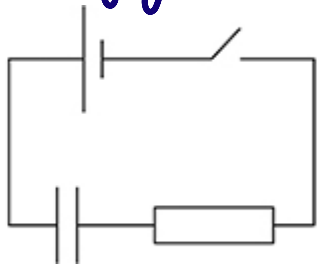
A LEVEL PHYSICS

WORKED SOLUTIONS

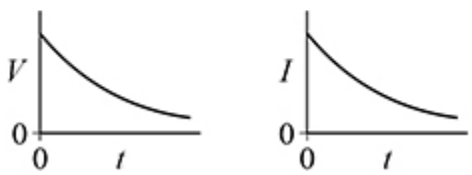
7.4. Capacitance MCQ

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

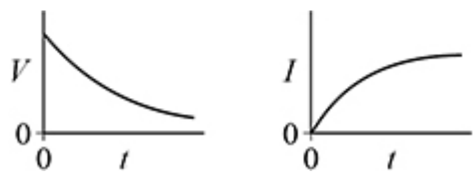


Which pair of graphs shows how the potential difference V across the capacitor and the current I in the circuit change with time t?

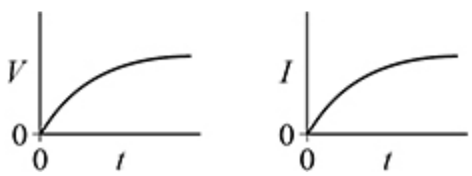
A



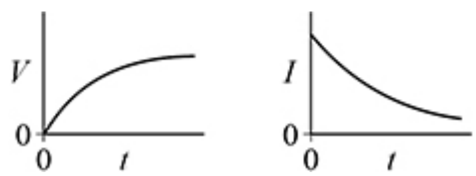
B



C



D



A ○

B ○

C ○

D ●

V increases
Q increases
I decreases

(Total 1 mark)

2. When a parallel-plate capacitor is connected across a battery, the energy stored in the capacitor is W.

The battery remains connected as the distance between the capacitor plates is halved.

What is the energy now stored in the capacitor?

A	$0.5W$	○
B	W	○
C	$2W$	●
D	$4W$	○

$W = \frac{1}{2}QV = \frac{1}{2}Q\frac{E}{d}$ $W \propto \frac{1}{d}$

$d \rightarrow \frac{d}{2}$ $W \rightarrow 2W$

(Total 1 mark)

3. An uncharged capacitor is connected to a power supply which supplies a constant current of 10 μA.

After 100 ms, the potential difference across the capacitor is 5.0 kV.

What is the capacitance of the capacitor?

A	2.0×10^{-10} F	●
B	4.0×10^{-10} F	○
C	2.5×10^{9} F	○
D	5.0×10^{9} F	○

$C = \frac{Q}{V} = \frac{It}{V} = \frac{10\times10^{-6} \times 100\times10^{-3}}{5.0\times10^{3}}$

$C = 2.0\times10^{-10}$

(Total 1 mark)

4. A parallel-plate capacitor is made using a sheet of dielectric material between, and in contact with, two plates.
The properties of four sheets of dielectric material are shown.

Which sheet will produce the maximum capacitance?

$C = A\varepsilon_0\varepsilon_r/d$

$C \propto \varepsilon_r/d$

Sheet	Relative permittivity	Thickness / mm		ε_r/d
A	2	0.40	●	5
B	3	0.90	○	3.33
C	4	1.0	○	4
D	6	1.6	○	3.75

(Total 1 mark)

5. A parallel-plate capacitor is made by inserting a sheet of dielectric material between two plates.
Both plates are in contact with the sheet.

Which relative permittivity and sheet thickness give the greatest capacitance?

	Relative permittivity	Thickness / mm	
A	2	0.40	●
B	3	0.90	○
C	4	1.0	○
D	6	1.6	○

Same question as Q4 above

(Total 1 mark)

6. A 10 μF capacitor stores 4.5 mJ of energy.
It then discharges through a 25 Ω resistor.

What is the maximum current during the discharge of the capacitor?

A 1.2 A

B 18 A

C 30 A

D 36 A

$W = \frac{1}{2}CV^2$ $V = \sqrt{\frac{2W}{C}} = \sqrt{\frac{2 \times 4.5\times10^{-3}}{10\times10^{-6}}}$

$V = 30V$

$I = \frac{V}{R} = \frac{30}{25} = 1.2A$

(Total 1 mark)

7. A 1.0 μF capacitor is charged for 20 s using a constant current of 10 μA.

What is the charge collected by the sphere each second? Question is confusing!

energy?

A 5.0×10^{-3} J

B 1.0×10^{-2} J

C 2.0×10^{-2} J

D 4.0×10^{-2} J

$W = \frac{1}{2}\frac{Q^2}{C} = \frac{1}{2}\frac{(It)^2}{C}$

$W = \frac{1}{2}\frac{(10\times10^{-6}\times20)^2}{1.0\times10^{-6}} = 2.0\times10^{-2}J$

(Total 1 mark)

8. A 1.0 μF capacitor initially stores 15 μC of charge. It then discharges through a 25 Ω resistor.

What is the maximum current during the discharge of the capacitor?

A 0.60 mA

B 1.2 mA

C 0.60 A

D 1.2 A

$V = \frac{Q}{C} = \frac{15\times10^{-6}}{1.0\times10^{-6}} = 15V$

$I = \frac{V}{R} = \frac{15}{25} = 0.60A$

(Total 1 mark)

9. The initial potential difference across a capacitor is V_0. The capacitor discharges through a circuit of time constant T. The base of natural logarithms is e.

What is the potential difference across the capacitor after time T?

A $\frac{V_0}{e}$

B $\frac{V_0}{e}$

C V_0e

D $V_0\ln 2$

$V = V_0 e^{-\frac{t}{T}}$

$t = T$

$V = V_0 e^{-1} = \frac{V_0}{e}$

(Total 1 mark)

10. 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

C $\frac{E}{2}$

D $\frac{E}{4}$

Not sure about this one!

I make it E/2 not E

(Total 1 mark)

11. 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?

$C = A\varepsilon_0\varepsilon_r / d$

A $\frac{1}{2}$

B 1

C 2

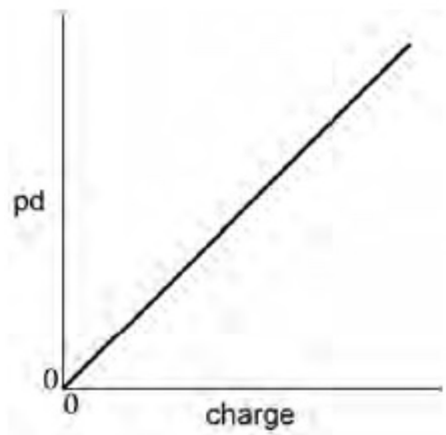
D 8

$\frac{\varepsilon_{r_1}}{\varepsilon_{r_2}} = \frac{d_1}{d_2} \cdot \frac{A_2}{A_1}$

$\frac{\varepsilon_{r_1}}{\varepsilon_{r_2}} = \frac{d}{2d} \cdot \frac{4l^2}{l^2} = \frac{1}{2} \times 4 = 2$

(Total 1 mark)

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



$C = \frac{Q}{V} = \frac{1}{\text{gradient}}$

gradient = constant

$\therefore$ C = constant

Which statement can be deduced from the graph?

A The charging current is constant.

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)

13. 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 ○

$\frac{Q}{Q_0} = e^{-t/RC}$

$= e^{-4.8/(20\times10^3 \times 120\times10^{-6})}$

$= 0.135$

$= 0.14$

(Total 1 mark)

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

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 $8C$ ●

$C = A\varepsilon_0\varepsilon_r/d$

$\frac{C_2}{C_1} = \frac{A_2}{A_1}\cdot\frac{d_1}{d_2} = \frac{4l^2}{l^2}\cdot\frac{d}{d/2} = 4\times2 = 8$

(Total 1 mark)

15. 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 $\frac{2Q^2}{C}$ ○

$E = \frac{1}{2}QV = \frac{1}{2}CV^2 = \frac{1}{2}\frac{Q^2}{C}$

$\Delta E = E_2 - E_1$

$= \frac{1}{2}C(2V)^2 - \frac{1}{2}CV^2$

$= 2CV^2 - \frac{1}{2}CV^2 = \frac{3}{2}CV^2$

(Total 1 mark)

$\frac{3}{2}CV^2 = \frac{3}{2}\frac{Q^2}{C}$