Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more Importance (Not applicable for subject English and Communication Skills).
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.
7) For programming language papers, credit may be given to any other program based on equivalent concept.

Q. 1) attempt any TEN of the following : **20M**

a) Draw the symbol of resistor and inductor.

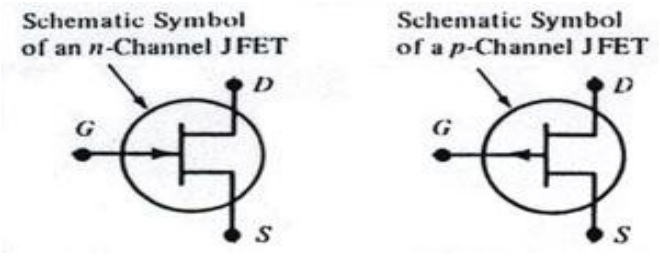
Ans:-

Resistor **1M**

Inductor **1M**

b) Draw the symbol of JFET n-channel and P-channel.

Ans:- **1M for each diagram**



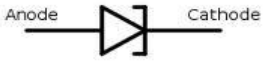
c) Draw the symbol of

i) Varacter Diode ii) Tunnel Diode

Ans:-

Varactor diode: **1M**

Tunnel diode: **1M**



d) State the need of multistage amplifiers.

Ans:-

Need of multistage amplifiers: **2M**

The output from single stage amplifier is usually insufficient to drive an O/P device. The gain of a single stage amplifier is inadequate for practical purposes. Consequently additional amplification over two or more stages is necessary.

e) State the value of knee voltage for silicon & germanium diode.

Ans:- The value of knee voltage:

Silicon: - 0.7 V or 0.6V **1M**

Germanium: - 0.3 V or 0.2V **1M**

f) Give two advantages and two disadvantages of ICs.

Ans:- Advantages: any two **½ M each**

1) Small size, weight is less.
2) It has very low power consumption.
3) It has very high operating speed.
4) It has extremely high reliability.
5) It is very cheap.
6) Easy replacement.
7) Higher yield.

Disadvantages: (any two) **½ M each**

1) Coil or inductor cannot be fabricated.
2) IC's function at fairly low voltages.
3) They handled limited amount of power.
4) Quite delicate and cannot withstand rough handling or excessive heat.

g) State the need of filter circuit.

Ans:- Need of the filter circuit. **2M**

The output of a rectifier contains ac and dc components if such a dc is applied in an electronic circuit, it will produce a hum (audible noise) and therefor to keep the ac components away from the load filter circuits are used, which removes the ac components and allows only dc components to reach the load.

h) Define transconductance and amplification factor for FET.

Ans:- Transconductance: **1M**

It is the ratio of small change in drain current (ΔI_D) to the corresponding change in gate to source voltage (ΔV_{GS}) FOR a constant drain to source voltage (ΔV_{DS}).

Or

$g_m = \Delta I_D / \Delta V_{GS}$

Amplification factor: **1M**

It is the ratio of change in drain to source voltage (ΔV_{DS}) to the corresponding change in gate to source voltage (ΔV_{GS}) for a constant drain current (I_D).

Or

Amplification factor $= \Delta V_{DS} / \Delta V_{GS}$

Or

It is also expressed as product of transconductance (g_m) and ac drain resistance (r_d).

Or

Amplification factor = transconductance (g_m) * ac drain resistance (r_d).

i) Draw the symbol of Schottky diode and state its applications.

Ans:- Symbol: **1M**

Applications: (any two) **½ mark each**

1) To rectify very high frequency signals.
2) As a switching device in digital computers.

3) In clipping & and clamping circuits.

4) In low power schottky TTL circuits.

5) In mixing and detecting circuits used in communication systems.

6) In low voltage power supply circuits.

J) Give the classification of ICs.

Ans:- Classification of IC's:

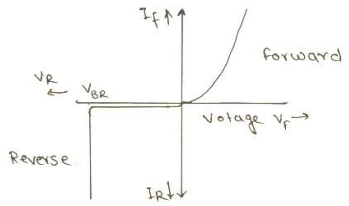
Based on function

1) Analog or linear **1M**

2) Digital or non-linear **1M**

k) Draw the characteristic of ideal P-N junction diode.

Ans:- Characteristics of PN junction diode:- **2M**



l) State the SI unit of Resistor.

Ans:- SI unit of resistor is ohm (Ω) . **2M**

Q 2) Attempt any four **16M**

a) Explain the resistor colour coding with neat diagram

Ans:- resistor colour coding:

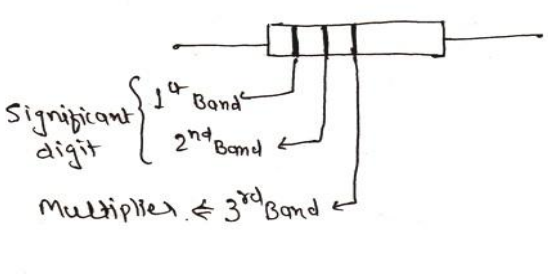
Note: 2 marks for explanation and 2 for example.

Resistors are designated by a colour code system. There are three common systems.

- Three band system
- Four band system
- Five band system

Three band system:

In this first two bands represent the significant figures, the third band is multiplier. And tolerance is ± 20%.



Ex.

Green	Blue	Orange
5	6	3

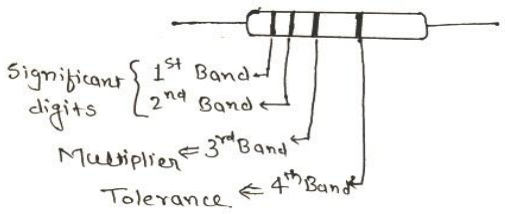
$56*10^3$ ± 20%.

56kΩ ± 20%.

Or

Four band system:

In this first two bands represent the significant figures, the third band is multiplier And fourth band represents the tolerance band.



Ex.

Brown	Green	Brown	Gold
1	5	1	± 5%

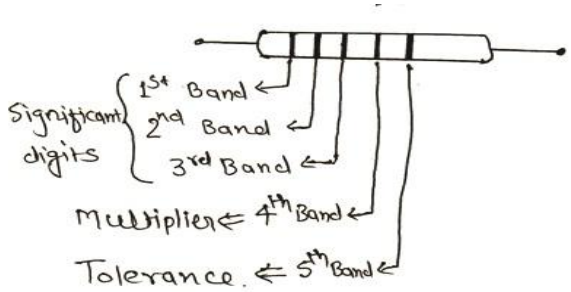
$15*10^1 \pm 5\%$.

$150\Omega \pm 5\%$.

Or

Five band system:

In this first three bands represent the significant figures, the fourth band is multiplier and fifth band represents the tolerance band.



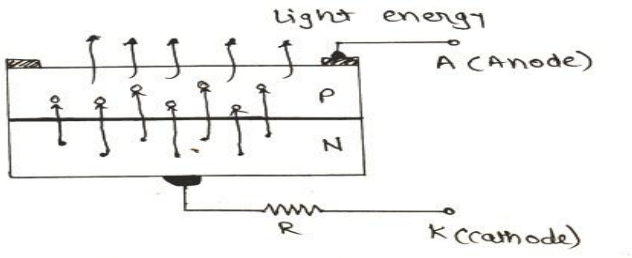
Brown	Black	Black	Brown	Brown
1	0	0	1	± 1%

$100*10^1 \pm 1\%$.

$1k\Omega \pm 1\%$.

b) Explain the operating principle of light emitting diode with neat diagram.

Ans:- Diagram: **2M**

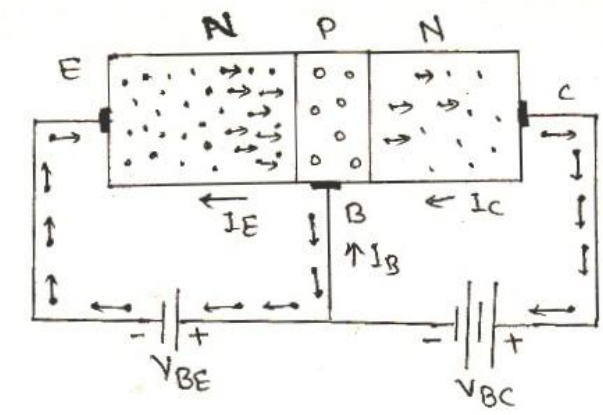


Working principle: **2M**

Above figure shows the basic structure of LED. When the LED is forward biased the electrons and holes move towards the junction and the recombination takes place. After recombination, the electron lying in the conduction band of N-region falls in to the holes lying in the valence band of P-region. The difference of energy between the conduction band and the valance band is radiated in the form of light energy.

c) Draw the neat diagram of NPN transistor and describe its working.

Ans:- Diagram: **2M**



Working: **2M**

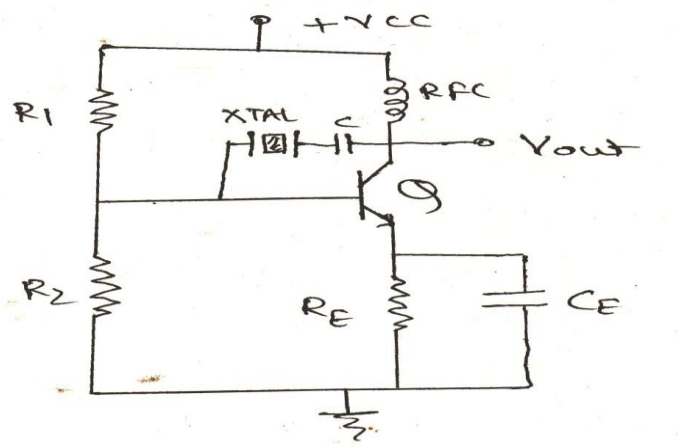
- Above fig shows NPN transistor with forward biased emitter-base junction and reverse biased collector-base junction.

- The forward bias causes the electrons in the N-type emitter to flow towards the base. This constitutes the emitter current I_E.
- As these electrons flow through the P-type they tend to combined with holes. As the base is likely doped and very thin therefor only a few electrons (2%) combine with holes to constitute base current I_B.
- The reminder electrons (98%) cross over in to the collector region to constitute collector current I_C.
- In this way almost the entire emitter current flows in the collector circuit. It is clear that emitter current is sum of collector and base current.

$$I_E = I_B + I_C$$

d) Draw the circuit diagram of crystal oscillator and describe its working.

Ans:- Circuit diagram: **2M**



Working:- **2M**

Above fig shows the transistor pierce crystal oscillator. In this circuit, the crystal is connected as a series element in the feedback path from collector to the base.

The resistors R_1, R_2 and R_E provide voltage divider stabilized d.c. bias circuit. The capacitor C_E provides a. c. bypass of emitter resistor and RFC coil provides for d. c. bias. The coupling capacitor C has negligible impedance at the circuit operating frequency.

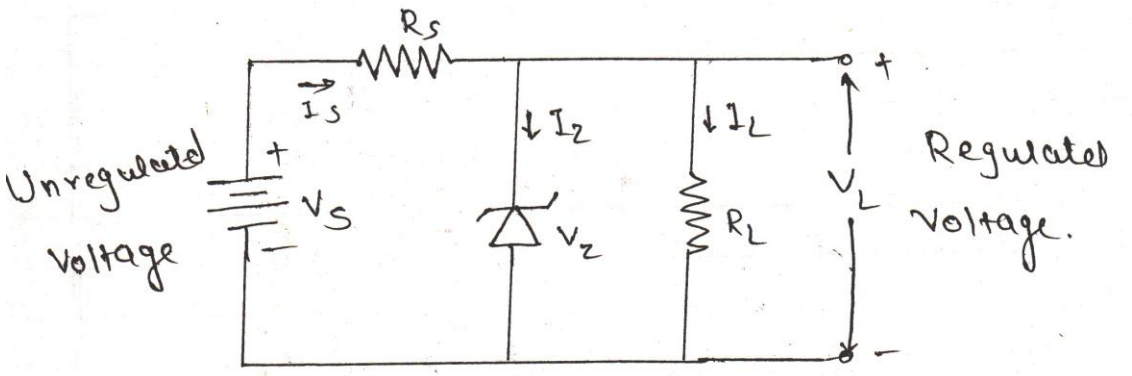
The circuit frequency of oscillation is set by the series resonant frequency of the crystal and its value is given by the relation

$F_0 = 1/2\pi\sqrt{LC_1}$

It may be noted that the changes in supply voltage, transistor device parameters etc have no effect on the circuit operating frequency, which is held stabilized by the crystal.

e) Draw the circuit diagram of zener diode voltage regulator and describe its working.

Ans:- Circuit diagram:- **2M**



Working:-

<u>Regulation with varying input voltage</u>:- **1M**

Here the load current is kept constant and the input voltage varies within limit.

As the input voltage increases, the input current I_S also increases. This increases current through zener diode without affecting the load current I_L. The increase in input current will also increase the voltage drop across series resistor R_S , thereby keeping load voltage as constant.

As the input voltage decreases, the input current I_S also decreases. This decreases current through zener diode consequently the voltage drop across series resistor R_S will be reduced. Thus the load voltage and load current remains constant.

<u>Regulation with varying Load current</u>:- **1M**

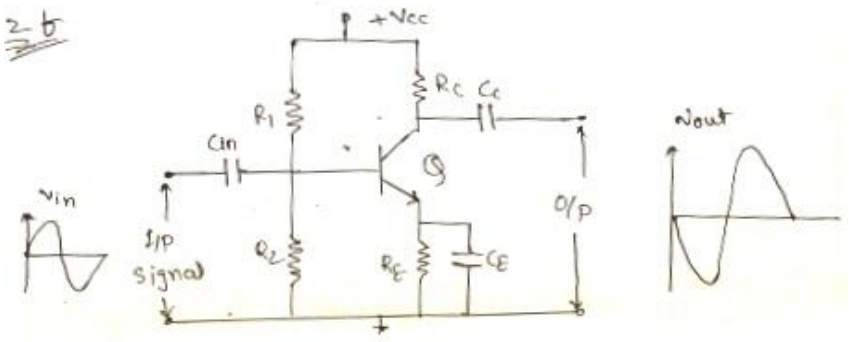
Here the input voltage is kept fixed and the load current varies.

When the load current increases, this causes I_Z to decrease as a result of this, the input current and voltage drop across R_S remains constant. Thus the V_L is also kept constant.

When load current decreases, as a result of this I_Z increases. This again keeps the value of I_S and the voltage drops across R_S as constant. Thus the load voltage remains constant.

f) With neat diagram explain the working of single stage CE amplifier.

Ans:- circuit diagram : **2M**



Working: **2M**

Above figure shows a single stage CE amplifier. A transistor can accomplish faithful amplification only if proper associated circuitry is used with it.

Biasing circuit:- resistor R_1, R_2 and R_E are used for biasing in the active region.

Input capacitor Cin:- It is used to couple the input signal to the base of the transistor. This capacitor allows only AC signal to flow and blocks DC signal to reach to the base.

Emitter bypass capacitor C_E :- It is used in parallel with R_E to provide a low reactance path to the amplified ac signal.

Output coupling capacitor: it is used to couple one stage of amplification to the next stage.

When the signal voltage increases in the positive half cycle, the base current also increases, this increases the collector current and hence voltage drops $i_C R_C$ increases. As V_{CC} is constant, output voltage V_{CE} decreases. As the signal voltage is increasing in the positive half cycle, the output voltage is increasing in the negative sense i.e. output is 180^0 out of phase with the input. The positive half cycle of the signal appears as amplified negative half cycle in the output and vice-versa.

Q3. Attempt any FOUR: 16M

a) Give the classification of inductor. State its unit & define inductance.

Ans:- (1 mark for definition, 1 mark for unit, 2 marks for classification)

Inductance: It is the property of a coil, which opposes changes in current by means of energy storage in the form of magnetic field.

The unit of Inductance in Henry (H)

Types of Inductors:

1. Fixed Inductors:

They are further classified into

Air core inductor:

Iron core Inductor:

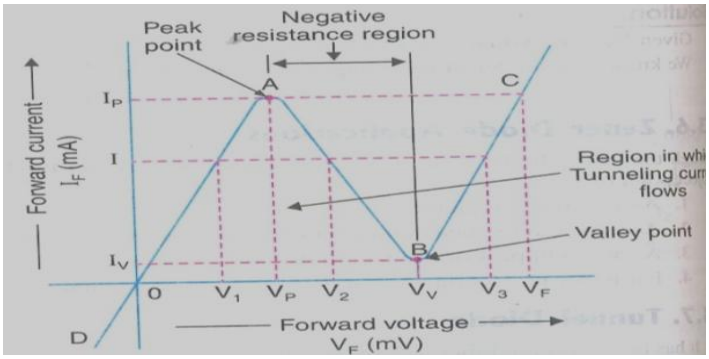
Ferrite core inductor:

2. Variable inductors: In this type of inductor, the core is adjustable and hence the value of inductor can be changed.

b) Explain the VI (IV) characteristics of tunnel diode.

Ans:- characteristics: 1 M

VI characteristics of Tunnel Diode



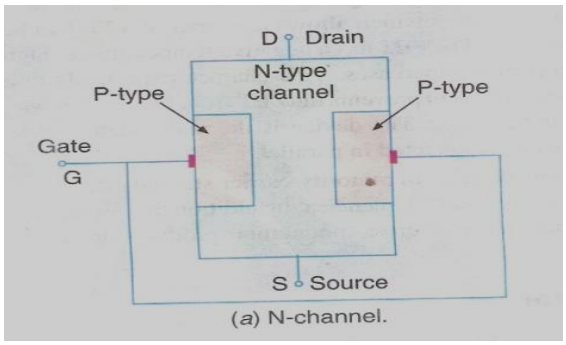
Explanation: **3M**

- As the applied forward voltage is increased from zero, the current increases very rapidly, till it reaches a maximum value known as peak current Ip, indicated by point A. the corresponding value of peak voltage is Vp.
- If the forward voltage is increased further, the current decreases till it reaches its minimum value known as valley current indicated by point B
- As voltage is further increased, in the usual manner as normal PN junction diode. Current again reaches its peak value at point C. The corresponding value of voltage is indicated by V_F.

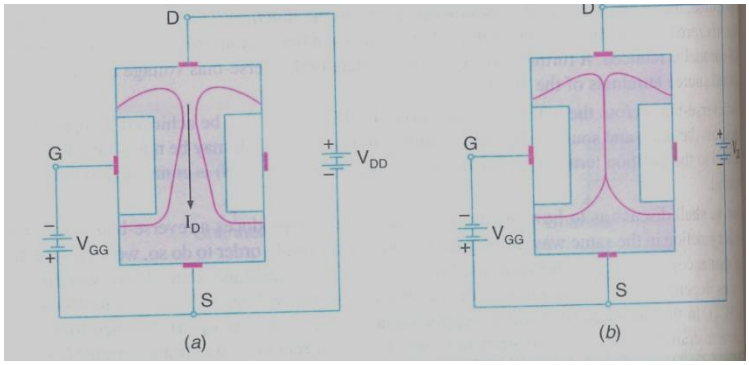
c) Draw the construction of N channels JFET & describe its working.

Ans:- Diagram: **1M**

Construction of N channel JFET



Working of JFET: For any one diagram of working **1M**



Working: **2M**

- In JFET the gate to source junction is reverse biased. The applied V_{GG} forms a depletion region within the channel.
- When voltage is applied between drain to source V_{DD}, the electrons flow from drain to source through the narrow channel existing between the depletion regions.

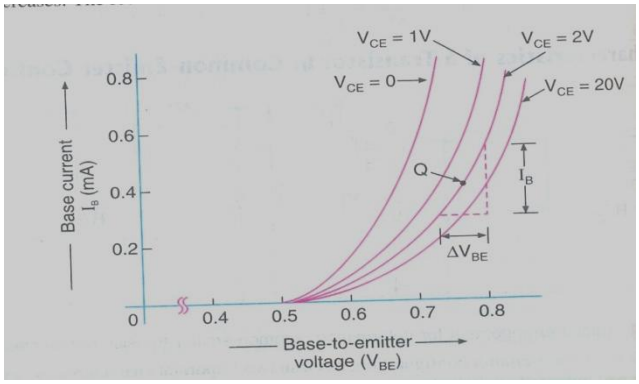
- Thus the width of the channel is reduced.
- When the gate to source voltage is increased further, a stage is reached when the two depletion regions touch each other, the channel is completely blocked and the drain current becomes zero.

d) Draw the input and output characteristics of CE configuration & label them.

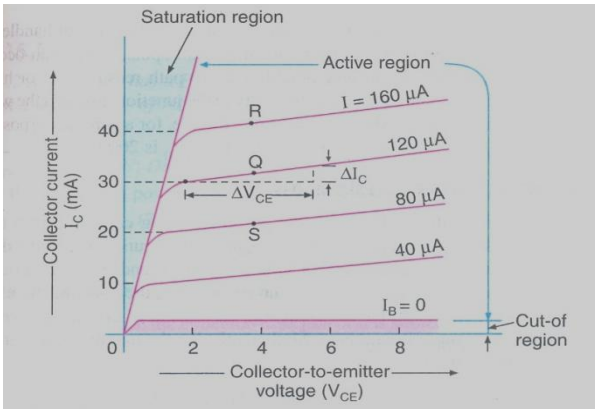
Ans: - for each characteristics **2M**

for labels **2M**

Input characteristics of CE configuration

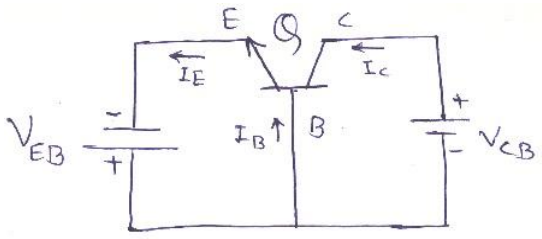


Output characteristics of CE configuration

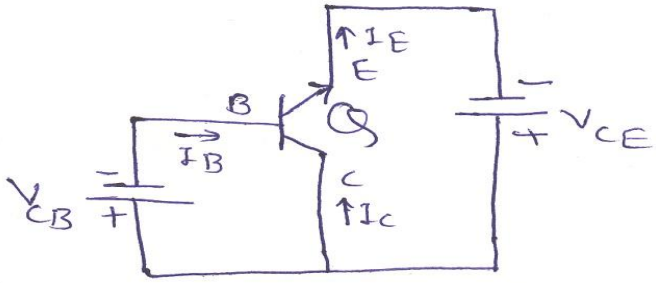


e) Draw neat diagram of CB and CC configuration of BJT.

Ans:- CB configuration: **2M**

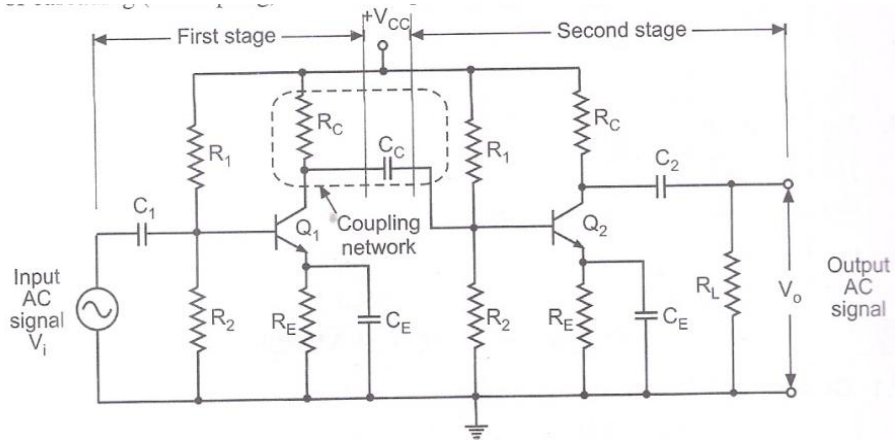


CC configuration: **2M**



f) Draw the circuit diagram of two stage RC coupled amplifier & describe its working.

Ans:- diagram: **2M**



Working: **2M**

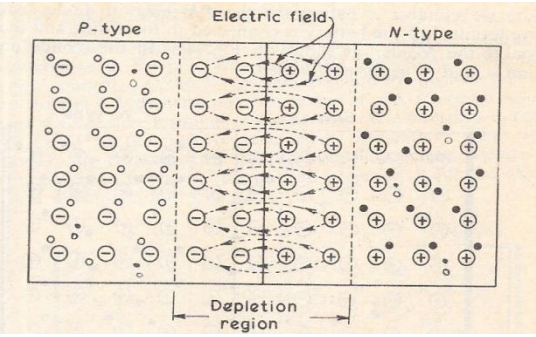
- When an AC signal is applied as input to the first stage, then it is amplified by the transistor Q1 and the output appears across the collector resistor R_C
- This signal is given as input to the second stage through coupling capacitor C_C.
- The second stage does the further amplification.
- The final output is obtained across R_L.

Q4) attempt any FOUR: **16M**

a) With neat diagram explain the concept of hole, majority & minority charge carriers in PN junction.

Ans:- ***Note: Any other suitable diagram showing holes, majority and minority carriers may also be considered***

Diagram: **1M**



Concept of hole, majority carriers, minority carriers: **1M each**

Concept of hole: When a trivalent impurity is added to a semiconductor crystal, the three valence electrons form three covalent bonds with electrons from three neighboring semiconductor atoms. The fourth bond remains incomplete and a vacancy which exists in the incomplete covalent bond constitutes a hole.

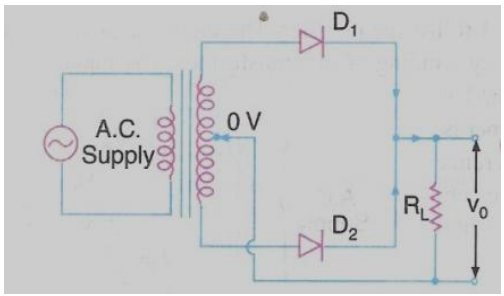
Majority Carriers and minority carriers: When an extrinsic semiconductor is formed, the added impurity gives a charge carrier to the semiconductor. Also there are thermally generated charge carriers in the semiconductor. The net concentration of charge carriers decides the majority and minority carriers. For e.g. in N type semiconductor electrons are the majority carriers and holes are the minority carriers. In P type semiconductor holes are the majority carriers and electrons are the minority carriers.

b) Draw the circuit diagram of single phase full wave rectifier with center tapped transformer. For the resistive load sketch the input & output voltage waveforms and describe the working.

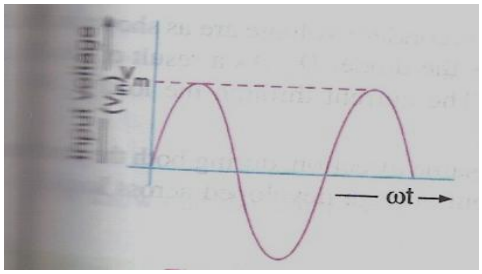
Ans:- ***Note: Any other suitable circuit diagram may also be considered***

Circuit diagram: **1M**

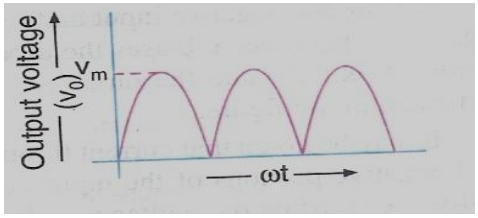
Single phase full wave rectifier with center tapped transformer



Input waveform: **½ M**



Output Waveform: **½ M**



Working: **2M**

- During the positive input half cycle, the upper half of the secondary is positive. This forward biases the diode D1 and reverses biases D2. Hence D1 conducts and D2 is OFF. Hence current flows through the load resistance as shown in output waveform.
- During the negative input half cycle, the lower half of the secondary is positive. This forward biases the diode D2 and reverse biases D2. Hence D2 conducts and D1 is OFF. Hence current flows through the load resistance as shown in output waveform.
- The current through the load flows in the same direction, during both positive and negative half cycles of the input voltage.

c) Distinguish between BJT & FET (Four points).

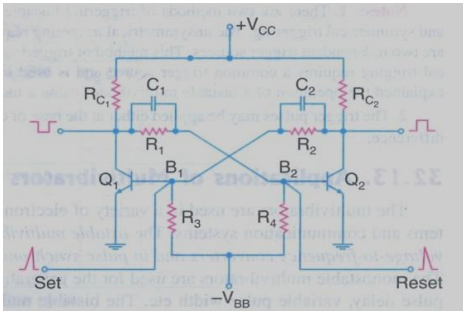
Ans:- Any four points: **1M for each**

Note: Any other suitable differences may also be considered.

Sr. no.	FET	BJT
1.	It is unipolar device i.e. current in the device is carried by either electrons or holes.	It is bipolar device i.e. current in the device is carried by electrons and holes.
2.	It is voltage controlled device i.e. voltage at the gate terminal controls the amount of current flowing through the device.	It is current controlled device i.e. base current controls the collector current.
3.	Input resistance is very high, of the order of several MΩ	Input resistance is low, of the order of several KΩ
4.	It has negative temperature coefficient of resistance at high current levels i.e. current decreases as the temperature increases.	It has positive temperature coefficient of resistance at high current levels i.e. current increases as the temperature increases.
5.	It does not suffer from minority carrier storage effects and therefore has higher switching speeds and cut-off frequency.	It suffers from minority carrier storage effects and therefore has lower switching speeds and cut-off frequency.
6.	It is less noisy.	It is more noisy as compared to FET.
7.	It is much simpler to fabricate as an IC and occupies less space on the IC chip.	It is complicated to fabricate as an IC and occupies more space on the IC chip.
8.	Thermal break down cannot occur.	Thermal break down can occur.

d) Explain the working of bistable multivibrator using transistor using ckt diagram.

Ans:- Circuit diagram: **2M**



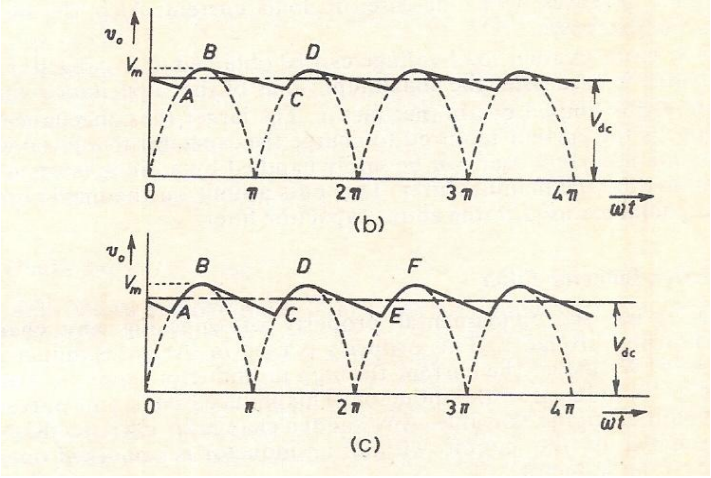
Working: **2M**

- When V_{CC} is switched on, one of the transistors will start conducting more than the other. Because of the feedback action, the ON transistor will be driven into saturation and the other transistor will be driven to cut-off. Suppose Q_1 is in saturation and Q_2 is cut-off.
- This is stable state of the circuit and the circuit will remain in this state till a trigger pulse is applied from outside.
- When a positive pulse is applied at the reset input, Q_2 will start conducting. As the collector voltage of Q_2 falls, it cuts off transistor Q_1.
- Thus the circuit switches to the other stable state.

e) Explain the working of C filter with input – output wave forms.

Ans:- ***Note: Working of C filter with half wave rectifier output may also be considered.***

Waveforms: **2M**



Working: **2M**

- When the rectifier output is increasing, the capacitor charges to the peak voltage, i.e. point B in the waveforms. As the rectifier output falls, the diode is now reverse biased and the capacitor now discharges through the load resistance from B to C.
- When the source voltage becomes more than the capacitor voltage, the capacitor quickly charges to the peak voltage from C to D.
- Thus the voltage across load resistance remains nearly constant.

f) State the need of oscillator and state its applications.

Ans:- Need: **2M**

- Any circuit that generates an alternating voltage is called an oscillator. To generate ac voltage, it takes energy from the dc source.
- In some applications voltages of low frequency are required where as in other application voltages of higher frequency are required.
- In industry, it is frequently necessary to heat different kind of materials.
- Oscillators are also needed in testing labrotaries.

Applications: any four **2M**

- Oscillators are used for providing the carrier frequency to modulator circuits.
- Oscillators can be used for frequency generation in electronics circuits.
- Oscillators are used in radios.
- Oscillators are used in TV transmitters.
- Oscillators are used to generate clock signals that regulate computers.
- Oscillators are used to generate clock signals in quartz clocks.

Q.5) attempt any FOUR: **16M**

a) Define (in words):

i) Reverse saturation current

ii) Knee voltage

iii) Depletion layer

iv) static resistance of diode

Ans:-

i) Reverse saturation current : **1M**

The current produced due to minority carriers generated by thermal energy is known as reverse saturation current. (Io)

ii) Knee voltage : **1M**

The applied forward voltage, at which the PN junction starts conducting is called knee voltage.

iii) Depletion layer : **1M**

The region containing the uncompensated acceptor and donor ions in the vicinity of the junction is called depletion layer.

iv) Static resistance of diode : **1M**

The DC resistance offered by the PN junction diode due to the forward bias is called static forward resistance.

b) Explain the working of bridge full wave rectifier with neat circuit diagram and input and output waveforms.

Ans:- **Diagram:** **1M**

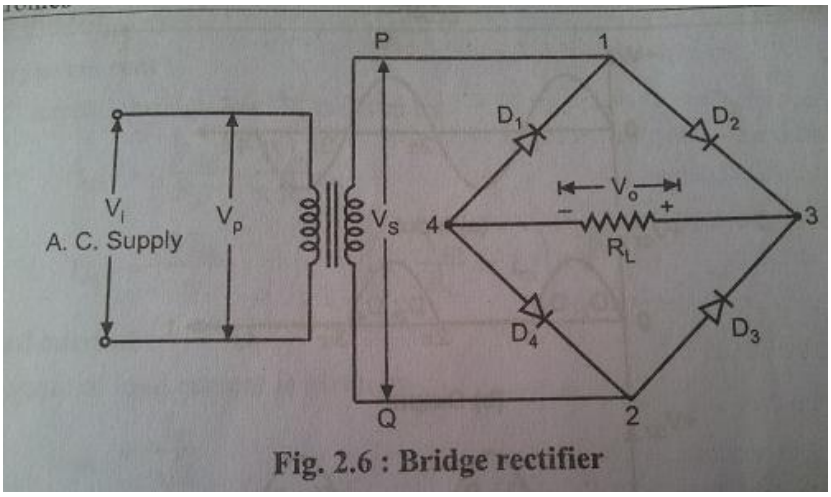
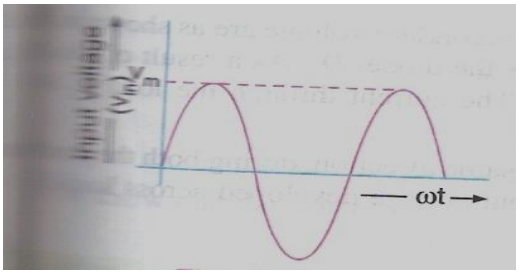
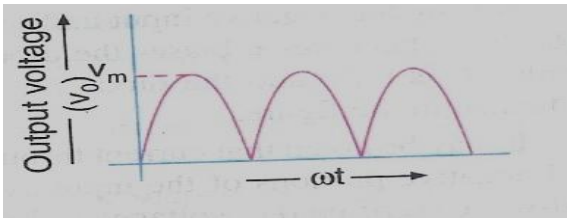


Fig. 2.6 : Bridge rectifier

Waveform: **1M**



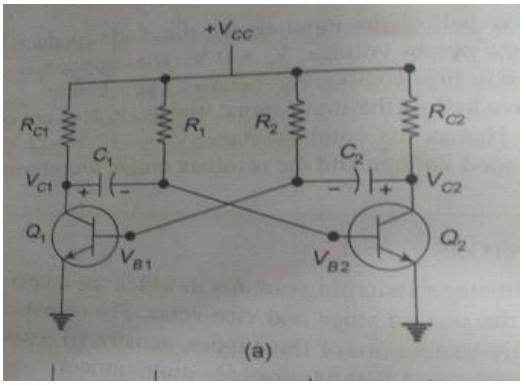


Explanation: **2M**

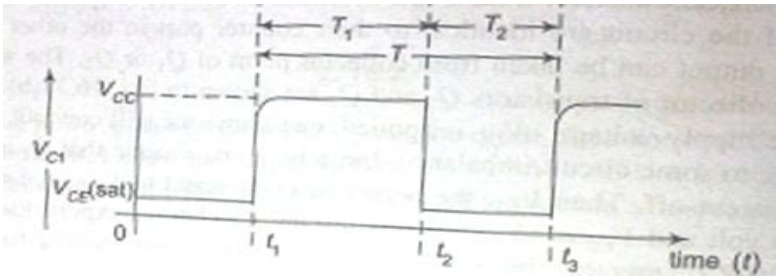
1) During the +ve half cycle diodes D2 and D4 conduct, current flows through the path P1$D_2$3 R_L4$D_4$2Q. (As only these two diodes are forward biased)
2) During the -ve half cycle diodes D3 and D1 conduct, current flows through the path Q2D_3 3R_L4$D_1$1P. (As only these two diodes are forward biased)
3) Current flows through the entire i/p cycle through the load.
4) We get a full wave rectified o/p

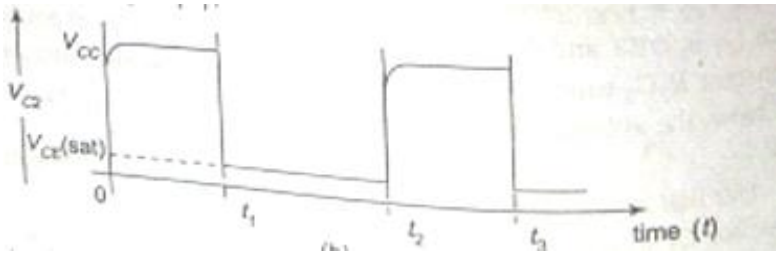
b) Draw the circuit diagram of Astable multivibrator using transistor. Sketch the output waveform & describe the working.

Ans:- Circuit: **1M**



Waveform: **1M**





Explanation: **2M**

- When Vcc is connected, one transistor will conduct more than other, and we can assume say Q1 is in sat. And Q2 is in cutoff mode. The Vc1 is at 0V and Vc2 = $+V_{cc}$.
- Hence C1 charges exponentially with R_1C_1 time constant towards V_{cc} through R_1. Hence VB2 also increases exp. Towards Vcc.
- When V_{B2} crosses the cutin voltage, Q_2 stars conducting and V_{C2} fall to Vce (sat).
- Also V_{B1} falls , thereby driving Q1, to OFF sate.
- Now VC1 rises, causes a small overshoot in voltage in VB2. Thus Q1 is OFF and Q2 is ON.
- $V_{C1}= V_{CC}$, $V_{B2}=V_{BE}$(sat), and $V_{C2}=V_{CE}$(sat)
- V_{B1} now increases exp. With R_2C_2 towards VCC. Therefore Q1 is driven into sat. and Q2 to cutoff.
- This regenerative process continues when Q2 is ON, falling voltage V_{C2} permits the discharging of the capacitor C2 which drives Q1 into cutoff.
- The rising voltage of V_{C1} feeds back to the base of Q2 tending to turn it ON.

T=Ton + Toff

T=0.693R1C1+0.693R2C2

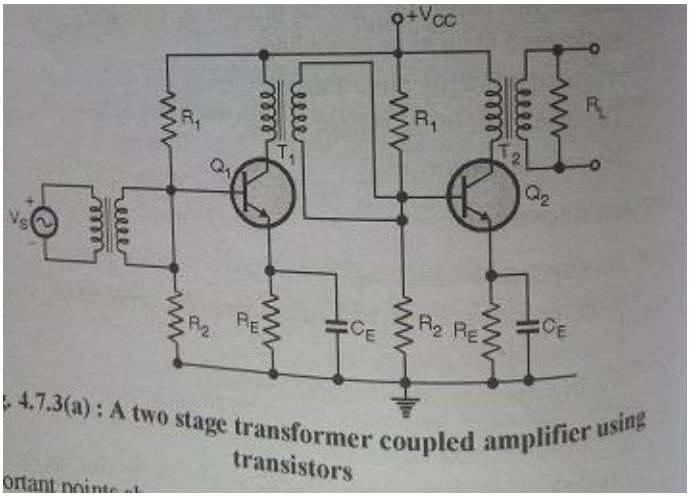
d) Differentiate between zener diode and PN junction diode

Ans:- **1M for each point**

Parameter	PN junction diode	Zener diode
Symbol		
Conduction	Only in one direction	Conducts in both the directions
Operated	Only in forward direction	Only in reverse direction
Application	Electronic switch	Voltage regulator

e) Draw neat circuit diagram of transformer coupled amplifier & describe its working.

Ans:- Circuit diagram: **2M**



4.7.3(a) : A two stage transformer coupled amplifier using transistors

Description: **2M**

- The coupling from one stage to the other takes place through the impedance matching transformers.
- The turns ratio has to be carefully adjusted in order to get a perfect impedance matching between the stages.
- T1 and T2 are the coupling transformers.

- It couples only ac signals.
- It is specially useful in the audio power amplifiers for impedance matching.
- The interwinding capacitances may give rise to resistance at some frequencies, frequency response is poor.

f) List the applications of LED and Varactor diode.

Ans:- ***Note : any other application if written by the student, can be given suitable marks.***

Application: any two

LED : **2M**

i) in 7 segment displays, indicators in various electronic circuits.

ii) in optocouplers, in infrared remote controls.

Application: any two

Varactor diode : **2M**

i) FM modulator.

ii) AFC in radio receiver, automatic tuning circuits, in TV receivers.

Q6) Attempt any FOUR: **16m**

a) Explain the formation of depletion layer in PN junction with neat sketch.

Ans:- Formation of depletion layer: **2M**

- Under no biasing conditions, free electrons from n side will diffuse into the p side and recombine with the holes.
- There will be +ve immobile ion on the n side, and –ve immobile ion on the p side.
- Since atom which accepts electron will become –ve ion and the one which gains a electron will become +ve immobile ion.
- Due to this +ve ions and –ve ions accumulate near the junction- -ve ion on p side and +ve ion on n side.

- They now create a barrier for the remaining charge carriers to cross the junction.
- This region of immobile ions formed on both sides is called depletion region and acts as a barrier. (0.3 V for Ge and 0.6 V for Si)

Diagram: **2M**

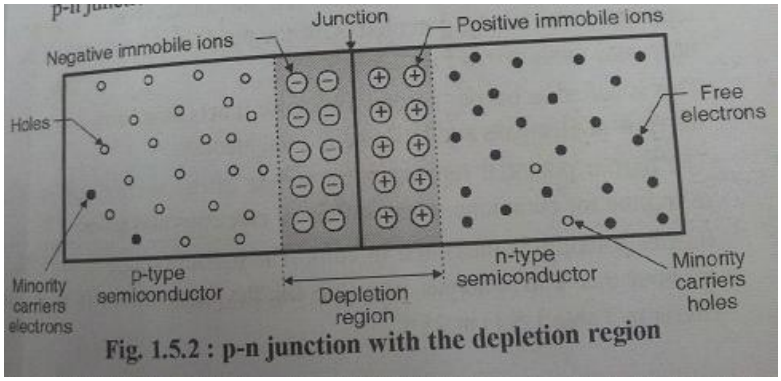
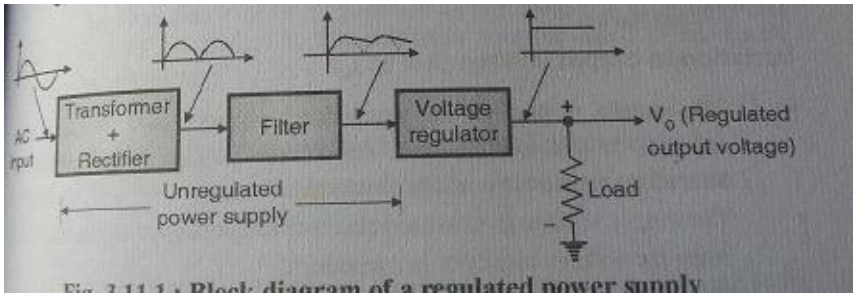


Fig. 1.5.2 : p-n junction with the depletion region

b) Draw block diagram of regulated power supply and describe each block

Ans:- Block Diagram: **2M**



Description about each block: **2M**

- The transformer steps down the ac voltage
- Rectifier converts ac to dc voltage.
- The output dc voltage is pulsating dc, hence filter is used, it removes the unwanted ac component from the rectifier o/p.

- The voltage regulator maintains the o/p voltage constant irrespective of changes in load and i/p fluctuations.
- The constant and pure dc is obtained across the load.

c) Explain the drain characteristics of n-channel J-FET with ckt diagram.

Ans:- Characteristics: **1M**

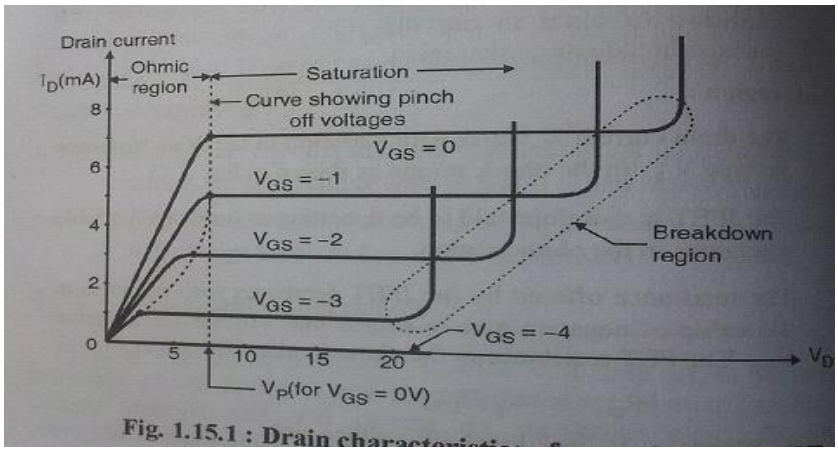
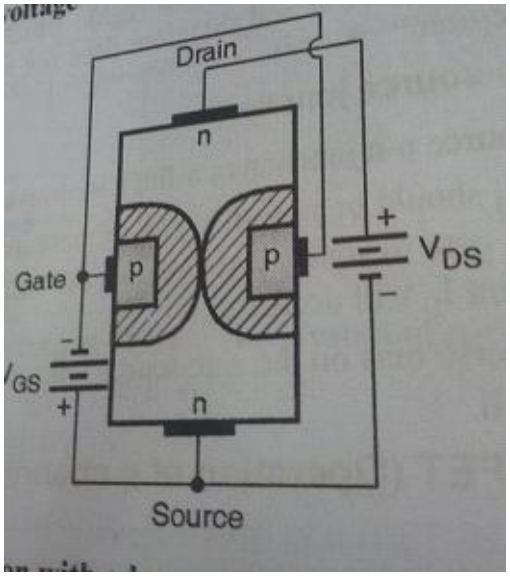


Fig. 1.15.1 : Drain characteristi...

Diagram: **1M**



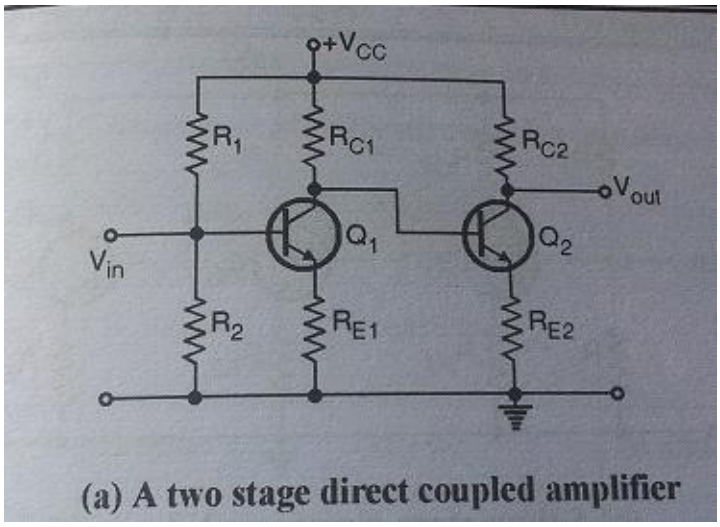
Explanation: **2M**

- Under no gate voltage conditions, I_{DSS} correspond to max drain current, because channel is widest.

- As gate is mad more and more –ve , channel width reduces, and drain current I_D reduces.
- The pinch off voltage is the value at which the drain current reaches its constant saturation value.

d) Draw neat circuit diagram of direct coupled amplifier & describe its working.

Ans:- Diagram: **2M**



(a) A two stage direct coupled amplifier

Description: **2M**

- There is no capacitor used for coupling one stage to the other. Q1 and Q2 are the transistors, Vcc is the dc supply, R1, R2, Rc1, Rc2, RE1, RE2 are the biasing elements. i.e. o/p of Q1 ie collector of Q1 is connected to base of Q2.
- The input AC signal is applied to base of Q1, o/p at collector of Q1 is connected directly to base of Q2. final o/p is obtained at collector of Q2. Hence it is called direct coupled amplifier.
- Due to the absence of coupling capacitors, the gain does not reduce on the lower frequency side.
- The amplifier can amplify even the dc signals.
- It suffers from the drift problem due to direct coupling.

e) Explain the dc load line and Q-point of a transistor.

Ans:- Diagram: **2M**

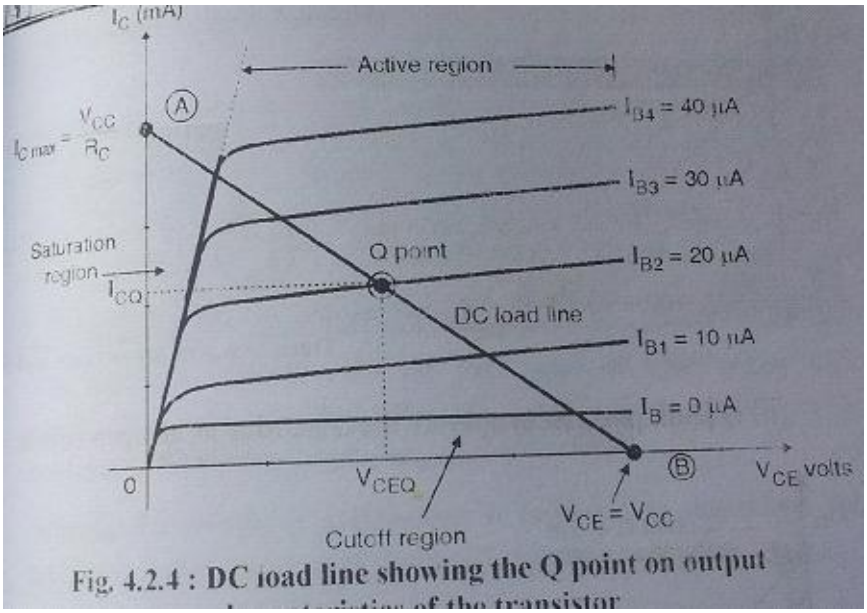


Fig. 4.2.4 : DC load line showing the Q point on output

Explanation: **2M**

- AB is dc load line.
- The dc word indicates that the line is drawn under dc operating conditions, i.e without any ac signal at the input.
- The word load line is used because the slope of this line is -1/Rc, where Rc is load resistance.
- Q-point is the point on the load line which represents the dc current through a transistor (ICQ) and voltage across it (VCEQ), when no ac signal is applied. (It represents dc biasing conditions)

f) Compare half wave rectifier, full wave rectifier using ct tap transformer and bridge full wave rectifier for four points.

Ans:- Any four points **1M for each point**

Parameter	Half wave rectifier	full wave rectifier	full wave rectifier
No of diodes	1	2	4
Conduction	Half cycle	Full cycle	Full cycle
PIV	Vm	2Vm	Vm
TUF	0.287	0.692	0.812
Ripple factor	1.21	0.48	0.48
Efficiency	0.48	0.812	0.812
Ripple frequency	50 Hz	100 Hz	100 Hz
Transformer core saturation	Possible	Not possible	Not possible