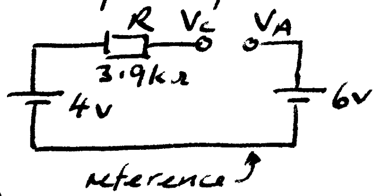
EEE123 Problem Sheet Solutions

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....



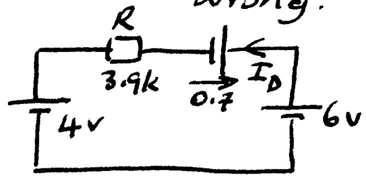
must find V_A and V_C w.r.t. reference....

$V_A = 6V$

$V_C = 4V$ (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....

$4V + I_D R + 0{\cdot}7V - 6V = 0$

or $I_D = \dfrac{6-4-0{\cdot}7}{3{\cdot}9k\Omega} = \underline{\underline{0{\cdot}33mA}}$.

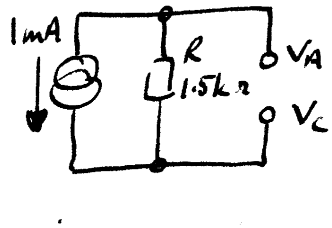
(c) –

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

$V_A - V_C$ = volts across R

$= -1mA \times 1{\cdot}5k\Omega$

$= \underline{-1{\cdot}5V}$.



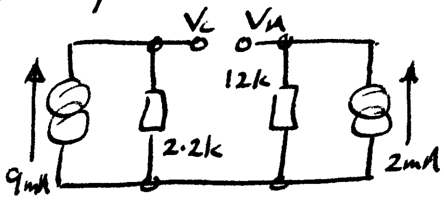
$\therefore$ diode reverse biassed by 1·5V $\Rightarrow$ assumption is correct.

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

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

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

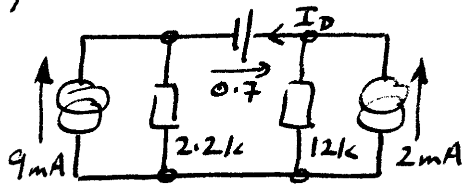
$V_A - V_C = 24 - 19.8 = \underline{4.2V}$.



∴ assumption wrong; diode conducts.

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

using superposition..



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

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

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

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

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).

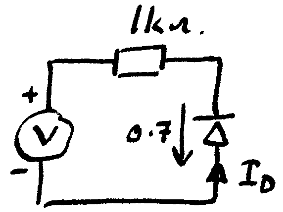
(f) –

(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 ....

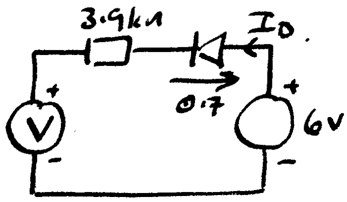


$$0.7v + V + I_D\,1k\Omega = 0$$

if $I_D = 0$,

$$0.7 + V = 0 \quad \text{or} \quad \underline{\underline{V = -0.7V}}$$

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

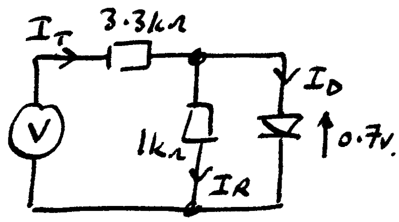


$$V + I_D\,3.9k\Omega + 0.7 - 6 = 0$$

and if $I_D = 0$,

$$V = 6 - 0.7 = \underline{\underline{5.3V}}$$

(c) – voltage across 1kΩ is 0.7V so...



$$I_R = 0.7/_{1k\Omega} = 0.7mA.$$

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

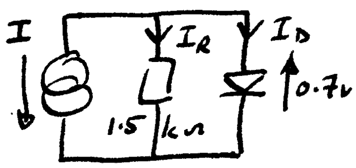
$$I_T = I_R + I_D = \frac{V - 0.7}{3.3k\Omega}.$$

and putting $I_D = 0$...

$$I_R = 0.7/_{1k\Omega} = \frac{V - 0.7}{3.3k\Omega}$$

$$\text{or} \quad V = \frac{0.7 \times 3.3}{1} + 0.7 = \underline{\underline{3.01V}}.$$

(d) – voltage across 1.5kΩ is 0.7V so....



$$I_R = 0.7/_{1.5k\Omega}.$$

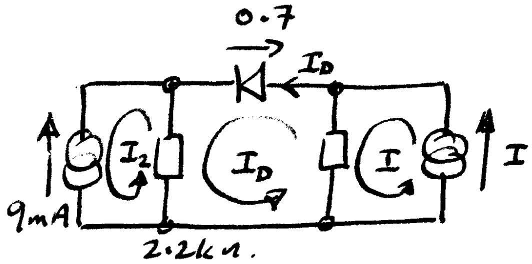
summing currents at diode anode node...

$$I + I_R + I_D = 0 = I + 0.7/_{1.5k\Omega} + I_D$$

if $I_D = 0$,

$$I + 0.7/_{1.5k\Omega} = 0 \quad \text{or} \quad I = -\frac{0.7}{1.5k\Omega} = \underline{\underline{-0.467mA}}$$

(e) – using loops ...



$0.7v + (I_D - I_2)2.2kΩ$
$+ (I_D - I)12kΩ = 0.$

but $I_2 = -9mA$

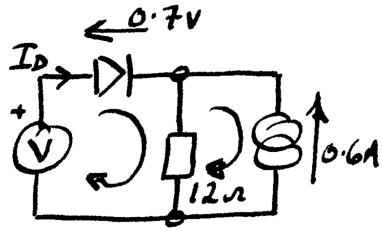
$\therefore 0.7v + 2.2kΩ\, I_D + 12kΩ\, I_D + 19.8V - I.12kΩ = 0$

and if $I_D = 0$

$0.7v + 19.8V - 12kΩ\, I = 0$

or $I = \dfrac{0.7V + 19.8V}{12kΩ} = + \dfrac{20.5}{12kΩ} = + \underline{\underline{1.71\,mA}}.$

(f) – using loops ....

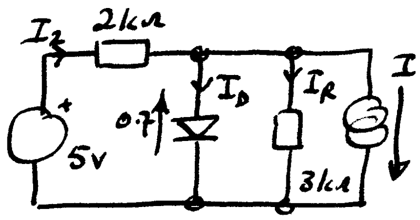


$-V + 0.7 + (I_D + 0.6)_\times 12 = 0$

if $I_D = 0$ ...

$-V + 0.7 + 7.2 = 0.$

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



(g) – since volts across 3kΩ is 0.7v,

$I_R = 0.7/3kΩ.$

summing current at diode anode node ...

$I_2 = I_D + I_R + I$

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

and if $I_D = 0$,

$\dfrac{4.3}{2kΩ} - \dfrac{0.7}{3kΩ} = I = \underline{\underline{1.92\,mA}}$