Question 1(a) [3 marks]

Explain difference between Active and passive network.

Answer:

Active Network	Passive Network
Contains at least one active element (voltage/current source)	Contains only passive elements (R, L, C)
Can deliver energy to the circuit	Cannot deliver energy to the circuit
Can amplify signal power	Cannot amplify signal power

Mnemonic: "Active Adds Power, Passive Parts Take"

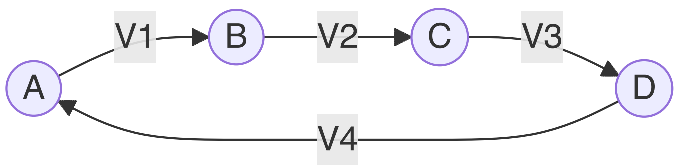
Question 1(b) [4 marks]

State and explain Kirchhoff's voltage law (KVL).

Answer:

Kirchhoff's Voltage Law (KVL) states that the algebraic sum of all voltages around any closed loop in a circuit is zero.

Diagram:



Mathematically: V1 + V2 + V3 + V4 = 0

- **Voltage drops**: When passing through a resistor in direction of current, voltage is negative
- **Voltage rises**: When passing through a source from negative to positive, voltage is positive

Mnemonic: "Voltage Loop Equals Zero"

Question 1(c) [7 marks]

Define the following terms: (1) Charge (2) Current (3) Potential (4) E.M.F. (5) Inductance (6) Capacitance (7) Frequency.

Answer:

Term	Definition
Charge	The quantity of electricity measured in coulombs (C)
Current	The rate of flow of electric charge measured in amperes (A)
Potential	The electrical pressure or energy per unit charge measured in volts (V)
E.M.F.	Electromotive Force is the energy supplied by a source per unit charge measured in volts (V)
Inductance	The property of an electric circuit that opposes change in current, measured in henries (H)
Capacitance	The ability of a body to store electrical charge, measured in farads (F)
Frequency	Number of complete cycles per second, measured in hertz (Hz)

Mnemonic: "Coulombs' Flow Pressurized by Energy Induces Capacitive Fluctuations"

Question 1(c) OR [7 marks]

State Ohm's law. Write its application and limitation.

Answer:

Ohm's Law states that the current flowing through a conductor is directly proportional to the potential difference and inversely proportional to the resistance.

Diagram:

```
V = I × R
```

Where:

- V = Voltage (volts)
- I = Current (amperes)
- R = Resistance (ohms)

Applications:

- Circuit design and analysis
- Power consumption calculations
- Component value determination
- Voltage divider networks
- Current divider networks

Limitations:

- Valid only for linear components

- Not applicable to non-ohmic devices (diodes, transistors)
- Invalid at high temperatures
- Not valid for semiconductors
- Cannot be applied to non-linear resistive elements

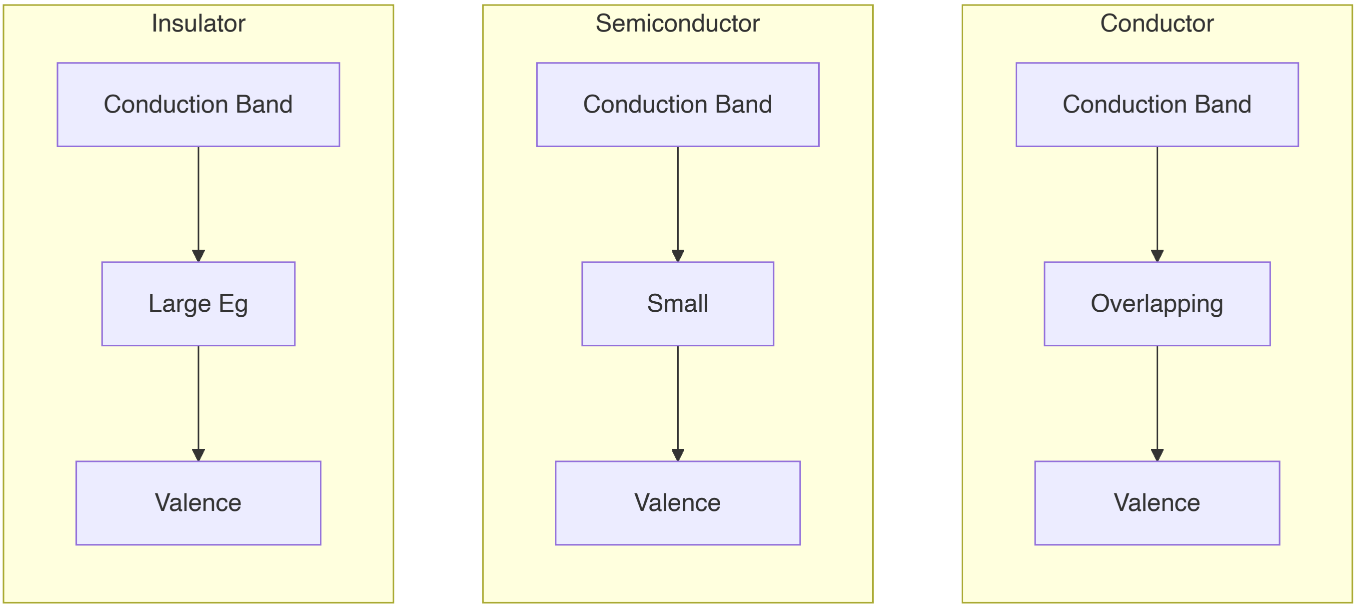
Mnemonic: "Volts Reveal Amps' Motion"

Question 2(a) [3 marks]

Draw and explain energy band diagrams for insulator, conductor and Semiconductor.

Answer:

Diagram:



- **Conductor**: Valence and conduction bands overlap, allowing free electron movement
- **Semiconductor**: Small energy gap (0.7-3 eV) between bands allows limited conduction
- **Insulator**: Large energy gap (>3 eV) prevents electrons from moving to conduction band

Mnemonic: "Conductors Overlap, Semiconductors Jump Small, Insulators Block All"

Question 2(b) [4 marks]

Write statement of Maximum power transfer theorem and reciprocity theorem.

Answer:

Theorem	Statement
Maximum Power Transfer Theorem	Maximum power is transferred from source to load when the load resistance equals the source internal resistance (RL = RS)
Reciprocity Theorem	In a linear, bilateral network, if voltage source E in branch 1 produces current I in branch 2, then the same voltage source E in branch 2 will produce the same current I in branch 1

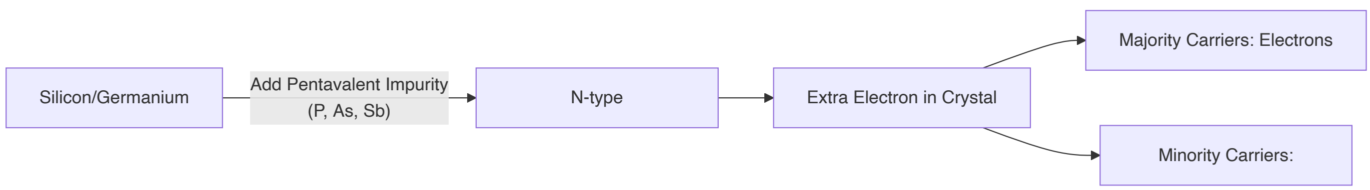
Mnemonic: "Match Resistance for Maximum Power; Swap Sources, Current Stays"

Question 2(c) [7 marks]

Explain the formation and conduction of N-type materials.

Answer:

Diagram:



- **Formation Process**:
  - Pure silicon/germanium doped with pentavalent impurity atoms (P, As, Sb)
  - Impurity atoms have 5 valence electrons (silicon has 4)
  - Four electrons form covalent bonds, fifth becomes free electron
  - Creates excess negative charge carriers
- **Conduction Mechanism**:
  - Majority carriers: Electrons
  - Minority carriers: Holes
  - Electron movement provides electrical conduction
  - Even at room temperature, free electrons enable current flow

Mnemonic: "Pentavalent Provides Plus-One Electron"

Question 2(a) OR [3 marks]

Define valence band, conduction band and forbidden gap.

Answer:

Term	Definition
Valence Band	Energy band occupied by valence electrons that are bound to specific atoms in the solid
Conduction Band	Higher energy band where electrons can move freely throughout the material, enabling electrical conduction
Forbidden Gap	Energy region between valence and conduction bands where no electron states exist

Mnemonic: "Valence Binds, Conduction Flows, Forbidden Gaps Block"

Question 2(b) OR [4 marks]

Define the terms active power, reactive power and power factor with power triangle.

Answer:

Diagram:

```
    |
    |   S (Apparent Power)
    |  /|
    | / |
    |/__|
    P   Q

P = Active Power
Q = Reactive Power
S = Apparent Power
cosθ = Power Factor
```

- **Active Power (P)**: Actual power consumed, measured in watts (W), P = VI cosθ
- **Reactive Power (Q)**: Power oscillating between source and load, measured in volt-amperes reactive (VAR), Q = VI sinθ
- **Power Factor**: Ratio of active power to apparent power, PF = cosθ = P/S

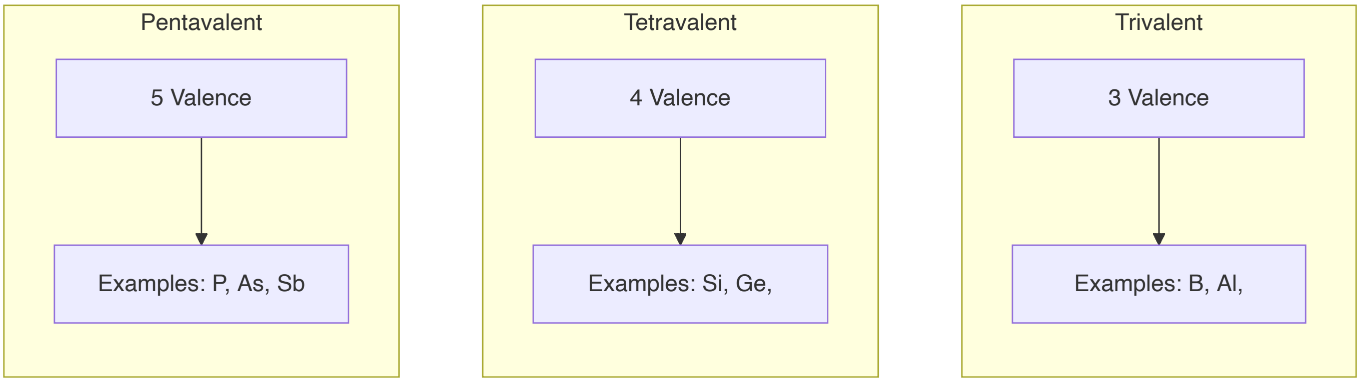
Mnemonic: "Real Power Works, Reactive Power Waits"

Question 2(c) OR [7 marks]

Explain the structure of atom of trivalent, tetravalent and pentavalent elements.

Answer:

Diagram:



Element Type	Structure	Examples	Semiconductor Use
Trivalent	3 electrons in outermost shell	B, Al, Ga, In	P-type dopant
Tetravalent	4 electrons in outermost shell	Si, Ge, C	Semiconductor base
Pentavalent	5 electrons in outermost shell	P, As, Sb	N-type dopant

Mnemonic: "Three Accepts, Four Forms, Five Donates"

Question 3(a) [3 marks]

Draw the symbol of photodiode and state its application.

Answer:

Diagram:

```
    |\
    | \
    |  \
-->|| \--->
    |  /
    | /
    |/
```

Applications of Photodiode:

- Light sensors and detectors
- Optical communication systems
- Solar cells and photovoltaic applications
- Camera exposure controls
- Medical equipment (pulse oximeters)

Mnemonic: "Light Triggers Electric Current"

Question 3(b) [4 marks]

Write a Short note on LED.

Answer:

Diagram:

```
    |\
    | \
    |  \
<---|| \--->
    |  /
    | /
    |/
    ▼ ▼
   Light
```

- **Structure**: P-N junction diode that emits light when forward biased
- **Working Principle**: Electron-hole recombination releases energy as photons
- **Types**: Various colors based on semiconductor material (GaAs, GaP, GaN)
- **Advantages**: Low power consumption, long life, small size, fast switching
- **Applications**: Displays, indicators, lighting, remote controls, optical communications

Mnemonic: "Electrons Jump, Photons Emit"

Question 3(c) [7 marks]

Draw and explain VI characteristic of PN junction diode.

Answer:

Diagram:

```
    Current
    ^
    |           /
    |          /
    |         /
    |        /
    |       /
    |      /
    |_____/_________> Voltage
    |    /|
    |   / |
    |  /  |
    | /   |
    |/    |
    |     |

    Forward bias  | Reverse bias
```

P-N Junction Diode V-I Characteristics:

- **Forward Bias Region**:
  - Diode conducts when voltage exceeds knee/cut-in voltage (0.3V for Ge, 0.7V for Si)
  - Current increases exponentially with voltage
  - Low resistance state
- **Reverse Bias Region**:
  - Very small leakage current flows
  - Current remains almost constant with increasing reverse voltage
  - High resistance state
  - Breakdown occurs at high reverse voltage
- **Key Points**:
  - Non-linear device
  - Unidirectional current flow
  - Temperature dependent

Mnemonic: "Forward Flows Freely, Reverse Resists Rigidly"

Question 3(a) OR [3 marks]

List the applications of PN junction diode.

Answer:

Applications of PN Junction Diode:

- Rectification in power supplies
- Signal demodulation
- Logic gates in digital circuits
- Voltage regulation (with zener diodes)
- Signal clipping and clamping circuits
- Protection circuits against reverse polarity

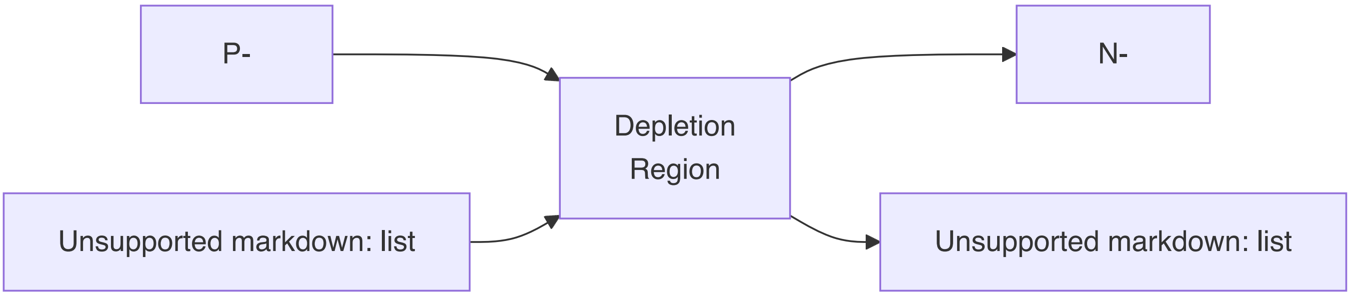
Mnemonic: "Rectify, Detect, Clip, Protect"

Question 3(b) OR [4 marks]

Explain the formation of depletion region in unbiased P-N junction.

Answer:

Diagram:



- **Formation Process**:
  - Electrons from N-side diffuse into P-side
  - Holes from P-side diffuse into N-side
  - Recombination occurs at junction
  - Immobile ions remain (positive in N-side, negative in P-side)
  - Electric field develops, opposing further diffusion
  - Equilibrium is established, creating depletion region
- **Characteristics**:
  - Free of charge carriers
  - Acts as insulator/barrier
  - Creates built-in potential

Mnemonic: "Diffusion Creates Barrier Field"

Question 3(c) OR [7 marks]

Explain construction, working and applications of PN junction diode.

Answer:

Diagram:

Construction:

- P-type semiconductor joined with N-type semiconductor
- Made from single crystal of silicon or germanium
- Metal contacts connected to P and N regions

Working:

- **Forward Bias**:
  - Positive to P, negative to N

  - Depletion region narrows
  - Current flows when voltage exceeds barrier potential
- **Reverse Bias**:
  - Positive to N, negative to P
  - Depletion region widens
  - Only small leakage current flows

Applications:

- Power rectification
- Signal detection
- Voltage regulation
- Switching applications
- Protection circuits
- Logic gates

Mnemonic: "Join P-N, Control Current Direction"

Question 4(a) [3 marks]

Define: (1) Ripple frequency (2) Ripple factor (3) PIV of a diode.

Answer:

Term	Definition
Ripple Frequency	Frequency of the AC component remaining in the rectified DC output (2× input frequency for full-wave, 1× for half-wave)
Ripple Factor	Ratio of RMS value of AC component to the DC component in rectifier output ($\gamma = V_{ac(rms)}/V_{dc}$)
PIV of a diode	Peak Inverse Voltage is the maximum reverse voltage a diode can withstand without breakdown

Mnemonic: "Frequency Fluctuates, Factor Measures, PIV Protects"

Question 4(b) [4 marks]

Give comparison between full wave rectifier with two diodes and full wave bridge rectifier.

Answer:

Parameter	Center-Tapped Full Wave	Bridge Rectifier
Number of Diodes	2	4
Transformer	Center-tapped required	Simple transformer
PIV	2Vm	Vm
Efficiency	81.2%	81.2%
Ripple Factor	0.48	0.48
Output	Vm/π	2Vm/π
Cost	Higher transformer cost	Higher diode cost

Mnemonic: "Two Diodes Tap Center, Four Make Bridge"

Question 4(c) [7 marks]

Explain zener diode as voltage regulator.

Answer:

Diagram:

```
        Rs
    +---www-----+
    |           |
Vin |           | Zener    RL    Vout
    |           Z Diode     R
    |           |           R
    +-----------+-----------+
```

Working Principle:

- Zener diode operates in reverse breakdown region
- Maintains constant voltage across its terminals
- Acts as voltage reference

Circuit Operation:

- Series resistor Rs limits current
- Zener conducts when input exceeds breakdown voltage
- Excess current flows through zener diode
- Output voltage remains constant at zener voltage

Advantages:

- Simple circuit

- Low cost
- Good regulation for small load changes

Limitations:

- Power dissipation in zener and series resistor
- Limited current capability
- Temperature dependency

Mnemonic: "Zener Breaks Down to Hold Voltage Steady"

Question 4(a) OR [3 marks]

What is rectifier? Explain full wave rectifier with waveforms.

Answer:

Rectifier: A circuit that converts AC voltage to pulsating DC voltage.

Diagram:

```
    +-------+
    |       |
A --+       +-- C
    | XFRMR |         D1
    |       |--+------|>|----+--+
    |       |  |             |  |
    |       |  |             |  |  RL   Output
    |       |  |             |  |
B --+       +--+             |  |
    |       |  |             |  |
    |       |  |             |  |
    |       |--+------|<|----+--+
    |       |         D2
    +-------+
```

Waveforms:

```
Input:    ^
          |   /\    /\    /\
          |  /  \  /  \  /  \
          | /    \/    \/    \
          +--------------------
          |
          |\    /\    /\    /
          | \  /  \  /  \  /
          |  \/    \/    \/

Output:   ^
          |   /\    /\    /\
          |  /  \  /  \  /  \
```

```
          | /    \/    \/    \
          +--------------------
```

Mnemonic: "Both Half-Cycles Become Positive"

Question 4(b) OR [4 marks]

Why filter is required in rectifier? State the different types of filter and explain any one type of filter.

Answer:

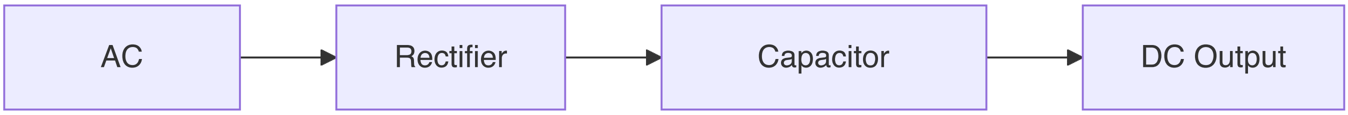
Need for Filter:

- Rectifier output contains AC ripple component
- Pure DC required for electronic circuits
- Filters smooth pulsating DC by removing AC components

Types of Filters:

- Capacitor filter (C-filter)
- Inductor filter (L-filter)
- LC filter
- π (Pi) filter
- CLC filter

Capacitor Filter:



Working:

- Capacitor charges during voltage rise
- Discharges slowly during voltage fall
- Provides current when input decreases
- Reduces ripple voltage

Advantages:

- Simple and inexpensive
- Effective for light loads
- Reduces ripple significantly

Mnemonic: "Capacitor Catches Peaks, Releases Slowly"

Question 4(c) OR [7 marks]

Write the need of rectifier. Explain bridge rectifier with circuit diagram and draw its input and output waveforms.

Answer:

Need of Rectifier:

- Convert AC to DC for electronic devices
- Most electronic circuits require DC power
- Batteries provide DC but AC is distributed
- Building block of power supplies
- Essential for charging systems

Bridge Rectifier Circuit:

```
           D1        D3
    +-----|>|--------+
    |                |
A --+                +-- DC+
    |                |
    |                |    RL
    |                |
B --+                +-- DC-
    |                |
    +-----|<|--------+
           D2        D4
```

Input Waveform:

```
    ^
    |    /\      /\
    |   /  \    /  \
    |  /    \  /    \
    | /      \/      \
    +-------------------
    |       /\      /\
    |      /  \    /  \
    |     /    \  /    \
    |\   /      \/
    | \ /
    |  V
```

Output Waveform:

```
^
|    /\      /\
|   /  \    /  \
|  /    \  /    \
| /      \/      \
+-------------------
```

Working:

- During positive half cycle: D1 and D4 conduct
- During negative half cycle: D2 and D3 conduct
- Load receives unidirectional current in both cycles
- Utilizes both halves of input waveform

Mnemonic: "Four Diodes Direct All Current One Way"

Question 5(a) [3 marks]

Explain causes of electronic waste.

Answer:

Causes of Electronic Waste:

- Rapid technological advancement
- Planned obsolescence of products
- Decreasing product lifespan
- Consumer behavior preferring new devices
- Limited repair options for electronics
- High repair costs compared to replacement

Mnemonic: "Technology Advances, Products Expire Rapidly"

Question 5(b) [4 marks]

Compare PNP and NPN transistors.

Answer:

Parameter	PNP Transistor	NPN Transistor
Symbol		
Majority Carriers	Holes	Electrons
Current Flow	Emitter to Collector	Collector to Emitter
Biasing	Emitter more positive than Base	Base more positive than Emitter
Switching Speed	Slower	Faster
Applications	Low frequency, high current	High frequency, switching

Diagram:

```
NPN:        PNP:

C           C
|           |
|           |
B---->      <----B
|           |
|           |
E           E
```

Mnemonic: "Negative-Positive-Negative vs Positive-Negative-Positive"

Question 5(c) [7 marks]

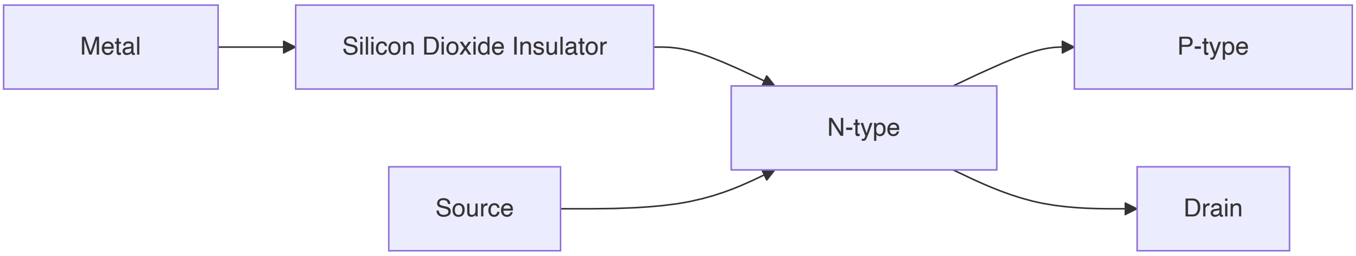
Draw the symbol, explain the construction and working of MOSFET.

Answer:

Symbol:

```
         D (Drain)
         |
         |
G (Gate) |
----||---+
         |
         |
         S (Source)
```

Construction:



Working Principle:

- **Enhancement Mode N-Channel MOSFET:**
  - No channel exists without gate voltage
  - Positive gate voltage attracts electrons from substrate
  - Induced channel allows current flow from drain to source
  - Increasing gate voltage enhances conductivity
- **Key Features:**
  - Voltage-controlled device (high input impedance)
  - No gate current required (unlike BJT)
  - Faster switching than BJT
  - Lower power dissipation

Applications:

- Digital logic circuits
- Switching applications
- Amplifiers
- Power control devices

Mnemonic: "Gate Voltage Creates Electron Channel"

Question 5(a) OR [3 marks]

Explain methods to handle electronic waste.

Answer:

Methods to Handle Electronic Waste:

Method	Description
Reduce	Designing longer-lasting electronics, modular design for upgrading
Reuse	Donating or selling functional devices, repurposing components
Recycle	Proper dismantling and material recovery (precious metals, plastics)
Regulation	E-waste management policies, extended producer responsibility
Recovery	Extracting valuable materials through specialized processes

Mnemonic: "Reduce, Reuse, Recycle, Regulate, Recover"

Question 5(b) OR [4 marks]

Derive the relationship between αdc and βdc.

Answer:

Diagram:

```
              IC
             ↑
             |
             |
   IB →      |      →
       B ----+---- C
             |
             |
             |
             E
             ↓
             IE
```

Transistor Current Relationships:

- IE = IC + IB (Current entering equals current leaving)
- αdc = IC/IE (Common Base current gain)
- βdc = IC/IB (Common Emitter current gain)

Derivation:

- From IE = IC + IB
- Divide both sides by IC: IE/IC = 1 + IB/IC
- Therefore: 1/αdc = 1 + 1/βdc
- Solving for βdc: βdc = αdc/(1-αdc)
- And for αdc: αdc = βdc/(1+βdc)

Table of Values:

αdc	βdc
0.9	9
0.95	19
0.99	99

Mnemonic: "Alpha-Beta Relate as αdc = βdc/(1+βdc)"

Question 5(c) OR [7 marks]

Explain common collector configuration with its input and output characteristics.

Answer:

Common Collector Circuit (Emitter Follower):

```
              +VCC
               |
               R
               |
               C
     +----+    |
     |    |    |
     Vin  |    +---+ Output
     |    |    |
     +----+-----+
          |    |
          B    E
          |    |
          +-----+
               |
               RE
               |
              GND
```

Input Characteristics: (IB vs VBE)

```
     IB ^
        |           /
        |          /
        |         /
        |        /
        |       /
        |      /
        |     /
        |    /
        |   /
        |  /
        | /
```

```
        |/
        +---------------> VBE
```

Output Characteristics: (IE vs VCE)

```
     IE ^
        |    ---------------
        |   /
        |  /
        | /
        |/
        +---------------> VCE

        IB3 > IB2 > IB1 > 0
```

Key Features:

- Voltage gain ≈ 1 (slightly less)
- High current gain (β+1)
- High input impedance
- Low output impedance
- No phase inversion between input and output
- Used as buffer/impedance matching circuit

Mnemonic: "Emitter Follows Base Voltage"