1) From, thevenin equivalent circuit, $R_T = 10k \| (10k + 5k) = 6k$

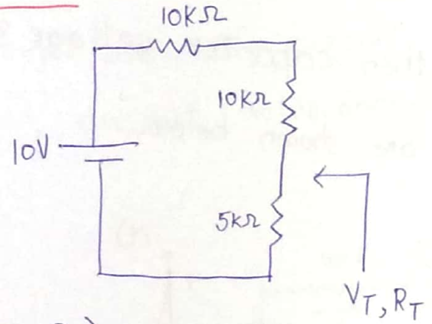
$V_T = \frac{10 \times 15}{10+10+15} = 6V$, thus $V_F = 6V$; $V_{in} = 0V$

Time constant, $\tau = R_T C = 6K \times 0.001 \times 10^{-6} = 6 msec$

$V_c(t) = 6(1 - e^{-t/\tau})\,V$ and $v_o(t) = V_c(t) \times \frac{5K}{5K+10K} = 2(1 - e^{\frac{-t}{6 \times 10^{-6}}})\,V$

$f = 5\,khz \Rightarrow T = \frac{1}{2f} = 100\,\mu sec$ where $T >> 5\tau$, so steady state will be reached

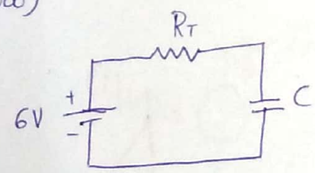
for $t_1 < t < t_2$ (below)



$V_{in} = -\frac{V \times (R_2 + R_3)}{R_1 + R_2 + R_3} = -6V$

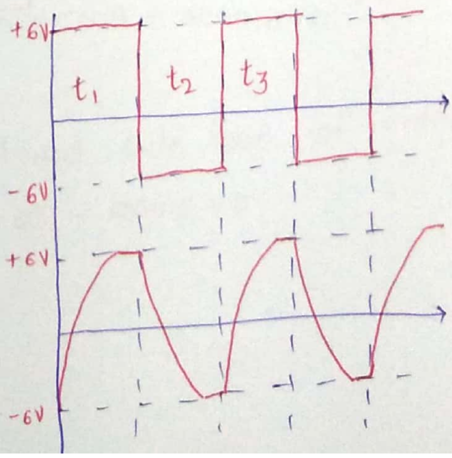
$V_F = \frac{V \times 15}{25} = 6V$ and $V_o(t) = \frac{1}{3} \times \{6 + (-6-6)e^{-t/\tau}\} = 2 - 4e^{-t/\tau}\,V$

for $t_2 < t < t_3$ (below)



$V_{in} = \frac{V \times 15}{25} = 6V$

$V_F = -\frac{V \times 15}{25} = -6V$ and $V_o(t) = \frac{1}{3} \times \{-6 + (12)e^{-t/\tau}\} = -2 + 4e^{-t/\tau}\,V$



Q 2) $V_c = 0$ at $t=0$ and S_2 is open and S_1 is closed

$\tau = R_1 C = 10^{-3}$ sec and $V_{in} = 0\,V$ and $V_F = 10V$ then

$V_c(t) = 10(1 - e^{-t/\tau})$ and $i(t) = \frac{V}{R} e^{-t/\tau}$

at $t = 2$msec, $V_c = 8.65V$ and $i = 0.135\,mA$

a) S_2 is closed at $t = 2$msec, then $R_T = 10K \| 10K = 5K$ and $V_T = 5V$

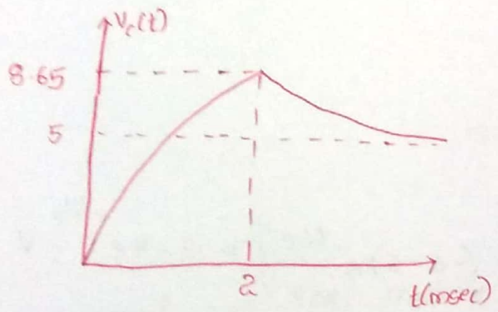
So, $\tau = R_T C = 0.5$msec and $V_{in} = 8.65V$, $V_F = 5V \Rightarrow V_c(t) = 5 + (8.65 - 5) e^{-\frac{(t-2)}{\tau}}$

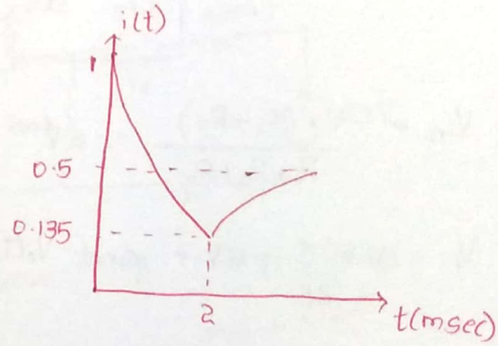
$\Rightarrow V_c(t) = 5 + 3.65\, e^{-\frac{(t-2)}{\tau}}\,V$

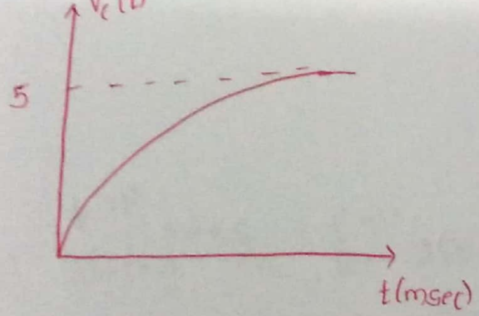
then, $i(t) = \frac{10 - V_c(t)}{10} = 0.5 - 0.365\, e^{-\frac{(t-2)}{\tau}}$

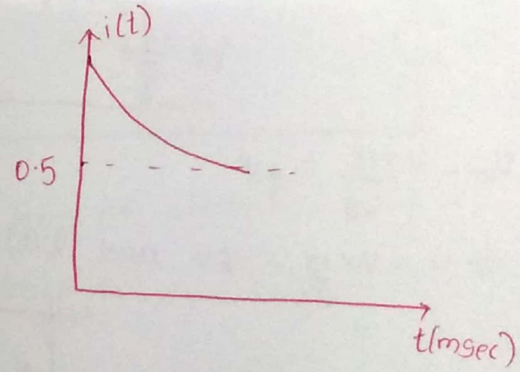
b) S_2 is closed, when $V_c = 5V$, then capacitor voltage remains at 5V

therefore, $V_F = 5V$ and plots are shown below.

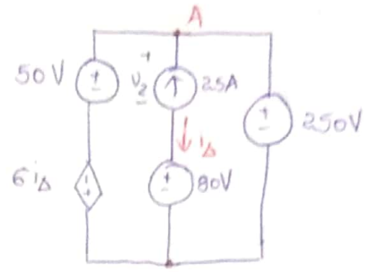








Q3) The interconnection is invalid



The current in the middle branch has to be −25A because 25A current is flowing from B to A node

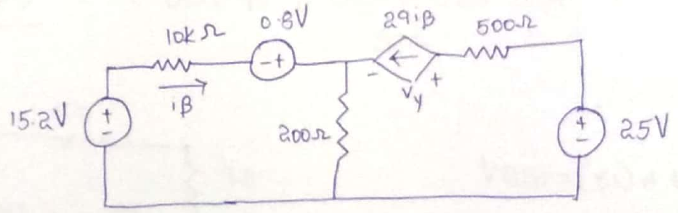
So, $6i_\Delta = 6(-25) = -150V$

$V_{AB} = 50 - (-150) = 200V$ on left side of circuit

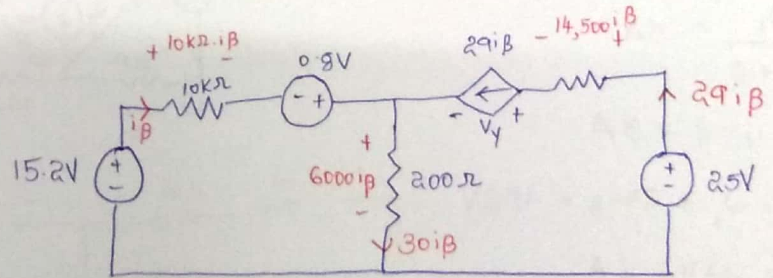
$V_{AB} = 250V$ on right side of circuit.

Therefore, circuit interconnection is valid.

4)



current in the middle branch, $i_{200\Omega} = i_\beta + 29i_\beta = 30i_\beta$



a) Writing KVL for left-hand side loop of circuit

$-15.2 + 10{,}000i_\beta - 0.8 + 6000i_\beta = 0$

$\Rightarrow i_\beta = 1mA$

Writing KVL for right-hand side loop of circuit ; wherein, $i_\beta = 1mA$

$-v_y - 14{,}500 i_\beta + 25 - 6000 i_\beta = 0$

$\Rightarrow \boxed{v_y = 4.5V}$

b) We will be using power equation, $P = VI = \frac{V^2}{R} = I^2R$

i) Power in 15.2V (voltage source) $= 1 \times 15.2 = -15.2\,mW$

ii) Power in $10k\Omega$ (resistor) $= 1^2 \times 10k\Omega = 10mW$

iii) Power in 0.8V (voltage source) $= -1 \times 0.8 = -0.8mW$

iv) Power in 200Ω (resistor) $= 30^2 \times 200 = 180mW$

v) Power in dependent Source $= 29 \times 4.5 = 130.5mW$

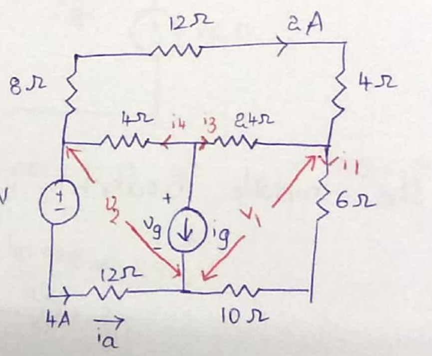
vi) Power in 500Ω $= 29^2 \times 500 = 420.5mW$

vii) Power in 25V $= -29 \times 25 = -725mW$

$\therefore$ The total power generated in circuit is sum of negative power values $= -15.2 - 0.8 - 725 = \underline{-741mW}$

$\therefore$ The total power absorbed in circuit is sum of positive values $= 10 + 180 + 130.5 + 420.5 = \underline{741mW}$

5)



$v_a = 80 + 4(12) = 128V$

$v_1 = 128 - \{8 + 12 + 4\} \times 2 = 80V$

$i_1 = \frac{v_1}{6+10} = 5A$

$i_3 = i_1 - 2 = 3A$

$v_g = v_1 + 24i_3 = 152V$

$i_4 = 2 + 4 = 6A$

$i_g = -i_4 - i_3 = -6 - 3 = -9A$

b) Power equation, $P = I^2R$

$P_{8\Omega} = (8)2^2 = 32W$ | $P_{12\Omega} = (12)(2^2) = 48W$

$P_{4\Omega} = (4)(2^2) = 16W$ | $P_{4\Omega} = (4)(6^2) = 144W$

$P_{24\Omega} = (24)(3)^2 = 216W$ | $P_{6\Omega} = (6)(5^2) = 150W$

$P_{10\Omega} = (10)(5)^2 = 250W$ | $P_{12\Omega} = (12)(4)^2 = 192W$

c) $v_g = 152V$

d) Power absorbed by all resistors

$$\sum P_{absorbed} = 32+16+216+250+48+144+150+192 = 1048W$$

Power associated with voltage source

$$P_{voltage-source} = (80)(4) = 320W$$

Power delivered by current source $= -v_g i_g = -(152)(9) = -1368W$

Thus, total power dissipated is $1048+320 = 1368W$
and total power developed is $1368W$

6)
$$50i_2 + \frac{v_o}{50} + \frac{v_o}{12.5} = 0 \Rightarrow 50i_2 + \frac{250mV}{50\Omega} + \frac{250mV}{12.5} = 0$$

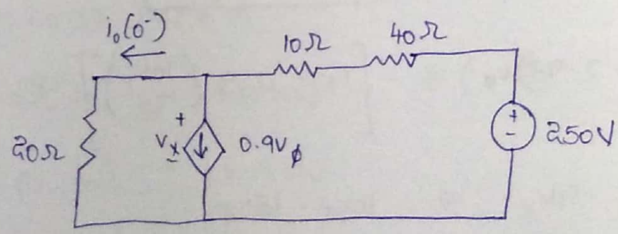
$\Rightarrow i_2 = -0.5mA$

$V_1 = i_2 \times 100 = -50mV$

$$20i_1 + \frac{(-0.050)}{25} + (-0.0005) = 0 \Rightarrow i_1 = 125\mu A$$

$v_g = 10i_1 + 40i_1 = 50i_1 \Rightarrow v_g = 6.25mV$

7) For $t<0$

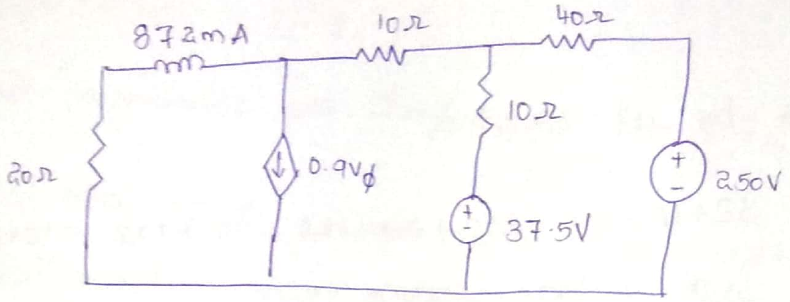


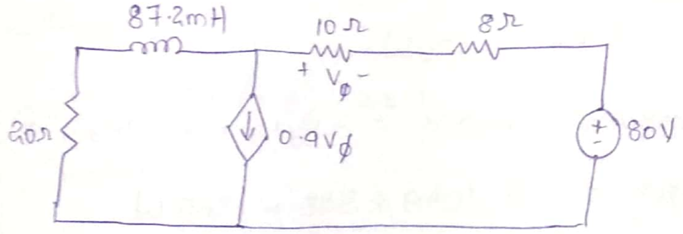
$$\frac{v_x}{20} + 9\left[\frac{v_x-250}{50}\right] + \left[\frac{v_x-250}{50}\right] = 0$$

$\Rightarrow v_x = 200V$

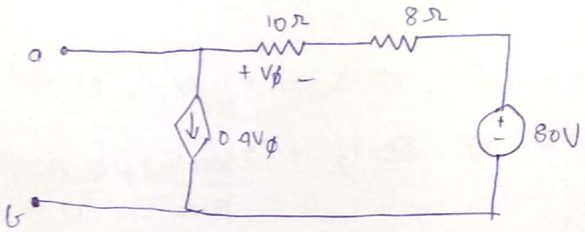
$$i_o(0^-) = \frac{200}{20} = 10A$$

t>0

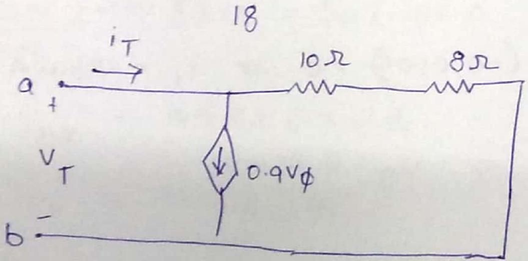




Find thevenin equivalent w.r.t a, b



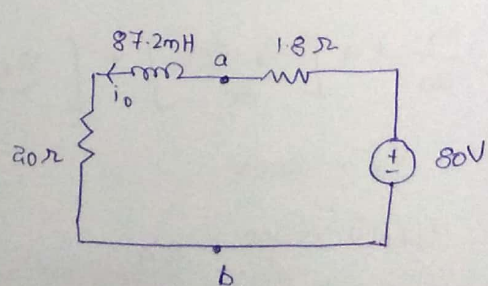
$$\frac{V_{Th}-80}{18} + \frac{9\,(V_{Th}-80)}{18} = 0 \Rightarrow V_{Th} = 80V$$



$$V_T = (i_T - 0.9V_\phi)\,18 = \left[i_T - 0.9\left(\frac{10V_T}{18}\right)\right] 18$$

$$V_T = 18i_T - 9V_T \Rightarrow 10V_T = 18i_T$$

$$\frac{V_T}{i_T} = R_{Th} = 1.8\Omega$$



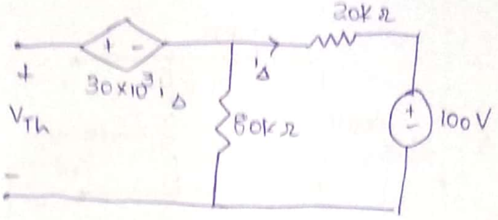
$$i_0(\infty) = 80/21.8 = 3.67\,A$$

$$\tau = \frac{87.2}{21.8}\times10^{-3} = 4ms\ ;\ 1/\tau = 250$$

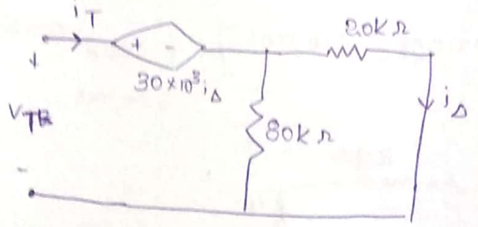
$$i_0 = 3.67 + (10-3.67)e^{-250t} = 3.67 + 6.33e^{-250t}\,A \quad , t\geq0$$

8) For $t<0$, $v_o(0) = 80V$

$t>0$:



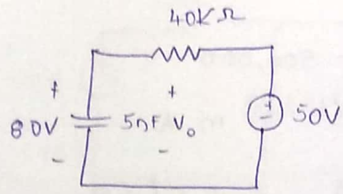
$$V_{Th} = 30\times10^3 i_\Delta + 0.8(100) = 30\times10^3\left(\frac{-100}{100\times10^3}\right) + 80 = 50V$$



$$v_T = 30\times10^3 i_\Delta + 1.6\times10^3 i_T = 30\times10^3(0.8)i_T + 16\times10^3 i_T = 40\times10^3 i_T$$

$$R_{Th} = \frac{v_T}{i_T} = 40k\Omega$$

$t>0$



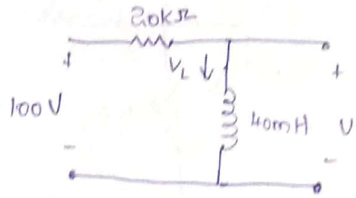
$$v_o = 50 + (80-50)e^{-t/\tau}$$

$$\tau = RC = (40\times10^3)(5\times10^{-9}) = 200\times10^{-6}; \quad 1/\tau = 5000$$

$$v_o = 50 + 30e^{-5000t} \text{ V}$$

11)

a) $0 \le t \le 2\mu sec$



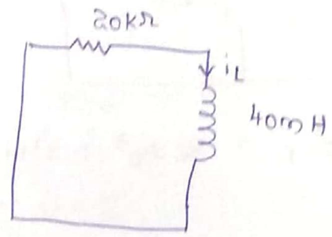
$i_L(0) = 0$; $i_L(\infty) = 5mA$

$\tau = \frac{L}{R} = \frac{0.04}{20{,}000} = 2\mu s$

$i_L = 5 - 5e^{-500{,}000t}$ mA , $0 \le t \le 2\mu sec$

$V_o = (0.04)\left[(500{,}000)(0.005)e^{-500{,}000t}\right] = 100e^{-500{,}000t}$ V , $0^+ \le t < 2\mu sec$

$2\mu s \le t < \infty$



$i_L(2\mu s) = 5 - 5e^{-1} \simeq 3.16mA$

$i_L(\infty) = 0$; $\tau = 2\mu s$; $1/\tau = 500{,}000$

$i_L = 0 + (3.16 - 0)\,e^{-500{,}000(t - 2\mu s)}$ mA

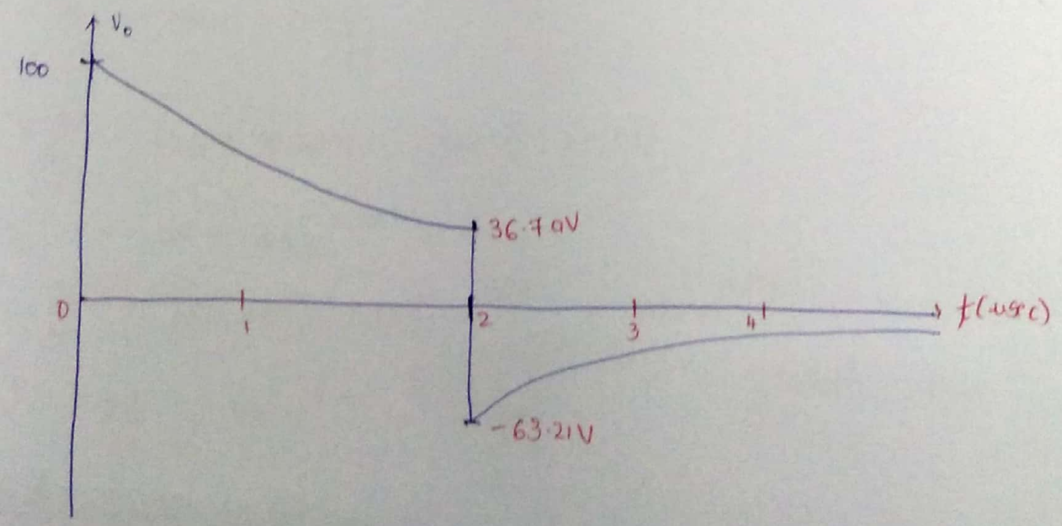
$= 3.16\,e^{-500{,}000(t-2\mu s)}$ mA , $2\mu s \le t \le \infty$

$v_o = L\frac{di_L}{dt} = (0.04)(3.16 \times 10^{-3})\left[-500{,}000e^{-500{,}000(t-2\mu s)}\right]$

$= (-5)(4)(3.16)\,e^{-500{,}000(t-2\mu s)}$

$= -63.21\,e^{-500{,}000(t-2\mu s)}$ V , $2\mu s \le t \le \infty$

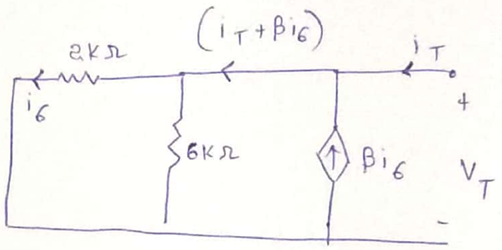
b)



c) $v_o(4\mu sec) = -23.25V$

$$i_o = \frac{23.25}{20{,}000} = 1.16mA$$

12) a)



$$v_T = 2000 i_6$$

$$i_6 = \frac{6}{8}(i_T + \beta i_6)$$

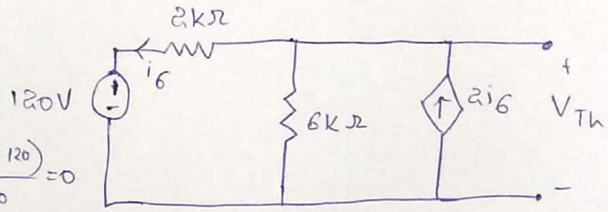
$$i_6 = 0.75 i_T + 0.75 \beta i_6$$

$$\Rightarrow i_6 = \frac{0.75 i_T}{1 - 0.75\beta} \quad ; \quad 2000 i_6 = \frac{1500 i_T}{1 - 0.75\beta}$$

$$R_{Th} = \frac{v_T}{i_T} = \frac{1500}{1 - 0.75\beta} = -3000$$

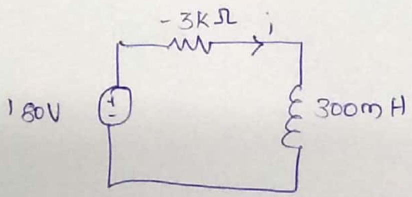
$$1 - 0.75\beta = -0.5 \Rightarrow \beta = 2$$

b)



$$\frac{V_{Th} - 120}{2000} + \frac{V_{Th}}{6000} - \frac{2(V_{Th}-120)}{2000} = 0$$

$$\Rightarrow V_{Th} = 180V$$



$$180 = -3000 i + 0.3\frac{di}{dt}$$

$$\Rightarrow \frac{di}{dt} = 600 + 10{,}000 i = 10{,}000(i + 0.06)$$

$$\Rightarrow i = -60 + 60 e^{10{,}000t} \ mA$$

$$\frac{di}{dt} = (60 \times 10^{-3})(10{,}000) e^{10{,}000t} = 600 e^{10{,}000t}$$

$$v = 0.3\frac{di}{dt} = 180 e^{10{,}000t} = 36{,}000 \quad ; \quad e^{10{,}000t} = 200$$

$$t = \frac{\ln 200}{10{,}000} = 529{,}83 \ \mu s$$

13) $V_{ph} = 400/\sqrt{3} = 231V$

load impedance per phase $= \frac{231}{30\angle -30} = 7.7\angle 30^\circ \Omega$

Total real power $= \sqrt{3} \times 400 \times 30 \times \cos 30^\circ = 18 KW$

Total reactive power $= \sqrt{3} \times 400 \times 30 \times \sin 30^\circ = 10.392$ KVAR

$\cancel{W_A = W_{AB} =}$

$W_A = V_{AB} I_A \cos(30^\circ + \theta) = 6 KW$

$\cancel{W_B = V_{AB} = I}$

$W_B = V_{AB} I_A \cos(30^\circ - \theta) = 12 KW$

14) $V_{RY} = 400\angle 0^\circ$, $V_{YB} = 400\angle -120$, $V_{BR} = 400\angle -240$

$I_{RY} = \frac{20000}{400} = 50 + 0j$ A

$I_{YB} = \frac{30,000}{400}\angle -120-36.86 = 75\angle -156.86^\circ$ A

$I_{BR} = \frac{20000}{400}\angle -240-53.13 = 50\angle -187^\circ$ A

$I_R = I_{RY} - I_{BR} = 99.82\angle -3.4^\circ$ A

$I_Y = I_{YB} - I_{RY} = 122.56\angle -166^\circ$ A

$I_B = I_{BR} - I_{YB} = 40.37\angle 61.4^\circ$ A

$W_1 = V_{RY} I_R \cos\angle(V_{RY}, I_R) = 39.8$ KW

$W_2 = V_{BY} I_B \cos\angle(V_{BY}, I_B) = 16.14$ KW

$W_1 + W_2 = 56$ KW

15) $3 V_{ph} I_{ph} \cos\theta = 5000$ KW ; $I_{ph} = 360.8$ A

Active component $= I\cos\theta = 288.7$ A

Reactive component $= I\sin\theta = 216.5$ A

At 0.9 pf, new output $= \frac{500 \times 0.9}{0.8} = 5625$ KW