SECTION B (5 x 14 = 70 marks)

B1.

(a) Either one of the following: [2 marks]

(1) Full-wave centre-tapped transformer rectifier

(2) Full-wave bridge rectifier

(3) Full-wave rectifier

(b) The frequency of the output voltage is twice that of the input ac voltage: $f_O = 2 \times 200$ Hz = **400 Hz** [2 marks]

(c) **Capacitor** (RC filter) [2 marks]

(d) To reduce the large fluctuations in the output of the rectifier [2 marks]

(e) Peak-to-peak voltage of ripple:

$V_{r(p\text{-}p)} = 2$ V

RMS value of Ripple voltage:

$$V_{r(rms)} = \frac{V_{r(p-p)}}{2\sqrt{3}} = \frac{2}{2\sqrt{3}} = 0.5773\ V$$ [2 marks]

Average output, $V_{DC} = V_p - \frac{1}{2} V_{r(p\text{-}p)}$ [2 marks]

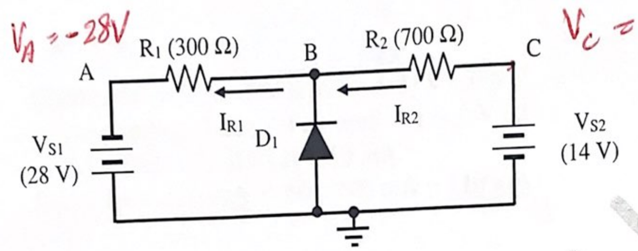
$= 101\text{V} - \frac{1}{2}(2\text{ V}) = 100$ V

Ripple factor, r:

$$r = \frac{V_{r(rms)}}{V_{DC}} = \frac{0.5773V}{100V} = 0.005773 = \underline{0.5773\,\%}$$ [2 marks]

Total: [14 marks]

B2.



(a) Applying voltage divider rule to the circuit ABC comprising R_1 and R_2 with diode D_1 removed:

$$V_{BA} = (V_C - V_A)\frac{R_1}{R_1 + R_2}$$

$$V_{BA} = (14 - (-28))V\frac{300}{300 + 700} = 12.6V$$ [2 marks]

$V_B = V_{BA} + V_A = 12.6V + (-28V) = \underline{-15.4\ V}$ [2 marks]

{Alternatively,
Total current = $(V_{S1} + V_{S2})/(R_1 + R_2) = (28V + 14V)/1000\Omega$
= 0.042 A = 42 mA
$V_{BA} = 0.042\ A \times 300\Omega = 12.6\ V$
$V_B = V_{BA} + V_A = 12.6\ V + (-28V) = -15.4\ V$}

Since V_B is more negative than -0.7 V, D_1 will be forward biased when it is connected between node B and Ground [2 marks]
Diode is **forward biased**

(b) Since the diode is forward biased, V_B = **-0.7 V** [2 marks]

(c) Current flowing through R_1, $I_{R1} = (V_B - V_A)/R_1$
$I_{R1} = (-0.7V - (-28V))/300\Omega = 0.091\ A$ = **91 mA** [1 mark]
In the direction from **node B to node A** [1 mark]

Current flowing through R_2, $I_{R2} = (V_C - V_B)/R_2$
$I_{R2} = (14V - (-0.7V))/700\Omega = 0.021\ A$ = **21 mA** [1 mark]
In the direction from **node C to node B** [1 mark]

(d) Applying KCL at node B:
Diode current , $I_D = I_{R1} - I_{R2}$
$I_D = (91 - 21)$ mA = **70 mA** [2 marks]

Total: [14 marks]

B3. or $Z_Z = \frac{V_{Z\,max} - V_{ZT}}{I_{Z\,max} - I_{ZT}} \Rightarrow 12 = \frac{6.8 - 6.2}{I_{Z\,max} - 60mA} \Rightarrow I_{Z\,max} = 110\ mA$

(a) Change of voltage: $\triangle V = (6.8 - 6.2)\ V = 0.6\ V$ [1 mark]

Corresponding change of current: $\triangle I = \triangle V / Z_Z$ [1 mark]

$\triangle I = 0.6 / 12 = 0.05\ A = 50\ mA$ [2 marks]

$I_{ZM} = (I_{ZT} + \triangle I)\ mA = (60 + 50)\ mA =$ **110 mA**

(b)

(i) The total current that flows through R (33Ω) is

$I_{33\Omega} = \frac{V_{IN} - V_{ZM}}{R} = \frac{12 - 6.8}{33} =$ **157.6 mA** [2 marks]

(ii) Since I_{ZM} is flowing through the Zener diode:

$I_L = I_{33\Omega} - I_{ZM} = (157.6 - 110)\ mA =$ **47.6 mA** [4 marks]

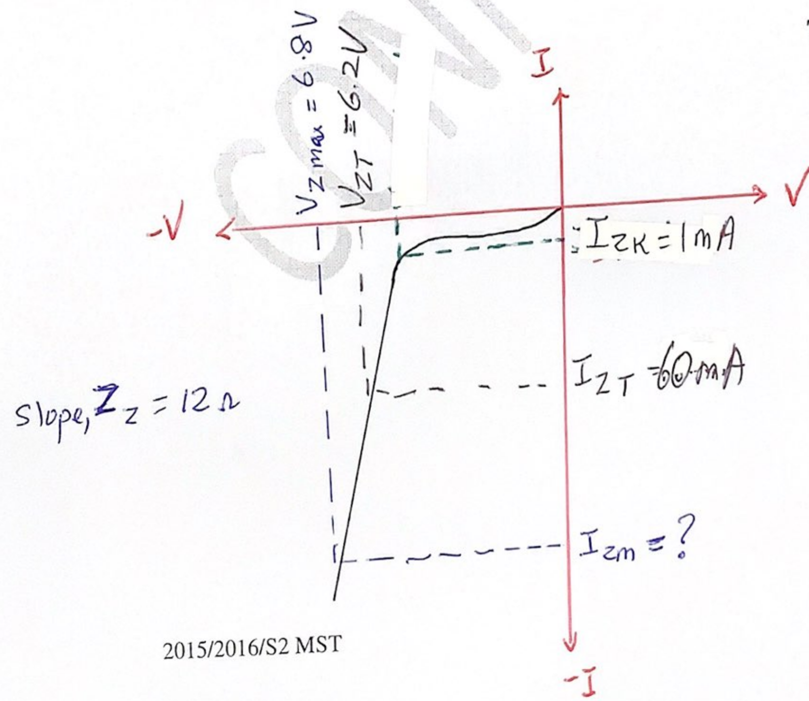
(c) Power $P_{33\Omega} = I_{33\Omega}{}^2 R = (157.6\ mA)^2 x 33\Omega$ [2 marks]

$= 0.1576^2$ x 33W

$=$ **0.82 W** (R > 0.82W) [2 marks]

Select resistor with power rating of **1W**

Total: [14 marks]



B4.

(a)

$I_B = (4 - 0.7)/10\text{ k} = 0.33\text{ mA}$ [1mark]

$I_C = 180 \times 0.33 = 59.4\text{ mA}$ [1mark]

$I_E = 0.33 + 59.4 = \underline{\mathbf{59.73\text{ mA}}}$ # [2marks]

$I_E = I_B + I_C$

$I_C R_C = 59.4\text{ mA} \times 150\ \Omega = 8.91\text{ V}$ [2 marks]

$V_{CE} = 12 - 8.91 = \underline{\mathbf{3.09\text{ V}}}$ # [2 marks]

$V_{CE} = V_{CC} - I_C . R_C$

(b)

<u>Active mode</u> [2 marks]

<u>Reason :</u> V_{CE} is not less than 0.2 V # [2 marks]

(Alternatively,

$I_C\text{ (sat)} = (V_{CC} - V_{CE(sat)})/R_C = (12 - 0.2)/150 = 78.67\text{ mA}$

I_C is less than $I_{C(sat)}$)

(c)

<u>An NPN transistor</u> [2 marks]

npn

Total: [14 marks]

If PNP transistor,

pnp

B5.

(a) (i) light dependent resistor [1 mark]
(ii) thermistor [1 mark]
(iii) moisture sensor [1 mark]

(b) **(i)** The voltage across LDR is given by:

$$V_{LDR} = \frac{R_{LDR}}{R_{LDR} + R_1} \times V_{CC}$$

$R_1 = 10\ k\Omega$

<u>When the light bulb is in the OFF state:</u>
<u>$V_{LDR} = 0.6V$</u>

$$0.6V = \frac{R_{LDR}}{R_{LDR} + 10k} \times 9\ V$$ [1 mark]

$(9 - 0.6)R_{LDR} = 0.6 \times 10k$ [1 mark]

➔$R_{LDR} = (6000/8.4)\ \Omega =$ **<u>714.3 Ω</u>** [1 mark]

<u>When the light bulb is in the ON state:</u>
<u>$V_{LDR} = 4.2V$</u>

$$4.2V = \frac{R_{LDR}}{R_{LDR} + 10k} \times 9\ V$$ [1 mark]

$(9 - 4.2)R_{LDR} = 4.2 \times 10k$ [1 mark]

➔$R_{LDR} = (42000/4.8)\ \Omega =$ **<u>8750 Ω = 8.75 kΩ</u>** [1 mark]

<u>Range of R_{LDR} = 714.3 Ω to 8.75 kΩ</u>

(ii)
When the light bulb is in the OFF state: $I_B = 0\,A$
<u>$I_C = 0\ A$</u> [1 mark]
<u>$V_{CE} = 9\ V$</u> $V_{CC} = V_{CE} = 9V$ [1 mark]

V_{CC} = Supply Voltage = 9V

When the light bulb is in the ON state:
<u>$V_{CE} = 0.2\ V$</u> $V_{CC} = V_{Bulb} + V_{CE}$ [1 mark]
V_{BULB} = Supply voltage $- V_{CE} = 9V - 0.2V = 8.8V$ [1 mark]
$I_C = V_{BULB} / R_{BULB} = 8.8V/200\ \Omega = 0.044\ A =$ **<u>44 mA</u>** [1 mark]

Total: [14 marks]