Exercise walk-through

Dielectrics ▪ 10.4

eXercise

You must be able to

- describe a **dielectric 电介质** as an insulator that becomes **polarized** in a field
- explain how the **dielectric constant 介电常数** κ increases capacitance, $C = \kappa C_0$
- describe how a dielectric reduces the field for a fixed charge
- compare a capacitor with a dielectric at **constant charge** versus **constant voltage**

Method — What a dielectric does

A dielectric is an insulator that **polarizes** in a field; its aligned charges partly cancel the applied field.

Method — Effect on capacitance

Inserting a dielectric raises the capacitance to $C = \kappa C_0$ ($\kappa > 1$).

Method — Constant charge vs constant voltage

- **Isolated (constant Q):** the field and voltage **drop**, so $U = \frac{1}{2}Q^2/C$ falls.
- **Connected to a battery (constant V):** more charge flows on, so Q and $U = \frac{1}{2}CV^2$ **rise**.

Practice 2.1 ▪ 1 mark

State what happens to a dielectric placed in an electric field.

Solution 2.1

Method: What a dielectric does

Worked steps

it becomes polarized (its charges shift to partly oppose the field) B1.

Practice 2.2 ▪ 2 marks

A capacitor $C_0 = 2.0\ \mu$F has a dielectric of $\kappa = 3.0$ inserted. Find the new capacitance.

Solution 2.2

Method: Effect on capacitance

Worked steps

$C = \kappa C_0 = 3.0 \times 2.0 = 6.0\ \mu\text{F}$ **M1** **A1**.

Practice 2.3 ▪ 1 mark

State what a dielectric does to the field between the plates at fixed charge.

Solution 2.3

Method: What a dielectric does

Worked steps

it reduces the field B1.

Exam-style 3.1 ▪ 1 mark

Inserting a dielectric ($\kappa > 1$) makes the capacitance

A smaller

B larger

C zero

D unchanged

Solution 3.1

Method: Effect on capacitance

A smaller

B larger ✓

C zero

D unchanged

Worked steps

B.

Exam-style 3.2 ▪ 1 mark

A dielectric is an

A conductor

B insulator that polarizes

C source of charge

D magnet

Solution 3.2

A conductor

B insulator that polarizes ✓

C source of charge

D magnet

Worked steps

B.

Exam-style 3.3 ▪ 1 mark

A $4.0\ \mu$F capacitor is charged to 50 V, then **disconnected**; a dielectric of $\kappa = 2.0$ is inserted.
(a) Find the new capacitance.
(b) State what happens to the voltage, and why.

Solution 3.3

Method: Effect on capacitance

Worked steps

(a) $C = \kappa C_0 = 2.0 \times 4.0 = 8.0\ \mu\text{F}$ B1. (b) the voltage halves to 25 V — the charge is fixed and $V = Q/C$, so doubling C halves V B1 B1.