Solutions

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

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

2.1

$\beta = \dfrac{2.0\text{ mA}}{20\ \mu\text{A}} = \mathbf{100}$; $I_E = \mathbf{2.02\ mA}$; $\alpha = \dfrac{2.0}{2.02} = \mathbf{0.990}$

2.2

$I_B = \dfrac{4.3}{10\text{ k}} = 0.43$ mA, so βI_B would be 43 mA; the most R_C allows is $\dfrac{4.8}{1.0\text{ k}} = 4.8$ mA: **saturated**; $V_{CE} \approx \mathbf{0.2\ V}$, $I_C = \mathbf{4.8\ mA}$

2.3

$(V_{CE}, I_C) = (\mathbf{10\ V}, 0)$; $(0, \mathbf{5.0\ mA})$; at 5.0 V: $I_C = \dfrac{10-5}{2.0\text{ k}} = \mathbf{2.5\ mA}$, the middle of the line, which gives the most room to swing

2.4

$R_C = \dfrac{5 - 2.0 - 0.2}{0.020} = 140\ \Omega$, use $\mathbf{150}\ \Omega$; $I_B = 5 \times \dfrac{20\text{ mA}}{50} = 2.0$ mA; $R_B = \dfrac{5 - 0.7}{2.0\text{ mA}} = 2.15$ kΩ, use $\mathbf{2.2\ k\Omega}$

3.1

$V_{Th} = 15 \times \dfrac{12}{80} = \mathbf{2.25\ V}$; $R_{Th} = 68 \parallel 12 = \mathbf{10.2\ k\Omega}$

$I_E = \dfrac{2.25 - 0.7}{1200 + 10\,200/121} = 1.21$ mA, so $I_C = \mathbf{1.20\ mA}$

$V_{CE} = 15 - 1.20 \times 4.7 - 1.21 \times 1.2 = \mathbf{7.9\ V}$: active

3.2

fixed: $I_C = 300 \times 24.0\ \mu\text{A} = 7.2$ mA; but the most R_C allows is $\dfrac{11.8}{2.2} = 5.4$ mA: it **saturates** and stops amplifying

divider: $I_E = \dfrac{1.55}{1200 + 10\,200/301} = 1.26$ mA, so $I_C = \mathbf{1.25\ mA}$; only about 4% above 1.20 mA

R_E gives negative feedback: if I_C rises, V_E rises and V_{BE} falls, so the current is set by $\dfrac{V_{Th} - 0.7}{R_E}$ and hardly by β

3.3

(a) $R_E = \dfrac{1.2}{1.0\text{ mA}} = \mathbf{1.2\ k\Omega}$; $V_C = 1.2 + 6 = 7.2$ V, $R_C = \dfrac{4.8}{1.0\text{ mA}} = 4.8$ kΩ, use $\mathbf{4.7\ k\Omega}$; $V_B = 1.2 + 0.7 = \mathbf{1.9\ V}$

(b) $I_B = 10\ \mu$A, divider current 100 µA; $R_2 = \dfrac{1.9}{100\ \mu\text{A}} = 19$ kΩ, use $\mathbf{18\ k\Omega}$; R_1 carries 110 µA: $\dfrac{12 - 1.9}{110\ \mu\text{A}} = 92$ kΩ, use $\mathbf{91\ k\Omega}$

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(c) $V_{Th} = 12 \times \dfrac{18}{109} = 1.98$ V, $R_{Th} = 15.0$ kΩ: $I_E = \dfrac{1.28}{1200 + 149} = \mathbf{0.95\ mA}$, $V_{CE} = 12 - 0.95 \times 5.9 = \mathbf{6.4\ V}$; within 5% of the target with room to swing either way: a good design