OCR
RECOGNISING ACHIEVEMENT

ADVANCED GCE UNIT **2826/01**

PHYSICS A

Unifying Concepts in Physics

THURSDAY 14 JUNE 2007 Morning

Time: 1 hour 15 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 60.
- 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	**8**	
2	**13**	
3	**21**	
4	**9**	
5	**9**	
TOTAL	**60**	

This document consists of **13** printed pages, and **3** blank pages.

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, $= 10 \lg \left(\dfrac{I}{I_0}\right)$

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Answer **all t**he questions.

1 Give details of a situation in which an object

(a) is in equilibrium but is not stationary

....

....

....

....[2]

(b) has its acceleration and its velocity

(i) at right angles to each other

....

....

....[1]

(ii) in opposite directions.

....

....

....[1]

(c) is accelerating while it is stationary

....

....

....[2]

(d) has zero resultant force on it but is not in equilibrium.

....

....

....[2]

[Total: 8]

2 Under certain conditions, when a liquid cools, the rate of fall of temperature is directly proportional to T_x, where T_x is the difference between the temperature of the liquid and the temperature of the surroundings. A graph of temperature against time is shown in Fig. 2.1 for an experiment in which the cooling liquid was 0.160 kg of water (a cup of tea). The temperature of the surroundings was 15 °C.

Fig. 2.1

(a) Calculate the **average** time taken for T_x, called the temperature excess, to fall to half its previous value. (The half-life of the temperature of the cup of tea.)

average time = ... min [3]

(b) The graph obeys the exponential decay equation

$$T_x = T_0 e^{-\lambda t}$$

where T_0 is the temperature **excess** at time $t = 0$

Use your answer to **(a)** to calculate a value for λ, the decay constant. Give the unit for λ.

λ = ... unit .... [4]

(c) At the start of this question it was stated that this law applied "under certain conditions".

State **three** conditions which would affect the rate of cooling of the liquid.

1. ....

....

2. ....

....

3. ....

....[3]

(d) The specific heat capacity of water is 4200 J kg^{-1} K^{-1}. Calculate how much heat is lost by the 0.160 kg of water in 70 min.

heat lost = ... J [3]

[Total: 13]

3 Movement of energy supplies from source to consumer is essential in the modern world. For example, oil from the Middle East is transported to Europe where it is refined and used. Back in the 16th century the same principle applied to shipping coal from Newcastle to London. Today a great deal of energy is transmitted, using the National Grid, from coal (and gas) power stations in the Midlands to the South, where there are fewer power stations. It would be more efficient to have the power stations near to people's homes and factories but people do not like living near power stations.

(a) Suggest why power stations are near coalfields, even though many coal mines have now ceased production.

....

....

....[2]

(b) State and explain **two** reasons why people do not like living near power stations.

1. ....

....

2. ....

....[4]

(c) Nuclear power stations are sited on the coast. Apart from keeping them some distance from centres of population, what reason is there for this?

....[1]

(d) In order to transmit electrical energy from a power station to a city, a distance of 100 km away, a power line of total resistance 5.0 Ω is used. The power is generated at 11 000 V and the current supplied is 800 A, as shown in Fig 3.1.

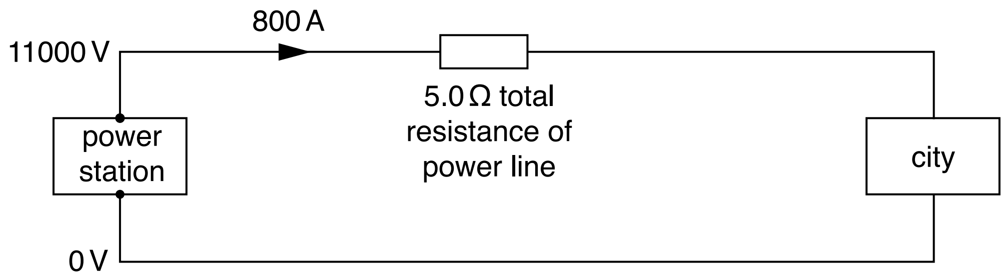

Fig. 3.1

Calculate

(i) the power supplied by the power station

power = ... W [2]

(ii) the voltage drop across the power line

voltage drop = ... V [2]

(iii) the voltage supplied to the city

voltage supplied = ... V [1]

(iv) the power supplied to the city

power = ... W [2]

(v) the efficiency, which is the percentage of the power generated by the power station that reaches the city.

efficiency = ... % [2]

(e) The figures used in **(d)** are impractical. The total power delivered is too small to be really useful and the efficiency is too low. An alternative power station has an output of 100 MW and 98% of this power is to be supplied to the city. The same power line has to be used. Calculate the output voltage required at the power station.

voltage = ... V [5]

[Total: 21]

4 Many televisions are now produced with flat panel screens. One type of flat panel screen is the plasma screen. In a plasma screen millions of tiny cells are sandwiched between two glass plates which enclose low pressure gas. In order to make a cell emit light a voltage is applied across the cell between two electrodes. This ionises the gas and ultra-violet radiation is emitted. This radiation falls on a phosphor which then emits light. One third of all the phosphors emit red light, one third emit green light and one third emit blue light. Three of the cells, one for each colour, are shown in Fig. 4.1.

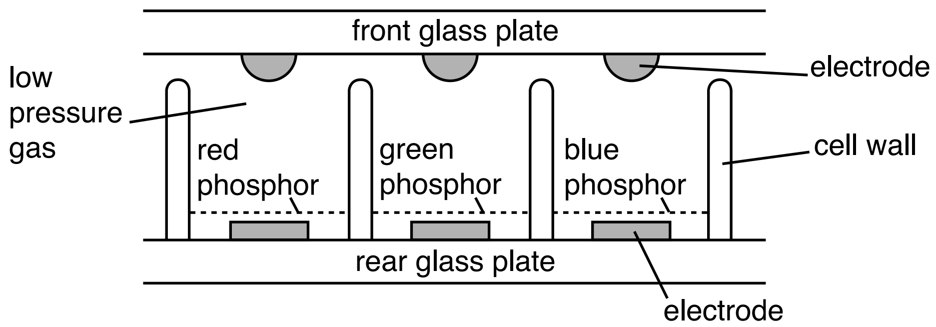

Fig. 4.1

(a) Explain the meaning of the word *ionise.*

....

....[1]

(b) Calculate the photon energy of ultra-violet radiation of wavelength 238 nm.

energy = ... J [3]

(c) Explain why it is possible to use ultra-violet photons to create photons of visible light in a phosphor, but it would **not** be possible to create ultra-violet photons from any photons of visible light.

....

....

....

....[2]

(d) A cell will emit light when a voltage of +15 V is applied to its positive electrode and a voltage of –15 V to its negative electrode. The electrode separation is 0.20 mm. Calculate the value of the uniform electric field causing the ionisation. State the SI unit for electric field.

electric field = ... unit .... [3]

[Total: 9]

5 During a bungee jump, the jumper falls a distance of 150 m before stopping for the first time. The jumper's mass is 80 kg.

(a) Assuming that frictional losses are negligible, complete the following table to show the energy changes between the top and the bottom of the fall. One value has been given.

	energy at the top / J	energy at the bottom / J
gravitational potential energy of jumper		0
kinetic energy of jumper		
elastic potential energy of elastic rope		

[3]

(b) The elastic rope being used has an unstretched length of 50 m and spring constant of 24 N m^{-1}. Calculate the tension in the rope when the jumper stops at the bottom.

tension = ... N [1]

(c) For a rope obeying Hooke's law show that the elastic potential energy stored in the rope is given by

$$E = \tfrac{1}{2}kx^2$$

where k is the elastic spring constant and x is the extension.

[2]

(d) **(i)** Another jumper has a mass of 100 kg. For this bungee jump a rope of unstretched length 45 m and a spring constant 26.7 N m^{-1} is used. Show that this data is valid for the same 150 m fall before stopping for the first time.

[2]

(ii) In fact, the rope used by the second jumper is a shorter length of the rope used by the first jumper. Explain why the spring constant for the shorter rope is larger.

....

....

....[1]

[Total : 9]

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