OCR
Oxford Cambridge and RSA

A Level Physics A

H556/02 Exploring physics

Wednesday 21 June 2017 – Morning

Time allowed: 2 hours 15 minutes

6829545160

You must have:
- the Data, Formulae and Relationship Booklet (sent with general stationery)

You may use:
- a scientific or graphical calculator
- a ruler (cm/mm)

First name										
Last name										
Centre number						Candidate number				

INSTRUCTIONS
- Use black ink. You may use an HB pencil for graphs and diagrams.
- Complete the boxes above with your name, centre number and candidate number.
- Answer **all** the questions.
- Write your answer to each question in the space provided. If additional space is required, use the lined page(s) at the end of this booklet. The question number(s) must be clearly shown.
- Do **not** write in the barcodes.

INFORMATION
- The total mark for this paper is **100**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended responses will be assessed in questions marked with an asterisk (*).
- This document consists of **32** pages.

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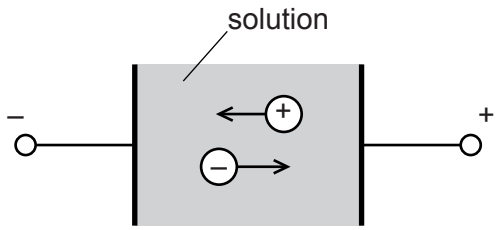
SECTION A

You should spend a maximum of 30 minutes on this section.

Write your answer to each question in the box provided.

Answer **all** the questions.

1 The diagram below shows the motion of positive and negative particles in a conducting solution.



Which statement is correct?

A The current in the solution is zero.

B The conventional current is to the left.

C The positive particles are always protons.

D The negative particles are always electrons.

Your answer ☐ **[1]**

2 One million electrons travel between two points in a circuit.
The **total** energy gained by the electrons is 1.6×10^{-10} J.

What is the potential difference between the two points?

A 1.6×10^{-16} V

B 1.6×10^{-4} V

C 1.0×10^{3} V

D 1.0×10^{9} V

Your answer ☐ **[1]**

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3 Which is **not** a unit of energy?

A kW h

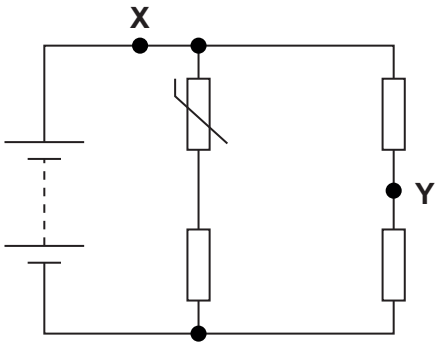
B eV

C J

D W

Your answer [ ] **[1]**

4 A circuit is shown below.



The battery has negligible internal resistance. The temperature of the NTC thermistor is **decreased**.

Which of the following statements is/are correct?

1 The current at **X** increases.
2 The current at **Y** remains the same.
3 The potential difference across the thermistor increases.

A 1, 2 and 3

B Only 2 and 3

C Only 3

D Only 2

Your answer [ ] **[1]**

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5 A progressive wave of amplitude *a* has intensity I. This wave combines with another wave of amplitude 0.6*a* at a point in space. The phase difference between the waves is 180°.

What is the resultant intensity of the combined waves in terms of I?

A $0.16I$

B $0.4I$

C $1.6I$

D $2.6I$

Your answer ☐ **[1]**

6 Stationary waves are produced in a tube closed at one end and open at the other end. The fundamental frequency is 120 Hz.

What is a possible frequency of a harmonic for this tube?

A 60 Hz

B 240 Hz

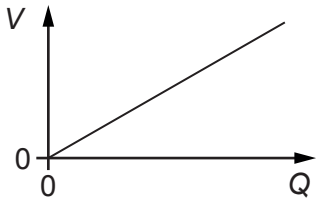
C 360 Hz

D 480 Hz

Your answer ☐ **[1]**

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7 The graph below shows the variation of potential difference V with charge Q for a capacitor.



Which row is correct for the gradient of the graph and the area under the graph?

	Gradient of graph	Area under the graph
A	capacitance^{-1}	work done
B	capacitance^{-1}	permittivity
C	capacitance	power
D	capacitance	energy

Your answer ☐ **[1]**

8 A capacitor discharges through a resistor. At time $t = 0$, the charge stored by the capacitor is 600 μC. The capacitor loses 5.0 % of its charge every second.

What is the charge **left** on the capacitor at time $t = 4.0$ s?

A 111 μC

B 120 μC

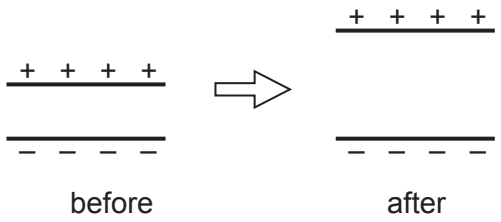
C 480 μC

D 489 μC

Your answer ☐ **[1]**

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9 Two isolated parallel capacitor plates have an equal and opposite charge.
The separation between the plates is doubled.
The charge on each plate remains the same but the potential difference between the plates doubles.



Which statement is correct?

A The capacitance of the capacitor doubles.

B The energy stored by the capacitor is halved.

C The permittivity of free space doubles.

D The electric field strength between the plates remains the same.

Your answer ☐ **[1]**

10 Which statement is correct?

A Hadrons are made up of protons and neutrons.

B A positron and a proton are examples of leptons.

C The positron and the electron have the same mass.

D The weak nuclear force is responsible for alpha-decay.

Your answer ☐ **[1]**

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11 An electron moves in a circle of radius 2.0 cm in a uniform magnetic field of flux density 170 mT.

What is the momentum of this electron?

A $3.4 \times 10^{-3}\,\text{kg m s}^{-1}$

B $5.4 \times 10^{-17}\,\text{kg m s}^{-1}$

C $1.4 \times 10^{-18}\,\text{kg m s}^{-1}$

D $5.4 \times 10^{-22}\,\text{kg m s}^{-1}$

Your answer ☐ **[1]**

12 A proton collides with a stationary oxygen-18 nucleus. The collision produces a fluorine-18 nucleus and particle X.

$$^{1}_{1}\text{p} + {}^{18}_{8}\text{O} \rightarrow {}^{18}_{9}\text{F} + \text{X}$$

What is particle X?

A neutron

B proton

C electron

D positron

Your answer ☐ **[1]**

13 A beam of charged particles is not deflected when it passes through a region where both electric and magnetic fields are present.

Which statement is **not** correct?

A All the particles have the same speed.

B The resultant force on each particle is zero.

C The magnetic force is equal to the electric force on each particle.

D The magnetic field and the electric field are in the same direction.

Your answer ☐ **[1]**

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14 There are four important attenuation mechanisms by which X-ray photons may interact when they pass through matter.

In which mechanism is the X-ray photon scattered with a longer wavelength?

A simple scattering

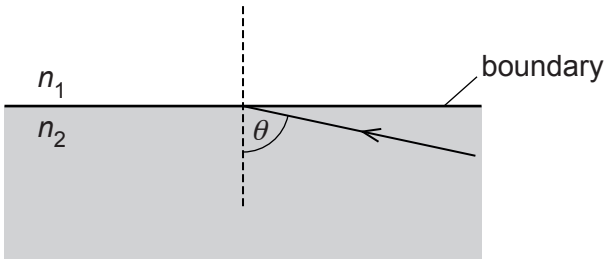
B Compton effect

C pair production

D photoelectric effect

Your answer ☐ **[1]**

15 A ray of monochromatic light is incident at the boundary between two transparent materials of refractive index n_1 and n_2. The critical angle θ is equal to 80°.



What is the ratio $\frac{n_1}{n_2}$?

A 0.17

B 0.98

C 1.02

D 5.76

Your answer ☐ **[1]**

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SECTION B

Answer **all** the questions.

16 (a) State the *principle of superposition* of waves.

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..... **[1]**

(b) Fig. 16.1 shows an arrangement to demonstrate the interference of monochromatic light.

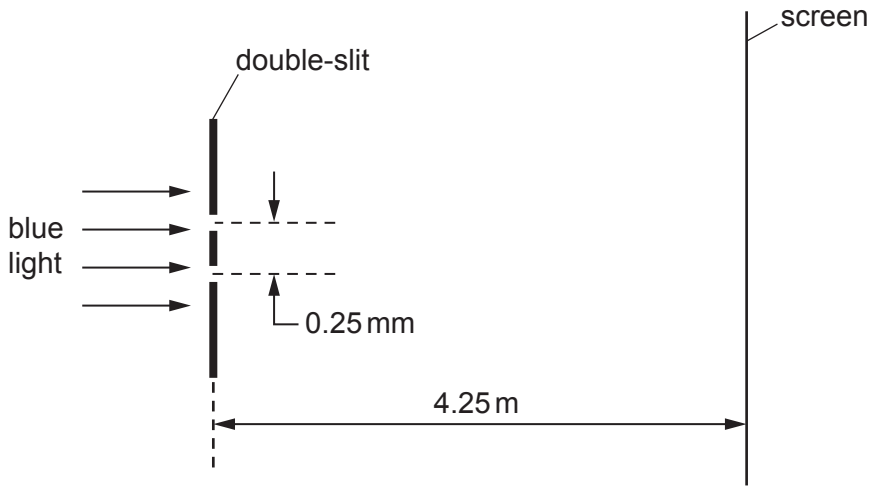


Fig. 16.1

Coherent blue light from a laser is incident at a double-slit. The separation between the slits is 0.25 mm. A series of dark and bright lines (fringes) appear on the screen. The screen is 4.25 m from the slits.
Fig. 16.2 shows the dark and bright fringes observed on the screen.



Fig. 16.2

The pattern shown in Fig. 16.2 is **drawn to scale**.

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(i) Use Fig. 16.2 to determine accurately the wavelength of the blue light from the laser.

wavelength = ... m **[3]**

(ii) The blue light is now replaced by a similar beam of red light.
State and explain the effect, if any, on the fringes observed on the screen.

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..... **[2]**

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17 **(a)** State **one** S.I. base quantity other than length, mass and time.

..... **[1]**

(b) Fig. 17 shows two resistors **X** and **Y** connected in series.

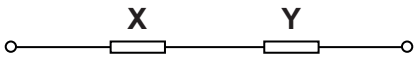


Fig. 17

The resistors are wires. Both wires have the same length L and diameter d. The material of **X** has resistivity ρ and the material of **Y** has resistivity 2ρ.

(i) Show that the total resistance R of the wires is given by the equation

$$R = \frac{12\rho L}{\pi d^2}.$$

[2]

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(ii) A student uses the equation in **(i)** to determine R.
The table below shows the data recorded by the student in her lab book.

Quantity	Value
ρ	$4.7 \times 10^{-7}\,\Omega\,\text{m}$
L	$9.5 \pm 0.1\,\text{cm}$
d	$0.270 \pm 0.003\,\text{mm}$

1. Name the likely instruments used by the student to measure L and d.

L: .....

d: .....
[1]

2. Use the data in the table and the equation in **(i)** to determine R and the absolute uncertainty. Write your answer to the correct number of significant figures.

R = ... ± ..... Ω **[4]**

3. The instrument used to measure d has a zero-error. The measured d is much **larger** than the actual value.
Discuss how the actual value of R compares with the value calculated above.

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18 **(a)** Fig. 18.1 shows a circuit.

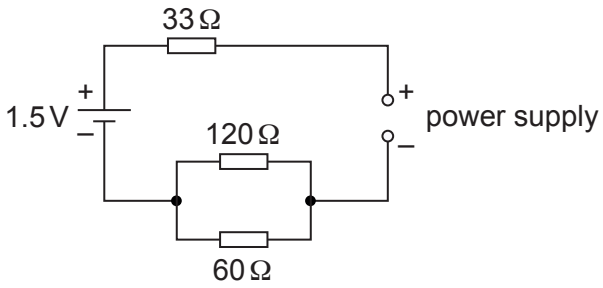


Fig. 18.1

The cell has e.m.f. 1.5 V. The cell and the variable power supply both have negligible internal resistance.

(i) The e.m.f. of the power supply is set at 4.2 V.
Calculate the current I in the 33 Ω resistor.

I = ... A **[3]**

(ii) The e.m.f. of the variable supply is now slowly decreased from 4.2 V to 0 V.
Describe the effect on the current I in the 33 Ω resistor.

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..... **[2]**

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(b)* A group of students are investigating the power dissipated in a variable resistor connected across the terminals of a cell. The cell has e.m.f. 1.5 V.
The students determine the power P dissipated in the variable resistor of resistance R.

Fig. 18.2 shows the data points plotted by the students on a graph of P (y-axis) against R (x-axis).

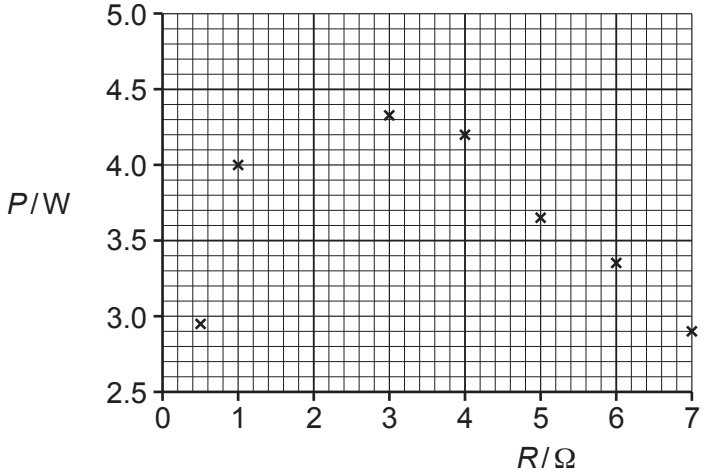


Fig. 18.2

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The group of students know that **maximum power** is dissipated in the variable resistor when R is equal to the internal resistance r of the cell.

Describe, with the help of a suitable circuit diagram, how the students may have determined P and R. Use Fig. 18.2 to estimate the internal resistance r of the cell and discuss any limitations of the data plotted by the group.

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19 **(a)** Electromagnetic radiation is incident on a negatively charged zinc plate. Electrons are emitted from the surface of the plate when a weak intensity ultraviolet source is used. Electrons are not emitted at all when an intense visible light from a lamp is used.

Explain these observations.

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..... **[4]**

(b) The **maximum** wavelength of the electromagnetic radiation incident on the surface of a metal which causes electrons to be emitted is 2.9×10^{-7} m.

Calculate the maximum kinetic energy of electrons emitted from the surface of the metal when each incident photon has energy of 5.1 eV.

maximum kinetic energy = ... J **[3]**

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(c) Electromagnetic radiation of constant wavelength is incident on a metal plate. Photoelectrons are emitted from the metal plate. Fig. 19.1 shows an arrangement used to determine the maximum kinetic energy of electrons emitted from a metal plate.

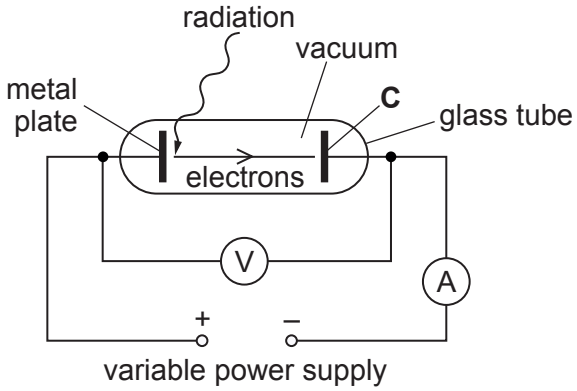


Fig. 19.1

The metal plate and the electrode **C** are both in a vacuum. The electrode **C** is connected to the negative terminal of the variable power supply.
Fig. 19.2 shows the variation of current I in the circuit as the potential difference V between the metal plate and **C** is increased from 0 V to 3.0 V.

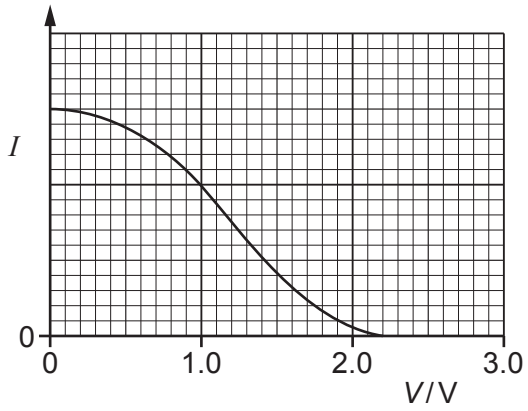


Fig. 19.2

Explain why the current decreases as V increases and describe how you can determine the maximum kinetic energy of the emitted electrons.

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20 **(a)** Fig. 20.1 shows a positively charged metal sphere and a negatively charged metal plate.

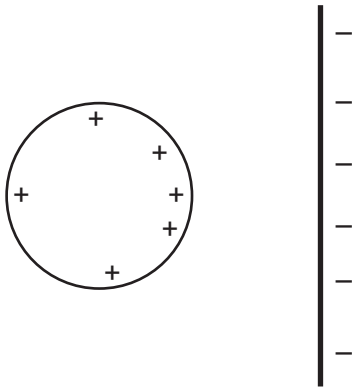


Fig. 20.1

On Fig. 20.1, draw a minimum of **five** electric field lines to show the field pattern between the sphere and the plate. **[2]**

(b) Define *electric potential* at a point in space.

.....

..... **[1]**

(c) A metal sphere is given a positive charge by connecting its surface briefly to the positive terminal of a power supply. The electric potential at the surface of the sphere is + 5.0 kV. The sphere has radius 1.5 cm.

(i) Show that the charge Q on the surface of the sphere is 8.3×10^{-9} C.

[2]

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(ii) Fig. 20.2 shows the charged sphere from **(i)** suspended from a nylon thread and placed between two oppositely charged vertical plates.

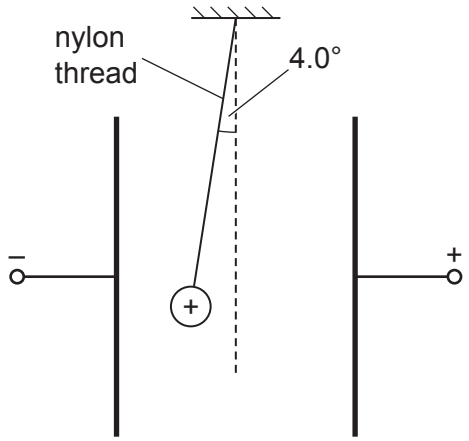


Fig. 20.2 (not to scale)

The weight of the sphere is 1.7×10^{-2} N. The string makes an angle of 4.0° with the vertical.

1. Show that the electric force on the charged sphere is 1.2×10^{-3} N.

[1]

2. Calculate the uniform electric field strength E between the parallel plates.

E = ... NC^{-1} **[2]**

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21 **(a)** A capacitor of capacitance 7.2 pF consists of two parallel metal plates separated by an insulator of thickness 1.2 mm. The area of overlap between the plates is $4.0 \times 10^{-4}\,m^2$. Calculate the permittivity of the insulator between the capacitor plates.

permittivity = ... $F\,m^{-1}$ **[2]**

(b) Fig. 21 shows a circuit.

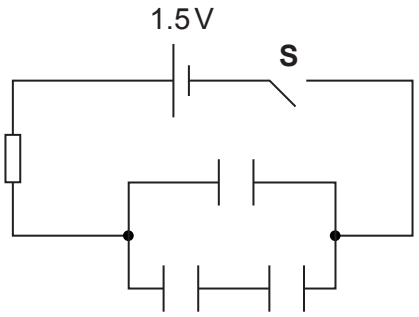


Fig. 21

The capacitance of each capacitor is 1000 μF. The resistance of the resistor is 10 kΩ. The cell has e.m.f. 1.5 V and negligible internal resistance.

(i) Calculate the total capacitance *C* in the circuit.

C = ... μF **[2]**

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(ii) The switch **S** is closed at time $t = 0$. There is zero potential difference across the capacitors at $t = 0$.
Calculate the potential difference V across the resistor at time $t = 12\,\text{s}$.

$V =$ ..... V **[2]**

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22 (a)* A student conducts an experiment to confirm that the uniform magnetic flux density *B* between the poles of a magnet is 30 mT.

A current-carrying wire of length 5.0 cm is placed perpendicular to the magnetic field.

The current *I* in the wire is changed and the force *F* experienced by the wire is measured. Fig. 22.1 shows the graph plotted by the student.

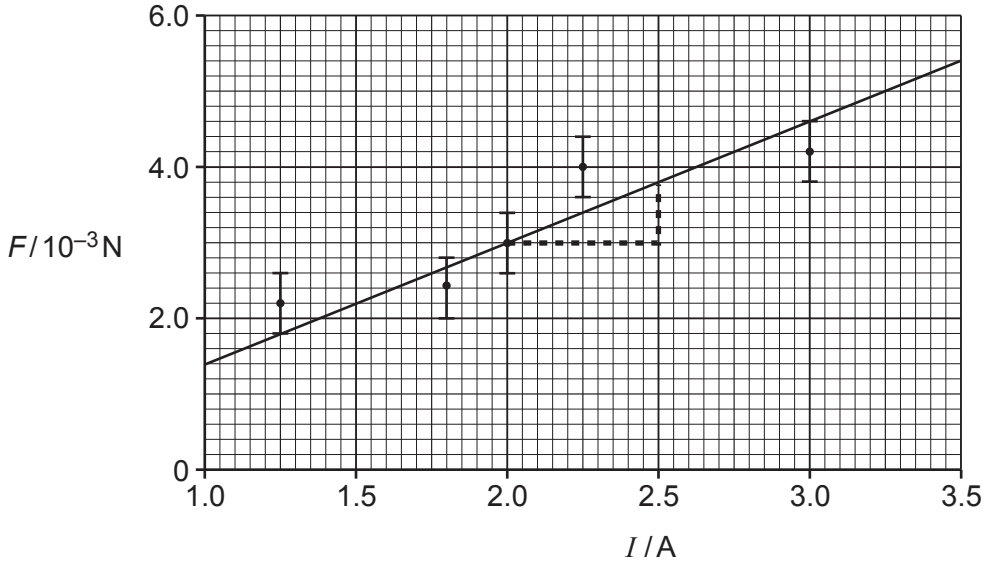


Fig. 22.1

The student's analysis is shown on the graph of Fig. 22.1 and in the space below.

$F = BIL$

$\text{gradient} = BL = \dfrac{(3.8 - 3.0) \times 10^{-3}}{2.5 - 2.0} = 0.0016$

$B = \dfrac{0.0016}{0.05} = 0.032\,\text{T} = 32\,\text{mT}$

This is just 2 mT out from the 30 mT value given by the manufacturer, so the experiment is very accurate.

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Evaluate the information from Fig. 22.1 and the analysis of the data from the experiment. No further calculations are necessary.

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(b) Fig. 22.2 shows a transformer circuit.

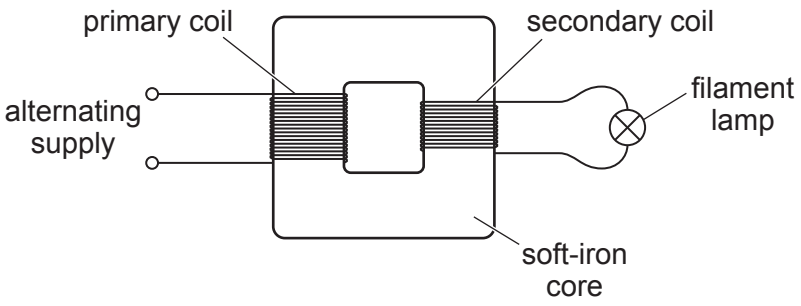


Fig. 22.2

The primary coil is connected to an alternating voltage supply. A filament lamp is connected to the output of the secondary coil.

(i) Use Faraday's law of electromagnetic induction to explain why the filament lamp is lit.

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..... **[3]**

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(ii) The primary coil has 400 turns and the secondary coil has 20 turns. The potential difference across the lamp is 12 V and it dissipates 24 W. The transformer is 100% efficient.

1. Calculate the current in the primary coil.

current = ... A **[2]**

2. The alternating voltage supply is replaced by a battery and an open switch in series. The switch is closed. The lamp is lit for a short period of time and then remains off. Explain this observation.

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..... **[2]**

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23 **(a)** Describe the nature of the *strong nuclear force*.

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..... **[2]**

(b) **(i)** Name a hadron found in the nucleus of an atom and state its quark combination.

name of hadron: ..... quark combination: ..... **[1]**

(ii) Write a decay equation in terms of a quark model for beta-minus decay.

[2]

(c) The radius of a nucleus is directly proportional to $A^{1/3}$, where A is the nucleon number.
The mass of a proton and a neutron are similar.
Explain why the mean density of all nuclei is about the same.

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..... **[2]**

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24 Stars produce energy by nuclear fusion.
One particular fusion reaction between two protons ($^{1}_{1}H$) is shown below.

$$^{1}_{1}H \quad + \quad ^{1}_{1}H \quad \rightarrow \quad ^{2}_{1}H \quad + \quad ^{0}_{+1}e \quad + \quad \nu$$

In this reaction 2.2 MeV of energy is released.

(a) Only one of the particles shown in the reaction has binding energy.
Determine the binding energy per nucleon of this particle. Explain your answer.

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..... **[2]**

(b) Explain why high temperatures are necessary for fusion reactions to occur in stars.

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..... **[2]**

(c) A gamma photon in a star can spontaneously create an electron-positron pair.
Calculate the **maximum** wavelength of a gamma photon for this creation event.

maximum wavelength = ... m **[3]**

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25 Fluorine-18 is a common radioactive isotope used in positron emission tomography (PET). Fluorine-18 emits positrons. A patient is injected with a radiopharmaceutical containing fluorine-18.

(a) Describe how a PET scanner is used to locate an area of increased activity within the patient.

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..... **[4]**

(b) The half-life of fluorine-18 is 110 minutes.
Calculate the time *t* in minutes for the activity of the radiopharmaceutical to decrease to 30% of its initial activity.

t = ... minutes **[3]**

(c) PET scanners are not available in all hospitals. This is because fluorine-18 requires expensive on-site particle accelerators and fluorine-18 has a very small 'shelf-life'.
Suggest the impact this may have on the treatment and diagnosis of patients in the country.

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END OF QUESTION PAPER

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ADDITIONAL ANSWER SPACE

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