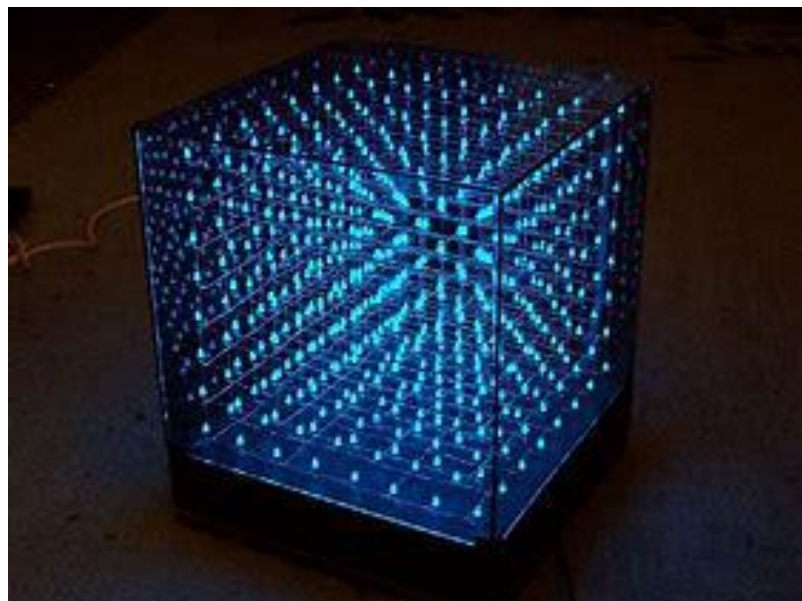


CfE Higher Physics

Electricity

2015 to 2018 Past papers



1.

A student makes the following statements about energy bands in different materials.

- I In metals the highest occupied energy band is not completely full.
- II In insulators the highest occupied energy band is full.
- III The gap between the valence band and conduction band is smaller in semiconductors than in insulators.

Which of these statements is/are correct?

- A I only
- B II only
- C I and II only
- D I and III only
- E I, II and III

2.

A student makes the following statements about conductors, insulators and semiconductors.

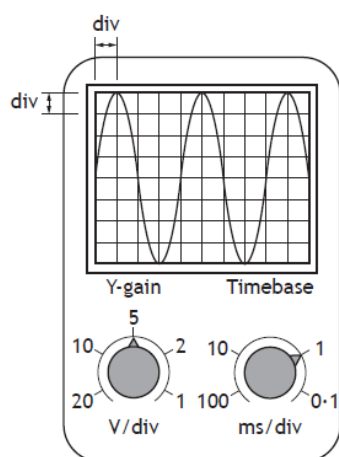
- I In conductors, the conduction band is completely filled with electrons.
- II In insulators, the gap between the valence band and the conduction band is large.
- III In semiconductors, increasing the temperature increases the conductivity.

Which of these statements is/are correct?

- A I only
- B II only
- C III only
- D I and II only
- E II and III only

3.

The output from a signal generator is connected to the input terminals of an oscilloscope. The trace observed on the oscilloscope screen, the Y-gain setting and the timebase setting are shown.

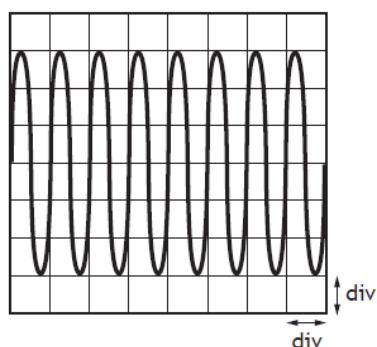


The frequency of the signal shown is calculated using the

- A timebase setting and the vertical height of the trace
- B timebase setting and the horizontal distance between the peaks of the trace
- C Y-gain setting and the vertical height of the trace
- D Y-gain setting and the horizontal distance between the peaks of the trace
- E Y-gain setting and the timebase setting.

4.

The output of a signal generator is connected to the input of an oscilloscope. The trace produced on the screen of the oscilloscope is shown.



The timebase control of the oscilloscope is set at 2 ms/div.

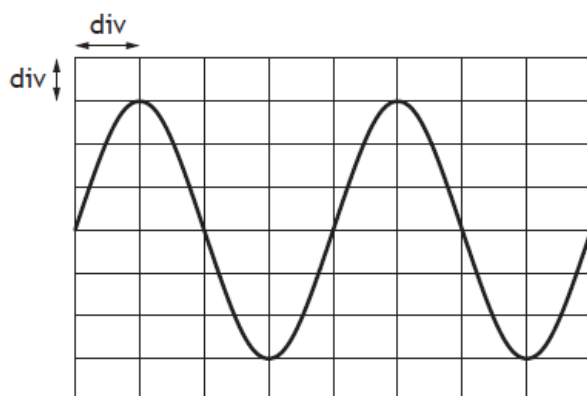
The Y-gain control of the oscilloscope is set at 4 mV/div.

Which row in the table shows the frequency and peak voltage of the output of the signal generator?

	frequency (Hz)	peak voltage (mV)
A	0.5	12
B	0.5	6
C	250	6
D	500	12
E	500	24

5.

The output from an a.c. power supply is connected to an oscilloscope. The trace seen on the oscilloscope screen is shown.



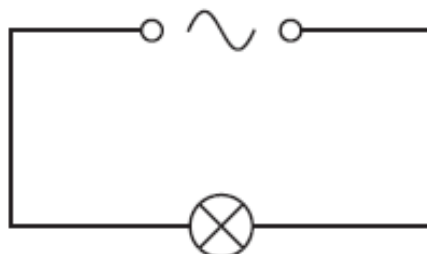
The Y-gain setting on the oscilloscope is 1.0 V/div .

The r.m.s. voltage of the power supply is

- A 2.1 V
- B 3.0 V
- C 4.0 V
- D 4.2 V
- E 6.0 V .

6.

A circuit is set up as shown.



The r.m.s voltage across the lamp is 12 V .

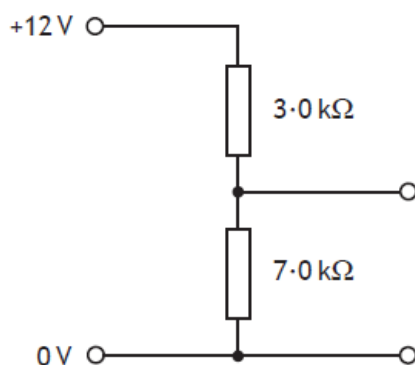
The power produced by the lamp is 24 W .

The peak current in the lamp is

- A 0.71 A
- B 1.4 A
- C 2.0 A
- D 2.8 A
- E 17 A .

7.

A potential divider circuit is set up as shown.

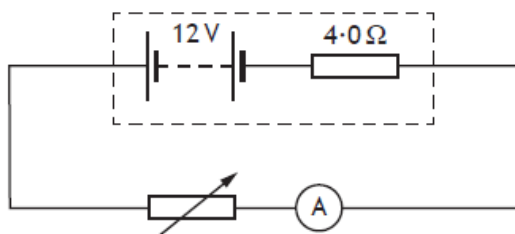


The potential difference across the $7.0\text{ k}\Omega$ resistor is

- A 3.6 V
- B 4.0 V
- C 5.1 V
- D 8.4 V
- E 9.0 V .

8.

A circuit is set up as shown.



The resistance of the variable resistor is increased and corresponding readings on the ammeter are recorded.

Resistance (Ω)	2.0	4.0	6.0	8.0
Current (A)	2.0	1.5	1.2	1.0

These results show that as the resistance of the variable resistor increases the power dissipated in the variable resistor

- A increases
- B decreases
- C remains constant
- D decreases and then increases
- E increases and then decreases.

9.

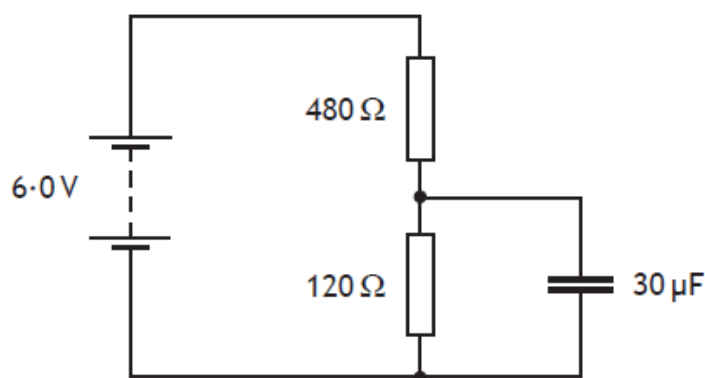
A $20\ \mu\text{F}$ capacitor is connected to a $12\ \text{V}$ d.c. supply.

The maximum charge stored on the capacitor is

- A $1.4 \times 10^{-3}\ \text{C}$
- B $2.4 \times 10^{-4}\ \text{C}$
- C $1.2 \times 10^{-4}\ \text{C}$
- D $1.7 \times 10^{-6}\ \text{C}$
- E $6.0 \times 10^{-7}\ \text{C}$.

10.

A circuit containing a capacitor is set up as shown.



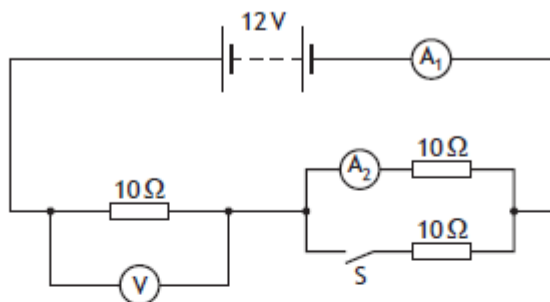
The supply has negligible internal resistance.

The maximum energy stored in the capacitor is

- A $5.4 \times 10^{-4}\ \text{J}$
- B $3.5 \times 10^{-4}\ \text{J}$
- C $1.4 \times 10^{-4}\ \text{J}$
- D $3.4 \times 10^{-5}\ \text{J}$
- E $2.2 \times 10^{-5}\ \text{J}$.

11.

A circuit is set up as shown.



The battery has negligible internal resistance.

A student makes the following statements about the readings on the meters in this circuit.

- I When switch S is open the reading on the voltmeter will be 6.0 V.
- II When switch S is open the reading on A_2 will be 0.60 A.
- III When switch S is closed the reading on A_1 will be 0.80 A.

Which of these statements is/are correct?

- A I only
- B II only
- C I and II only
- D II and III only
- E I, II and III

12.

The power dissipated in a $120\ \Omega$ resistor is 4.8 W.

The current in the resistor is

- A 0.020 A
- B 0.040 A
- C 0.20 A
- D 5.0 A
- E 25 A.

13.

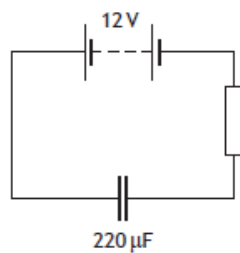
A $24.0\ \mu\text{F}$ capacitor is charged until the potential difference across it is 125 V.

The charge stored on the capacitor is

- A $5.21 \times 10^6\ \text{C}$
- B $7.75 \times 10^{-2}\ \text{C}$
- C $1.50 \times 10^{-3}\ \text{C}$
- D $3.00 \times 10^{-3}\ \text{C}$
- E $1.92 \times 10^{-7}\ \text{C}$.

14.

A circuit is set up as shown.

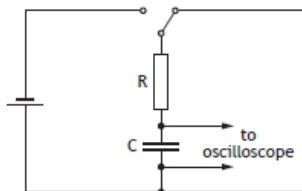


When the capacitor is fully charged the energy stored in the capacitor is

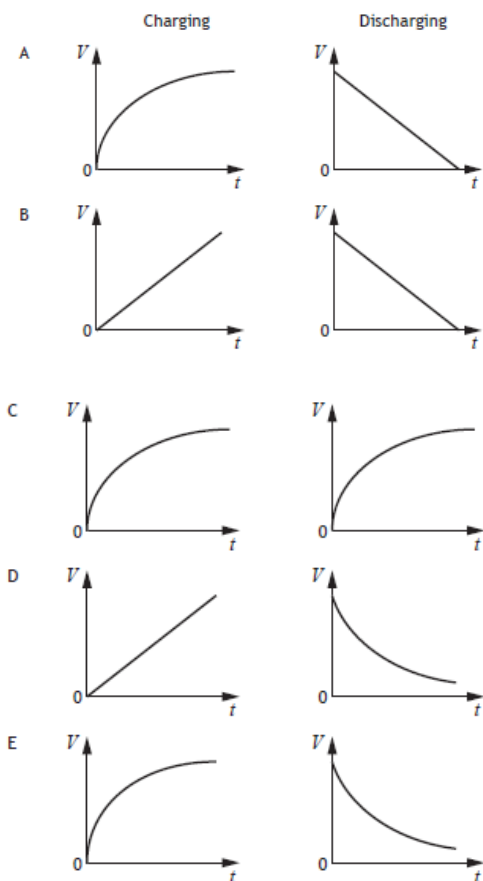
- A $1.6 \times 10^{-5} \text{ J}$
- B $1.3 \times 10^{-3} \text{ J}$
- C $2.6 \times 10^{-3} \text{ J}$
- D $1.6 \times 10^{-2} \text{ J}$
- E $1.6 \times 10^4 \text{ J}$

15.

The circuit shown is used to charge and then discharge a capacitor C.

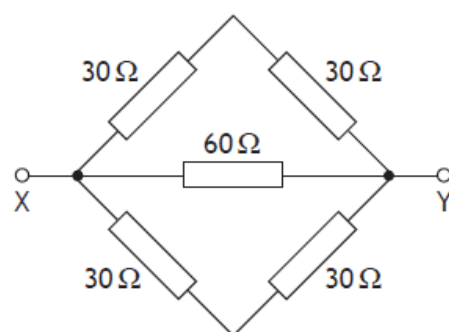


Which pair of graphs shows how the potential difference V across the capacitor varies with time t during charging and discharging?



16.

Five resistors are connected as shown.

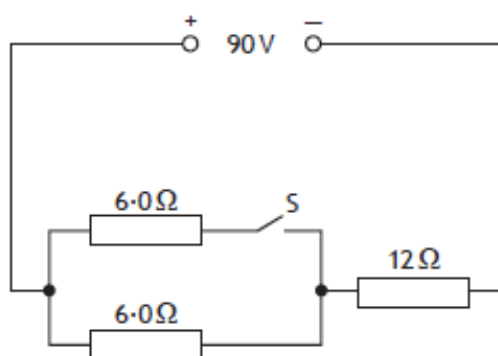


The resistance between X and Y is

- A $12\ \Omega$
- B $20\ \Omega$
- C $30\ \Omega$
- D $60\ \Omega$
- E $180\ \Omega$.

17.

A circuit is set up as shown.



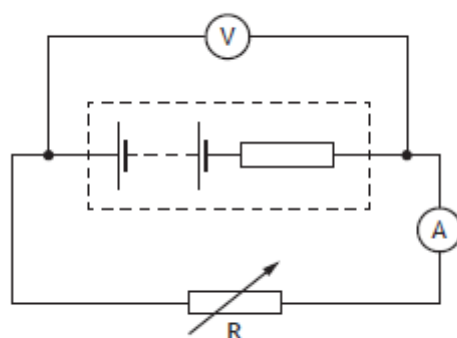
The internal resistance of the supply is negligible.

Which row in the table shows the potential difference (p.d.) across the $12\ \Omega$ resistor when switch S is open and when S is closed?

	<i>p.d. across $12\ \Omega$ resistor when S is open (V)</i>	<i>p.d. across $12\ \Omega$ resistor when S is closed (V)</i>
A	30	18
B	45	45
C	60	45
D	60	72
E	72	60

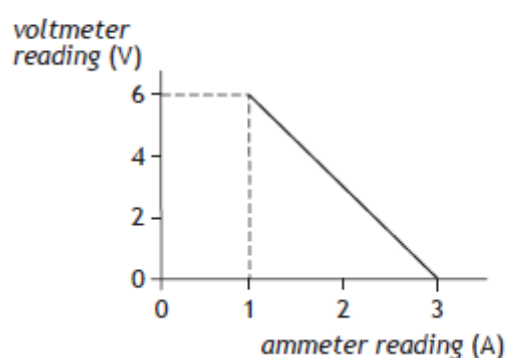
18.

A circuit is set up as shown.



The variable resistor R is adjusted and a series of readings taken from the voltmeter and ammeter.

The graph shows how the voltmeter reading varies with the ammeter reading.

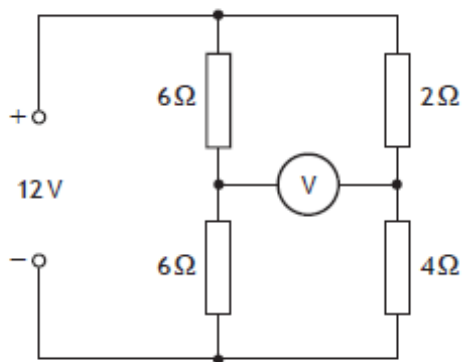


Which row in the table shows the values for the e.m.f. and internal resistance of the battery in the circuit?

	<i>e.m.f.</i> (V)	<i>internal resistance</i> (Ω)
A	6	2
B	6	3
C	9	2
D	9	3
E	9	6

19.

The following circuit is set up.



The reading on the voltmeter is

- A 0V
- B 2V
- C 6V
- D 8V
- E 12V.

20.

The upward lift force L on the wings of an aircraft is calculated using the relationship

$$L = \frac{1}{2} \rho v^2 A C_L$$

where:

- ρ is the density of air
- v is the speed of the wings through the air
- A is the area of the wings
- C_L is the coefficient of lift.

The weight of a model aircraft is 80.0N.

The area of the wings on the model aircraft is 3.0m².

The coefficient of lift for these wings is 1.6.

The density of air is 1.29 kg m⁻³

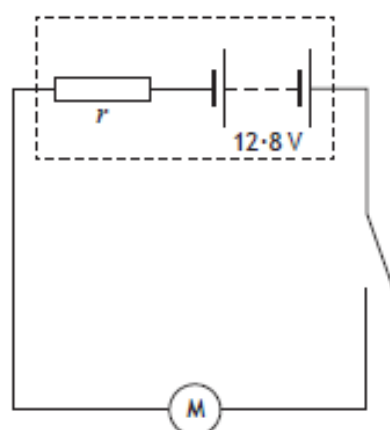
The speed required for the model aircraft to maintain a level flight is

- A 2.5 ms⁻¹
- B 3.6 ms⁻¹
- C 5.1 ms⁻¹
- D 12.9 ms⁻¹
- E 25.8 ms⁻¹.

1	E	11	E		
2	E	12	C		
3	B	13	D		
4	D	14	D		
5	A	15	E		
6	D	16	B		
7	D	17	D		
8	E	18	D		
9	B	19	B		
10	E	20	C		

1.

A car battery is connected to an electric motor as shown.



The electric motor requires a large current to operate.

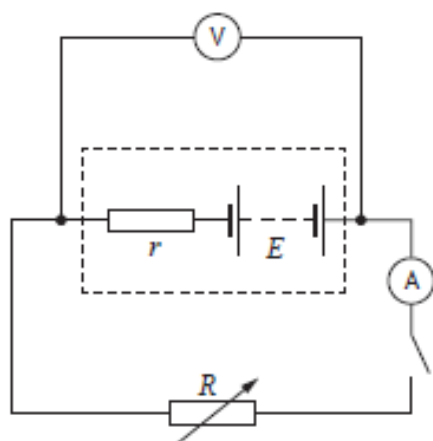
- (a) The car battery has an e.m.f. of 12.8 V and an internal resistance r of $6.0 \times 10^{-3}\ \Omega$. The motor has a resistance of $0.050\ \Omega$.

(i) State what is meant by an *e.m.f. of 12.8 V* . 1

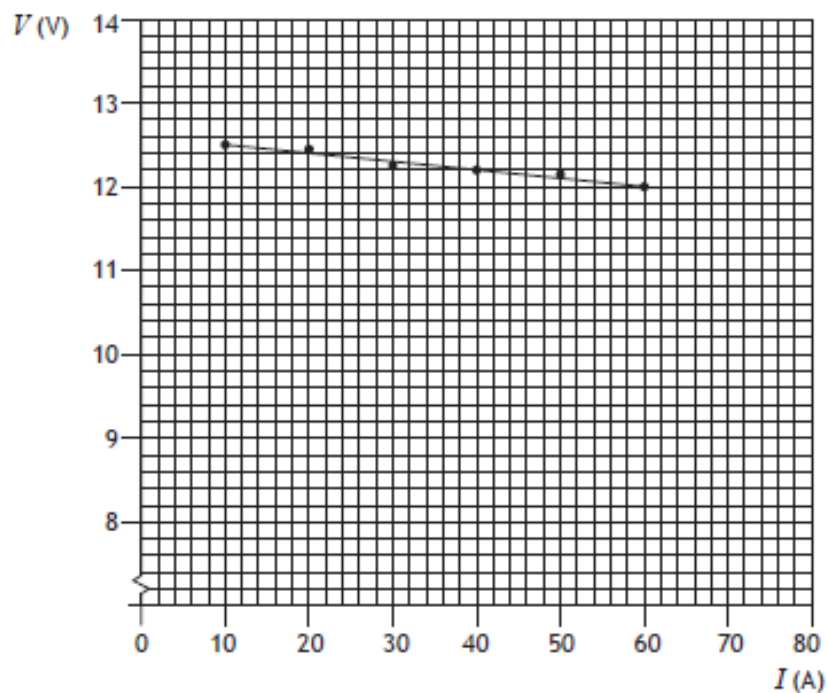
(ii) Calculate the current in the circuit when the motor is operating. 3

(iii) Suggest why the connecting wires used in this circuit have a large diameter. 1

- (b) A technician sets up the following circuit with a different car battery connected to a variable resistor R .



Readings of current I and terminal potential difference V from this circuit are used to produce the following graph.



(b) (continued)

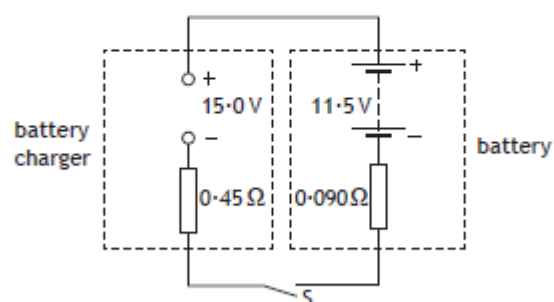
Use information from the graph to determine:

- (i) the e.m.f. of the battery; 1
- (ii) the internal resistance of the battery; 3

(b) (continued)

- (iii) After being used for some time the e.m.f. of the battery decreases to 11.5 V and the internal resistance increases to $0.090\ \Omega$.

The battery is connected to a battery charger of constant e.m.f. 15.0 V and internal resistance of $0.45\ \Omega$ as shown.



(A) Switch S is closed.

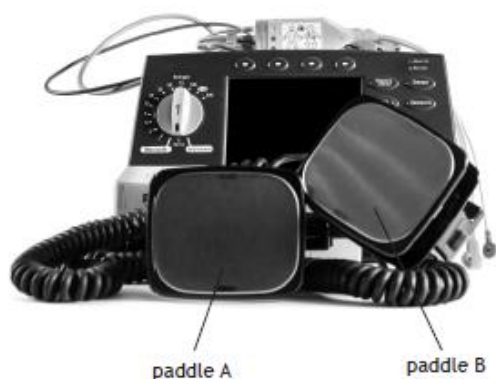
Calculate the initial charging current. 3

- (B) Explain why the charging current decreases as the battery charges. 2

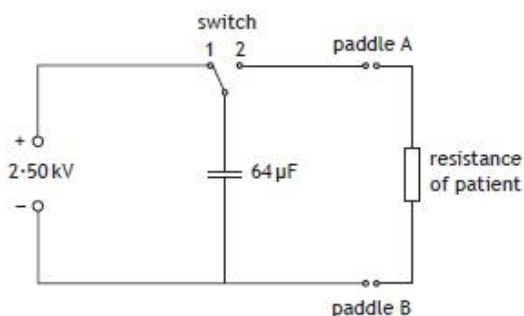
2.

A defibrillator is a device that provides a high energy electrical impulse to correct abnormal heart beats.

MARKS



The diagram shows a simplified version of a defibrillator circuit.



The switch is set to position 1 and the capacitor charges.

- (a) Show the charge on the capacitor when it is fully charged is 0.16 C .

2

(continued)

MARKS

- (b) Calculate the maximum energy stored by the capacitor.

3

Space for working and answer

- (c) To provide the electrical impulse required the capacitor is discharged through the person's chest using the paddles as shown



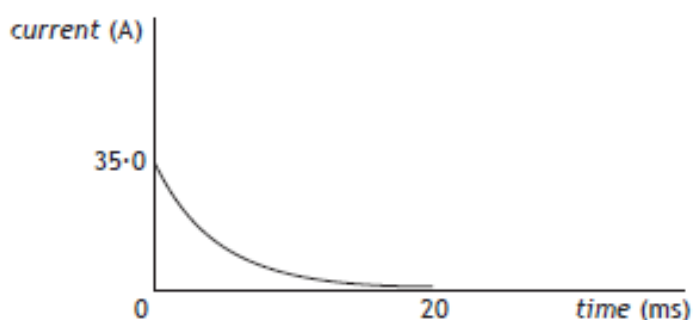
The initial discharge current through the person is 35.0 A .

- (i) Calculate the effective resistance of the part of the person's body between the paddles.

3

(c) (continued)

- (ii) The graph shows how the current between the paddles varies with time during the discharge of the capacitor.



The effective resistance of the person remains the same during this time.

Explain why the current decreases with time.

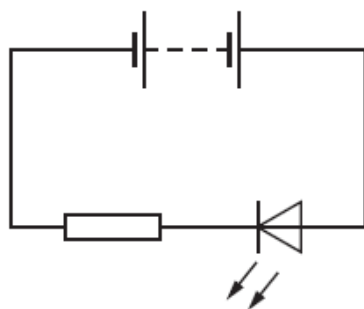
1

- (iii) The defibrillator is used on a different person with larger effective resistance. The capacitor is again charged to 2.50 kV.

On the graph in (c)(ii) add a line to show how the current in this person varies with time.

3.

A student is describing how the following circuit works.



The student states:

“The electricity comes out of the battery with energy and flows through the resistor using up some of the energy, it then goes through the LED and the rest of the energy is changed into light waves.”

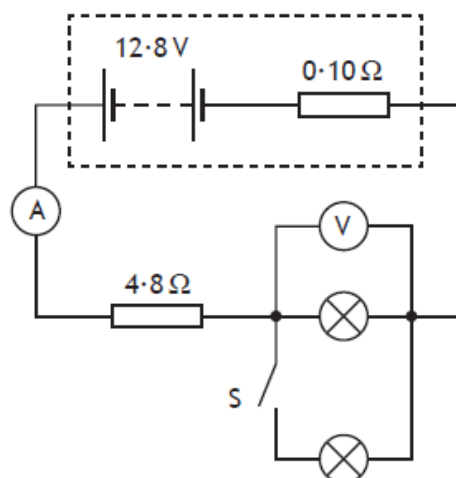
Use your knowledge of physics to comment on this statement.

3

4.

A technician sets up a circuit as shown, using a car battery and two identical lamps.

The battery has an e.m.f. of 12.8 V and an internal resistance of $0.10\ \Omega$.



(a) Switch S is open. The reading on the ammeter is 1.80 A .

(i) Determine the reading on the voltmeter.

4

(ii) Switch S is now closed.

State the effect this has on the reading on the voltmeter.

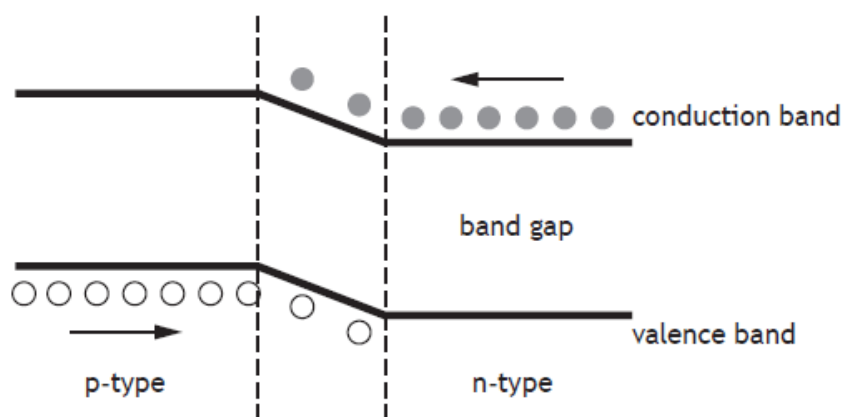
Justify your answer.

3

(b) Some cars use LEDs in place of filament lamps.

An LED is made from semiconductor material that has been doped with impurities to create a p-n junction.

The diagram represents the band structure of an LED.



(i) A voltage is applied across an LED so that it is forward biased and emits light.

Using band theory, explain how the LED emits light.

3

- (ii) The energy gap between the valence band and conduction band is known as the band gap.

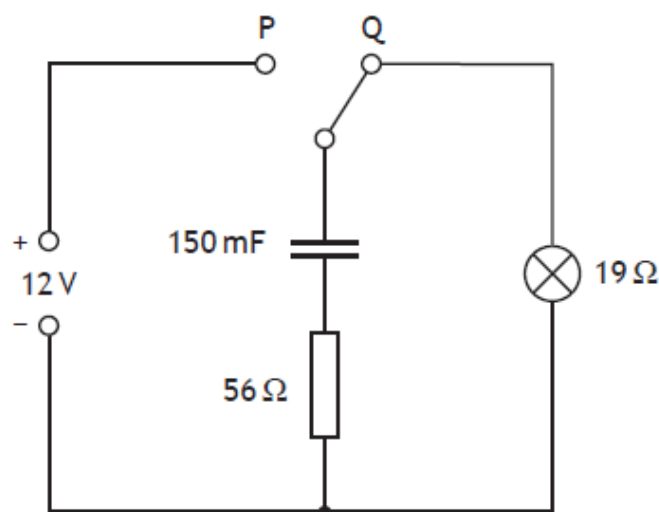
The band gap for the LED is $3.03 \times 10^{-19} \text{ J}$

(A) Calculate the wavelength of the light emitted by the LED. 4

(B) Determine the colour of the light emitted by the LED. 1

5.

A technician sets up a circuit as shown.



The power supply has negligible internal resistance.

- (a) The capacitor is initially uncharged.

The switch is moved to position P and the capacitor charges.

- (i) State the potential difference across the capacitor when it is fully charged. 1

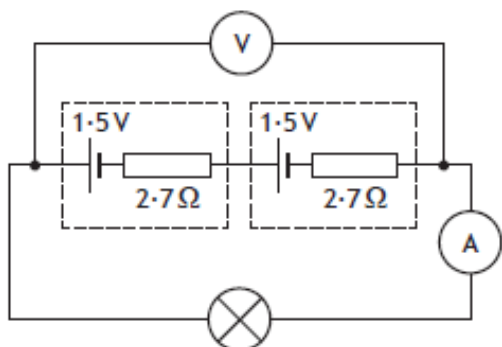
- (ii) Calculate the maximum energy stored by the capacitor. 3

- (b) The switch is now moved back to position Q.
Determine the maximum discharge current in the circuit. 3
Space for working and answer

- (c) The technician replaces the 150 mF capacitor with a capacitor of capacitance 47 mF.
The switch is moved to position P and the capacitor is fully charged.
The switch is now moved to position Q.
State the effect that this change has on the time the lamp stays lit.
You must justify your answer. 2

6.

A lamp is connected to a battery containing two cells as shown.



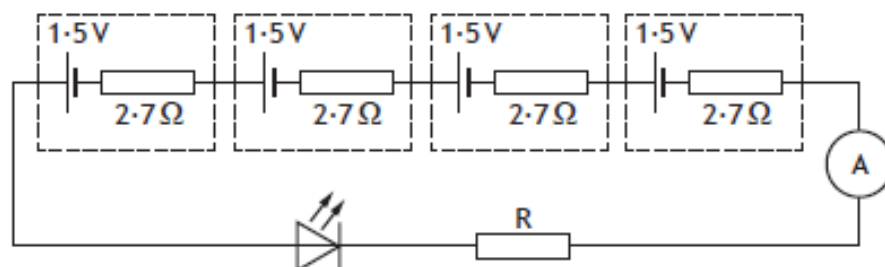
The e.m.f. of each cell is 1.5 V and the internal resistance of each cell is $2.7\ \Omega$.
The reading on the ammeter is 64 mA.

- (a) State what is meant by *an e.m.f. of 1.5 V*. 1
- (b) (i) Show that the lost volts in the battery is 0.35 V. 2
Space for working and answer
- (ii) Determine the reading on the voltmeter. 1

(iii) Calculate the power dissipated by the lamp.

3

- (c) In a different circuit, an LED is connected to a battery containing four cells.



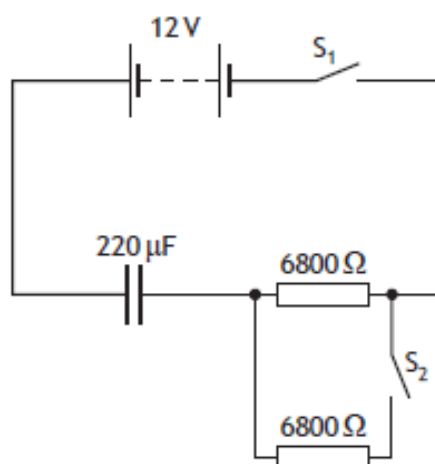
The potential difference across the LED is 3.6 V when the current is 26 mA.
Determine the resistance of resistor R.

4

7.

An uncharged $220\ \mu\text{F}$ capacitor is connected in a circuit as shown.

MARKS



The 12 V battery has negligible internal resistance.

- (a) Switch S_1 is closed and the capacitor charges in a time of 7.5 s.

Calculate the initial charging current.

3

- (b) Switch S_1 is opened.

The capacitor is discharged.

Switch S_2 is now closed and then switch S_1 is closed.

Explain why the time for the capacitor to fully charge is less than in part (a).

2

8.

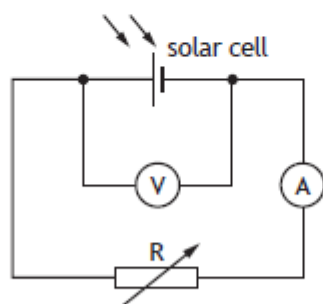
Solar cells are made by joining n-type and p-type semiconductor materials. A layer is formed at the junction between the materials.

- (a) A potential difference is produced when photons enter the layer between the p-type and n-type materials.

State the name of this effect.

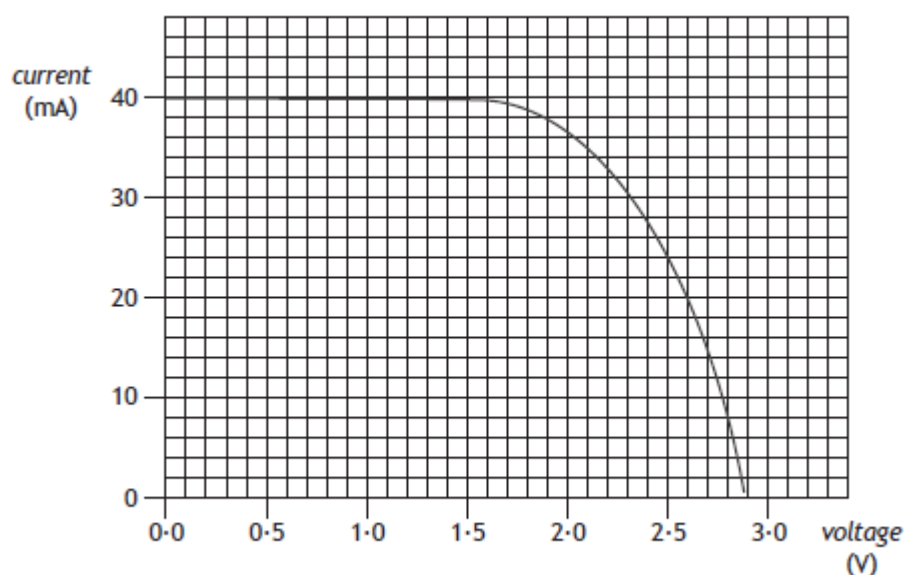
1

- (b) A student carries out an experiment using a solar cell connected to a variable resistor R as shown.



A lamp is placed above the solar cell and switched on.

The variable resistor is altered and readings of current and voltage are taken. These readings are used to produce the following graph.



(b) (continued)

- (i) Solar cells have a maximum power output for a particular irradiance of light.

In this experiment, the maximum power output occurs when the voltage is 2.1 V.

Use information from the graph to estimate a value for the maximum power output from the solar cell.

3

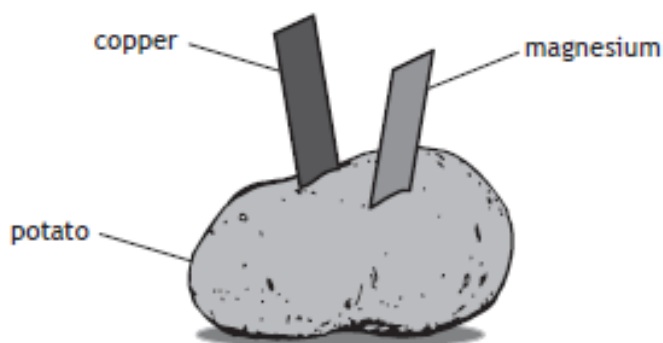
(ii) The lamp is now moved closer to the solar cell.

Explain, in terms of photons, why the maximum output power from the solar cell increases.

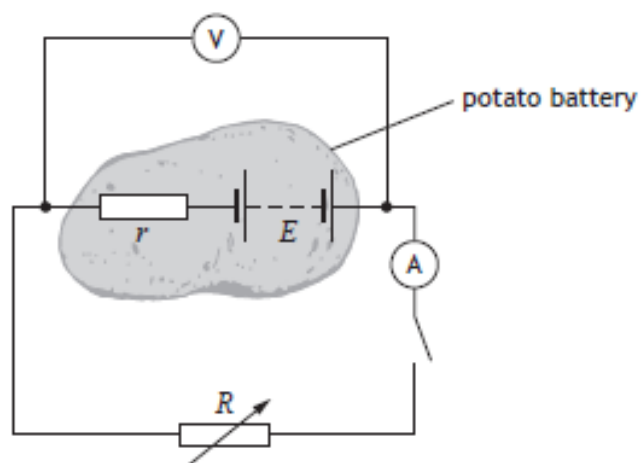
1

9.

A student constructs a battery using a potato, a strip of copper and a strip of magnesium.



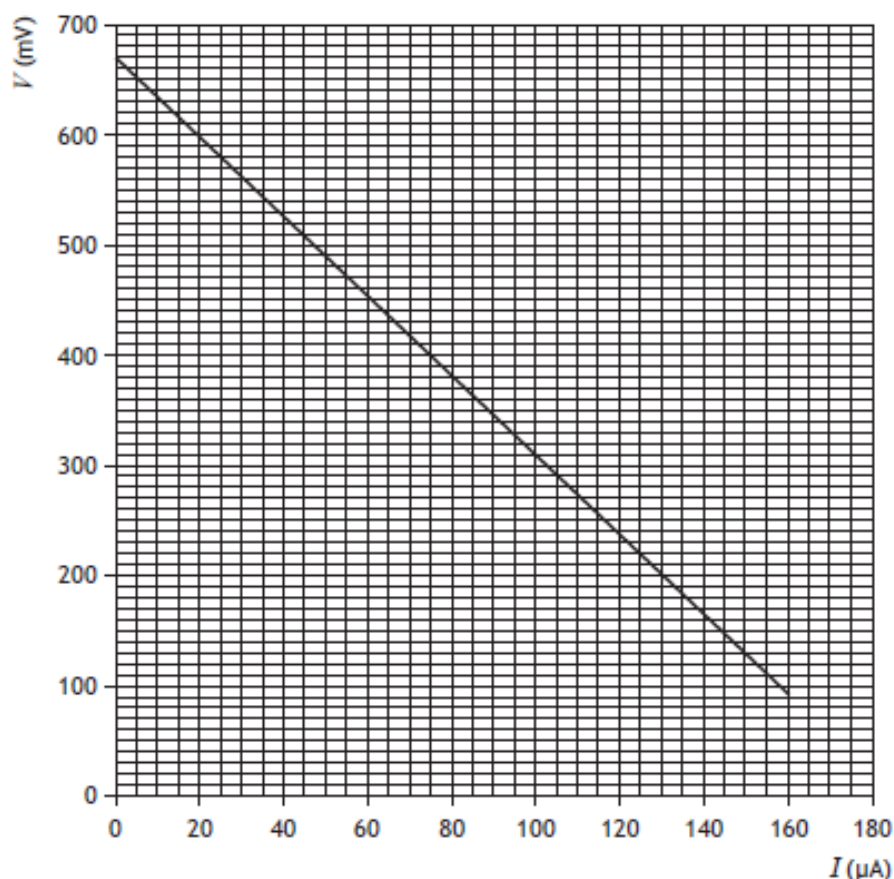
The student then sets up the following circuit with the potato battery connected to a variable resistor R , in order that the electromotive force (e.m.f.) and internal resistance of the battery may be determined.



(a) State what is meant by the term *electromotive force (e.m.f.)*.

1

- (b) The student uses readings of current I and terminal potential difference V from this circuit to produce the graph shown.



Determine the internal resistance of the potato battery.

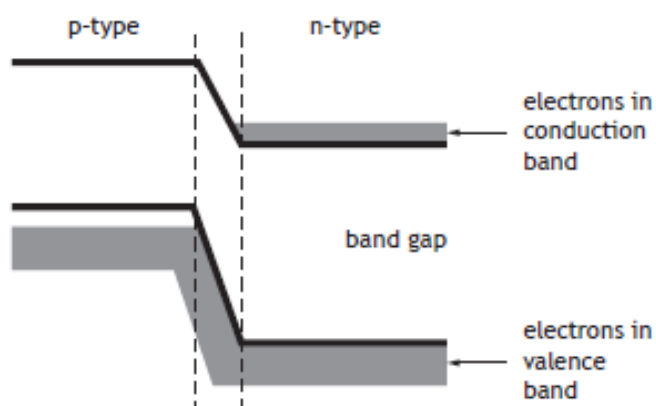
3

- (c) The student connects a red LED and a blue LED, in turn, to the battery.

The LEDs are forward biased when connected.

The student observes that the battery will operate the red LED but not the blue LED.

The diagram represents the band structure of the blue LED.



LEDs emit light when electrons fall from the conduction band into the valence band of the p-type semiconductor.

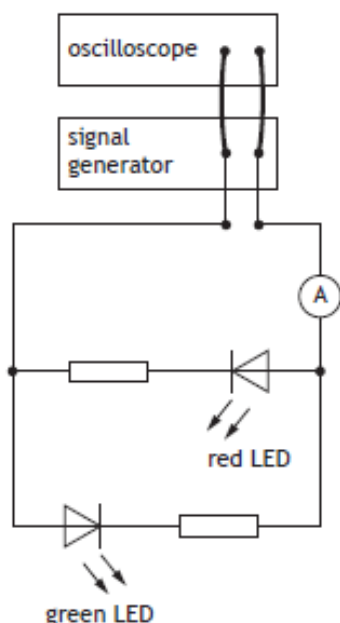
Explain, using band theory, why the blue LED will not operate with this battery.

1

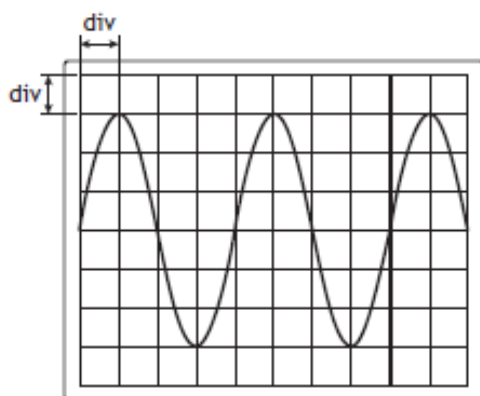
10.

A student carries out a series of experiments to investigate alternating current.

(a) A signal generator is connected to an oscilloscope and a circuit as shown.



The output of the signal generator is displayed on the oscilloscope.



The Y-gain setting on the oscilloscope is 1.0 V/div .

The timebase setting on the oscilloscope is 0.5 s/div .

(a) (continued)

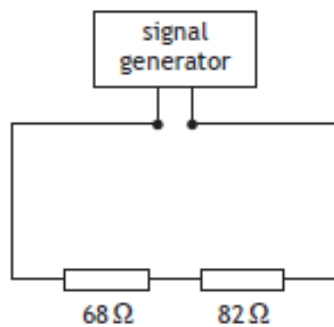
(i) Determine the peak voltage of the output of the signal generator. 1

(ii) Determine the frequency of the output of the signal generator. 3

(iii) The student observes that the red LED is only lit when the ammeter gives a positive reading and the green LED is only lit when the ammeter gives a negative reading.

Explain these observations. 2

- (b) The signal generator is now connected in a circuit as shown.
The settings on the signal generator are unchanged.
The signal generator has negligible internal resistance.

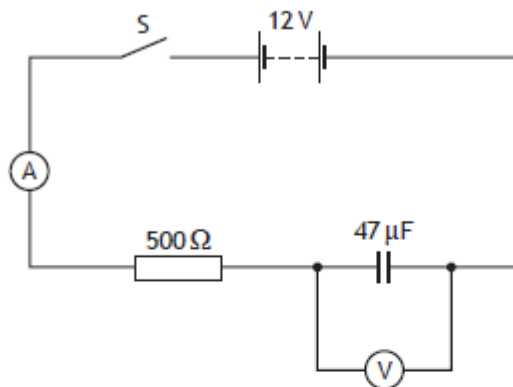


Determine the r.m.s. voltage across the 82 Ω resistor.

5

11.

A 12 volt battery of negligible internal resistance is connected in a circuit as shown.



The capacitor is initially uncharged. Switch S is then closed and the capacitor starts to charge.

- (a) Sketch a graph of the current against time from the instant switch S is closed.

Numerical values are not required.

1

- (b) At one instant during the charging of the capacitor the reading on the ammeter is 5.0 mA.

Calculate the reading on the voltmeter at this instant.

4

- (c) (i) Calculate the maximum charge stored on the capacitor. 3

Space for working and answer

- (ii) Calculate the maximum energy stored in the capacitor in this circuit. 3

Space for working and answer

- (d) The $500\ \Omega$ resistor is now replaced with a $2.0\ \text{k}\Omega$ resistor.
What effect, if any, does this have on the maximum energy stored in the capacitor?

Justify your answer. 2

12.

Recent innovations in capacitor technology have led to the development of “ultracapacitors”. Ultracapacitors of a similar size to standard AA rechargeable cells are now available with ratings of around $100\ \text{F}$ with a maximum working voltage of $2.7\ \text{V}$.

By comparison, AA rechargeable cells operate at $1.5\ \text{V}$ and can store up to $3400\ \text{mA h}$ of charge.

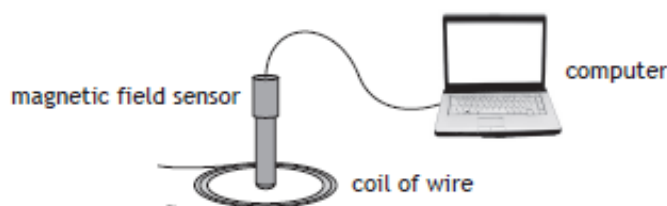
(charge in $\text{mA h} = \text{current in mA} \times \text{time in hours}$)

Use your knowledge of physics to compare the advantages and/or disadvantages of using ultracapacitors and rechargeable cells. 3

13.

A student is investigating how the magnetic field strength at the centre of a coil of wire depends on the direct current in the coil.

The strength of the magnetic field is measured with a magnetic field sensor placed in the centre of the coil. The sensor is connected to a computer as shown.



The computer displays values of magnetic field strength. The unit of magnetic field strength is the tesla (T).

- (a) The student designs a circuit to vary and measure the current in the coil of wire.

The circuit symbol for a coil of wire is shown.



Draw a circuit diagram to show how the current in the coil could be varied and measured.

2

- (b) The following results are obtained.

Current in coil (A)	Magnetic field strength (T)
0.20	1.4×10^{-4}
0.40	2.4×10^{-4}
0.60	3.0×10^{-4}
0.80	3.6×10^{-4}
1.00	4.6×10^{-4}

Using the square-ruled paper on *Page thirty-one*, plot a graph of magnetic field strength against current.

3

- (c) The student concludes that the results show that there is a systematic uncertainty in the measurements.

Suggest a reason why the student has come to this conclusion.

1

- (d) The magnetic field strength B at the centre of a coil of wire is given by the relationship

$$B = 6.3 \times 10^{-7} \frac{NI}{r}$$

where B is the magnetic field strength in tesla
 N is the number of turns in the coil
 I is the current in the coil in amperes
 r is the radius of the coil in metres.

The number of turns in the coil used by the student is 30.

Use this relationship and the gradient of your graph to calculate the radius of the coil.

4

(a)	(i)	12.8 J (of energy) <u>is gained</u> <u>by/supplied to</u> 1 coulomb (of charge passing through the battery)	1	
	(ii)	$E = V + Ir$ and $V = IR$ (1) $E = I(R + r)$ $12.8 = I(0.050 + 6.0 \times 10^{-3})$ (1) $I = 230$ A (1)	3	<p>Both required for 1 mark</p> <p>If candidates start with this expression, it gets the formula mark</p> $R_{\text{Total}} = 0.050 + 6.0 \times 10^{-3}$ $= 0.056 \text{ } (\Omega)$ $I = E/R_T$ $= 12.8/0.056$ $= 230 \text{ A}$ <p>(1) (1) (1)</p> <p>accept $I = V/R$ if sub correct</p> <p>accept 200, 229, 228.6</p> <p>Or consistent with (a) (i)</p>
	(iii)	<p>(Wire of large diameter) has a low resistance (1)</p> <p>or</p> <p>to <u>prevent</u> overheating (1)</p> <p>or</p> <p>to <u>prevent</u> wires melting (1)</p>	1	<p>Not: motor requires large current, on its own</p> <p>Not: The wires will melt, on its own.</p> <p>eg wires melt (no justification) 0 marks, <u>thin</u> wires could melt due to large current 1 mark</p>
(b)	(i)	12.6 V	1	No tolerance
	(ii)	<p>(gradient = $-r$)</p> <p>gradient = $(12 - 12.5)/(60 - 10)$ (1) $= -0.01$ (1) internal resistance = 0.01Ω (1)</p>	3	<p>Gradient = r is wrong physics, award 0 marks</p> <p>gradient formula or implied (1) calculating gradient (1)</p> <p>or</p> $E = V + Ir$ $12.6 = 12 + 60r$ $r = 0.01 \Omega$ <p>(1) (1) (1)</p> <p>If using this method, they must use data from the line or points which lie on the line.</p> <p>Or consistent with (b) (i)</p>

(iii)	(A)	$I = \frac{V}{R} \quad (1)$ $= \frac{(15 - 11.5)}{(0.09 + 0.45)} \quad (1)$ $= 6.5 \text{ A} \quad (1)$	3	Accept 6, 6.48, 6.481
	(B)	<p>The e.m.f. of the battery increases (1)</p> <p>Difference between the two e.m.f.s decreases (1)</p>	2	<p>Independent marks</p> <p>Accept voltage or pd in place of emf</p> <p>or equivalent</p> <p>Apply \pm rule</p>

2.

(a)		$C = \frac{Q}{V} \quad (1)$ $64 \times 10^{-6} = \frac{Q}{2.50 \times 10^3} \quad (1)$ $Q = 0.16(C)$	2	<p>Must start with formula</p> <p>Maximum 1 mark if final answer not shown</p> <p>Note: $C = \frac{Q}{V}$</p> $64 \times 10^{-6} = \frac{Q}{2.50}$ $Q = 0.16$ <p>Is awarded a maximum of 1 mark for the formula, as knowledge of units has not been <u>shown</u>.</p> <p>It is acceptable to work back to find the value of capacitance.</p>
(b)		$E = \frac{1}{2} QV \quad (1)$ $E = \frac{1}{2} \times 0.16 \times 2.50 \times 10^3 \quad (1)$ $E = 200 \text{ J} \quad (1)$	3	<p>Alternative methods:</p> $E = \frac{1}{2} CV^2 \quad (1)$ $= \frac{1}{2} \times 64 \times 10^{-6} \times (2.50 \times 10^3)^2 \quad (1)$ $= 200 \text{ J} \quad (1)$ <p>or</p> $E = \frac{1}{2} \frac{Q^2}{C} \quad (1)$ $= \frac{1}{2} \frac{0.16^2}{64 \times 10^{-6}} \quad (1)$ $= 200 \text{ J} \quad (1)$ <p>Note: max 2 marks if not $\times 10^{-6}$, unless value shown as 0.064×10^{-3}, which is acceptable or answer quoted as $200 \times 10^6 \mu\text{J}$ or similar. (treat as unit error)</p>

(c)	(i)	$v = IR$ (1) $2.50 \times 10^3 = 35.0 \times R$ (1) $R = 71.4 \Omega$ (1)	3	Accept 71, 71.43, 71.429
	(ii)	The voltage decreases (1)	1	

	(iii)	Smaller initial current (1) Time to reach 0 A is longer (1)	2	Line must be a curve to award the second mark Line must tend towards the time axis to gain the second mark. Do not worry about areas under the lines being different.
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3. Open Ended Question.

4.

(a)	(i)	$V = IR$ (1) $V = 1.80(4.8 + 0.10)$ (1) $V = 8.82 \text{ (V)}$ (1) Voltmeter reading ($= 12.8 - 8.82$) $= 4.0 \text{ V}$ (1)	4	$lost \text{ volts} = Ir$ $lost \text{ volts} = 1.80 \times 0.10$ $lost \text{ volts} = 0.18 \text{ V}$ $V = IR$ $V = 1.80 \times 4.8$ $V = 8.64 \text{ V}$ $V = 12.8 - 0.18 - 8.64$ $V = 4.0 \text{ V}$ OR $E = V + Ir$ $12.8 = V + (1.80 \times 0.10)$ $V = 12.62 \text{ V}$ $V = IR$ $V = 1.80 \times 4.8$ $V = 8.64 \text{ V}$ $V = 12.62 - 8.64$ $V = 4.0 \text{ V}$ 1 for all equations 1 for all substitutions 1 for all correct intermediate values 1 for final answer Sig figs: Accept 4, 3.98, 3.980
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	(ii)	<p>(Reading on voltmeter)/(voltage across lamp) decreases (1)</p> <p>(total) resistance decreases/ current increases. (1)</p> <p>lost volts increases/V_{tpd} decreases/p.d. across 4.8Ω increases/share of p.d. across parallel branch decreases (1)</p>	3	<p>Look for this statement first - if incorrect then 0 marks.</p> <p>'Reading on voltmeter decreases' on its own is worth 1 mark</p> <p>Any wrong physics in justification then maximum 1 mark for the statement</p> <p>Last 2 marks are independent of each other</p> <p>Can be justified by calculation (R_{lamp} is 2.2Ω, $I = 2.1 \text{ A}$, gives $V = 2.3 \text{ V}$)</p>
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(b)	(i)	<p>(Voltage applied causes) <u>electrons</u> to move towards <u>conduction band</u> of p-type/ away from n-type (towards the junction) (1)</p> <p>Electrons move/ drop from conduction band to valence band (1)</p> <p><u>Photon</u> emitted (when electron drops) (1)</p>	3	<p>Look for reference to either conduction or valence band first. Otherwise 0 marks.</p> <p>Bands must be named correctly in first two marking point eg not valency and not conductive</p> <p>Any answer using recombination of holes and electrons on its own, with no reference to band theory, is worth 0 marks.</p> <p>Must be directional</p> <p>Any wrong physics eg holes move up (from valence band to conduction band)- 0 marks</p> <p>This mark is dependent upon having at least one of the first two statements</p>
	(ii) (A)	$E = hf$ $3.03 \times 10^{-19} = 6.63 \times 10^{-34} \times f \quad (1)$ $f = 4.57 \times 10^{14} \text{ (Hz)}$ $v = f\lambda \quad (1) \text{ for both equations}$ $3 \times 10^8 = 4.57 \times 10^{14} \times \lambda \quad (1)$ $\lambda = 6.56 \times 10^{-7} \text{ m} \quad (1)$	4	<p>Alternative:</p> $E = \frac{hc}{\lambda} \quad (1)$ <p>Correct substitution (2) (1 for E and h; 1 for c)</p> <p>Final value of λ (1)</p> <p>Sig figs: Accept 6.6×10^{-7}, 6.564×10^{-7}, 6.5644×10^{-7}</p>

	(ii) (B)	Red (1)	1	<p>or consistent with (A)</p> <p>If wavelength stated in this part, then colour must be consistent with this value</p>
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5.

(a)	(i)	12 V	1	Accept 12.0 V
	(ii)	$E = \frac{1}{2} C V^2$ (1) $E = \frac{1}{2} \times 150 \times 10^{-3} \times 12^2$ (1) $E = 11 \text{ J}$ (1)	3	Or consistent with a(i) Sig figs: 10 J 10.8 J 10.80 J $Q = CV$ and $E = \frac{1}{2} QV$ OR $Q = CV$ and $E = \frac{1}{2} \frac{Q^2}{C}$ (1) Both substitutions (1) Final answer (1)
(b)		$(R_T = 56 + 19 = 75 \text{ } (\Omega))$ $I = \frac{V}{R}$ (1) $I = \frac{12}{75}$ (1) $I = 0.16 \text{ A}$ (1)	3	Or consistent with a(i) Candidates can arrive at this answer by alternative methods. Sig figs: 0.2 A 0.160 A 0.1600 A
(c)		(Lamp stays lit for a) shorter time (1) (as smaller capacitance results in) less energy stored / less charge stored (1)	2	Look for this first Must provide relevant justification which is not wrong physics. If wrong physics - 0 marks. E is less because $E = \frac{1}{2} C V^2$ is acceptable. If candidate says the current stays the same, they must identify it is the <u>initial</u> current.

6.

(a)		1.5 J (of energy) is <u>supplied</u> to/gained by each coulomb (of charge passing through the cell).	1	Accept 'given to'... Accept 'battery'/'source'.
(b)	(i)	lost volts = Ir 1 lost volts = $64 \times 10^{-3} \times (2 \times 2.7)$ 1 lost volts = 0.35 V	2	"SHOW" question. Must start with a correct formula. Accept $V = IR$ Accept 5.4 as substitution for 'r' Accept working out lost volts for one cell, then doubling.
	(ii)	$V = 2.7 \text{ V}$	1	Must use 0.35 V Do not accept 3V on its own, but if 3V is clearly shown as a rounded value - 1 mark.
	(iii)	$P = IV$ 1 $P = 64 \times 10^{-3} \times 2.7$ 1 $P = 0.17 \text{ W}$ 1	3	Or consistent with (b)(ii) Sig figs: Accept 0.2, 0.173, 0.1728

(c)		$V = E - Ir$ $V = 6.0 - (26 \times 10^{-3} \times (4 \times 2.7))$ 1 $V = 5.7192 \text{ (V)}$ $R = \frac{V_R}{I}$ (both formulae) 1 $R = \frac{5.7192 - 3.6}{26 \times 10^{-3}}$ 1 $R = 82 \Omega$ 1	4	1 mark for quoting <u>both</u> formulae - explicitly or implied. Sig figs: Accept 80, 81.5, 81.51 Alternative methods: $R_T = \frac{V}{I}$ $R_T = \frac{6.0}{26 \times 10^{-3}} = 230.8(\Omega)$ $R_{LED} = \frac{V}{I}$ $R_{LED} = \frac{3.6}{26 \times 10^{-3}} = 138.5(\Omega)$ $R = 230.8 - (138.5 + 10.8)$ $R = 82 \Omega$
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7.

(a)		$V = IR$ 1 $12 = I \times 6800$ 1 $I = 1.8 \times 10^{-3} \text{ A}$ 1	3	Sig figs: Accept 2, 1.76, 1.765
(b)		The (circuit/total) resistance is less 1 Initial charging current is greater 1	2	Independent marks. Accept: Average current is greater OR The current <u>at any given time</u> is greater. 'Current greater' on its own is not sufficient for 2 nd mark.

8.

(a)		Photovoltaic (effect)	1	
(b)	(i)	$I = 35 \text{ mA}$ (from graph) 1 $P = IV$ 1 $(P = 0.035 \times 2.1)$ $P = 0.074 \text{ W}$ 1	3	$P = IV$ anywhere, 1 mark. Sig figs: Accept 0.07, 0.0735 Accept a value for I between 34.5 and 35 mA inclusive. $I = 34.5 \text{ mA}$ gives $P = 0.073 \text{ W}$ Sig figs for above: Accept 0.07, 0.0725, 0.07245
	(ii)	Greater number of <u>photons</u> (strike the solar cell) <u>per second</u>	1	The answer has to imply a 'rate'. Any correct statement followed by wrong physics, 0 marks.

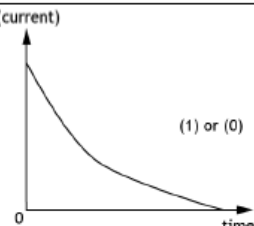
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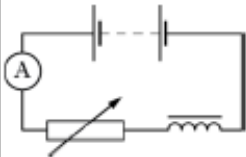


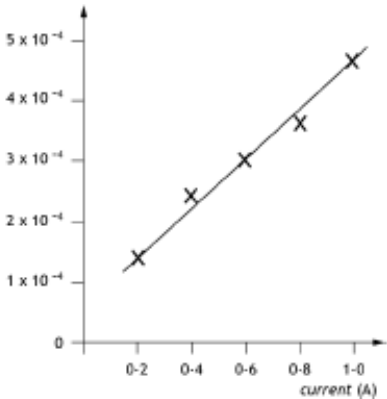
(a)		The number of joules/energy gained by/supplied to 1 coulomb (of charge passing through the cell).	1	Accept unit charge for 1 coulomb.
(b)		$\text{gradient} = \frac{(290 \times 10^{-3} - 470 \times 10^{-3})}{(105 \times 10^{-6} - 55 \times 10^{-6})} \quad (1)$ $\text{gradient} = -3600 \quad (1)$ $(\text{gradient} = -r)$ $r = 3600 \, \Omega \quad (1)$	3	Accept: 4000 Gradient = r is wrong physics, award 0 marks. subs into gradient formula (1) calculating gradient (1) Alternative method: $E = V + Ir \quad (1)$ $670 \times 10^{-3} = 400 \times 10^{-3} + 75 \times 10^{-6} r \quad (1)$ $r = 3600 \, \Omega \quad (1)$
(c)		The electrons do not gain enough energy to move into/towards the conduction band of the p-type.	1	Electrons in conduction band (of the n-type) do not gain enough energy to move into/towards the p-type.

10.

(a)	(i)	$(3 \times 1.0 =) 3.0 \text{ V}$ (1)	1	Accept: 3, 3.00, 3.000
	(ii)	$f = \frac{1}{T}$ (1) $f = \frac{1}{2}$ (1) $f = 0.5 \text{ Hz}$ (1)	3	Accept: 0.50, 0.500
	(iii)	The LEDs will light when they are forward biased. (1) The change in polarity of voltage changes the biasing. (1)	2	Independent marks LEDs will only conduct in one direction (1) Identifying current/voltage has changed direction (1) Do not accept 'different direction' alone. One LED conducts during one half of the cycle the other LED conducts during the other half of the cycle.
(b)		$V_2 = \left(\frac{R_2}{R_1 + R_2} \right) V_s$ (1) $V_2 = \left(\frac{82}{68 + 82} \right) \times 3.0$ (1) $V_2 = 1.64 \text{ (V)}$ $V_{\text{peak}} = \sqrt{2} V_{\text{rms}}$ (1) $1.64 = \sqrt{2} V_{\text{rms}}$ (1) $V_{\text{rms}} = 1.2 \text{ V}$ (1)	5	OR consistent with (a)(i) Accept: 1, 1.16, 1.160 Alternative Methods: $V_{\text{peak}} = \sqrt{2} V_{\text{rms}}$ (1) $3.0 = \sqrt{2} V_{\text{rms}}$ (1) $V_{\text{rms}} = 2.12132034 \text{ (V)}$ $V_2 = \left(\frac{R_2}{R_1 + R_2} \right) V_s$ (1) $V_2 = \left(\frac{82}{68 + 82} \right) \times 2.12132034$ (1)

11.

a		 (1) or (0)	1	
b		$V_R = IR$ $= 5 \times 10^{-3} \times 500$ (1) $= 2.5 \text{ (V)}$ (1) $V_C = 12 - 2.5$ (1) $= 9.5 \text{ V}$ (1)	4	
c	i	$Q = CV$ (1) $= 47 \times 10^{-6} \times 12$ (1) $= 5.64 \times 10^{-4} \text{ C}$ (1)	3	
c	ii	$E = \frac{1}{2} CV^2$ (1) $= 0.5 \times 47 \times 10^{-6} \times 12^2$ (1) $= 3.4 \times 10^{-3} \text{ J}$ (1)	3	Must use 12 V – otherwise max 1 for correct formula. Alternative: $Q = CV$ $= 47 \times 10^{-6} \times 12$ $= 5.64 \times 10^{-4} \text{ (C)}$ $E = \frac{1}{2} QV$ $= \frac{1}{2} \times 5.64 \times 10^{-4} \times 12$ $= 3.4 \times 10^{-3} \text{ J}$ (1) for both formulae (1) for both substitutions
d		Max energy the same/“no effect” (1) Values for “C” and “V” are the same as before (1)	2	

a	<p>Suitable components selected and circuit symbols correct (1)</p> <p>suitable circuit (ie it would work) (1), eg</p>  <p>resistor must be variable (unless variable supply used).</p>	2	<p>Values not required</p> <p>Accept </p> <p>OR </p>
b	<p>magnetic field strength (T)</p> 	3	<p>3 marks for a fully correct graph.</p> <p>Axes labels must have both the name of the quantity and its unit.</p> <p>Each point must be plotted to within \pm a half scale division.</p> <p>There must be a single, straight, best-fit line through the points.</p> <p>A non-linear scale on either axis is wrong and prevents access to any marks.</p>
c	<p>(the graph is a straight line that) does not pass through origin OR (1) the magnetic field strength is not zero when the current is zero</p>	1	
d	<p>gradient = $6.3 \times 10^{-7} \frac{N}{r}$ (1)</p> <p>$3.8 \times 10^{-4} = 6.3 \times 10^{-7} \frac{30}{r}$ (1)</p> <p>$r = 0.05 \text{ m}$ (1)</p> <p>gradient of graph = $3.8 \times 10^{-4} (\text{TA}^{-1})$ (1)</p>	4	<p>Accept: 3.6×10^{-4} to 4.0×10^{-4}</p> <p>If values of B and I (from the table or the graph line) are used in the formula, 0 marks.</p> <p>0.0497 m; 0.04974 m</p>