RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced GCE

PHYSICS A

2826/01

Unifying Concepts in Physics

Thursday **15 JUNE 2006** Morning 1 hour 15 minutes

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

Candidate Name	Centre Number	Candidate Number

TIME 1 hour 15 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 provided on the question paper.
- Read the questions 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 a scientific calculator.
- You are advised to show all the steps in any calculations.

FOR EXAMINER'S USE		
Qu.	**Max.**	**Mark**
1	10	
2	7	
3	14	
4	12	
5	17	
TOTAL	60	

This question paper consists of 12 printed pages.

SP (DR) S92575/4

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

For Examiner's Use

Answer **all** the questions.

1 Certain measurements are quite easy to take accurately if laboratory instruments are available. They can also be done accurately – to 2 or 3 significant figures – using simple apparatus such as a 3-metre tape measure, kitchen scales and a watch. Outline, using these items only, how you could determine the following.

(a) The thickness of a sheet of paper in a paperback book.

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....[2]

(b) The mass of a paperclip.

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....[1]

(c) **(i)** The diameter of a large cylindrical stone column in a cathedral.

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....[2]

(ii) Explain the problem in measuring the diameter directly by holding the tape measure stretched alongside of the column.

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....[1]

For Examiner's Use

(d) **(i)** The length of a pavement in a road outside a school.

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....[2]

(ii) The average speed of a car travelling along this road, whilst you are standing on the pavement.

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....[2]

[Total: 10]

2 For each of the following, give the full name of the SI unit used.

(a) electric charge ....

(b) capacitance ....

(c) frequency ....

(d) stress ....

(e) gravitational field strength ....

(f) magnetic flux ....

(g) radioactive activity ....[7]

[Total: 7]

For Examiner's Use

3 Data can be displayed in graphical form in many different ways. Sometimes it is necessary to change from one way of displaying data to another. Four graphs are drawn on page 7.

(a) (i) Calculate the total distance travelled from the velocity-time **graph A**.

distance = ... m [3]

(ii) Using **graph A**, draw the corresponding distance-time graph. [3]

(b) Graph B shows how the current I in a circuit varies with the total circuit resistance R when the e.m.f. of the supply is kept constant.

(i) Draw the corresponding graph of $1/I$ against R. [2]

(ii) What is the e.m.f. of the supply?

e.m.f. = ... V [1]

(iii) How is the gradient of the graph you have drawn related to your answer to **(b)(ii)**?

....

....[1]

(c) Graph C shows how g, the acceleration due to gravity, varies with r, the distance from the centre of the Earth. A log-log graph showing the same data has been drawn on new axes.

(i) Calculate the gradient of the log-log graph.

gradient = ...[2]

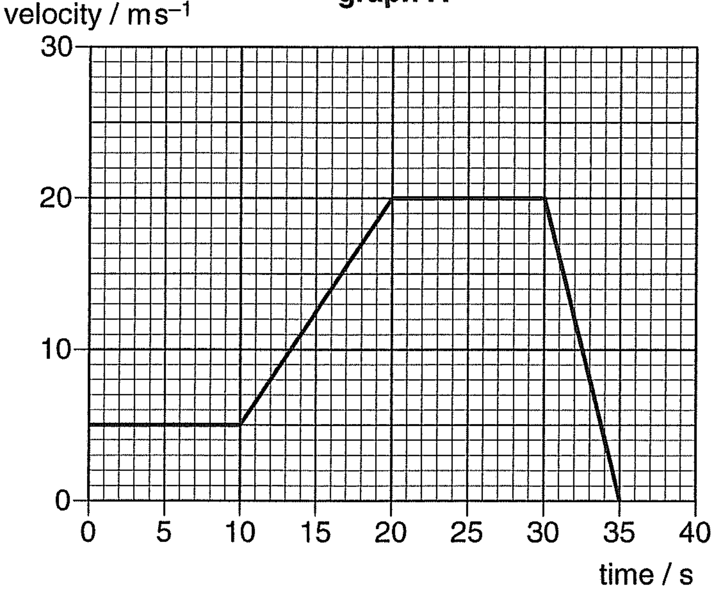
(ii) What can be deduced from the value of the gradient?

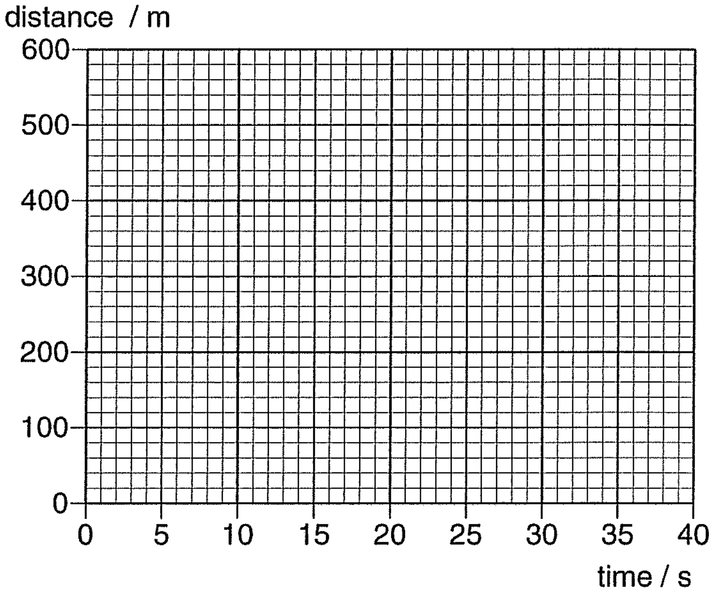
....

....[2]

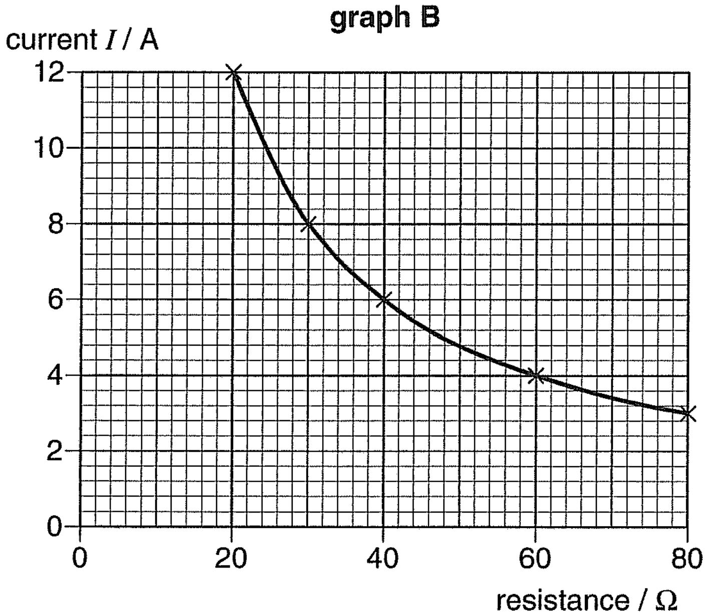
[Total: 14]

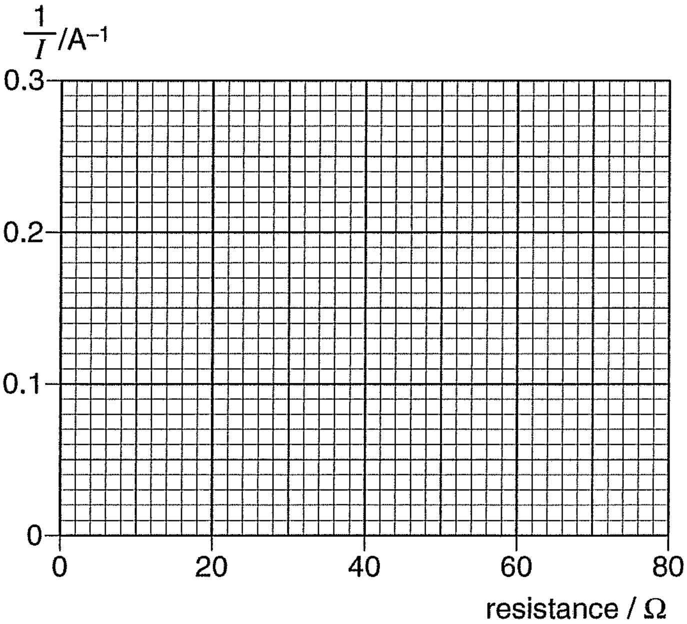
graph A



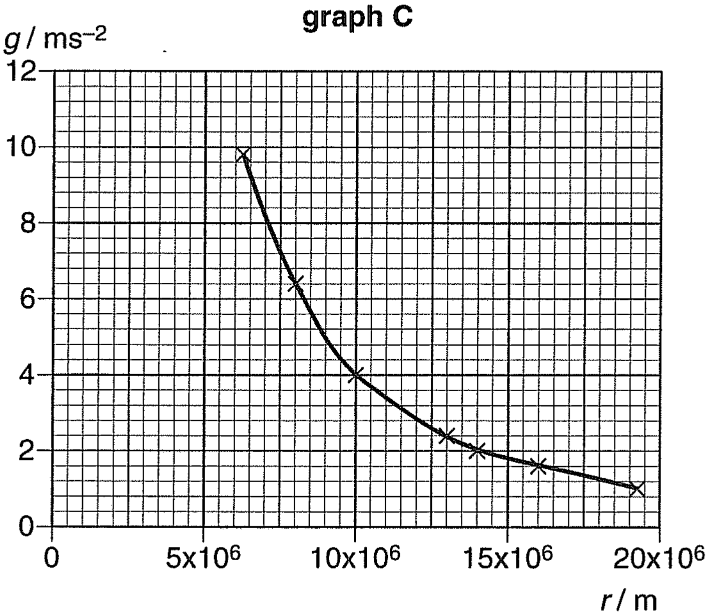


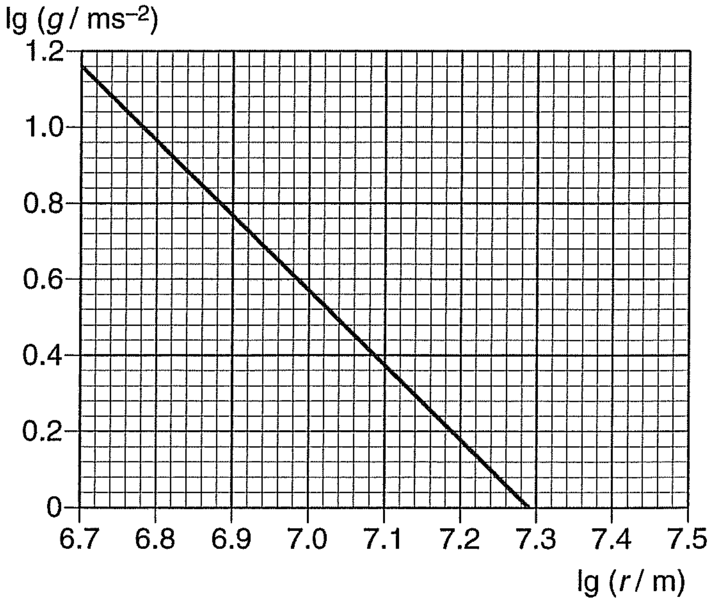
graph B





graph C





[Turn over

For Examiner's Use

4 (a) The three states of matter, solid, liquid and gas, are characterised by having different separations and patterns of movement of the molecules. Discuss the changes that take place to the following list of quantities when melting and boiling occur. Assume that no chemical changes occur.

- separation of molecules
- speed of molecules
- pattern of movement of molecules
- internal energy of molecules

In your answer, comment on similarities and differences between melting and boiling.

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For Examiner's Use

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(b) Suggest and explain **two** differences which might exist between hydrogen gas at 200 K and hydrogen at 200 000 000 K.

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....[3]

[Total: 12]

For Examiner's Use

5 Read the following paragraph and answer the questions about it which follow.

The kilogram is the last remaining standard in the SI system which is based on a physical object. The standard kilogram is a cylinder of platinum and iridium kept in a dry vault, at constant pressure and temperature, on the outskirts of Paris.
One way of re-defining the kilogram, so that it is not possible for it to change with time or circumstances, would be to count the number of atoms in a silicon sphere which has a measured mass of one kilogram and hence to find the mass of a silicon atom. This can then be used as a standard available anywhere in the world. To do this for the kilogram actually turns out to be very difficult.
At present, masses can be compared with very high precision – better than 1 μg in 1 kg. Plans are in hand to measure the mass of a silicon atom to an uncertainty of no more than 2 parts in 10^8. To do this, the following quantities need to be known to at least this degree of uncertainty or better.

- the diameter of the 1 kg silicon sphere
- the separation of atoms in silicon
- the regularity of the arrangement atoms in the sphere
- the proportion of each isotope of silicon in the sphere

(Adapted from an article by Ian Robinson in Physics World, May 2004.)

(a) State **two** circumstances which could very slightly change the mass of the standard kilogram when it is being used for a mass determination.

1. ....

2. ....[2]

(b) What percentage uncertainty is there in a mass measurement accurate to 1 μg in 1 kg?

percentage uncertainty = ...% [2]

(c) Silicon is used in the suggested re-definition because the technology is available to produce large, very pure single crystals of silicon from which the sphere of mass one kilogram and diameter 94.0 mm can be made.

(i) Calculate the density of silicon.

density of silicon = ...kg m^{-3} [4]

For Examiner's Use

(ii) Calculate the uncertainty in measuring the diameter of the silicon sphere if the uncertainty in the volume is to be only 2 parts in 10^8.

uncertainty = ...[2]

(d) The spacing of atoms in silicon can be measured very accurately using X-ray diffraction. Knowing this spacing, the number of silicon atoms in the sphere can be calculated accurately providing the silicon is pure and the crystal structure is regular. Suggest and explain a problem with obtaining high accuracy if **one** of these conditions is not met.

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....[2]

(e) Silicon has 3 stable isotopes.

(i) What is meant by the term *isotope*?

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....[1]

(ii) Why is it important to know accurately the relative proportions of these isotopes in the silicon sphere?

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....[2]

(iii) It would be preferable to have the sphere made entirely of one isotope. Suggest why this is difficult to achieve.

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....[2]

[Total: 17]

END OF QUESTION PAPER