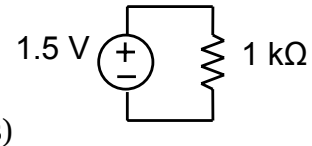
EE42/100 Spring 2006 Problem Set 1

Solutions

2.

a. Electrons move from bottom to top in the resistor.
b. Current flows from top to bottom in the resistor.
c. $V = I \cdot R \Rightarrow I = V / R = 1.5\ V / 1\ k\Omega =$ $\boxed{1.5\ mA}$
d. charge of one electron = $-1.602 \cdot 10^{-19}$ C
1.5 mA = 1.5 mC/s (positive charges) = -1.5 mC/s (negative charges)
-1.5 mC/s / ($-1.602 \cdot 10^{-19}$ C/electron) = $\boxed{9.363 \cdot 10^{15}\ \text{electrons/s}}$



3.

$\boxed{I_1 = 0\ A}$ (open circuit)
$I_3 = I_S + I_0 = 8A + -2A =$ $\boxed{I_3 = 6\ A}$
$I_S = I_2 + I_3 \Rightarrow I_2 = I_S - I_3 = 8A - 6A =$ $\boxed{I_2 = 2\ A}$

4.

Recall that ground nodes are connected to each other.
$I_1 = I_2 + I_3 \Rightarrow I_3 = I_1 - I_2 = 5\ mA - -3\ mA =$ $\boxed{8\ mA}$

5.

a. Voltage divider
$V_1 = V_{IN} \cdot 20\ \Omega / (20\ \Omega + 30\ \Omega) = 15\ V \cdot 20\ \Omega / (20\ \Omega + 30\ \Omega) =$ $\boxed{V_1 = 6\ V}$
$I_2 = (15\ V - V_1) / 30\ \Omega = (15\ V - 6\ V) / 30\ \Omega =$ $\boxed{I_2 = 0.3\ A}$
$I_1 + I_2 = 0 \Rightarrow I_1 = -I_2 =$ $\boxed{I_1 = -0.3\ A}$

b.
$V_1 = 1/4\ A \cdot 20\ \Omega =$ $\boxed{V_1 = 5\ V}$
$V_1 = -I_2 \cdot 30\ \Omega \Rightarrow I_2 = -5\ V / 30\ \Omega =$ $\boxed{I_2 = -1/6\ A}$

c.
$-0.5\ A \cdot 30\ \Omega = -I_2 \cdot 20\ \Omega \Rightarrow I_2 = --0.5\ A \cdot 30\ \Omega / 20\ \Omega =$ $\boxed{I_2 = 0.75\ A}$
$-0.5\ A = I_1 + I_2 \Rightarrow I_1 = -0.5A - 0.75A =$ $\boxed{I_1 = -1.25\ A}$
$V_1 = -I_1 \cdot 30\ \Omega + --0.5\ A \cdot 30\ \Omega = --1.25A \cdot 30\ \Omega + 15\ V =$ $\boxed{V_1 = 52.5\ V}$

6.

a. $V_{OUT} = V_{IN} \cdot R_a / (R_1 + R_a) \Rightarrow (R_1 + R_a) \cdot V_{OUT} = V_{IN} \cdot R_a$
$\Rightarrow R_a \cdot (V_{IN} - V_{OUT}) = R_1 \cdot V_{OUT} \Rightarrow R_a = R_1 \cdot V_{OUT} / (V_{IN} - V_{OUT})$
$R_a = 15\ k\Omega \cdot 20\ V / (50\ V - 20\ V) =$ $\boxed{R_a = 10\ k\Omega}$
$P = V \cdot I = V^2 / R$
$P_a = V_{OUT}^2 / R_a = (20\ V)^2 / 10\ k\Omega = 40\ mW \Rightarrow$ $\boxed{\text{use 1/8 W rating for } R_a}$
$P_1 = (V_{IN} - V_{OUT})^2 / R_1 = (50V - 20V)^2 / 15\ k\Omega = 60\ mW \Rightarrow$ $\boxed{\text{use 1/8 W rating for } R_1}$

b. Answers vary
Let $R_a = 2.25\ \Omega$
$R_b = R_a \cdot V_{OUT} / (V_{IN} - V_{OUT}) = 1\ \Omega \cdot 2.25\ V / (5\ V - 2.25\ V) = R_b = 2.75\ \Omega$
$P_a = V_{OUT}^{\ 2} / R_a = (2.25\ V)^{\ 2} / 2.25\ k\Omega = 225\ mW$ => use ¼ W rating for R_a
$P_b = (V_{IN} - V_{OUT})^2 / R_b = (5\ V - 2.25\ V)^{\ 2} / 2.75\ k\Omega = 275\ mW$ => use ½ W rating for R_b

c. $V_{OUT} = V_{IN} \cdot R_4 / (R_3 + R_L + R_4)$ => $(R_3 + R_L + R_4) \cdot V_{OUT} = V_{IN} \cdot R_4$
=> $R_L \cdot V_{OUT} = V_{IN} \cdot R_4 - (R_3 + R_4) \cdot V_{OUT}$
=> $R_L = V_{IN} \cdot R_4 / V_{OUT} - R_3 + R_4$
$= 110\ V \cdot 2.7\ k\Omega / 28.3V - 1\ k\Omega - 2.7\ k\Omega = R_L = 6.795\ k\Omega$
$P_4 = V_{OUT}^{\ 2} / R_4 = (28.3\ V)^2 / 2.7\ k\Omega = 296.6\ mW$ => use ½ W rating for R_4
$I = V_{OUT} / R_4 = (28.3\ V)^2 / 2.7\ k\Omega = 10.48\ mA$
$P = V \cdot I = I^2 \cdot R$
$P_3 = I^2 / R_3 = (10.48\ mA)^2 \cdot 1\ k\Omega = 109.9\ mW$ => use 1/8 W rating for R_3
$P_L = I^2 / R_L = (10.48\ mA)^2 \cdot 6.795\ k\Omega = 746.5\ mW$ => use 1 W rating for R_L

7.
a.
$v = -I_1 \cdot R_2$ => $I_1 = -v / R_2$
$I_1 + I_2 + 3 = 0$ => $I_2 = -I_1 - 3\ A = --v / R_2 - 3\ A = (12\ V - v) / R_3$
=> $v \cdot (1 / R_3 + 1 / R_2) = 12\ V / R_3 + 3$
=> $v = (12\ V / R_3 + 3\ A) / (1 / R_3 + 1 / R_2) = (12\ V / 5\ \Omega + 3\ A) / (1 / 5\ \Omega + 1 / 10\ \Omega)$
$v = 18\ V$
$I_1 = -18\ V / 10\ \Omega = I_1 = -1.8\ A$
$I_2 = --1.8\ A - 3\ A = I_2 = -1.2\ A$

b.
$P_{IS} = V_{IS} \cdot I_{IS} = (R_1 \cdot 3A - v) \cdot 3A = (25\ \Omega \cdot 3\ A - 18\ V) \cdot 3\ A = -279\ W$
=> current source delivers 279 W
$P_{VS} = V_{VS} \cdot I_{VS} = 12\ V \cdot (-I_2 - 12\ V / R_4) = 12\ V \cdot (-1.2A - 12\ V / 7\ \Omega)$
=> voltage source delivers 6.171 W

c.
$P_{DISSIPATED} = P_{DELIVERED} = -(P_{IS} + P_{VS}) = -(279\ W + 6.171\ W) = P_{DISSIPATED} = 285.171\ W$