OCR
RECOGNISING ACHIEVEMENT

ADVANCED GCE **2826/01**

PHYSICS A

Unifying Concepts in Physics

MONDAY 21 JANUARY 2008 Morning

Time: 1 hour 15 minutes

Candidates answer on the question paper.
Additional materials: Electronic calculator
Ruler (cm/mm)

CUP/T36927

Candidate Forename		Candidate Surname	

Centre Number						Candidate Number				

INSTRUCTIONS TO CANDIDATES

- Write your name in capital letters, your Centre Number and Candidate Number in the boxes above.
- Use blue or 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.
- Do **not** write outside the box bordering each page.
- Write your answer to each question in the space provided.

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	**14**	
2	**17**	
3	**13**	
4	**7**	
5	**9**	
TOTAL	**60**	

This document consists of **12** printed pages.

[Turn over

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, $p = \frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$

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 spherical raindrop falling from a cloud through still air will normally reach a terminal velocity. The air resistance F on a raindrop is given by the expression

$$F = krv$$

where r is the radius of the raindrop and v its terminal velocity. k is a constant.

(a) Deduce an SI unit for k.

unit ..... [2]

(b) **(i)** Draw a labelled force diagram showing the **two** main forces acting on a spherical raindrop when falling with terminal velocity.

raindrop ◯

[1]

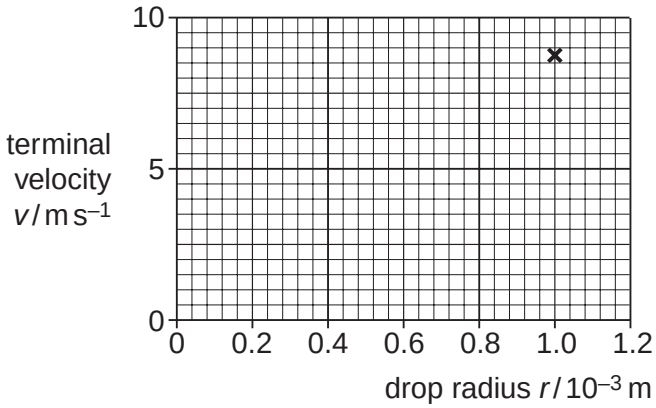
(ii) Write down expressions for the two forces in terms of k, r, v, g and ρ where ρ is the density of water. Hence show that the terminal velocity is proportional to r^2.

[2]

(c) The density of water is $1000\,\text{kg}\,\text{m}^{-3}$. The terminal velocity of a raindrop of radius 1.0 mm is $8.7\,\text{m}\,\text{s}^{-1}$. Deduce a value for k.

k = ... [3]

(d) Plot a graph to show how the terminal velocity v varies with drop radius r. The value from **(c)** has already been plotted on Fig 1.1. Calculate the position of **two** more points for different radii. Draw a smooth curve through the points to complete the graph.



[3]

Fig. 1.1

(e) On a fine day in the U.K. the sky often has a few cumulus clouds which are not falling. The cloud consists of small water droplets. A glider pilot will try to be underneath a cumulus cloud when she wishes to gain height.

Suggest

- how it is possible for the cloud not to fall
- why the glider gains height under the cloud.

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..... [3]

[Total: 14]

2 This question is about the economics of panels of solar cells.

Data

radius of the Earth	6.4×10^6 m
power per unit area at the Earth from the Sun	1.2×10^3 W m^{-2}
efficiency of solar panel	10%
energy provided on the Earth by burning fossil fuels	3×10^{20} joules per year
cost of 12 V panel of solar cells rated at 80 W maximum	£400
cost of lead-acid battery for use with solar panel	£100
cost of 1 kWh from mains electricity supplier	10 p

Answer the following questions using the data above as necessary.

(a) (i) Calculate the area of cross-section of the Earth.

area = ... m^2 [2]

(ii) Hence show that the total amount of energy the Earth receives from the Sun in one year is approximately 5×10^{24} J.

[1]

(b) Calculate the ratio

$$\frac{\text{energy supplied to the Earth by the Sun}}{\text{energy provided on the Earth by burning fossil fuels}}.$$

ratio = ... [1]

(c) (i) Explain how an 80 W panel of solar cells should be arranged in order to give maximum output. A sketch may help your answer.

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..... [1]

(ii) Although the maximum power of the solar panel is 80 W, its average output power is only 20 W. Suggest **three** reasons why the average output of the solar panel is so low.

1. .....

2. .....

3. ..... [3]

(iii) Explain why a battery is necessary for use with a solar panel.

.....

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..... [1]

(d) Calculate

(i) the approximate area of the 80 W panel of cells

area = ... m^2 [1]

(ii) the maximum current from the solar panel

current = ... A [2]

(iii) the length of time it would take for the solar panel to supply 1 kWh of energy at a rate of 20 W

time = ... hours [1]

(iv) the time it would need to operate at 20 W in order to repay its purchase price through saving mains electricity.

time = ... hours [2]

(e) Use your answers to **(d)** to comment on the usefulness of panels of solar cells.

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..... [2]

[Total: 17]

3 **(a)** State the meaning of the following terms.

(i) nuclide .....

..... [1]

(ii) isotopes .....

..... [1]

(iii) ion .....

..... [1]

(b) A potassium source is used to produce a beam of potassium ions. The rate of production of the ions in the beam is 5.4×10^{7} per second and the charge on each ion is $+1.6 \times 10^{-19}$ C. Calculate

(i) the electric current of the beam

current = ... A [1]

(ii) the mass of a potassium ion of $^{39}_{19}K$.

mass = ... kg [3]

(c) The potassium ions are accelerated to a speed of $5.0 \times 10^{5}\,m\,s^{-1}$ and then passed into a magnetic field of magnetic flux density 0.84 T, as shown in Fig. 3.1.

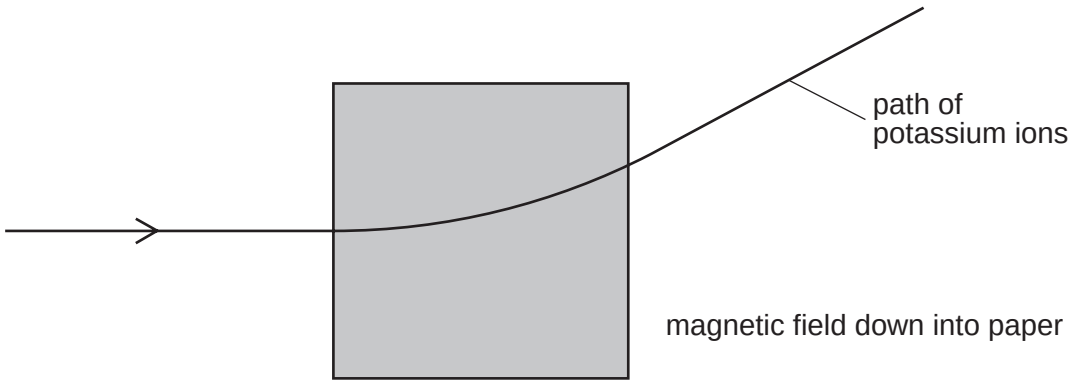

Fig. 3.1

Calculate the radius of the path of the ions in the magnetic field.

radius = ... m [4]

(d) In an actual experiment it is found that 93% of potassium ions follow the path calculated in **(c)**. The remaining 7% of ions follow a different path with a slightly larger radius. Suggest why this happens.

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..... [2]

[Total: 13]

4 This question is about waves.

(a) **(i)** State the frequency of a sound within the frequency range of a musical instrument.

frequency = ... Hz [1]

(ii) Choose the best estimate for the speed of sound in air from the following list. Put a ring around your chosen value.

$3 \times 10^{2}\,m\,s^{-1}$ $3 \times 10^{4}\,m\,s^{-1}$ $3 \times 10^{6}\,m\,s^{-1}$ $3 \times 10^{8}\,m\,s^{-1}$

[1]

(iii) Deduce the wavelength of the sound chosen in **(i)**.

wavelength = ... m [1]

(b) By describing the terms in bold, explain how **diffraction** is essential for observable double slit **interference** to occur. Diagrams may help your answer.

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..... [4]

[Total: 7]

5 **(a)** There are several physical processes in which a quantity decreases exponentially. Name **two** of these processes.

1. .....

2. ..... [2]

(b) The following three graphs, Figs. 5.1(a), (b) and (c), show different patterns of decay. One of them is an exponential decay.
Determine which of the three is the exponential, giving reasons for your choice. Explain also how you were able to reject the other two.

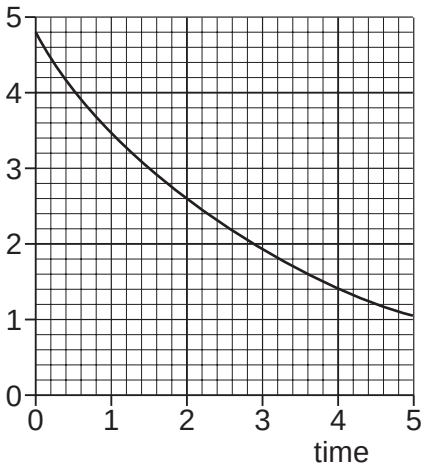

Fig. 5.1(a)

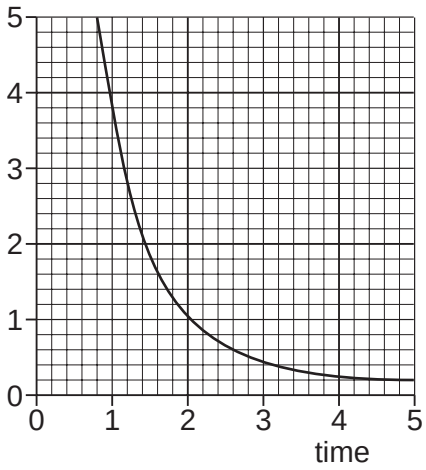

Fig. 5.1(b)

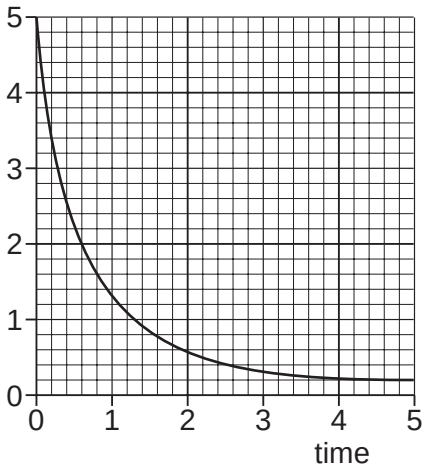

Fig. 5.1(c)

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..... [5]

(c) **(i)** Exponential growth is also possible. Suggest how you could check whether or not a graph showed exponential growth.

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..... [1]

(ii) Suggest an example of exponential growth, not necessarily from physics.

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..... [1]

[Total: 9]

END OF QUESTION PAPER

PLEASE DO NOT WRITE ON THIS PAGE