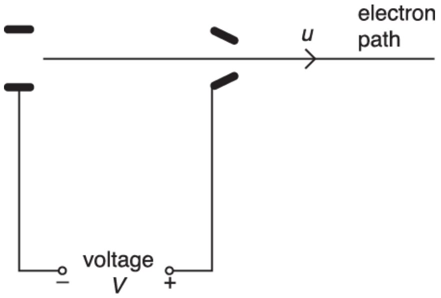
Energy, Power and Resistance EMF and PD

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

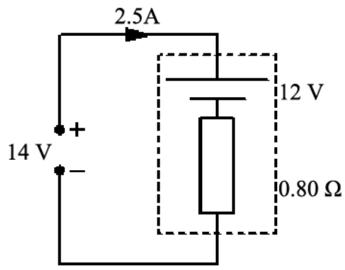
Your answer ☐ **[1]**

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. A 14 V d.c. supply is used to charge a 12 V car battery of internal resistance 0.80 Ω 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 μA.

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

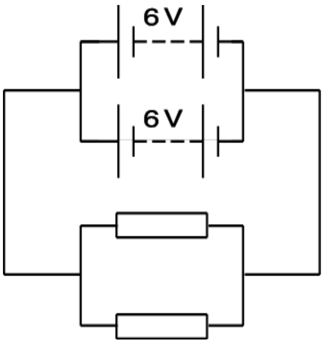
[1]

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

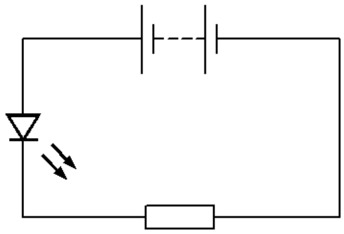
C A N A N A

D N A N A N

Your answer [ ]

[1]

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 Ω is connected to an external resistor. The current in the resistor is 350 mA.

What is the power dissipated in the external resistor?

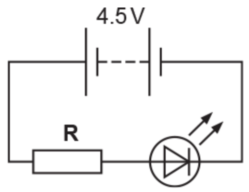
A. 1.9 W
B. 2.5 W
C. 2.8 W
D. 3.1 W

Your answer ☐

[1]

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]

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 kg m^2 A^{-1} 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 1.0×10^7 m s^{-1}.

[3]

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

λ = ... 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 2*d* apart.

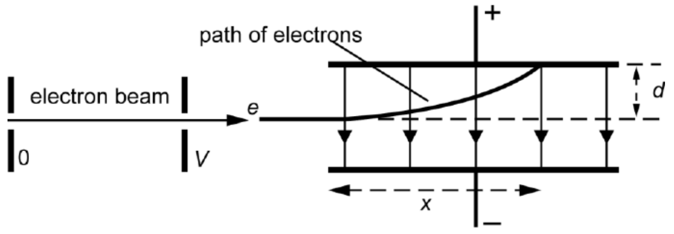


Fig. 2.1

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]

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

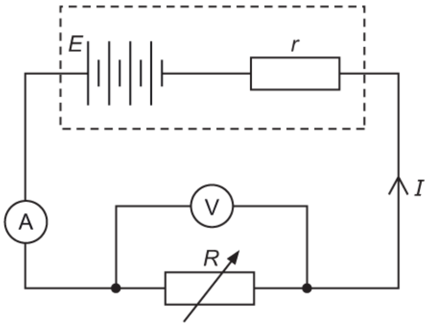


Fig. 5.1

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.

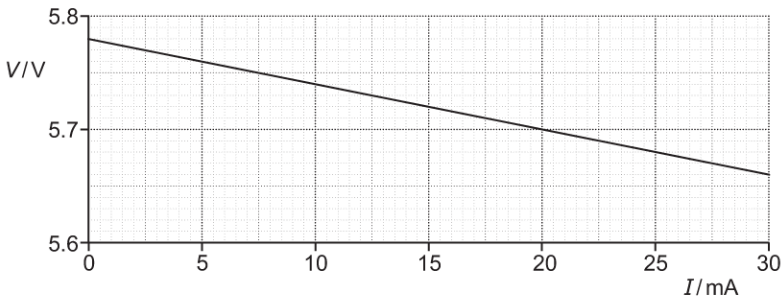


Fig. 5.2

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 = ... Ω **[1]**

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

W = ... J **[2]**

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

Q = ... unit .... **[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 1.2×10^{-6} m^2 and length 6.0×10^{-3} 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 = ... 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.

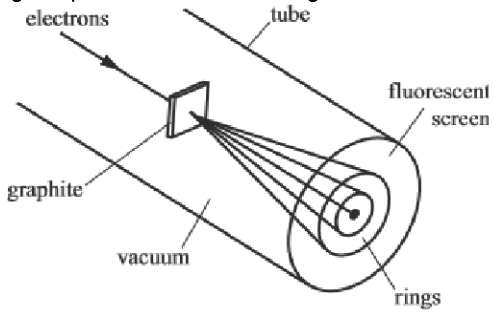


Fig. 26.1

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 x 10^{-11} m.

[2]

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.

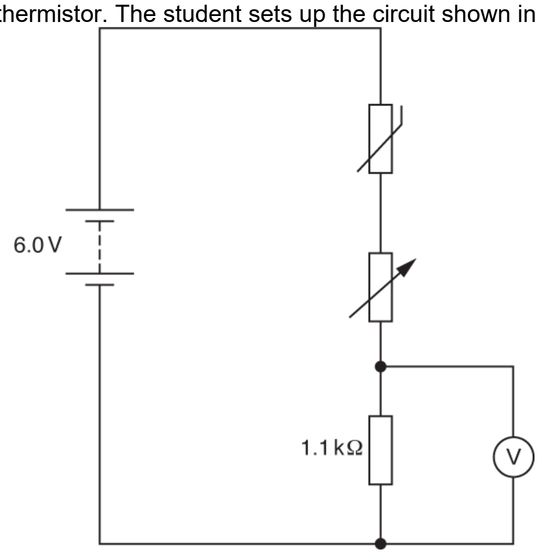


Fig. 4.2

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

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

[4]

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

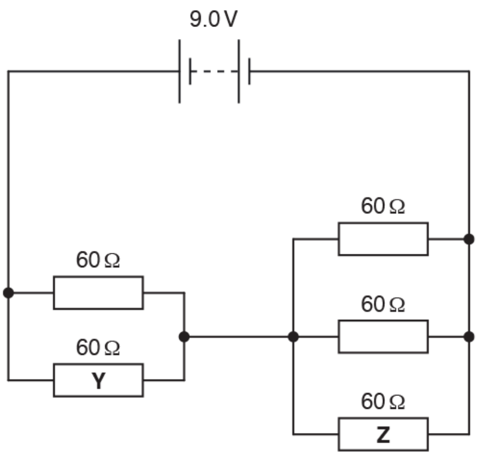


Fig. 4

i. Show that the total resistance in the circuit is 50 Ω.
Make your reasoning clear.

[2]

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

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

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

Q = ... unit: .... **[3]**

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

W = ... J **[1]**

(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.

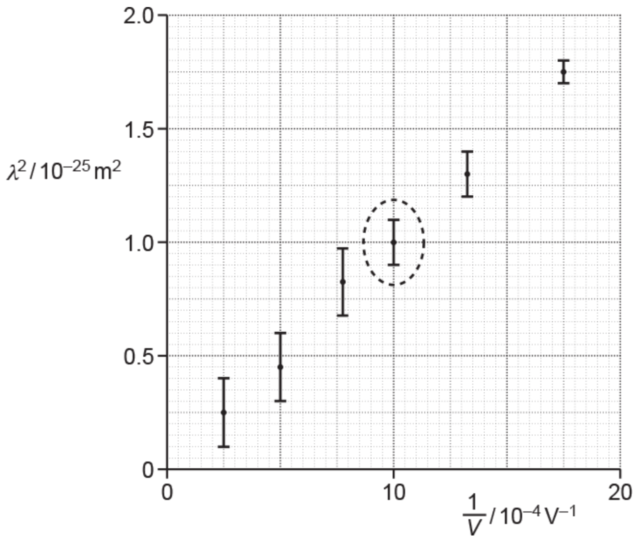
The charged particles are accelerated through a potential difference *V*. The de Broglie wavelength *λ* of these particles is then determined by the researcher.

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