NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF ENGINEERING

DEPARTMENT OF ELECTRONIC ENGINEERING

ANALOGUE ELECTRONICS 1

EEE2115

Examination Paper

December 2024

This examination paper consists of 6 pages

Time Allowed: 3 hours

Total Marks: 100

Special Requirements: h - parameter equations and tables

Examiner's Name: Mr J. Katekwe

INSTRUCTIONS

1 Answer **ALL** questions
2 Each question carries 25 marks
3 Use of calculators is permissible.

MARK ALLOCATION

QUESTION	MARKS
1.	**25**
2.	**25**
3.	**25**
4.	**25**
Total	**100**

QUESTION 1

The transistor parameters for the amplifier shown in Figure 1 are hfe= 50, hie = $1.1k\Omega$, hre = 2.5×10^{-4} and $hoe = 25\mu/A$.

a. Draw the h-parameter equivalent circuit [4 marks]

b. Determine:

i. The total input impedance [5 marks]

ii. The total output impedance [4 marks]

iii. Current gain [3 marks]

iv. Voltage gain [4 marks]

v. Output voltage Vo peak-peak if Rs = 220 ohms and Vi = 30 milliVolts. [5 marks]

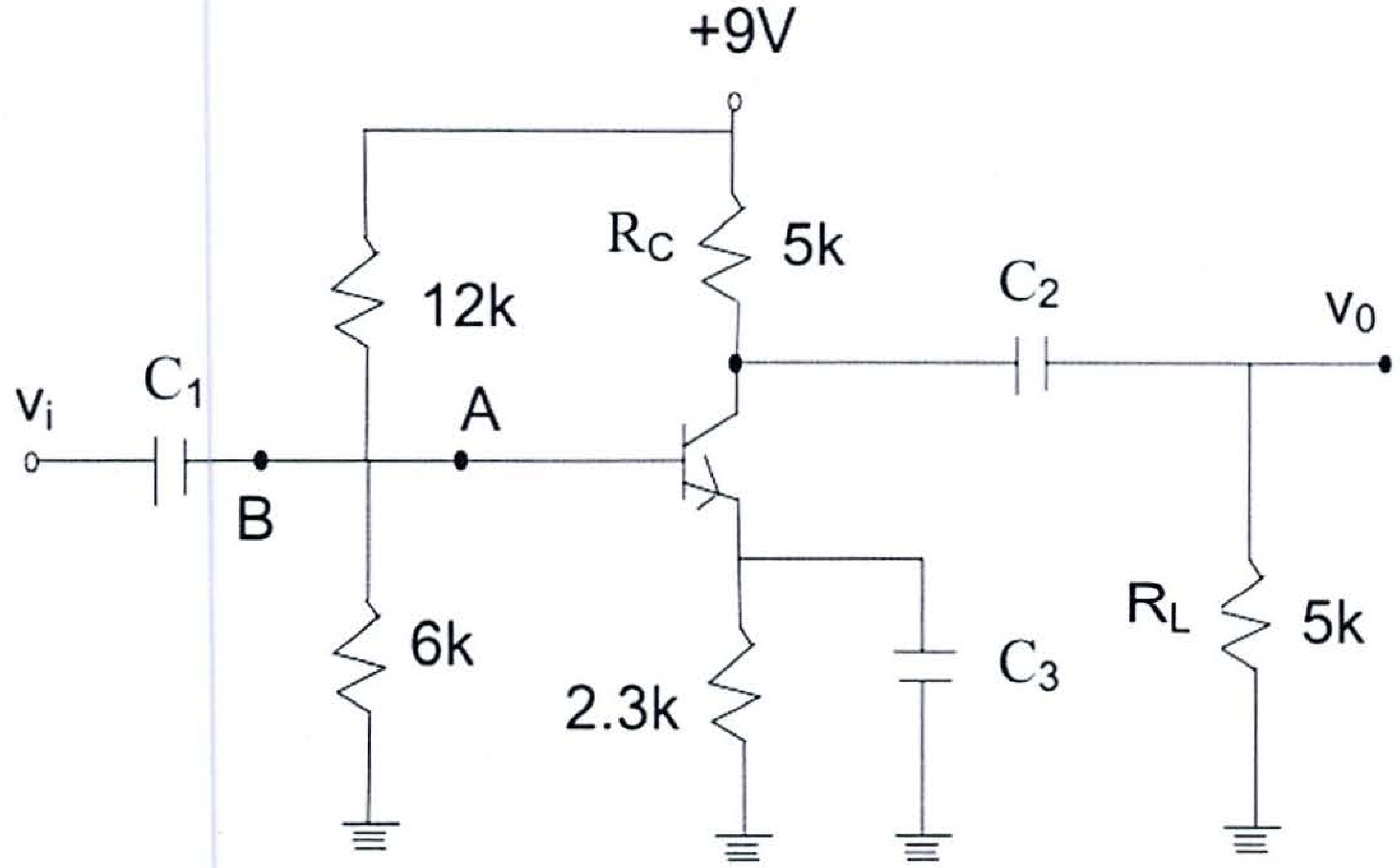

Figure 1

[25 marks]

QUESTION 2

Figure 2 shows an amplifier with Darlington connected identical transistors Q1 and Q2. The transistors have identical parameters hfe= 50, hie = $1.1k\Omega$, hre = 2.5×10^{-4} and $hoe = 25\mu/A$.

a. Draw the h-parameter equivalent circuit. [5 marks]

b. Determine:

i. The total input impedance. [7 marks]

ii. The total output impedance. [5 marks]

iii. Values of the input and output coupling capacitors $C1$ and $C2$ if the amplifier has a lower cut off frequency of 20Hz. [4 marks]

iv. Explain the reduction in gain at very low and very high frequencies [4 marks]

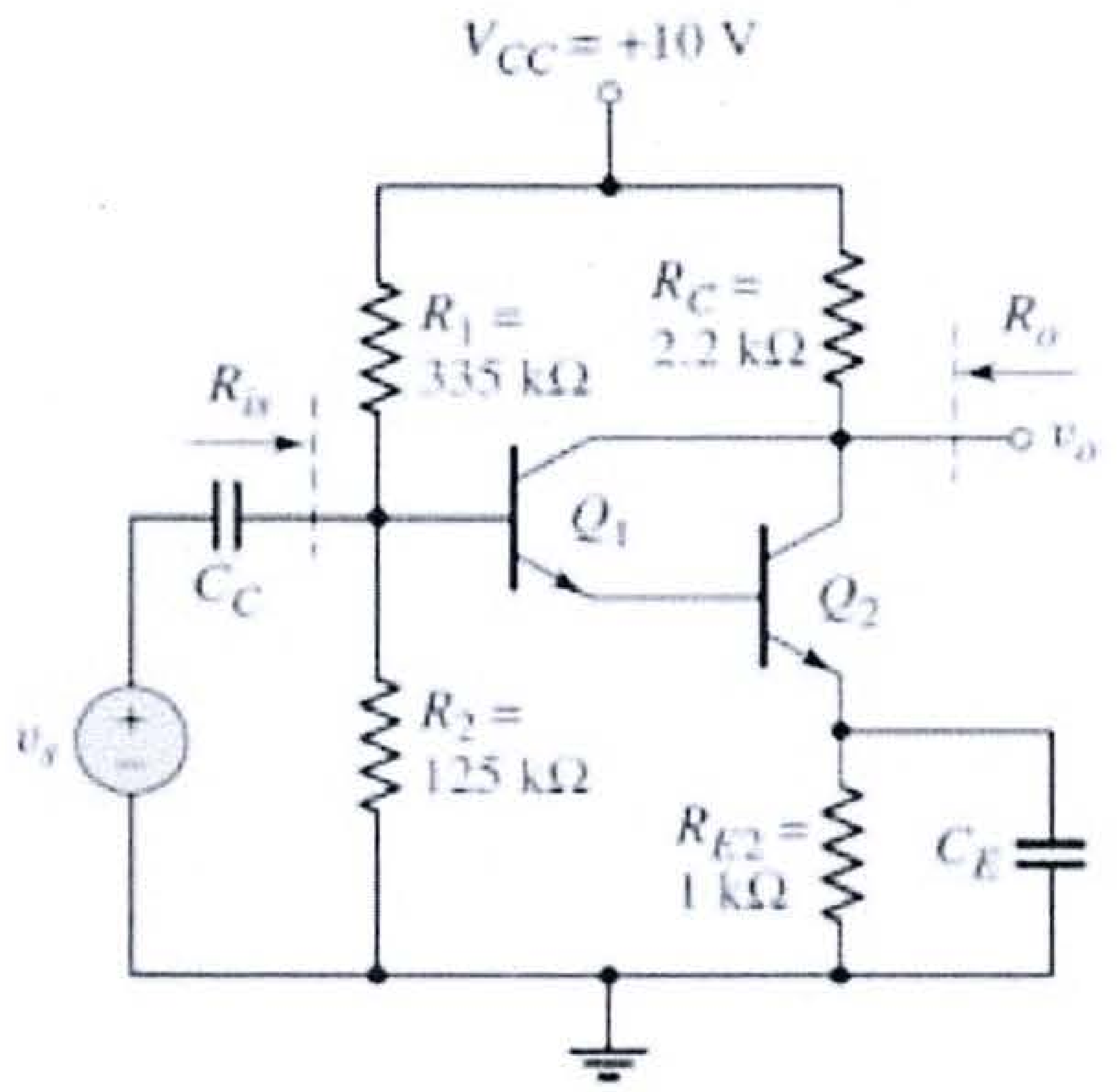

Figure 2

[25 marks]

QUESTION 3

A differential or long tailed amplifier can be operated in four modes.

a. List the four modes of operation of the differential amplifier and draw the schematic diagram for each mode of operation. [4 marks]
b. State the 3 properties of differential amplifiers. [3 marks]

The differential amplifier's tail resistor can be replaced with a current source to improve its performance. Figure 3 shows one such current source.

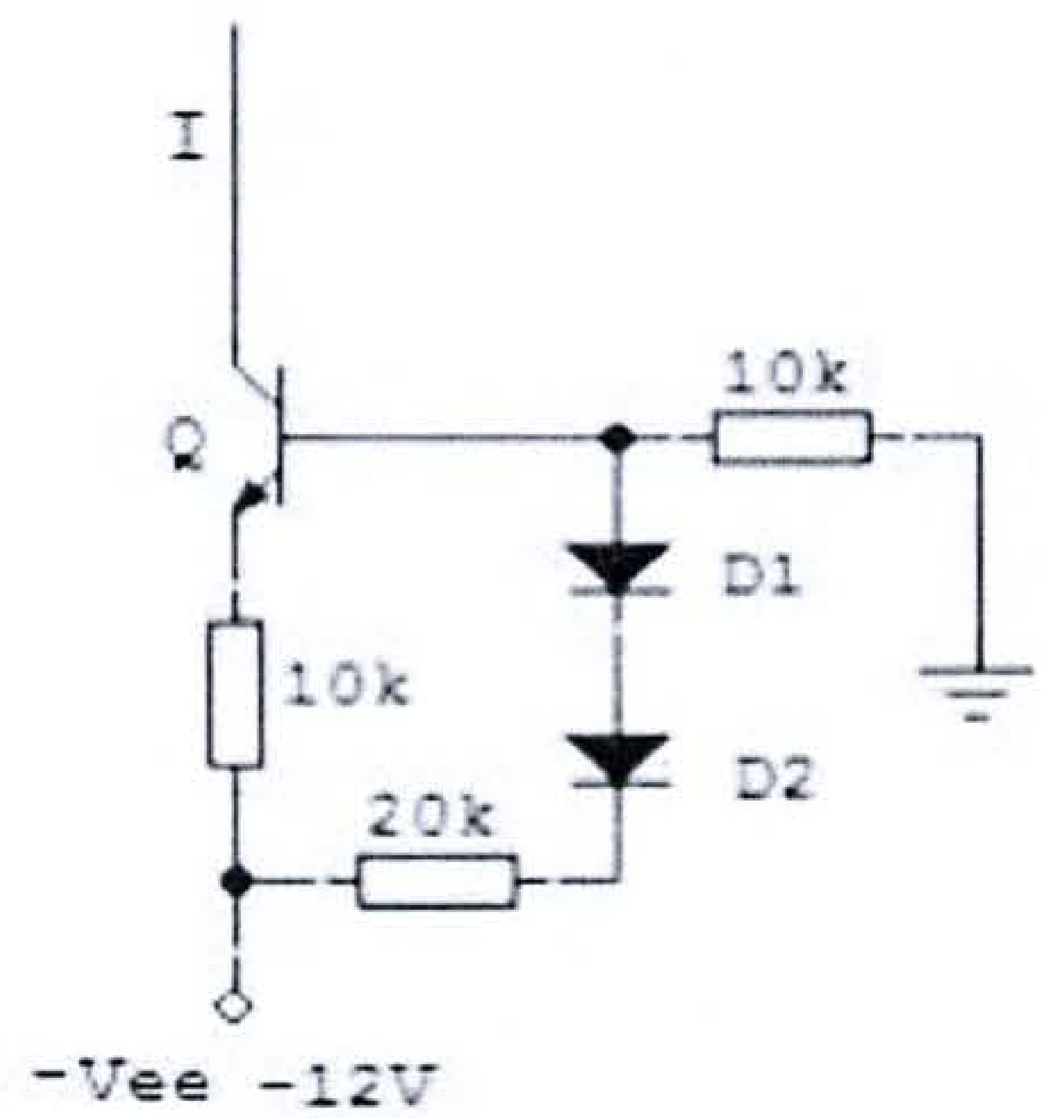

Figure 3

c. Assuming that the differential amplifier has identical transistors, find the biasing collector current that the current source will supply to each of the two amplifier transistors.

[6 marks]

d. A negative feedback connected amplifier has a gain of $13\frac{1}{3}$ and a feedback network gain to open loop gain ratio of $\frac{1}{3920}$. Show that the gain of the same amplifier without feedback lies between 200 and 300.

[8 marks]

e. With the aid of an appropriate waveform, explain the operation of an ideal Class A large signal amplifier with resistive load. [4 marks]

[25 marks]

QUESTION 4

Figure 4 shows a two stage small signal amplifier. The transistor parameters for the two transistors are $hfe = 50$, $hie = 1.1k\Omega$, $hre = 2.5 \times 10^{-4}$ and $hoe = 25\mu/A$.

a. Draw the h-parameter equivalent circuit. [4 marks]

b. Determine:

   i. The total input impedance. [7 marks]

   ii. The total output impedance. [3 marks]

   iii. The voltage gain. [3 marks]

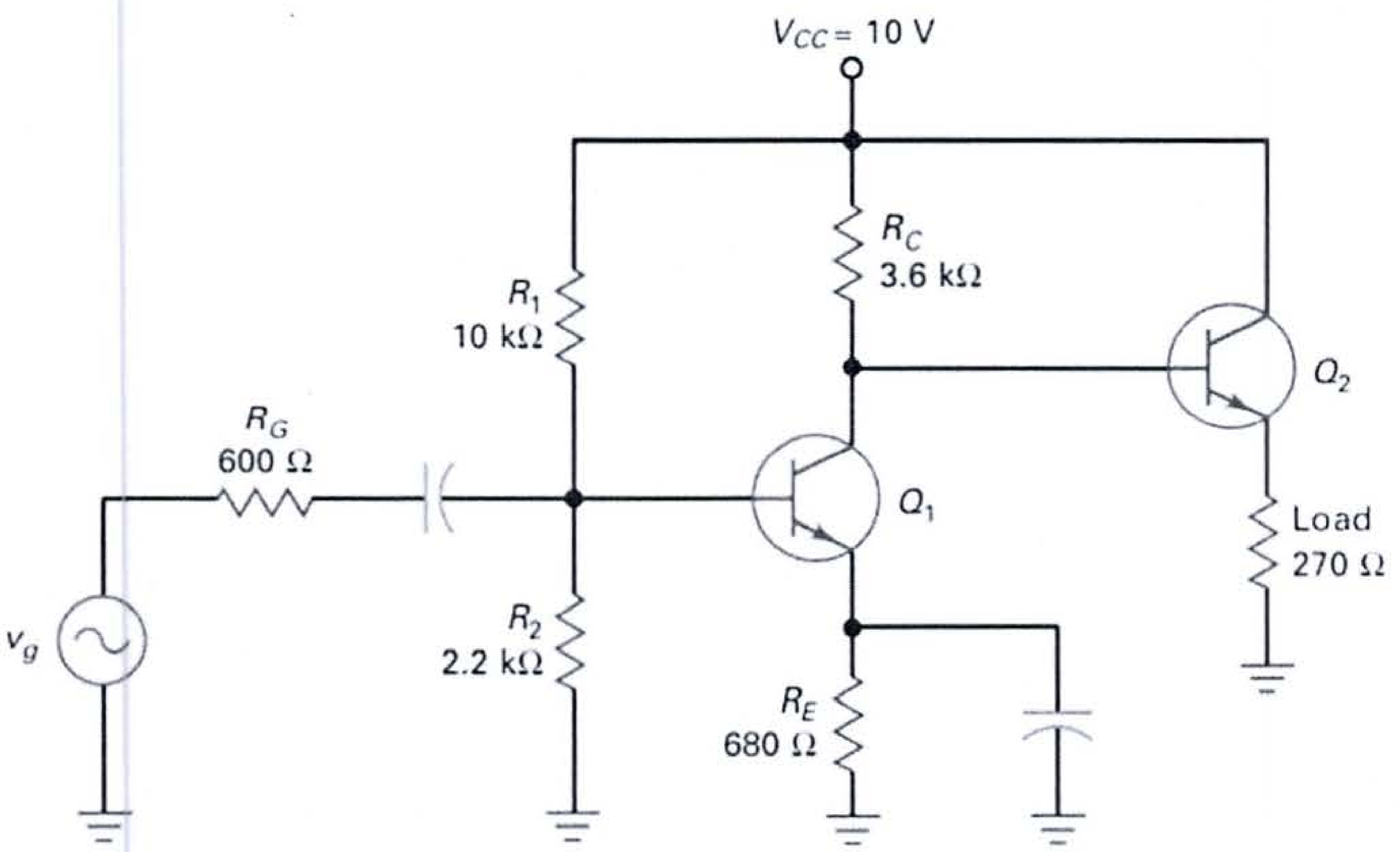

Figure 4

c. Briefly describe the RC method used for coupling multistage amplifiers with its frequency response. [5 marks]

d. Compare the RC, Transformer and Direct Coupling methods used in multistage amplifiers in terms of cost, frequency and use. *Tabulate your answer* [3 marks]

[25 marks]

h-PARAMETER EQUATIONS AND CONVERSION TABLES

Table 1: Generic small signals device h-parameter performance equations	
Z_i	$h_{11} - \dfrac{h_{12}h_{21}}{h_{22} + \dfrac{1}{R_L}}$
A_i	$\dfrac{h_{21}}{1 + h_{22}R_L}$
A_v	$\dfrac{-h_{21}}{Z_i\left(h_{22} + \dfrac{1}{R_L}\right)}$
Z_o	$\dfrac{1}{h_{22} - \dfrac{h_{12}h_{21}}{h_{11}}}$

Table 2: Common emitter to common collector h-parameter conversion	
h_{ic}	h_{ie}
h_{fc}	$-(1 + h_{fe})$
h_{rc}	$1 - h_{re}$
h_{oc}	h_{oe}

Table 3: Common emitter to common base h-parameter conversion	
h_{ib}	$\dfrac{h_{ie}}{h_{oe}h_{ie} + (1 + h_{fe})(1 - h_{re})}$
h_{fb}	$\dfrac{-h_{fe}(1 - h_{re}) - h_{oe}h_{ie}}{h_{oe}h_{ie} + (1 + h_{fe})(1 - h_{re})}$
h_{rb}	$\dfrac{h_{oe}h_{ie} - h_{re}(1 + h_{fe})}{h_{oe}h_{ie} + (1 + h_{fe})(1 - h_{re})}$
h_{ob}	$\dfrac{h_{oe}}{h_{oe}h_{ie} + (1 + h_{fe})(1 - h_{re})}$

Table 4: Darlington pair common emitter h-parameter equations	
h'_{ie}	$h_{ie_1} + h_{fe_1}h_{ie_2}$
h'_{fe}	$h_{fe_1}h_{fe_2}$
h'_{re}	$\dfrac{h_{oe_1}h_{ie_2}}{1 + h_{oe_1}h_{ie_2}}$
h'_{oe}	$\dfrac{h_{oe_1}h_{fe_2}}{1 + h_{oe_1}h_{ie_2}} + h_{oe_2}$