EEE103 / EEE121 / EEE141 Problem Sheet Solutions

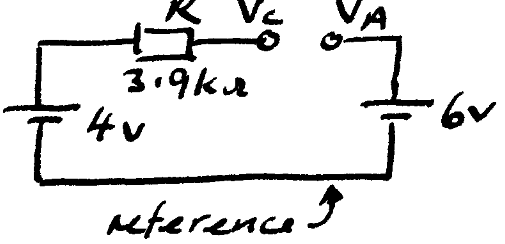
Diode Conduction State:

Q1 Solutions are only provided for those problems that are given with a numerical answer.

(a) –

(b) – make an assumption; here it will be assumed that the diode is not conducting so diode must be replaced by an open circuit....

must find V_A and V_C w.r.t. reference....

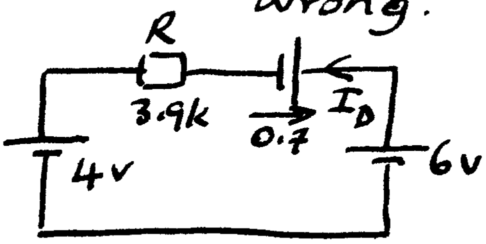


$V_A = 6V$

$V_C = 4V$ (no volts are dropped across R)

$\therefore V_A - V_C = 2V \Rightarrow$ diode conducts; assumption wrong.

– now must recalculate to find forward bias current....



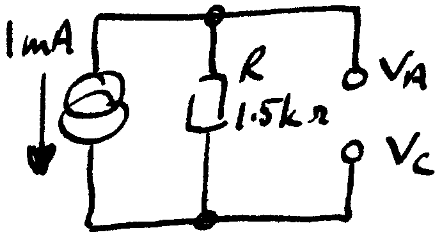
since this is a series loop, simplest way to proceed is add up voltage around loop....

$$4V + I_D R + 0.7V - 6V = 0$$

$$\text{or } I_D = \frac{6 - 4 - 0.7}{3.9k\Omega} = \underline{\underline{0.33mA}}.$$

(c) –

(d) – assume diode not conducting as in (b)



$$\begin{aligned} V_A - V_C &= \text{volts across } R \\ &= -1mA \times 1.5k\Omega \\ &= \underline{\underline{-1.5V}}. \end{aligned}$$

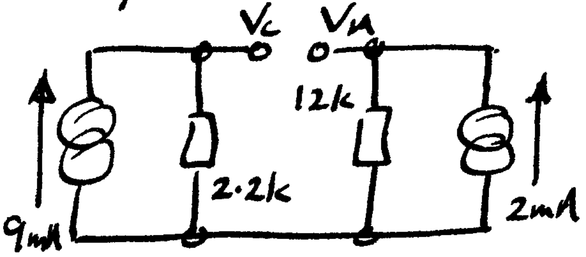
$\therefore$ diode reverse biased by 1.5V $\Rightarrow$ assumption is correct.

(e) – assume diode not conducting ....

$V_A = 2mA \times 12k\Omega = 24V$

$V_C = 9mA \times 2.2k\Omega = 19.8V$

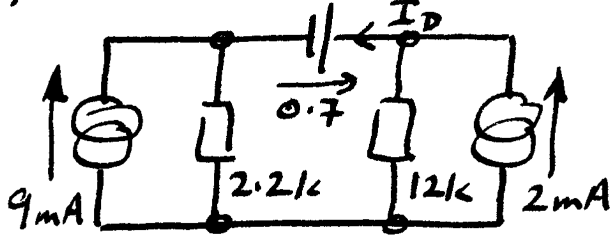
$V_A - V_C = 24 - 19.8 = \underline{\underline{4.2V}}$.



∴ assumption wrong; diode conducts.

– now replace diode by a 0.7V source ...

using superposition..



$I_{D(0.7V)} = -\,{}^{0.7}/_{14.2k\Omega}$

$I_{D(9mA)} = -\dfrac{9mA . 2.2k}{14.2k}$.

$I_{D(2mA)} = +\dfrac{2mA . 12k}{14.2k}$

$I_{TOT} = \dfrac{1}{14.2k}\left[-0.7 - 19.8 + 24\right] = \dfrac{3.5V}{14.2k\Omega} = \underline{\underline{246\mu A}}$.

Note that converting the combinations (9mA, 2.2kΩ) and (2mA, 12kΩ) into Thevenin equivalents yields a single loop that can be solved easily as in (b).

(f) –

(g) –

Q2 In all the examples of Q2, the condition $V_D = 0.7V$, $I_D = 0$ is required so assume a conducting diode, find I_D in terms of variable source then put $I_D = 0$.

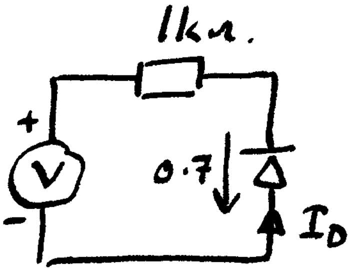
Alternatively replace diode by an open circuit and find out the value of source that will give $V_A - V_C = 0.7V$.

(a) – the loop equation for this circuit is ....

$$0{\cdot}7\text{v} + V + I_D\,1\text{k}\Omega = 0$$

if $I_D = 0$,

$0{\cdot}7 + V = 0$ or $\underline{\underline{V = -0{\cdot}7\text{V}}}$.

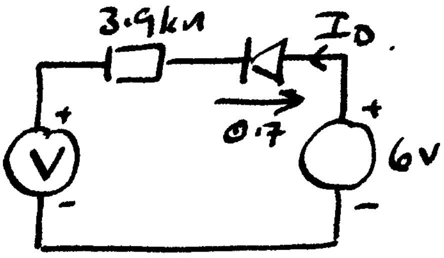


(b) – the loop equation for this circuit is ....

$$V + I_D\,3{\cdot}9\text{k}\Omega + 0{\cdot}7 - 6 = 0$$

and if $I_D = 0$,

$V = 6 - 0{\cdot}7 = \underline{\underline{5{\cdot}3\text{V}}}$



(c) – voltage across 1kΩ is 0·7V so...

$I_R = 0{\cdot}7/1\text{k}\Omega = 0{\cdot}7\text{mA}.$

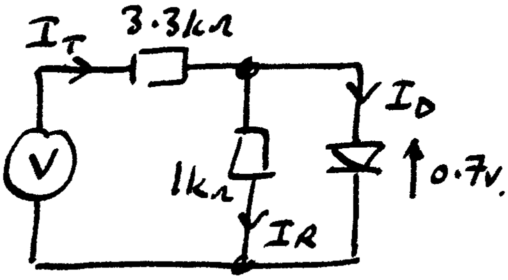
summing currents at diode's anode node....

$$I_T = I_R + I_D = \frac{V - 0{\cdot}7}{3{\cdot}3\text{k}\Omega}.$$

and putting $I_D = 0$...

$$I_R = 0{\cdot}7/1\text{k}\Omega = \frac{V - 0{\cdot}7}{3{\cdot}3\text{k}\Omega}$$

or $V = \dfrac{0{\cdot}7 \times 3{\cdot}3}{1} + 0{\cdot}7 = \underline{\underline{3{\cdot}01\text{V}}}$.



(d) – voltage across 1·5kΩ is 0·7V so....

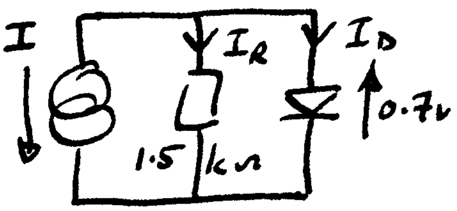
$I_R = 0{\cdot}7/1{\cdot}5\text{k}\Omega.$

summing currents at diode anode node...

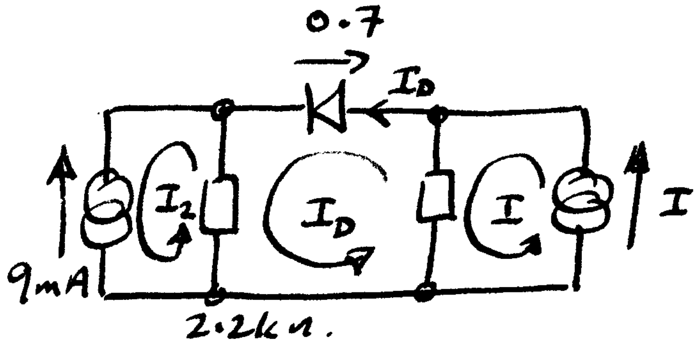
$$I + I_R + I_D = 0 = I + 0{\cdot}7/1{\cdot}5\text{k}\Omega + I_D$$

if $I_D = 0$,

$I + 0{\cdot}7/1{\cdot}5\text{k}\Omega = 0$ or $I = -\dfrac{0{\cdot}7}{1{\cdot}5\text{k}\Omega} = \underline{\underline{-0{\cdot}467\text{mA}}}$



(e) – using loops ...



$0.7\text{v} + (I_D - I_2)2.2\text{k}\Omega$
$+ (I_D - I)12\text{k}\Omega = 0.$

but $I_2 = -9\text{mA}$

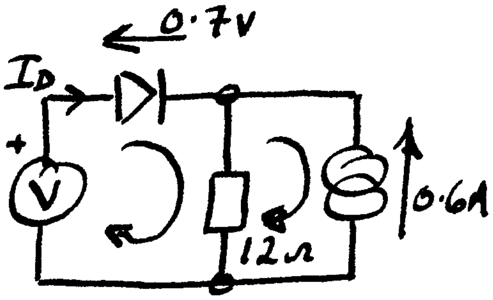
$\therefore\ 0.7\text{v} + 2.2\text{k}\Omega\, I_D + 12\text{k}\Omega\, I_D + 19.8\text{V} - I . 12\text{k}\Omega = 0$

and if $I_D = 0$

$0.7\text{v} + 19.8\text{V} - 12\text{k}\Omega\, I = 0$

or $I = \dfrac{0.7\text{V} + 19.8\text{V}}{12\text{k}\Omega} = +\dfrac{20.5}{12\text{k}\Omega} = \underline{\underline{+1.71\text{mA}}}.$

(f) – using loops ....

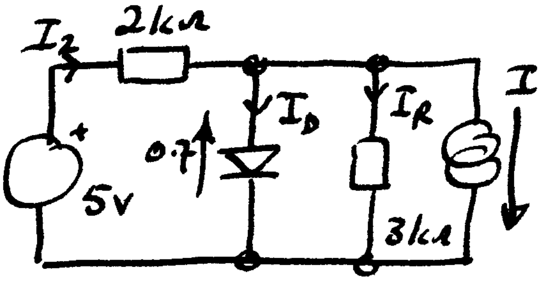


$-V + 0.7 + (I_D + 0.6) \times 12 = 0$

if $I_D = 0$ ...

$-V + 0.7 + 7.2 = 0.$

or $\underline{\underline{V = 7.9\text{V}}}.$



(g). – since volts across 3kΩ is 0.7v,

$I_R = 0.7/3\text{k}\Omega.$

summing current at diode anode node ...

$I_2 = I_D + I_R + I$

or $\dfrac{5 - 0.7}{2\text{k}\Omega} = I_D + \dfrac{0.7}{3\text{k}\Omega} + I.$

and if $I_D = 0$,

$\dfrac{4.3}{2\text{k}\Omega} - \dfrac{0.7}{3\text{k}\Omega} = I = \underline{\underline{1.92\text{mA}}}$

Q3 (a) -

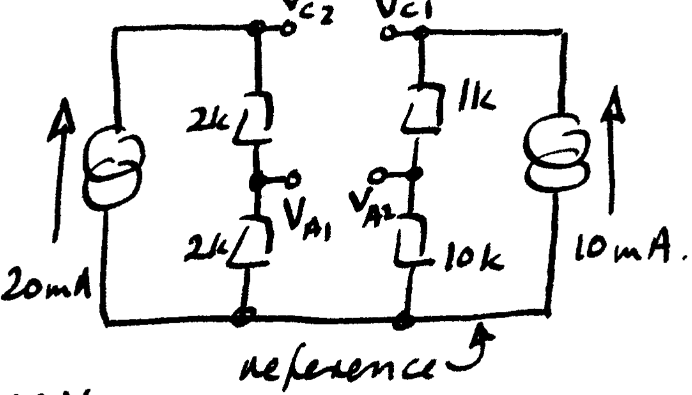
(b) - assume diodes are non conducting...

$V_{A1} = 20mA \times 2k\Omega$
$= 40V$.

$V_{C2} = 20mA \times 4k\Omega$
$= 80V$

$V_{A2} = 10mA \times 10k\Omega$
$= 100V$

$V_{C1} = 10mA \times 11k\Omega = 110V$.



∴ $V_{A1} - V_{C1} = 40 - 110 = -70V$.

$V_{A2} - V_{C2} = 100 - 80 = +20V$

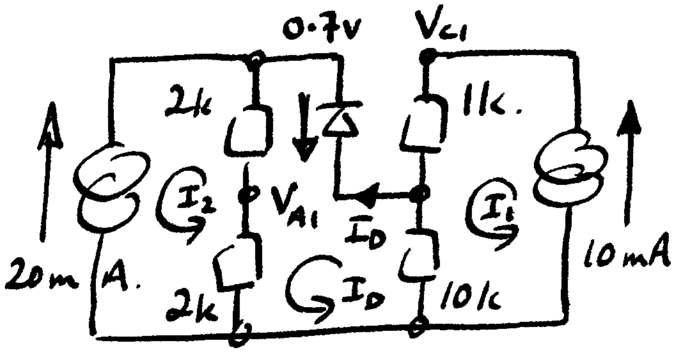
∴ diode 1 is not conducting.
diode 2 is conducting.

The circuit must now be re-examined with D_1 not conducting and D_2 conducting to find the forward current through D_2 and to check that D_1's state is not affected by the wrong assumption about D_2.

- using loops ....

$I_2 = -20mA$

$I_1 = 10mA$.



$$(I_D - I_2)2k + (I_D - I_1)10k + (I_D - I_2)2k + 0.7 = 0.$$

$$I_D[2k + 10k + 2k] + 0.7 + 40V - 100V + 40V = 0$$

$$I_D = \frac{19.3}{14k\Omega} = \underline{\underline{1.38mA}}$$

$$V_{A1} = 2k(I_D - I_2) = 2k\Omega(1.38 + 20)mA = 42.8V$$

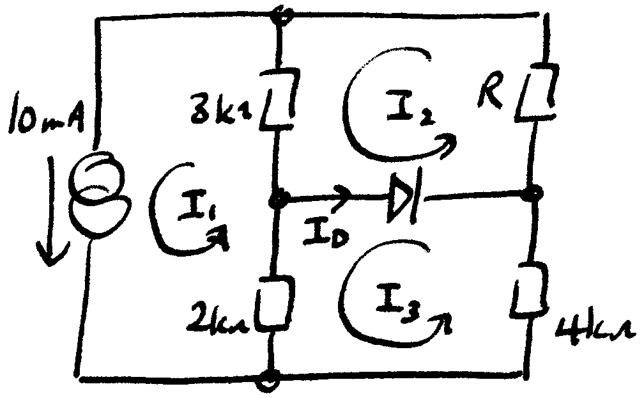
$$V_{C1} = 10mA \times 1k - (I_D - 10mA)10k = 96.2V$$

∴ D_1 still non - conducting.

Q4 (a) - let the voltage across the diode be 0.7v.

$I_1 = 10mA$

$I_D = I_2 - I_3$.



$(I_2 - I_1)3k\Omega + 0.7 + I_2 R = 0$ [I_2 loop]

or $I_2(3k\Omega + R) = 30 - 0.7 = 29.3$.

$(I_3 - I_1)2k\Omega - 0.7 + I_3 4k\Omega = 0$.

or $I_3 = \dfrac{20.7}{6k\Omega} = 3.45mA$.

$$I_D = 0 = \frac{29.3}{3k\Omega + R} - 3.45mA.$$

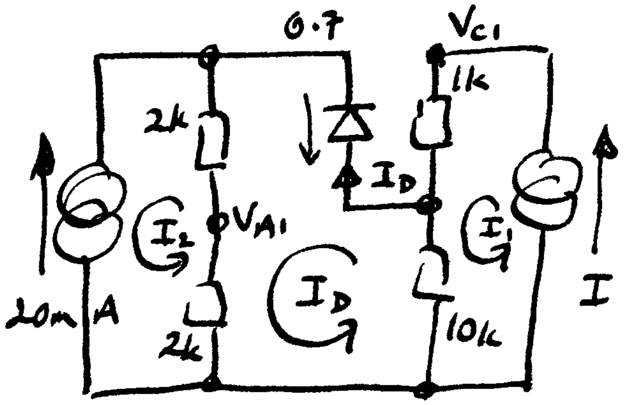
$$\text{or} \quad R = \frac{29.3 - 3.45mA \times 3k\Omega}{3.45mA}.$$

$$= \frac{29.3}{3.45mA} - 3k\Omega. = \underline{\underline{5.49k\Omega}}.$$

(b) $I_2 = -20mA$

$I_1 = I$

$(I_D - I_1)10k + 0.7$
$+ (I_D - I_2)4k = 0$.



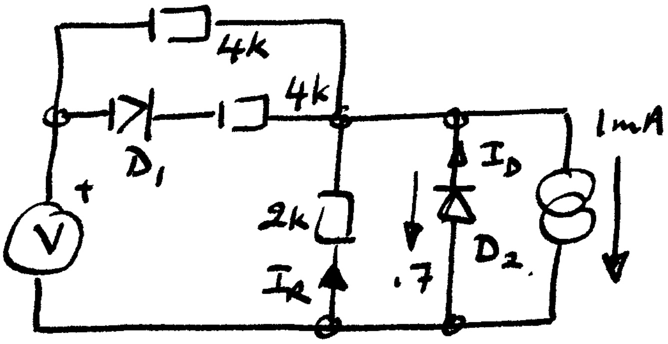
or $I_D 14k - 10k I + 80 + 0.7 = 0$.

if $I_D = 0$, $I = \dfrac{80.7}{10k} = \underline{\underline{8.07mA}}$

[$V_{A1} = 40V$, $V_{C1} = 88.7V$ so D_1 remains in a non-conducting state.]

(c) - there is 0.7 across D_1 and D_2 and the condition sought is $I_D = 0$.

$I_R = 0.7/2k\Omega$.



Summing currents at D_2 cathode node....

$$I_D + I_R - 1mA + \frac{(V-(-0.7))}{4k\Omega} + \frac{(V-0.7-(-0.7))}{4k\Omega} = 0.$$

or $$I_D + 0.7/_{2k\Omega} - 1mA + \frac{2V}{4k\Omega} + \frac{0.7}{4k\Omega} = 0.$$

if $I_D = 0$, $$\frac{2V}{4k\Omega} = 1mA - \frac{0.7}{2k\Omega} - \frac{0.7}{4k\Omega}$$

$$= 475\mu A.$$

$$\therefore V = \frac{475\mu A \times 4k\Omega}{2}$$

$$\underline{\underline{= 0.95\,V}}.$$

with $V = 0.95$, $$I_{D1} = \frac{V - 0.7 - (-0.7)}{4k\Omega}.$$

$$= \frac{0.95}{4k\Omega} = \underline{\underline{237.5\mu A}}.$$

so D_1 is still in a conducting state.