higher education & training

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REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

INDUSTRIAL ELECTRONICS N3

(8080613)

6 April 2021 (X-paper)
09:00–12:00

This question paper consists of 9 pages and 1 formula sheet.

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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. Read all the questions carefully.
3. Number the answers according to the numbering system used in this question paper.
4. Use π = 3,142.
5. Start each section on a new page.
6. Use only a blue or black pen.
7. All the final answers must be approximated accurately to THREE decimals.
8. Write neatly and legibly.

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SECTION A

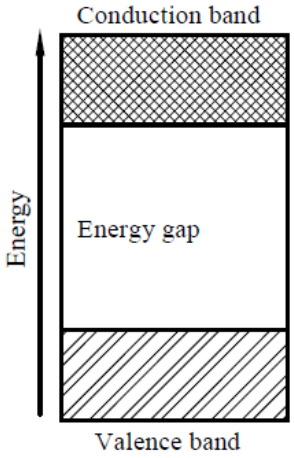
QUESTION 1

1.1 Various options are given as possible answers to the following questions. Choose the correct answer and write only the letter (A–D) next to the question number (1.1.1–1.1.5) in the ANSWER BOOK.

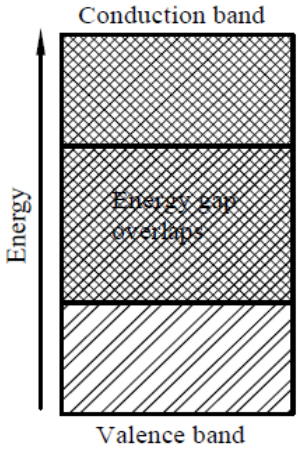
1.1.1 The energy gaps are an indication of the type of material used.

Which of the following diagrams represent a semiconductor?

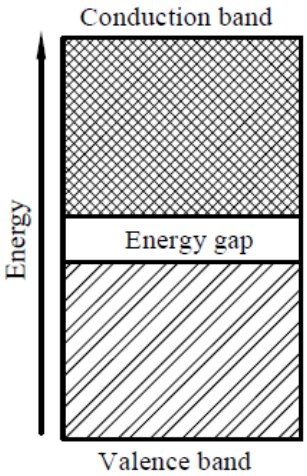
A



B



C



1.1.2 Different bonds exist between atoms.

Which of the following is a description of a metallic bond?

A Ions are kept together by electrostatic charges between them.
B Electrons are not attached to a specific atom.
C Atoms share electrons orbiting around them.
D Negative electrons are attracted to the positive nucleus.

1.1.3 When a PN-junction diode is connected to a power supply, its function depends on its polarity.

Which of the following describes forward biasing?

A The negative terminal of the battery is connected to the P-type material and the positive terminal is connected to the N-type material.
B No battery connected to the PN-junction diode.
C The positive terminal of the battery is connected to the P-type material and the negative terminal is connected to the N-type material.
D None of the above

1.1.4 Forward surge current can be defined as …

A the maximum current the diode can handle when forward-biased.
B the maximum allowable current that can flow through the diode for a specified time and still leave the diode capable of blocking.
C the current that will leak through the diode at various reverse voltages.
D the reverse current that will flow at a specified test current to provide the nominal Zener voltage.

1.1.5 The output from a … clipper consists only of a positive half of the input wave form.

A negative series and positive shunt
B positive shunt and negative shunt
C negative series and negative shunt
D positive series and positive shunt

(5 × 1) (5)

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1.2 Indicate whether the following statements are TRUE or FALSE by writing only 'True' or 'False' next to the question number (1.2.1–1.2.5) in the ANSWER BOOK.

1.2.1 The cut-off region in a transistor is when the base emitter is forward biased, and the base collector is reverse biased.

1.2.2 The common base amplifier has a low voltage gain.

1.2.3 Accuracy is the closeness to which a measuring instrument reading approaches the true value.

1.2.4 In a positive temperature coefficient thermistor, the resistance decreases when the temperature increases.

1.2.5 The gain in a voltage follower is equal to 1.

(5 × 1) (5)

1.3 Choose a term from COLUMN B that matches a description in COLUMN A. Write only the letter (A–G) next to the question number (1.3.1–1.3.5) in the ANSWER BOOK.

COLUMN A		COLUMN B	
1.3.1	Control that is achieved by controlling the time at which the gate of the SCR is triggered	A	calibration
1.3.2	The setting of a measuring instrument to measure a quantity as accurately as possible	B	PN-junction diode
1.3.3	The base-emitter junction is forward biased, and the base-collector junction is reverse biased	C	phase control
1.3.4	Two-terminal device with a low forward biased impedance and high reverse biased impedance	D	Zener diode
1.3.5	The sharing of electrons between atoms to complete their valence shells	E	covalent bond
		F	active region
		G	cyclotronic control

(5 × 1) (5)

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1.4 Choose ONE term for each of the following descriptions from the list below and write it next to the question number (1.4.1–1.4.5) in the ANSWER BOOK.

conductors; metallic bond; positive feedback; optocoupler; mechanical characteristics; semiconductors; negative feedback; ionic bond; electrical characteristics; opto-detector

1.4.1 Elements with fewer than four electrons in their valence shell.

1.4.2 A positive ion joins a negative ion.

1.4.3 Maximum and minimum ratings are specified

1.4.4 Device consisting of a LED and a photodiode/phototransistor.

1.4.5 The input signal of the amplifier is fed back in phase with the output. (5 × 1) (5)

[20]

TOTAL SECTION A: 20

SECTION B

QUESTION 2

2.1 FIGURE 1 shows a series parallel circuit. Use Kirchhoff's law to answer the questions.

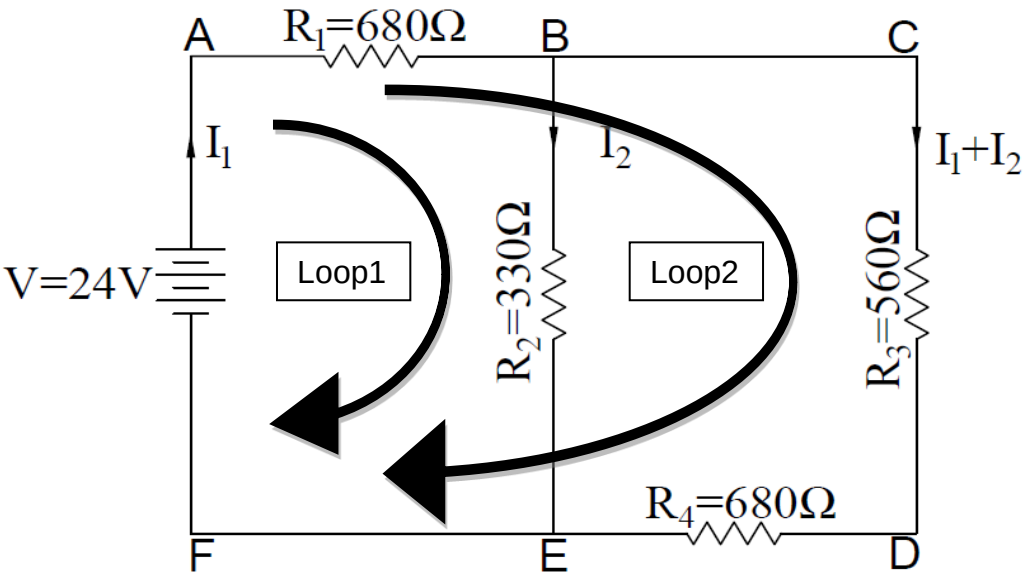


FIGURE 1

2.1.1 Determine the equation for Loop 1 (ABEFA). (2)

2.1.2 Determine the equation for Loop 2 (ABCDEFA). (2)

2.1.3 Determine the values of I_1 and I_2 by using the equations in QUESTION 2.1.1 and QUESTION 2.1.2 (4)

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2.2 FIGURE 2 shows a resistor circuit. Use Kirchhoff's current law to answer the questions.

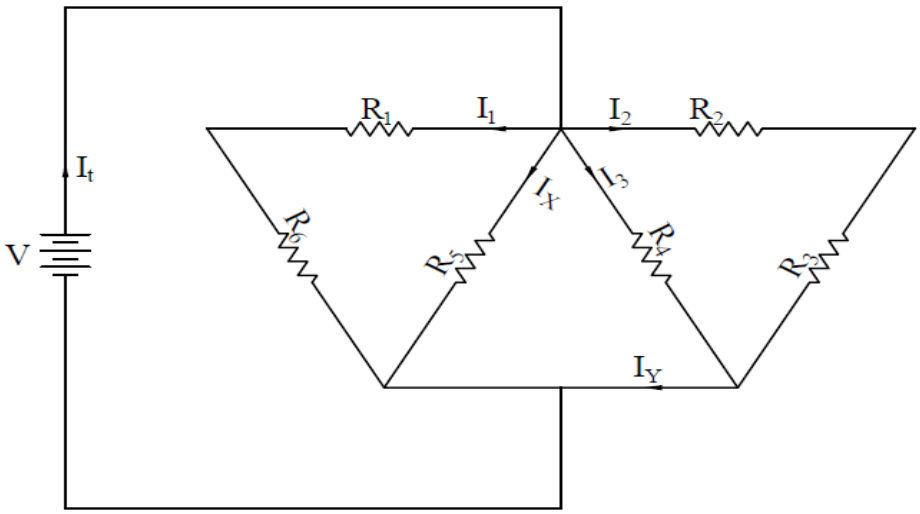


FIGURE 2

2.2.1 Determine the equation for I_Y.

2.2.2 Determine the equation for I_X. (2 × 2) (4)

2.3 FIGURE 3 shows a series RCL circuit. Answer the questions.

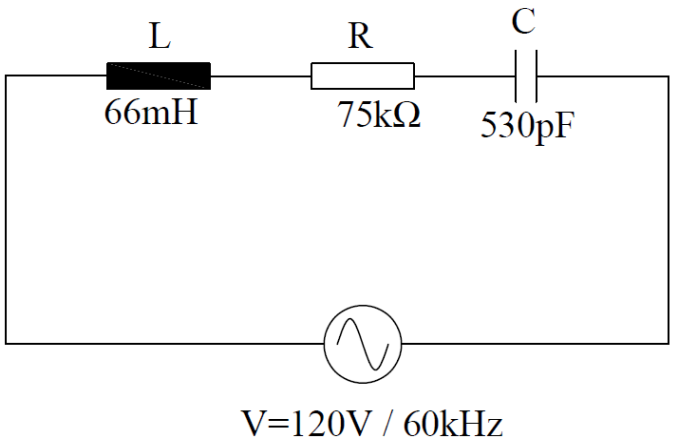


FIGURE 3

2.3.1 Calculate the inductive reactance. (1)

2.3.2 Calculate the capacitive reactance. (1)

2.3.3 Calculate the total impedance. (2)

2.3.4 Calculate the total current of the circuit. (2)

2.3.5 Calculate the voltage across the capacitor. (2)

2.3.6 Calculate the voltage across the inductor. (2)

2.3.7 Calculate the phase angle. (1)

2.3.8 Calculate the resonant frequency. (2)

[25]

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QUESTION 3

3.1 Transistors are not only used in amplifier switch circuits. They may also be used as regulators.

Draw a neat labelled circuit diagram of a transistor used as a constant-current regulator. (3)

3.2 The load line of a common emitter amplifier represents all the possible combinations of collector currents and collector-emitter voltages for amplification. The position of the bias point determines the amplification class.

Describe the following amplification classes.

3.2.1 Class B

3.2.2 Class C (2 × 2) (4)

3.3 Answer the following questions regarding photo transistors.

3.3.1 Draw a neat, labelled characteristic curve of a photo transistor. (3)

3.3.2 FIGURE 4 shows a circuit diagram of the application of a photo transistor. Describe the operation of the circuit.

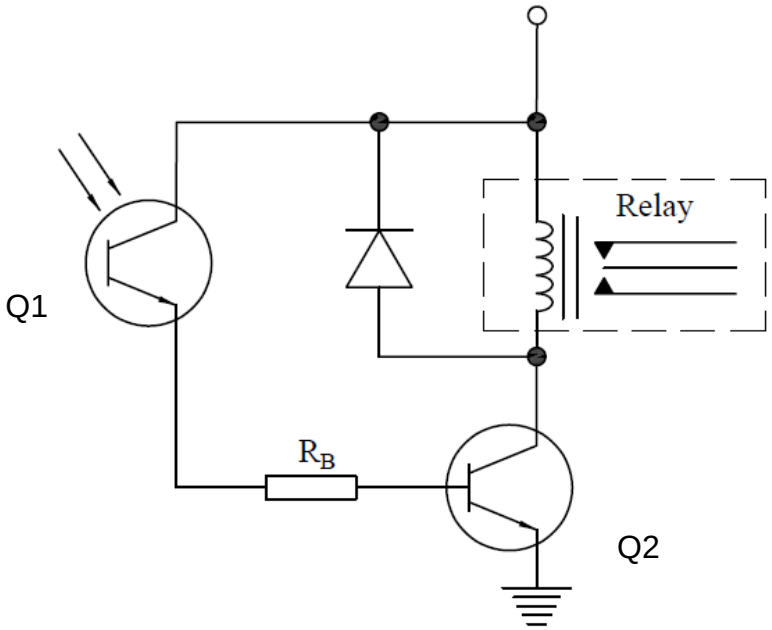


FIGURE 4 (2)

3.4 Draw a neat, labelled circuit diagram of an operational amplifier that is used as an audio amplifier. (4)

3.5 If the input wave of an integrating operational amplifier is a square wave, draw the output wave form. (2)

[18]

QUESTION 4

4.1 Draw a neat, labelled circuit diagram of a full-wave doubler. (4)

4.2 The reverse voltage in a varactor diode determines the thickness of the depletion layer and also the junction capacitance.

4.2.1 Draw the characteristic curve of a varactor diode. (3)

4.2.2 Draw a neat circuit symbol for a varactor diode. (1)

4.2.3 Name one use of a varactor diode. (1)

4.3 Photo conductors are one of the most common transducers used in electronics.

Describe the operation of a photo conductor. (2)

4.4 The Wheatstone bridge is used as a basis for most transducer circuits.

Describe the working principle of a Wheatstone bridge. (2)

4.5 Microphones use the piezo-electrical effect of crystal transducers to produce electrical current.

Draw a neat, labelled sketch of the basic construction of a microphone. (4)

[17]

QUESTION 5

5.1 Draw a neat, labelled block diagram of a continuous balance digital volt meter. (5)

5.2 Draw a neat, labelled block diagram of a frequency counter. (5)

5.3 Silicon controlled rectifiers are part of the thyristor family and are essentially power diodes.

Draw the characteristic curve for a silicon-controlled rectifier. (4)

5.4 To understand the working of a silicon-controlled rectifier it is best to consider it as two transistors.

Describe the working of a silicon-controlled rectifier by using the two-transistor analogy. (4)

5.5 Silicon-controlled rectifiers are not easy to switch off.

Name ONE method to switch off silicon-controlled rectifiers. (2)

[20]

TOTAL SECTION B: 80
GRAND TOTAL: 100

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INDUSTRIAL ELECTRONICS N3

FORMULA SHEET

Direct-current theory

$V = I \cdot R$ $\quad P = V \cdot I$ $\quad P = \frac{V^2}{R}$

$P = I^2 \cdot R$

Alternating-current theory

$X_L = 2\pi fL$ $\quad X_C = \frac{1}{2\pi fC}$ $\quad Z = \sqrt{R^2 + (X_L \sim X_C)^2}$

$V_T = \sqrt{V_R^2 + (V_L \sim V_C)^2}$ $\quad I = \frac{V_T}{Z}$ $\quad \theta = \cos^{-1}\frac{R}{Z}$

$V = I \cdot R$ $\quad V = I \cdot X_L$ $\quad V = I \cdot X_C$

$f_r = \frac{1}{2\pi\sqrt{LC}}$ $\quad I_R = \frac{V_T}{R}$ $\quad I_L = \frac{V_T}{X_L}$

$I_C = \frac{V_T}{X_C}$ $\quad I_T = \sqrt{I_R^2 + I_X^2}$ $\quad I_X = I_L \sim I_C$

$\theta = \tan^{-1}\frac{I_X}{I_R}$ $\quad \theta = \cos^{-1}\frac{I_R}{I_T}$ $\quad Z = \frac{V}{I_T}$

$Z_D = \frac{L}{RC}$ $\quad I_T = \frac{V}{Z_D}$ $\quad f_r = \frac{1}{2\pi}\sqrt{\frac{1}{LC} - \frac{R^2}{L^2}}$

$I_C = I_{RL}\, Sin\theta_L$ $\quad I_T = I_{RL}\, Cos\theta_L$ $\quad I_T = \sqrt{{I_{T_H}}^2 + {I_{T_V}}^2}$

Transistors

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

Transducers

$R = \frac{\rho \cdot l}{a}$ $\quad C = \frac{k \cdot A \cdot E_o}{d}$

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