Chomsky Normal Form → CFG is in CNF if all the production are of the form

$A \to BC$

Or $A \to a$

Procedure

1. Simplify the grammar i.e. remove
   - ① NULL production
   - ② unit ,,
   - ③ useless ,,

2. **Remove intermediate terminal**

   i.e $A \to BdC$ (Remove d from it)

   ✓ for each terminal α introduce a new Non terminal A_1 and production $A_1 \to \alpha$, replace α by A_1

   ✓ therefore the above production will turn to

   $A \to BDC$

   $D \to d$

3. **Restricting number of NT**

   $A \to A_1 A_2 \ldots A_n$

   Rewrite it as

   $A \to A_1 Z_1$

   $Z_1 \to A_2 Z_2$

   $Z_{n-2} \to A_{n-1} A_n$

Ex. $A \rightarrow BCDA$

$A \rightarrow BA_1$
$A_1 \rightarrow CA_2$
$A_2 \rightarrow DA$

Ex.1. $S \rightarrow AS \mid aAb \mid Bcd$
$A \rightarrow abC \mid Ba$
$B \rightarrow aB \mid b$
$C \rightarrow dC \mid aB \mid d$

Step-1 Grammar is simplified

Step-2 For each terminal introduce a new NT.

$P \rightarrow a \quad Q \rightarrow b \quad R \rightarrow c \quad Z \rightarrow d$

$S \rightarrow AS \mid PAQ \mid BRZ$
$A \rightarrow PQC \mid BP$
$B \rightarrow PB \mid b$
$C \rightarrow ZC \mid PB \mid d$

Step 3 Restricting number of NT

$S \rightarrow AS \mid PS_1 \mid BS_2$
$S_1 \rightarrow AQ$
$S_2 \rightarrow RZ$
$A \rightarrow PA_1 \mid BP$
$A_1 \rightarrow QC$
$B \rightarrow PB \mid b$
$C \rightarrow ZC \mid PB \mid d$
$P \rightarrow a$
$Q \rightarrow b$
$R \rightarrow c$
$Z \rightarrow d$

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Greibach Normal Form

→ A CFG is said to be GNF if all its production are of form

$A \rightarrow ax$

$a \in T$ and $x \in V^*$

Method

1. Simplify the grammar
2. Remove intermediate terminal, no need to remove first appearing terminal
3. if production is form
   a) $A \rightarrow B\alpha$ then replace B by its productio
   b) $A \rightarrow A\alpha \mid \beta$ then replace A by

$A \rightarrow \beta A_1 \mid \beta$

$A_1 \rightarrow \alpha A_1 \mid \alpha$

Ex1 $S \rightarrow AB$

$A \rightarrow aA \mid bB \mid b$

$B \rightarrow b$

Modified grammar

$A \rightarrow aA \mid bB \mid b$

$B \rightarrow b$

$S \rightarrow aAB \mid bBB \mid bB$

Ex2 $S \to abSb \mid aa$

Modified grammar.

$A \to a$

$B \to b$

$S \to aBSB \mid aA$

Ex.3 $S \to AQ \mid b$

$A \to SB \mid a$

Modified grammar

$Z \to a$

$S \to AZ \mid b$

$A \to SB \mid a$

$A \to \underline{A}\,\underline{Z}\,\underline{B} \mid \underline{b}\,\underline{B} \mid \underline{a}$

$A \to bBA_1 \mid aA_1 \mid bB \mid a$

$A_1 \to ZBA_1 \mid ZB$

Remove Z

$A_1 \to aBA_1 \mid aB$

So Resulting G

$Z \to a$

$S \to bBA_1Z \mid aA_1Z$

$S \to bBZ \mid aZ \mid b$

$A \to bBA_1 \mid aA_1 \mid bB \mid a$

$A_1 \to aBA_1 \mid aB$

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Assignment

Convert following grammar into CNF and GNF

① $S \to abAB$
$A \to bAB \mid \wedge$
$B \to BAa \mid A \mid \wedge$

② $S \to AB \mid aB$
$A \to aab \mid \wedge$
$B \to bbA$

③ $S \to ABb \mid a$
$A \to aaA \mid B$
$B \to bAb$

④ $S \to aSA$
$A \to bABC$
$B \to b$
$C \to aBC$