

PAST EXAM PAPER & MEMO N3

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higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T710(E)(M31)T
APRIL EXAMINATION

NATIONAL CERTIFICATE

INDUSTRIAL ELECTRONICS N3

(8080613)

31 March 2016 (X-Paper)
09:00–12:00

Calculators and drawing instruments may be used.

This question paper consists of 8 pages, 1 answer sheet and 1 formula sheet.

DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA
NATIONAL CERTIFICATE
INDUSTRIAL ELECTRONICS N3
TIME: 3 HOURS
MARKS: 100

INSTRUCTIONS AND INFORMATION

1. Answer ALL the questions.
 2. QUESTION 5.3.2—5.3.3 must be answered on the attached ANSWER SHEET and handed in with the ANSWER BOOK.
 3. Read ALL the questions carefully.
 4. Number the answers according to the numbering system used in this question paper.
 5. Questions must be answered in blue or black ink.
 6. Use $\pi = 3,142$.
 7. All the final answers must be approximated accurately to THREE decimal places.
 8. Write neatly and legibly.
-

QUESTION 1

1.1 Indicate whether the following statements are TRUE or FALSE. Choose the answer and write only 'true' or 'false' next to the question number (1.1.1–1.1.8) in the ANSWER BOOK.

1.1.1 Kirchoff's current law states that the algebraic sum of the currents entering a point is equal to the algebraic sum of the currents leaving a point.

1.1.2 The current through a pure inductor will lag the voltage across the inductor by 90° .

1.1.3 Covalent bonds are formed where ions are kept together by electrostatic charges between them.

1.1.4 The major application of zener diodes is as capacitors in tuning circuits.

1.1.5 The collector current of a transistor will increase when the base-emitter forward-bias voltage is increased.

1.1.6 Forced commutation is used in direct current circuits.

1.1.7 An operational amplifier has the ability to handle both alternating current and direct current signals.

1.1.8 Capacitive transducers only operate from a DC supply.

(8 × 1) (8)

1.2 Various options are given as possible answers to the following questions. Choose the answer and write only the letter (A–C) next to the question number (1.2.1–1.2.7) in the ANSWER BOOK.

1.2.1 The total impedance of a series RLC circuit ...

A is equal to the sum of the values of resistance, inductive reactance and capacitive reactance.

B always increases as the applied frequency increases.

C is the minimum at the resonant frequency.

1.2.2 In intrinsic material the number of electrons in the conduction band is ... the number of holes in the valence band.

A equal to

B greater than

C less than

1.2.3 The following diodes are normally used in the reverse-bias condition:

- A Photo diode, zener, varactor
- B PN-junction, zener, varactor
- C PN-junction, photo diode, zener

1.2.4 A Darlington pair is ...

- A a very good current amplifier.
- B normally associated with high-frequency applications.
- C a very good voltage amplifier.

1.2.5 Transients are at their worst when an SCR is switched on at ...

- A 180°
- B 90°
- C 30°

1.2.6 Which ONE of the following statements of an operational amplifier is WRONG?

- A Its parameters are matched and track well with temperature changes.
- B It has a high voltage gain.
- C It has low input impedance and a high output impedance.

1.2.7 The nearest an instrument reading will reach the true value of the quantity being measured is called the ...

- A precision.
- B accuracy.
- C resolution.

(7 × 1)

(7)
[15]

QUESTION 2

2.1 Study FIGURE 1 below and determine, with the aid of Kirchoff's laws:

2.1.1 The equation for loop 1 (ABCEFA). (2)

2.1.2 The equation for loop 2 (CDEC). (2)

2.1.3 The magnitude of the currents I_1 and I_2 by making use of the equations in QUESTION 2.1.1 and QUESTION 2.1.2. (4)

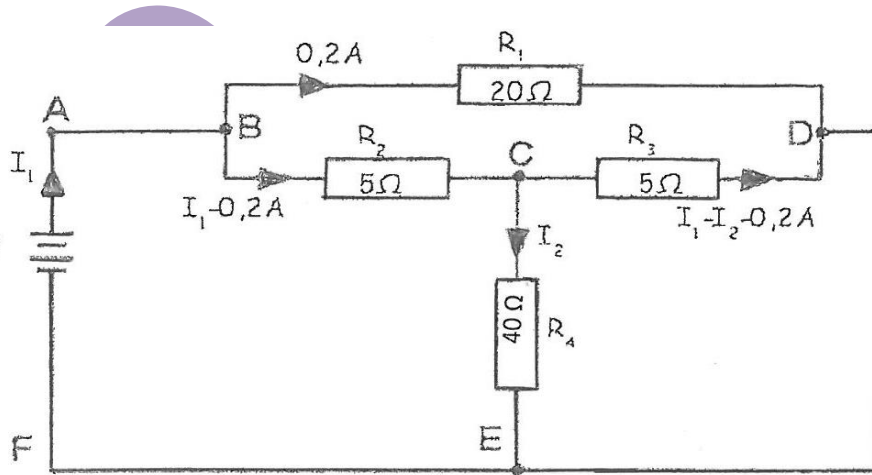


FIGURE 1

2.2 Study FIGURE 2 below and answer the question.

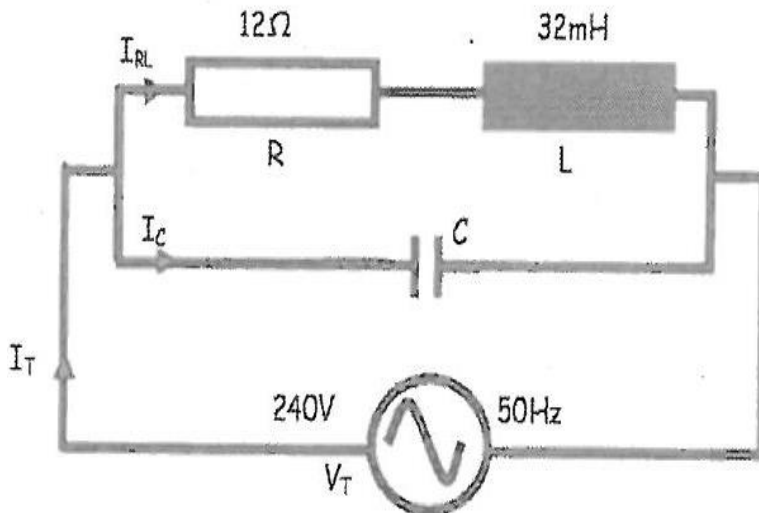


FIGURE 2

If the total current is at the minimum for the circuit in FIGURE 2, calculate the value of the capacitor.

(7)
[15]

QUESTION 3

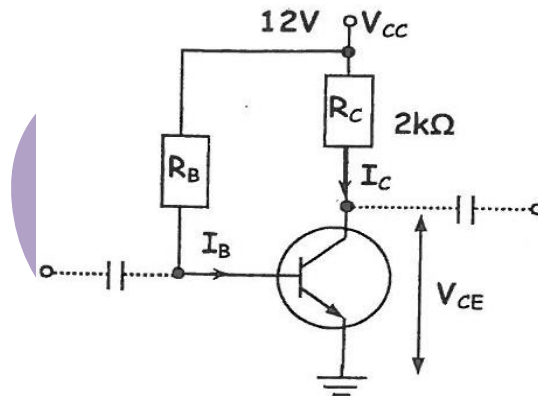
- 3.1 Define 'positive ion'. (1)
- 3.2 Draw the construction of a PN-junction diode when it is forward biased. (2)
- 3.3 Give an explanation for the following parameters:
- 3.3.1 I_R
- 3.3.2 V_{RRM}
- 3.3.3 I_F (3 × 2) (6)
- 3.4 Show with the aid of neat labelled sketches, the width of the forbidden gaps for each of the following:
- 3.4.1 Insulator
- 3.4.2 Semiconductor
- 3.4.3 Conductor (3 × 2) (6)
- [15]**

QUESTION 4

- 4.1 Draw a neat, labelled diagram of the negative parallel clipper. (2)
- 4.2 Draw a neat, labelled circuit diagram of a full-wave voltage doubler. (4)
- 4.3 Consider an LED (light-emitting diode):
- 4.3.1 Draw the symbol (1)
- 4.3.2 Draw the characteristic curve (1)
- 4.3.3 Give two applications (2)
- [10]**

QUESTION 5

- 5.1 Draw a neat, labelled circuit diagram of a push-pull amplifier. Indicate on the circuit ALL relevant waveforms and bias polarities. (7)
- 5.2 Explain with the aid of a block diagram, the concept of negative feedback. (5)
- 5.3 Refer to the common emitter-amplifier circuit diagram below and determine the following:



- 5.3.1 Calculate the value of I_c (in mA) which will enable you to draw the DC load line if $R_c = 2\text{ k}\Omega$ and $V_{cc} = 12\text{ V}$. (2)
- 5.3.2 Make use of the characteristic curve on the attached ANSWER SHEET to draw the DC load line. (2)
- 5.3.3 Indicate the position of the suitable Q-point on the DC load line so that the transistor will operate as a class-A amplifier. (1)
- 5.3.4 Write down the value of I_c , V_{ce} and the value of I_b at the Q-point indicated in QUESTION 5.3.3. (3)
- [20]**

QUESTION 6

- 6.1 A silicon-controlled rectifier (SCR) can be controlled by using four different methods. The following statements are descriptions or definitions of these methods.

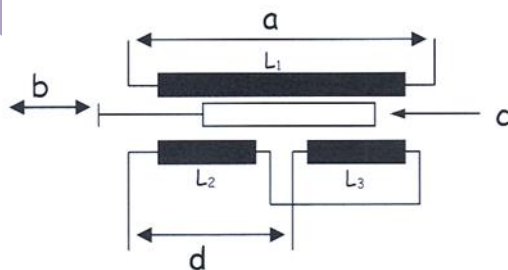
Name each method which is described in the statement below. Write only the name of the method next to the question number (6.1.1–6.1.4) in the ANSWER BOOK.

- 6.1.1 This method of control is a combination of phase and cycle control.
- 6.1.2 This method of control is used when the SCR performs simple switching.
- 6.1.3 This method of control is achieved by switching the control device on for a number of full cycles and then switching the control device off for a number of full cycles.

- 6.1.4 This method of control is achieved by controlling the time at which the gate of the SCR is triggered. (4 × 1) (4)
- 6.2 Define the *holding current*. (2)
- 6.3 An SCR can be represented by means of TWO transistors. Draw the applicable circuit diagram and label all the terminals clearly. (4)
- 6.4 Name THREE characteristics of operational amplifiers. (3)
- 6.5 Briefly explain the principle of operation of the photoconductive cell. (2)
- [15]**

QUESTION 7

- 7.1 Name TWO types of errors pertaining to measuring instruments. (2)
- 7.2 Refer to FIGURE 3 below and answer the questions.

**FIGURE 3**

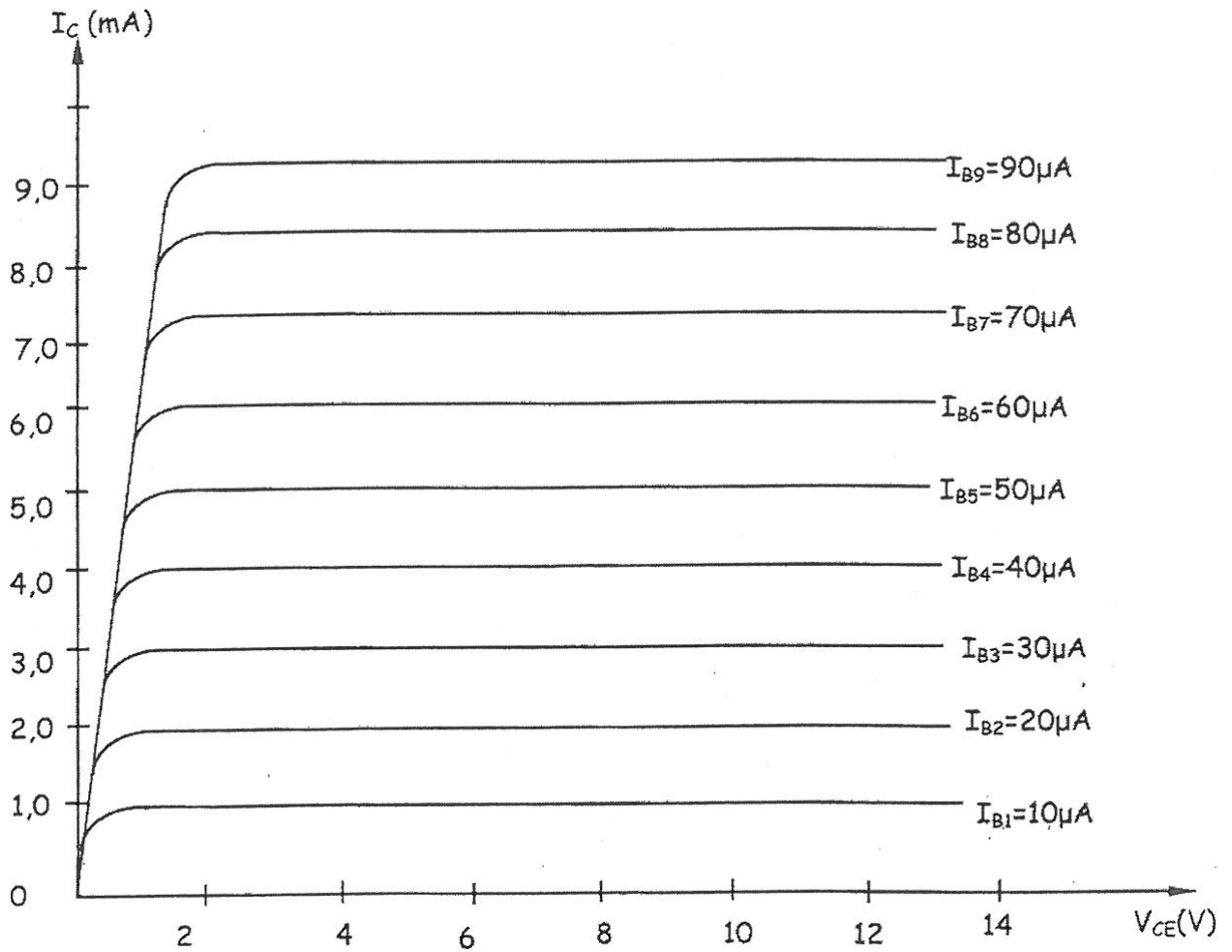
- 7.2.1 Identify the transducer. (1)
- 7.2.2 Name the parts **a** to **d** given in FIGURE 3. (4 × 1/2) (2)
- 7.2.3 Give a brief explanation of its operating principle. (3)
- 7.3 Give TWO uses of the cathode-ray oscilloscope. (2)
- [10]**

TOTAL: 100

ANSWER SHEET EXAMINATION NUMBER:

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QUESTION 5.3.2—5.3.3



NB: Hand the completed ANSWER SHEET in with the ANSWER BOOK.

INDUSTRIAL ELECTRONICS N3**FORMULA SHEET***Direct-current theory:*

$$V = I \cdot R$$

$$P = V \cdot I$$

$$P = \frac{V^2}{R}$$

$$P = I^2 \cdot R$$

Alternating-current theory:

$$X_L = 2\pi fL$$

$$X_C = \frac{1}{2\pi fC}$$

$$Z = \sqrt{R^2 + (X_L \sim X_C)^2}$$

$$V_T = \sqrt{V_R^2 + (V_L \sim V_C)^2}$$

$$I = \frac{V_T}{Z}$$

$$\theta = \cos^{-1} \frac{R}{Z}$$

$$V = I \cdot R$$

$$V = I \cdot X_L$$

$$V = I \cdot X_C$$

$$f_r = \frac{1}{2\pi\sqrt{LC}}$$

$$I_R = \frac{V_T}{R}$$

$$I_L = \frac{V_T}{X_L}$$

$$I_C = \frac{V_T}{X_C}$$

$$I_T = \sqrt{I_R^2 + I_X^2}$$

$$I_X = I_L \sim I_C$$

$$\theta = \tan^{-1} \frac{I_X}{I_R}$$

$$\theta = \cos^{-1} \frac{I_R}{I_T}$$

$$Z = \frac{V}{I_T}$$

$$Z_D = \frac{L}{RC}$$

$$I_T = \frac{V}{Z_D}$$

$$f_r = \frac{1}{2\pi} \sqrt{\frac{1}{LC} - \frac{R^2}{L^2}}$$

$$I_C = I_{RL} \sin\theta_L$$

$$I_T = I_{RL} \cos\theta_L$$

$$I_T = \sqrt{I_{TH}^2 + I_{TV}^2}$$

Transistors:

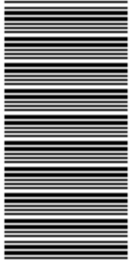
$$I_C = \frac{V_{CC}}{R_L}$$

Transducers:

$$R = \frac{\rho \cdot l}{a}$$

$$C = \frac{k \cdot A \cdot E_o}{d}$$

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MARKING GUIDELINE

NATIONAL CERTIFICATE

APRIL EXAMINATION

INDUSTRIAL ELECTRONICS N3

31 MARCH 2016

This marking guideline consists of 9 pages.

QUESTION 1

1.1	1.1.1	True		
	1.1.2	True		
	1.1.3	False		
	1.1.4	False		
	1.1.5	True		
	1.1.6	True		
	1.1.7	True		
	1.1.8	False		
			(8 × 1)	(8)

1.2	1.2.1	C		
	1.2.2	A		
	1.2.3	A		
	1.2.4	A		
	1.2.5	B		
	1.2.6	C		
	1.2.7	B		
			(7 × 1)	(7)
				[15]

QUESTION 2

2.1	2.1.1	Loop ABCEFA		
		$4 = 5(I_1 - 0,2) + 40I_2$ $= 5I_1 - 1 + 40I_2$ $5 = 5I_1 + 40I_2 \checkmark$ $1 = I_1 + 8I_2 \dots \dots \dots [1] \checkmark$		(2)

	2.1.2	Loop CDEC		
		$0 = 5(I_1 - I_2 - 0,2) - 40I_2$ $= 5I_1 - 5I_2 - 1 - 40I_2 \checkmark$ $1 = 5I_1 - 45I_2 \dots \dots \dots [2] \checkmark$		(2)

	2.1.3	$[1] \times 5 : \quad 5 = 5I_1 + 40I_2$ $[2] \times -1 : \quad -1 = -5I_1 + 45I_2$ $[1] + [2] : \quad 4 = 85I_2 \quad \checkmark$ $\therefore I_2 = 4/85$ $\quad = \underline{0,047 \text{ A}} \checkmark$		
--	-------	--	--	--

Substitute I₂ in [1]

$$1 = I_1 + 8(0,047) \quad \checkmark$$

$$\begin{aligned} I_1 &= 1 - 0,376 \\ &= \underline{0,624 \text{ A}} \quad \checkmark \end{aligned} \quad (4)$$

2.2

$$\begin{aligned} X_L &= 2\pi fL \\ &= 2 \times \pi \times 50 \times 32 \times 10^{-3} \\ &= \underline{10,053 \Omega} \quad \checkmark \end{aligned}$$

Alternate Solution:

$$f_r = \frac{1}{2\pi} \sqrt{1/(LC) - R^2/L^2}$$

Make C the subject and solve.

$$\begin{aligned} Z_{RL} &= R^2 + X_L^2 \\ &= 12^2 + 10,053^2 \\ &= \underline{15,564} \quad \checkmark \end{aligned}$$

$$\begin{aligned} \theta_L &= \cos^{-1} R/Z_{RL} \\ &= \cos^{-1} 12/15,564 \\ &= \underline{39,952^\circ} \quad \checkmark \end{aligned}$$

$$\begin{aligned} I_{RL} &= V/Z_{RL} \\ &= 240/15,564 \\ &= \underline{15,332 \text{ A}} \quad \checkmark \end{aligned}$$

I is at minimum \therefore circuit is resonating

$$\begin{aligned} \therefore I_C &= I_{RL} \sin \theta \\ &= 15,332 \times 0,642 \\ &= \underline{9,845 \text{ A}} \quad \checkmark \end{aligned}$$

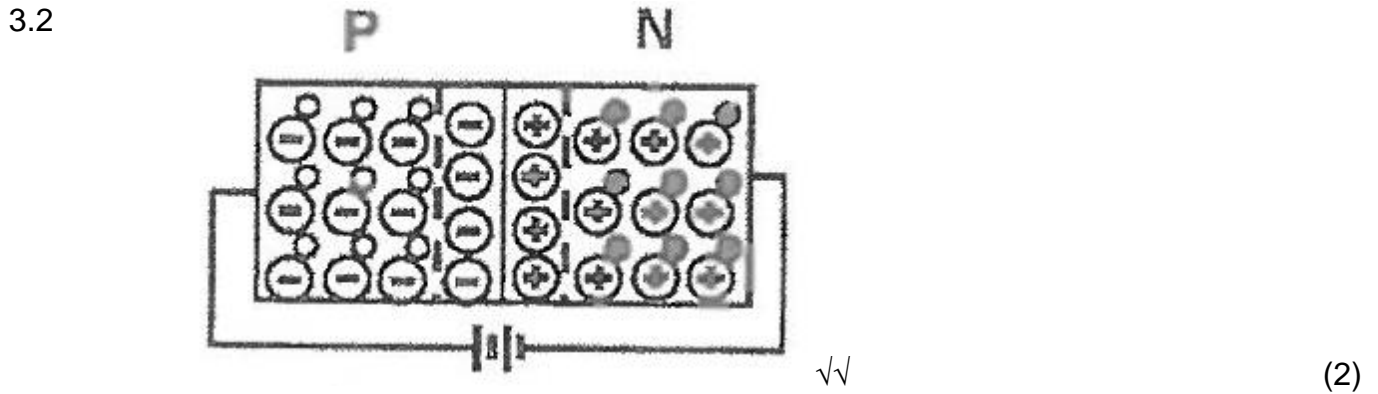
$$\begin{aligned} X_C &= V/I_C \\ &= 240/9,845 \\ &= \underline{24,378 \Omega} \quad \checkmark \end{aligned}$$

$$\begin{aligned} X_C &= 1/2\pi fC \\ \therefore C &= 1/2\pi fX_C \\ &= 1/2 \times \pi \times 50 \times 24,378 \\ &= \underline{130,573 \mu\text{F}} \quad \checkmark \end{aligned} \quad (7)$$

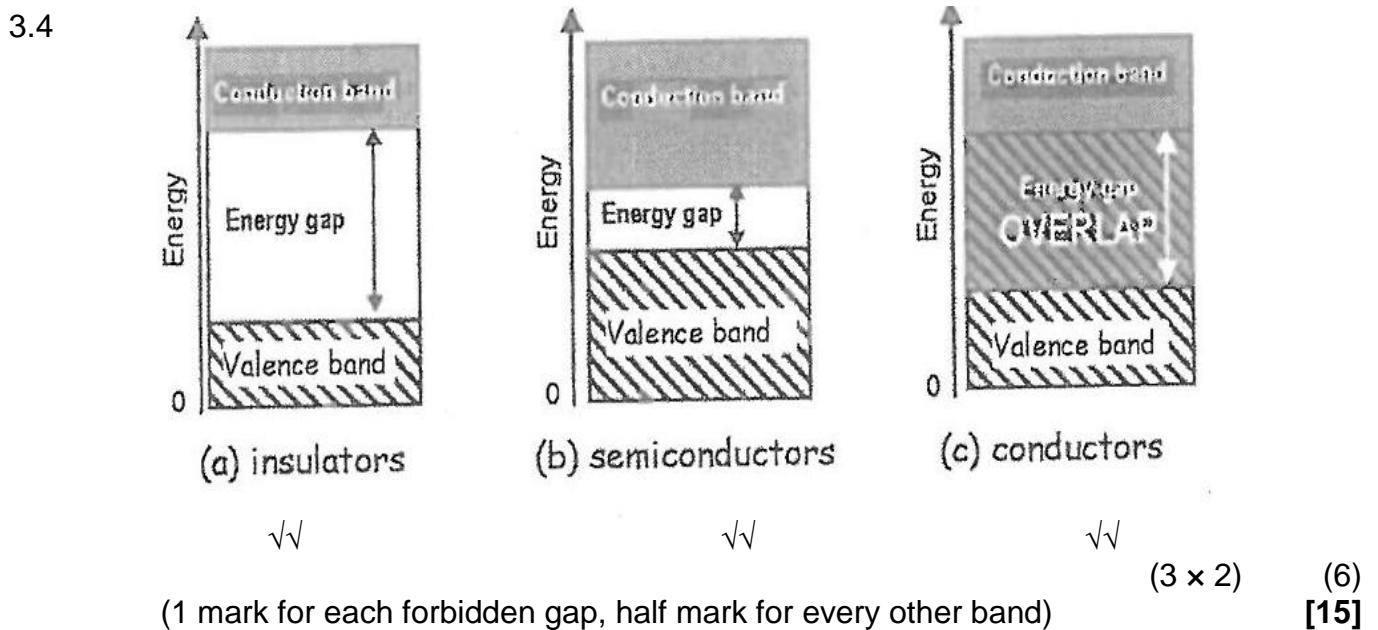
[15]

QUESTION 3

3.1 It is when an atom loses an electron. ✓ (1)



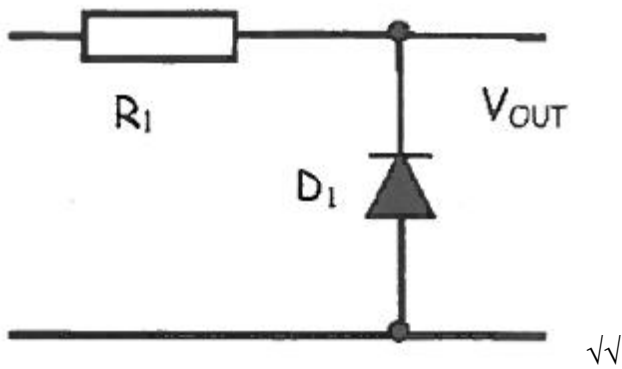
- 3.3 3.3.1 I_R – Reverse current or a leakage current ✓
The amount of current that will leak through the diode at various reverse voltages. ✓
- 3.3.2 V_{RRM} – The peak repetitive reverse voltage or peak inverse voltage ✓
The maximum reverse voltage applied repetitively. ✓
- 3.3.3 I_F - Forward current ✓
The maximum amount of current the diode can handle when forward-biased. ✓
- (3 × 2) (6)



(1 mark for each forbidden gap, half mark for every other band)

QUESTION 4

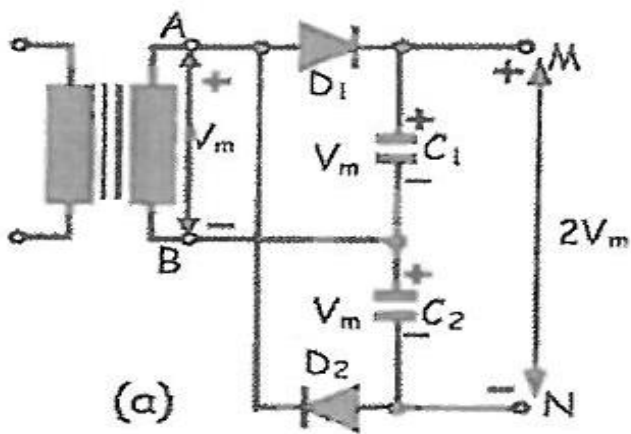
4.1



✓✓

(2)

4.2



(a)

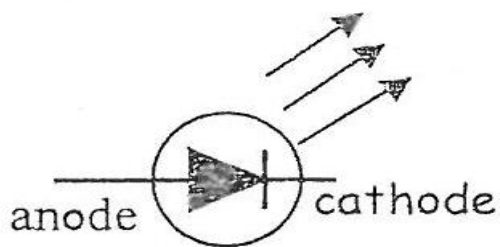
✓✓✓✓

(a mark for each component)

(4)

4.3

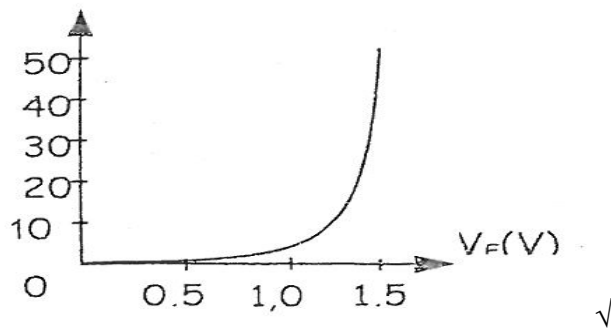
4.3.1



✓

(1)

4.3.2



✓

(1)

- 4.3.3 Seven segments
- Dot matrix
- Bar-graph displays
- Security systems
- Remote controls

(Any 2 x 1) (2)
[10]

QUESTION 5

5.1

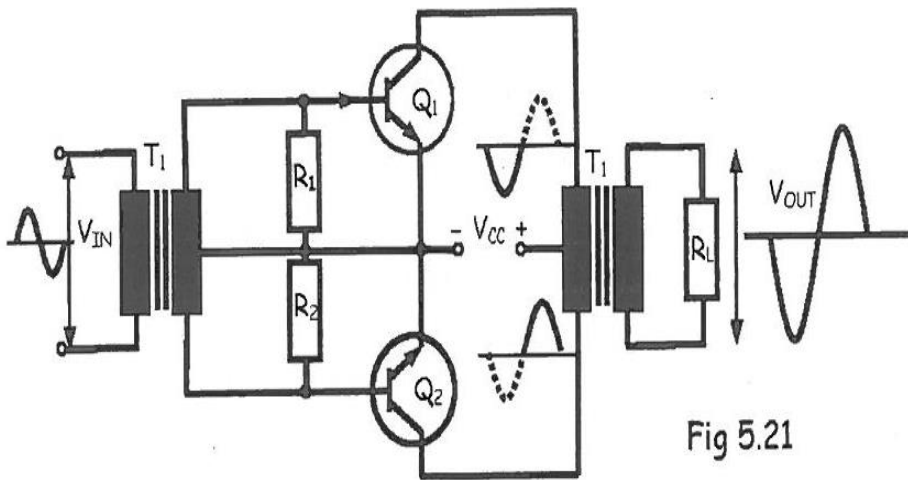
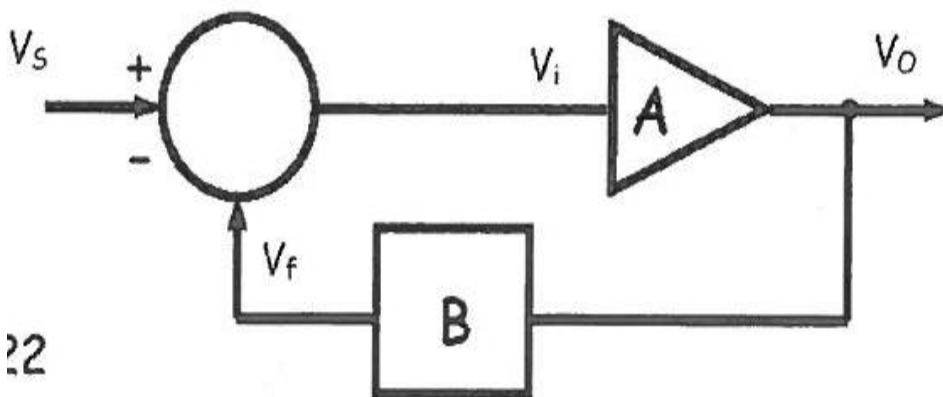


Fig 5.21

(7)

A mark for each component; the marks for the transformers will incl. input and output waveforms

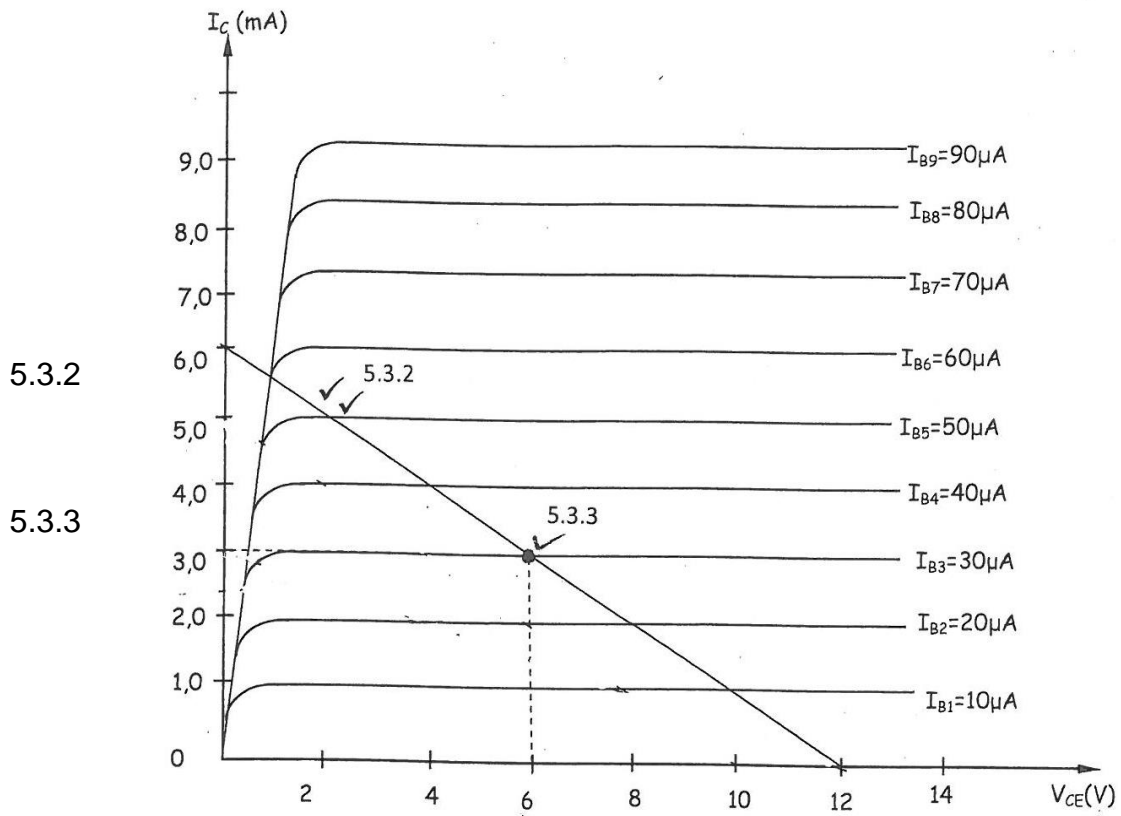
5.2



This circuit diagram shows an amplifier A with a feedback network B. The feedback voltage V_f is taken from the output V_o and is fed back in anti-phase with the input voltage V_s . ✓✓

In this way the input voltage is reduced in that $V_i = V_s - V_f$. ✓ (5)

- 5.3 5.3.1 $I_c = V_{cc}/R_c$
- $= 12/2000$ ✓
- $= 6\text{ mA}$ ✓ (2)



5.3.2

5.3.3

(3)

5.3.4 $I_{BQ} = 30 \mu A$
 $I_{CQ} = 3 \text{ mA}$
 $V_{CQ} = 6 \text{ V}$

(3)

[20]

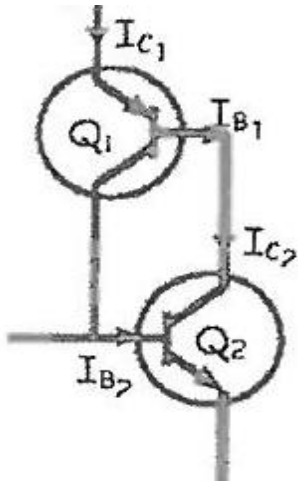
QUESTION 6

- 6.1 6.1.1 Cyclotronic control
 6.1.2 Static switching
 6.1.3 Cycle control
 6.1.4 Phase control

(4 × 1) (4)

- 6.2 Holding current is defined as the minimum current required to hold the SCR in its conducting state. (2)

6.3



(4)

- 6.4 • High input impedance
 • Low output impedance
 • High voltage gain
 • Wide bandwidth
 • Its parameters are matched and track well with temperature changes.
 • Can handle both AC and DC signals. (Any 3 x 1) (3)

- 6.5 When exposed to light energy it generates a voltage across the cell. (2)

[15]

QUESTION 7

7.1	<ul style="list-style-type: none">• Random errors• Gross errors• Systematic errors	(Any 2 x 1)	(2)
7.2	7.2.1 LVDT/ (Linear Variable Differential Transducer)		(1)
	7.2.2 (a) supply (b) movement (c) core (d) output	(4 x ½)	(2)
	7.2.3 Positioning the magnetic core through ✓ an externally applied force varies the difference in voltage ✓ of two secondary windings of a transformer. The magnitude of this difference is an indication of the direction and magnitude of the applied force. ✓		(3)
7.3	<ul style="list-style-type: none">• Measure DC volts• Measure AC volts• Measure frequency• Indicate phase difference between signals• Analyse waveforms• Indicate wave distortion	(Any 2 x 1)	(2)
			[10]
		TOTAL:	100

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