Cambridge Pre-U

Cambridge International Examinations
Cambridge Pre-U Certificate

CANDIDATE NAME	

CENTRE NUMBER						CANDIDATE NUMBER					

5148653846

PHYSICS (PRINCIPAL) **9792/02**

Paper 2 Written Paper **May/June 2017**

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 an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

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

Section 2
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	
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5	
6	
7	
8	
9	
Total	

The syllabus is approved for use in England, Wales and Northern Ireland as a Cambridge International Level 3 Pre-U Certificate.

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

DC (RW/SG) 128732/4

CAMBRIDGE International Examinations

Data

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

Formulae

uniformly accelerated motion

$$s = ut + \tfrac{1}{2}at^2$$

$$v^2 = u^2 + 2as$$

$$s = \left(\frac{u+v}{2}\right)t$$

heating

$$\Delta E = mc\Delta\theta$$

change of state

$$\Delta E = mL$$

refraction

$$n = \frac{\sin\theta_1}{\sin\theta_2}$$

$$n = \frac{v_1}{v_2}$$

diffraction

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

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

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

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

photon energy $E = hf$

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

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

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

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

$F = -m\omega^2 x$

$E = \frac{1}{2}mA^2\omega^2$

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

capacitor discharge $Q = Q_0 e^{-\frac{t}{RC}}$

electric force $F = \dfrac{Q_1Q_2}{4\pi\varepsilon_0 r^2}$

electrostatic potential energy $W = \dfrac{Q_1Q_2}{4\pi\varepsilon_0 r}$

gravitational force $F = -\dfrac{Gm_1m_2}{r^2}$

gravitational potential energy $E = -\dfrac{Gm_1m_2}{r}$

magnetic force $F = BIl\sin\theta$

$F = BQv\sin\theta$

electromagnetic induction $E = -\dfrac{\mathrm{d}(N\Phi)}{\mathrm{d}t}$

Hall effect $V = Bvd$

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

length contraction $l' = l\sqrt{1-\dfrac{v^2}{c^2}}$

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

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

radioactive decay $\dfrac{\mathrm{d}N}{\mathrm{d}t} = -\lambda N$

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

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

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

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

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

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

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

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

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

Section 1

You are advised to spend about 1 hour 30 minutes on this section.

1 **(a)** Define *gravitational field strength*.

....

....[1]

(b) Fig. 1.1 represents a region of space near the surface of the Earth.

Fig. 1.1

(i) On Fig. 1.1, draw **five solid** lines, with arrows, to represent the gravitational field in this region. [2]

(ii) Add to Fig. 1.1, a dashed line that joins points of equal gravitational potential. [1]

(c) A point P is 15.5 m above the surface of the Earth.

(i) Calculate the gravitational potential difference between P and the surface of the Earth.

gravitational potential difference = ... $J\,kg^{-1}$ [1]

(ii) An object at rest at P is dropped and falls freely until it strikes the surface of the Earth.

Calculate the maximum possible speed of the object as it strikes the Earth.

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

[Total: 7]

2 When subjected to forces, objects can undergo deformation.

(a) **(i)** State how *elastic* deformation differs from *plastic* deformation.

....

....

....[1]

(ii) State the name of a material that, when under increasing stress, shows

1. very little plastic deformation,

....[1]

2. both elastic and plastic deformation,

....[1]

3. plastic deformation, but very little elastic deformation.

....[1]

(b) A wire of length 7.65 m and cross-sectional area $3.51 \times 10^{-2}\,\text{cm}^2$ is made from a material of Young modulus $1.86 \times 10^{11}\,\text{Pa}$.

One end of the wire is fixed to a ceiling. A load of mass 12.8 kg is attached to the lower end of the wire.

Calculate

(i) the extension of the wire,

extension = ... m [3]

(ii) the energy stored in the stretched wire.

energy = ... J [2]

[Total: 9]

3 **(a)** Define

(i) *momentum*,

....[1]

(ii) *impulse*.

....[1]

(b) An aeroplane is at rest on a runway. It accelerates in a straight line along the runway and after 55.0 s it takes off.

While the aeroplane is in contact with the runway, the resultant force on it varies. Fig. 3.1 is a sketch graph that shows how the resultant force varies with time.

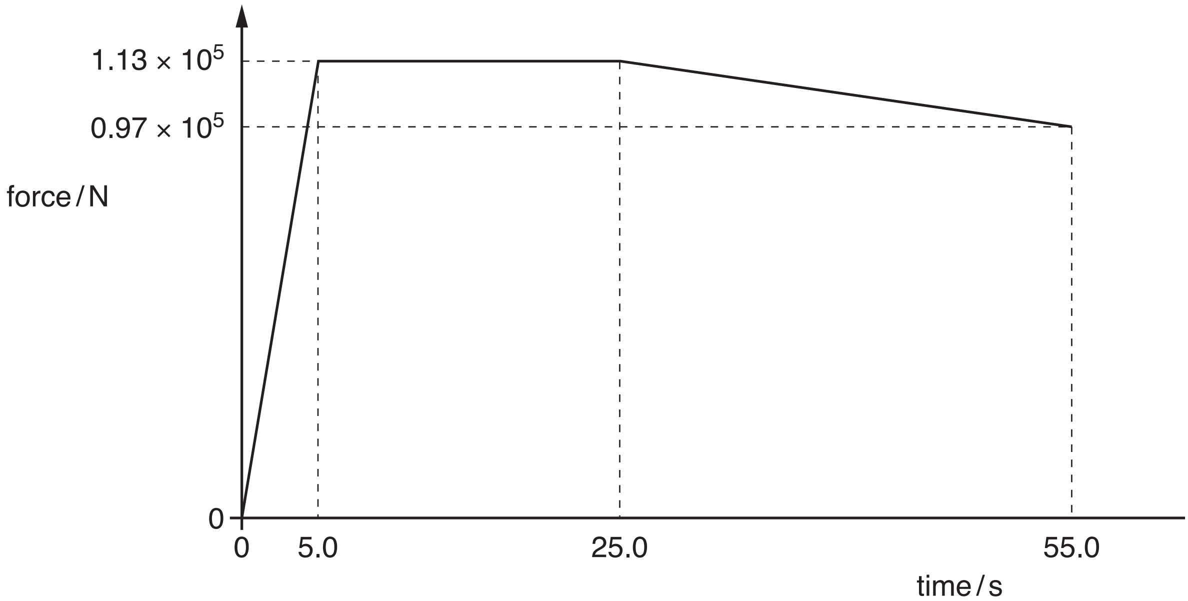

Fig. 3.1

(i) State **two** reasons why the acceleration of the aeroplane is not constant as it travels along the runway.

1. ....

....

2. ....

....
[2]

(ii) Calculate the momentum of the aeroplane at take-off.

momentum = ... N s [4]

(iii) The total mass of the aeroplane is 7.31×10^4 kg.

Calculate the velocity v_{max} of the aeroplane at take-off.

v_{max} = ... m s^{-1} [1]

(iv) On Fig. 3.2, sketch the shape of the velocity-time graph for the aeroplane as it travels along the runway.

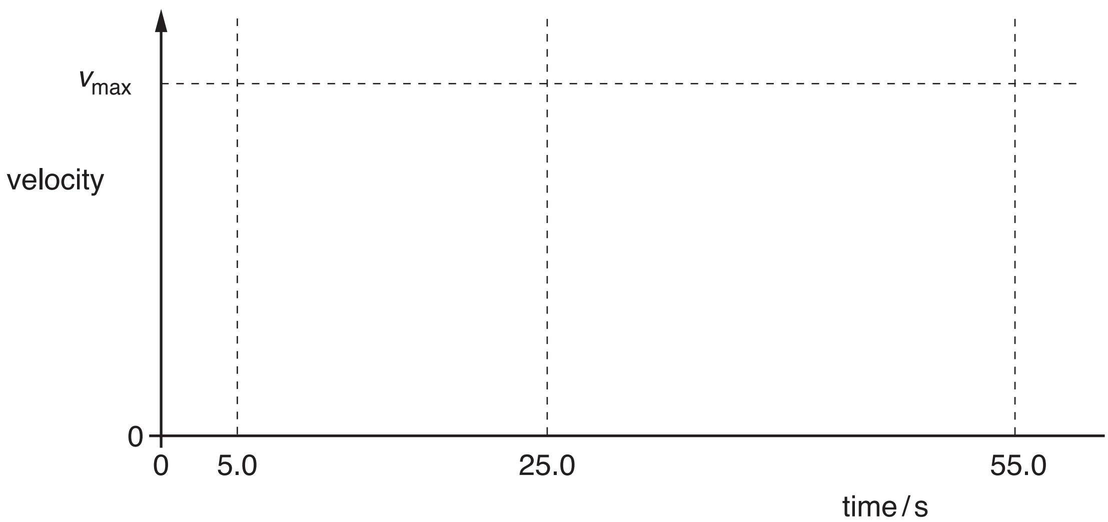

Fig. 3.2 [3]

(v) Estimate the distance the aeroplane travels along the runway.

distance = ... m [2]

[Total: 14]

4 **(a)** **(i)** State Kirchhoff's first law.

....

....[1]

(ii) Fig. 4.1 shows the part of a circuit that includes five resistors.

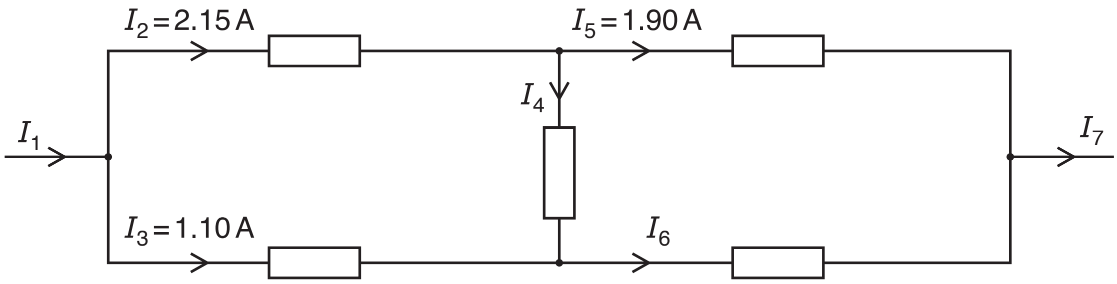

Fig. 4.1

The currents in the different branches of the circuit and their directions are shown in Fig. 4.1. The values of the currents I_2, I_3 and I_5 are shown.

Deduce the values of I_1, I_4, I_6 and I_7 and complete the table. [2]

current / A	I_1	I_2	I_3	I_4	I_5	I_6	I_7
		2.15	1.10		1.90		

(b) **(i)** State Kirchhoff's second law.

....

....[1]

(ii) Fig. 4.2 shows a circuit that includes a 12.0 V battery of negligible internal resistance and five resistors.

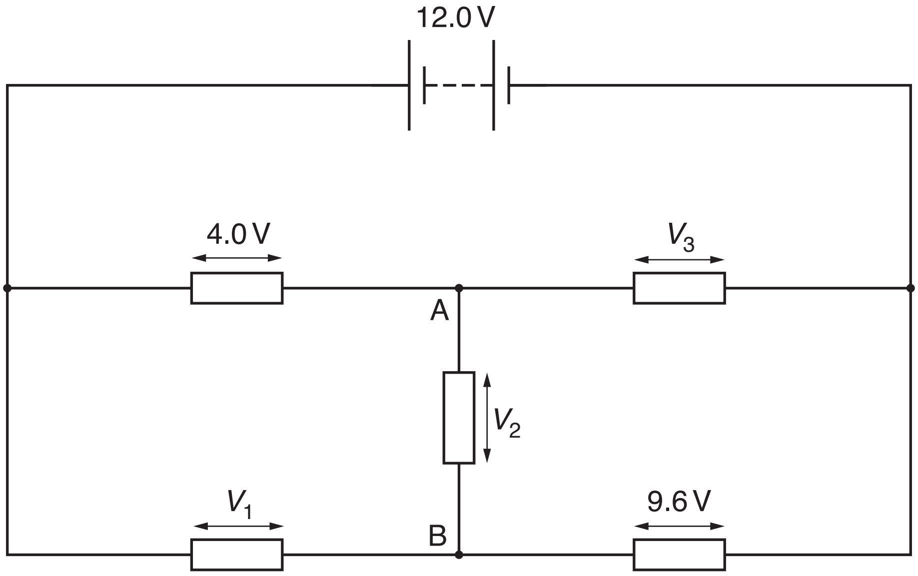

Fig. 4.2

The potential differences across the five different resistors are shown in Fig. 4.2.

Deduce the potential differences V_1, V_2 and V_3.

V_1 = ... V

V_2 = ... V

V_3 = ... V
[2]

(iii) State the direction of the current in the resistor between points A and B and explain why it is in this direction.

....

....[2]

(c) Kirchhoff's first law and Kirchhoff's second law are each related to a different principle of conservation.

State what is conserved in each law.

first law ....

second law ....
[2]

[Total: 10]

5 Fig. 5.1 shows a ray of monochromatic light entering a rectangular block of glass at an angle of incidence of 60.0°.

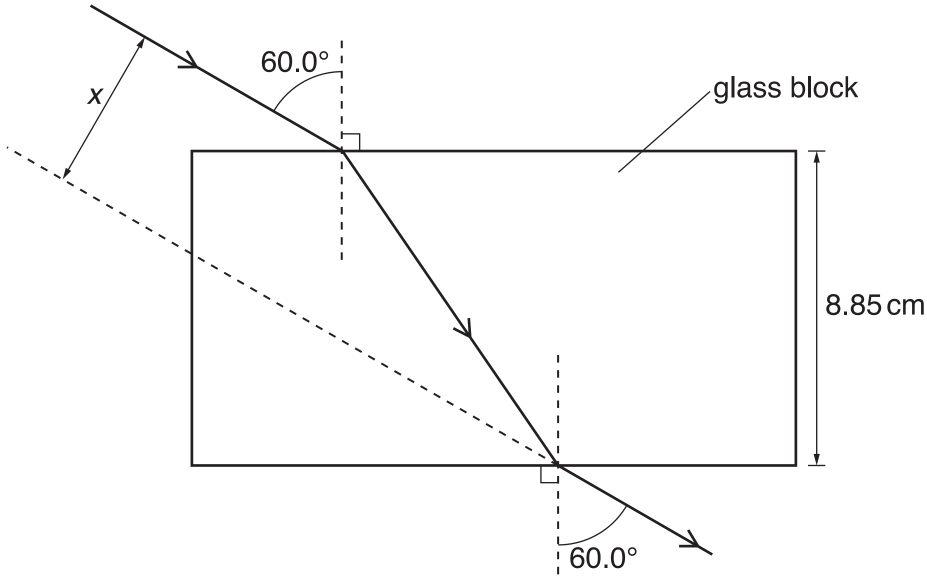

Fig. 5.1 (not to scale)

The glass block is 8.85 cm wide. The refractive index of the glass is 1.54 for light of this frequency.

(a) The ray of light that emerges from the block is parallel to the ray of light that enters the block. The ray is displaced sideways by a distance *x*.

Calculate the distance *x*.

x = ... cm [4]

(b) The dashed line in Fig. 5.2 represents the path taken by the ray of light in **(a)**.

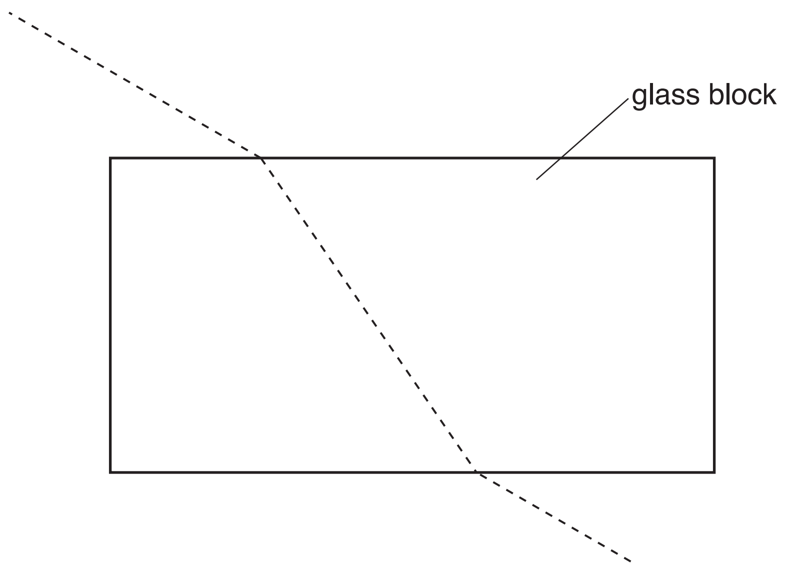

Fig. 5.2 (not to scale)

Monochromatic light of a different frequency enters the block along the same path. This light travels in glass at a slower speed than the light shown in Fig. 5.1.

On Fig. 5.2, draw the path taken by this light as it travels through the block and after it leaves the block. Use a ruler. [2]

[Total: 6]

6 Draw sketch diagrams to illustrate

(a) a standing (stationary) wave on a string at different times in its cycle,

[2]

(b) a wave that is $\frac{\pi}{2}$ radians out of phase with the wave shown in Fig. 6.1,

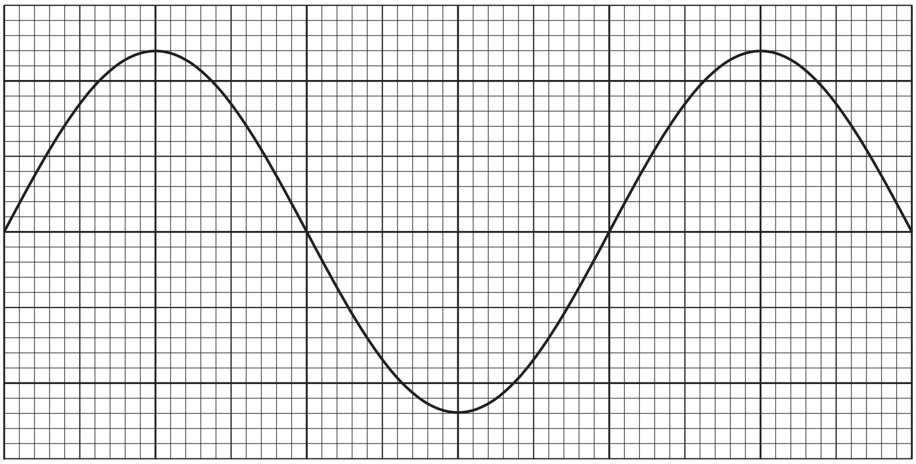

Fig. 6.1 [2]

(c) the diffraction of a plane wave passing through a gap that is smaller than the wavelength of the wave.

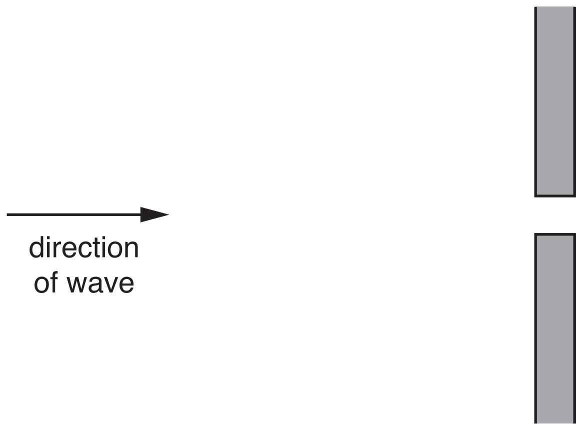

Fig. 6.2 [3]

[Total: 7]

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7 A neutron collides with a nucleus of uranium-235 in the nuclear reactor in a power station. The uranium nucleus undergoes fission.

(a) The fission of the uranium nucleus forms a nucleus of xenon-143 (Xe) and a nucleus of strontium-90.

The proton number of uranium (U) is 92 and the proton number of strontium (Sr) is 38.

Using nuclide notation, write the nuclear equation for this reaction.

[3]

(b) The initial collision starts a chain reaction in the reactor.

(i) Explain how the fission of uranium-235 makes it possible for a chain reaction to occur.

....

....

....[2]

(ii) Suggest why a control mechanism is needed in the reactor.

....

....[1]

(c) In the nuclear reactor, the fission of one uranium nucleus releases, on average, 215 MeV of energy.

The specific heat capacity of water is $4190\,\mathrm{J\,kg^{-1}\,K^{-1}}$.

Calculate the number of uranium nuclei that must undergo fission in order to supply the energy needed to increase the temperature of 25.6 kg of water by 42.0 K.

number of nuclei = ...[4]

(d) The activity of strontium-90 in a quantity of nuclear waste from the power station is currently 4.93×10^8 Bq.

The half-life of the isotope strontium-90 is 28.8 years.

Predict what the activity due to the strontium-90 will be in 720 years' time.

activity = ... Bq [3]

[Total: 13]

8 **(a)** **(i)** Describe **two** observed features of the photoelectric effect that cannot be explained using classical wave theory.

1. ....

....

2. ....

.... [2]

(ii) Explain how quantum theory accounts for the observed features given in **(a)(i)**.

1. ....

....

2. ....

.... [2]

(b) The apparatus represented in Fig. 8.1 is used in an experiment that determines a value for the Planck constant.

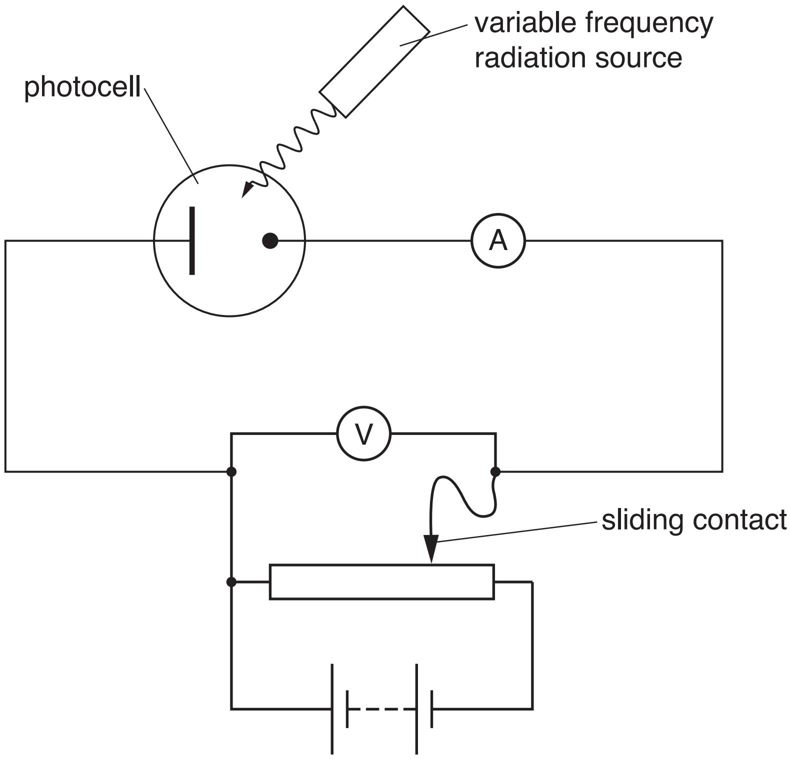

Fig. 8.1

(i) Explain how the apparatus represented by Fig. 8.1 is used to determine the stopping voltage.

....

....

....

....[2]

(ii) Explain how this experiment is used to determine a value for the Planck constant.

....

....

....

....

....

....[3]

[Total: 9]

Section 2

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

9 A nickel-cadmium (NiCd) cell is rechargeable.

Fig. 9.1 shows a type AA nickel-cadmium cell.

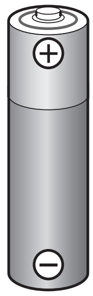

Fig. 9.1

This cell has a capacity of 600 mAh.

(a) Determine the discharge time for this cell when delivering a current of 120 mA. Assume the efficiency is 100%.

discharge time = ... h [1]

(b) With reference to Extract 3,

(i) describe the voltage characteristics of the cell up to about 70% of full charge,

....

....

....

....[3]

(ii) describe the problems that might occur if the cell is overcharged.

....

....

....

....[3]

(c) A student uses a battery of four of these NiCd cells to power a buzzer. He then adds an additional NiCd cell, but mistakenly connects it the wrong way round. The effective resistance of the buzzer is 4.3 Ω.

The internal resistance of a single nickel-cadmium cell is 0.54 Ω and its electromotive force (emf) is 1.24 V.

Fig. 9.2 is a circuit diagram for his arrangement.

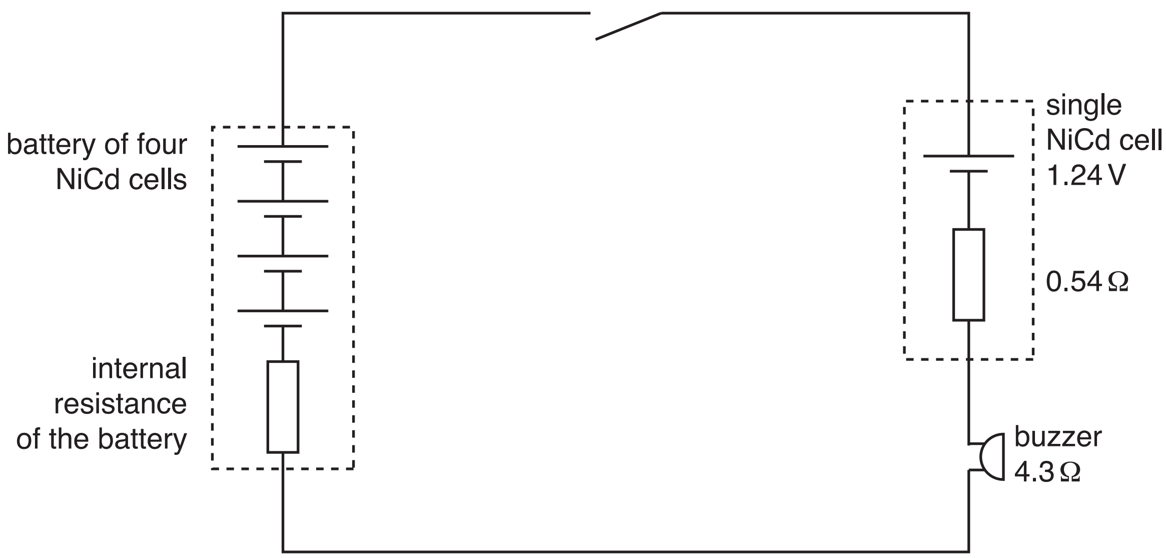

Fig. 9.2

(i) Determine the current in the circuit when the switch is closed.

current = ... A [2]

(ii) On Fig. 9.2, draw an arrow to show the direction of the conventional current in the circuit. [1]

(iii) Determine the potential difference across the battery of four cells.

potential difference = ... V [2]

(d) A battery charger is used to recharge an NiCd cell.

The charger includes a low-voltage 50 Hz a.c. power supply and four identical diodes W, X, Y and Z which do not conduct in the reverse direction. In the forward direction, each diode conducts when the potential difference (p.d.) across the diode is greater than 0.70 V.

Fig. 9.3 shows how the cell is connected to the a.c. power supply using the four diodes.

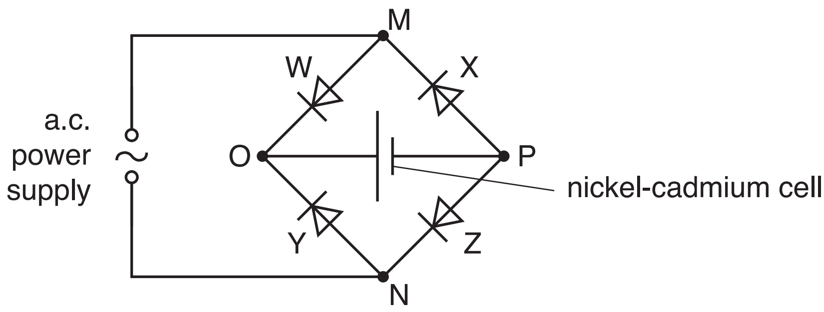

Fig. 9.3

(i) The current in the cell during each half-cycle of the a.c. power supply is always in the same direction.

Explain this with reference to the circuit in Fig. 9.3.

....

....

....

....[2]

(ii) Fig. 9.4 shows how the emf of the a.c. power supply and the current in the cell vary with time.

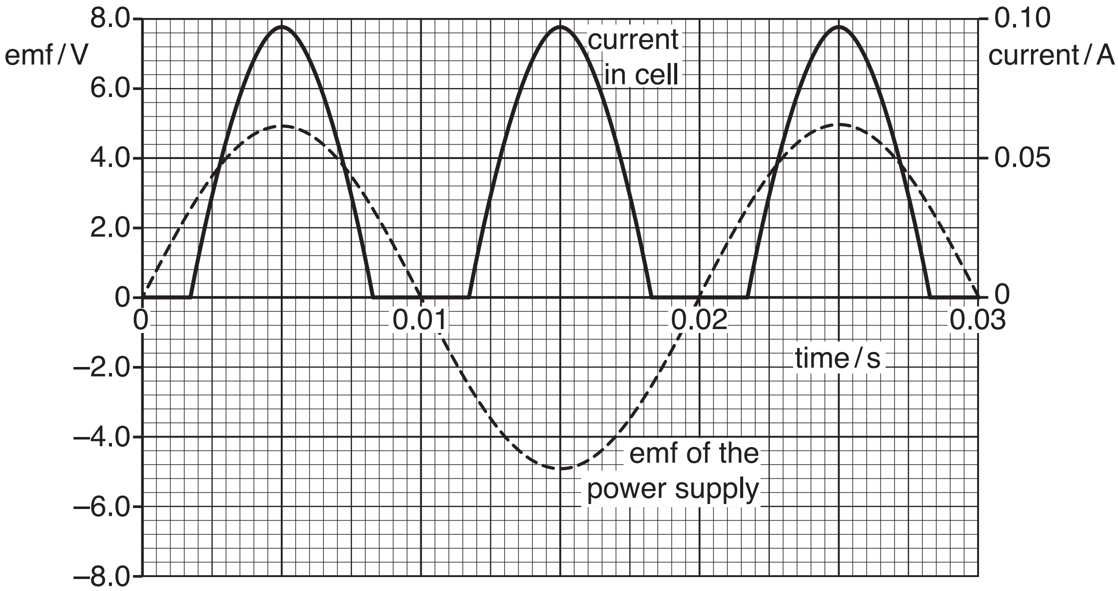

Fig. 9.4

1. At certain times, there is no current in the cell, even though the emf of the power supply is greater than zero.

Suggest **one** reason why, at these times, there is no current in the cell.

....

....[1]

2. Use Fig. 9.4 to estimate the quantity of charge that flows in the cell in a 0.010 s period of time.

charge = ... C [2]

(iii) Immediately after it is manufactured, the cell is uncharged. The cell has a capacity of 600 mAh.

Use the answer obtained in **(d)(ii)2** to determine the time taken to charge the cell fully. Assume a charging efficiency of 100%.

time = ... s [2]

(e) A capacitor of capacitance of 62.5 μF is charged using an NiCd cell.

Fig. 9.5 is the circuit used.

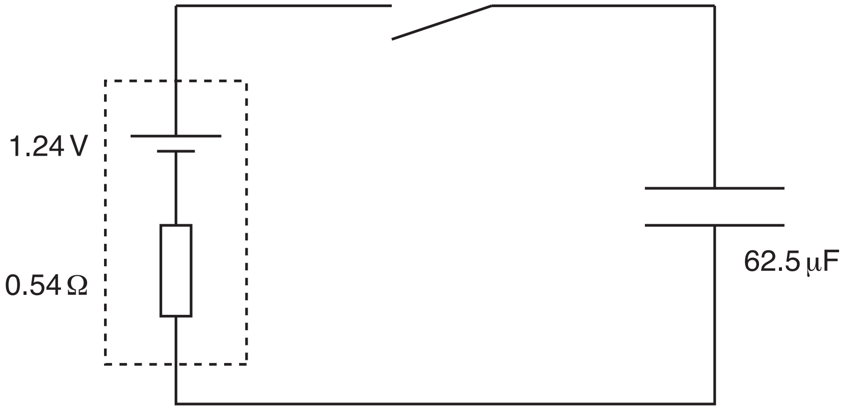

Fig. 9.5

The switch is closed. There is a current in the cell that decreases until it is zero.

(i) Explain why the current in the cell decreases and eventually falls to zero.

....

....

....

....

....[3]

(ii) The capacitor is discharged. The switch is then closed momentarily for 0.20 ms.

Discuss whether this time interval would be sufficiently long to fully charge the capacitor.

Support your answer with appropriate calculations.

....

....

....

....[3]

[Total: 25]

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