Capacitors Questions – OCR A Level Physics

Praneel Physics

1. Define the term capacitance. **(P)**

Working and Answer:

Capacitance is the charge stored per unit potential difference, $C = \frac{Q}{V}$.

2. State the unit of capacitance. **(P)**

Working and Answer:

Farad (F).

3. What is meant by a dielectric in a capacitor? **(P)**

Working and Answer:

An insulating material placed between the plates of a capacitor to increase its capacitance.

4. Give one use of capacitors in electrical circuits. **(P)**

Working and Answer:

Capacitors are used for smoothing voltage in power supplies.

5. Explain how the energy is stored in a capacitor. **(PP)**

Working and Answer:

Energy is stored in the electric field between the plates as work is done to move charge against the potential difference.

6. Describe how the capacitance of a parallel plate capacitor depends on its geometry and dielectric. **(PP)**

Working and Answer:

$$C = \varepsilon \frac{A}{d}$$

Capacitance increases with plate area A, dielectric permittivity ε, and decreases with plate separation d.

7. Sketch and describe the voltage-time graph for a discharging capacitor. **(PP)**

Working and Answer:

Exponential decay; voltage decreases rapidly at first then gradually approaches zero.

8. What is the time constant for a capacitor-resistor circuit and what does it represent? **(PP)**

Working and Answer:

$$\tau = RC$$

It represents the time taken for the charge or voltage to fall to $1/e \approx 37\%$ of its initial value.

9. A capacitor of $220\,\mu$F is charged to $12\,$V. Calculate the energy stored. **(PPP)**

Working and Answer:

$$E = \frac{1}{2}CV^2 = 0.5 \times 220 \times 10^{-6} \times 12^2 = 0.0158\,\text{J}$$

10. Calculate the time constant of a circuit with a $1000\,\Omega$ resistor and a $470\,\mu$F capacitor. **(PPP)**

Working and Answer:

$$\tau = RC = 1000 \times 470 \times 10^{-6} = 0.47\,\text{s}$$

11. A capacitor discharges from 6.0 V to 2.2 V in 4.0 s. Estimate the time constant. **(PPP)**

Working and Answer:

$$V = V_0 e^{-t/RC} \Rightarrow \frac{2.2}{6.0} = e^{-4/\tau} \Rightarrow \tau \approx 3.1\,\text{s}$$

12. A capacitor stores 0.20 C of charge at 10 V. Find its capacitance. **(PPP)**

Working and Answer:

$$C = \frac{Q}{V} = \frac{0.20}{10} = 0.02\,\text{F}$$

13. Derive the expression for energy stored in a capacitor. **(PPPP)**

Working and Answer:

Work done to move charge dq is $V\,dq$, but $V = \frac{q}{C}$:

$$E = \int_0^Q \frac{q}{C}\,dq = \frac{1}{2}\frac{Q^2}{C}$$

So:

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

14. A capacitor of $10\,\mu$F is discharged through a $100\,\text{k}\Omega$ resistor. How long will it take for the voltage to drop to 10% of its original value? **(PPPP)**

Working and Answer:

$$\frac{V}{V_0} = e^{-t/RC} \Rightarrow \ln(0.1) = -t/1 \Rightarrow t = 2.3 \times \tau = 2.3\,\text{s}$$

15. Explain how energy is dissipated in a resistor during capacitor discharge. **(PPPP)**

Working and Answer:

As current flows through the resistor, electrical energy stored in the capacitor is converted to thermal energy due to resistance.

16. Describe how the presence of a dielectric affects the energy stored in a capacitor. **(PPPP)**

Working and Answer:

The dielectric increases capacitance, so for the same voltage more charge and energy can be stored.

17. Three capacitors of $4\,\mu$F, $6\,\mu$F, and $12\,\mu$F are connected in series. Calculate the total capacitance. **(PPPPP)**

Working and Answer:

$$\frac{1}{C} = \frac{1}{4} + \frac{1}{6} + \frac{1}{12} = \frac{1}{2} \Rightarrow C = 2\,\mu\text{F}$$

18. Two $10\,\mu$F capacitors are connected in parallel and charged to 9.0 V. Find the total energy stored. **(PPPPP)**

Working and Answer:

$$C_{total} = 20\,\mu\text{F}, \quad E = \frac{1}{2}CV^2 = 0.5 \times 20 \times 10^{-6} \times 81 = 8.1 \times 10^{-4}\,\text{J}$$

19. Calculate the charge remaining after 5 s in a capacitor discharging through a resistor if $Q_0 = 2.0\,\text{C}$ and $\tau = 3\,\text{s}$. **(PPPPP)**

Working and Answer:

$$Q = Q_0 e^{-t/\tau} = 2.0 \times e^{-5/3} \approx 2.0 \times 0.188 = 0.376\,\text{C}$$

20. A $22\,\mu$F capacitor is charged to 15 V then discharged through a resistor. How much energy is lost to heat during discharge? **(PPPPP)**

Working and Answer:

$$E = \frac{1}{2}CV^2 = 0.5 \times 22 \times 10^{-6} \times 225 = 2.475 \times 10^{-3}\,\text{J}$$

21. A capacitor discharges to 20% of its original charge in 6.0 s. Estimate the time constant. **(PPPPP)**

Working and Answer:

$$\frac{Q}{Q_0} = e^{-6/\tau} = 0.2 \Rightarrow \tau = \frac{6}{\ln(5)} \approx 3.73\,\text{s}$$