

19.1 Capacitors and capacitance

Name: _____ Class: _____ Date: _____

Total: 24 marks

KEY WORDS capacitance • capacitor • potential difference • resistor
• farad

Objective

Build the skills to answer exam questions on **capacitance** – $C = Q/V$ and combining capacitors.

You must be able to:

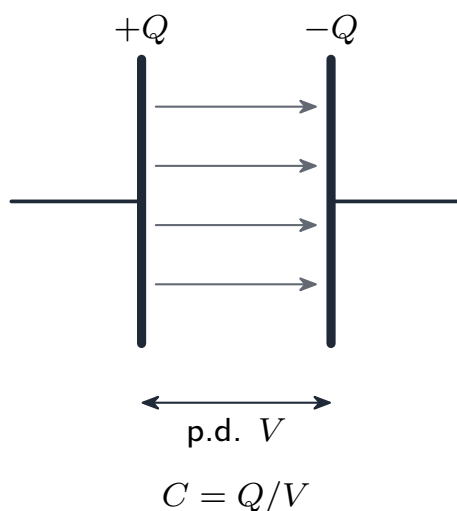
- define **capacitance** and use $C = Q/V$
- combine capacitors in **series** and **parallel**

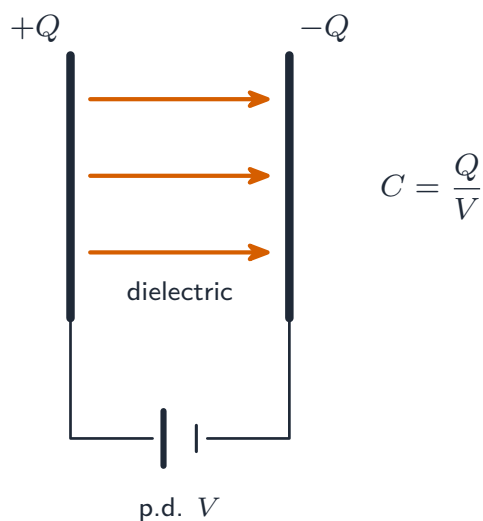
1 Worked examples

Study these first. Each one shows the method for a question type used later – follow the steps and you can do the Practice and Exam-style questions yourself.

■ Capacitance

A **capacitor** stores charge: $+Q$ on one plate, $-Q$ on the other, with p.d. V across the gap:





A parallel-plate capacitor

$$C = \frac{Q}{V} \quad (\text{farad, F} = \text{C V}^{-1}).$$

■ **Combining capacitors (opposite to resistors)**

- **parallel:** $C = C_1 + C_2 + \dots$
- **series:** $\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \dots$

2 Practice

Now apply the methods above.

2.1 Define **capacitance**.

[1]

2.2 State the **unit** of capacitance.

[1]

2.3 A capacitor holds $60 \mu\text{C}$ of charge at 12 V. Find its **capacitance**.

[2]

2.4 Write the formula for capacitors in **parallel**.

[1]

3 Exam-style questions

3.1 The unit of capacitance is the:

[1]

☐

A coulomb

B farad

C volt

D ohm

3.2 A $100\ \mu\text{F}$ capacitor is charged to $9.0\ \text{V}$. Calculate the **charge** stored.

[2]

3.3 A $4.0\ \mu\text{F}$ and a $2.0\ \mu\text{F}$ capacitor are connected in **series**. Calculate the combined capacitance.

[3]

3.4 Write the formula for capacitors in **series**.

[1]

3.5 Three capacitors are available: $C_1 = 120 \mu\text{F}$, $C_2 = 180 \mu\text{F}$ and $C_3 = 220 \mu\text{F}$.

(a) C_1 and C_2 are connected in **series** across a supply. **Complete** the table to show how the charge on each and the p.d. across each relate to the total charge Q_S and the supply p.d. V_S . [2]

quantity	relationship
charges Q_1 , Q_2 and Q_S	_____
p.d.s V_1 , V_2 and V_S	_____

(b) **Determine** the combined capacitance of C_1 and C_2 in series. [2]

(c) The supply provides 12 V. **Calculate** the charge stored by that series combination, and the p.d. across C_1 . [3]

(d) C_3 is now connected in **parallel** with the series pair. **Determine** the total capacitance of the whole network, and the total charge it now stores at 12 V. [3]

(e) **State and explain** which single capacitor in the network stores the **most** charge. [2]

Solutions

Each answer shows the steps, then the **result**.

2.1

- the **charge stored per unit potential difference** ($C = Q/V$)

2.2

- the **farad** (F)

2.3

- $C = Q/V$

$$C = \frac{Q}{V} = \frac{60 \times 10^{-6} \text{ C}}{12 \text{ V}} = \mathbf{5.0 \mu F}$$

2.4

- $C = C_1 + C_2 + \dots$

3.1 B

- the SI unit of capacitance is the **farad**

3.2

- $Q = CV$

$$Q = CV = (100 \times 10^{-6} \text{ F})(9.0 \text{ V}) = \mathbf{9.0 \times 10^{-4} \text{ C}}$$

3.3

- series: $1/C = 1/C_1 + 1/C_2$

$$\frac{1}{C} = \frac{1}{4.0 \mu\text{F}} + \frac{1}{2.0 \mu\text{F}} = \frac{3}{4.0 \mu\text{F}}$$

- $C = \mathbf{1.3 \mu F}$

3.4

- $1/C = 1/C_1 + 1/C_2 + \dots$

3.5

(a) charges: $Q_1 = Q_2 = Q_S$ – the same charge passes through every capacitor in a series chain

- p.d.s: $V_1 + V_2 = V_S$

(b) in series, $\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2}$

$$C = \frac{C_1 C_2}{C_1 + C_2} = \frac{(120 \mu\text{F})(180 \mu\text{F})}{300 \mu\text{F}} = \mathbf{72 \mu F}$$

(c) $Q = CV$

$$Q = CV = (72 \times 10^{-6} \text{ F})(12 \text{ V}) = \mathbf{8.6 \times 10^{-4} \text{ C}}$$

$$V_1 = \frac{Q}{C_1} = \frac{8.64 \times 10^{-4} \text{ C}}{120 \times 10^{-6} \text{ F}} = \mathbf{7.2 \text{ V}}$$

- the **smaller** capacitor takes the larger share of the p.d.

(d) capacitors in parallel add: $C_{\text{total}} = C_1 + C_2 = 72 \mu\text{F} + 220 \mu\text{F} = \mathbf{292 \mu\text{F}}$

$$Q_{\text{total}} = C_{\text{total}}V = (292 \times 10^{-6} \text{ F})(12 \text{ V}) = \mathbf{3.5 \times 10^{-3} \text{ C}}$$

(e) C_3

- it has the full 12 V across it and the largest capacitance, so $Q = CV$ is largest; the series pair shares the same p.d. and behaves as only $72 \mu\text{F}$