

Q5) (a) Convert the CFG to CNF

$$S \rightarrow aABB$$

$$A \rightarrow aA \mid a$$

$$B \rightarrow bB \mid b$$

\Rightarrow It is already simplified

Production	Solution
$B \rightarrow b$	$B \rightarrow b$
$B \rightarrow bB$	$B \rightarrow C_1 B, C_1 \rightarrow b$
$A \rightarrow a$	$A \rightarrow a$
$A \rightarrow aA$	$A \rightarrow C_2 A, C_2 \rightarrow a$
$S \rightarrow aABB$	
$S \rightarrow C_2 A C_1 B$	
$S \rightarrow C_2 A C_3$	$C_3 \rightarrow C_1 B$
$S \rightarrow C_2 C_4$	$C_4 \rightarrow A C_3$
	$S' \rightarrow C_2 C_4$

$$G' = \{V', P', T', S'\}$$

$$T' = \{A, B, S', C_1, C_2, C_3, C_4\}$$

P: {

$$S' \rightarrow C_2 C_4$$

$$A \rightarrow a \mid C_2 A$$

$$B \rightarrow b \mid C_1 B$$

$$C_1 \rightarrow b$$

$$C_2 \rightarrow a$$

$$C_3 \rightarrow C_1 B$$

$$C_4 \rightarrow A C_3$$

}

$$S = S'$$

where $G = G'$

$$S \rightarrow aAbB$$

$$A \rightarrow Ab \mid b$$

$$B \rightarrow Ba \mid a$$

e) We have already simplified grammar

Production

Solution

$$S \rightarrow a$$

$$B \rightarrow a$$

$$B \rightarrow Ba$$

$$C_1 \rightarrow a$$

$$C_1 \rightarrow a$$

$$B \rightarrow BC_1$$

$$B \rightarrow BC_1$$

$$A \rightarrow b$$

$$A \rightarrow b$$

$$A \rightarrow Ab$$

$$C_2 \rightarrow b$$

$$C_2 \rightarrow b$$

$$A \rightarrow AC_2$$

$$A \rightarrow AC_2$$

$$S \rightarrow aAbB$$

$$S \rightarrow C_1AC_2B$$

$$S \rightarrow C_1AC_3$$

$$C_3 \rightarrow C_2B$$

$$C_4 \rightarrow AC_3$$

$$S \rightarrow C_1C_4$$

$$C_3 \rightarrow C_2B$$

$$C_4 \rightarrow AC_3$$

$$S \rightarrow C_1C_4$$

$$S' \rightarrow C_1C_4$$

$$A \rightarrow AC_2 \mid b$$

$$B \rightarrow BC_1 \mid a$$

$$C_1 \rightarrow a$$

$$C_2 \rightarrow b$$

$$C_3 \rightarrow C_2B$$

$$C_4 \rightarrow AC_3$$

$$\begin{aligned}
 (d) \quad S &\rightarrow bA \mid aB \\
 A &\rightarrow bAA \mid aS \mid a \\
 B &\rightarrow aBB \mid bS \mid b
 \end{aligned}$$

\Rightarrow Already simplified

production	solution
$B \rightarrow b$	$B \rightarrow b \checkmark$
$B \rightarrow bS$	
$C_1 \rightarrow b$	$C_1 \rightarrow b \checkmark$
$B \rightarrow C_1 S$	$B \rightarrow C_1 S \checkmark$
$B \rightarrow aBB$	
$C_2 \rightarrow a$	$C_2 \rightarrow a \checkmark$
$B \rightarrow C_2 BB$	
$C_3 \rightarrow BB$	$C_3 \rightarrow BB \checkmark$
$B \rightarrow C_2 C_3$	$B \rightarrow C_2 C_3 \checkmark$
$A \rightarrow a$	$A \rightarrow a \checkmark$
$A \rightarrow aS$	
$A \rightarrow C_2 S$	$A \rightarrow C_2 S \checkmark$
$A \rightarrow bAA$	
$A \rightarrow C_1 AA$	
$C_4 \rightarrow AA$	$C_4 \rightarrow AA \checkmark$
$A \rightarrow C_1 C_4$	$A \rightarrow C_1 C_4 \checkmark$
$S \rightarrow aB$	
$S \rightarrow C_2 B$	$S \rightarrow C_2 B \checkmark$
$S \rightarrow bA$	
$S \rightarrow C_1 A$	$S \rightarrow C_1 A \checkmark$

$$S \rightarrow C_1 A \mid C_2 B$$

$$A \rightarrow C_1 C_4 \mid C_2 S \mid a$$

$$B \rightarrow C_2 C_3 \mid C_1 S \mid b$$

$$C_1 \rightarrow b, C_2 \rightarrow a, C_3 \rightarrow BB, C_4 \rightarrow AA$$

$$\begin{aligned} S &\rightarrow ASB \mid \epsilon \\ B &\rightarrow SbS \mid A \mid bb \\ A &\rightarrow aAS \mid a \end{aligned}$$

⇒ Unit production

$$\begin{aligned} S &\rightarrow ASB \mid \epsilon \\ B &\rightarrow SbS \mid bb \mid aAS \mid a \\ A &\rightarrow aAS \mid a \end{aligned}$$

Null production

$$\begin{aligned} S &\rightarrow ASB \mid AB \\ B &\rightarrow SbS \mid bb \mid aAS \mid a \mid bS \mid Sb \mid b \mid aA \\ A &\rightarrow aAS \mid a \mid aA \end{aligned}$$

Production

Solution

$$A \rightarrow aA$$

$$C_1 \rightarrow a$$

$$C_1 \rightarrow a$$

$$A \rightarrow C_1 A \quad \checkmark$$

$$A \rightarrow C_1 A$$

$$A \rightarrow a \quad \checkmark$$

$$A \rightarrow a$$

$$A \rightarrow aAS$$

$$A \rightarrow C_1 AS$$

$$C_2 \rightarrow AS$$

$$C_2 \rightarrow AS$$

$$A \rightarrow C_1 C_2$$

$$A \rightarrow C_1 C_2 \quad \checkmark$$

$$B \rightarrow aA$$

$$B \rightarrow C_1 A \quad \checkmark$$

$$B \rightarrow C_1 A$$

$$B \rightarrow b \quad \checkmark$$

$$B \rightarrow b$$

$$B \rightarrow Sb$$

$$C_3 \rightarrow b$$

$$C_3 \rightarrow b$$

$$B \rightarrow SC_3 \quad \checkmark$$

$$B \rightarrow SC_3$$

$$B \rightarrow bS$$

$$B \rightarrow C_3 S \quad \checkmark$$

$$B \rightarrow C_3 S$$

$$B \rightarrow a \quad \checkmark$$

$$B \rightarrow a$$

$$B \rightarrow aAS$$

$$B \rightarrow C_1 C_2$$

$$B \rightarrow bb$$

$$B \rightarrow sbS$$

$$B \rightarrow SC_3 S$$

$$C_4 \rightarrow C_3 S$$

$$B \rightarrow SC_4$$

$$S \rightarrow AB$$

$$S \rightarrow ASB$$

$$S \rightarrow AC_5$$

$$C_5 \rightarrow SB$$

$$S \rightarrow AC_5 \mid AB$$

$$A \rightarrow C_1 C_2 \mid C_1 A \mid a$$

$$B \rightarrow C_3 C_3 \mid SC_4 \mid SC_3 \mid C_3 S \mid C_1 A \mid b \mid a$$

$$C_1 \rightarrow a$$

$$C_2 \rightarrow AS$$

$$C_3 \rightarrow b$$

$$C_4 \rightarrow C_3 S$$

$$C_5 \rightarrow SB$$

$$A \rightarrow C_1 C_2 \checkmark \text{ (Already)}$$

$$B \rightarrow C_3 C_3 \checkmark$$

$$C_4 \rightarrow C_3 S$$

$$B \rightarrow SC_4 \checkmark$$

$$S \rightarrow AB \checkmark$$

$$S \rightarrow AC_5 \checkmark$$

$$C_5 \rightarrow SB$$

$$(F) \quad S \rightarrow aSa \mid bSb \mid a \mid b$$

\Rightarrow Production

$$S \rightarrow a$$

$$S \rightarrow b$$

$$S \rightarrow bSb$$

$$C_1 \rightarrow b$$

$$S \rightarrow C_1 S C_1$$

$$S \rightarrow C_1 C_2$$

$$C_2 \rightarrow SC_1$$

$$S \rightarrow aSa$$

$$C_1 \rightarrow a$$

$$S \rightarrow C_3 S C_3$$

$$S \rightarrow C_3 C_4$$

$$C_4 \rightarrow SC_3$$

Solution

$$S \rightarrow a$$

$$S \rightarrow b$$

$$C_1 \rightarrow b$$

$$S \rightarrow C_1 C_2$$

$$C_2 \rightarrow SC_1$$

$$C_3 \rightarrow a$$

$$S \rightarrow C_3 C_4$$

$$C_4 \rightarrow SC_3$$

$$S \rightarrow a \mid b \mid C_3 C_4 \mid C_1 C_2$$

$$C_1 \rightarrow b$$

$$C_2 \rightarrow SC_1$$

$$C_3 \rightarrow a$$

$$C_4 \rightarrow SC_3$$