basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE

GRADE 12

ELECTRICAL TECHNOLOGY: ELECTRONICS

NOVEMBER 2022

MARKING GUIDELINES

MARKS: 200

These marking guidelines consist of 15 pages.

INSTRUCTIONS TO THE MARKERS

1. All questions with multiple answers imply that any relevant, acceptable answer should be considered.

2. Calculations:

    2.1 All calculations must show the formulae.

    2.2 Substitution of values must be done correctly.

    2.3 All answers MUST contain the correct unit to be considered.

    2.4 Alternative methods must be considered, provided that the correct answer is obtained.

    2.5 Where an incorrect answer could be carried over to the next step, the first answer will be deemed incorrect. However, should the incorrect answer be carried over correctly, the marker has to re-calculate the values, using the incorrect answer from the first calculation. If correctly used, the candidate should receive the full marks for subsequent calculations.

3. This memorandum is only a guide with model answers. Alternative interpretations must be considered and marked on merit. However, this principle should be applied consistently throughout the marking session at ALL marking centres.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

1.1	C ✓	(1)
1.2	B ✓	(1)
1.3	D ✓	(1)
1.4	A ✓	(1)
1.5	C ✓	(1)
1.6	C ✓	(1)
1.7	D ✓	(1)
1.8	C ✓	(1)
1.9	A ✓	(1)
1.10	C ✓	(1)
1.11	D ✓	(1)
1.12	C ✓	(1)
1.13	D ✓	(1)
1.14	C ✓	(1)
1.15	B ✓	(1) **[15]**

QUESTION 2: OCCUPATIONAL HEALTH AND SAFETY

2.1 The employer should be respected ✓
The employer should not be discriminated against. ✓
Your right to fair labour practices.
Your right to work reasonable hours.
Your right to belong to a trade union.
Your right to earn a living wage.
Your right not to be discriminated against. (2)

2.2 Move in an orderly manner. ✓
Follow the evacuation route as displayed in your workshop. ✓
Move to the designated assembly point in a calm and orderly manner. (2)

2.3 Misusing equipment is a dangerous practice which might damage the equipment ✓ and render it unsafe, compromising the safety and or threatens the health of others. ✓ (2)

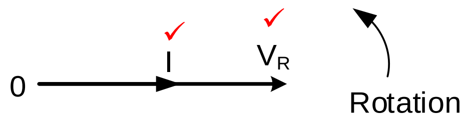
2.4 An employer shall not dismiss an employee ✓ without the correct procedures being followed.
An employer shall not reduce the remuneration of an employee as punishment.
Alter terms of condition of employment to one that is less favourable. ✓
Alter a position relative to other employees employed by that employer to disadvantage them. (2)

2.5 Quantitative risk analysis✓
Qualitative risk analysis✓ (2)
[10]

QUESTION 3: RLC CIRCUITS

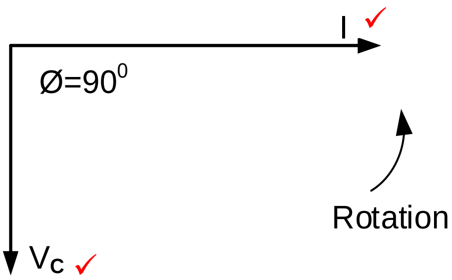
3.1 Inductance is the created back-emf in an inductor that tends to oppose ✓ a changing electric current passing through it. ✓
Inductance is the tendency of a coil to oppose a change in current flowing through it when connected to an AC supply. (2)

3.2 3.2.1



(2)

3.2.2



(2)

3.3 3.3.1
$$Z = \sqrt{R^2 + (X_L - X_C)^2} \quad ✓$$
$$= \sqrt{25^2 + (94-13)^2} \quad ✓$$
$$= 84{,}77\ \Omega \quad ✓$$
(3)

3.3.2
$$\theta = \cos^{-1}\frac{R}{Z} \quad ✓$$
$$= \cos^{-1}\frac{25}{84{,}77} \quad ✓$$
$$= 72{,}85^\circ \quad ✓$$
(3)

3.3.3
$$L = \frac{X_L}{2 \times \pi f} \quad ✓$$
$$= \frac{94}{2 \times \pi \times 60} \quad ✓$$
$$= 0{,}25\ H \quad ✓$$
$$= 250\ mH$$
(3)

3.3.4 A lagging power factor is when the current lags the voltage ✓ in an RLC circuit. (1)

3.3.5 At resonance, the circuit becomes resistive✓ because the capacitive reactance and inductive reactance cancels each ✓ other, resulting with an in-phase relationship between current and voltage. (2)

3.4 3.4.1

$$I_T = \sqrt{I_R^{\ 2} + (I_L - I_C)^2} \checkmark \checkmark$$
$$= \sqrt{11^2 + (9-7)^2}$$
$$= 11{,}18 \text{ A} \checkmark$$

(3)

3.4.2

$$\text{Cos}\,\theta = \frac{I_R}{I_T} \checkmark$$
$$= \frac{11}{11{,}18} \checkmark$$
$$= 0{,}98 \checkmark$$

(3)

3.4.3

$$P = V \times I \times \text{Cos}\theta \checkmark$$
$$= 110 \times 11{,}18 \times 0{,}98 \checkmark$$
$$= 1205{,}20 \text{ W}$$
$$= 1{,}21 \text{ kW} \checkmark$$

(3)

3.4.4 The circuit has a lagging power factor ✓ as the inductive current is greater than the capacitive current. ✓ (2)

3.5 3.5.1 A parallel ✓ RLC ✓ circuit
NOTE:
Because of the error in the prescribed textbook 1 mark will be allocated if the learner indicates that response A = series RLC (2)

3.5.2 The impedance will be maximum✓ and the current will be minimum ✓ (2)

3.5.3 When the frequency increase to resonant frequency the impedance increases. ✓ When the frequency increase above the resonant frequency, the impedance decreases. ✓
NOTE:
The impedance increases with an increase in frequency = 1 mark
The impedance decreases with an increase in frequency = 1 mark (2)
[35]

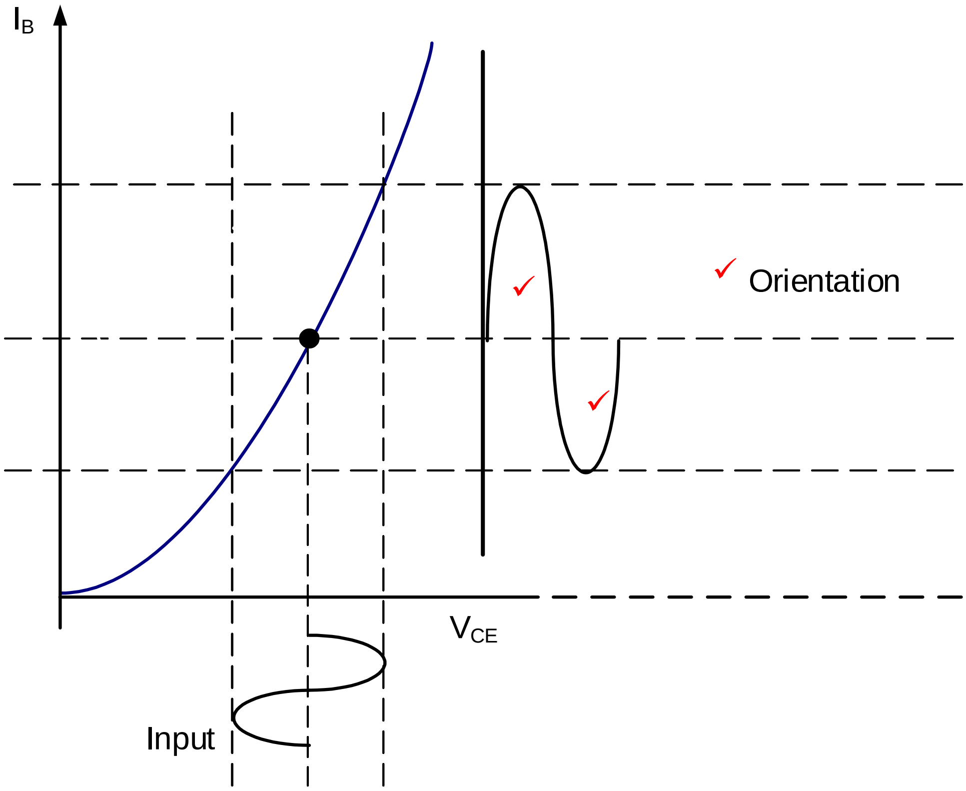
QUESTION 4: SEMICONDUCTOR DEVICES

4.1 4.1.1 N-channel enhancement MOSFET ✓ (1)

4.1.2 When the gate voltage V_{GS} is increased to a sufficient level✓ it will form the internal conduction channel of the MOSFET ✓ between the drain and the source allowing the drain current to flow.✓ (3)

4.2 4.2.1 Input/transfer ✓characteristics of a FET (1)

4.2.2



(3)

4.3 4.3.1
- Used as a triggering device to switch SCRs and TRIACs in power control circuits. ✓
- Used in timing circuits
- Non–sinusoidal oscillators
- Relaxation oscillators
- Saw tooth generators. (1)

4.3.2 When an external voltage is applied across the base terminals, it creates two resistances r_{b1} and r_{b2} ✓ which forms a potential divider within the bar ✓ to set the critical voltage (V_X) at the emitter PN- junction.

OR

(The two internal resistances form a potential divider circuit which sets a voltage V_X at the point where P- doped emitter region is positioned.) (2)

4.3.3 When the UJT is triggered "ON", current flows into the lower base region. As its resistance falls✓, the current through the bar rises✓, at the same time the potential ✓on the emitter (V_E) decreases. (3)

4.4 4.4.1 UJT as saw tooth generator✓. (1)

4.4.2
- When DC power is applied, the capacitor C charges exponentially through R_1 until it reaches the peak-point voltage (V_P) ✓
- At the peak point voltage, the pn-junction becomes forward biased✓ and the emitter characteristics goes into the negative region✓ (V_E decreases and I_E increases).
- When the UJT is driven into its cut-off mode, the capacitor discharges through the forward–biased junction E_{B1} and R_3. ✓

OR

When the supply voltage is connected to the circuit, the capacitor starts charging through resistance R, which controls the UJT performance. When the voltage across the capacitor rises to reach the UJT's peak voltage (V_P), the UJT fires on moving into negative resistance region. The resistive value of the lower bar (B_1) decreases allowing the capacitor to discharge through R_3. (4)

4.5 4.5.1 It is used as a switch.✓ (1)

4.5.2 The fly-wheel diode protects the Darlington transistor against damage from the back emf induced in the coil.✓ (1)

4.5.3 When the supply is connected as in the circuit diagram, together with an additional input voltage of 1,4 V the Darlington transistor will be forward biased✓, causing the collector current to flow✓ and the relay coil will be energised✓, causing the normally open contact (N/O) to close. (3)

4.6 4.6.1 0 V.✓
If a learner refers to '*virtual ground*' it will be accepted. (1)

4.6.2

$$A_V = -\frac{R_F}{R_{IN}} \quad ✓$$

$$= -\frac{1400}{1000} \quad ✓$$

$$= -1{,}4 \quad ✓$$

(3)

4.6.3 The output signal will have a 180º phase shift. ✓
The output signal will be inverted. (1)

4.7 4.7.1 Along DA ✓and BE✓ of the graph FIGURE B (2)

4.7.2

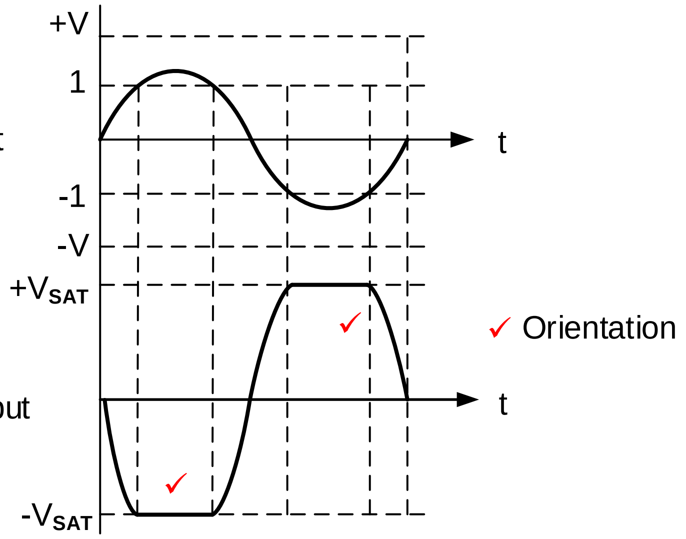
$$A_V = \frac{V_{OUT}}{V_{IN}} = \frac{AC}{OC} \quad ✓$$

$$= \frac{+13}{-1} \quad ✓$$

$$= -13 \quad ✓$$

(3)

4.7.3



(3)

4.7.4 Negative feedback will be reduced. ✓
The gain of the amplifier will be increased ✓ resulting in the increase of the output voltage. ✓ (3)

4.8 4.8.1 Pin 7 provides the discharge path for the timing capacitor and timing resistor. ✓
Pin 7 provides a discharge path to ground. (1)

4.8.2 When the voltage at Pin 2 falls below 1/3 ✓ of the supply voltage, ✓ it pulls Pin 2 to ground✓, the output goes high, ✓thereby activating the 555 circuit. (4)

[45]

QUESTION 5: SWITCHING CIRCUITS

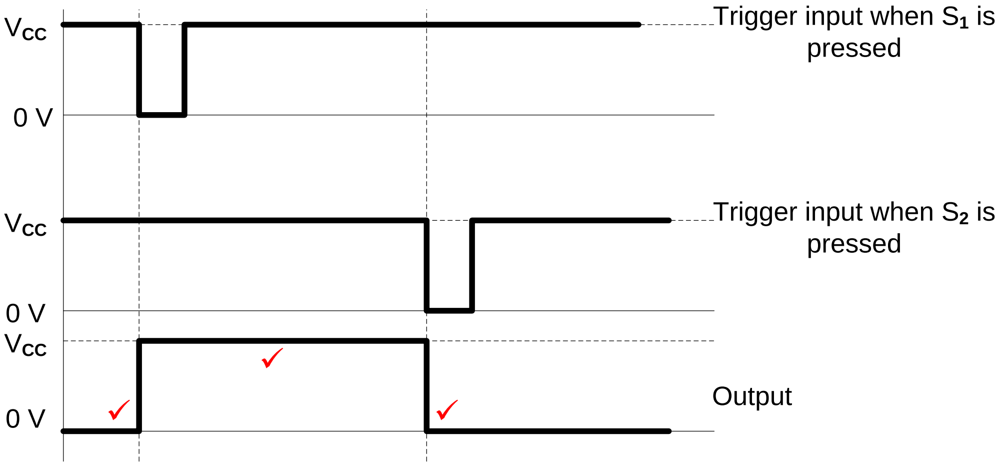
5.1 The output of a monostable multivibrator has only one stable state. ✓
The output of an astable multivibrator will toggle between high and low states continuously. ✓
The output of an astable multivibrator has no stable state. (2)

5.2 5.2.1 The bistable multivibrator is used in automated applications. ✓
(where a device is required to run continuously back and forth on the same path)
Counting circuits.
Storing circuits.
Frequency divider circuits.
Latches. (1)

5.2.2 To prevent the IC from resetting. ✓ When a positive pulse (trigger pulse 1) is applied to the Trigger input, the output will change to low (0 V) ✓ and remain there until a low pulse (trigger pulse 2) is applied. ✓ (3)

5.2.3 Without pull-up resistor R_2 connected to the supply, the voltage on pin 2 will continuously vary ✓ between $\frac{1}{3}V_{CC}$ and 0 V.✓(floating) (2)

5.2.4



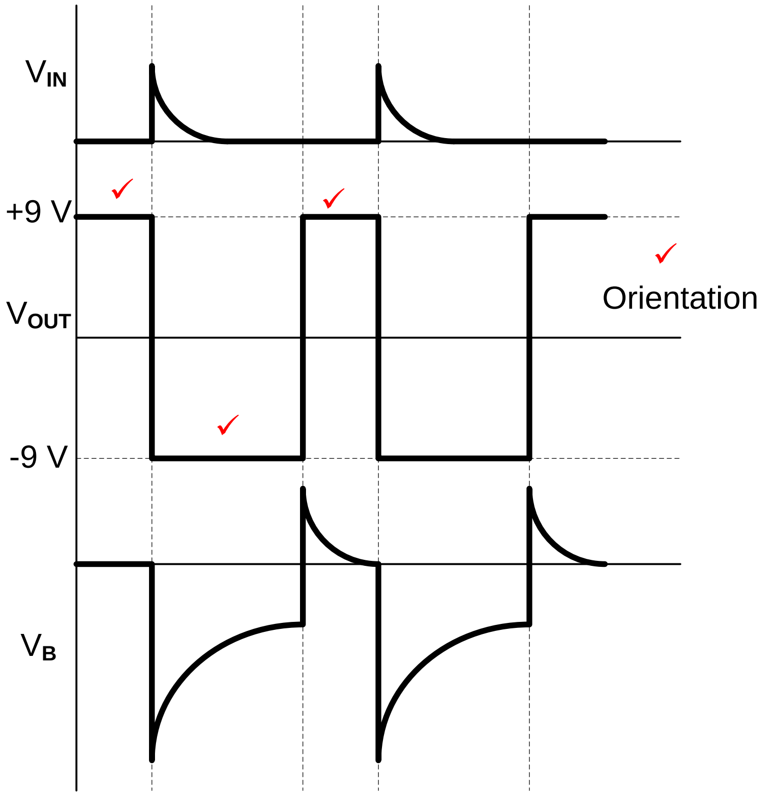
NOTE:
An inverted output waveform will lose 1 mark for orientation and be awarded 2 marks for the correct trigger points. (3)

5.3 5.3.1 C_2 and R_3 sets the time period ✓ that the circuit will remain in its changed state. ✓ (2)

5.3.2 0 V ✓ (1)

5.3.3 The moment a positive pulse is applied to the inverting input, the output changes from positive saturation (9 V) ✓ to negative saturation (-9 V) ✓ for the duration of the RC time constant. ✓ (3)

5.3.4



NOTE:
An exact inverted output waveform will lose 1 mark for orientation and be awarded 3 marks. (4)

5.4 5.4.1 Positive ✓ (1)

5.4.2 The output changes from +9 V to –9 V the moment V_A (inverting voltage) becomes higher than V_B. (non-inverting voltage) ✓ (1)

5.4.3 An increase in the value of R_F will increase the RC time constant ✓ on the input of the Op-amp, because the capacitor takes longer to charge up to the voltage V_B, ✓ it results in a decrease in frequency on the output. ✓ (3)

5.5 5.5.1 +9 V and -9 V ✓ (1)

5.5.2 R_F and R_1 used to determine the trigger voltage level ✓ on the non-inverting input. ✓
If a candidates mention that R_F and R_1 is a voltage divider 1 mark is allocated. (2)

5.5.3 The output changes from high to low when the input voltage (V_{in}) is higher ✓ than the upper trigger voltage (V_X). ✓ (2)

5.6
- The Op-amp compares the voltages appearing on its two input terminals. ✓
- When the input voltage on the inverting input is lower than the reference voltage ✓
- the Op-amp is driven to positive saturation. ✓
- As soon as the input on the inverting terminal is higher than the reference voltage,
- the Op-amp is driven into negative saturation. (3)

5.7 5.7.1 Inverting summing amplifier. ✓ (1)

5.7.2 The gain of the amplifier is -1, ✓ because R_1=R_2=R_3=R_F ✓ (2)

5.7.3
$$\begin{aligned} V_{OUT} &= -(V_1 + V_2 + V_3) \checkmark \\ &= -(0{,}9 + 1{,}2 + 2{,}1) \checkmark \\ &= -\,4{,}2\ V \checkmark \end{aligned}$$
(3)

$$\begin{aligned} V_{OUT} &= -\left(V_1 \times \frac{R_F}{R_1} + V_2 \times \frac{R_F}{R_2} + V_3 \times \frac{R_F}{R_3}\right) \\ &= -\left(0{,}9 \times \frac{22 \times 10^3}{22 \times 10^3} + 1{,}2 \times \frac{22 \times 10^3}{22 \times 10^3} + 2{,}1 \times \frac{22 \times 10^3}{22 \times 10^3}\right) \\ &= -4{,}2\ V \end{aligned}$$

5.7.4 An increase in the value of the feedback resistor will cause negative feedback to decrease ✓ which will result in an increase in gain.✓
Gain will increase, therefore output voltage will also increase. (2)

5.8 5.8.1 How long the input voltage has been present. ✓
The value of the input voltage. ✓
The frequency
Value of the resistor and capacitor
The RC-time constant
The value of the supply voltage (2)

5.8.2 Both inputs to the Op-amp are kept at 0 V ✓ according to Ohm's law when a constant positive voltage is applied across the input resistor it causes a constant fixed current to flow, ✓ which is fed via the virtual ground point to the capacitor, ✓ this means that the voltage on its right-hand plate will decrease at a fixed linear rate towards -V. ✓ (4)

5.8.3 When the RC time constant is long, the capacitor will charge slowly✓ causing the slope of the output to decrease. ✓ The output will change direction before reaching saturation. (2)
[50]

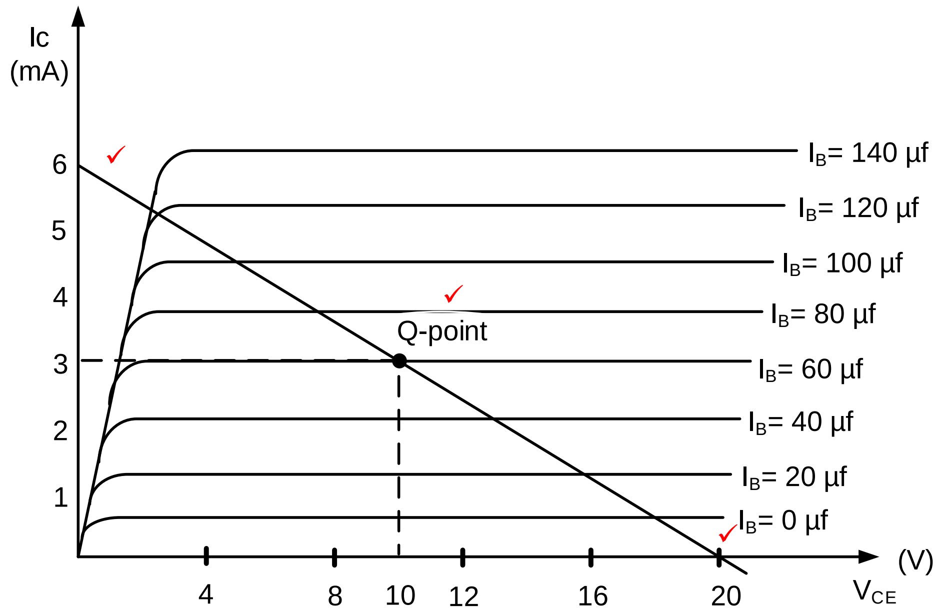
QUESTION 6: AMPLIFIERS

6.1 Small signal amplifiers/Audio amplifier.✓
Power amplifier/Large signal amplifiers.✓ (2)

6.2 6.2.1 20 V.✓ (1)

6.2.2
$$I_C = \frac{V_{CC}}{R_C} \quad ✓$$
$$= \frac{20}{3{,}3 \times 10^3} \quad ✓$$
$$= 0{,}006$$
$$= 6\,mA \quad ✓$$
(3)

6.2.3



(2)

6.2.4 Indicated on ANSWER SHEET 6.2.3 (1)

6.2.5 3 mA ✓ (1)

6.3 6.3.1 Resistors R_1 and R_2 are voltage dividers ✓ which set the voltage across the base emitter junction ✓ (V_{BE}) to 0,7 V to bias Q_1. (2)

6.3.2 The values of the coupling capacitors are made large to be able to handle the wide range of frequencies. ✓ (1)

6.3.3 Stabilization ✓ and to prevent thermal runaway ✓ (2)

6.3.4 RC coupling enables each stage to individually maintain its own DC biasing level ✓ without interference (loading) from any of its neighbouring stages. ✓
RC coupling enables each stage to operate completely independently blocking all DC interference between stages. (2)

6.4 6.4.1
- It used in circuits requiring large current outputs. ✓
- Where two-phase split outputs are required.
- Used between Radio frequencies amplifier stages.
- In impedance matching. (1)

6.4.2
- Excellent impedance matching can be achieved. ✓
- Total DC isolation between stages.✓
- It is more efficient than RC coupling. (2)

6.4.3 AC Relay ✓
AC Motor ✓
NOTE:
Because it is given in the textbook the following will be accepted:
Relay
Motor (2)

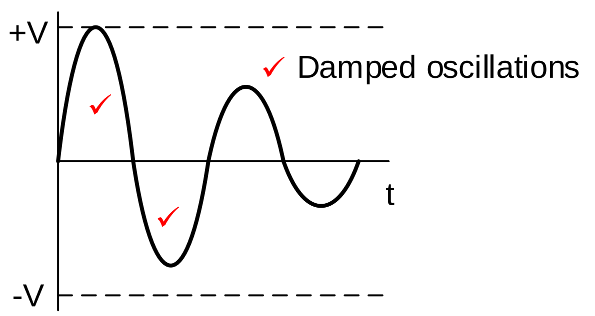
6.5 6.5.1
- Provides an AC path to ground ✓ thereby avoiding any signal degeneration. (1)

6.5.2 The amplifier selects the required signal frequency ✓ and gives a degree of amplification ✓ to pass on to the mixer stage. (2)

6.5.3 To enable the Radio-frequency amplifier to be tuned ✓ to a range of frequencies. ✓ (2)

6.6 6.6.1 When the switch is moved to position 2 - the capacitor will discharge its electrostatic charges through the inductor, ✓ which will then store this charge as an electro-magnetic field.✓ (2)

6.6.2



(3)

6.6.3 The frequency of oscillations can be increased by decreasing the value of L or C, ✓ (1)

6.7 6.7.1
- It is used to produce a sine waveform of the desired frequency. ✓
- It is used as a local oscillator in Radio receivers.
- Used as Radio frequency oscillator. (1)

6.7.2 C_1 and C_2 allow only radio frequency to pass ✓ from the amplifier to the tank circuit and back, ✓ while blocking any DC current from passing. (2)

	6.7.3	Oscillation is maintained by positive feedback fed back from the collector to the tank circuit. ✓ The signal is then fed back to the base maintaining oscillation✓	(2)
6.8	6.8.1	Q_1 creates a 180° phase shift ✓ to ensure that the overall phase shift is 0°. Q_1 amplifies the oscillating signal to a gain of 1.	(1)
	6.8.2	To adjust the frequency of the phase-shift oscillator, the three feedback capacitors ✓ can be operated as a single ganged component so that all the capacitor values are adjusted simultaneously. ✓	(2)
	6.8.3	Oscillator circuits use positive feedback✓ and transistors amplifier circuits use negative feedback✓.	(2)
6.9	RC oscillators generate low frequency signals✓ LC oscillators generate high frequency signals✓.		(2) **[45]**

TOTAL: 200