AQA A-LEVEL PHYSICS · 7408

PHYSICS



EXAM QUESTION PACK

3.7.4 CAPACITANCE

SCORE	PERCENTAGE
/87	%

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Q1.

(a) State what is meant by a capacitance of 370 μF

_____

_____

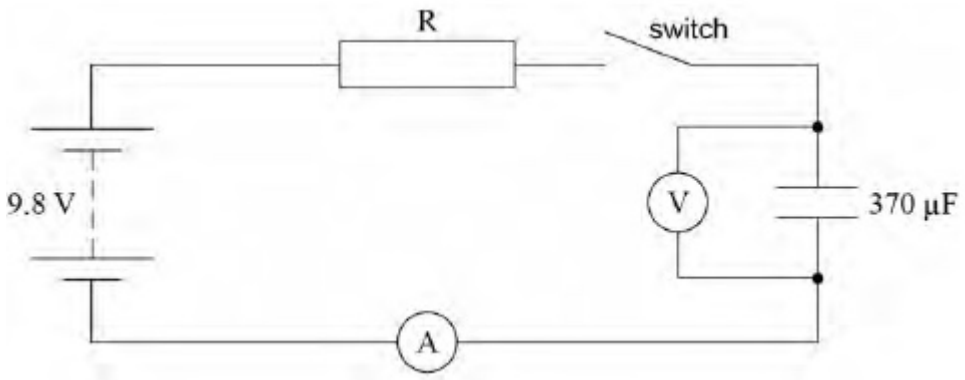
_____

_____

(2)

(b) The charging of a 370 μF capacitor is investigated using the circuit shown in **Figure 1**.
Both meters in the circuit are ideal.

Figure 1



The power supply of emf 9.8V has a negligible internal resistance. The capacitor is initially uncharged. When the switch is closed at time $t = 0$ charge begins to flow through resistor R. The time constant of the charging circuit is 1.0 s

Calculate the resistance of R.

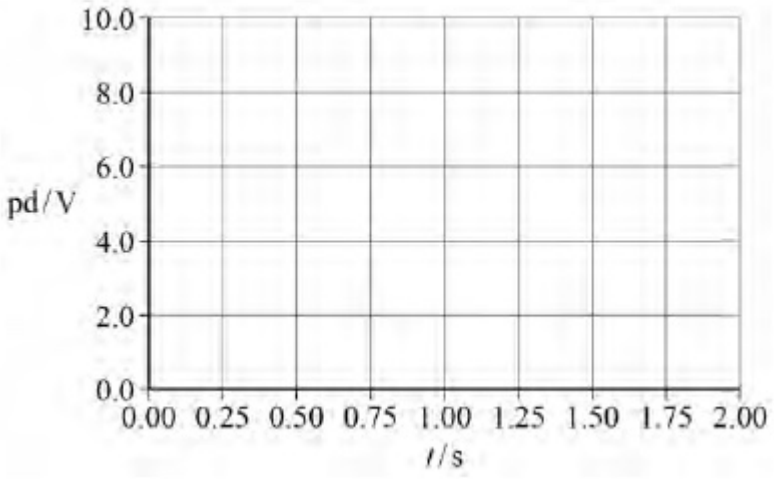
resistance of R = _____ Ω

(1)

(c) Identify, with the symbol X on **Figure 2**, the potential difference (pd) across the capacitor when the switch has been closed for 2.0 s
Sketch the graph that shows how the pd varies from $t = 0$ to $t = 2.0$ s

Figure 2

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(2)

(d) Calculate the time taken for the charging current to fall to half its initial value.

time = _____ s

(1)

(e) Calculate the time taken for the charge on the capacitor to reach 3.0 mC

time = _____ s

(3)

(Total 9 marks)

Q2.

An air-filled parallel-plate capacitor is charged from a source of emf. The electric field has a strength E between the plates. The capacitor is disconnected from the source of emf and the separation between the isolated plates is doubled.

What is the final electric field between the plates?

A $2E$ ⬭

B E ⬭

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C $\frac{E}{2}$ ⬭

D $\frac{E}{4}$ ⬭

(Total 1 mark)

Q3.

A parallel-plate capacitor has square plates of length l separated by distance d and is filled with a dielectric.

A second capacitor has square plates of length $2l$ separated by distance $2d$ and has air as its dielectric.

Both capacitors have the same capacitance.

What is the relative permittivity of the dielectric in the first capacitor?

A $\frac{1}{2}$ ⬭

B 1 ⬭

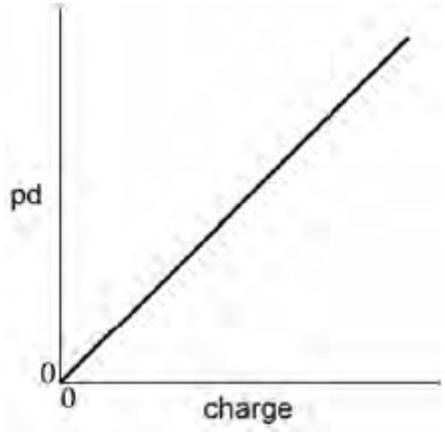
C 2 ⬭

D 8 ⬭

(Total 1 mark)

Q4.

The graph shows the variation of potential difference (pd) with charge for a capacitor while it is charging.



Which statement can be deduced from the graph?

A The charging current is constant. ⬭

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B The energy stored in the capacitor increases uniformly with time. ⬭

C The capacitance of the capacitor is constant. ⬭

D The power supply used to charge the capacitor had a constant terminal pd. ⬭

(Total 1 mark)

Q5.

A parallel-plate capacitor is fully charged and then disconnected from the power supply. A dielectric is then inserted between the plates.

Which row correctly identifies the charge on the plates and the electric field strength between the plates?

	Charge	Electric field strength	
A	Stays the same	Increases	⬭
B	Increases	Decreases	⬭
C	Increases	Increases	⬭
D	Stays the same	Decreases	⬭

(Total 1 mark)

Q6.

A capacitor of capacitance C has a charge of Q stored on the plates. The potential difference between the plates is doubled.

What is the change in the energy stored by the capacitor?

A $\frac{Q^2}{2C}$ ⬭

B $\frac{Q^2}{C}$ ⬭

C $\frac{3Q^2}{2C}$ ⬭

D $\frac{2Q^2}{C}$ ⬭

(Total 1 mark)

Q7.

A capacitor consists of two parallel square plates of side l separated by distance d. The capacitance of the arrangement is C.

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What is the capacitance of a capacitor with square plates of side $2l$ separated by a distance $\frac{d}{2}$?

A C ⬭

B $2C$ ⬭

C $4C$ ⬭

D $8C$ ⬭

(Total 1 mark)

Q8.

A capacitor of capacitance 120 μF is charged and then discharged through a 20 kΩ resistor.

What fraction of the original charge remains on the capacitor 4.8 s after the discharge begins?

A 0.14 ⬭

B 0.37 ⬭

C 0.63 ⬭

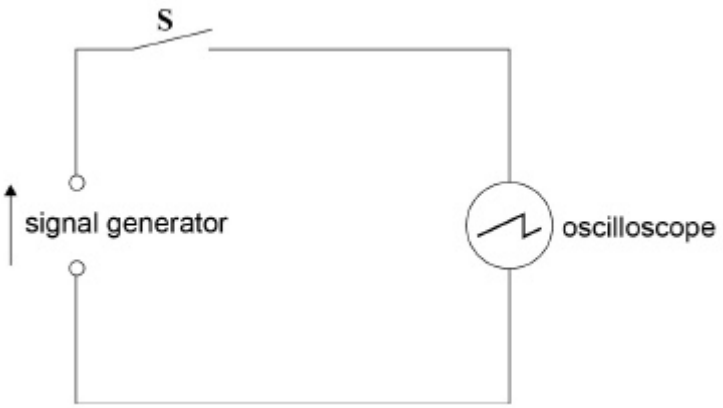
D 0.86 ⬭

(Total 1 mark)

Q9.

A signal generator is connected to an oscilloscope, as shown in **Figure 1**.

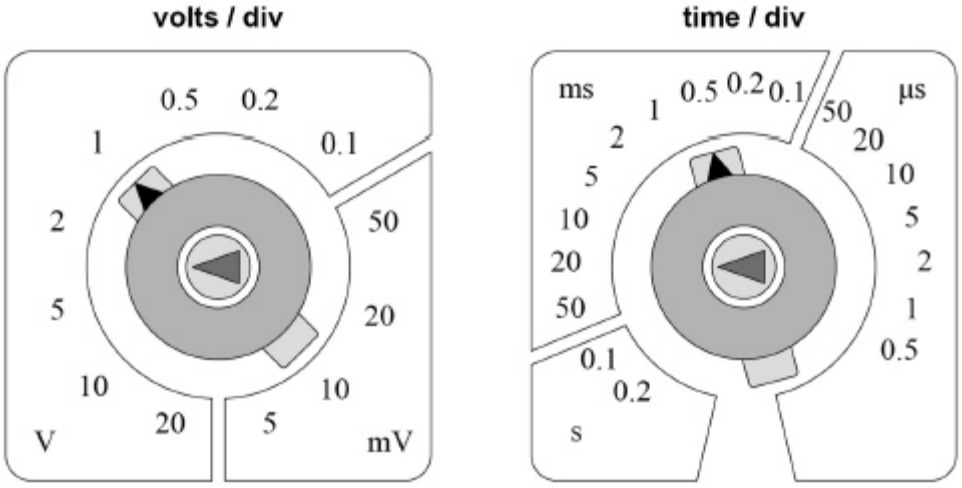
Figure 1



The Y-voltage gain and time-base settings of the oscilloscope are shown in **Figure 2**.

Figure 2

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When switch **S** is open (off) the oscilloscope displays the waveform shown in **Figure 3**.

When **S** is closed (on) the oscilloscope displays the waveform shown in **Figure 4**.

(a) Determine the peak-to-peak voltage V of the waveform shown in **Figure 4**.

V = _____ V

(1)

(b) Determine the frequency f of the waveform shown in **Figure 4**.

f = _____ Hz

(2)

Figure 3

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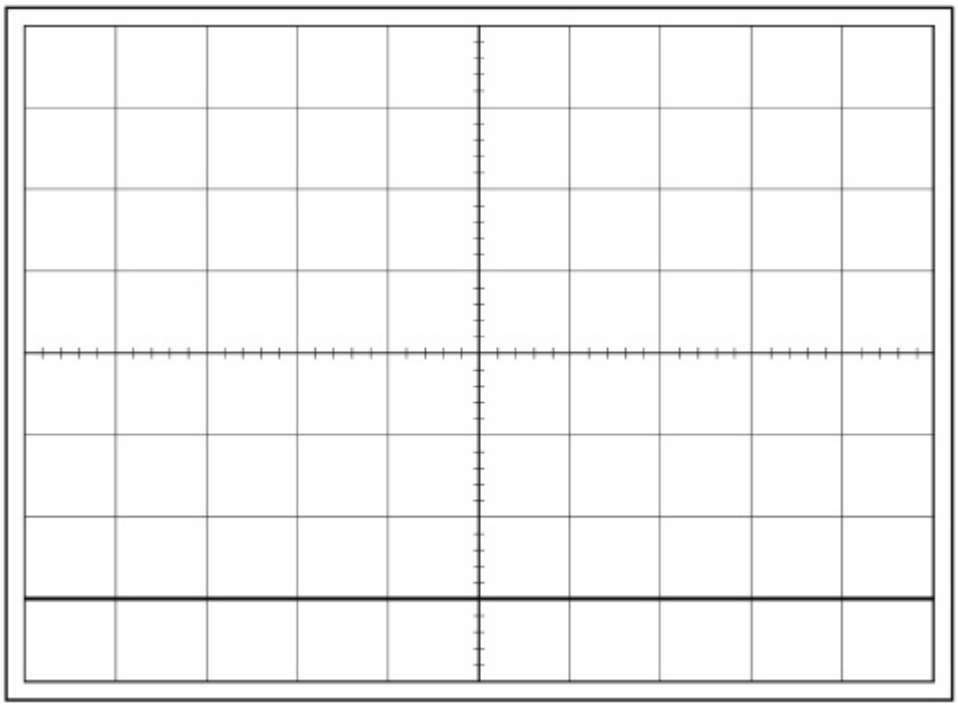
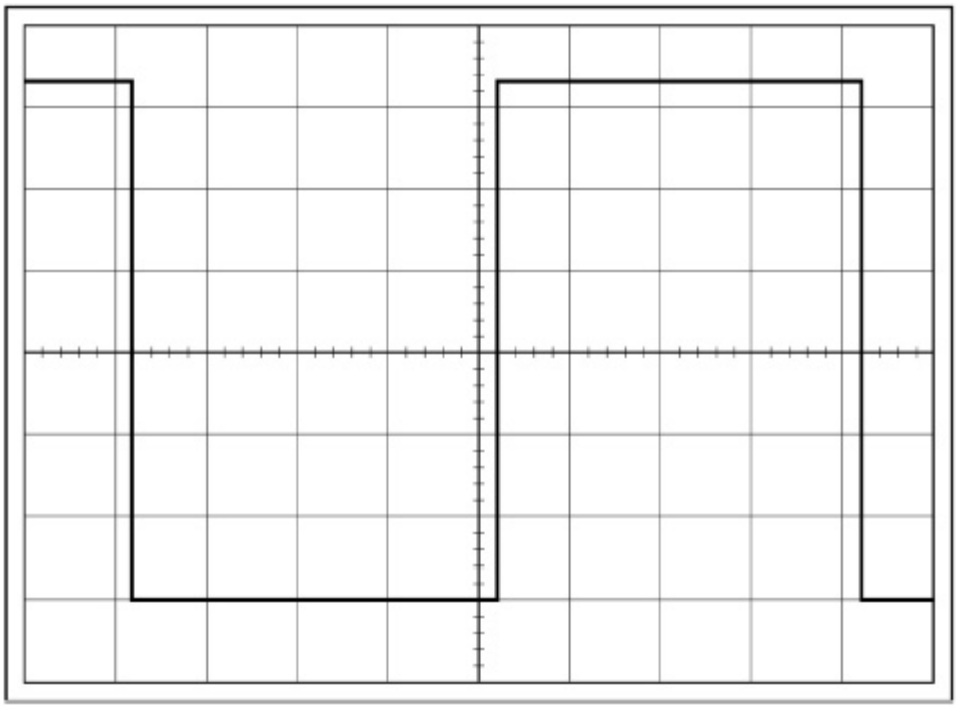


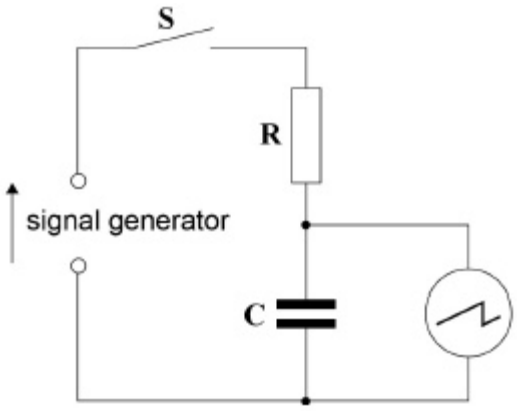
Figure 4



(c) **Figure 5** shows the signal generator connected in series with a resistor **R** and a capacitor **C**.

Figure 5

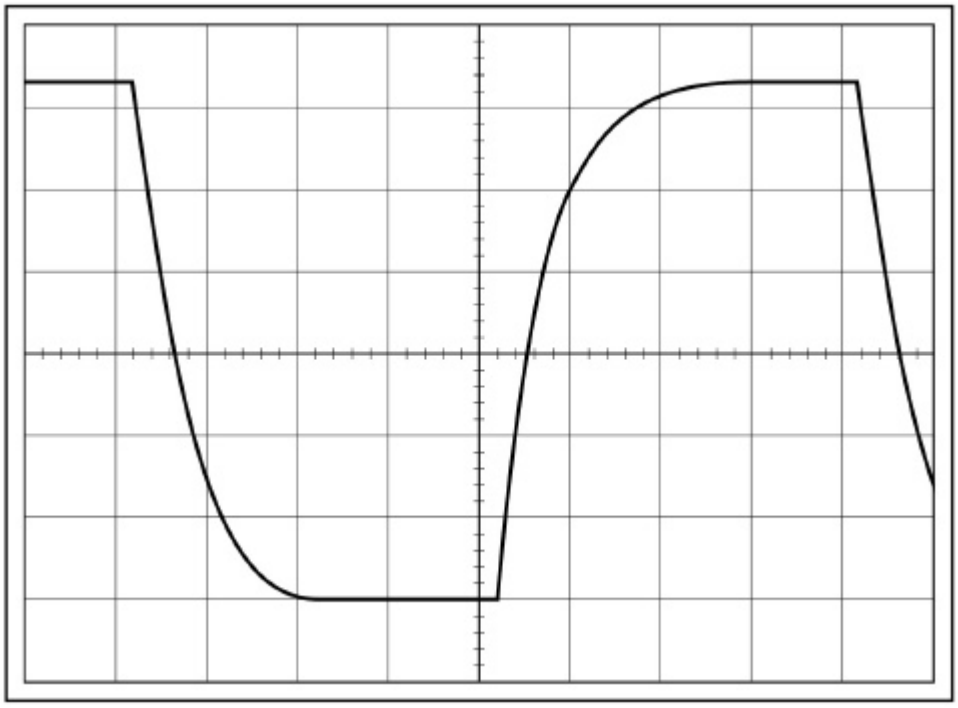
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The oscilloscope is connected across the capacitor.
The Y-voltage gain and time-base settings are still the same as shown in **Figure 2**.

When **S** is closed (on) the oscilloscope displays the waveform shown in **Figure 6**.

Figure 6



Determine the time constant of the circuit in **Figure 5**.

time constant = _____ s

(2)

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(d) A student suggests that setting the time-base to 0.2 ms division^{-1} might reduce uncertainty in the determination of the time constant.

State and explain any possible advantage or disadvantage in making this suggested adjustment.

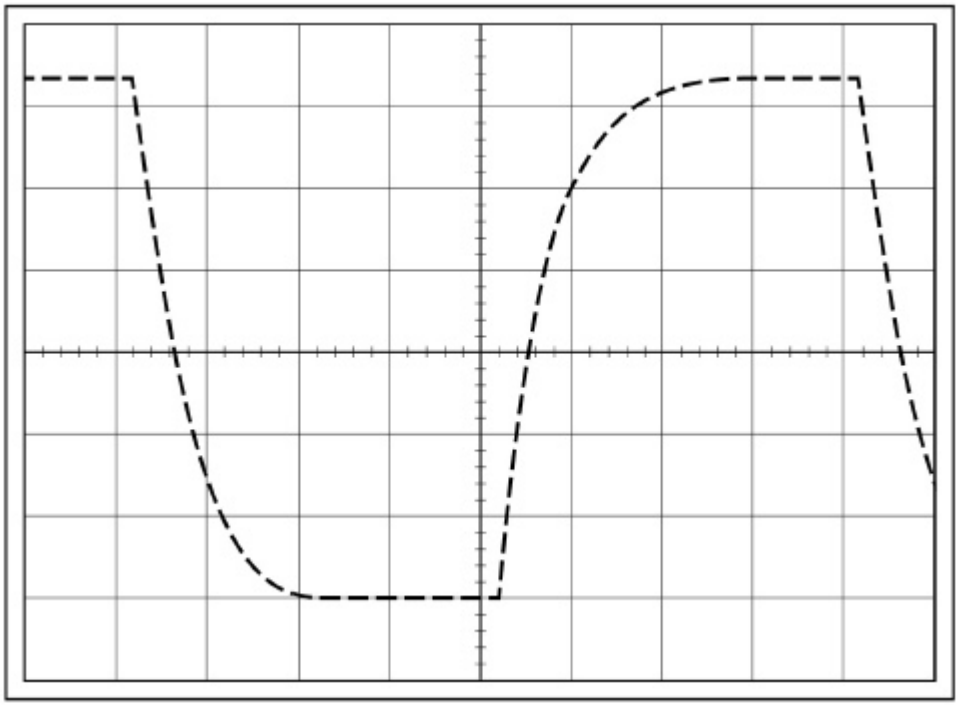
(3)

(e) The student connects an identical resistor in parallel with **R** and uses the oscilloscope to display the waveform across **C**.

Draw on **Figure 7** the waveform you expect the student to see.

The waveform of **Figure 6** is shown as a dashed line to help you show how the waveform changes.

Figure 7



Explain the change in the waveform.

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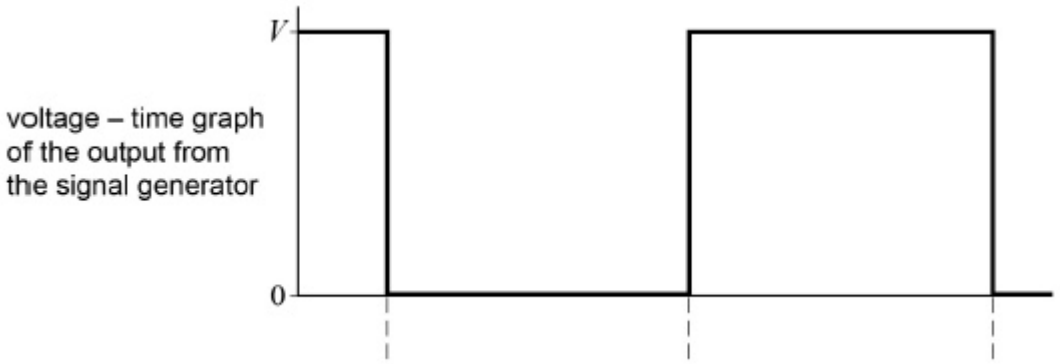
(2)

(f) **Figure 8a** is a graph of voltage against time showing the output of the signal generator. **Figure 8b** shows the voltage across **C** during the same time interval.

The student interchanges the positions of **R** and **C** and connects the oscilloscope across **R**.

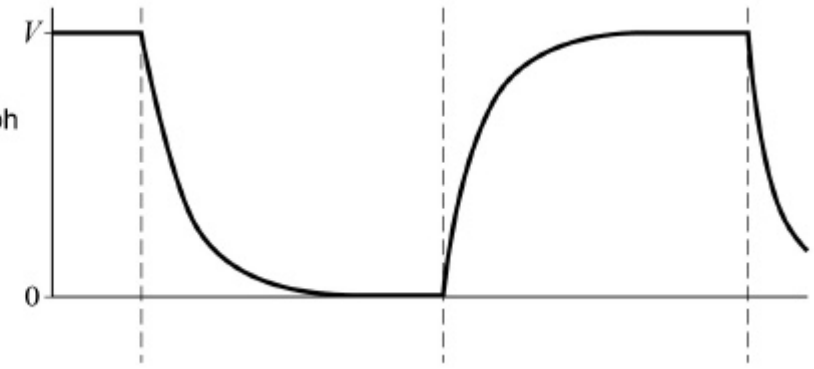
Complete **Figure 8c** to draw the voltage across R during the time interval.

Figure 8a



voltage – time graph of the output from the signal generator

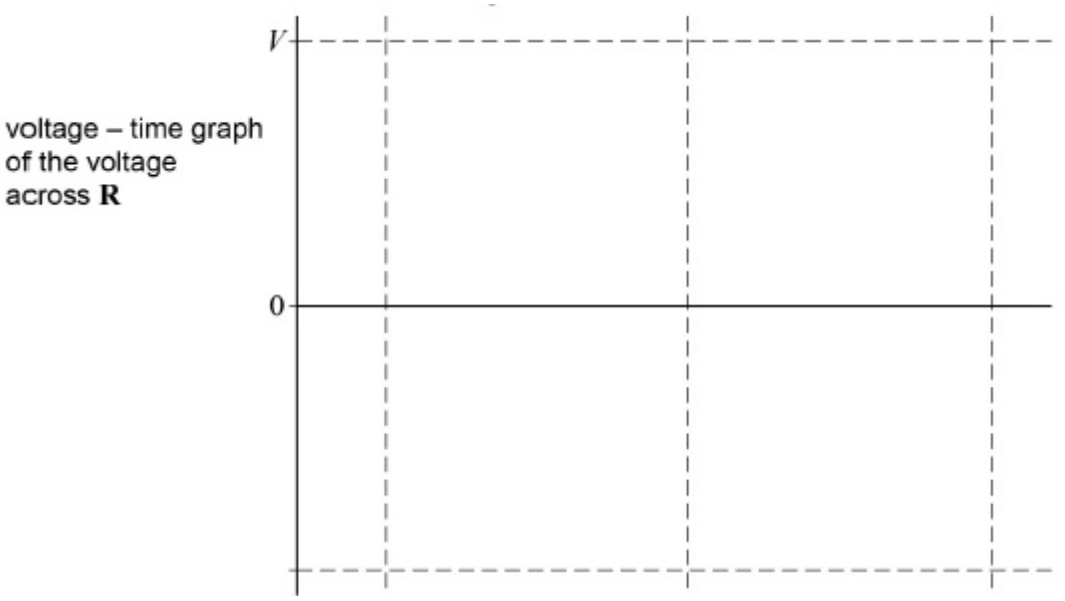
Figure 8b



voltage – time graph of the voltage across **C**

Figure 8c

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(2)

(g) State and explain what changes, if any, the student needs to make to the settings of the oscilloscope so the waveform across **R** is fully displayed.

(2)

(Total 14 marks)

Q10.

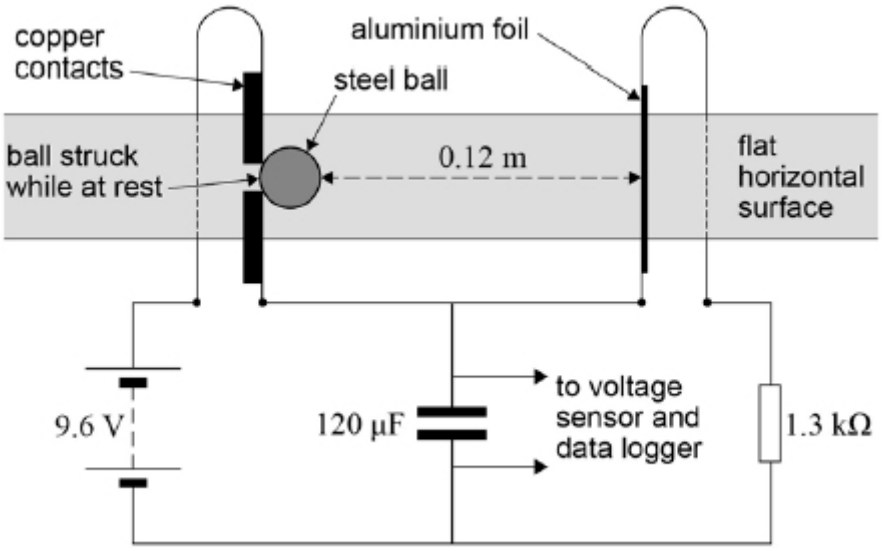
(a) Explain what is meant by a capacitance of 120 μF.

(1)

(b) **Figure 1** shows a plan view of the apparatus used by a student to measure the speed of a steel ball immediately after it has been struck from rest.

Figure 1

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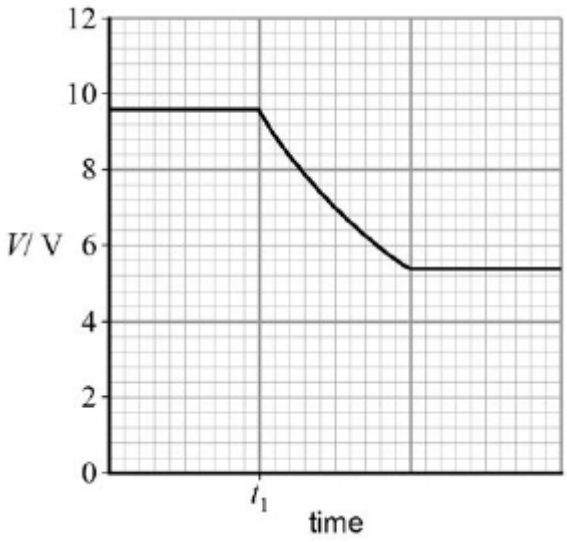


When the ball is touching the copper contacts, the 120 μF capacitor charges to a potential difference of 9.6 V. Once the ball has left the contacts, the capacitor discharges through the 1.3 kΩ resistor. When the ball has travelled a distance of 0.12 m, it breaks the aluminium foil so that the capacitor stops discharging.

Figure 2 shows the variation of potential difference *V* recorded by the data logger.

The ball is struck at time t_1.

Figure 2



Calculate the charge that passes through the resistor as the capacitor discharges.

charge = _____ C

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(1)

(c) Calculate the maximum current in the resistor during the experiment shown in **Figure 2**

maximum current = _____ A

(1)

(d) Calculate the energy that is transferred as the capacitor discharges through the 1.3 kΩ resistor.

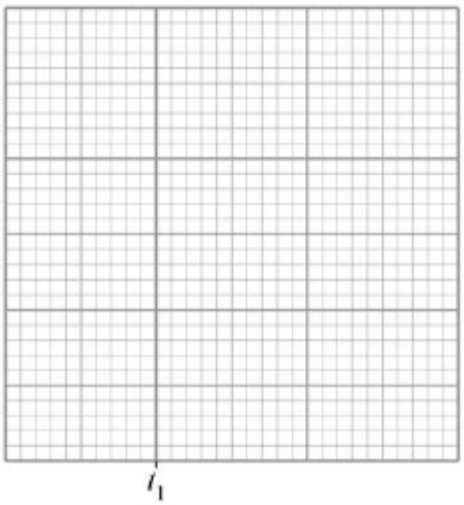
energy = _____ J

(3)

(e) Sketch a graph on the axes of **Figure 3** that shows the variation of the magnitude of the current in the resistor during the time interval shown in **Figure 2**.

A scale is required on the current axis but not on the time axis.

Figure 3



(3)

(f) Calculate the time for which the capacitor is discharging and hence determine the mean speed of the ball.

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speed = _____ m s^{-1}

(4)

(g) Discuss **two** reasons why your answer to part **(f)** is likely to be lower than the speed of the ball immediately after it is struck.

_____

_____

_____

_____

(2)

(Total 15 marks)

Q11.

Initially a capacitor stores 600 μC of charge. When it loses half of this charge, the potential difference (pd) across it decreases by 50 V.

What is the capacitance of the capacitor?

A 1.5 μF ⬭

B 3.0 μF ⬭

C 6.0 μF ⬭

D 12 μF ⬭

(Total 1 mark)

Q12.

The separation of the plates of an isolated charged parallel−plate capacitor is increased.

What also increases?

A the capacitance of the capacitor ⬭

B the charge on the plates ⬭

C the strength of the electric field between the plates ⬭

D the pd between the plates ⬭

(Total 1 mark)

Q13.

The initial charge stored by a capacitor of capacitance 0.50 μF is 2.0 μC. The capacitor is then discharged through a resistor.

How much energy is stored by the capacitor after a time equal to one time constant?

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A 0.06 μJ ⬭

B 0.54 μJ ⬭

C 1.0 μJ ⬭

D 4.0 μJ ⬭

(Total 1 mark)

Q14.

A 500 μF capacitor is charged to a pd of 10.0 V. It is then discharged through a 100 kΩ resistor.

What is the time taken for the pd to fall from 10.0 V to 5.0 V?

A 35 s ⬭

B 50 s ⬭

C 72 s ⬭

D 100 s ⬭

(Total 1 mark)

Q19.

A variable capacitor has a capacitance which can be varied from 6.0×10^{-12} F to 3.0×10^{-12} F. The capacitor is set to its maximum capacitance and fully charged using a 48 V supply. The capacitor is then disconnected from the supply and isolated. Finally the capacitance is reduced to its minimum value without any charge being lost by the capacitor.

Which line, **A** to **D**, in the table correctly shows the potential difference (pd) across the capacitor and the charge it stores after the capacitance has been reduced?

	pd / V	**Charge / C**
A	48	2.9×10^{-10}
B	24	2.9×10^{-10}
C	96	2.9×10^{-10}
D	96	1.4×10^{-10}

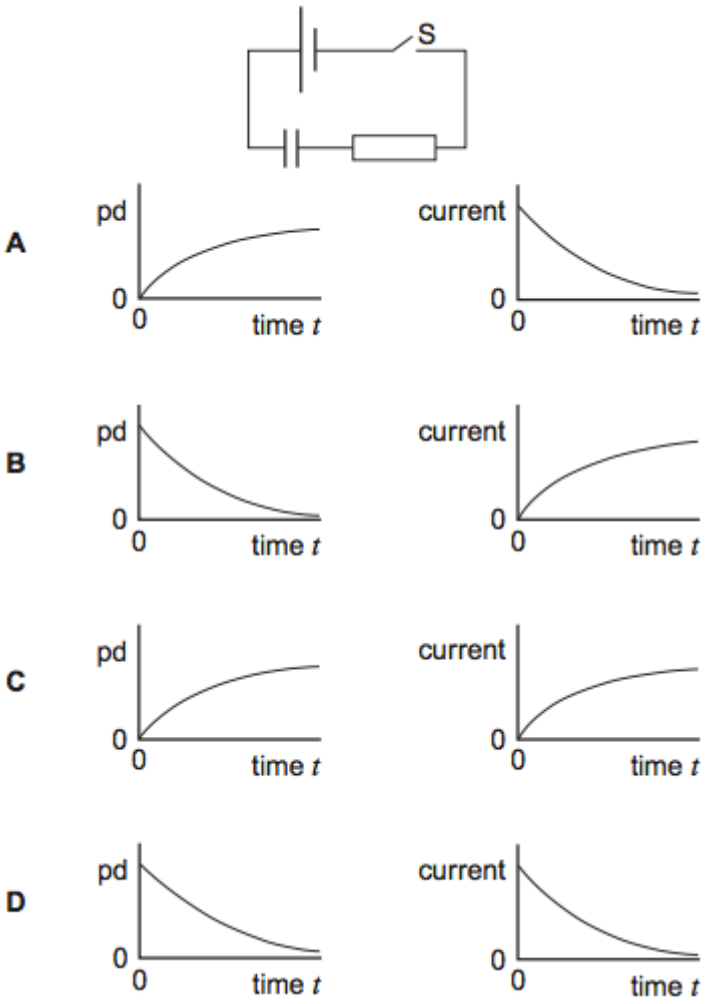
(Total 1 mark)

Q20.

The capacitor in the circuit is initially uncharged. The switch S is closed at time $t = 0$.

Which pair of graphs, **A** to **D**, correctly shows how the pd across the capacitor and the current in the circuit change with time?

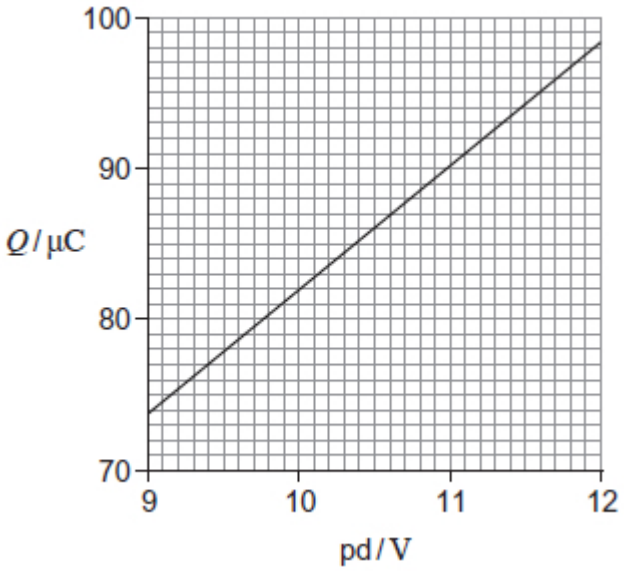
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(Total 1 mark)

Q21.

The graph shows how the charge Q stored by a capacitor varies with the potential difference (pd) V across it as V is increased from 9.0 V to 12.0 V.



(a) (i) Use the graph to determine an accurate value for the capacitance of the

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capacitor.

capacitance = _____ μF

(2)

(ii) Calculate the additional energy stored by the capacitor when V is increased from 9.0 V to 12.0 V.

additional energy = _____ J

(3)

(b) When a 470 μF capacitor is discharged through a fixed resistor R, the pd across it decreases by 80% in 45 s.

(i) Calculate the time constant of the capacitor–resistor circuit.

time constant = _____ s

(3)

(ii) Determine the resistance of R.

resistance = _____ Ω

(2)

(iii) At which point during the discharging process is the capacitor losing charge at the smallest rate? Tick (✓) the correct answer.

	✓ if correct
when the charge on the capacitor is greatest	

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when energy is dissipated at the greatest rate	
when the current in the resistor is greatest	
when the pd across R is least	

(1)

(Total 11 marks)

Q22.

An uncharged 4.7 nF capacitor is connected to a 1.5 V supply and becomes fully charged.

How many electrons are transferred to the negative plate of the capacitor during this charging process?

A 2.2×10^{10}

B 3.3×10^{10}

C 4.4×10^{10}

D 8.8×10^{10}

(Total 1 mark)

Q23.

When fully charged the 2.0 mF capacitor used as a backup for a memory unit has a potential difference of 5.0 V across it. The capacitor is required to supply a constant current of 1.0 μA and can be used until the potential difference across it falls by 10%. For how long can the capacitor be used before it must be recharged?

A 10 s

B 100 s

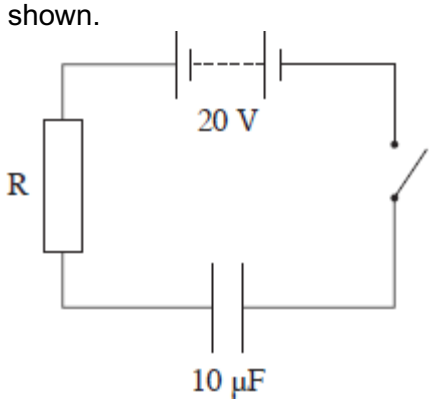
C 200 s

D 1000 s

(Total 1 mark)

Q24.

A capacitor of capacitance 10 μF is charged through a resistor R to a potential difference (pd) of 20 V using the circuit shown.



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When the capacitor is fully charged which one of the following statements is **incorrect**?

A The energy stored by the capacitor is 2 mJ.

B The total energy taken from the battery during the charging process is 2 mJ.

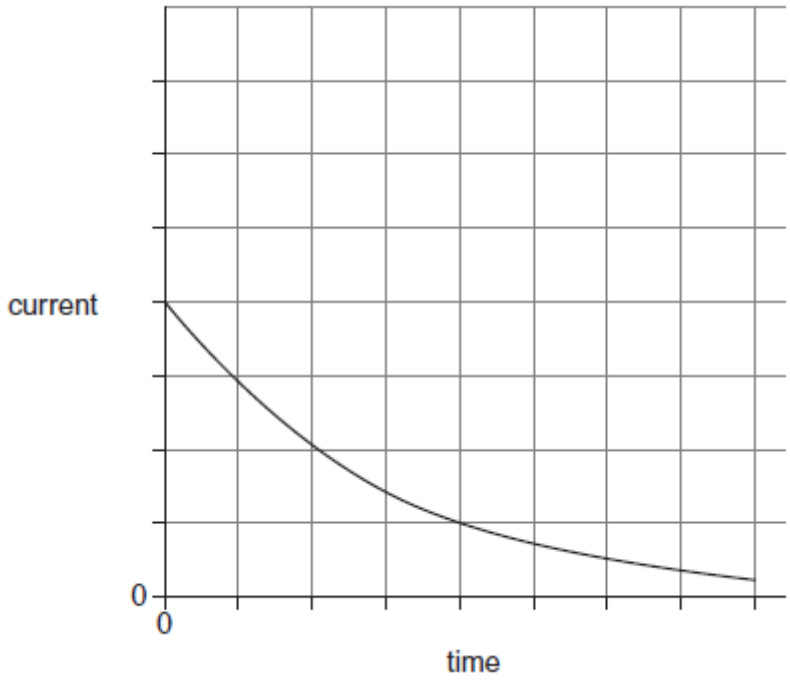
C The pd across the capacitor is 20 V.

D The pd across the resistor is 0 V.

(Total 1 mark)

Q25.

(a) The graph shows how the current varies with time as a capacitor is discharged through a 150 Ω resistor.



(i) Explain how the initial charge on the capacitor could be determined from a graph of current against time.

_____

_____

_____

_____

(1)

(ii) The same capacitor is charged to the same initial potential difference (pd) and then discharged through a 300 kΩ resistor. Sketch a second graph on the same axes above to show how the current varies with time in this case.

(3)

(b) In an experiment to show that a capacitor stores energy, a student charges a capacitor from a battery and then discharges it through a small electric motor. The motor is used to lift a mass vertically.

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(i) The capacitance of the capacitor is 0.12 F and it is charged to a pd of 9.0 V. The weight of the mass raised is 3.5 N.
Calculate the maximum height to which the mass could be raised.
Give your answer to an appropriate number of significant figures.

maximum height _____ m

(4)

(ii) Give **two** reasons why the value you have calculated in part (i) would not be achieved in practice.

1. _____

_____

_____

_____

2. _____

_____

_____

_____

(2)

(Total 10 marks)

Q26.

The specification for a pacemaker requires a suitable charge to be delivered in 1.4 ms. A designer uses a circuit with a capacitor of capacitance 3.0 μF and a 2.5 V power supply to deliver the charge. The designer calculates that a suitable charge will be delivered to the heart as the capacitor discharges from a potential difference (pd) of 2.5 V to a pd of 1.2 V in 1.4 ms.

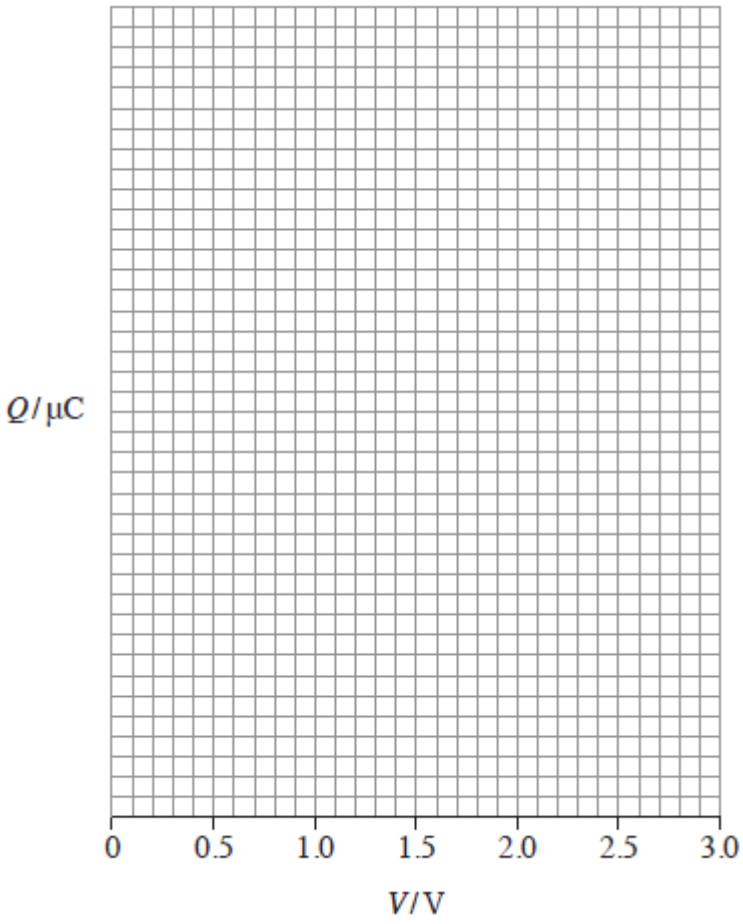
(a) (i) Calculate the charge on the capacitor when it is charged to a pd of 2.5 V.

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charge _____ C

(1)

(ii) Draw a graph showing how the charge, Q, on the capacitor varies with the pd, V, as it discharges through the heart.
Include an appropriate scale on the charge axis.



(3)

(b) Calculate the energy delivered to the heart in a single pulse from the pacemaker when the capacitor discharges to 1.2 V from 2.5 V.

energy _____ J

(3)

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(c) (i) Calculate the resistance of the heart that has been assumed in the design.

resistance _____ Ω

(3)

(ii) Explain why the rate of change of pd between the capacitor plates decreases as the capacitor discharges.

_____

_____

_____

_____

_____

(2)

(Total 12 marks)

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