## Solutions

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

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

**2.1**

15 V and 3.0 Ω → 5.0 A in parallel with 3.0 Ω; 3.0 ∥ 6.0 = 2.0 Ω, so 5.0 A with 2.0 Ω, back to 10 V with 2.0 Ω; $i_L = \dfrac{10}{2.0 + 3.0} = \mathbf{2.0\ A}$

**2.2**

$V_{Th} = \mathbf{9.0\ V}$; $R_{Th} = \dfrac{9.0}{0.45} = \mathbf{20}\ \Omega$; $v = 9.0 \times \dfrac{70}{90} = \mathbf{7.0\ V}$

**2.3**

short a–b: $I_N = \dfrac{24}{8.0} = \mathbf{3.0\ A}$; $R_{Th} = 8.0 \parallel 8.0 = \mathbf{4.0}\ \Omega$; drawn as 3.0 A in parallel with 4.0 Ω, arrow towards a

**2.4**

$R_L = R_{Th} = \mathbf{6.0}\ \Omega$; $P_{\max} = \dfrac{18^2}{4 \times 6.0} = \mathbf{13.5\ W}$; 12 Ω: $i = 1.0$ A, $P = \mathbf{12\ W}$, only 11% less

**3.1**

12 V alone: $12 \times \dfrac{6}{10} = 7.2$ V; 2.0 A alone: $2.0 \times (4 \parallel 6) = 4.8$ V; $V_{Th} = \mathbf{12.0\ V}$

$R_{Th} = 4 \parallel 6 = \mathbf{2.4}\ \Omega$; $i_L = \dfrac{12.0}{2.4 + 3.6} = \mathbf{2.0\ A}$

check: $\dfrac{v - 12}{4} + \dfrac{v}{6} + \dfrac{v}{3.6} = 2$ gives $v = 7.2$ V and $\dfrac{7.2}{3.6} = 2.0$ A

**3.2**

12 V alone: $2 \parallel 4 = 1.33\ \Omega$, $v = 12 \times \dfrac{1.33}{5.33} = 3.0$ V, $i' = 0.75$ A; 6.0 V alone: $4 \parallel 4 = 2.0\ \Omega$, $v = 3.0$ V, $i'' = 0.75$ A

$i = \mathbf{1.5\ A}$, $P = 1.5^2 \times 4.0 = \mathbf{9.0\ W}$

separate powers: $0.75^2 \times 4.0 = 2.25$ W each, total 4.5 W, not 9.0 W; power goes as $i^2$, and $(i' + i'')^2 \neq i'^2 + i''^2$: power is not linear, so superposition does not apply to it

**3.3**

(a) $R_L = \mathbf{0.20}\ \Omega$; $P_{\max} = \dfrac{48^2}{0.80} = \mathbf{2.88\ kW}$; efficiency **50**%: another 2.88 kW heats the battery

(b) $i = \dfrac{48}{2.4} = \mathbf{20\ A}$, $P_L = 20^2 \times 2.2 = \mathbf{880\ W}$; $\eta = \dfrac{2.2}{2.4} = \mathbf{91.7}\%$

(c) $\dfrac{R_L}{R_L + 0.20} \geq 0.95$ gives $R_L \geq \mathbf{3.8}\ \Omega$; $P_L = \left(\dfrac{48}{4.0}\right)^2 \times 3.8 = \mathbf{547\ W}$



a power system must waste little energy and keep the source cool, so $R_L \gg R_{Th}$; a radio receiver has a tiny signal and needs as much of it as possible, so it matches



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