AP PHYSICS C: ELECTRICITY AND MAGNETISM • EXERCISE SHEET

10.4 Dielectrics

Name: _____ Class: _____ Date: _____ **Total: 9 marks**

KEY WORDS dielectric 电介质 • dielectric constant 介电常数 • polarized 极化 • capacitor 电容器 • capacitance 电容

Objective

Build the skills to answer exam questions on **dielectrics**.

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**

1 Worked examples

Study these first. Each one shows the method for a question type used later.

■ What a dielectric does

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

■ Effect on capacitance

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

■ 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**.

2 Practice

2.1 State what happens to a dielectric placed in an electric field. [1]

2.2 A capacitor $C_0 = 2.0\ \mu$F has a dielectric of $\kappa = 3.0$ inserted. Find the new capacitance. [2]

2.3 State what a dielectric does to the field between the plates at fixed charge. [1]

3 Exam-style questions

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

- **A** smaller
- **B** larger
- **C** zero
- **D** unchanged

3.2 A dielectric is an [1]

- **A** conductor
- **B** insulator that polarizes
- **C** source of charge
- **D** magnet

3.3 A 4.0 μF capacitor is charged to 50 V, then **disconnected**; a dielectric of $\kappa = 2.0$ is inserted.

(a) Find the new capacitance. [1]

(b) State what happens to the voltage, and why. [2]

Solutions

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

2.2 $C = \kappa C_0 = 3.0 \times 2.0 = 6.0\ \mu\text{F}$.

2.3 it reduces the field.

3.1 B.

3.2 B.

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