Past-paper walk-through

Resistance and resistivity ▪ 9.3

eXercise

Questions in this set

- 9702/11 N25 Q33 ▪ 1 mark
- 9702/12 N25 Q33 ▪ 1 mark
- 9702/14 N25 Q32 ▪ 1 mark
- 9702/14 N25 Q34 ▪ 1 mark
- 9702/24 N25 Q5 ▪ 10 marks
- 9702/11 J25 Q32 ▪ 1 mark
- 9702/11 J25 Q33 ▪ 1 mark
- 9702/11 J25 Q35 ▪ 1 mark
- 9702/12 J25 Q33 ▪ 1 mark
- 9702/13 J25 Q34 ▪ 1 mark

Questions in this set

- 9702/23 J25 Q7 ▪ 8 marks
- 9702/24 J25 Q5 ▪ 8 marks

Reading the mark scheme

- **B1** a mark that stands on its own – the point is either made or not.
- **M1** a *method* mark: the right approach, even if the number is wrong.
- **A1** an *answer* mark, and it usually needs its M mark first.
- **C1** a working mark on the way to the answer.
- // separates answers the examiner accepts equally.
- **ecf** = error carried forward: a later part is marked on your own earlier answer.
- **owtte** = "or words to that effect" – the wording need not match.

Question 33

9702/11 N25 ▪ Q33 ▪ 1 mark

The graphs show possible current–voltage (I–V) characteristics for a filament lamp and for a semiconductor diode.

Which row identifies the I–V graphs for the lamp and for the diode? **[1]**

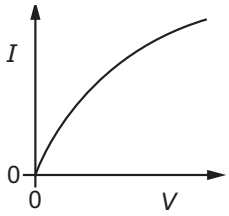
A filament lamp: P; semiconductor diode: R

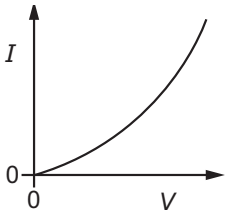
B filament lamp: P; semiconductor diode: S

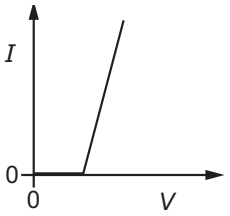
C filament lamp: Q; semiconductor diode: R

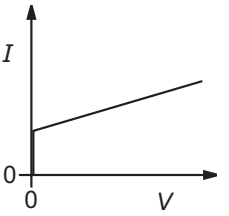
D filament lamp: Q; semiconductor diode: S

Question 33









Question 33

	filament lamp	semiconductor diode
A	P	R
B	P	S
C	Q	R
D	Q	S

Solution 33

A filament lamp: P; semiconductor diode: R ✓

B filament lamp: P; semiconductor diode: S

C filament lamp: Q; semiconductor diode: R

D filament lamp: Q; semiconductor diode: S

Why

- A filament lamp heats up as the current rises, so its resistance grows and the graph bends towards the voltage axis – symmetrically about the origin.
- A diode conducts one way only: flat for reverse voltage, rising sharply past a forward threshold.
- So take the symmetric S-shape for the lamp and the one-sided curve for the diode.

Question 33

9702/12 N25 ▪ Q33 ▪ 1 mark

33 A piece of wire X has resistivity ρ, length L and cross-sectional area A. Wire X has a resistance R.

A second piece of wire Y is made of a different metal. It has the same resistance as X but has twice the length of X.

Which row gives possible values for the resistivity and the cross-sectional area of Y?

	resistivity	cross-sectional area
A	$\frac{1}{2}\rho$	$\frac{1}{2}A$
B	$\frac{1}{2}\rho$	A
C	ρ	$\frac{1}{2}A$
D	2ρ	A

Question 33

Solution 33

Answer: **B**

Why

- $R = \rho L/A$ for X, and Y must give the same R with length $2L$.
- So $\rho_Y(2L)/A_Y = \rho L/A$, which means $\rho_Y/A_Y = \rho/2A$.
- Halving the resistivity while keeping the same area does exactly that.

Question 32

9702/14 N25 ▪ Q32 ▪ 1 mark

Which component has the *I*–*V* graph shown? **[1]**

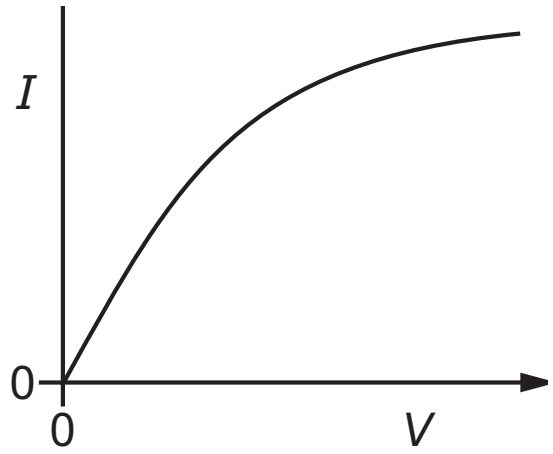
A filament lamp

B metallic conductor at constant temperature

C resistor of fixed resistance

D semiconductor diode

Question 32



Solution 32

A filament lamp ✓

B metallic conductor at constant temperature

C resistor of fixed resistance

D semiconductor diode

Why

- As the current rises the filament heats up, so its resistance increases.
- The graph therefore bends towards the voltage axis instead of staying straight.
- It is still symmetric about the origin, which rules out a diode; a fixed resistor would give a straight line.

Question 34

9702/14 N25 ▪ Q34 ▪ 1 mark

A copper wire of length 2 m has a circular cross-section. There is a constant current in the wire when it is connected to a mobile phone in order to charge the battery.
The wire has a fault. A 1 m length of the wire has half the diameter of the other 1 m length.
The power dissipated in the thicker length of wire is P.
What is the power dissipated in the thinner length of wire? **[1]**

A $\frac{1}{4}P$

B $\frac{1}{2}P$

C $2P$

D $4P$

Solution 34

A $\frac{1}{4}P$

B $\frac{1}{2}P$

C $2P$

D $4P$ ✓

Why

- Halving the diameter quarters the cross-sectional area, so that metre has four times the resistance.
- The two lengths are in series, so exactly the same current flows in both.
- $P = I^2R$, so the thinner metre dissipates $4P$.

Question 5

9702/24 N25 ▪ Q5 ▪ 10 marks

A student uses a circuit containing an ammeter, a voltmeter and a cell to take measurements to determine the resistance of a length of nichrome wire.

(a)(i) Define resistance. **[1]**

(a)(ii) Draw a circuit diagram to show how the components should be connected. Use the symbol for a resistor to represent the nichrome wire. **[2]**

(b)(i) Show that the resistance of the wire is $5.00\ \Omega$. **[1]**

(b)(ii) Calculate, to three significant figures, the resistivity ρ of the nichrome. **[3]**

(b)(iii) Calculate the percentage uncertainty in ρ. **[2]**

(b)(iv) Determine the absolute uncertainty in ρ. **[1]**

Question 5

quantity	measurement
length	$(0.864 \pm 0.001)\,\mathrm{m}$
diameter	$(0.496 \pm 0.002)\,\mathrm{mm}$
voltmeter reading	$(1.38 \pm 0.02)\,\mathrm{V}$
ammeter reading	$(0.276 \pm 0.001)\,\mathrm{A}$

Solution 5

(a)(i)

Mark scheme

- potential difference per unit current B1

Solution 5

(a)(ii) Worked steps

- Draw one closed loop: cell, ammeter and the resistor (the nichrome wire) in **series**.
- Put the voltmeter in **parallel** across the resistor only.
- Use the standard symbols throughout, and label the meters A and V.

Solution 5

Why that way round: an ammeter must carry the current you are measuring, so it goes in the loop; a voltmeter measures the p.d. across a component, so it goes beside it.

Mark scheme

- resistor connected to cell in a closed loop and correct circuit symbols used for all components **B1**
- ammeter connected in series with resistor and voltmeter connected in parallel with resistor **B1**

Solution 5

(b)(i)

Worked steps

- $R = \dfrac{V}{I} = \dfrac{1.38}{0.276}$
- $R = 5.00\ \Omega$, as required.

Mark scheme

- (resistance) = 1.38 / 0.276 = 5.00 (Ω) **A1**

Solution 5

(b)(ii) Worked steps

- $R = \dfrac{\rho L}{A}$, so $\rho = \dfrac{RA}{L}$.
- The wire is circular and the **diameter** $d = 0.496$ mm is given, so $A = \dfrac{\pi d^2}{4}$.
- $\rho = \dfrac{5.00 \times \pi \times (0.496 \times 10^{-3})^2}{4 \times 0.864}$
- $\rho = 1.12 \times 10^{-6}\ \Omega$ m (3 s.f.)

Solution 5

Mark scheme

- $\rho = \text{RA} / \text{L}$ C1
- $\rho = 5.00 \times \pi \times (0.496 \times 10–3)2 / (4 \times 0.864)$ C1
- $= 1.12 \times 10–6\ \Omega\ \text{m}$ A1

Solution 5

(b)(iii) Worked steps

For a product or quotient, **add** the percentage uncertainties; a squared quantity counts twice.

- Length: $\dfrac{0.001}{0.864} = 0.12\%$
- Diameter, counted twice because it is squared: $2 \times \dfrac{0.002}{0.496} = 0.81\%$
- Voltage: $\dfrac{0.02}{1.38} = 1.4\%$
- Current: $\dfrac{0.001}{0.276} = 0.36\%$
- Total $= 0.12 + 0.81 + 1.4 + 0.36 \approx 2.7\%$

Solution 5

Mark scheme

- calculation of a fractional or percentage uncertainty in one quantity
- 0.001 / 0.864 or 0.002 / 0.496 or 0.02 / 1.38 or 0.001 / 0.276 **C1**
- percentage uncertainty $= [(0.001 / 0.864) + (2 \times 0.002 / 0.496) + (0.02 / 1.38) + (0.001 / 0.276)] \times 100$
- $= 2.7\%$ **A1**

Solution 5

(b)(iv)

Worked steps

- Absolute uncertainty = percentage × value = $0.027 \times 1.12 \times 10^{-6}$
- $\Delta\rho = 3 \times 10^{-8}$ Ω m (one significant figure, as an uncertainty should be).

Mark scheme

- $\Delta\rho$ = 0.03 × 1.12 × 10–6
- = 3 × 10–8 Ω m **A1**

Question 32

9702/11 J25 ▪ Q32 ▪ 1 mark

Which expression gives the definition of resistance? **[1]**

A current divided by potential difference

B current multiplied by potential difference

C potential difference divided by current

D resistivity multiplied by length

Solution 32

A current divided by potential difference

B current multiplied by potential difference

C potential difference divided by current ✓

D resistivity multiplied by length

Why

- Resistance is defined as potential difference divided by current, $R = V/I$.
- A is the reciprocal of that, and B has the units of power.
- D is only part of the resistivity formula, which also needs the cross-sectional area.

Question 33

9702/11 J25 ▪ Q33 ▪ 1 mark

The graph shows the *I*–*V* characteristic of an electrical component.
What is the component? **[1]**

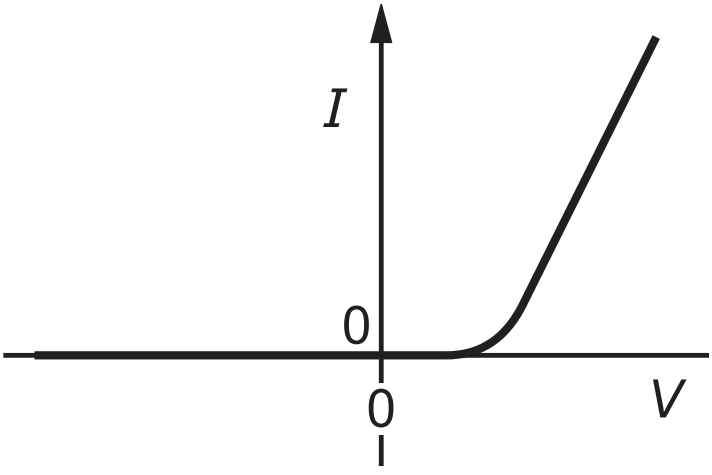
A a filament lamp

B a metallic conductor at constant temperature

C a resistor

D a semiconductor diode

Question 33



Solution 33

A a filament lamp

B a metallic conductor at constant temperature

C a resistor

D a semiconductor diode ✓

Why

- A diode conducts in one direction only.
- So the graph stays flat for reverse voltage and rises steeply past a forward threshold.
- That asymmetry about the origin is the giveaway; a resistor gives a straight line and a filament lamp a symmetric curve.

Question 35

9702/11 J25 ▪ Q35 ▪ 1 mark

The diagram shows a circuit containing a thermistor, a fixed resistor and a battery.
The graph shows the $I - V$ characteristics of both components.
The battery has an e.m.f. of 12 V and negligible internal resistance.
What is the current in the fixed resistor? **[1]**

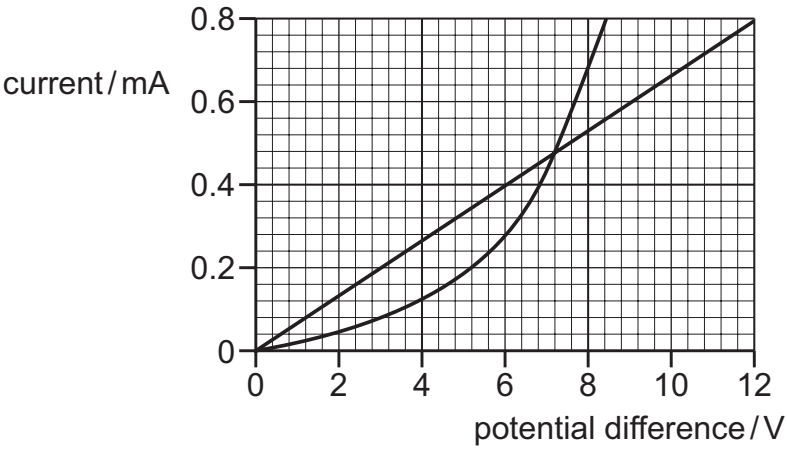
A 0.36 mA

B 0.40 mA

C 0.48 mA

D 0.80 mA

Question 35



Solution 35

A 0.36 mA ✓

B 0.40 mA

C 0.48 mA

D 0.80 mA

Why

- In series the current is the same in both components, and their p.d.s must add to 12 V.
- So look along the graph for the current at which the thermistor's voltage plus the resistor's voltage is 12 V.
- That happens at 0.36 mA – neither component is ohmic, so you cannot simply use V/R.

Question 33

9702/12 J25 ▪ Q33 ▪ 1 mark

The $I - V$ characteristics for three electrical components are shown.

Which components obey Ohm's law? **[1]**

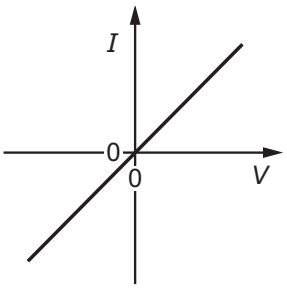
A 1, 2 and 3

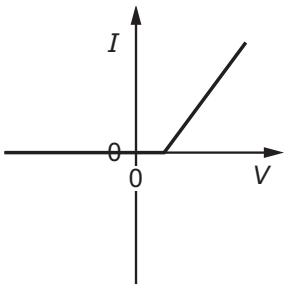
B 1 and 2 only

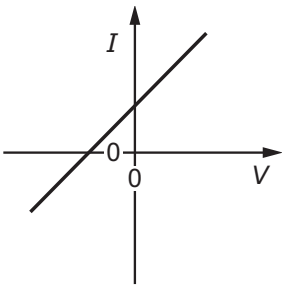
C 1 and 3 only

D 1 only

Question 33







Solution 33

A 1, 2 and 3

B 1 and 2 only

C 1 and 3 only

D 1 only ✓

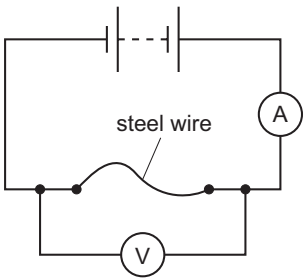
Why

- Ohm's law requires the current to be *proportional* to the p.d. – a straight line through the origin.
- Only the first graph is such a line.
- A curve, or a straight line that misses the origin, is not ohmic.

Question 34

9702/13 J25 ▪ Q34 ▪ 1 mark

34 A steel wire with a length of 2.20 m is connected to a battery as shown.



The reading on the voltmeter is 1.50 V and the reading on the ammeter is 4.90 A.

Question 34

The resistivity of steel is $6.90 \times 10^{-7}\,\Omega\,\text{m}$.

What is the diameter of the steel wire?

A $1.76 \times 10^{-4}\,\text{m}$ **B** $3.52 \times 10^{-4}\,\text{m}$ **C** $1.26 \times 10^{-3}\,\text{m}$ **D** $2.51 \times 10^{-3}\,\text{m}$

Solution 34

Answer: **D**

Why

- $R = V/I = 1.50/4.90 = 0.306\ \Omega$.
- $A = \rho L/R = (6.90 \times 10^{-7})(2.20)/0.306 = 4.96 \times 10^{-6}$ m^2.
- $d = \sqrt{4A/\pi} = 2.5 \times 10^{-3}$ m; C is the radius, from dropping the factor of 4.

Question 7

9702/23 J25 ▪ Q7 ▪ 8 marks

7 A nichrome resistance wire has length 150 cm, cross-sectional area 2.45 × 10−7 m2 and resistivity 1.12 × 10−6 Ω m.

(a) Calculate, to three significant figures, the resistance of the wire.

resistance = Ω [3]

(b) The nichrome wire forms part of a potentiometer circuit together with a cell of electromotive force (e.m.f.) 1.2 V and negligible internal resistance, as shown in Fig. 7.1. 1.2 V 150 cm 64 cm cell X nichrome wire Fig. 7.1 (not to scale)

The circuit is used to determine the e.m.f. of cell X.

The galvanometer is used in a null method to find the null point 64 cm from the left-hand end of the nichrome wire.

(i) Explain what is meant by a null method [1] , ,

(ii) Calculate the e.m.f. of cell X.

Question 7

e.m.f. = V [2]

(iii) The cell of e.m.f. 1.2 V is replaced by a new cell with the same e.m.f. but with an internal resistance that is not negligible.

State and explain the effect, if any, of the internal resistance of the new cell on the position of the null point [2]

, ,

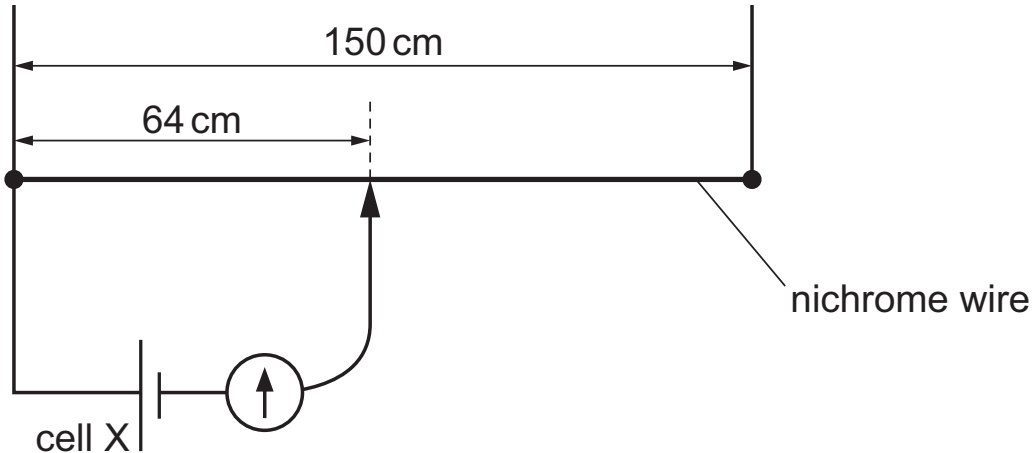
(a) Calculate, to three significant figures, the resistance of the wire. **[3]**

(b)(i) The nichrome wire forms part of a potentiometer circuit together with a cell of electromotive force (e.m.f.) 1.2 V and negligible internal resistance. State how the balance point is found. **[1]**

(b)(ii) The balance length is 64 cm. Calculate the e.m.f. of the second cell. **[2]**

(b)(iii) State and explain the effect on the position of the balance point if the 1.2 V cell had appreciable internal resistance. **[2]**

Question 7



Solution 7

(a) Worked steps

- $R = \dfrac{\rho L}{A}$, with the length in **metres**: $L = 150$ cm $= 1.5$ m.
- $R = \dfrac{1.12 \times 10^{-6} \times 1.5}{2.45 \times 10^{-7}}$
- $R = 6.86\ \Omega$ (3 s.f.)

Solution 7

Mark scheme

- $R = \rho L / A$
- $= (1.12 \times 10{-}6 \times 1.5) / 2.45 \times 10{-}7$
- $= 6.86\,\Omega$

Solution 7

(b)(i)

Worked steps

- Move the sliding contact until the galvanometer reads **zero**.
- At that null point no current flows through the cell being tested, so its e.m.f. is being compared directly against the p.d. along the wire.

Mark scheme

- (A method where the) reading (on the galvanometer) is zero.
- 9702/23
- May/June 2025

Solution 7

(b)(ii) Worked steps

The wire is uniform, so p.d. is proportional to length along it.

- $\frac{E}{1.2} = \frac{64}{150}$
- $E = \frac{64}{150} \times 1.2$
- $E = 0.51$ V

Solution 7

Mark scheme

- e.m.f. / 1.2 = 64 / 150
- e.m.f. = $(64 / 150) \times 1.2$
- = $0.51\,\text{V}$

Solution 7

(b)(iii)

Worked steps

- With internal resistance, some of the 1.2 V is dropped inside the cell, so the p.d. across the whole wire is **less** than 1.2 V.
- Each centimetre of wire therefore carries a smaller p.d., so a **longer** length is needed to balance the same e.m.f.
- The balance point moves further along the wire (to the right).

Mark scheme

- (the internal resistance will cause a) drop in p.d. across the wire / the terminal p.d. is lower
- So the null point will move to the right

Question 5

9702/24 J25 ▪ Q5 ▪ 8 marks

(a) (i) State and explain the effect, if any, on the resistance of a filament wire in a lamp as the current in the wire decreases.

(a)(i) State and explain the effect, if any, on the resistance of a filament wire in a lamp as the current in the wire decreases. **[1]**

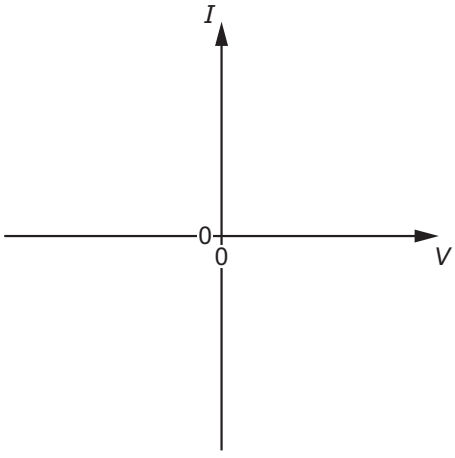
(a)(ii) On Fig. 5.1, sketch the $I - V$ characteristic of a filament lamp. **[2]**

(b)(i) Calculate the e.m.f. E of the battery. **[2]**

(b)(ii) The filament wire of lamp B has a cross-sectional area of 1.4×10^{-9} m^2. The number of free (conduction) electrons per unit volume in the metal of the filament wire is 3.4×10^{28} m^{-3}.

Calculate the average drift speed of the free electrons in the filament wire of lamp B. **[3]**

Question 5



Solution 5

(a)(i)

Mark scheme

- temperature decreases, resistance decreases

Solution 5

(a)(ii)

Worked steps

A filament lamp gets hotter as the current rises, so its resistance **rises** — the graph bends over.

- Start at the origin.
- Draw a line whose gradient **decreases** as V increases (resistance $= V/I$ is rising).
- The characteristic is symmetrical, so draw the matching curve in the third quadrant.

Mark scheme

- line from origin with decreasing gradient drawn in first quadrant
- or line from origin with decreasing gradient drawn in third quadrant
- line drawn in the third or first quadrant of similar composition (straight line from origin followed by correct curve) and similar size as compared by eye to the first line

Solution 5

(b)(i) Worked steps

- $P = EI$ for the whole circuit, so $E = \dfrac{P}{I}$.
- $E = \dfrac{18}{1.5}$
- $E = 12$ V

Solution 5

Mark scheme

- $E = P/I$
- $= 18/1.5$
- $= 12$ V

Solution 5

(b)(ii) Worked steps

First find the current in lamp B — it is the branch current, not the total.

- $I_B = 3.3 - 1.5 = 1.8$ A
- Use $I = Anvq$, so $v = \dfrac{I}{Anq}$.
- $v = \dfrac{1.8}{1.4 \times 10^{-9} \times 3.4 \times 10^{28} \times 1.6 \times 10^{-19}}$
- $v = 0.24$ m s^{-1}

Solution 5

Mark scheme

- $I = 3.3 - 1.5$
- $= 1.8$
- $I = Anvq$
- $1.8 = 1.4 \times 10^{-9} \times 3.4 \times 10^{28} \times v \times 1.6 \times 10^{-19}$
- $v = 0.24$ m s^{-1}