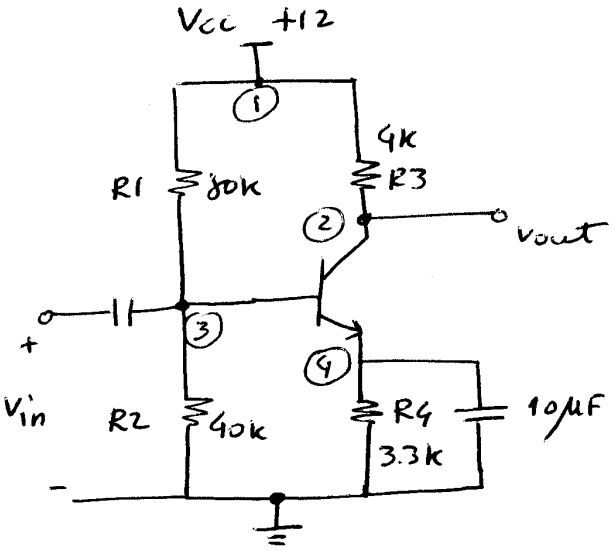
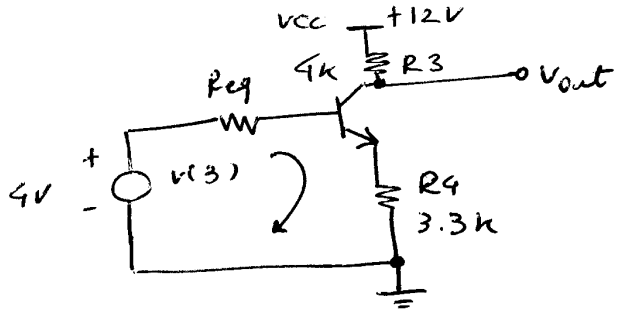
1)



1a) circuito equivalente thevenin

$$V(3) = \frac{R2}{R1+R2} V_{CC} = \frac{40k}{80k+40k} \times 12 = 4V$$

$$R_{eq} = R1 \,||\, R2 = \frac{R1\,R2}{R1+R2} = \frac{40k \times 80k}{40k+80k} = 26.7\,k\Omega$$



Pela lei das malhas

$$V(3) = R_{eq} I_B + V_{BE} + I_E R_4$$

$$V(3) = R_{eq} I_B + V_{BE} + (\beta+1) I_B R_4$$

Logo

$$I_B = \frac{V(3) - V_{BE}}{R_{eq} + (\beta+1) R_4} = \frac{4 - 0.7}{26.7 \times 10^3 + 251 \times 3.3 \times 10^3} = 3.86\,\mu A$$

$V(4) = I_E R4$

$= (\beta+1) I_B \times R4$

$= 251 \times 3.86 \times 10^{-6} \times 3.3 \times 10^{3} = 3.2\,V$

$V(2) = V_{cc} - I_C R3$

$= 12 - 250 \times 3.86 \times 10^{-6} \times 4 \times 10^{3}$

$= 8.14\,V$

logo

$V(1) = 12\,V$ $\quad I_B = 3.86\,\mu A$

$V(2) = 8.14\,V$ $\quad I_C = 0.965\,mA$

$V(3) = 4\,V$ $\quad I_E = 0.969\,mA$

$V(4) = 3.2\,V$

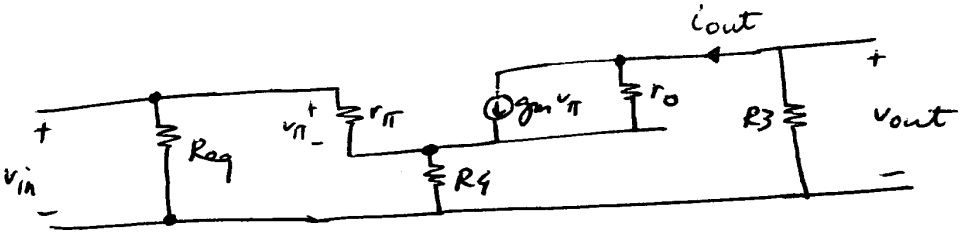
1b)

$\frac{1}{r_\pi} = \frac{\partial I_B}{\partial v_{BE}} = \frac{I_B}{V_T}$ logo $r_\pi = \frac{V_T}{I_B} = \frac{25\,mV}{3.86\,\mu A} = 6477\,\Omega$

$g_m = \frac{\partial I_C}{\partial v_{BE}} = \frac{I_C}{V_T} = \beta \frac{I_B}{V_T} = \frac{\beta}{r_\pi} = 0.0386\,A/V$

$\frac{1}{r_o} = \frac{\partial I_C}{\partial v_{CE}} = \frac{I_C}{V_A}$ logo $r_o = \frac{V_A}{I_C} = \frac{70}{250 \times 3.86 \times 10^{-6}} = 72539\,\Omega$

1c) circuito equivalente para pequenos sinais



$$v_{in} = v_\pi + R_4\, i_{out}$$

$$v_{out} = -R_3\, i_{out} = (i_{out} - g_m v_\pi) r_o + R_4\, i_{out}$$

logo $$(-R_3 - R_4 - r_o)\, i_{out} = -g_m r_o v_\pi$$

$$i_{out} = \frac{g_m r_o v_\pi}{R_3 + R_4 + r_o}$$

$$v_{in} = \left[1 + \frac{g_m r_o R_4}{R_3 + R_4 + r_o}\right] v_\pi$$

$$v_{out} = \frac{-R_3 g_m r_o}{R_3 + R_4 + r_o}\, v_\pi$$

logo $$A_V = \frac{v_{out}}{v_{in}} = -\frac{\dfrac{R_3 g_m r_o}{R_3 + R_4 + r_o}}{1 + \dfrac{g_m r_o R_4}{R_3 + R_4 + r_o}} = -\frac{R_3 g_m r_o}{R_3 + R_4 + r_o + g_m r_o R_4}$$

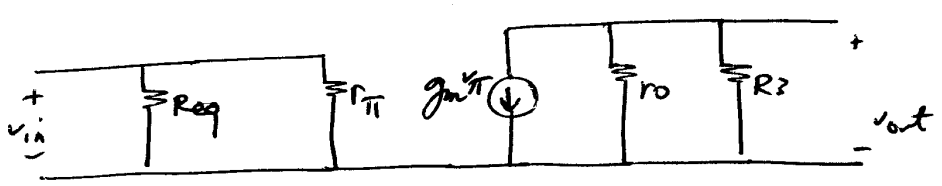
$$A_V \cong -\frac{R_3}{R_4}$$

1d) Condensador em paralelo com R_4

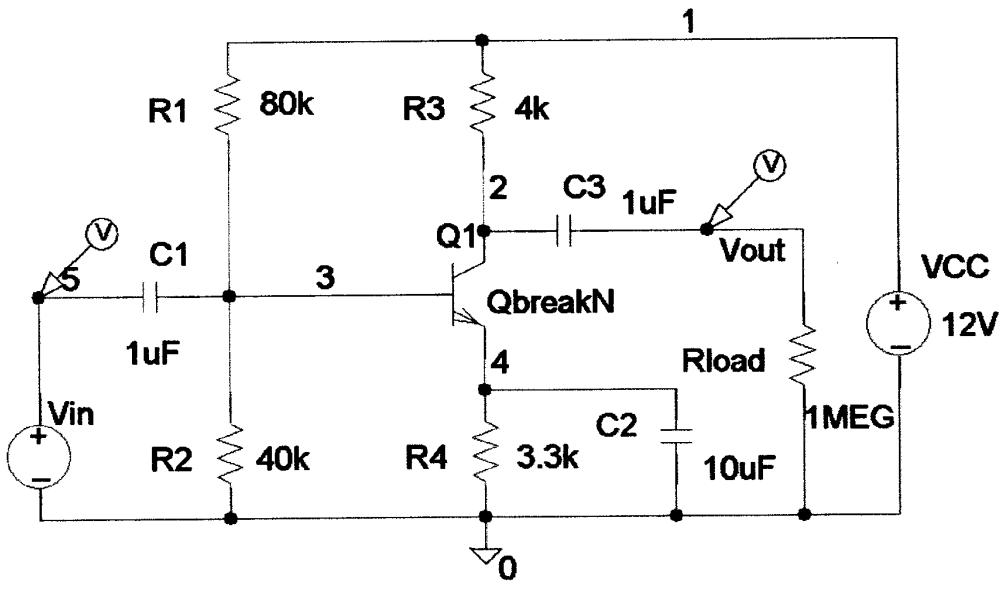
logo R_4 equivalente $= 0$

logo $$A_V = -\frac{R_3 g_m r_o}{R_3 + r_o} = -(R_3 \| r_o)\, g_m \cong -R_3 g_m$$

(Como seria de esperar do circuito equivalente !)



1e)
Diagrama esquemático (com condensador)



netlist

```
* D:\Aulas\electronica1\Electronica1\fp9\exerc1\Schematic1.sch

* Schematics Netlist *


R1          3 1  80k
R2          0 3  40k
R4          0 4  3.3k
C2          0 4  10uF
C1          5 3  1uF
Vin         5 0 DC 0  SIN (0 1MV 1KHZ)
VCC         1 0 DC 12V
Rload       0 Vout  1MEG
R3          2 1  4k
C3          2 Vout  1uF
Q1          2 3 4 QbreakN


.model QbreakN NPN (BF=250, VAF=70)


** Analysis setup **
.tran 0.1ms 3ms
.OP

.probe


.END
```

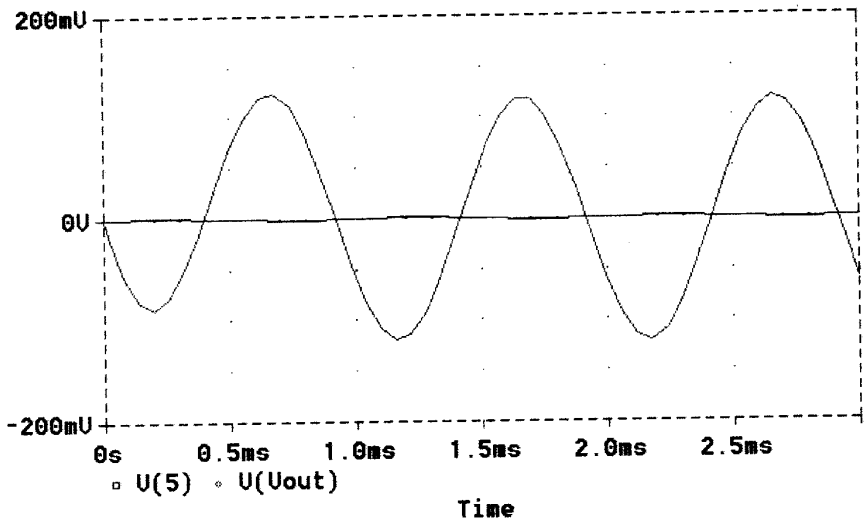
ponto de polarização

```
****     SMALL SIGNAL BIAS SOLUTION       TEMPERATURE =   27.000 DEG C

********************************************************************************
******
```

NODE	VOLTAGE	NODE	VOLTAGE	NODE	VOLTAGE	NODE	VOLTAGE
(1)	12.0000	(2)	8.2158	(3)	3.9049	(4)	3.1337
(5)	0.0000	(Vout)	0.0000				

PROBE (com condensador)



PROBE (sem condensador)