Write your name here

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**Pearson Edexcel GCE**

| Centre Number | Candidate Number |
|---|---|
| | |

# Physics

## Advanced Subsidiary
## Unit 2: Physics at Work

Thursday 4 June 2015 – Afternoon
**Time: 1 hour 30 minutes**

Paper Reference
**6PH02/01**

**You must have:**
Ruler

Total Marks

### Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

### Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- The list of data, formulae and relationships is printed at the end of this booklet.
- Candidates may use a scientific calculator.

### Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

*Turn over* ▶

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## SECTION A

**Answer ALL questions.**

**For questions 1–10, in Section A, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.**

**1** The current in a filament lamp is 250 mA.

How much charge flows through the lamp in 3 minutes?

☒ **A** 0.75 C

☒ **B** 45 C

☒ **C** 750 C

☒ **D** 45 000 C

**(Total for Question 1 = 1 mark)**

---

**2** A source of sound of constant frequency is moving towards an observer. Compared to the frequency of the source, the frequency of sound heard by the observer is

☒ **A** higher, because the speed of sound increases.

☒ **B** lower, because the air is compressed.

☒ **C** higher, because the wavelength of the sound decreases.

☒ **D** lower, because the amplitude increases.

**(Total for Question 2 = 1 mark)**

---

**3** Radiation of frequency $f$ and wavelength $\lambda$ is emitted when an electron falls from energy level $E_2$ to energy level $E_1$.

$E_2 - E_1$ is equal to

☒ **A** $\frac{hc}{f}$

☒ **B** $\frac{hc}{\lambda}$

☒ **C** $\frac{hf}{c}$

☒ **D** $\frac{h\lambda}{c}$

**(Total for Question 3 = 1 mark)**

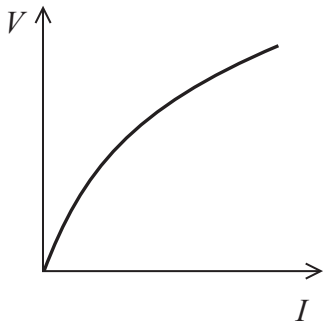
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**4** Which of the following can be explained only by the wave nature of electromagnetic radiation?

- ☒ **A** atomic line spectra
- ☒ **B** electron diffraction
- ☒ **C** photoelectric effect
- ☒ **D** X-ray diffraction

**(Total for Question 4 = 1 mark)**

**5** The graph shows how potential difference $V$ varies with current $I$ for a circuit component.



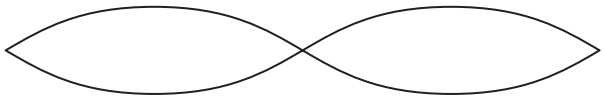

Which of the following could be the circuit component?

- ☒ **A** copper wire
- ☒ **B** filament lamp
- ☒ **C** fixed resistor
- ☒ **D** thermistor

**(Total for Question 5 = 1 mark)**

**Questions 6 and 7 refer to the diagram below.**

The diagram represents a stationary wave on a string.

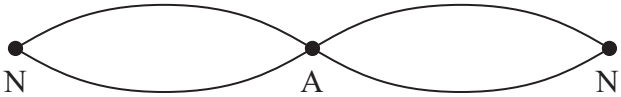


**6** Which diagram correctly shows the position of nodes N and/or antinodes A?

☒ **A**



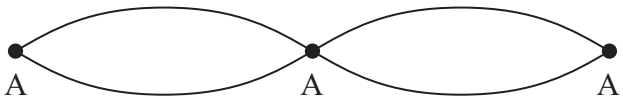

☒ **B**




☒ **C**




☒ **D**




**(Total for Question 6 = 1 mark)**

**7** The length of the string is 4 m.
What is the wavelength of the stationary wave?

☒ **A** 1 m

☒ **B** 2 m

☒ **C** 4 m

☒ **D** 8 m

**(Total for Question 7 = 1 mark)**

**8** Which of the following expresses the volt in SI base units?

☒ **A** $\text{kg m}^2\,\text{s}^{-2}\,\text{C}^{-1}$

☒ **B** $\text{kg m}^2\,\text{s}^{-3}\,\text{C}$

☒ **C** $\text{kg m}^2\,\text{s}\,\text{A}^{-1}$

☒ **D** $\text{kg m}^2\,\text{s}^{-3}\,\text{A}^{-1}$

**(Total for Question 8 = 1 mark)**

**9** A light illuminates a circular area of radius 30 cm. In a time of 20 s the total incident energy from the light is 70 J.

The radiation flux can be calculated from

☒ **A** $\dfrac{70}{(\pi \times 0.30^2 \times 20)}$

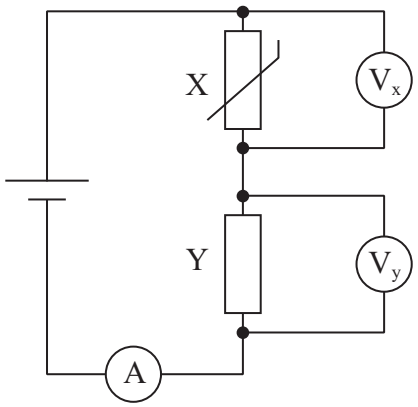
☒ **B** $\dfrac{70}{(\pi \times 0.15^2 \times 20)}$

☒ **C** $\dfrac{70 \times \pi \times 0.30^2}{20}$

☒ **D** $\dfrac{70 \times 20}{(\pi \times 0.15^2)}$

**(Total for Question 9 = 1 mark)**

**10** The diagram shows a potential divider circuit that contains a negative temperature coefficient thermistor.




The temperature of the room containing the circuit increases.

Select the row of the table that correctly shows the changes in readings on the meters.

| | $V_x$ | $V_y$ | A |
|---|---|---|---|
| ☒ **A** | decrease | increase | decrease |
| ☒ **B** | decrease | increase | increase |
| ☒ **C** | increase | decrease | decrease |
| ☒ **D** | increase | decrease | increase |

**(Total for Question 10 = 1 mark)**

**TOTAL FOR SECTION A = 10 MARKS**

## SECTION B

**Answer ALL questions in the spaces provided.**

**11** When electromagnetic radiation is incident on a metal plate, electrons may be emitted.

(a) State what is meant by threshold frequency.

**(1)**

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(b) Calculate the threshold frequency for a metal with a work function of 2.28 eV.

**(3)**

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Threshold frequency = .....

**(Total for Question 11 = 4 marks)**

**12** An ultrasonic distance estimator can be used to measure the length of a room.



The estimator is held against one wall. It emits pulses of ultrasound and detects them when they return after reflection by the opposite wall.

(a) Explain why the ultrasound must be emitted in pulses.

**(1)**

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(b) The shortest distance the estimator can measure is 40 cm.
Calculate the longest pulse duration that would allow this distance to be measured.

speed of ultrasound in air = 330 m $s^{-1}$

**(3)**

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Pulse duration = .....

(c) When the estimator is pointed at a sloping wall, as shown in the photograph, it is unable to measure this distance.



Suggest why the estimator is unable to measure the distance to the sloping wall.

**(1)**

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**(Total for Question 12 = 5 marks)**

**13** (a) State what is meant by drift velocity when applied to a metal conductor.

**(1)**

(b) Two conductors of the same material and length carry the same current. Conductor X has twice the cross-sectional area of conductor Y.

(i) By referring to an appropriate equation, compare the drift velocities for conductor X and conductor Y.

**(2)**

*(ii) Explain the difference in resistance of conductor X and conductor Y in terms of the difference in drift velocity.

**(3)**

**(Total for Question 13 = 6 marks)**

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**14** The instruction booklet for an electric garden shredder includes the following advice.

When using an extension cable, the following dimensions should be observed:

| Cross-sectional area of conductor / $mm^2$ | Maximum cable length / m |
|---|---|
| 1.00 | 40 |
| 1.50 | 60 |
| 2.50 | 100 |

(a) Describe the relationship between area and length in the table.

**(1)**

.....

.....

(b) The cable for the shredder contains two conductors in series, the live wire and the neutral wire. A cable of length 40 m has a total conductor length of 80 m.

(i) Show that the resistance of a copper conductor of length 80 m and cross-sectional area 1.00 $mm^2$ is about 1.3 **Ω**.

resistivity of copper = $1.68 \times 10^{-8}$ **Ω** m

**(2)**

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(ii) When in use the current for the shredder is 11 A.
Calculate the rate of energy dissipation by the 40 m, 1.00 $mm^2$ cable when it is used with the shredder.

**(2)**

Rate of energy dissipation = .....

(iii) Calculate the total potential difference across the conductors in the 40 m cable when it is used with the shredder.

**(2)**

Potential difference = .....

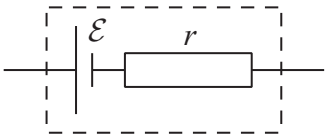
(c) Suggest why the advice in the instruction booklet is included.

**(2)**

**(Total for Question 14 = 9 marks)**

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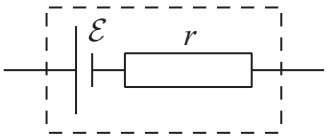
**15** A cell may be represented as an e.m.f. $\mathcal{E}$ in series with an internal resistance $r$.




A student used the relationship $V = \mathcal{E} - Ir$ and a graphical method to determine $\mathcal{E}$ and $r$. She connected a cell in a circuit and took a series of measurements of the current $I$ in the cell and the potential difference $V$ across the terminals of the cell.

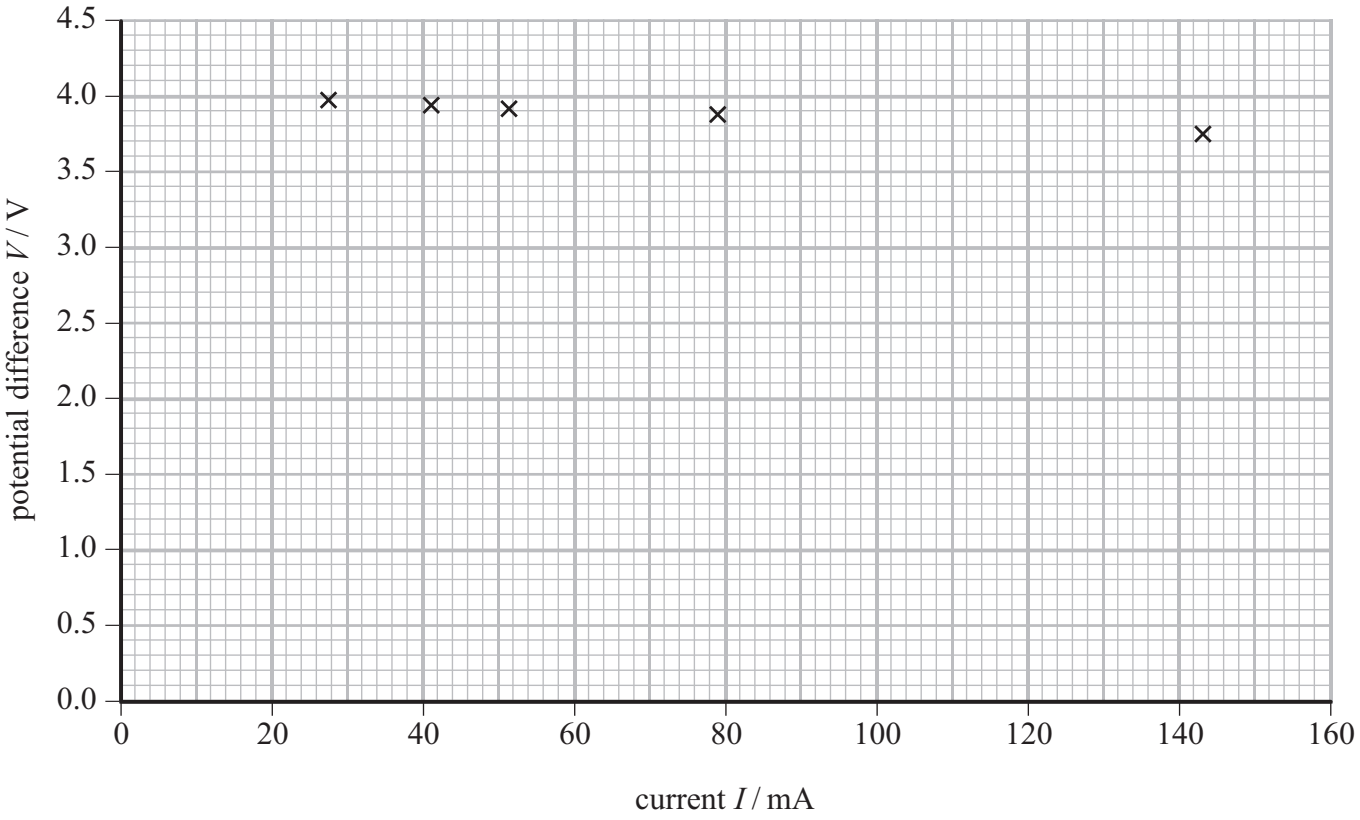
(a) Complete a circuit diagram of a circuit she could have used.

**(2)**



(b) The student's measurements are shown in the table and plotted on the graph.

| $I$ / mA | $V$ / V |
|---|---|
| 27.5 | 3.97 |
| 41.0 | 3.94 |
| 51.6 | 3.90 |
| 78.6 | 3.88 |
| 143.0 | 3.75 |



Determine values for $\mathcal{E}$ and $r$ from the graph and show how you obtained your answers.

**(4)**

$\mathcal{E}$ = .....

$r$ = .....

(c) Explain how the graph could be constructed to obtain better values for $\mathcal{E}$ and $r$.

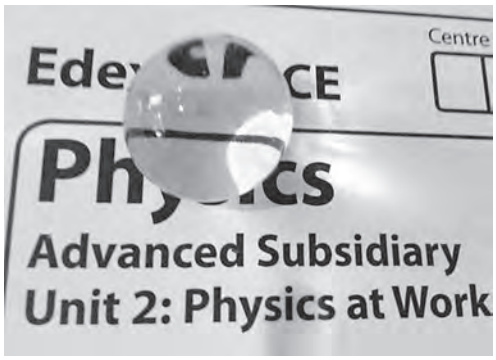
**(2)**

**(Total for Question 15 = 8 marks)**

**16** Flower arrangers sometimes use gel balls instead of water to fill vases.



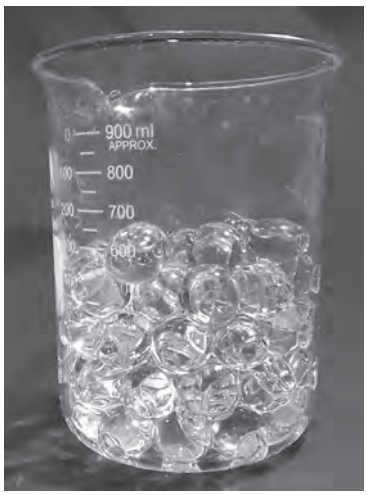
The photograph below shows some writing seen through one of these gel balls. The writing is distorted because the gel ball refracts light.




(a) Explain what is meant by refraction.

**(2)**

(b) The photographs below show a beaker containing gel balls. When water is added to the beaker, the gel balls below the water surface are no longer visible.






Explain how this shows that the gel has the same refractive index as water.

**(2)**

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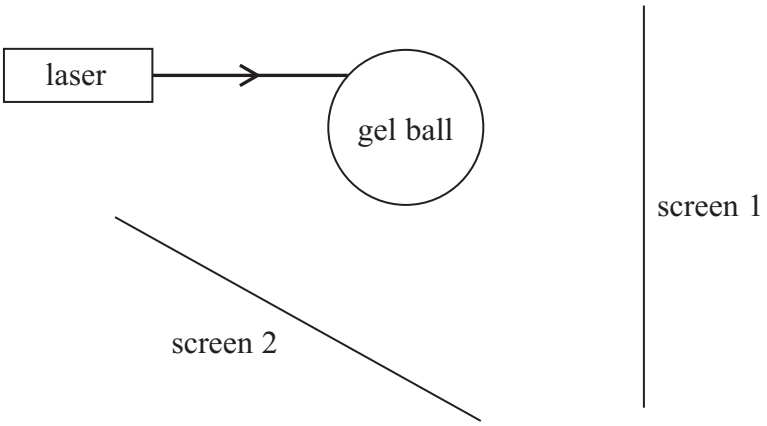
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(c) A student decides to use a gel ball to model the formation of a rainbow by raindrops. He wants to see if total internal reflection occurs.

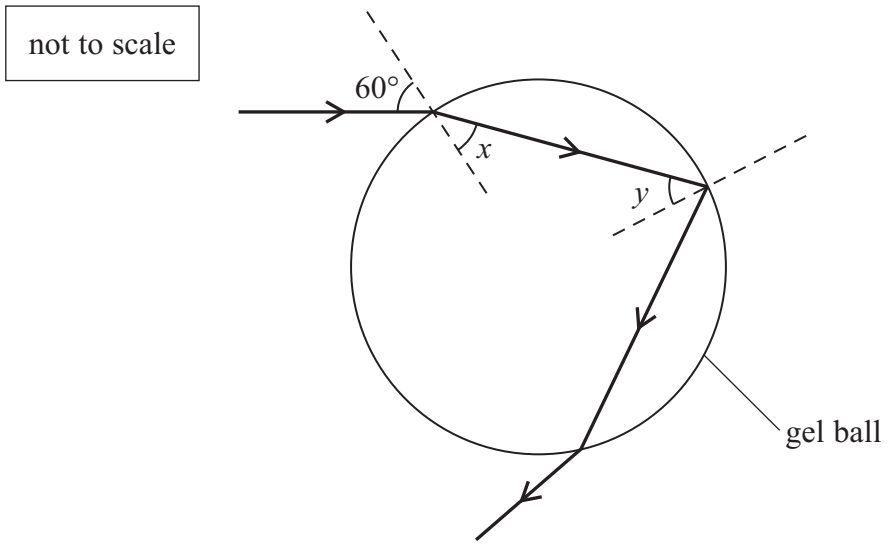
Explain what is meant by total internal reflection.

**(2)**

(d) The student shines a narrow laser beam at a gel ball using the arrangement shown.




When the angle of incidence of the laser beam with the gel ball is 60°, light from the laser illuminates screen 2 following the path shown.



(i) Show that the angle $x$ is about 40°.

refractive index of gel = 1.33

**(2)**

(ii) Show that the critical angle for light striking the boundary of gel with air is about 50°.

**(2)**

(iii) Angle $x$ has the same value as angle $y$.
Explain whether light from the laser will be observed on screen 1.

**(2)**

**(Total for Question 16 = 12 marks)**

**17** (a) State what is meant by the principle of superposition of waves.

**(2)**

(b) Electromagnetic waves involve oscillating electric fields.

A student made the following notes about the polarisation of electromagnetic waves. The notes contain a number of errors.

*Electromagnetic waves are transverse, with oscillations parallel to the direction of motion.*

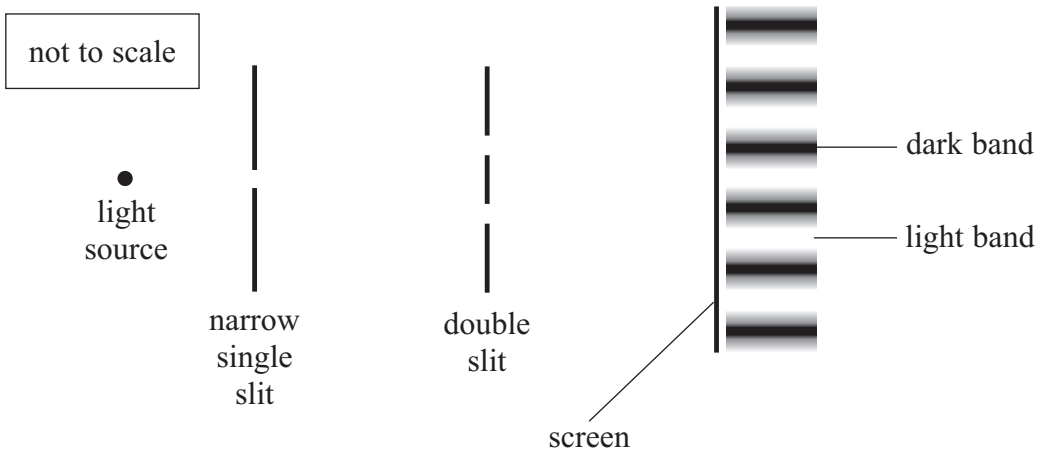
*When they pass through a polarising filter all the components of the oscillations perpendicular to the filter's plane of polarisation are rotated.*

*The oscillations of the polarised wave are all in the same plane which is perpendicular to the direction of energy transfer.*

Copy the passage, correcting the errors.

**(4)**

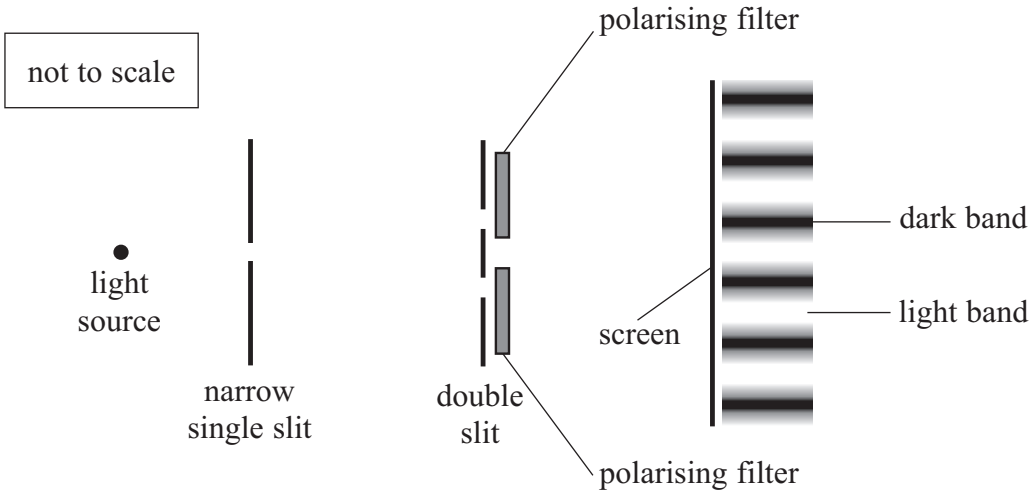
(c) The arrangement in the diagram demonstrates the effect of superposition. When a monochromatic light source is used, a series of dark and light bands is formed on the screen.




*(i) Explain how the dark and light bands are formed by light reaching the screen from the two slits of the double slit.

**(3)**

(ii) Polarising filters are placed behind the slits as shown. When the planes of polarisation are parallel, the pattern of light and dark bands is still seen.




If one polarising filter is rotated through 90° there are no dark bands and the screen is illuminated evenly.

Explain why there are no dark bands when one filter has a plane of polarisation at 90° to that of the other filter.

**(3)**

**(Total for Question 17 = 12 marks)**

**18** When food is cooked in a microwave oven, microwave radiation is absorbed by water molecules, increasing the internal energy of the food.

(a) A student heats water in a microwave oven for 1 minute to determine the efficiency of the oven at transferring energy to the water. The current in the microwave oven is 5.0 A and the potential difference is 230 V. The increase in internal energy of the water is 29 000 J.

Calculate the efficiency of the microwave oven at heating the water.

**(4)**

Efficiency = .....

(b) The photograph shows a microwave leakage detector.

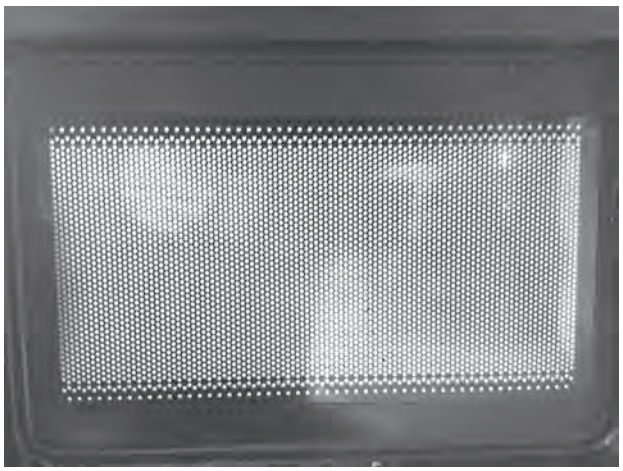



The detector is held next to the microwave oven to see if any microwave radiation is leaking to the surroundings.

Suggest why microwave radiation leaking to the surroundings could be dangerous to people.

**(2)**

(c) The internal walls of the microwave oven are solid metal. The photograph shows the door of a microwave oven.



The door consists of two sheets of glass with a layer of metal between. The layer of metal has many small holes in it, so that food inside the microwave oven may be seen while it is being heated without exposing the user to dangerous levels of microwave radiation. It has been suggested that, due to diffraction effects, light can pass through the holes but microwaves cannot.

(i) Explain what is meant by diffraction.

**(2)**

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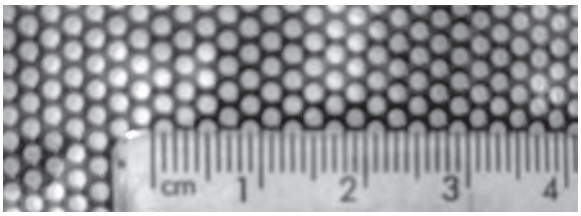
(ii) Calculate the wavelength of the microwave radiation used in the oven.

microwave frequency = 2.5 GHz.

**(2)**

Wavelength = .....

(iii) The photograph shows a section of the microwave oven door. Use the photograph to determine the diameter of the holes.




**(1)**

Diameter = .....

*(iv) Discuss the suggestion that, due to diffraction effects, light can pass through the holes but microwaves cannot.

**(3)**

**(Total for Question 18 = 14 marks)**

**TOTAL FOR SECTION B = 70 MARKS**

**TOTAL FOR PAPER = 80 MARKS**

## List of data, formulae and relationships

| | | |
|---|---|---|
| Acceleration of free fall | $g = 9.81\ \text{m s}^{-2}$ | (close to Earth's surface) |
| Electron charge | $e = -1.60 \times 10^{-19}\ \text{C}$ | |
| Electron mass | $m_e = 9.11 \times 10^{-31}\ \text{kg}$ | |
| Electronvolt | $1\ \text{eV} = 1.60 \times 10^{-19}\ \text{J}$ | |
| Gravitational field strength | $g = 9.81\ \text{N kg}^{-1}$ | (close to Earth's surface) |
| Planck constant | $h = 6.63 \times 10^{-34}\ \text{J s}$ | |
| Speed of light in a vacuum | $c = 3.00 \times 10^{8}\ \text{m s}^{-1}$ | |

***Unit 1***

*Mechanics*

Kinematic equations of motion

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

Forces

$$\Sigma F = ma$$
$$g = F/m$$
$$W = mg$$

Work and energy

$$\Delta W = F\Delta s$$
$$E_k = \tfrac{1}{2}mv^2$$
$$\Delta E_{grav} = mg\Delta h$$

*Materials*

Stokes' law $F = 6\pi\eta rv$

Hooke's law $F = k\Delta x$

Density $\rho = m/V$

Pressure $p = F/A$

Young modulus $E = \sigma/\varepsilon$ where
Stress $\sigma = F/A$
Strain $\varepsilon = \Delta x/x$

Elastic strain energy $E_{el} = \tfrac{1}{2}F\Delta x$

***Unit 2***

*Waves*

| | |
|---|---|
| Wave speed | $v = f\lambda$ |
| Refractive index | ${}_1\mu_2 = \sin i / \sin r = v_1/v_2$ |

*Electricity*

| | |
|---|---|
| Potential difference | $V = W/Q$ |
| Resistance | $R = V/I$ |
| Electrical power, energy and efficiency | $P = VI$<br>$P = I^2R$<br>$P = V^2/R$<br>$W = VIt$ |

$$\% \text{ efficiency} = \frac{\text{useful energy output}}{\text{total energy input}} \times 100$$

$$\% \text{ efficiency} = \frac{\text{useful power output}}{\text{total power input}} \times 100$$

| | |
|---|---|
| Resistivity | $R = \rho l/A$ |
| Current | $I = \Delta Q/\Delta t$<br>$I = nqvA$ |
| Resistors in series | $R = R_1 + R_2 + R_3$ |
| Resistors in parallel | $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$ |

*Quantum physics*

| | |
|---|---|
| Photon model | $E = hf$ |
| Einstein's photoelectric equation | $hf = \phi + \frac{1}{2}mv^2_{max}$ |

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