basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE

GRADE 11

ELECTRICAL TECHNOLOGY

EXEMPLAR 2017

MARKS: 200

TIME: 3 hours

This question paper consists of 21 pages and a 2-page formula sheet.

INSTRUCTIONS AND INFORMATION

1. This question paper consists of 17 questions.

2. Learners offering ELECTRICAL must answer only the following questions:

QUESTION	1	2	3	4	5	6	7	8	9
TICK AFTER ANSWERING									

3. Learners offering ELECTRONICS must answer only the following questions:

QUESTION	1	2	6	10	11	12	13	14	15
TICK AFTER ANSWERING									

4. Learners offering DIGITAL ELECTRONICS must answer only the following questions:

QUESTION	1	2	6	10	11	14	15	16	17
TICK AFTER ANSWERING									

5. Sketches and diagrams must be large, neat and fully labelled.

6. Show ALL calculations and round off answers correctly to TWO decimal places. Show the units for ALL answers of calculations.

7. Number the answers correctly according to the numbering system used in this question paper.

8. You may use a non-programmable calculator.

9. Show the units for all answers of calculations.

10. A formula sheet is provided at the end of this question paper.

11. Write neatly and legibly.

(ELECTRICAL, ELECTRONICS AND DIGITAL)

QUESTION 1: OCCUPATIONAL HEALTH AND SAFETY

1.1 Describe the term *regulation* with respect to the OHS act. (2)

1.2 Name the type of sign that has a green background. (1)

1.3 Name ONE unsafe condition that may result in an injury. (1)

1.4 Describe the term *ergonomics* with respect to safety. (2)
[6]

(ELECTRICAL, ELECTRONICS AND DIGITAL)

QUESTION 2: TOOLS AND MEASURING INSTRUMENTS

2.1 State TWO applications of an oscilloscope. (2)

2.2 Explain the advantage of a clamp meter over a digital multimeter when measuring current. (2)

2.3 Describe the function of a *crimping tool*. (2)
[6]

(ELECTRICAL)

QUESTION 3: DC MACHINES

3.1 Explain the difference between a *generator* and a *motor*. (4)

3.2 List THREE parts of a DC machine other than the armature and the commutator. (3)

3.3 Describe the purpose of EACH of the following parts of a DC machine:

3.3.1 Armature (3)

3.3.2 Commutator (3)

3.4 Explain the term *armature reaction*. (2)

3.5 State TWO types of commutation. (2)

3.6 Name ONE application of EACH of the following types of motors:

3.6.1 Series motor (1)

3.6.2 Compound motor (1)

3.7 Name TWO types of losses in DC machines. (2)

3.8 A DC motor draws a current of 125 mA when connected to a 12 V supply. The power developed at its shaft is 1,4 W. Calculate the efficiency of the motor.

Given:
$I = 125\ mA$
$V = 12\ V$
$P_{OUT} = 1,4\ W$

(5)
[26]

(ELECTRICAL)

QUESTION 4: SINGLE-PHASE AC GENERATION

4.1 Define the term *flux density*. (2)

4.2 Explain the difference between *alternating current* and *direct current*. (4)

4.3 Explain the generation of a single-phase supply by rotating a conductor loop through a two-pole magnetic field. (5)

4.4 A 350-turns coil has a length of 40 mm. Calculate the magnetic field strength of this coil if it conducts a current of 200 μA. (3)

Given:
$N = 350$
$\ell = 400\ mm$
$I = 200\ \mu A$

4.5 Calculate the flux density of a bar magnet which has a flux of 2,7 mWb and a cross-sectional area of 9 cm^2. (3)

Given:
$\Phi = 2,7\ mWb$
$A = 9\ cm^2$

4.6 A coil with 150 turns has a cross-sectional area of 60 cm^2 and rotates at a speed of 1 400 r/min in a magnetic field with a flux density of 0,5 T. Calculate the:

Given:
$N = 150$
$A = 60\ cm^2$
$n = 1\ 400\ r/min$
$B = 0,5\ T$

4.6.1 Frequency (3)

4.6.2 EMF-generated (3)

4.6.3 Instantaneous value at an angle of 68° (3)
[26]

(ELECTRICAL)

QUESTION 5: SINGLE-PHASE TRANSFORMERS

5.1 Name TWO types of transformer core. (2)

5.2 State the application of EACH of the following transformers:

5.2.1 Auto-transformer (1)

5.2.2 Centre-tap transformer (1)

5.3 State Lenz's law. (2)

5.4 Describe the operational principle of a transformer. (6)

5.5 List THREE types of losses in a transformer. (3)

5.6 Refer to FIGURE 5.1 below and answer the questions that follow.

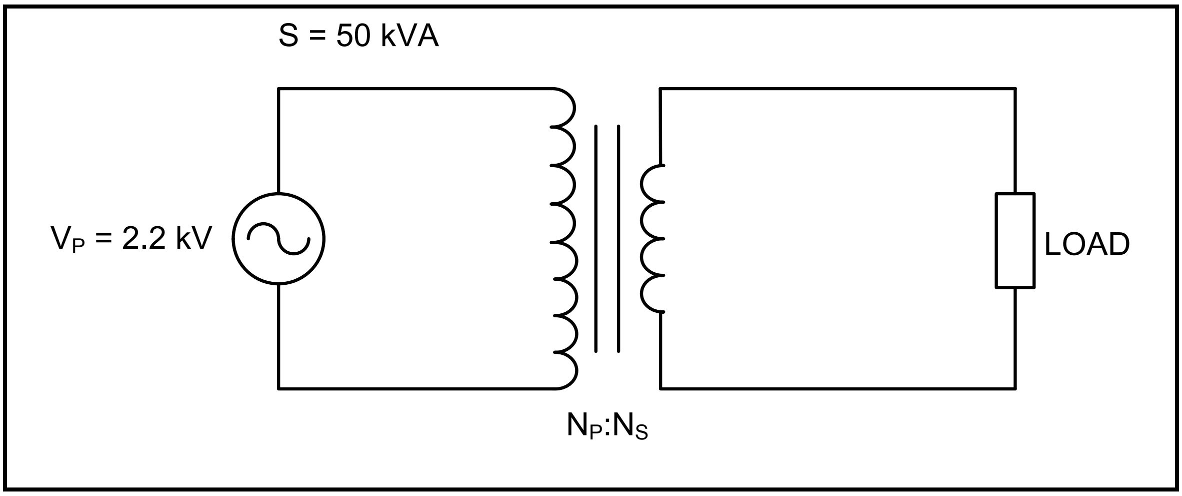

FIGURE 5.1: SINGLE-PHASE TRANSFORMER

Given:
S = 50 kVA
V_P = 2,2 kV
f = 50 Hz
η = 100%
$N_P : N_S = 15 : 1$

Calculate the following

5.6.1 The secondary voltage (3)

5.6.2 The primary current (3)

5.6.3 The secondary current (3)
[24]

(ELECTRICAL, ELECTRONICS AND DIGITAL)

QUESTION 6: RLC CIRCUITS

6.1 State the size of the phase angle between the voltage and current vectors of the following pure components:

6.1.1 Resistor (1)

6.1.2 Capacitor (1)

6.2 Refer to the circuit in FIGURE 6.1 below and answer the questions that follow.

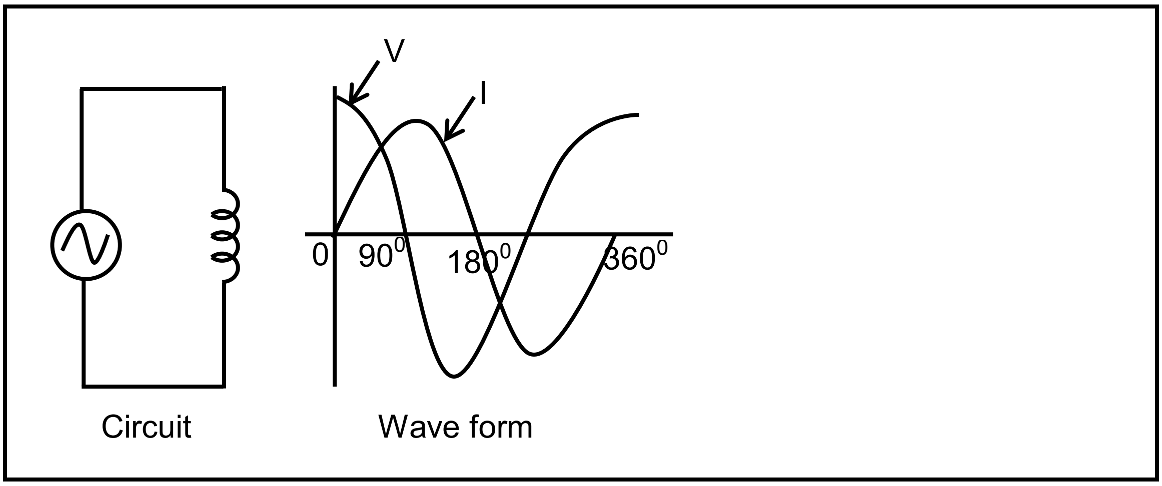

FIGURE 6.1

6.2.1 Describe the effect on the current when the frequency increases. (2)

6.2.2 Draw a labelled phasor diagram. (4)

6.3 Refer to FIGURE 6.2 and below and answer the questions that follow.

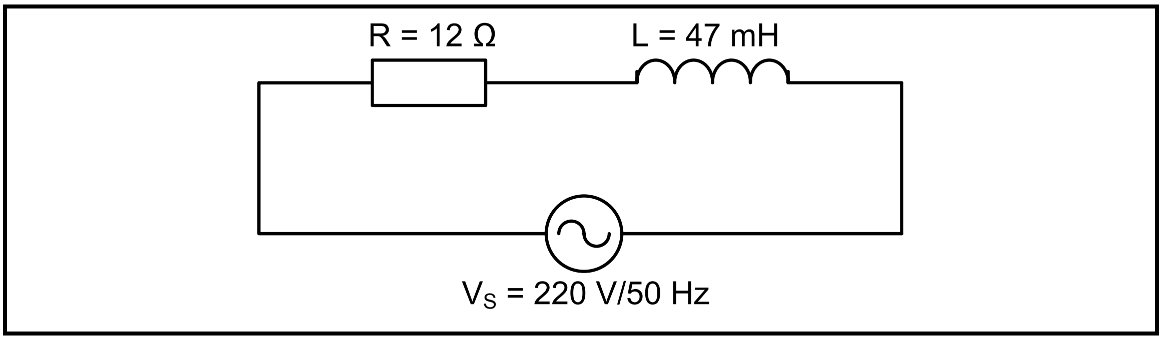

FIGURE 6.2

Given:
R = 12 Ω
L = 47 Mh
V = 220 V
f = 50 Hz

Calculate the following:

6.3.1 Inductive reactance (3)

6.3.2 Impedance of the circuit (3)

6.3.3 Total current drawn from supply (3)

6.3.4 The phase angle of the circuit (3)

6.3.5 The active power of the circuit (3)

6.3.6 State if a frequency change will affect the value of the resistor (1)
[24]

(ELECTRICAL)

QUESTION 7: CONTROL DEVICES

7.1 Describe why electrical equipment and circuits must have electrical protection. (2)

7.2 Refer to overcurrent protection and answer the questions that follow.

7.2.1 Describe why this type of protection is important. (2)

7.2.2 State ONE advantage of a resettable overload over a fuse. (1)

7.3 Describe the function of no-volt protection. (4)

7.4 The diagram in FIGURE 7.1 below is the control circuit of a DOL starter. Answer the questions that follow.

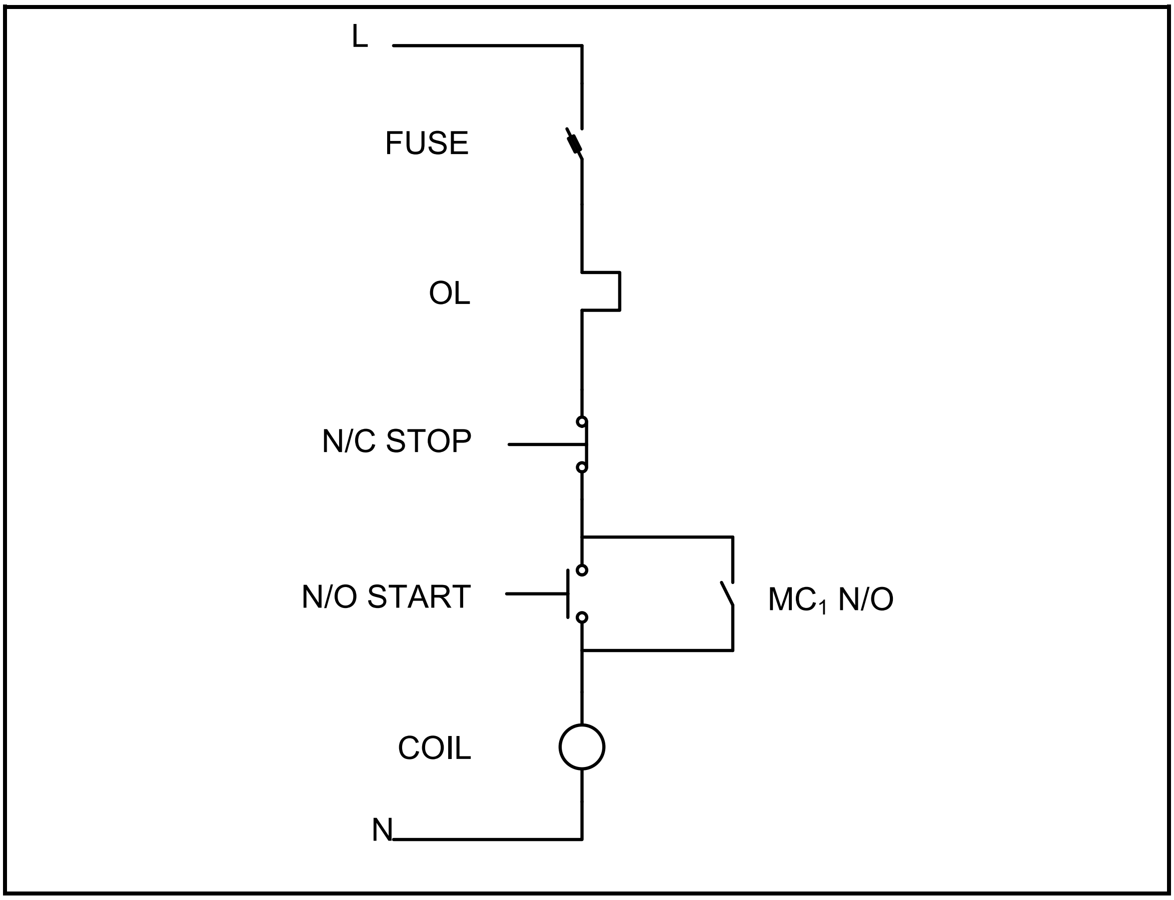

FIGURE 7.1: DOL CONTROL CIRCUIT

7.4.1 State the function of the coil. (3)

7.4.2 Describe why the N/C stop contact is connected in series with the control circuit. (3)

7.4.3 Describe how the circuit is kept closed once the N/O start button is released. (3)

7.5 Refer to PLCs and answer the questions that follow.

7.5.1 Describe the term *hardware*. (2)

7.5.2 Describe the difference between *hard-wired* and *soft-wired systems*. (4)

7.5.3 Name TWO types of input devices. (2)

7.5.4 State ONE safety precaution that must be considered when working with a PLC. (1)

7.6 Draw the ladder diagram of an OR function. Assume the output is connected to a coil of a motor. (5)
[32]

(ELECTRICAL)

QUESTION 8: SINGLE-PHASE MOTORS

8.1 Describe a unique feature of a universal motor when compared to other single-phase motors. (2)

8.2 Describe the difference between a *synchronous motor* and an *induction motor*. (2)

8.3 Name TWO types of split-phase motors other than a capacitor-start motor. (2)

8.4 Explain the purpose of a centrifugal switch with reference to an induction motor. (3)

8.5 Draw a labelled circuit diagram of capacitor-start motor. (6)

8.6 List THREE items that should form part of the visual inspection of a motor before it is energised. (3)

8.7 State TWO practical applications of a capacitor-start and run motor. (2)

8.8 Explain how the direction of rotation of a capacitor-start motor may be reversed. (2)

8.9 Explain how an increase in the load will affect the speed of a motor. (4)

8.10 Explain the operation of a split-phase motor. (6)
[32]

(ELECTRICAL)

QUESTION 9: POWER SUPPLIES

9.1 FIGURE 9.1 below shows the block diagram of a power supply.

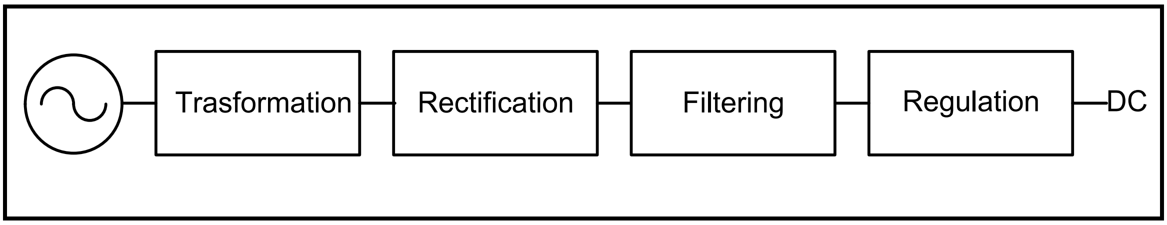

FIGURE 9.1: BLOCK DIAGRAM OF A POWER SUPPLY

Describe the function of the following:

9.1.1 Transformation (2)
9.1.2 Rectification (2)

9.2 Describe the operation of a diode connected in:

9.2.1 Forward bias (3)
9.2.2 Reverse bias (3)

9.3 Refer to the regulator diagram in FIGURE 9.2 below and answer the questions that follow.

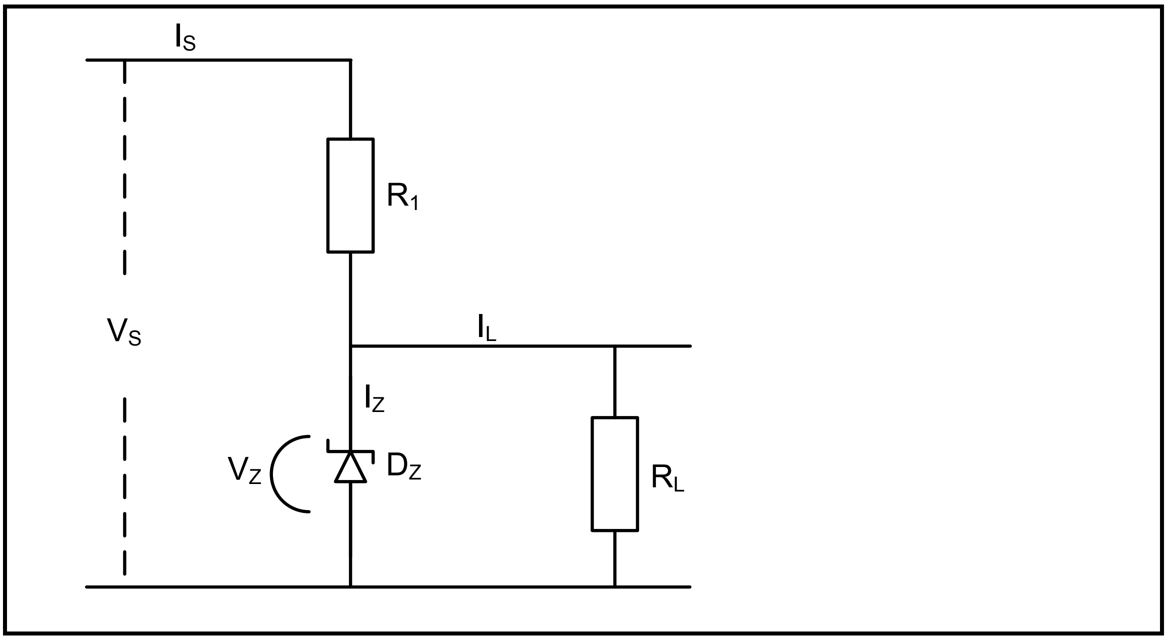

FIGURE 9.2: REGULATOR CIRCUIT

Given:
P_Z = 2 W
V_S = 12 V
V_Z = 5 V
R_L = 1 kΩ

9.3.1 State the function of the series resistor. (1)

9.3.2 Calculate the maximum current flowing through the Zener diode(I_Z). (3)

9.3.3 Calculate the minimum value of the series resistor R_S. (3)

9.3.4 Calculate the load current I_L if a load resistor of 1 kΩ is connected across the Zener diode (3)

9.4 Refer to the full-wave rectification circuit in FIGURE 9.3 below and draw a fully labelled output waveform across the load resistor R_L.

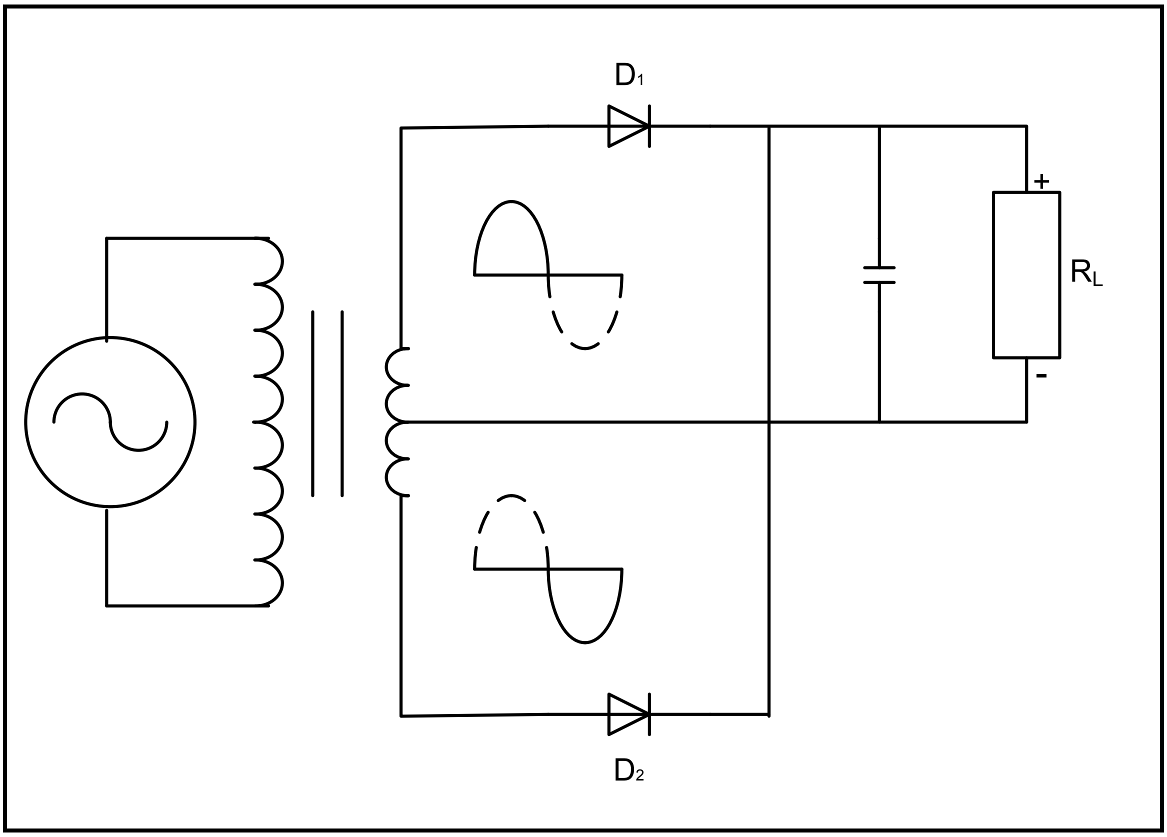

FIGURE 9.3: FULL-WAVE RECTIFICATION (4)

[24]

(ELECTRONICS AND DIGITAL)

QUESTION 10: WAVE FORMS

10.1 Name ONE application of a radio wave (1)

10.2 Identify the wave forms shown in FIGURES 10.2.1 to 10.2.4 below.

10.2.1

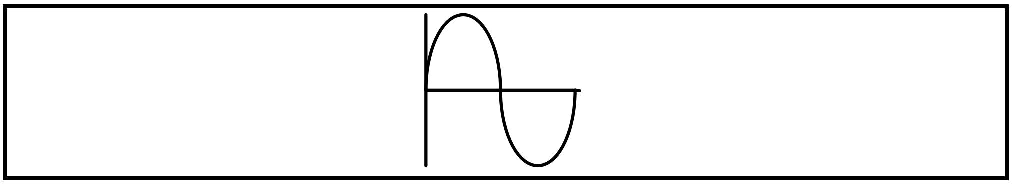

FIGURE 10.1 (1)

10.2.2

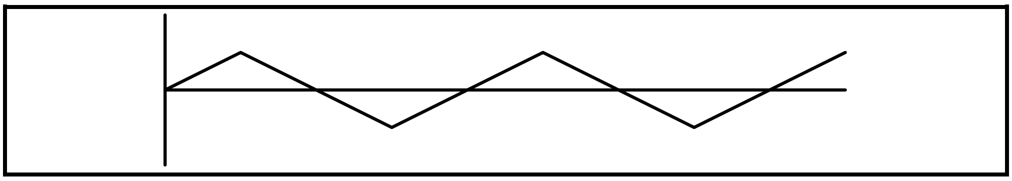

FIGURE 10.2 (1)

10.2.3

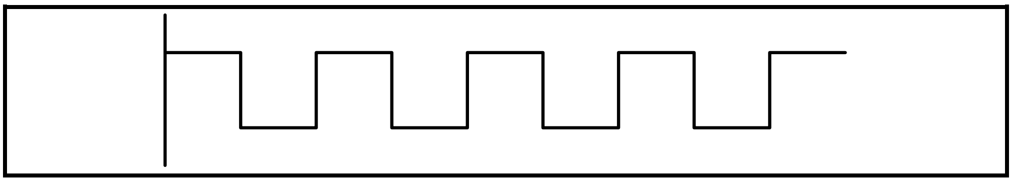

FIGURE 10.3 (1)

10.2.4

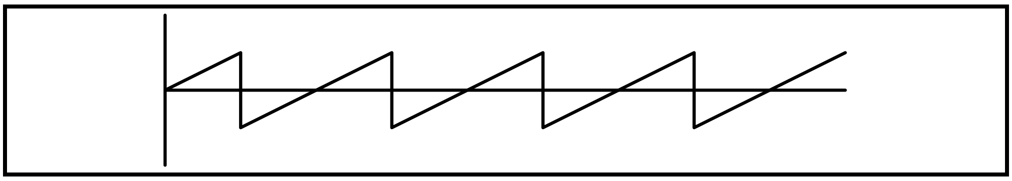

FIGURE 10.4 (1)

10.3 Define the *term period* with reference to a wave form. (3)

10.4 Refer to FIGURE 10.5 below and answer the questions that follow.

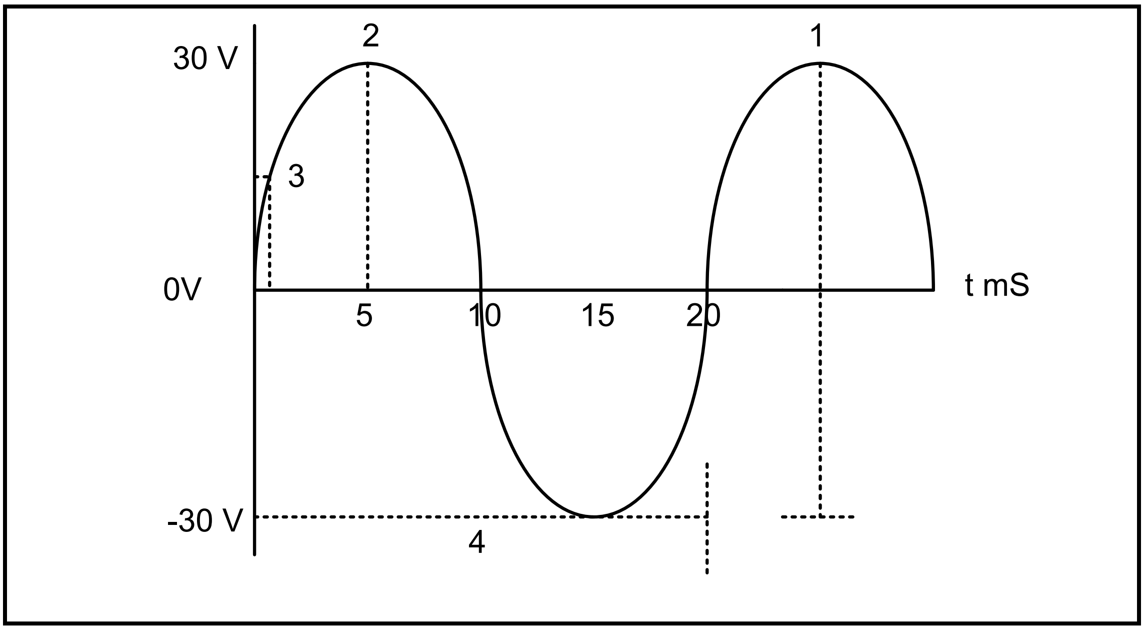

FIGURE 10.5

10.4.1 Identify **1**–**4**. (4)

10.4.2 Determine the value of the voltage at **2**. (1)

10.4.3 Determine the period. (1)

10.4.4 Calculate the frequency. (3)

10.4.5 Calculate the instantaneous voltage at 8 ms. (4)

10.5 Refer to FIGURE 10.6 below and answer the questions that follow.

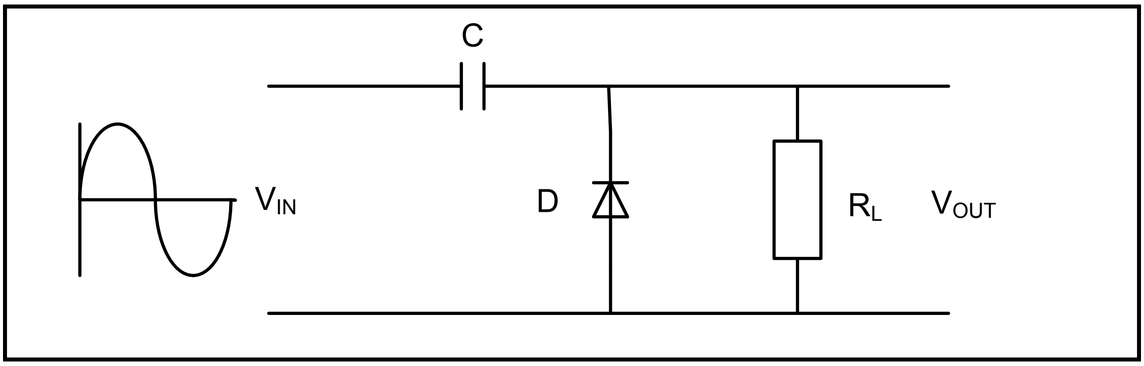

FIGURE 10.6

10.5.1 State whether the circuit in FIGURE 5.6 is a clipper or a clamper. (1)

10.5.2 Describe the concept of *clamping* in electronics. (4)
[26]

(ELECTRONICS AND DIGITAL)

QUESTION 11: SEMICONDUCTOR DEVICES

11.1 Describe the term *semiconductor*. (2)

11.2 Semiconductors are mass produced and are often small in physical size. Manufactures supply component data sheets. Answer the following questions with reference to component data sheets.

11.2.1 State ONE source where such data sheets may be found. (1)

11.2.2 Working temperature may be displayed on the sheet. Explain why this information is important. (3)

11.2.3 Other than working temperature, state TWO types of information given on data sheets. (2)

11.3 Explain the difference between *conventional current flow* and *electron flow*. (4)

11.4 Describe the term *solid state*, with reference to semiconductors. (2)

11.5 Describe how N type material is formed. (5)

11.6 With reference to P type material, name the charge of the following:

11.6.1 Majority-charge carriers (1)

11.6.2 Minority-charge carriers (1)

11.7 State ONE application of a Zener diode. (1)

11.8 In which mode is the Zener diode designed to operate? (1)

11.9 Refer to the NPN-transistor in FIGURE 11.1 below and describe its operation.

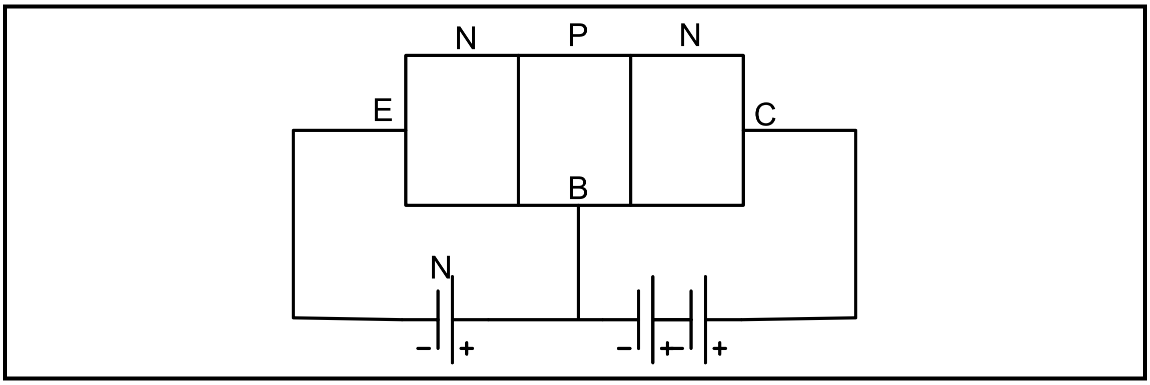

FIGURE 11.1: NPN TRANSISTOR CIRCUIT (8)

11.10 Answer the following questions with reference to a transistor DC load line.

11.10.1 State on which of the characteristic curves of a transistor the load line is drawn. (1)

11.10.2 State what factor determines the Q point of a load line. (1)

11.10.3 Describe where the Q point could be placed for an audio amplifier application. (4)

11.11 Answer the following questions with reference to an SCR.

11.11.1 Draw a labelled symbol of an SCR. (3)

11.11.2 State ONE application of an SCR. (1)

11.11.3 Describe the term *holding current*. (2)

11.12 Answer the following questions with reference to a TRIAC.

11.12.1 State ONE advantage of a TRIAC over an SCR. (1)

11.12.2 Describe ONE method to switch on a TRIAC. (2)

11.13 Describe a *DIAC*. (2)
[48]

(ELECTRONICS)

QUESTION 12: POWER SUPPLIES

12.1 Answer the following questions with reference to FIGURE 12.1 below.

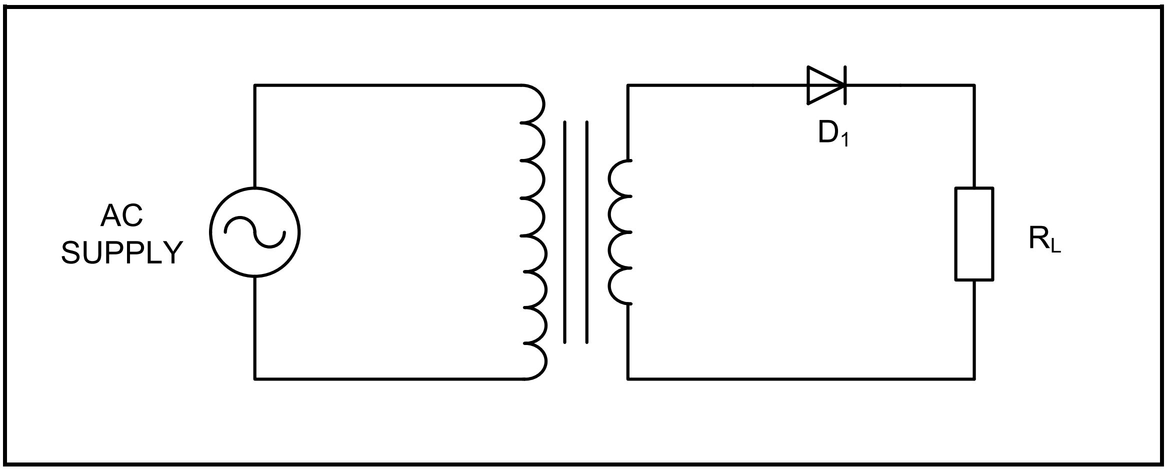

FIGURE 12.1

12.1.1 Draw the voltage waveform across R_L. (3)

12.1.2 Draw the voltage waveform across D_1. (3)

12.2 Refer to figure 12.2 below and answer the questions that follow.

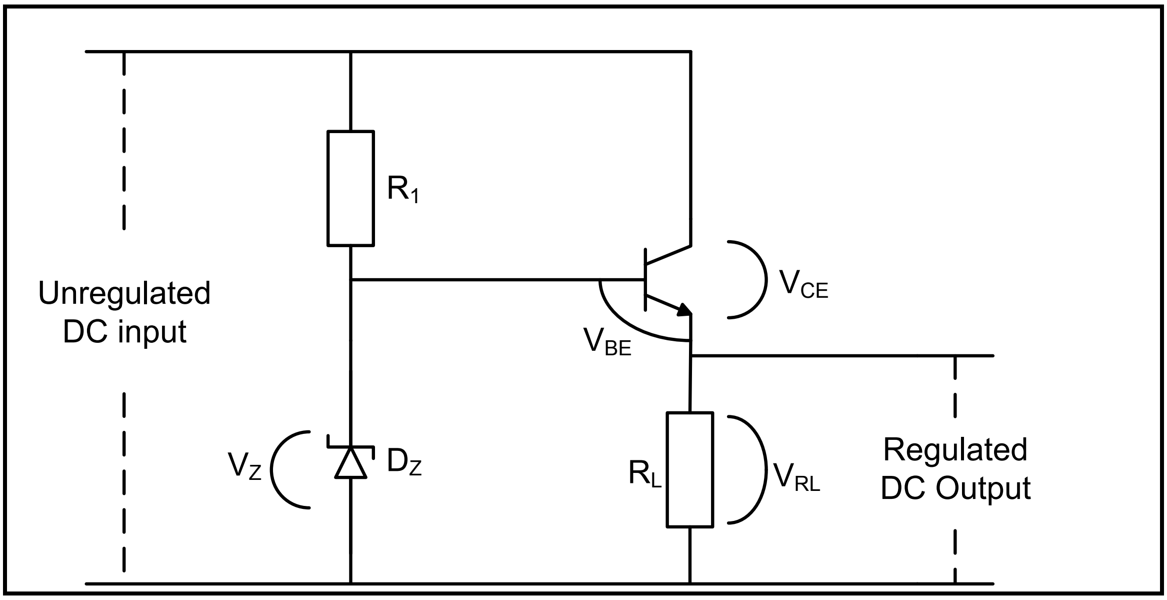

FIGURE 12.2: ZENER AS A SERIES REGULATOR

12.2.1 State why the circuit is called a series-regulated power supply unit. (1)

12.2.2 Describe why an increase in the supply voltage does not increase the output voltage. (4)

12.3 Refer to the circuit diagram in FIGURE 12.3 below and answer the questions that follow.

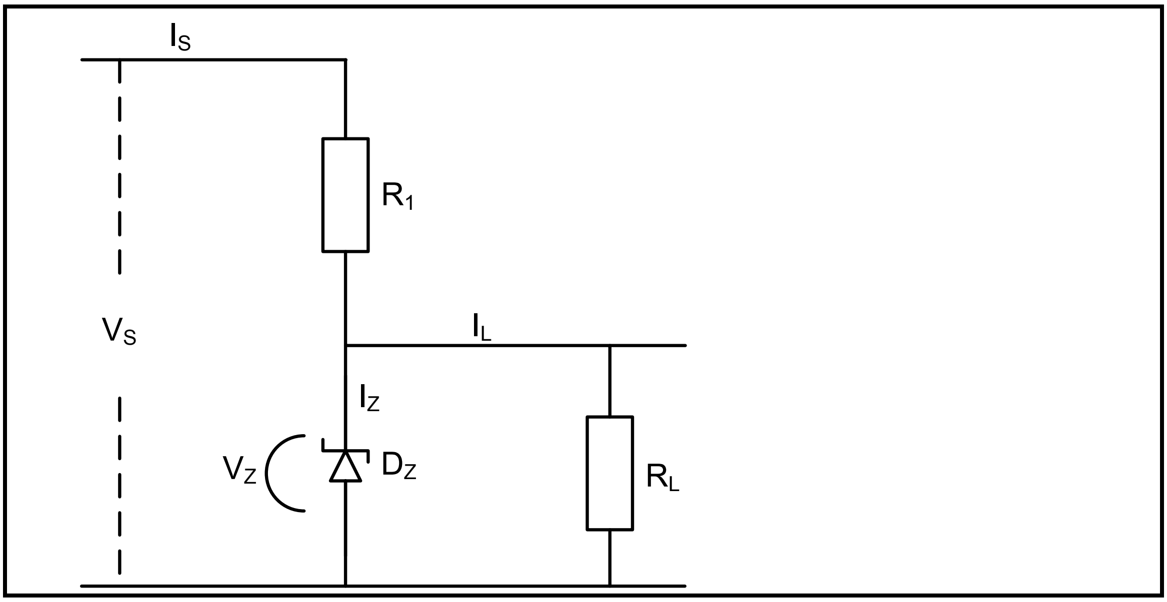

FIGURE 12.3: REGULATED ZENER DIODE CIRCUIT

Given:

P_Z = 2 W
V_S = 12 V
V_Z = 5 V
RL = 1 kΩ

Calculate:

12.3.1 The maximum current flowing through the Zener diode, I_Z (3)

12.3.2 The minimum value of the series resistor, R_S (3)

12.3.3 The load current I_L if a load resistor of 1 kΩ is connected across the Zener diode (3)

[20]

(ELECTRONICS)

QUESTION 13: AMPLIFIERS

13.1 Define an *amplifier*. (2)

13.2 Describe *class A amplification.* (3)

13.3 State ONE use of a class AB amplifier. (1)

13.4 Explain the concept of *biasing* in amplifier circuits. (5)

13.5 List THREE types of biasing used in amplifier design. (3)

13.6 Refer to FIGURE 13.1 below and answer the questions that follow.

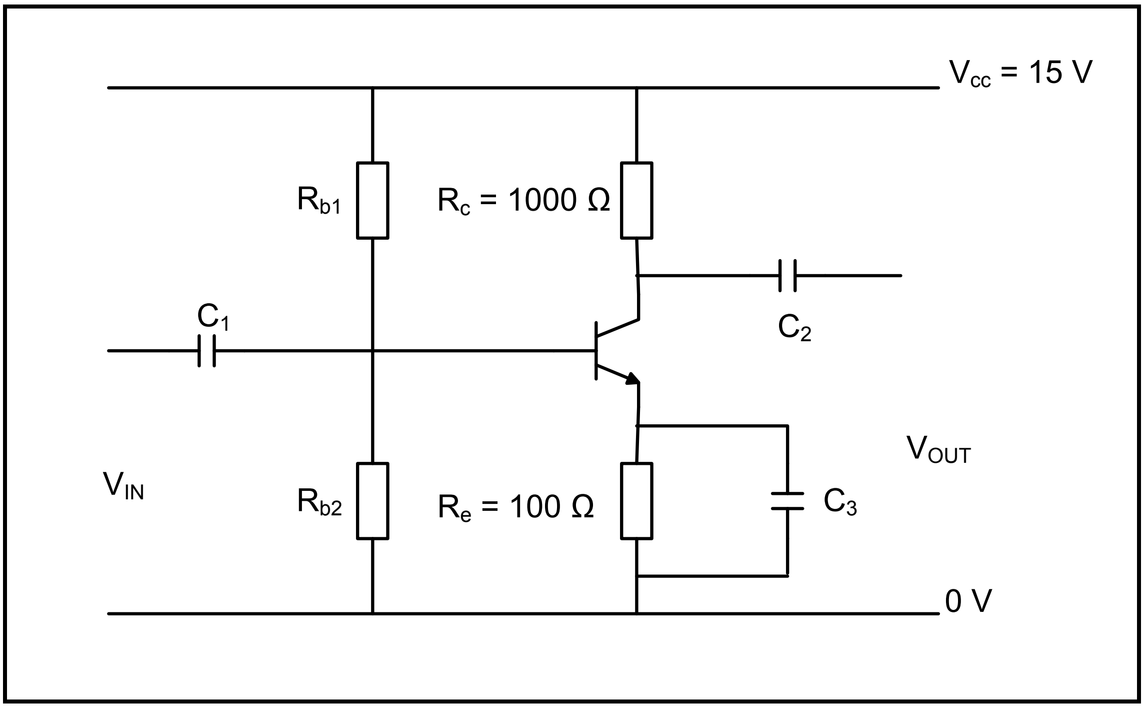

FIGURE 13.1: AMPLIFIER CIRCUIT

13.6.1 Describe the function of the transistor. (3)

13.6.2 Explain the purpose of resistors R_{b1} and R_{b2} (3)

13.6.3 Describe the function of the output capacitor C_2. (2)

13.6.4 Calculate the collector current. (3)

13.7 Draw the load line showing the maximum voltage and current that will flow through the amplifier in FIGURE 13.1. (3)

13.8 State TWO advantages of negative feedback. (2)

13.9 State TWO advantages of positive feedback. (2)
[32]

(ELECTRONICS AND DIGITAL)

QUESTION 14: SENSORS AND TRANSDUCERS

14.1 Define the following terms:

14.1.1 Sensor (3)
14.1.2 Piezo-electric effect (2)

14.2 Describe the basic operation of a dynamic microphone. (4)

14.3 Describe how an increase in temperature affects the resistance of a thermistor with a positive temperature coefficient. (1)

14.4 State ONE practical application of a thermistor. (1)

14.5 State the function of a gas/humidity sensor. (1)
[12]

(ELECTRONICS AND DIGITAL)

QUESTION 15: COMMUNICATION SYSTEMS

15.1 Draw a labelled basic circuit diagram of an LC oscillator. (4)

15.2 Describe the role of an oscillator with reference to communication systems. (2)

15.3 Define the term *natural oscillation*. (3)

15.4 Explain why positive feedback is used in an oscillator. (2)

15.5 Describe modulation in transmitters. (3)

15.6 List THREE basic methods of modulation. (3)

15.7 FIGURE 15.1 below shows the block diagram of an AM-tuned radio receiver.

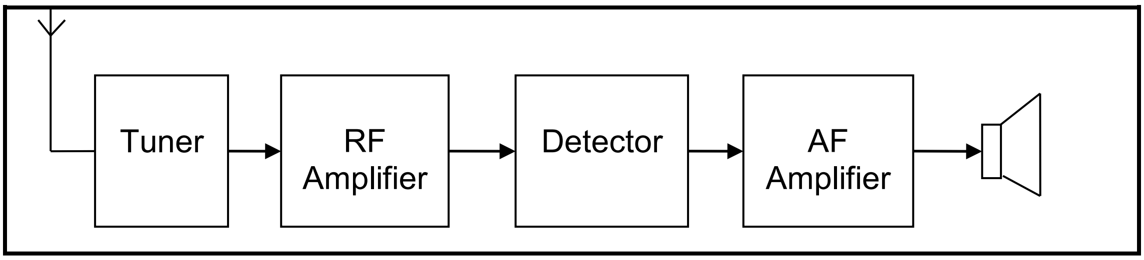

FIGURE 15.1: AM TUNED RADIO RECEIVER

Explain the function of the following:

15.7.1 Tuner (3)
15.7.2 RF amplifier (2)
15.7.3 Detector (2)
15.7.4 AF amplifier (2)
[26]

(DIGITAL)

QUESTION 16: LOGICS

16.1 Refer to FIGURE 16.1 below and answer the questions that follow.

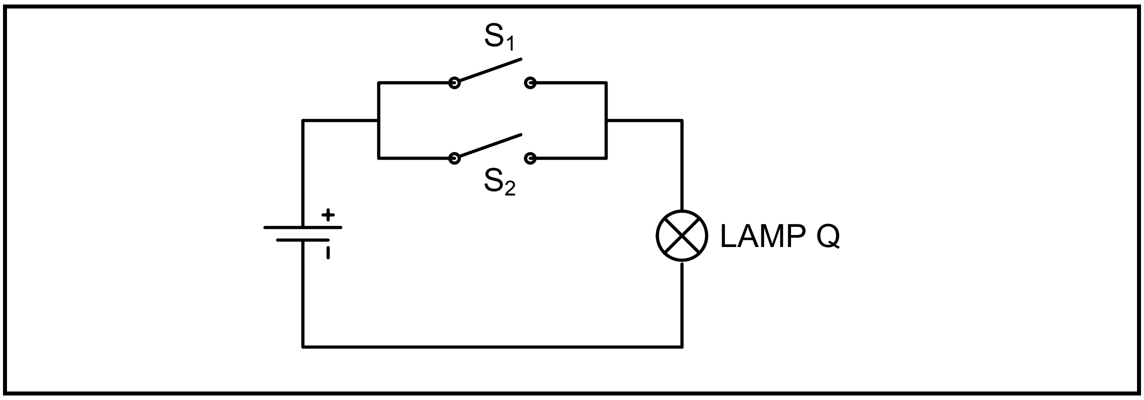

FIGURE 16.1

16.1.1 Identify the logic function of the circuit in FIGURE 16.1. (1)

16.1.2 Draw the logic symbol that is represented by the circuit. (2)

16.1.3 Write out the Boolean expression. (2)

16.1.4 Draw the truth table of the gate. (4)

16.2 Refer to FIGURE 16.2 below and answer the questions that follow.

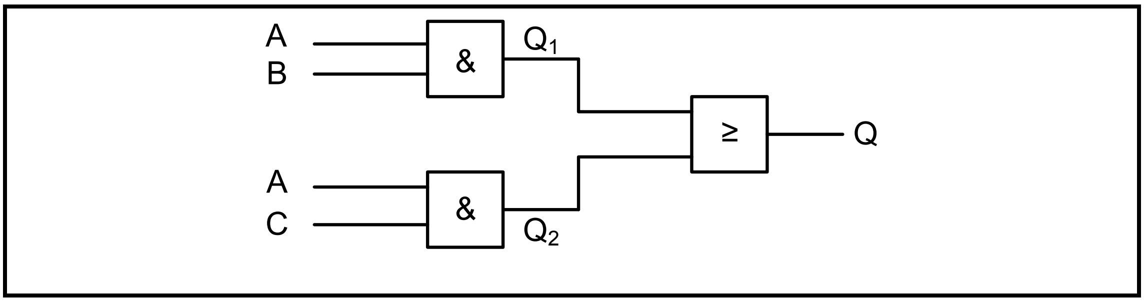

FIGURE 16.2

Give the Boolean expression at the following points:

16.2.1 Q_1 (2)
16.2.2 Q_2 (2)
16.2.3 Q (3)

16.3 Using Boolean algebra, simplify the expression below:

$$X = \overline{A}\,B\,\overline{C} + A\,B\,\overline{C} + A\,\overline{B}\,\overline{C} + \overline{A}\,\overline{B}\,\overline{C}$$ (7)

16.4 Use a Karnaugh map to simplify the expression below:

$$X = A\,\overline{B}\,\overline{C} + A\,\overline{B}\,C + \overline{A}\,\overline{B}\,C + \overline{A}\,\overline{B}\,\overline{C}$$ (7)

16.5 Draw the circuit of a half adder using logic gates. (4)

16.6 Name TWO different states a logic probe can operate in. (2)

16.7 State TWO disadvantages of TTL. (2)

16.8 State TWO disadvantages of CMOS. (2)
[40]

(DIGITAL)

QUESTION 17: POWER SUPPLIES

17.1 Give TWO reasons for using a power supply. (2)

17.2 Refer to FIGURE 17.1 below of the circuit of series-regulated power supply unit and answer the questions that follow.

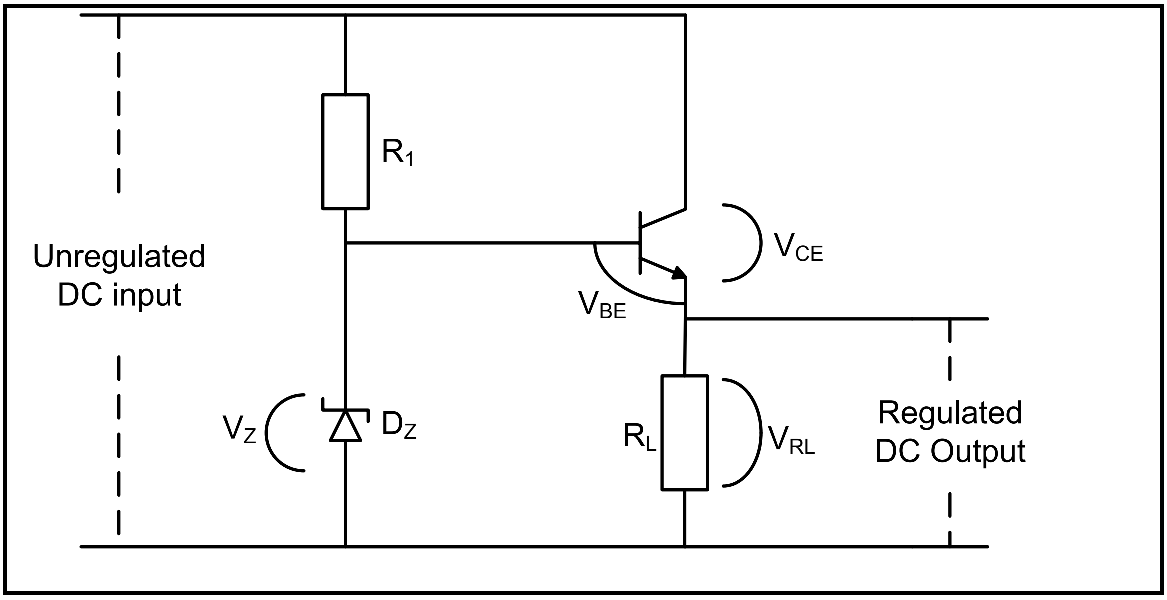

FIGURE 17.1: CIRCUIT OF SERIES-REGULATED POWER SUPPLY UNIT

17.2.1 Explain why the circuit is called a series-regulated power supply unit. (1)

17.6.2 Explain why an increase in the supply voltage does not increase the output voltage. (4)

17.3 State TWO advantages of the linear power supply unit (2)

17.4 State TWO application of a switch mode power supply. (2)
[12]

TOTAL: 200

FORMULA SHEET

Single-phase AC Generation

Magnetic field strength

$$H = \frac{N \times I}{l}\left(A/m\right)$$

Flux density

$$\beta = \frac{\varphi}{A}(\text{Tesla})$$

Pole pairs

$$p = \frac{\text{number of poles}}{2}$$

Area of the coil

$$A = lb\left(m^2\right)$$

Frequency of rotation

$$F = \frac{1}{T}(Hertz)$$

$$f = p \times n$$

Instantaneous value

$$\omega = 2\pi f(\text{radians})$$
$$\theta = \omega\, t(\text{degrees})$$
$$i = I_{max} \times \text{Sin}\theta\,(V)$$
$$v = V_{max} \times \text{Sin}\theta\,(V)$$

Maximum value

$$V_{max} = V_{RMS} \times 1.414\,(V)$$

$$V_{max} = 2\pi\beta AnN(V)$$
$$E = \beta lv(V)$$

RMS value

$$V_{RMS} = V_{max} \times 0.707\,(V)$$

Single-phase Transformer

Power

$$P = VL\text{Cos}\theta(\text{Watt})$$

$$S = VL\,(VA)$$
$$Pr = VL\text{Sin}\theta(\text{Watt})$$

Ration calculation

$$\frac{V_p}{V_S} = \frac{N_P}{N_S} = \frac{I_S}{I_P}$$

$$\eta = \frac{Po}{Pin} \times 100\%$$

RLC circuits

Inductive reactance

$$X_L = 2\pi fL(\Omega)$$

Capacitive reactance

$$X_C = \frac{1}{2\pi fC}(\Omega)$$

Impedance

$$Z = \sqrt{R^2 + (X - X)^2}\,\Omega$$

Power

$$P = VI\,\text{Cos}\theta\,(\text{Watt})$$

Power factor

$$\text{Cos}\theta = \frac{R}{Z}$$

$$\text{Cos}\theta = \frac{V_R}{V_Z}$$

Phase angle

$$\theta = \text{Cos}^{-1}\ \frac{R}{Z}(\text{deg})$$

$$\theta = \text{Cos}^{-1}\ \frac{V_R}{V_Z}(\text{deg})$$

Average value $V_{Average} = V_{max} \times 0.637\,(V)$	Resonance frequency $f_r = \frac{1}{2\pi\sqrt{LC}}(\text{Hertz})$ Q factor $q = \frac{1}{R}\sqrt{\frac{L}{C}}$ $q = \frac{1}{R}\sqrt{\frac{L}{C}}$ $q = \frac{X_C}{R}$
Control devices $I_{op} = I_{max} \times 125\%(\text{Ampere})$	
Power supply $P = V_Z \times I_Z$ $R_S = \frac{V_S - V_Z}{I_Z}$ $I_L = \frac{V_Z}{R_L}$	**Bandwidth** $BW = \frac{f_r}{q}(Hertz)$ $l =$
Amplifiers $I_C = \frac{V_{CC}}{R_C + R_E}$	