THIS IS A LEGACY SPECIFICATION

RECOGNISING ACHIEVEMENT

ADVANCED GCE
PHYSICS A
Unifying Concepts in Physics

2826/01

Candidates answer on the question paper

OCR Supplied Materials:
None

Other Materials Required:
- Electronic calculator
- Ruler (cm/mm)

Wednesday 21 January 2009
Morning

Duration: 1 hour 15 minutes

Candidate Forename		Candidate Surname	

Centre Number						Candidate Number				

INSTRUCTIONS TO CANDIDATES

- Write your name clearly in capital letters, your Centre Number and Candidate Number in the boxes above.
- Use black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure that you know what you have to do before starting your answer.
- Answer **all** the questions.
- Do **not** write in the bar codes.
- Write your answer to each question in the space provided, however additional paper may be used if necessary.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets **[ ]** at the end of each question or part question.
- The total number of marks for this paper is **60**.
- You may use an electronic calculator.
- You are advised to show all the steps in any calculations.
- This document consists of **12** pages. Any blank pages are indicated.

FOR EXAMINER'S USE		
Qu.	**Max**	**Mark**
1	**11**	
2	**11**	
3	**18**	
4	**20**	
TOTAL	**60**	

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

Answer **all** the questions.

1 Explain the difference between the following terms.

(a) *refraction* and *diffraction*

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....

....

.... **[2]**

(b) *heat* and *temperature*

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....

.... **[3]**

(c) *electromotive force* and *potential difference*

....

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....

.... **[2]**

(d) *energy* and *power*

....

....

.... **[2]**

(e) *magnetic flux density* and *magnetic flux*

....

....

.... **[2]**

[Total: 11]

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2 **(a)** **(i)** A spring **A** is stretched by a force F. It undergoes an elastic extension x.

Deduce, in terms of F and x,

1 the spring constant k of the spring

spring constant = ... **[1]**

2 the work done in extending the spring.

work done = ... **[1]**

(ii) Another spring **B** of spring constant $2k$ is joined in series with spring **A** and the combined springs are pulled by the same force F as shown in Fig. 2.1.

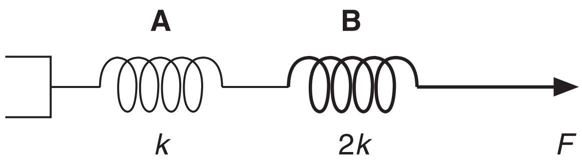

Fig. 2.1

Deduce, in terms of k and F, the extension of each spring and the work done on each spring. Put the expressions you obtain in the table of Fig. 2.2.

spring	spring constant	force	extension	work done
A	k	F		
B	$2k$	F		

[3]

Fig. 2.2

(b) Now consider an electrical situation where two resistors **X** and **Y** are connected in series. Resistor **X** has resistance R and resistor **Y** has resistance $2R$ and they carry a current I as shown in Fig. 2.3.

Fig. 2.3

Deduce, in terms of I and R, the potential difference across each resistor and the electrical work done per second on each resistor. Put the expressions you obtain in the table of Fig. 2.4.

resistor	resistance	current	potential difference	work done per second
X	R	I		
Y	$2R$	I		

[3]

Fig. 2.4

(c) The trends shown in Fig. 2.4 should be opposite to the trends shown in Fig. 2.2. Explain why this is and state how a different definition of spring constant would make the two situations directly comparable.

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.... **[3]**

[Total: 11]

3 Nuclear and conventional power stations use high-pressure steam to cause the rotation of a turbine that is connected to an electricity generator as shown in Fig. 3.1.

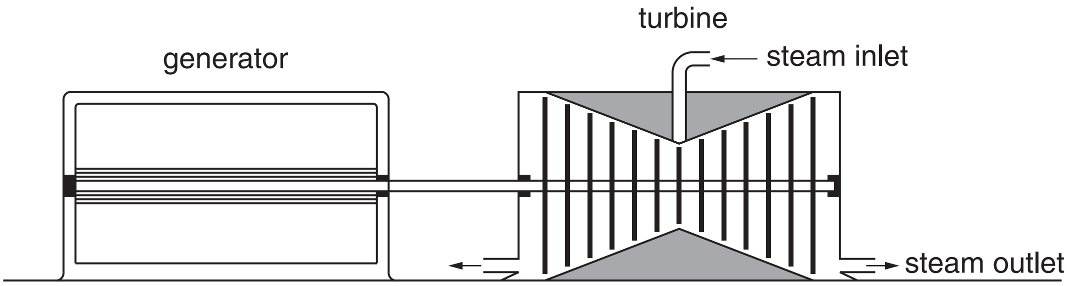

Fig. 3.1

The laws of thermodynamics show that the turbine of such a system, with a high input temperature T_H and a low output temperature T_L, has a maximum theoretical efficiency η_{max} given by

$$\eta_{max} = 1 - \frac{T_L}{T_H}.$$

(a) (i) Explain how the form of this equation indicates that temperatures cannot be in Celsius and must be in kelvin.

....

.... **[2]**

(ii) Calculate the maximum theoretical efficiency of a steam turbine with an inlet temperature of 850 K and an outlet temperature of 340 K.

maximum theoretical efficiency = ... % **[1]**

(iii) Explain what conditions are required for input and output temperatures in order to obtain highest values of turbine efficiency.

Input temperature must be ....

Output temperature must be .... **[1]**

(iv) Explain the basic problems that will arise with each of these conditions.

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....

.... **[4]**

(b) Combined heat and power systems (C.H.P.) are being introduced as a way of making more efficient use of energy resources. One system uses a small power station with electrical output of 20 MW. Consider the steam turbine in **(a)** with its input temperature at 850 K and its output temperature at 340 K. In practice its efficiency is 42%. The efficiency of the generator can be assumed to be 100%.

(i) Calculate the input power at 850 K.

input power = ... MW **[2]**

(ii) Calculate the power wasted as heat at the low temperature of 340 K.

power wasted = ... MW **[1]**

(iii) This wasted power heats cooling water from its original temperature of 290 K to the output temperature of 340 K. Calculate the mass of cooling water per second that needs to be used. The specific heat capacity of water is 4200 J kg^{-1} K^{-1}.

mass per second = ... kg s^{-1} **[3]**

(iv) In a C.H.P. system the heated cooling water at 340 K is used to warm buildings. Suggest **two** practical problems with such a system. One of these problems should be associated with the choice of temperature of the heated cooling water.

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....

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.... **[4]**

[Total: 18]

4 A capacitor of capacitance 80×10^{-3} F is connected in a circuit together with a battery of e.m.f. 20 V and a resistor of resistance 50 kΩ, as shown in Fig. 4.1.

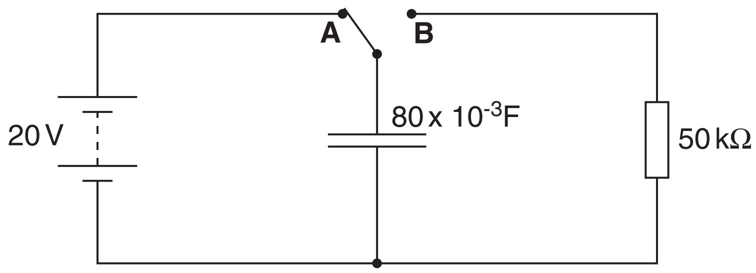


Fig. 4.1

(a) The capacitor is charged by moving the switch to terminal **A**. Calculate

(i) the charge Q_0 stored on the capacitor

charge Q_0 = ... C **[2]**

(ii) the energy stored in the capacitor.

energy = ... J **[2]**

(b) The switch is then moved to **B** at time $t = 0$.

(i) Show that the time constant of the capacitor – resistor circuit is 4000 s.

[1]

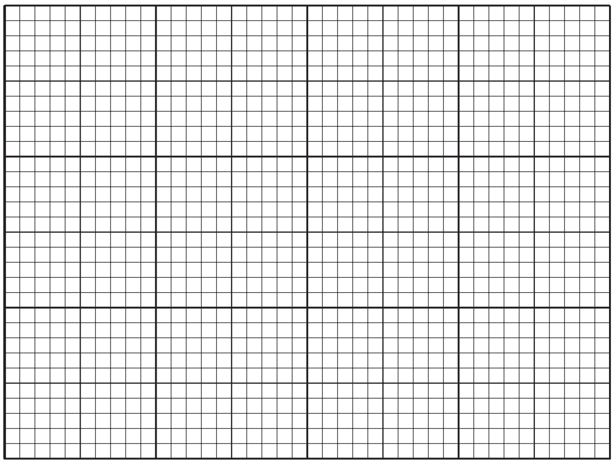
(ii) State the equation relating the charge on the capacitor, Q, at time t, with Q_0, C and R where C is the capacitance of the capacitor and R is the resistance of the resistor. Use the equation to find the corresponding equation for ln Q.

[2]

(iii) Complete the table. Hence plot a graph of ln Q against time on the grid.

t/s	t/CR	ln Q_0	ln Q
0			
1000			
4000			
6000			

ln$Q$



[5]

(iv) **1** Deduce the gradient of the graph.

gradient = ... **[1]**

2 Express the gradient in algebraic terms, using information from **(b)(ii)**.

[1]

(v) Determine the time taken for the charge on the capacitor to fall to 0.0010 Q_0.

time taken = ... s **[3]**

THIS QUESTION CONTINUES ON PAGE 12

(c) **(i)** State the expression for the energy E stored by the capacitor in terms of Q and C.

[1]

(ii) Without drawing another graph, deduce how the gradient of the graph of ln E against t, is related to the gradient of the ln Q against t graph you have drawn.

[2]

[Total: 20]

END OF QUESTION PAPER