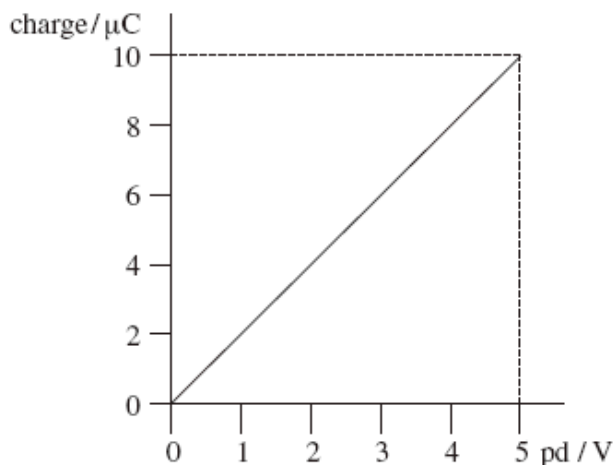


Q1. A $400\ \mu\text{F}$ capacitor is charged so that the voltage across its plates rises at a constant rate from $0\ \text{V}$ to $4.0\ \text{V}$ in $20\ \text{s}$. What current is being used to charge the capacitor?

- A $5\ \mu\text{A}$
- B $20\ \mu\text{A}$
- C $40\ \mu\text{A}$
- D $80\ \mu\text{A}$

(Total 1 mark)

Q2. The graph shows how the charge stored by a capacitor varies with the pd applied across it.



Which line, **A** to **D**, in the table gives the capacitance and the energy stored when the potential difference is $5.0\ \text{V}$?

| | capacitance/ μF | energy stored/ μJ |
|----------|----------------------------|------------------------------|
| A | 2.0 | 25 |
| B | 2.0 | 50 |
| C | 10.0 | 25 |
| D | 10.0 | 50 |

(Total 1 mark)

Q3. In experiments to pass a very high current through a gas, a bank of capacitors of total capacitance $50 \mu\text{F}$ is charged to 30 kV . If the bank of capacitors could be discharged completely in 5.0 ms , what would be the mean power delivered?

- A 22 kW
- B 110 kW
- C 4.5 MW
- D 9.0 MW

(Total 1 mark)

Q4. A 10 mF capacitor is charged to 10 V and then discharged completely through a small motor. During the process, the motor lifts a weight of mass 0.10 kg . If 10% of the energy stored in the capacitor is used to lift the weight, through what approximate height will the weight be lifted?

- A 0.05 m
- B 0.10 m
- C 0.50 m
- D 1.00 m

(Total 1 mark)

Q5. A capacitor of capacitance C stores an amount of energy E when the pd across it is V . Which line, **A** to **D**, in the table gives the correct stored energy and pd when the charge is increased by 50% ?

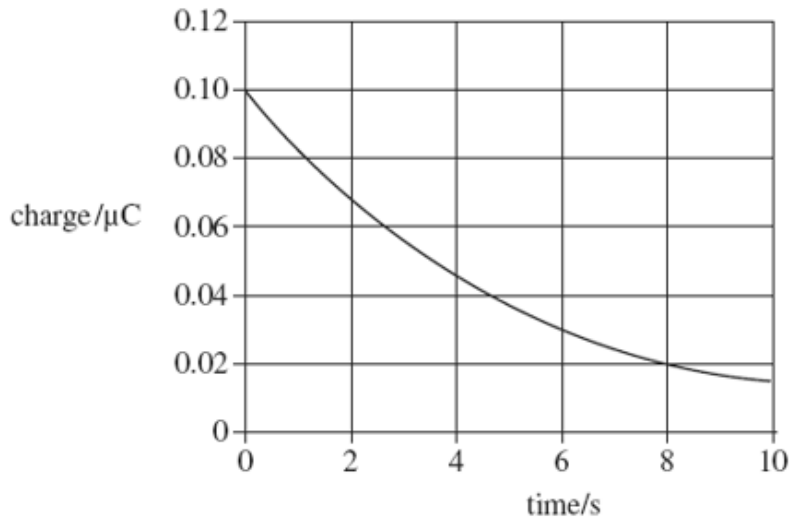
| | energy | pd |
|----------|----------|----------|
| A | $1.5 E$ | $1.5 V$ |
| B | $1.5 E$ | $2.25 V$ |
| C | $2.25 E$ | $1.5 V$ |
| D | $2.25 E$ | $2.25 V$ |

(Total 1 mark)

- Q6.** A capacitor of capacitance C discharges through a resistor of resistance R . Which one of the following statements is **not** true?
- A** The time constant will decrease if C is increased.
 - B** The time constant will increase if R is increased.
 - C** After charging to the same voltage, the initial discharge current will increase if R is decreased.
 - D** After charging to the same voltage, the initial discharge current will be unaffected if C is increased.

(Total 1 mark)

- Q7.** The graph shows how the charge on a capacitor varies with time as it is discharged through a resistor.

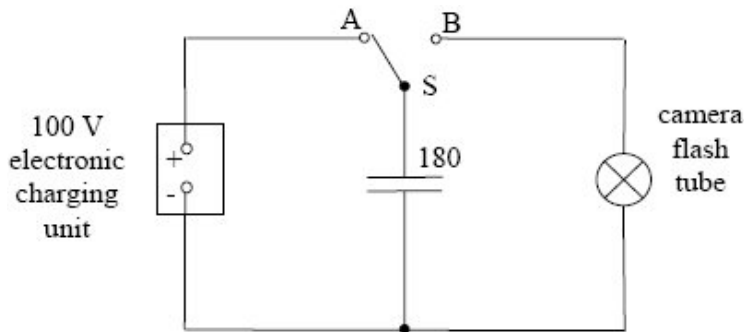


What is the time constant for the circuit?

- A** 3.0 s
- B** 4.0 s
- C** 5.0 s
- D** 8.0 s

(Total 1 mark)

Q8. The flash tube in a camera produces a flash of light when a $180 \mu\text{F}$ capacitor is discharged across the tube.



(a) The capacitor is charged to a pd of 100 V from an electronic charging unit in the camera, as shown in the diagram above. Calculate,

(i) the energy stored in the capacitor,

.....

(ii) the work done by the battery.

.....

(2)

(b) When a photograph is taken, switch S in the diagram above is automatically moved from A to B and the capacitor is discharged across the flash tube. The discharge circuit has a resistance of 1.5Ω . Emission of light from the flash tube ceases when the pd falls below 30 V.

(i) Calculate the duration of the light flash.

.....

- (ii) The capacitor in the circuit in the diagram above is replaced by a capacitor of greater capacitance. Discuss the effect of this change on the photograph image of a moving object.

.....

.....

.....

.....

.....

(4)
(Total 6 marks)

Q9. A capacitor of capacitance $330 \mu\text{F}$ is charged to a potential difference of 9.0 V . It is then discharged through a resistor of resistance $470 \text{ k}\Omega$.

Calculate

- (a) the energy stored by the capacitor when it is fully charged,

.....

.....

.....

.....

(2)

- (b) the time constant of the discharging circuit,

.....

.....

(1)

(c) the p.d. across the capacitor 60 s after the discharge has begun.

.....
.....
.....
.....
.....
.....

(3)
(Total 6 marks)

Q10. A $680 \mu\text{F}$ capacitor is charged fully from a 12 V battery. At time $t = 0$ the capacitor begins to discharge through a resistor. When $t = 25$ s the energy remaining in the capacitor is one quarter of the energy it stored at 12 V.

(a) Determine the pd across the capacitor when $t = 25\text{s}$.

.....
.....
.....
.....

(2)

(b) (i) Show that the time constant of the discharge circuit is 36 s.

.....
.....
.....
.....
.....

(ii) Calculate the resistance of the resistor.

.....
.....

(4)
(Total 6 marks)

Q11. Capacitors and rechargeable batteries are examples of electrical devices that can be used repeatedly to store energy.

- (a) (i) A capacitor of capacitance 70 F is used to provide the emergency back-up in a low voltage power supply.

Calculate the energy stored by this capacitor when fully charged to its maximum operating voltage of 1.2 V. Express your answer to an appropriate number of significant figures.

answer =J

(3)

- (ii) A rechargeable 1.2 V cell used in a cordless telephone can supply a steady current of 55 mA for 10 hours. Show that this cell, when fully charged, stores almost 50 times more energy than the capacitor in part (a)(i).

(2)

- (b) Give **two** reasons why a capacitor is **not** a suitable source for powering a cordless telephone.

Reason 1.....

.....

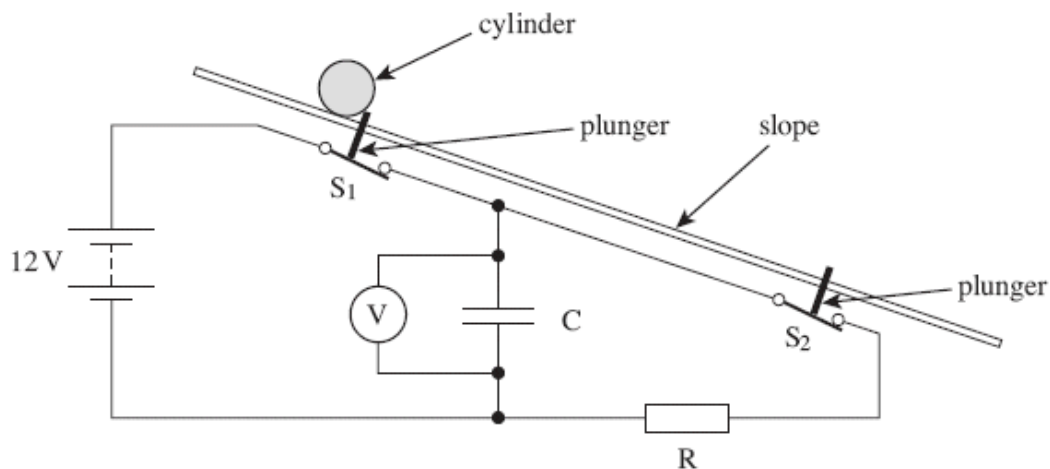
Reason 2.....

.....

(2)

(Total 7 marks)

- Q12.** A student was required to design an experiment to measure the acceleration of a heavy cylinder as it rolled down an inclined slope of constant gradient. He suggested an arrangement that would make use of a capacitor-resistor discharge circuit to measure the time taken for the cylinder to travel between two points on the slope. The principle of this arrangement is shown in the figure below.



S_1 and S_2 are two switches that would be opened in turn by plungers as the cylinder passed over them. Once opened, the switches would remain open. The cylinder would be released from rest as it opened S_1 . The pd across the capacitor would be measured by the voltmeter.

- (ii) What value does this result give for the acceleration of the cylinder down the slope, assuming the acceleration is constant?

answer =m s⁻²

(2)
(Total 11 marks)

M1. D

[1]

M2. A

[1]

M3. C

[1]

M4. A

[1]

M5. C

[1]

M6. A

[1]

M7. C

[1]

M8. (a) (i) $E (= \frac{1}{2} CV^2 = 0.5 \times 180 \times 10^{-6} \times 100^2) = 0.90\text{J}$ **(1)**

(ii) $W (= QV = CV^2 = 180 \times 10^{-6} \times 100^2) = 1.8 \text{ J}$ **(1)**

(b) (i) $(V = V_0 e^{-t/RC})$ gives $30 = 100 e^{-t/RC}$ (1)

$$\therefore t = (-RC \ln (30/100)) = -1.5 \times 180 \times 10^{-6} \times -1.204 \text{ s}$$

$$= 3.3 \times 10^{-4} \text{ s (1)}$$

(ii) image would be less sharp (or blurred) because the discharge would last longer and the image would be photographed as it is moving (1)

image would be brighter because the capacitor stores more energy and therefore produces more light (1)

4

[6]

M9. (a) $Q (= CV = 330 \times 9.0) = 2970 \text{ } (\mu\text{C})$ (1)

$$E (= \frac{1}{2} QV) = \frac{1}{2} \times 2.97 \times 10^{-3} \times 9.0 = 1.34 \times 10^{-2} \text{ J (1)}$$

$$[\text{or } E (= \frac{1}{2} CV^2) = \frac{1}{2} \times 300 \times 10^{-6} \times 9.0^2 \text{ (1)} = 1.34 \times 10^{-2} \text{ J (1)}]$$

2

(b) time constant $(= RC) = 470 \times 10^3 \times 330 \times 10^{-6} = 155 \text{ s (1)}$

1

(c) $Q (= Q_0 e^{-t/RC}) = 2970 \times e^{-60/155}$

$$= 2020 \text{ } (\mu\text{C})$$

(allow C.E. for time constant from (b))

$$V = \left(\frac{Q}{C} \right) = \frac{2020}{330} = 6.11 \text{ V (1)}$$

(allow C.E. for Q)

$$[\text{or } V = V_0 e^{-t/RC} \text{ (1)} = 9.0 e^{-60/155} \text{ (1)} = 6.11 \text{ V (1)}]$$

3

[6]

M10. (a) $E \propto V^2$ (or $E = \frac{1}{2} CV^2$) (1)

pd after 25 s = 6 V (1)

2

(b) (i) use of $Q = Q_0 e^{-t/RC}$ or $V = V_0 e^{-t/RC}$ (1)

$$\text{(e.g. } 6 = 12e^{-25/RC}) \text{ gives } e^{-\frac{25}{RC}} = \frac{12}{6} \text{ and } \frac{25}{RC} = \ln 2 \text{ (1)}$$

$$(RC = 36(.1) \text{ s})$$

[alternatives for (i):

$$V = 12 e^{-25/36} \text{ gives } V = 6.0 \text{ V (1) (5.99 V)}$$

or time for pd to halve is $0.69RC$

$$\therefore RC = \frac{25}{0.69} \text{ (1) } = 36(.2) \text{ s]$$

$$(ii) R = \frac{36.1}{680 \times 10^{-6}} \text{ (1) } = 5.3(0) \times 10^4 \Omega \text{ (1)}$$

4

[6]

M11. (a) (i) energy stored by capacitor ($= \frac{1}{2} CV^2$)

$$= \frac{1}{2} \times 70 \times 1.2^2 \checkmark \checkmark (= 50.4) = 50 \text{ (J)} \checkmark$$

to **2 sf** only \checkmark

3

(ii) energy stored by cell ($= I V t$) $= 55 \times 10^{-3} \times 1.2 \times 10 \times 3600 \checkmark$

$$(= 2380 \text{ J})$$

$$\frac{\text{energy stored by cell}}{\text{energy stored by capacitor}} = \frac{2380}{50} = 48 \text{ (ie about 50)} \checkmark$$

2

(b) capacitor would be impossibly large (to fit in phone) \checkmark

capacitor would need recharging very frequently

[or capacitor could only power the phone for a short time] \checkmark

capacitor voltage [or current supplied or charge] would fall continuously while in use \checkmark

max 2

[7]

- M12. (a) The candidate's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear.**

The candidate's answer will be assessed holistically. The answer will be assigned to one of the three levels according to the following criteria.

High Level (good to excellent) 5 or 6 marks

The information conveyed by the answer is clearly organised, logical and coherent, using appropriate specialist vocabulary correctly. The form and style of writing is appropriate to answer the question.

The candidate provides a comprehensive and logical description of the sequence of releasing the ball and taking measurements of initial and final voltages. They should identify the correct distance measurement and show a good appreciation of how to use these measurements to calculate the time and acceleration from them. Time should be found from capacitor discharge, using known C and R values. Repeated readings would be expected in any answer worthy of full marks, but five marks may be awarded where repetition is omitted.

Intermediate Level (modest to adequate) 3 or 4 marks

The information conveyed by the answer may be less well organised and not fully coherent. There is less use of specialist vocabulary, or specialist vocabulary may be used incorrectly. The form and style of writing is less appropriate.

The candidate provides a comprehensive and logical description of the sequence of releasing the ball and taking measurements of the initial and final voltages. They are likely to show some appreciation of the use of suvat equations to calculate the acceleration, although they may not recognise the need to measure a distance.

Low Level (poor to limited) 1 or 2 marks

The information conveyed by the answer is poorly organised and may not be relevant or coherent. There is little correct use of specialist vocabulary. The form and style of writing may only be partly appropriate.

The candidate is likely to have recognised that initial and final voltages should be measured, but may not appreciate the need for any other measurement. They may present few details of how to calculate the acceleration from the voltage measurements.

The explanation expected in a competent answer should include a coherent selection of the following points.

Measurements

- initial pd across C (V_0) from voltmeter (before releasing roller)
- distance s along slope between plungers
- final pd across C (V_1) from voltmeter
- measurements repeated to provide a more reliable result

Analysis

- time t is found from $V_1 = V_0 e^{-t/RC}$, giving $t = RC \ln (V_0/V_1)$
- from $s = ut + \frac{1}{2} at^2$ with $u = 0$, acceleration $a = 2s/t^2$
- repeat and find average a from several results

(b) (i) $RC = 22 \times 10^{-6} \times 200 \times 10^3$ [or = 4.4 (s)] **(1)** (4.40)

$$5.8 = 12.0 e^{-t/4.40} \text{ **(1)**}$$

$$\text{gives } t = 4.40 \ln (12.0/5.8) = 3.2 \text{ (3.20) (s) **(1)}**}$$

3

(ii) $\alpha \left(= \frac{2s}{t^2} \right) = \frac{2 \times 2.5}{3.20^2} \text{ **(1)}**}$

$$= 0.49 \text{ (0.488) (m s}^{-2}\text{) **(1)}**}$$

2

[11]

