Cambridge Pre-U

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NAME

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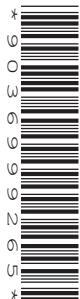
PHYSICS **9792/02**

Paper 2 Part A Written Paper **October/November 2013**

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use a pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Section A
Answer **all** questions.
You are advised to spend about 1 hour 30 minutes on this section.

Section B
Answer the **one** question.
You are advised to spend about 30 minutes on this section.
The question is based on the material in the Insert.

Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	
2	
3	
4	
5	
6	
7	
8	
9	
Total	

This document consists of **21** printed pages, **3** blank pages and **1** insert.

UNIVERSITY *of* CAMBRIDGE
International Examinations

[Turn over

Data

gravitational field strength close to Earth's surface	$g = 9.81\,\text{N}\,\text{kg}^{-1}$
elementary charge	$e = 1.60 \times 10^{-19}\,\text{C}$
speed of light in vacuum	$c = 3.00 \times 10^{8}\,\text{m}\,\text{s}^{-1}$
Planck constant	$h = 6.63 \times 10^{-34}\,\text{J}\,\text{s}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\text{F}\,\text{m}^{-1}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\text{N}\,\text{m}^2\,\text{kg}^{-2}$
electron mass	$m_\text{e} = 9.11 \times 10^{-31}\,\text{kg}$
proton mass	$m_\text{p} = 1.67 \times 10^{-27}\,\text{kg}$
unified atomic mass constant	$u = 1.66 \times 10^{-27}\,\text{kg}$
molar gas constant	$R = 8.31\,\text{J}\,\text{K}^{-1}\,\text{mol}^{-1}$
Avogadro constant	$N_\text{A} = 6.02 \times 10^{23}\,\text{mol}^{-1}$
Boltzmann constant	$k = 1.38 \times 10^{-23}\,\text{J}\,\text{K}^{-1}$
Stefan-Boltzmann constant	$\sigma = 5.67 \times 10^{-8}\,\text{W}\,\text{m}^{-2}\,\text{K}^{-4}$

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$	change of state	$\Delta E = mL$
	$v^2 = u^2 + 2as$	refraction	$n = \dfrac{\sin\theta_1}{\sin\theta_2}$
	$s = \left(\dfrac{u+v}{2}\right)t$		$n = \dfrac{v_1}{v_2}$
heating	$\Delta E = mc\Delta\theta$		

diffraction

single slit, minima $\qquad n\lambda = b \sin\theta$

grating, maxima $\qquad n\lambda = d \sin\theta$

double slit interference $\qquad \lambda = \dfrac{ax}{D}$

Rayleigh criterion $\qquad \theta \approx \dfrac{\lambda}{b}$

photon energy $\qquad E = hf$

de Broglie wavelength $\qquad \lambda = \dfrac{h}{p}$

simple harmonic motion $\qquad x = A \cos\omega t$

$\qquad v = -A\omega \sin\omega t$

$\qquad a = -A\omega^2 \cos\omega t$

$\qquad F = -m\omega^2 x$

$\qquad E = \dfrac{1}{2}mA^2\omega^2$

energy stored in a capacitor $\qquad W = \dfrac{1}{2}QV$

electric force $\qquad F = \dfrac{Q_1 Q_2}{4\pi\varepsilon_0 r^2}$

electrostatic potential energy $\qquad W = \dfrac{Q_1 Q_2}{4\pi\varepsilon_0 r}$

gravitational force $\qquad F = -\dfrac{Gm_1 m_2}{r^2}$

gravitational potential energy $\qquad E = -\dfrac{Gm_1 m_2}{r}$

magnetic force $\qquad F = BIl \sin\theta$

$\qquad F = BQv \sin\theta$

electromagnetic induction $\qquad E = -\dfrac{d(N\Phi)}{dt}$

Hall effect $\qquad V = Bvd$

time dilation $\qquad t' = \dfrac{t}{\sqrt{1 - \dfrac{v^2}{c^2}}}$

kinetic theory $\qquad \dfrac{1}{2}m\langle c^2 \rangle = \dfrac{3}{2}kT$

work done on/by a gas $\qquad W = p\Delta V$

radioactive decay $\qquad \dfrac{dN}{dt} = -\lambda N$

$\qquad N = N_0 e^{-\lambda t}$

$\qquad t_{\frac{1}{2}} = \dfrac{\ln 2}{\lambda}$

attenuation losses $\qquad I = I_0 e^{-\mu x}$

mass-energy equivalence $\qquad \Delta E = c^2 \Delta m$

hydrogen energy levels $\qquad E_n = \dfrac{-13.6\,\text{eV}}{n^2}$

Heisenberg uncertainty principle $\qquad \Delta p \Delta x \geqslant \dfrac{h}{2\pi}$

$\qquad \Delta E \Delta t \geqslant \dfrac{h}{2\pi}$

Wien's displacement law $\qquad \lambda_{\text{max}} \propto \dfrac{1}{T}$

Stefan's law $\qquad L = 4\pi\sigma r^2 T^4$

electromagnetic radiation from a moving source $\qquad \dfrac{\Delta\lambda}{\lambda} \approx \dfrac{\Delta f}{f} \approx \dfrac{v}{c}$

Section A

You are advised to spend 1 hour 30 minutes answering the questions in this section.

1 Fig. 1.1 shows a kite flying in a steady wind.
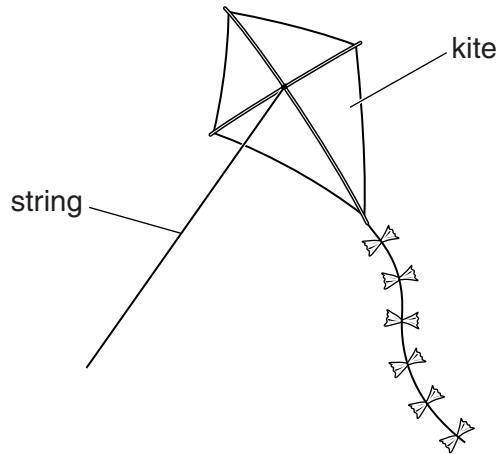
Fig. 1.1

Figs. 1.2 and 1.3 are side views of the same kite.

(a) In Fig. 1.2, the kite is flying with the string attached. The kite is in equilibrium.
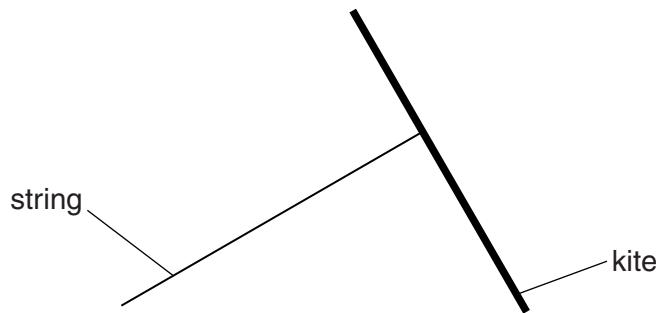
Fig. 1.2

By drawing labelled force vectors on Fig. 1.2, show the approximate direction of the force of the wind on the kite. [3]

(b) In Fig. 1.3, the string has become detached.
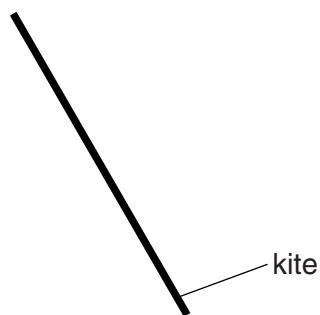
— kite

Fig. 1.3

Explain why, without the pull of the string, the kite in Fig. 1.3 cannot be in equilibrium. Use Fig. 1.3 to illustrate your answer.

....

....

....[2]

[Total: 5]

2 A solid vertical cylinder has an area of cross-section 0.45 m² and is submerged in water of density 1000 kg m⁻³. The top of the cylinder is 1.4 m from the surface of the water and the bottom of the cylinder is 3.2 m from the surface of the water, as shown in Fig. 2.1.

surface

1.4 m

water

3.2 m

1.8 m
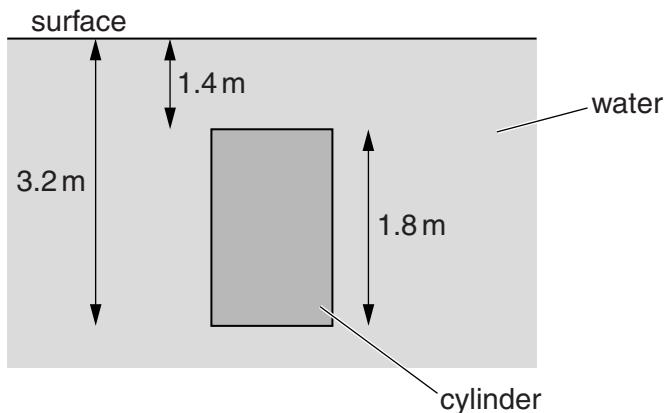
cylinder

Fig. 2.1

(a) (i) Calculate the pressure due to the water on the top surface of the cylinder. Give the name of the SI unit of pressure.

pressure = ... unit ....[2]

(ii) Calculate the pressure due to the water on the bottom surface of the cylinder.

pressure = ...[1]

(b) Calculate the magnitude of the resultant force on the cylinder due to the water pressure.

resultant force = ... N [2]

(c) The cylinder is made from a material that has a density of 2400 kg m^{-3}. It is held in a fixed position by a vertical rod, with the top of the cylinder 1.4 m from the surface as shown in Fig. 2.2.
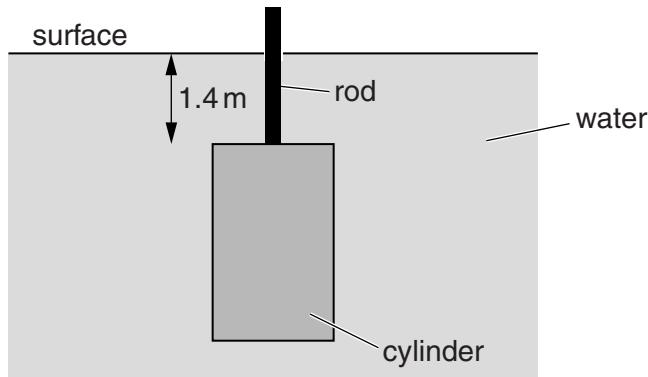
Fig. 2.2

Calculate the force exerted on the cylinder by the rod.

force = ... N [3]

[Total: 8]

[Turn over

3 **(a)** State what is meant by the following terms. In each case name a material that can exhibit such behaviour.

    (i) *brittle*

    ....

    ....

    .... is a *brittle* material. [2]

    (ii) *tough*

    ....

    ....

    .... is a *tough* material. [2]

    (iii) *ductile*

    ....

    ....

    .... is a *ductile* material. [2]

(b) A sample of a metal has an area of cross-section of $4.2 \times 10^{-7}\,\text{m}^2$.

Fig. 3.1 shows a graph of the stress against the strain for this sample when tested to failure.
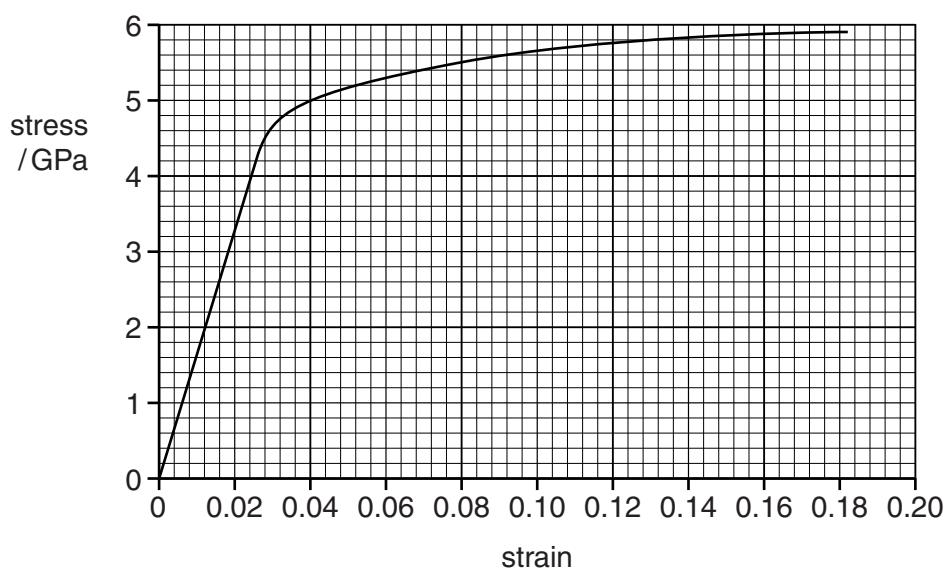
Fig. 3.1

By taking readings from the graph, determine

  (i) the Young modulus of the metal,

Young modulus = ... Pa [3]

  (ii) the breaking stress for the metal.

breaking stress = ... Pa [1]

(c) Calculate the breaking force for the metal sample.

breaking force = ... N [1]

(d) Explain why the metal sample will actually break with a different force than that calculated in **(c)**.

....

....

....[2]

[Total: 13]

4 The average amount of energy supplied by the Sun each day to a horizontal square metre of the United Kingdom varies throughout the year as shown in Fig. 4.1.
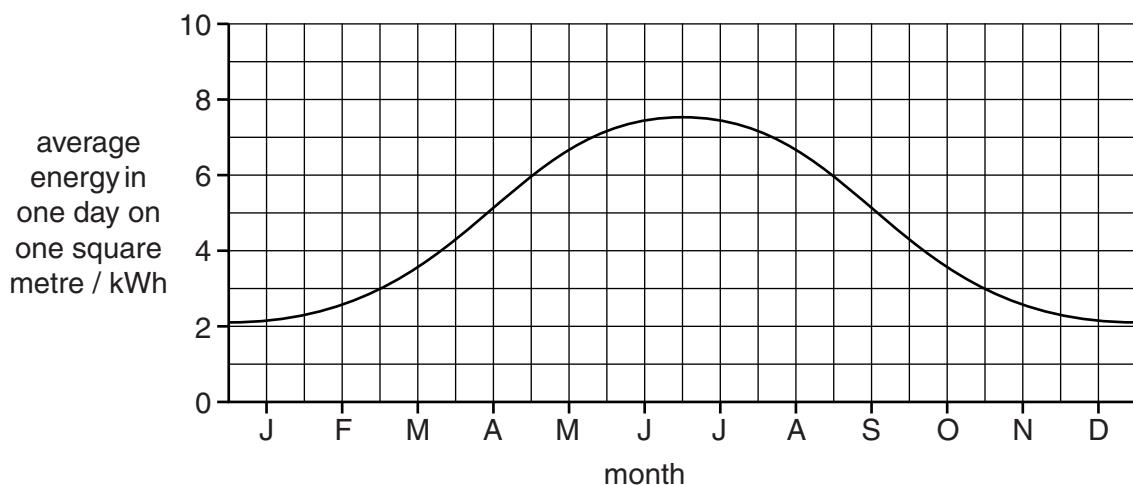
Fig. 4.1

(a) At a coastal resort the sea temperature throughout the year was averaged over a period of 40 years. This showed an average temperature minimum of 7.5 °C and an average temperature maximum of 20.5 °C.

On Fig. 4.2, sketch the likely shape of this graph. Give a reason why the position of the maximum and minimum of the graph you draw do not correspond to the maximum and minimum of Fig. 4.1.
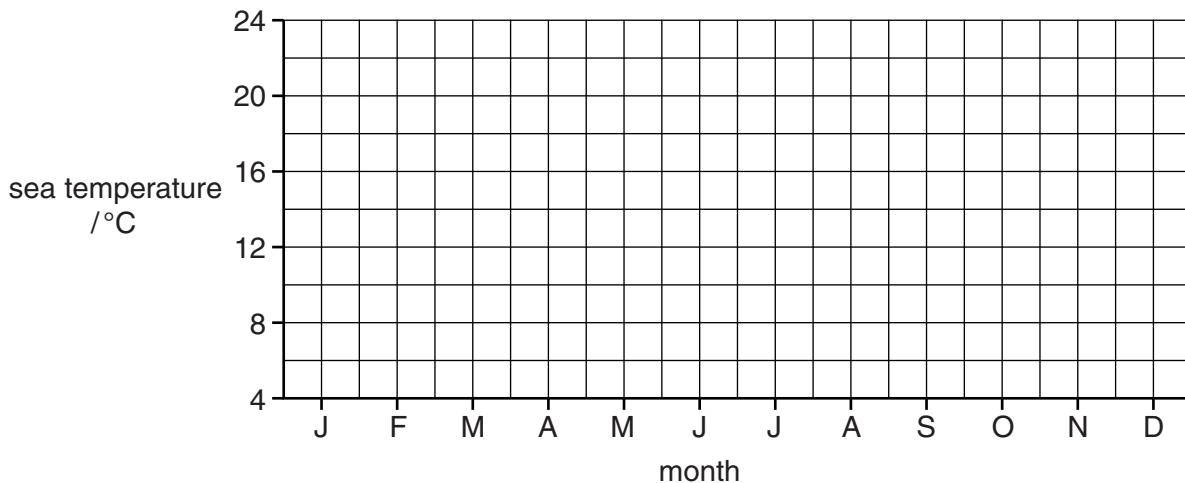
Fig. 4.2

....

....

....

....[3]

(b) Assume that 60% of the energy from the Sun is used to heat the top metre of the sea water at the coastal resort.

  (i) Use information from Fig. 4.1 to estimate the temperature rise this would cause in the top metre of sea water for a day in August.

  Density of sea water = 1.0×10^3 kg m^{-3}.
  Specific heat capacity of sea water = 4.2×10^3 J kg^{-1} °C^{-1}.

  temperature rise = ... °C [3]

  (ii) Explain why the temperature rise over the 31 days of August will not be 31 times your answer to **(b)(i)**.

  ....

  ....

  ....

  ....

  ....

  ....[3]

[Total: 9]

 [Turn over

5 (a) Define *electromotive force (e.m.f.)* and distinguish between *e.m.f.* and *terminal potential difference (p.d.)*.

....

....

....

....

....[3]

   (b) A battery of e.m.f. 20 V and negligible internal resistance supplies a current of 8.0 mA to the circuit shown in Fig. 5.1.
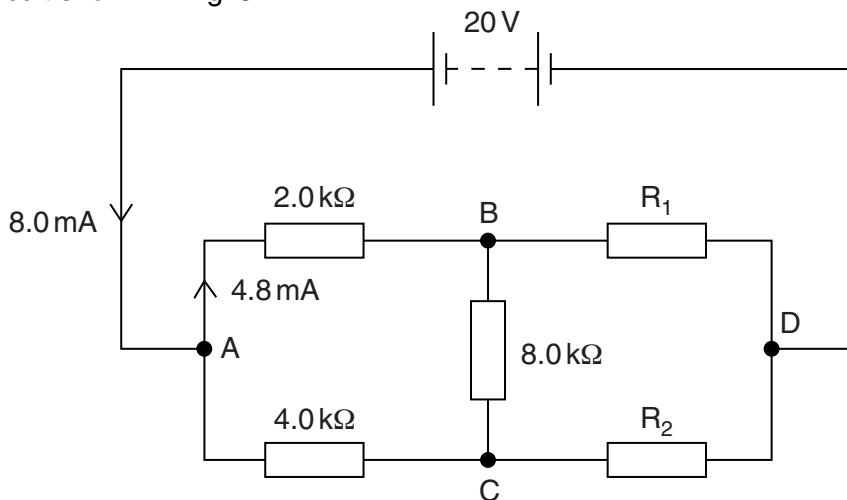
Fig. 5.1

At point A, the current divides and there is a current of 4.8 mA in the 2.0 kΩ resistor.

Determine the following values.

   (i)   p.d. between A and B   p.d. = ... V   [1]

   (ii) current from A to C in 4.0 kΩ resistor   current = ... mA   [1]

   (iii) p.d. between A and C   p.d. = ... V

   (iv) p.d. between B and C   p.d. = ... V   [1]

   (v)   current from B to C in 8.0 kΩ resistor   current = ... mA   [1]

   (vi) current from B to D in R₁   current = ... mA

   (vii) current from C to D in R₂   current = ... mA

   (viii) p.d. between C and D   p.d. = ... V   [1]

   (ix) resistance of R₂   resistance = ... kΩ   [1]

   (x)   current from D to battery   current = ... mA   [1]

(c) Explain why the equations

$$R = R_1 + R_2 \qquad \text{and} \qquad \frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$$

cannot be used to determine the total resistance of this circuit.

....

....

....[2]

(d) Use relevant values from **(b)** to determine the total resistance of the whole circuit. Give your answer in ohms.

resistance = ... Ω [2]

[Total: 14]

 [Turn over

6 **(a)** A sound wave has a frequency of 12 000 Hz and a speed of 340 m s^{-1}.

Calculate its wavelength.

wavelength = ... m [1]

(b) The wave in **(a)** is reflected back along its initial path and a standing wave is set up.

(i) In the space below, sketch a diagram to illustrate the displacement of the particles in a standing wave with three antinodes.

[2]

(ii) On your sketch, mark the wavelength of the sound wave. [1]

(c) The maximum variation in pressure along the length of a stationary sound wave takes place at the nodes on a displacement diagram.

By describing the movement of molecules near a node, explain why this is so.

....

....

....[2]

(d) When an earthquake occurs near the Earth's surface, both longitudinal and transverse pressure waves are created. The longitudinal waves, called P-waves, travel through the Earth with an average speed of 4.3 km s^{-1}. The transverse waves, called S-waves, travel through the Earth more slowly with an average speed of 2.7 km s^{-1}. Fig. 6.1 shows a path of waves through the Earth.
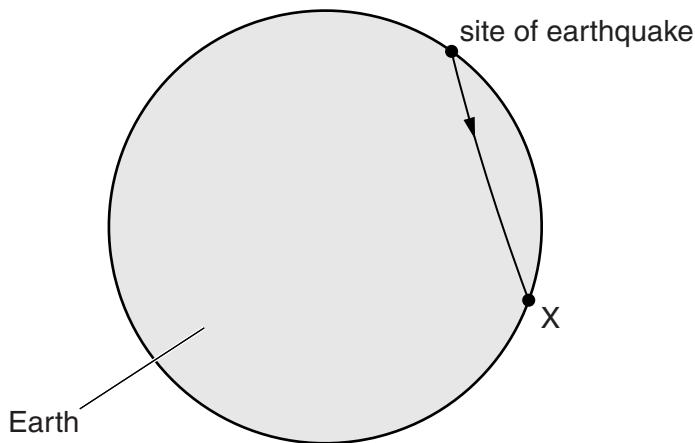
Fig. 6.1 (not to scale)

Both P-waves and the S-waves travel to point X.

Calculate the time interval between the initial arrival of the P-waves and the initial arrival of the S-waves at X, a distance of 3300 km from the site of the earthquake.

time interval = ... s [2]

[Total: 8]

7 (a) Complete the following table comparing the properties of alpha, beta and gamma radiations.

	α-radiation	β-radiation	γ-radiation
nature		particle	
charge	+2*e*		
mass		5.44×10^{-4} u	
penetration power	stopped by a piece of paper		
ionising ability			small

[8]

(b) State **two** sources of background radiation and suggest ways in which their effects may be reduced.

source ....

how its effect may be reduced ....

....

source ....

how its effect may be reduced ....

....

[4]

(c) A scientist is measuring background radiation.

Suggest how his results may indicate that radioactive decay is

(i) *random*, ...

....[1]

(ii) *spontaneous.* ....

....[1]

[Total: 14]

8 Fig. 8.1 shows the apparatus used to demonstrate the diffraction of electrons. Electrons are accelerated towards a graphite target.
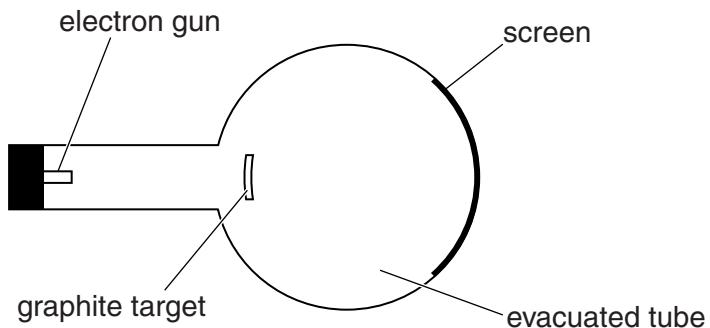
electron gun

screen

graphite target

evacuated tube

Fig. 8.1

(a) Calculate the wavelength associated with an electron travelling with a speed of $3.0 \times 10^7\,\text{m s}^{-1}$.

wavelength = ... m [2]

(b) Use a diagram to describe what would be seen on the screen.

[2]

[Total: 4]

Section B

You are advised to spend about 30 minutes answering this section.
Your answers should, where possible, make use of any relevant Physics.

9 **(a)** Fig. E4.1 in Extract 4 of the insert gives typical characteristics for LEDs manufactured from different materials. It shows the wavelengths emitted and the perceived colour of the LEDs.

Consider the **lowest frequency** light emitted by a silicon carbide (SiC) LED of perceived colour blue.

For this light, determine

(i) the frequency,

frequency = ...Hz [3]

(ii) the energy, in joules, of a photon,

energy = ... J [2]

(iii) the energy, in electron-volts, of a photon.

energy = ...eV [2]

(b) The minimum voltage that must be connected across an LED to make it emit light is called the forward operating voltage V_F.

Fig. E4.1 shows that LEDs of different compositions have different values of V_F.

Explain

  (i) why no light is emitted by an LED when the voltage supplied is less than its value of V_F,

  ....

  ....[1]

  (ii) why the value of V_F for an LED that emits blue light is greater than that for a LED that emits red light.

  ....

  ....[1]

(c) The light produced by a SiC LED is produced in the silicon layer. In Extract 5 of the insert it is stated that the refractive index of silicon is 4.24 and that of air is 1.00.

  (i) Calculate

  1. the speed of light in silicon,

  speed = ...$m\,s^{-1}$ [2]

  2. the critical angle for light passing from silicon into air.

  critical angle = ...° [2]

  (ii) Explain why encapsulating a semiconductor chip in a suitable material increases the efficiency of the LED.

  ....

  ....

  ....

  ....
  [2]

(d) Fig. 9.1 is the current-voltage characteristic for a white-light LED with a forward operating voltage of 4.10V.
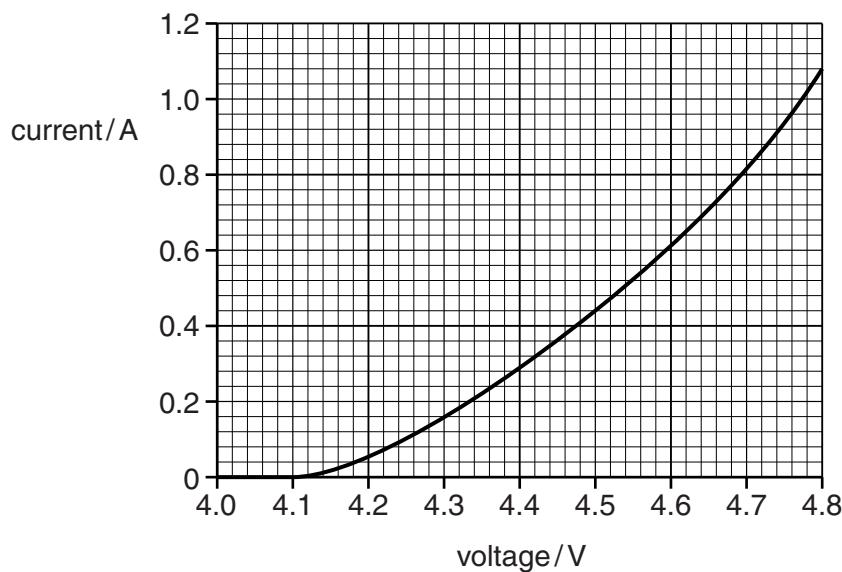
Fig. 9.1

The LED is used as the only source of light in a torch. It is connected in series with a 4.50V battery of negligible internal resistance.

(i) Determine the electrical power supplied to the LED in the torch.

power = ...W [2]

(ii) In Extract 6 of the insert, the terms *luminous flux* and *luminous efficacy* are explained. The luminous flux produced by the torch is 33.5 lumens.

Calculate the luminous efficacy of the LED in lumens per watt.

luminous efficacy = ... lmW^{-1} [1]

(e) In recent years, LEDs have become an increasingly common source of light and infra-red radiation in many areas.

Give examples of where LEDs are currently used and suggest where they might be used in the future. Explain the advantages of using LEDs in these cases.

Your answer should include some domestic, industrial or technological uses.

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....[7]

[Total: 25]

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