1. 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.

2. A resistor is connected across a power supply.

Which statement is correct about the conduction electrons in this resistor?

A. They travel at the speed of light between collisions with ions.
B. They make random collisions with vibrating electrons.
C. They travel at their mean drift velocity between collisions.
D. They drift towards the positive end of the power supply.

3. The power rating of a toaster is given as 2000 W. Which of the following is **not** an equivalent power rating?

A. 2×10^{-9} TW
B. 2000 N m s^{-1}
C. 2 kJ s^{-1}
D. 2000 mJ s^{-}

4. 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

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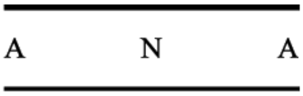
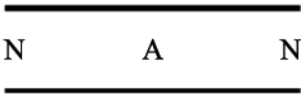
5. Stationary waves are produced in a flute when it is played. When all finger-holes are covered up, the flute can be treated as a pipe open at both ends. A flute is played so that it sounds the next harmonic above the fundamental frequency.

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

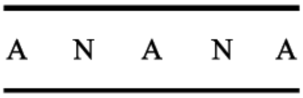
A



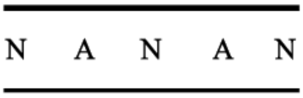
B



C



D



6. 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

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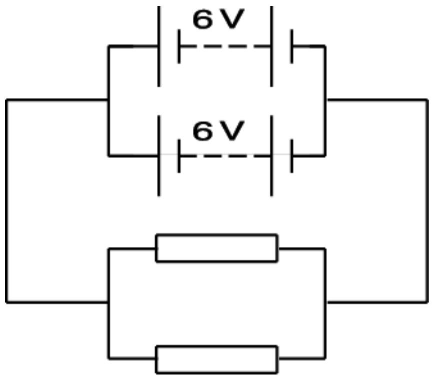
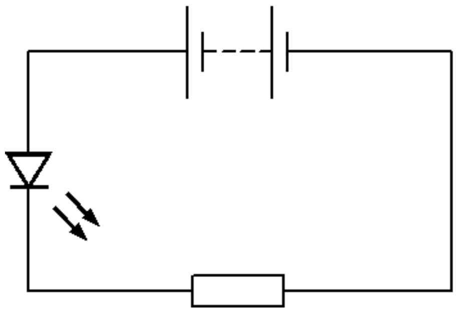
7. Two batteries, each of e.m.f 6.0 V and negligible internal resistance, are joined in parallel. The cells are connected to two identical resistors, joined in parallel.



What is the voltage across each resistor?

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

8. 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

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9. 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

10. 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

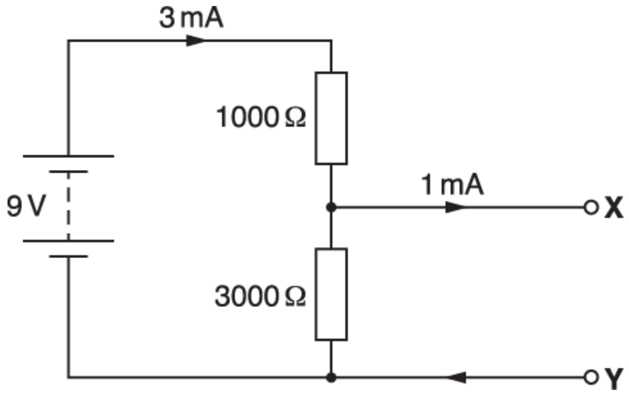
11. A student is given two identical filament lamps. Each lamp is labelled as '12 V, 24 W'. The student connects the two lamps in series across a 12 V supply of negligible internal resistance.

Which of the following statements is / are true when the lamps are in **series**?

1 The resistance of each lamp is 6.0 Ω
2 The current in the circuit is greater than 1.0 A.
3 The potential difference across each lamp is 6.0 V.

A 1, 2 and 3
B Only 2 and 3
C Only 1 and 2
D Only 2

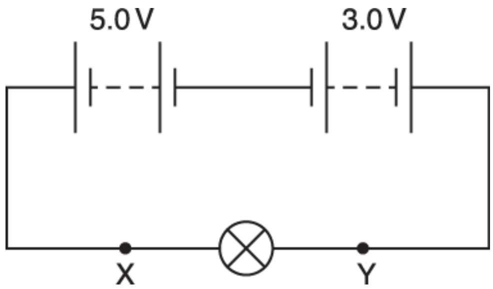
12. A 9V battery is connected to two resistors as shown. The terminals **X** and **Y** are connected to another circuit that draws a current of 1 mA. The current from the battery is 3 mA.



What is the power supplied to the circuit connected between **X** and **Y**?

A 6 mW
B 12 mW
C 18 mW
D 27 mW

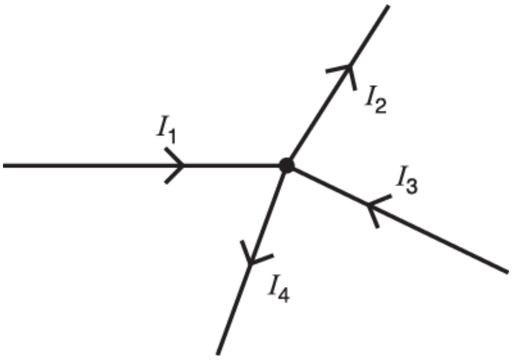
13. Two batteries are connected in a circuit with a lamp as shown.



The batteries have e.m.f. 5.0 V and 3.0 V.
Which row is correct?

	Direction of conventional current	Magnitude of current
A	clockwise	greater at Y than at X
B	clockwise	same at Y and X
C	anticlockwise	greater at X than at Y
D	anticlockwise	same at X and Y

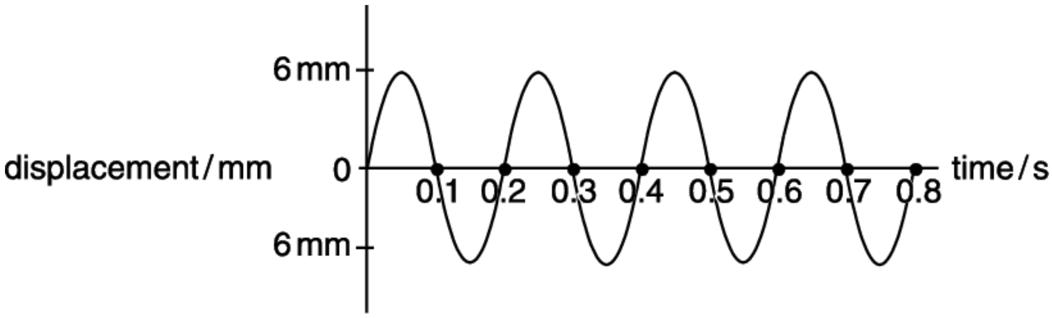
14. The diagram shows the conventional currents entering and leaving a junction in an electric circuit. I_1, I_2, I_3 and I_4 are all positive.



Which statement is always true?

A $I_1 + I_2 = I_3 + I_4$
B $I_1 - I_2 + I_3 - I_4 = 0$
C $I_1 = I_2$ and $I_3 = I_4$
D $I_1 + I_2 + I_3 + I_4 = 0$

15. The graph shows the variation of displacement with time for a progressive wave.



Which of the following statements can be deduced from the graph?

A. The frequency of the wave is 5 Hz.
B. The graph represents a transverse wave motion.
C. The amplitude of the wave is 12 mm.
D. The wavelength of the wave is 60 m.

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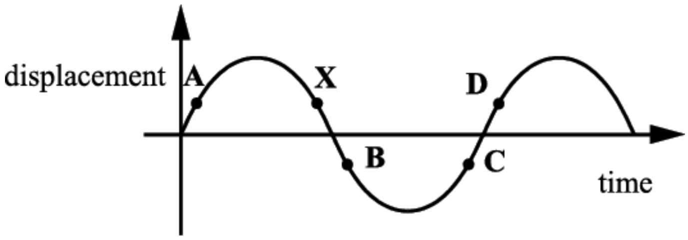
16. The diagram below shows the displacement-time graph of a particle as a progressive wave travels through a medium.



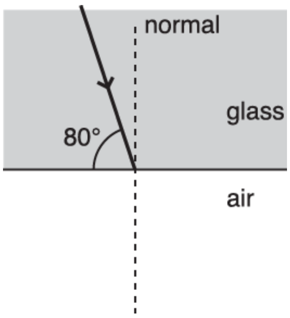
Which point **A**, **B**, **C**, or **D** has a phase difference of 180° with reference to point **X**?

17. Which of the following statements is / are true about photons?

1. The speed of a photon changes at the boundary between air and glass.
2. Photons are electrically neutral.
3. The energy of a photon depends only on its wavelength.

A. 1, 2 and 3 are correct
B. Only 1 and 2 are correct
C. Only 2 and 3 are correct
D. Only 1 is correct

19. The speed of light in air is 3.0×10^8 m s^{-1} and the speed of light in glass is 2.0×10^8 m s^{-1}. A ray of monochromatic light in glass strikes the glass-air boundary at an angle of 80° to the boundary.



What is the angle made to the normal by the ray of light leaving the boundary?

A 6.6°
B 15°
C 41°
D 49°

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19. A student views the display of a laptop screen through a polarising filter. The intensity of the light changes when the filter is rotated. Which property of light is demonstrated in this experiment?

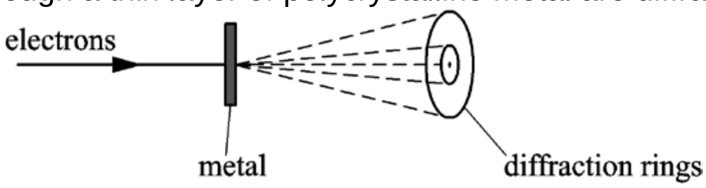
A It has wavelength of about 5×10^{-7} m.

B It travels at the speed of light.

C It is a transverse wave.

D It is a longitudinal wave.

20. Electrons travelling through a thin layer of polycrystalline metal are diffracted.



Which statement is correct about these electrons?

A. The electrons travel as photons through the metal.
B. The electrons have a wavelength of about 10^{-10} m.
C. The electrons are diffracted by holes in the metal.
D. The electrons repel each other to produce the diffraction.

21. What is the de Broglie wavelength in nm of a proton travelling at 1.5×10^{4} m s^{-1}?

A 2.6×10^{-2} nm

B 2.6 nm

C 49 nm

D 4.9×10^{4} nm

22. Electrons travelling through a thin film of carbon are diffracted.
Which statement is correct? The electrons behave like ....

A photons and are deflected by the carbon atoms.

B photons and change direction as their speed changes.

C waves and are refracted by the holes in the carbon film.

D waves of wavelength similar to the spacing between carbon atoms.

23. An electron moves in a circle of radius 2.0 cm in a uniform magnetic field of flux density 170mT. What is the momentum of this electron?

A 3.4×10^{-3} kg m s^{-1}

B 5.4×10^{-17} kg m s^{-1}

C 1.4×10^{-18} kg m s^{-1}

D 5.4×10^{-22} kg m s^{-1}

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26(a). A copper rod of cross-sectional area 3.0×10^{-4} m^2 is used to transmit large currents.
A charge of 650 C passes along the rod every 5.0 s. Calculate

i. the current *I* in the rod

I = ... A **[1]**

ii. the total number of electrons passing any point in the rod per second

number per second = ... **[1]**

iii. the mean drift velocity of the electrons in the rod given that the number density of free electrons is 1.0×10^{29} m^{-3}.

mean drift velocity = ... m s^{-1} **[2**

(b). A copper rod of cross-sectional area 3.0×10^{-4} m^2 is used to transmit large currents.
A charge of 650 C passes along the rod every 5.0 s. Calculate
The copper rod is **(b)** labelled **X** in **Fig. 4.1** and is connected to a longer thinner copper rod **Y**.

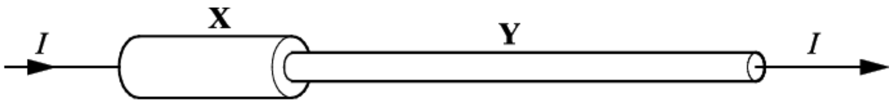

Fig. 4.1

i. State why the current in **Y** must also be *I*.

....

.... **[1]**

ii. Rod **Y** has half the cross-sectional area of rod **X**. Calculate the mean drift velocity of electrons in **Y**.

mean drift velocity = ... m s^{-1} **[1]**

27(a). The smallest conductor within a computer processing chip can be represented as a rectangular block that is one atom high, four atoms wide and twenty atoms long. One such block is shown in Fig. 3.1.

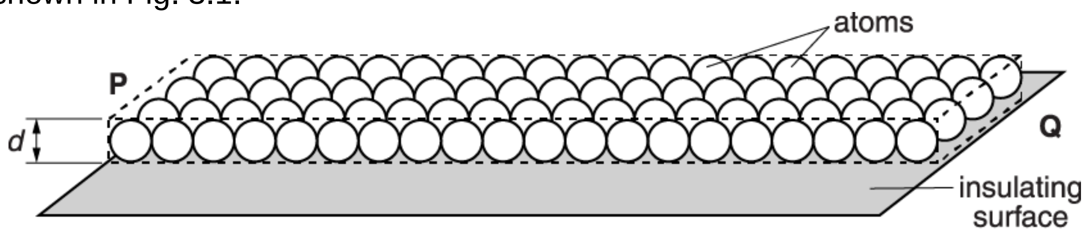

Fig. 3.1

The block is made from phosphorus atoms of diameter $d = 3.8 \times 10^{-10}$ m. The atoms are deposited on an insulating surface. This ensures that the atoms touch each other.

i. Show that the resistance between the ends **P** and **Q** of this block is greater than 200 Ω. The resistivity of phosphorus is 1.7×10^{-8} Ω m.

ii. Show that the number density of free electrons within the block is about 2×10^{28} m^{-3}. Assume that each phosphorus atom contributes one free electron.

iii. Calculate the current between **P** and **Q** when the mean drift velocity of free electrons in the block is 1.9×10^{-5} m s^{-1}.

current = ...

iv. There are about 10^9 of these tiny conductors in a single chip each carrying the current calculated in **(iii)**. Estimate the total power dissipated in these conductors in a single chip.

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power = ...

(b). The smallest conductor within a computer processing chip can be represented as a rectangular block that is one atom high, four atoms wide and twenty atoms long. One such block is shown in Fig. 3.1.

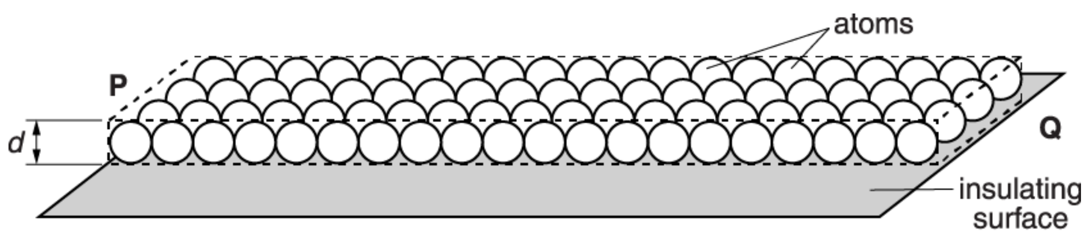


Fig. 3.1

The block is made from phosphorus atoms of diameter $d = 3.8 \times 10^{-10}$ m. The atoms are deposited on an insulating surface. This ensures that the atoms touch each other.
It takes about 4×10^{-4} s for an electron to pass from **P** to **Q** but the electrical signal, an electromagnetic wave, is transmitted across the block in about 3×10^{-17} s. Explain why these times are so different.

....

....

....

.... **[2]**

28. Fig. 4.1 shows the *I*-*V* characteristic of a blue light-emitting diode (LED).

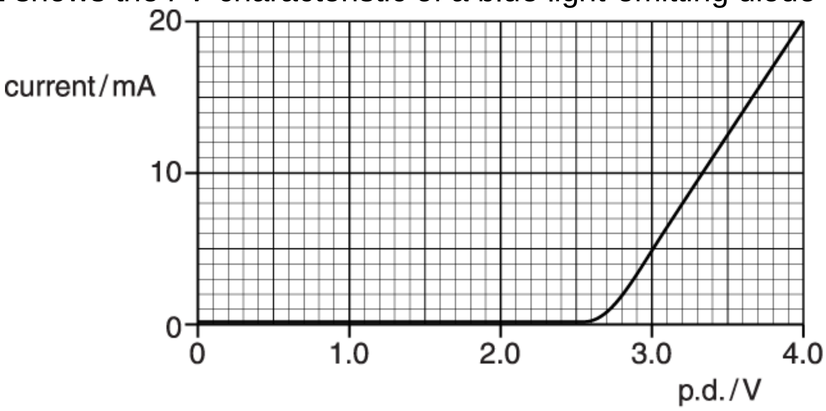


Fig. 4.1

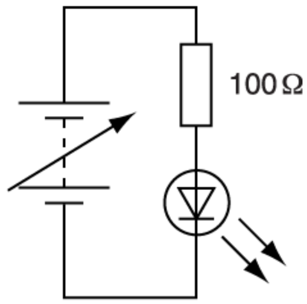


Fig. 4.2

Calculate for a current of 20 mA

i. the number *n* of electrons passing through the LED per second

n = ... s

ii. the total energy of the light emitted per second

energy per second = ... J s

iii. the efficiency of the LED in transforming electrical energy into light energy.

efficiency = ...

29. A filament lamp **X** is part of an electrical circuit. The circuit has a battery of electromotive force (e.m.f.) 6.0 V and negligible internal resistance. The potential difference across the lamp can be increased **continuously** from 0 to 6.0 V. This potential difference is measured using a voltmeter.
The lamp glows brightly at 6.0 V.

i. Draw a circuit diagram for this electrical arrangement.

[2]

ii. Describe and explain the variation of the resistance of this lamp as the potential difference across it is changed from 0 to 6.0 V.

---

[4]

iii. The filament lamp **X** is now connected in a different circuit as shown in Fig. 16.

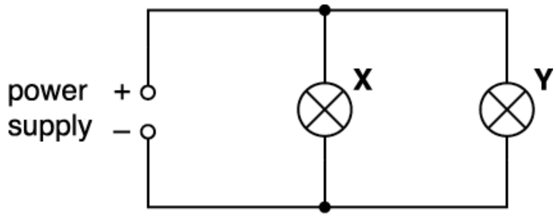


Fig. 16

The power dissipated in **X** is three times more than the power dissipated in the filamentlamp **Y**. The filament wire of lamp **X** has a diameter half that of lamp **Y**. The filament wires of **X** and **Y** are made of the same material and are at the same temperature.

Calculate the ratio

$$\frac{\text{mean drift velocity of charge carriers in lamp } \mathbf{X}}{\text{mean drift velocity of charge carriers in lamp } \mathbf{Y}}.$$

ratio = ... **[3]**

30. A battery charger contains a microprocessor circuit so that it can charge an AA rechargeable cell at a constant current of 450 mA. It takes 4 hours 40 minutes to charge a 1.5 V cell from a fully discharged state.

i. Calculate the charge Q passing through the cell during the charging process.

Q = ... unit ....

ii. Fig. 3.1 shows the cell of internal resistance 0.90 Ω connected to the battery charger. Assume that the e.m.f. of the cell is 1.5 V.

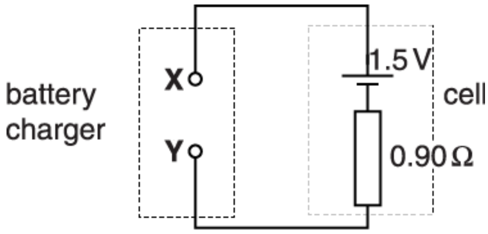


Fig. 3.1

1. State whether the terminal **X** of the battery charger is positive or negative.

   ....

2. Mark the direction of the current in the circuit on Fig. 3.1. Label your arrow *I*. Give a reason for your choice.

-- **[2]**

3. Calculate the terminal p.d. V_{XY} between **X** and **Y** during the charging process.

   V_{XY} = ...

4. Show that the mean rate of increase of energy stored in the cell during the charging process is about 0.7 J s^{-1}.

31(a). **Fig. 4.1** shows part of the $I - V$ characteristic of a silicon diode.

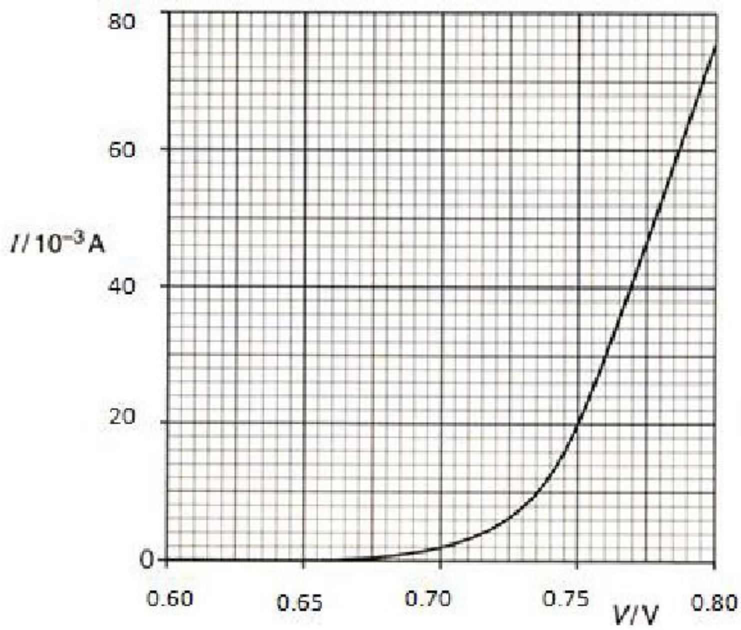


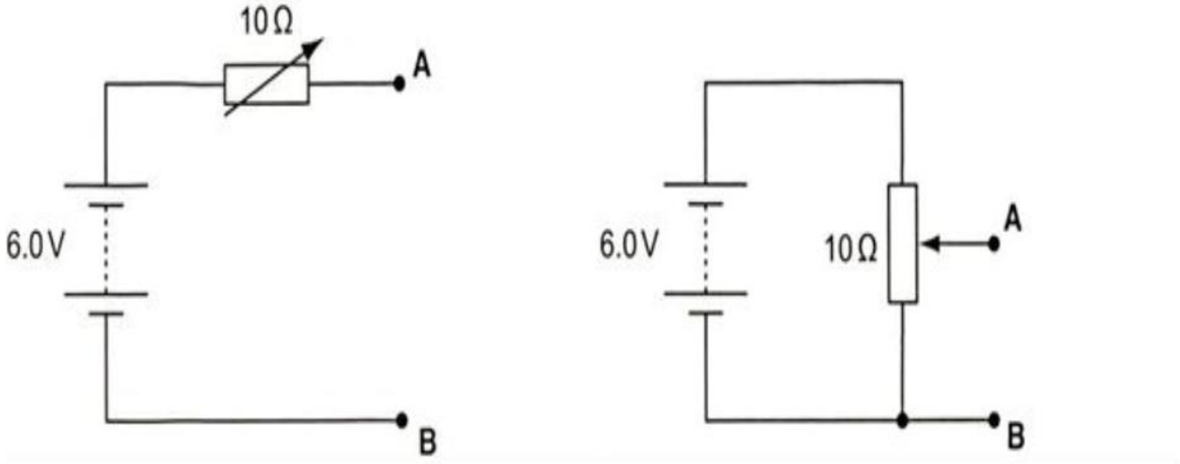
Fig. 4.1

The graph has three distinct regions, from 0.60 V to 0.65 V, 0.65 V to 0.75 V and above 0.75 V.

State and justify how the resistance of the diode increases, remains the same or decreases in each of these regions.

[5]

(b). *In order to determine the *I-V* characteristic for an LED, one student connects to the incomplete circuit **X** shown in **Fig. 4.2(a)** and a second student connects to the incomplete circuit **Y** shown in **Fig. 4.2(b).** Each adds an LED with a resistor in series and suitable meters to take the measurements between terminals **A** and **B**.



Incomplete circuit X **Fig. 4.2(a)**

Incomplete circuit Y **Fig. 4.2(b)**

Only one of these circuits is suitable to carry out the task.
Draw an LED with a 100 Ω resistor in series and suitable meters to complete the correct circuit on **Fig. 4.2(a)** or **4.2(b)**.

Explain why only one of the circuits is suitable to carry out the task and why the 100 Ω resistor has been included.

....

....

....

....

....

....

....

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....

....

.... **[6]**

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32. The circuit in Fig. 2.1 consists of a cell and five resistors.

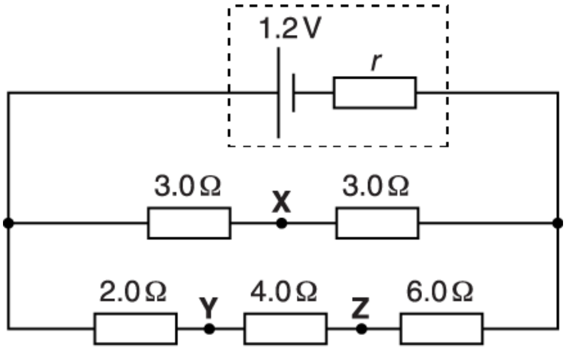

Fig. 2.1

The cell has e.m.f. 1.2 V and internal resistance *r*. The current at point **X** is 0.16 A.

i. Define *potential difference*.

[2]

ii. Explain what is meant by *internal resistance*.

[1]

iii. Explain why the current at **X** must be twice the current at **Y** or **Z**.

[2]

iv. Calculate the p.d. across the 6.0 Ω resistor.

p.d. = ...

v. Suggest why the p.d. V_{XZ} between **X** and **Z** is zero.

....

....

....

....

.... **[2]**

vi. Calculate the value of the internal resistance *r*.

r = ...

33(a). The maximum power input to a domestic fan heater is 2.6 kW when connected to the 230 V mains supply. The electric circuit of the fan heater consists of two heating elements (resistors) rated at 1.5 kW and 1.0 kW, a motor rated at 100 W and three switches. Both heating elements are made of wire of the same resistivity and length.

i. Explain, without calculation, why the diameter *d* of the 1.0 kW heater wire must be less than the diameter *D* of the 1.5 kW heater wire, designed for use with a 230 V supply.

-- **[2]**

Show that *d* is approximately equal to 0.8 *D*.

[3]

(b). i. Show that the resistance of the 1.5 kW heating element is about 35Ω.

ii. The 1.5 kW heating element is made from a wire of cross-sectional area 7.8×10^{-8} m^2 and resistivity 1.1×10^{-6} Ωm. Calculate the length of the wire.

length = ...

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34(a). A student designs a circuit to vary the brightness of a filament lamp. The circuit is shown in **Fig. 17.2**.

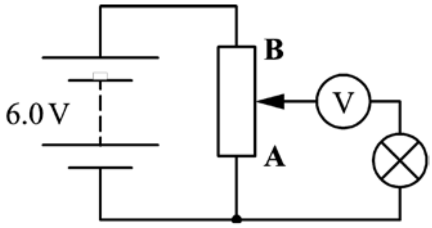

Fig. 17.2

The circuit is set up. Moving the slider from **A** to **B** changes the voltmeter reading from 0 V to 6.0 V but the lamp stays off. The lamp is not faulty.

Explain the observations above and refine the circuit design so that the brightness of the lamp can be varied as the slider is moved from **A** to **B**.

---

[3]

(b). *** Fig. 17.3** shows how the resistance of a thermistor varies with temperature.

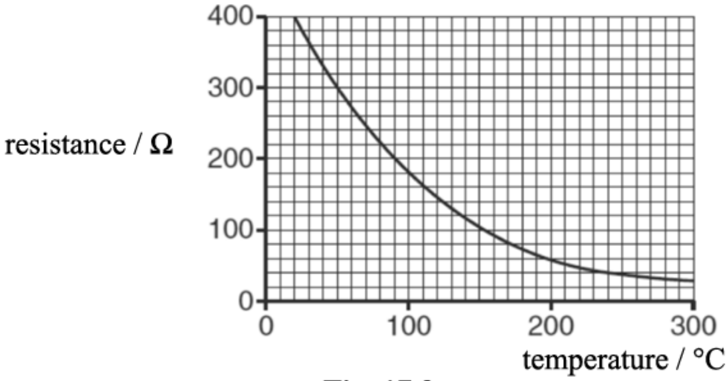

Fig. 17.3

Fig. 17.4 shows a potential divider circuit which uses this thermistor. The circuit is designed to monitor the changes in the temperature of an oven in the range 200 °C to 300 °C.

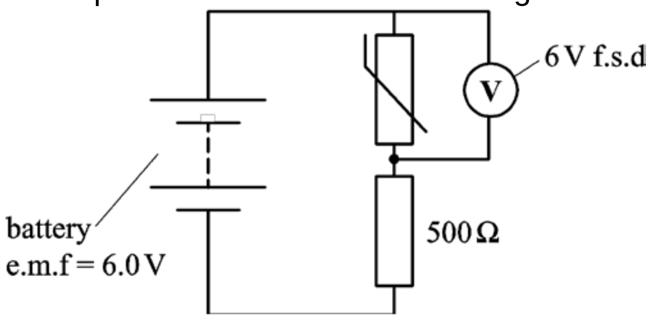

Fig. 17.4

The voltmeter has very high resistance and has a full scale deflection (f.s.d.) of 6.0 V.

Explain how the circuit works and use calculations to discuss a significant limitation of this design.

[6]

35. * Students are given a light dependent resistor (LDR) and asked to design a circuit for a light meter to monitor changes in light intensity. The meter reading must rise when the light intensity increases.

The incident light may cause the resistance of the LDR to vary between 1500 Ω and 250 Ω.

The students are asked to use the d.c. supply and one of the resistors from **(a)** above and either a voltmeter or ammeter.

Draw a suitable circuit.

Explain why the reading on the meter increases with increasing light intensity and which of the three fixed resistors gives the largest scale change on the meter for the change in light intensity.

[6]

36. A laser **A** is placed close to two slits as shown in **Fig. 25.2**.

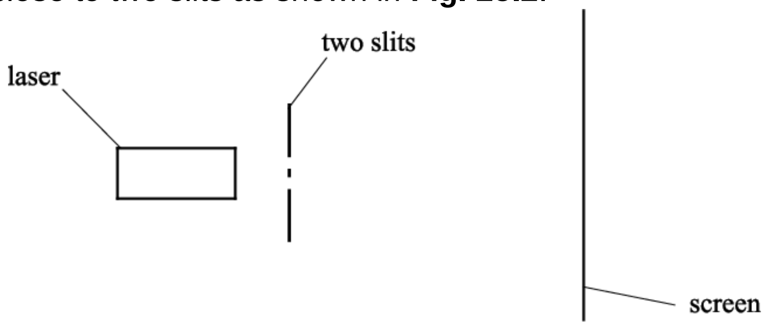

Fig. 25.2

The laser emits monochromatic light. Bright and dark fringes are observed on a screen.

i. Explain why bright and dark fringes are observed on the screen.

---

[3]

ii. The laser **A** is replaced with another laser **B**. Laser **B** emits light of a different colour with a much greater intensity. The fringe patterns observed on the screen with these two lasers are shown in **Fig. 25.3**.

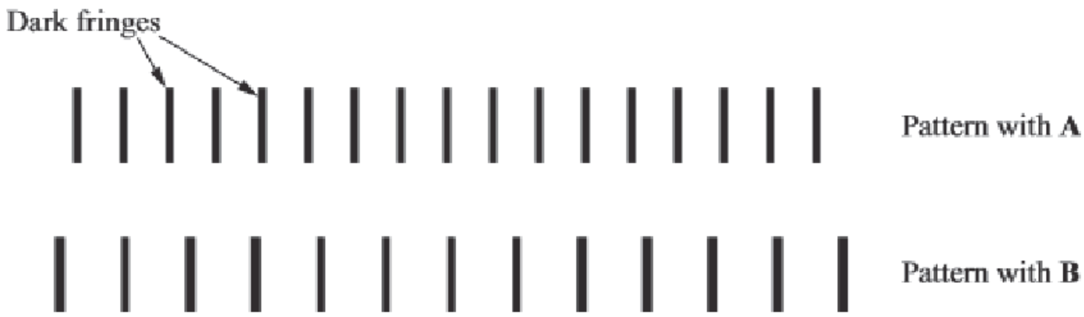

Fig. 25.3 (drawn to scale)

According to a student, laser **B** produces a more spread out fringe pattern because the intensity of its light is much greater than that of laser **A**. This suggestion is incorrect. Give the correct explanation.

---

[1]

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iii. State the effect on the pattern of light seen on the screen when one of the slits is blocked.

-- [1]

37. A puddle of water reflects sunlight. A student knows that reflected light is partially polarised. She looks at the reflected light from the puddle of water through a polarising filter, see Fig.22.2.

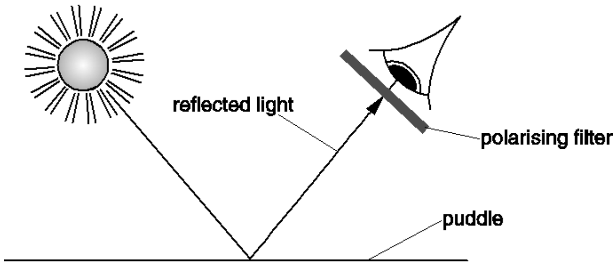

Fig. 22.2

i. Explain what is meant by the term ***polarised waves***.
You may wish to illustrate your answer with a labelled diagram.

-- [2]

ii. Describe how the student can use the polarising filter to determine if the reflected light from the puddle is partially polarised. State clearly what she should observe.

-- [3]

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38. * Students are given a glass block and a ray box to determine the refractive index of glass. The students measure the angle of incidence *i* and the angle of refraction *r*. The table shows the results collected by the students.

i / ° + 0.5°	10	20	30	40	50	60	70	80
r / ° ± 0.5°	6	13	20	25	31	35	39	41

The refractive index of air is 1.00.

Describe, with the help of a labelled diagram, how the students may have conducted the experiments in the laboratory. Discuss how you could use the data from the table to graphically determine a value for the refractive index of glass.

[6]

39(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]**

(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.

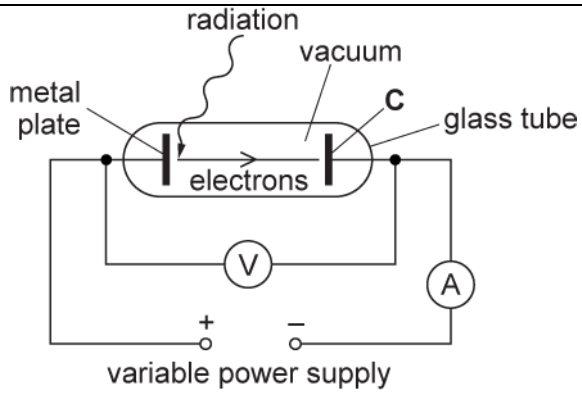

Fig. 19.1

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.

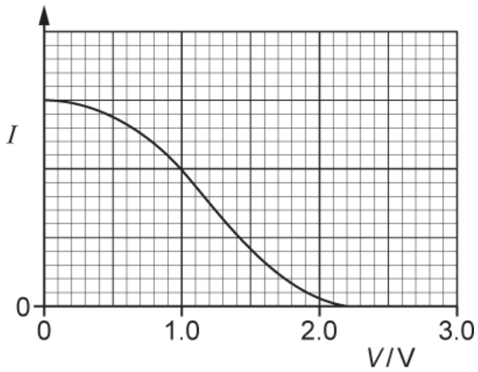

Fig. 19.2

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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....

....

.... **[3]**

40. Fig. 4.2 shows the same a section of string now held under tension between a clamp and a pulley, 80 cm apart. A mechanical oscillator is attached to the string close to the clamped end. The frequency of the mechanical oscillator is varied until the stationary wave shown is set up between the clamp and the pulley. The same four points as in Fig. 4.1 are marked on the string.

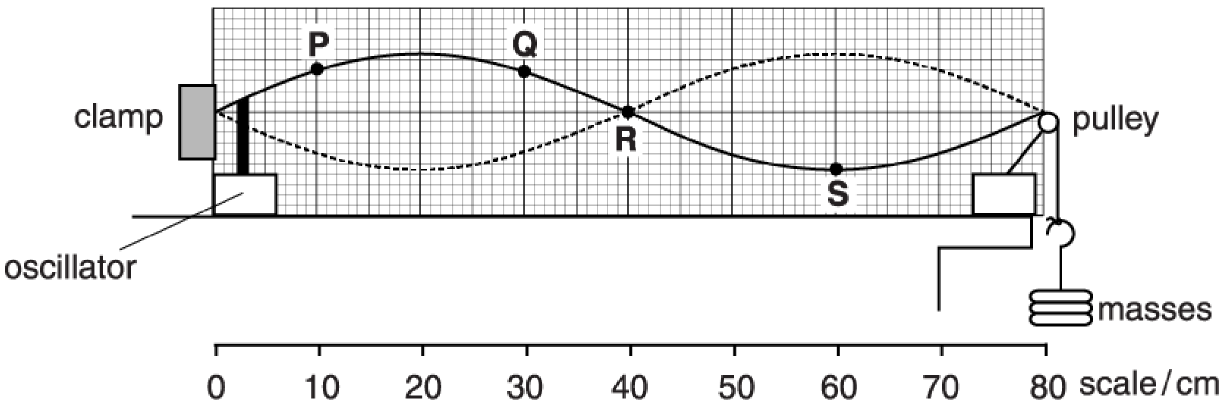

Fig. 4.2

i. Describe how a stationary wave is different from a progressive wave.

....

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....

.... **[2]**

ii. Explain how the stationary wave is formed on this string.

....

....

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....

.... **[3]**

iii. Describe, using the terms amplitude, frequency and phase difference, how the motions of the points **P**, **Q** and **S**

1. are similar,

---

2. are different.

---

iv. In Fig. 4.2 the frequency of oscillation is 30 Hz. State, with a reason, the lowest frequency of oscillation of the string at which the motions of all of the points **P**, **Q**, **R** and **S** are

1. in phase,

---

2. all at rest.

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41(a). In a demonstration experiment of the photoelectric effect, light of wavelength 440 nm incident on a clean metal surface causes electrons to be emitted. No electrons are emitted from the surface when the wavelength of the incident light is greater than 550 nm.

i. Show that the maximum speed of the emitted electrons in the experiment is about 4.5 × 105 m s^{-1}.

ii. Calculate the minimum de Broglie wavelength of an emitted electron.

wavelength = ...

(b). i. Define the term *work function*.

--- **[2]**

ii. Explain how the work function is related to the threshold frequency.

--- **[2]**

iii. Calculate the value of the work function for this metal.

work function = ...

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