Solutions

Marking: **M1** a correct method, **A1** the correct answer, **B1** an independent mark.

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

2.1

0–1 ms: $i = 47\times10^{-6}\times5000 = +\mathbf{0.235\ A}$; 1–2 ms: $-\mathbf{0.235\ A}$; $w_{\max} = \tfrac{1}{2}(47\times10^{-6})(5.0)^2 = \mathbf{0.59\ mJ}$

2.2

during the rise: $v = 0.020 \times \dfrac{3.0}{0.050} = \mathbf{1.2\ V}$; after: $\dfrac{di}{dt} = 0$, so $v = \mathbf{0}$; $w = \tfrac{1}{2}(0.020)(3.0)^2 = \mathbf{90\ mJ}$

2.3

$C = \dfrac{10 \times 15}{25} = \mathbf{6.0\ \mu F}$; $q = 6.0 \times 10^{-6} \times 100 = \mathbf{600\ \mu C}$ on each; $v_{10} = \dfrac{600}{10} = \mathbf{60\ V}$, $v_{15} = \mathbf{40\ V}$

2.4

C open, L short: $i_L = \dfrac{9.0}{3.0\text{ k}} = \mathbf{3.0\ mA}$; $v_C = 3.0\text{ mA} \times 2.0\text{ k}\Omega = \mathbf{6.0\ V}$; $w_C = \tfrac{1}{2}(10^{-5})(36) = \mathbf{0.18\ mJ}$, $w_L = \tfrac{1}{2}(0.050)(0.0030)^2 = \mathbf{0.23\ \mu J}$

3.1

constant current, so $\Delta v = \dfrac{i\,t}{C}$: $t = \dfrac{1.0 \times 3.0}{50 \times 10^{-6}} = 6.0 \times 10^4\text{ s} = \mathbf{16.7\ h}$

energy $= \tfrac{1}{2}(1.0)(5.0^2 - 2.0^2) = \mathbf{10.5\ J}$; check: average voltage 3.5 V $\times$ 50 µA $\times\, 6.0 \times 10^4$ s $= 10.5$ J

$C = \dfrac{50 \times 10^{-6} \times 86\,400}{3.0} = 1.44$ F, so use a **1.5 F** part

3.2

$i = \dfrac{12}{200} = 60$ mA, $w = \tfrac{1}{2}(0.20)(0.060)^2 = \mathbf{0.36\ mJ}$

$v = L\dfrac{di}{dt} \approx 0.20 \times \dfrac{0.060}{1.0 \times 10^{-6}} = \mathbf{12\ kV}$

the current in L cannot stop at once; the huge voltage breaks down the transistor or sparks

a **flyback diode** across the coil gives the current a path: it decays with $\tau = \dfrac{L}{R} = 1.0$ ms, and the transistor sees only about 12.7 V

3.3

(a) $w = \tfrac{1}{2}(330 \times 10^{-6})(300)^2 = \mathbf{14.9\ J}$; $q = Cv = \mathbf{0.099\ C}$

(b) $P = \dfrac{14.85}{1.0 \times 10^{-3}} = \mathbf{14.9\ kW}$; power into C: $0.80 \times 3.0 \times 1.5 = 3.6$ W; $t = \dfrac{14.85}{3.6} = \mathbf{4.1\ s}$

(c) more current: $\dfrac{14.85}{3.0 \times 0.80 \times 3.0} = \mathbf{2.1\ A}$ from the battery; or less energy: $3.6 \times 3.0 = 10.8$ J, so $C = \dfrac{2 \times 10.8}{300^2} = \mathbf{240\ \mu F}$

a choice with a reason: e.g. 2.1 A keeps the full flash if the battery can give it; 240 µF gives a 27% weaker flash but keeps the battery current low

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