Solution: All the prochctions in the grammar are not in CNF. We have to convert them into CNF keeping the language generating power the same. Let us replace 'a' by D_a, b ' by D_b, and ' c ' by D_c. So, three new productions $D_a \rightarrow a, D_b \rightarrow b$, and$D_c \rightarrow c$ are added to the grammar. By replacing 'a' by D_a, ' $'b'$ by D_b, and ' $'c'$ by D_c, and adding three productions, the modified grammar becomes

$$S \rightarrow ABD_a$$
$$A \rightarrow DaD_aD_b$$
$$B \rightarrow AD_c$$
$$D_a \rightarrow a$$
$$D_b \rightarrow b$$
$$D_c \rightarrow c$$

S → ABDa and A → DaDaDb are not in CNF. Take two non-terminals E and F. Replace AB by E and DaDa by F. So, two new productions E → AB and F → DaDa will be added to the grammer.By replacement and adding the productions, the modified prammar will be

$$S \rightarrow ABD_a$$
$$A \rightarrow DaD_aD_b$$
$$B \rightarrow AD_c$$
$$D_a \rightarrow a$$
$$D_b \rightarrow b$$
$$D_c \rightarrow c$$
$$E \rightarrow AB$$
$$F \rightarrow D_aD_a$$

In the previous grammar, all the productions are in the form of Non-terminal → string of exactly two non-terminals or non-terminal → single terminal. So, the grammar is in CNF.

Example 6.39 Convert the following grammar into CNF.

$$E \rightarrow E + E$$
$$E \rightarrow E^*E$$
$$E \rightarrow id$$

where $\Sigma = (+, ^*, id)$

Solution: Except E → id, all the other productions of the grammar are not in CNF. In the grammar E → E + E and E → E*E, there are two terminals + and *. Take two non-terminals C and D for replacing + and *, respectively. Two new productions will be added to the grammar. By replacing + and ∗, the modified production rules will be

$$E \rightarrow ECE$$
$$E \rightarrow EDE$$
$$E \rightarrow id$$
$$C \rightarrow +$$
$$D \rightarrow ^*$$

In the production rules $E \rightarrow ECE$ and $E \rightarrow EDE$, there are three non-terminals. Replace EC by another non-terminal F and ED by G. So, two new productions $F \rightarrow EC$ and $G \rightarrow ED$ will be added to the grammar. By replacing and adding the new productions, the modified prammar will be