Calculators may be used.

Candidates will require drawing instruments, pens and a ruler.

This question paper consists of 8 pages, a diagram sheet and a formula sheet.
INSTRUCTIONS AND INFORMATION

1. Answer ALL the questions.
2. Read ALL the questions carefully.
3. Number the answers correctly according to the numbering system used in this question paper.
4. Start each question on a NEW page.
5. ALL the sketches and diagrams must be large, clear and neat.
6. Keep questions and subsections of questions together.
7. Leave margins clear.
8. Questions must be answered in blue or black ink.
9. Use \( \pi = 3.142 \).
10. ALL the final answers must be approximated accurately to THREE decimal places.
11. Write neatly and legibly.
SECTION A

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 – 1.1.10) in the ANSWER BOOK.

1.1.1 Zener breakdown occurs when the applied electric field pulls the electrons from the covalent bonds. (1)

1.1.2 The collector current of a transistor will increase when the base/emitter forward-bias voltage is increased. (1)

1.1.3 In a capacitor the frequency is directly proportional to the capacitive reactance. (1)

1.1.4 The output frequency of a full-wave voltage doubler is half the supply frequency. (1)

1.1.5 Atoms with more than four valence electrons are conductors. (1)

1.1.6 In a PNP transistor the base is biased negative with respect to the emitter and the collector is biased to a more negative value than the base. (1)

1.1.7 An inductor is connected in parallel with a capacitor. If the inductance is doubled, and the capacitance is halved, the impedance at resonance will be doubled. (1)

1.1.8 The graph showing the variation of inductive reactance with frequency, is a straight line. (1)

1.1.9 Doping improves the conduction capabilities of a semiconductor. (1)

1.1.10 RC coupling amplifiers do not have a good frequency response. (1)
1.2 Various options are given as possible answers to the following questions. Choose the answer and write only the letter (A – D) next to the question number (1.2.1 – 1.2.10) in the ANSWER BOOK.

1.2.1 Light in an LED is generated by ...
A intense heating of the junction, like the filament of a light bulb.
B bound electrons spontaneously leaping out of their ‘sockets’ creating a photon of light.
C free electrons falling into holes and giving up their energy in the form of electromagnetic radiation.
D the creation of a free electron and a hole.

1.2.2 The method used to switch an SCR off in a DC circuit is called ...
A cyclotronic control.
B phase control.
C forced commutation.
D cycle control.

1.2.3 The output from a ... clipper consists only of the positive half of the input signal.
A positive series or positive shunt
B negative series or positive shunt
C positive shunt or negative shunt
D negative shunt or negative series

1.2.4 When a PN-junction is formed, some free electrons from the N-type material are attracted across the junction to fill the holes in the P-type material. This is known as ...
A reverse bias.
B forward bias.
C diffusion.
D doping.

1.2.5 If the frequency of the voltage applied to a capacitor is increased then ...
A its reactance will fall.
B its reactance will rise.
C the current through the capacitor will fall.
D the current through the capacitor will remain unchanged.
1.2.6 A phototransistor switches on when the ... exposed to light.
A base-emitter junction is
B base-collector junction is
C base-emitter and base-collector junctions are
D base-emitter or base-collector junction is

1.2.7 The following transducers do not require any external power source:
A Photovoltaic cell and crystal
B Crystal and thermistor
C Strain gauge and thermistor
D Photovoltaic cell and thermistor

1.2.8 The method used to stabilise the gain in a transistor amplifier is called ...
A amplification.
B voltage regulation.
C rectification.
D negative feedback.

1.2.9 The process where a voltage is developed across a device when it is subjected to a force, is called ...
A voltage regulation.
B photoelectric effect.
C piezoelectric effect.
D synchronisation.

1.2.10 In the active region ...
A both the collector-base junction and emitter-base junction are reverse-biased.
B the collector base is reverse-biased and the emitter base is forward-biased.
C both the collector base and emitter base are forward-biased.
D the collector base is forward-biased and the emitter base is reverse-biased.

TOTAL SECTION A: 20
SECTION B

QUESTION 2

2.1 Refer to FIGURE 1 on the attached DIAGRAM SHEET and determine the following with the aid of Kirchhoff's laws:

2.1.1 The equation for loop 1 (PQRTUP). Set up the equation by starting at point P and proceed in the direction of loop 1 (thick arrow). (2)

2.1.2 The equation for loop 2 (QSRQ). Set up the equation by starting at point Q and proceed in the direction of loop 2 (thick arrow). (2)

2.1.3 The magnitude of the currents 1 and 2 by making use of the equations in QUESTION 2.1.1 and QUESTION 2.1.2. (4)

2.2 In SCR control, we make use of commutation.

2.2.1 Name TWO commutation methods. (2)

2.2.2 Briefly explain each method. (2)

2.3 An SCR can be controlled by making use of FOUR different methods. The following statements are descriptions or definitions of these methods. Name the method described by each statement:

2.3.1 This method of control is used when the SCR performs simple switching. (1)

2.3.2 This method of control is a combination of phase control and cycle control. (1)

2.3.3 This method of control is achieved by controlling the time at which the gate of the SCR is triggered. (1)

2.3.4 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. (1)
QUESTION 3

3.1 A resonant parallel circuit consists of an inductor of 200 mH, a resistance of 4 ohms and a capacitor of 50 µF connected across a 220 volt supply.

Calculate the following:

3.1.1 Resonant frequency (2)

3.1.2 Current flowing through the inductor (3)

3.1.3 Dynamic impedance (2)

3.2 Draw the IEC circuit symbol and a neatly labelled characteristic curve of the following:

3.2.1 Photodiode (3)

3.2.2 Phototransistor (3)

3.2.3 Varactor diode (3)

QUESTION 4

4.1 Use an NPN transistor and draw the circuit diagram of a parallel voltage regulator. (5)

4.2 Draw a labelled output characteristic curve of a common-emitter amplifier. On the curve draw a load line and indicate where you would place the Q-point on the load line for a class C amplifier. (4)

4.3 Complete the following paragraph that explains the operation of a phototransistor by using the word(s) given in the list below. Write only the word(s) next to the question number (4.3.1 – 4.3.5) in the ANSWER BOOK. A word may be used more than once.

holes; electrons; reverse; forward; decrease; increase; collector-base; emitter/base

The light that shines on the 4.3.1 ... region causes 4.3.2 ... leakage current to flow. This, in effect, is a withdrawal of 4.3.3 ... from the base, which is necessary to turn the transistor on. A/An 4.3.4 ... in the light intensity would correspond with a/an 4.3.5 ... in base current and a larger increase in the collector current. (5)

4.4 Draw a labelled circuit symbol (IEC) of a P-channel depletion MOSFET. (2)
QUESTION 5

5.1 Explain how a selenium photovoltaic cell is used as a transducer by giving the following:

5.1.1 A labelled sketch of the construction (4)
5.1.2 The basic principle of operation (2)
5.1.3 Give ONE area of application (1)

5.2 Name THREE characteristics of operational amplifiers (3)

5.3 Draw the input waveform given in FIGURE 2 on the attached DIAGRAM SHEET and the corresponding output waveforms for the following operational amplifiers in the ANSWER BOOK.

5.3.1 Integrator (2)
5.3.2 Differentiator (2)
5.3.3 Summing amplifier [16]

QUESTION 6

6.1 FIGURE 3 on the attached DIAGRAM SHEET shows a block diagram of an oscilloscope. Name ALL the numbered parts. Write only the answer next to the question number (1 – 14) in the ANSWER BOOK. (7)

6.2 Name TWO errors pertaining to measuring instruments and state a cause of each error. (2 \times 2) (4)

6.3 Briefly explain, with the aid of sketches, the following bonds:

6.3.1 Ionic (2)
6.3.2 Covalent [16] (3)

TOTAL SECTION B: 80
GRAND TOTAL: 100