NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF SCIENCE AND TECHNOLOGY EDUCATION

DEPARTMENT OF SCIENCE, MATHEMATICS AND TECHNOLOGY EDUCATION

ELECTRONICS 1 PST2173 EXAM 2024

Main Examination Paper

NOVEMBER 2024

This Examination Paper consists of 8 printed pages

Time Allowed:	3 hours
Total Marks:	100
Special Requirements:	None
Internal Examiner:	MR K. NYATHI
External Examiner:	Dr N. ZEZEKWA

INSTRUCTIONS

ANSWER **ALL** PARTS OF QUESTION 1 IN SECTION A AND ANY **THREE** QUESTIONS FROM SECTION B. SECTION A CARRIES 40 MARKS AND SECTION B CARRIES 60 MARKS.

MARK ALLOCATION

QUESTION	MARKS
1.	40
2.	20
3.	20
4.	20
5.	20
6.	20
Maximum possible mark	100

QUESTION 1

1. (a) Briefly explain the following expressions:

    (i)   Intrinsic semi-conductors

    (ii)   Extrinsic semi-conductors

    (iii)   Zener Diodes **[6]**

(b) Calculate total resistance for circuit shown in fig 1.0 below. **[3]**
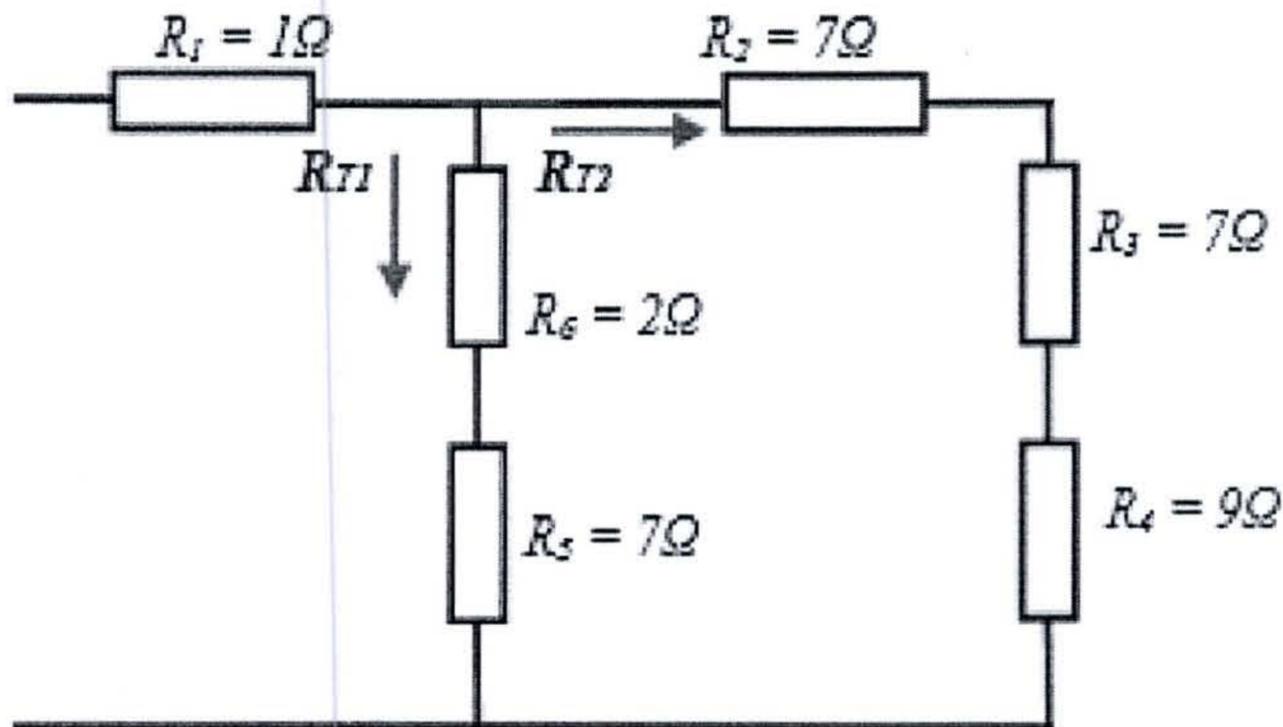

fig 1.0

(c) With the aid of a well labeled diagram discuss why it is easier to create electron-hole pairs in a germanium **pn** junction diode than in a silicon **pn** junction diode. **[4]**

(d) (i) Define a **Transistor.** **[1]**

(ii) Draw the circuit diagrams of p-n-p and n-p-n transistors with proper biasing voltages. Indicate the reference directions for the currents and the reference polarities for the voltage. **[4]**

(e) Explain the meaning of the following mode of transistor operation.

    (i) Common – Base configuration **[2]**

    (ii) Common – Emitter configuration **[2]**

    (iii) Common – Collector configuration **[2]**

(f) A full wave rectifier uses two diodes, the internal resistance of each diode maybe assumed constant at 20 Ω. The transformer *r.m.s* secondary voltage from center tap to each end of the secondary is 50 V and the load resistance is 980 Ω. Find:

        i.   The *mean load current*.   [2]

        ii.   The *r.m.s* value of load current.   [1]

(g) (i) Draw a well labeled V_{CE}–I_C characteristic curve of a bipolar junction transistor when $I_B = 0$.   [2]

  (ii) What is the source of the collector current when $I_B = 0$?   [1]

  (iii) For a bipolar junction transistor show that: [4]

$$\alpha = \frac{\beta}{1 + \beta}.$$

    (i)   With respect to an ideal op-amp define the following terms:

        (i)   slew rate

        (ii)   output impedance

        (iii)   bandwidth   [6]

QUESTION 2

(a) Explain the following terms as they are used in semiconductor diodes:

    (i) Reverse current

    (ii) Peak inverse voltage

    (iii). Forward current   [3]

    (b) Draw a diagram of a centre-tapped rectifier and sketch the output voltage in response to a 12V r.m.s ac input. Explain why the output has the form it does in terms of the operation of the centre tap circuit.   [7]

    (c) Describe the action of the following filter circuits:

        (*i*) capacitor filter

        (*ii*) choke input filter

        (*iii*) capacitor input filter.   [6]

    (d) Draw the forward current (I_f) versus the forward voltage (V_f) graph on a Zener diode and on the show the following characteristics of a Zener diode in operation:

        (i)   Reverse characteristics

        (ii)   Knee voltage

        (iii)   Forward characteristics   [4]

QUESTION 3

(a) With the aid of diagram, give two differences between the Rectifier diodes and Zener diodes. [4]

(b) Calculate the voltage Vo in the given circuit of Figure 3.1 for the following conditions:

    (i)   Vin = 7 V

    (ii)   Vin = 22   [4]
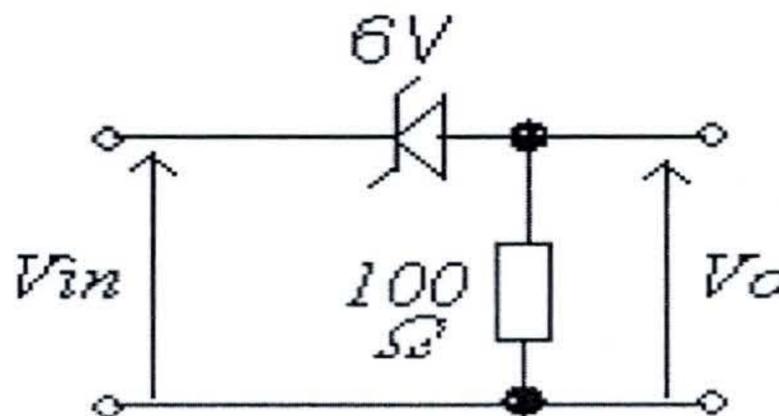

Fig 3.1

(b) In the circuit below Figure 3.2 **Rs = 20 Ω, Vz =18 V** and **RL = 200 Ω.** If Vin can vary from 20 V to 30 V, find:

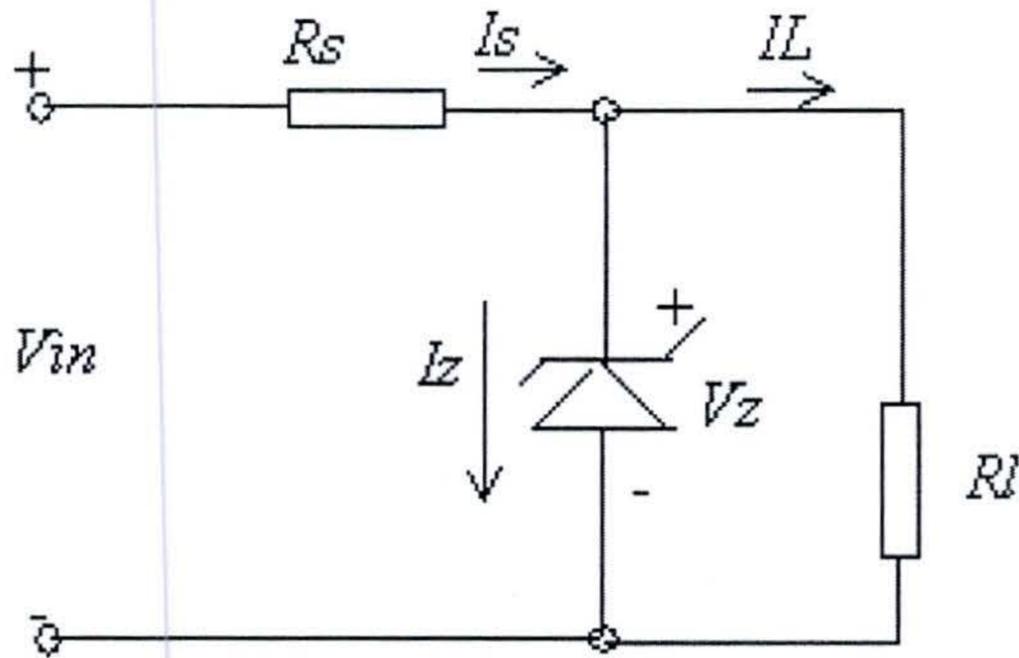Fig 3.2

(i) The minimum and maximum currents in the Zener Diode, [4]

(ii) The minimum and maximum power dissipated in the diode, and [4]

 (iii) The minimum rated power dissipation that Rs should have. [4]

QUESTION 4

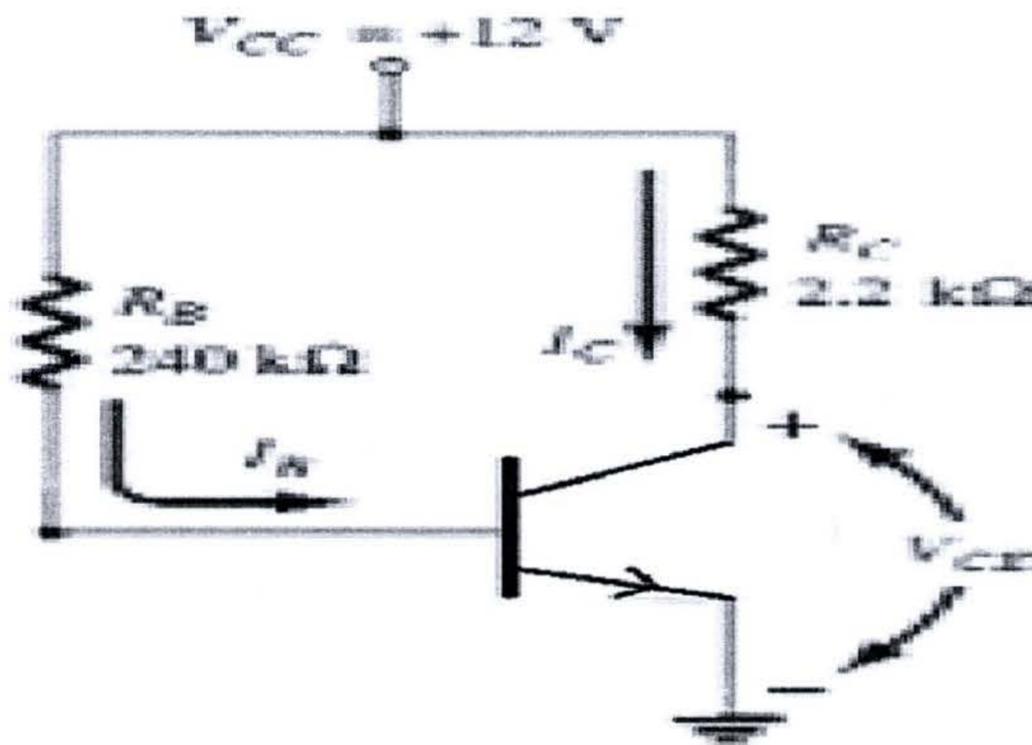Determine the following for the fixed-bias configuration of Fig. 4.1 given that $\beta = 50$.

Fig 4.1

(a) I_B and I_C.

(b) V_{CE}.

(c) V_B and V_C.

(d) V_{BC}.   [6]

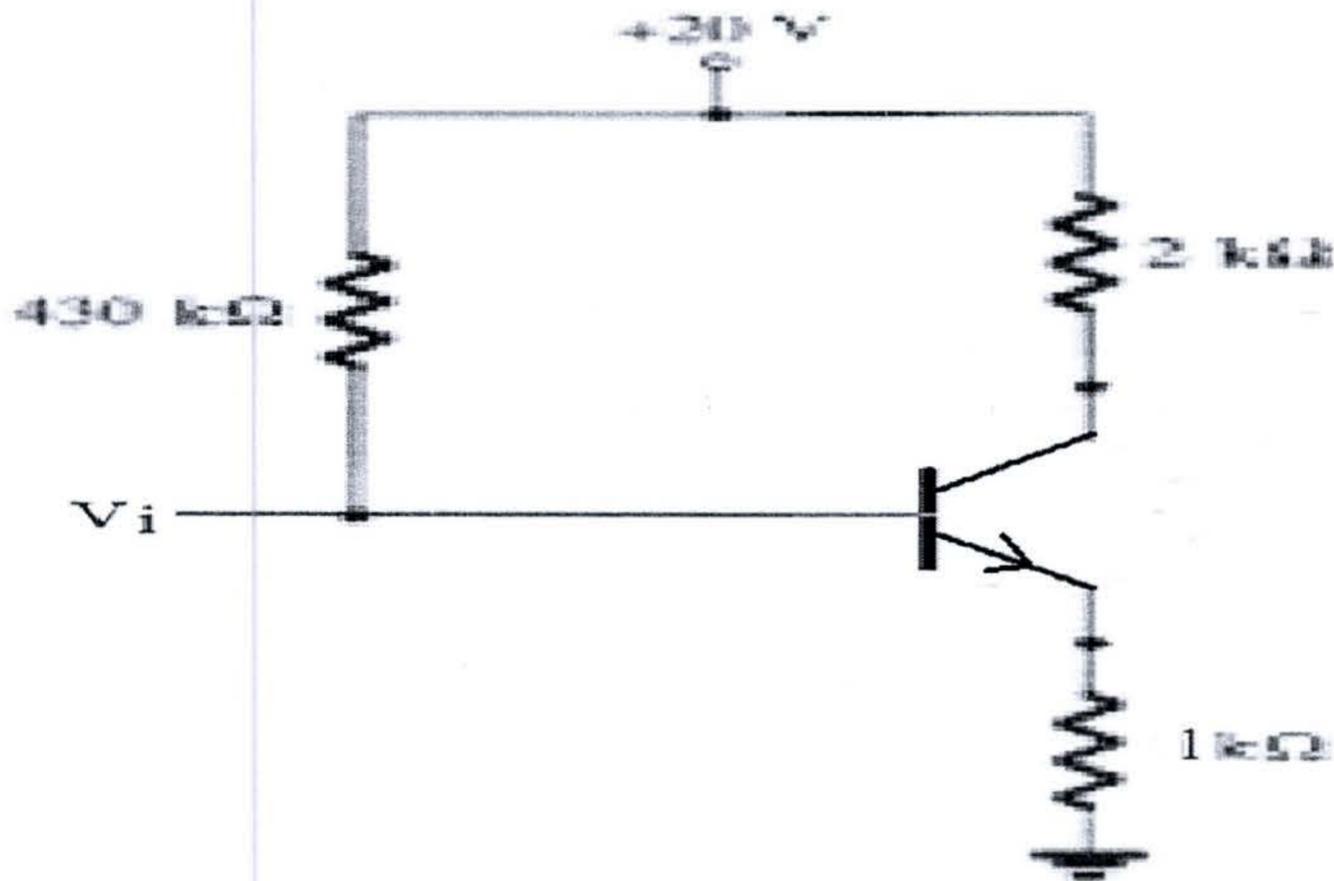(b) For the emitter bias network of Fig. 4.2, given that $\beta = 50$.

Fig 4.2

Determine the following:

(i) I_B.

(ii) I_C.

(iii) V_{CE}.

(iv) V_C.

(v) V_E.

(vi) V_B.

(vii) V_{BC}.   [14]

QUESTION 5

(a) Briefly describe the following terms as used in electronics:

(i) Virtual earth

(ii) voltage-controlled sources

(iii) Open loop gain   [6]

(b) (i) Draw a circuit diagram of a non-inverting amplifier.   [2]

(ii) Give the equation of the closed loop gain A_{cl} for your amplifier.   [1]

(c) (i) Describe with the aid of a diagram the use of an operational amplifier as a voltage summing

amplifier. [3]

(ii) Hence show that for a voltage summing op-amp with 3 inputs signal voltage V_1, V_2 and V_3 connected to R_1, R_2 and R_3 respectively with negative feedback resistor R_f its output voltage is given by the following expression:

$$V_o = -R_f\left[\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3}\right]$$ [3]

(c) A student designs an electronic sensor to monitor wherther the temperature in a refrigerator is above or below a particular value. The circuit is shown in fig 5.1 below.
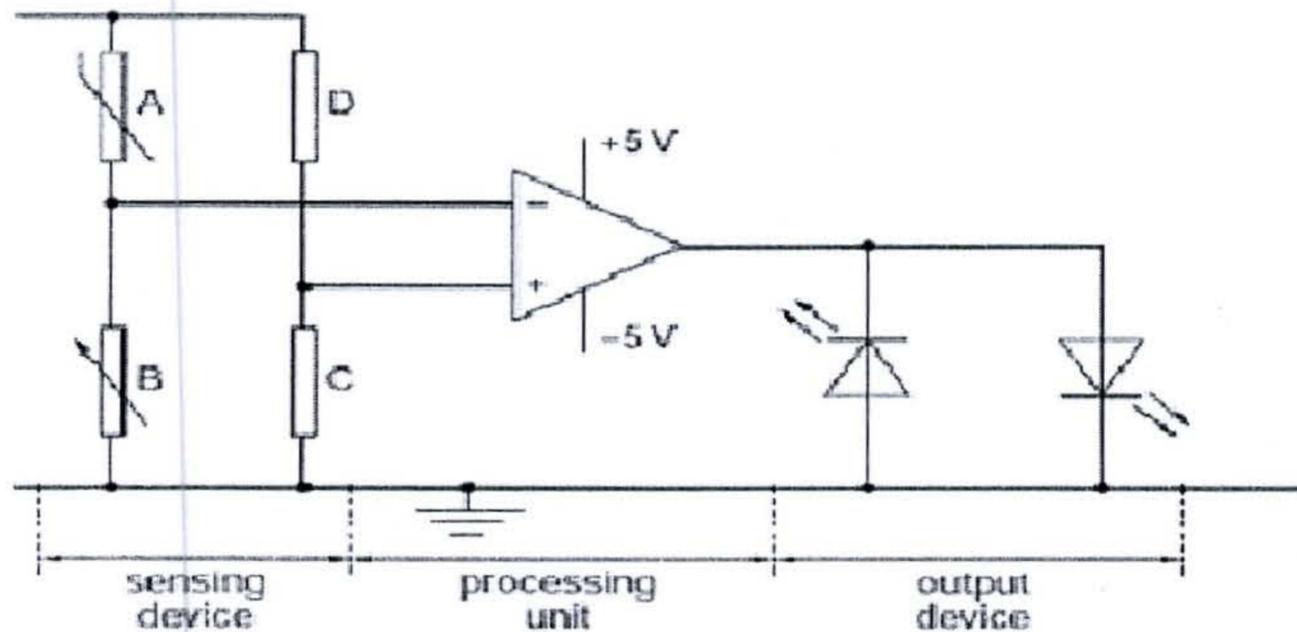

Fig 5.1

(i) Name the electronic components used as output devices.

(ii) An operational amplifier (op-amp) is used as the processing unit. Describe the function of this processing unit.

(iii) State the function of resistors A and B.

(iv) The output device of the circuit in Fig. 5.1 above is changed so that the new output device may be used to switch a high-voltage circuit.

　　1. State the component that is used in the new output device.

　　2. Redraw the circuit in fig 5.1 above and include the device you mentioned in (iv) (1).

　　[5]

QUESTION 6

(a) With the aid of well labeled diagrams discuss why glass is an insulator, silicon is a semiconductor and copper are a good conductor of electricity at room temperature. [6]

(b) In a semiconducting material like germanium, holes are generated in the valence band when electrons are thermally elevated into the conduction band. Describe how holes

conduct electricity in a semiconductor. [7]

(c) What is breakdown diode? What is its use? Describe physically how two mechanisms of breakdown occur in a p-n junction diode. [7]

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