the generation of very strong magnetic fields.

....

....[1]

[Total : 9]

For Examiner's Use

6 **(a)** Infra-red radiation of wavelength 1.3 µm is used for transmission of information along optic fibres.

(i) Calculate the energy of a single photon of this radiation.

photon energy = ... J [2]

(ii) Explain, using band theory, why glass is transparent to photons of this energy.

....

....

....[2]

(iii) Glass is also transparent to visible light. Explain the advantage of using infra-red radiation rather than visible light for transmission along optic fibres.

....

....

....[2]

(b) Infra-red radiation of similar wavelength can be produced by both light-emitting diodes (LEDs) and lasers. Discuss why radiation from a laser rather than from an LED is used for transmission along optic fibres.

....

....

....

....

....

....[3]

[Total : 9]

7 The light from a tungsten lamp falls on the front face of a light-dependent resistor (LDR). The distance between the lamp and the LDR is fixed. The LDR is shielded from other light sources.

It is suggested that the relationship between I_L and P is of the form

$$I_L = KP^n$$

where I_L is the current through the LDR, P is the power of the tungsten lamp and K and n are constants.

Fig. 7.1 gives data for the voltage V across the lamp, the current I through the lamp, as well as P and I_L.

V/V	I/mA	P/mW	I_L/μA	lg(P/mW)	lg(I_L/μA)
3.0	101	303	350	2.48	2.54
4.0	120	480	1050	2.68	3.02
5.0	141		2560		
6.0	149		4680		
7.0	165		8420		

Fig. 7.1

(a) Complete the table. [3]

(b) On Fig. 7.2 plot a graph of lg(I_L/μA) against lg(P/mW). [3]

(c) State what aspect of your graph shows that the suggested relationship applies.

....

....[1]

(d) Use your graph to determine the value of n.

n = ... [4]

For Examiner's Use

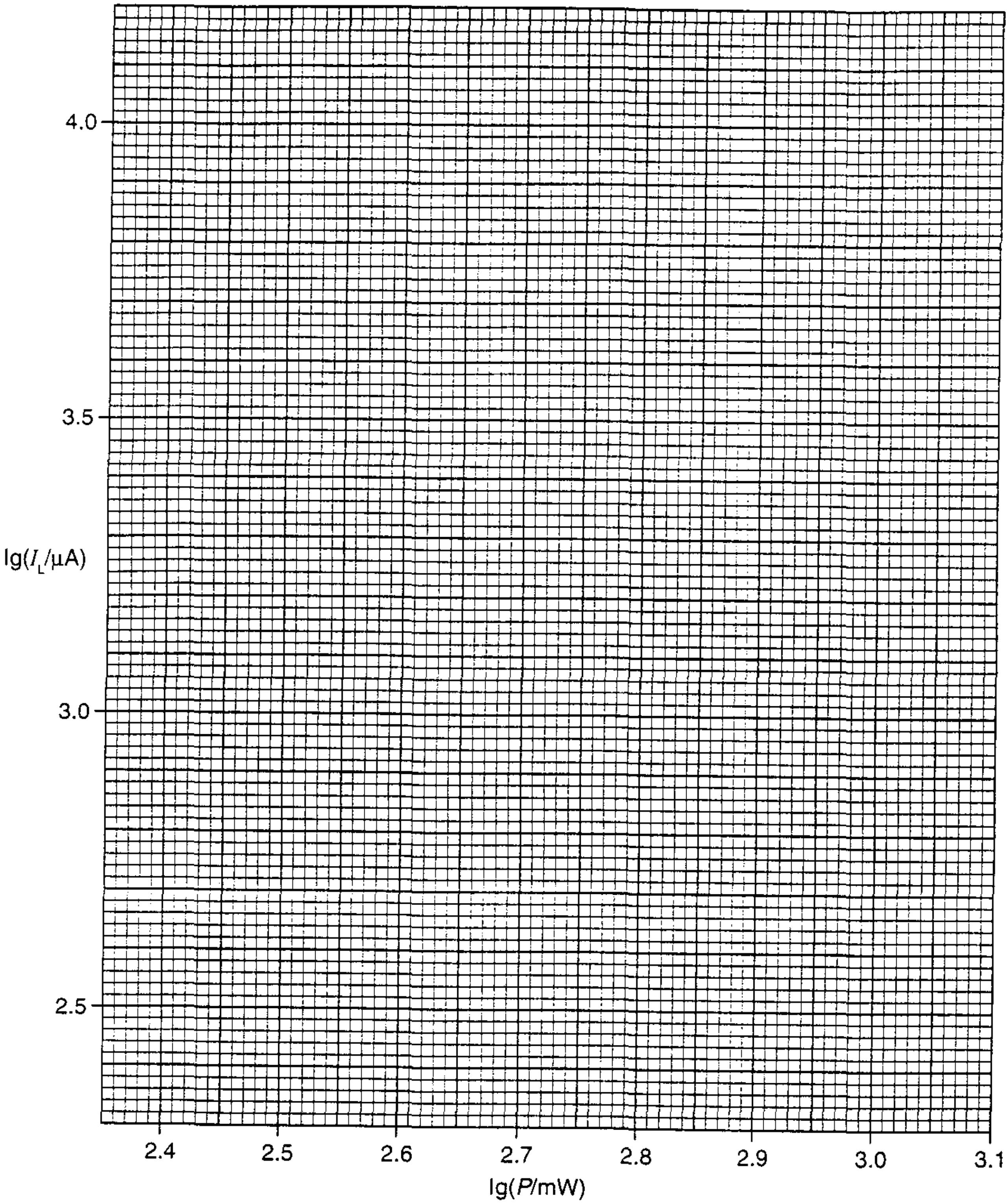

Fig. 7.2

[Total : 11]

[Turn over

For Examiner's Use

8 The following passage is based on a scientific article.

Power stations are normally most efficient when running under full load. The variation in demand over a day means that there must be capacity to meet peak demand, but much of this will be out of use for most of the day. This is wasteful of capital equipment when it is standing idle and of the fuel needed to run the station up to full demand and down at times of minimum demand.

The demand shown for January in Fig. 8.1 below is met for most of the day by power stations which are called *base load* stations. It has been suggested that during periods of peak demand, hydroelectric stations may be used to top-up the supply. The water for the hydroelectric stations is pumped into reservoirs at times when the *base load* stations' output is greater than demand. This is called a 'pumped storage' system.

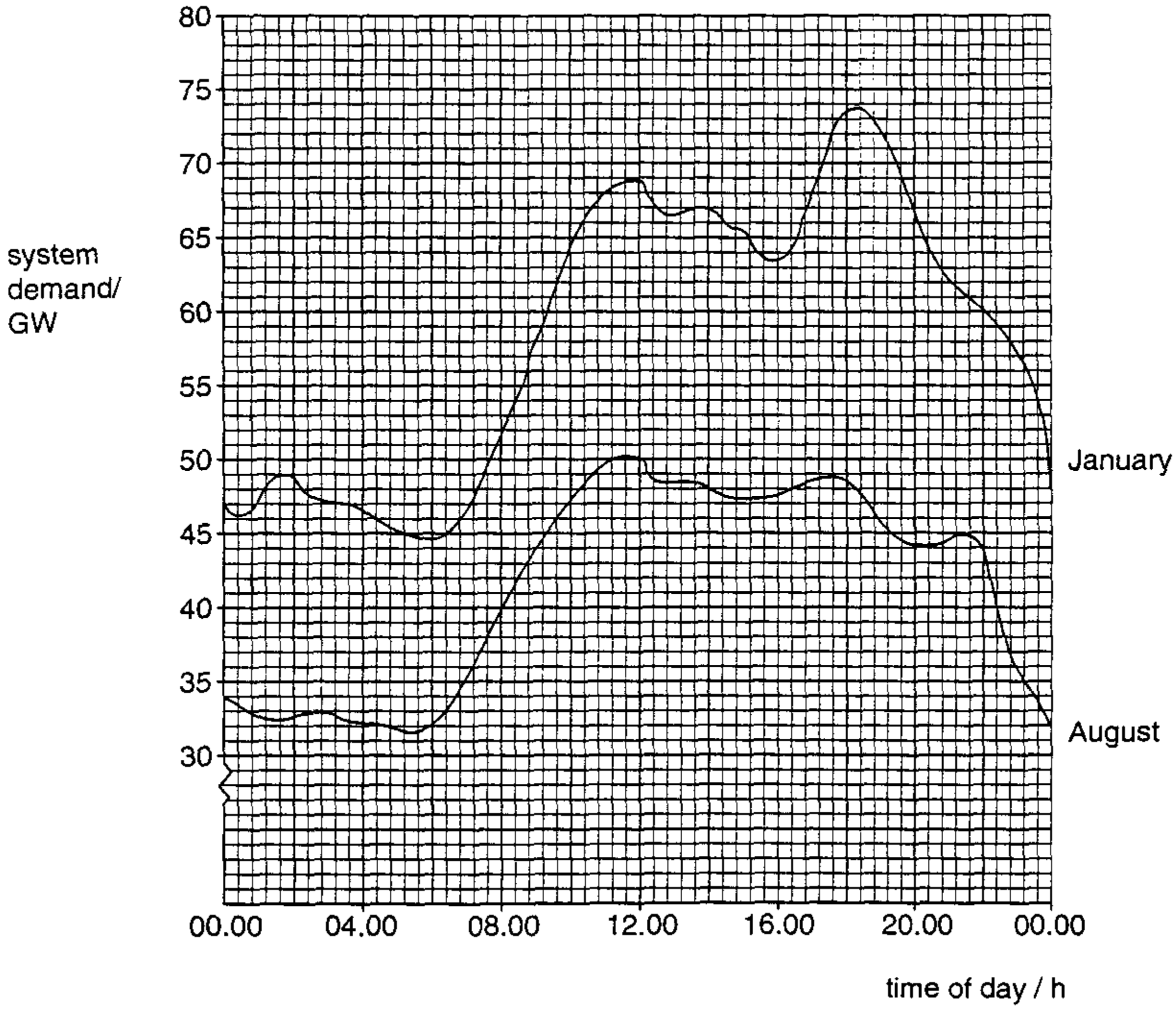

Fig. 8.1

Fig. 8.1 shows the average variation in electricity demand from the electricity companies in the UK with time of day for January and August.

For Examiner's Use

Answer the following questions about this passage.

(a) State **four** major features of the graphs of Fig. 8.1 for January and August and suggest reasons for these features.

1. ....

....

2. ....

....

3. ....

....

4. ....

....

[4]

(b) Suggest **two** reasons why a *base load* coal-fired power station cannot simply be switched on or off when the demand suddenly changes.

....

....

....[2]

(c) **(i)** Use Fig. 8.1 to estimate the *base load* power for January, that would allow the system to meet the demand for 18 hours out of a 24 hour period.
Show this as a horizontal line labelled BL on Fig. 8.1.

(ii) Estimate the maximum power output of the hydroelectric power stations needed to meet the extra demand.

power = ... GW
[2]

For Examiner's Use

(d) Water in one of the hydroelectric power stations falls through a vertical distance of 100 m.

(i) Show that the minimum volume of water required per second to flow through the turbines to produce an output of 1.0 GW from the generator is about $1 \times 10^3 \, m^3$. (The density of water = $1000 \, kg \, m^{-3}$.)

[4]

(ii) Calculate the length of one side of a square reservoir of depth 35 m which would just supply water at a rate of $1.0 \times 10^3 \, m^3 \, s^{-1}$ for a continuous period of 4 hours.

length = ... m [4]

(iii) Comment on the feasibility of a number of such power stations to meet the extra requirements during periods of peak demand.

....

....[2]

(iv) Give **two** reasons why the actual volume of water required per second to produce an output of 1.0 GW is greater than that calculated in **(d)(i)**.

....

....

....[2]

[Total : 20]

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Copyright Acknowledgements:

Question 8. Passage based on Question 24 in the 'Physics Nuffield Students' Guide', p.441, published by Addison Wesley & Longman.
Graph data based on SATIS no.601, 'Students' Guide', p.7 and 8, published by ASE, Hatfield, Herts.