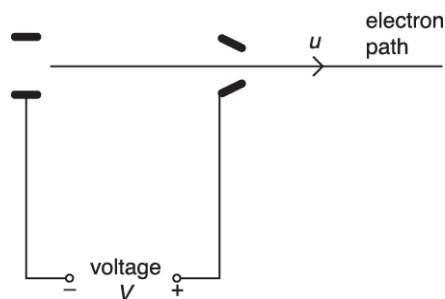


Energy, Power and Resistance EMF and PD

1. An electron gun is used to accelerate electrons from rest through a voltage V . The electrons emerge with a speed u .



The voltage in the gun is halved to $\frac{V}{2}$. At what speed do the electrons emerge?

- A $\frac{u}{4}$
- B $\frac{u}{2}$
- C $\frac{u}{\sqrt{2}}$
- D $u\sqrt{2}$

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]

3. Which definition is correct and uses only quantities rather than units?

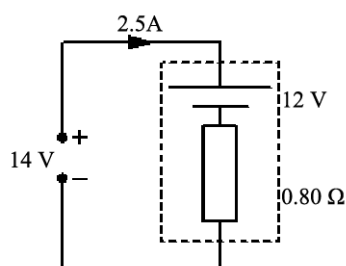
- A Acceleration is the change in velocity per second.
- B Resistance is potential difference per ampere.
- C Intensity is energy per unit cross-sectional area.
- D Electromotive force is energy transferred per unit charge.

Your answer

[1]

4.2 Energy, Power and Resistance - EMF and PD

4. A 14 V d.c. supply is used to charge a 12 V car battery of internal resistance $0.80\ \Omega$ for 6.0 hours. The current in the circuit is 2.5 A.



How much electrical energy is provided by the charging supply?

- A. 13 kJ
- B. 110 kJ
- C. 650 kJ
- D. 760 kJ

Your answer

[1]

5. In a particle-accelerator electrons are accelerated through a potential difference of 120 kV. The electron beam current is $8.0\ \mu\text{A}$.

What is the total energy transferred to the electrons in a time of 2.0 hours?

- A 0.96 J
- B 120 J
- C 1900 J
- D 6900 J

Your answer

[1]

6. A small heater is connected to a power supply. The power supply is switched on for 100 s. The current in the heater is 3.0 A and it dissipates 1200 J of thermal energy.

What is the potential difference across the heater?

- A 0.25V
- B 4.0V
- C 12V
- D 300V

Your answer

[1]

4.2 Energy, Power and Resistance - EMF and PD

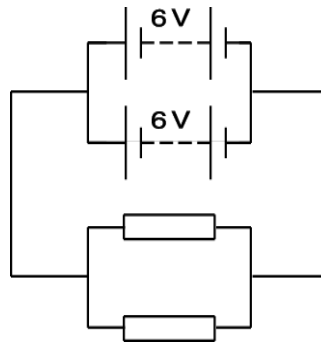
7. Which of the following is **not** a source of electromotive force (e.m.f.)?

- A chemical cell
- B light-dependent resistor
- C power supply
- D solar cell

Your answer

[1]

8. Two batteries, each of e.m.f 6.0 V and negligible internal resistance, are joined in parallel. The cells are connected to two identical resistors, joined in parallel.



What is the voltage across each resistor?

- A. 1.5 V
- B. 3.0 V
- C. 6.0 V
- D. 12.0 V

Your answer

[1]

9. Stationary waves are produced in a flute when it is played. When all finger-holes are covered up, the flute can be treated as a pipe open at both ends. A flute is played so that it sounds the next harmonic above the fundamental frequency.

Which diagram correctly shows the node N and antinode A positions for the displacement of air for this harmonic?

- A

A	N	A
---	---	---
- B

N	A	N
---	---	---
- C

A	N	A	N	A
---	---	---	---	---
- D

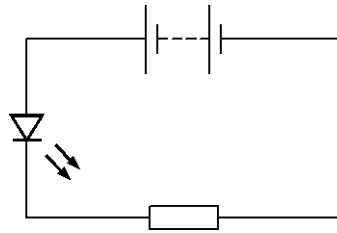
N	A	N	A	N
---	---	---	---	---

Your answer

[1]

4.2 Energy, Power and Resistance - EMF and PD

10. A light-emitting diode (LED) and a resistor are connected in series to a battery of negligible internal resistance.



The e.m.f. of the battery is 8.0 V. A charge of 10 C passing through the resistor transfers 60 J of energy. What is the potential difference across the LED?

- A. 2.0 V
- B. 6.0 V
- C. 8.0 V
- D. 14.0 V

Your answer

[1]

11. The p.d. across a resistor is 12 V. The power dissipated is 6.0 W.

Which statement is correct?

- A. The charge passing through the resistor in one second is 2.0 coulomb.
- B. The resistor transfers 6.0 joule for each coulomb passing through the resistor.
- C. The resistor transfers 12 joule in 2.0 second.
- D. The resistor dissipates 6.0 joule when the current is 2.0 ampere.

Your answer

[1]

12. A battery of e.m.f. of 8.0 V and internal resistance $2.5\ \Omega$ is connected to an external resistor. The current in the resistor is 350 mA.

What is the power dissipated in the external resistor?

- A. 1.9 W
- B. 2.5 W
- C. 2.8 W
- D. 3.1 W

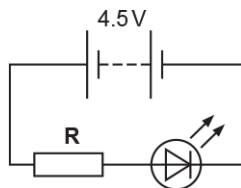
Your answer

[1]

4.2 Energy, Power and Resistance - EMF and PD

13. A light-emitting diode (LED) emits red light when it is positively biased and has a potential difference (p.d.) greater than about 1.8 V.

An LED is connected into a circuit, as shown below.



The battery has electromotive force (e.m.f.) 4.5 V and negligible internal resistance.

The resistor **R** has resistance 150 Ω .

Assume the p.d. across the LED is 1.8 V.

Calculate the ratio $\frac{\text{power dissipated by LED}}{\text{power dissipated by resistor}}$.

ratio = **[2]**

14. A filament lamp is described as being 120 V, 60 W. The lamp is connected to a supply so that it lights normally.

Which statement is correct?

- A. The charge passing through the filament in one second is 2.0 coulomb.
- B. The lamp transfers 60 joule for each coulomb passing through the filament.
- C. The lamp transfers 120 joule in 2.0 second.
- D. The supply provides 60 joule to the lamp when the current is 2.0 ampere.

Your answer

☐

[1]

4.2 Energy, Power and Resistance - EMF and PD

15. The unit of potential difference is the volt.

Use the equation $W = VQ$ to show that the volt may be written in base units as $\text{kg m}^2 \text{A}^{-1} \text{s}^{-3}$.

[3]

16(a). Electron diffraction provides evidence for the wave-like behaviour of particles. Electrons are diffracted by a thin slice of graphite.

In one experiment, electrons are accelerated from rest through a potential difference of 300 V.

Show that the final speed v of the electrons is $1.0 \times 10^7 \text{ m s}^{-1}$.

[3]

(b). Determine the de Broglie wavelength λ of the electrons.

$\lambda = \dots\dots\dots \text{ m}$ **[2]**

17. Electrons in a beam are accelerated from rest by a potential difference V between two vertical plates before entering a uniform electric field of electric field strength E between two horizontal parallel plates, a distance $2d$ apart.

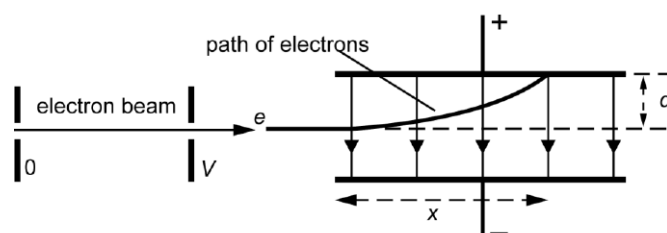


Fig. 2.1

The path of the electrons is shown in Fig. 2.1. The electron beam travels a horizontal distance x parallel to the plates before hitting the top plate. The beam has been deflected through a vertical distance d .

Show that x is related to V by the equation

$$x^2 = \frac{4dV}{E}$$

[5]

4.2 Energy, Power and Resistance - EMF and PD

18 (a). The circuit diagram shows a battery of e.m.f. E and internal resistance r connected to a variable resistor R .

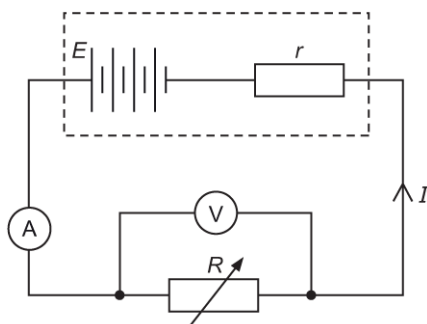


Fig. 5.1

The current I in the variable resistor is measured using an ammeter and the potential difference V across the variable resistor is measured using a voltmeter.

The resistance R of the variable resistor is varied. I and V are recorded for each value of R . A graph of V (y -axis) against I (x -axis) is plotted.

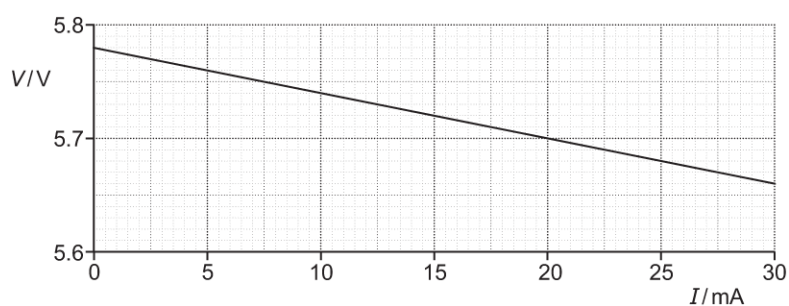


Fig. 5.2

Explain how values for E and r may be determined from the graph.
No calculations are required.

[2]

(b). The resistance of the variable resistor is now fixed. The current is 25 mA.

- i. Use the graph to determine the resistance R of the variable resistor.

$R = \dots\dots\dots \Omega$ **[1]**

4.2 Energy, Power and Resistance - EMF and PD

- ii. Calculate the energy W dissipated in the variable resistor in 5.0 minutes.

$W = \dots\dots\dots$ J [2]

- iii. Calculate the charge Q passing through the variable resistor in 5.0 minutes. Include an appropriate unit.

$Q = \dots\dots\dots$ unit $\dots\dots\dots$ [2]

19. A chemical cell is connected across a resistor.

- i. The terms electromotive force (e.m.f.) and potential difference (p.d.) are terms associated with the circuit.

State **one** similarity and **one** difference between e.m.f. and p.d.

similarity:

difference:

[2]

- ii. The resistor is cylindrical in shape. It has cross-sectional area $1.2 \times 10^{-6} \text{ m}^2$ and length $6.0 \times 10^{-3} \text{ m}$. In this resistor there are 9.6×10^{16} free electrons.
Calculate the mean drift velocity v of the electrons when the current in the resistor is 3.0 mA.

$v = \dots\dots\dots$ m s^{-1} [3]

20. Fig. 26.1 shows part of the apparatus for an experiment in which electrons pass through a thin slice of graphite (carbon atoms) and emerge to produce concentric rings on a fluorescent screen.

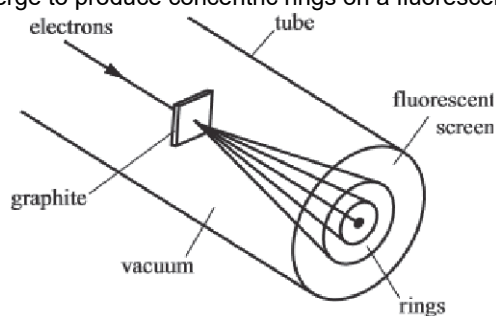


Fig. 26.1

- i. Explain how this experiment demonstrates the wave-nature of electrons.

[3]

- ii. The beam of electrons in the apparatus shown in **Fig. 26.1** is produced by accelerating electrons through a potential difference of 1200 V.

Show that the de Broglie wavelength of the electrons is 3.5×10^{-11} m.

- iii. When de Broglie first put forward his idea it was new to the scientific community. Describe one way in which they could validate his ideas.

[1]

21. A student monitors the temperature in a room by using a potential divider circuit containing a negative temperature coefficient (NTC) thermistor. The student sets up the circuit shown in Fig. 4.2.

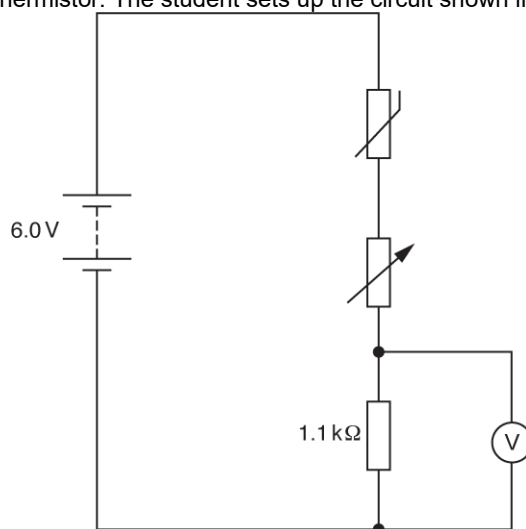


Fig. 4.2

The battery has an e.m.f. of 6.0 V and negligible internal resistance.

- i. When the temperature of the thermistor is 12 °C the thermistor has a resistance of 6.8 kΩ. The resistance of the variable resistor is set to a value of 1.4 kΩ. Calculate the reading V on the voltmeter.

$V = \dots\dots\dots$ V [2]

- ii. Explain how the reading on the voltmeter will change when the temperature of the thermistor increases.

[4]

4.2 Energy, Power and Resistance - EMF and PD

22 (a). Fig. 4 shows a circuit with five identical $60\ \Omega$ resistors. The battery has electromotive force (e.m.f.) $9.0\ \text{V}$ and negligible internal resistance.

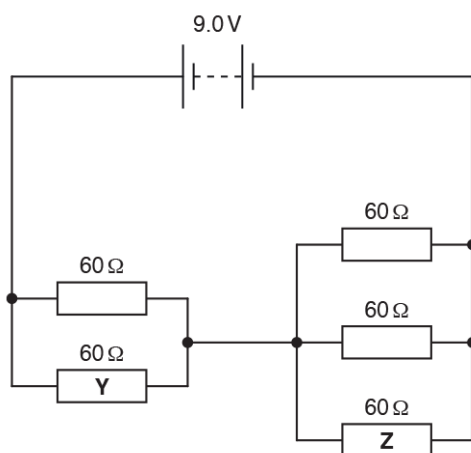


Fig. 4

- i. Show that the total resistance in the circuit is $50\ \Omega$.
Make your reasoning clear.

[2]

- ii. Calculate the potential difference V across resistor **Y**.

$V = \dots\dots\dots \text{V}$ [2]

- iii. Calculate the charge Q passing through resistor **Y** in two minutes (include an appropriate unit).

$Q = \dots\dots\dots \text{unit: } \dots\dots\dots$ [3]

- iv. Calculate the energy W dissipated in resistor **Y** in two minutes.

$W = \dots\dots\dots \text{J}$ [1]

4.2 Energy, Power and Resistance - EMF and PD

(b). Explain how the mean drift velocity of electrons in resistor **Y** compares with the mean drift velocity of electrons in resistor **Z**.

[3]

23. A researcher is investigating the de Broglie wavelength of charged particles.

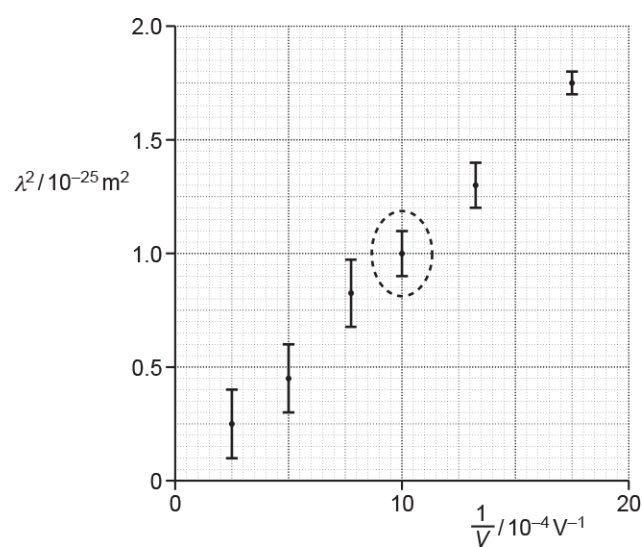
The charged particles are accelerated through a potential difference V . The de Broglie wavelength λ of these particles is then determined by the researcher.

Each particle has mass m and charge q .

- i. Show that the de Broglie wavelength λ is given by the expression $\lambda^2 = \frac{h^2}{2mq} \times \frac{1}{V}$.

[2]

- ii. The researcher plots data points on a λ^2 against $\frac{1}{V}$ grid, as shown below.



- 1** Calculate the percentage uncertainty in λ for the data point circled on the grid.

percentage uncertainty = % **[2]**

- 2** Draw a straight line of best fit through the data points. **[1]**

- 3** The charge q on the particle is $2e$, where e is the elementary charge.

Use your best fit straight line to show that the mass m of the particle is about 10^{-26} kg.

[4]

END OF QUESTION PAPER