G: S🡪aAbBa

A🡪BBb|ACb

B🡪ADa|CAb

C🡪a

D🡪b

Convert to Chomsky:

S🡪A’T1

T1🡪 AT2

T2🡪 B’T3

T3🡪BA’

A🡪BT4|AT5

A’🡪a

T4🡪 BB’

T5🡪 CB’

B🡪AT6|CT7

B’🡪b

T6🡪 DA’

T7🡪 AB’

C🡪a

D🡪b

Remove Left Recursion on A rule:

S🡪A’T1

T1🡪 AT2

T2🡪 B’T3

T3🡪BA’

A🡪BT4R1|BT4

A’🡪a

T4🡪 BB’

T5🡪 CB’

B🡪AT6|CT7

B’🡪b

T6🡪 DA’

T7🡪 AB’

C🡪a

D🡪b

R1🡪T5R1|T5

Replace B rule because A on the left is lower than B:

S🡪A’T1

T1🡪 AT2

T2🡪 B’T3

T3🡪BA’

A🡪BT4R1|BT4

A’🡪a

T4🡪 BB’

T5🡪 CB’

B🡪 BT4R1T6|BT4T6|CT7

B’🡪b

T6🡪 DA’

T7🡪 AB’

C🡪a

D🡪b

R1🡪T5R1|T5

Remove Left Recursion from B rule:

S🡪A’T1

T1🡪 AT2

T2🡪 B’T3

T3🡪BA’

A🡪BT4R1|BT4

A’🡪a

T4🡪 BB’

T5🡪 CB’

B🡪 CT7R2|CT7

B’🡪b

T6🡪 DA’

T7🡪 AB’

C🡪a

D🡪b

R1🡪T5R1|T5

R2🡪T4R1T6R2|T4T6R2|T4R1T6|T4T6

Replace T7 because A is lower than T7:

S🡪A’T1

T1🡪 AT2

T2🡪 B’T3

T3🡪BA’

A🡪BT4R1|BT4

A’🡪a

T4🡪 BB’

T5🡪 CB’

B🡪 CT7R2|CT7

B’🡪b

T6🡪 DA’

T7🡪 BT4R1B’|BT4B’

C🡪a

D🡪b

R1🡪T5R1|T5

R2🡪T4R1T6R2|T4T6R2|T4R1T6|T4T6

Replace T7 again because B is lower than T7:

S🡪A’T1

T1🡪 AT2

T2🡪 B’T3

T3🡪BA’

A🡪BT4R1|BT4

A’🡪a

T4🡪 BB’

T5🡪 CB’

B🡪 CT7R2|CT7

B’🡪b

T6🡪 DA’

T7🡪 CT7R2T4R1B’|CT7T4R1B’|CT7R2T4B’|CT7T4B’

C🡪a

D🡪b

R1🡪T5R1|T5

R2🡪T4R1T6R2|T4T6R2|T4R1T6|T4T6

Now all the original variables satisfy the condition that the left variable must be higher than itself.

The highest variable that does not have a terminal for every left symbol is T7:

S🡪A’T1

T1🡪 AT2

T2🡪 B’T3

T3🡪BA’

A🡪BT4R1|BT4

A’🡪a

T4🡪 BB’

T5🡪 CB’

B🡪 CT7R2|CT7

B’🡪b

T6🡪 DA’

T7🡪 aT7R2T4R1B’|aT7T4R1B’|aT7R2T4B’|aT7T4B’

C🡪a

D🡪b

R1🡪T5R1|T5

R2🡪T4R1T6R2|T4T6R2|T4R1T6|T4T6

Now T6:

S🡪A’T1

T1🡪 AT2

T2🡪 B’T3

T3🡪BA’

A🡪BT4R1|BT4

A’🡪a

T4🡪 BB’

T5🡪 CB’

B🡪 CT7R2|CT7

B’🡪b

T6🡪 bA’

T7🡪 aT7R2T4R1B’|aT7T4R1B’|aT7R2T4B’|aT7T4B’

C🡪a

D🡪b

R1🡪T5R1|T5

R2🡪T4R1T6R2|T4T6R2|T4R1T6|T4T6

Now for B and T5:

S🡪A’T1

T1🡪 AT2

T2🡪 B’T3

T3🡪BA’

A🡪BT4R1|BT4

A’🡪a

T4🡪 BB’

T5🡪 aB’

B🡪 aT7R2|aT7

B’🡪b

T6🡪 bA’

T7🡪 aT7R2T4R1B’|aT7T4R1B’|aT7R2T4B’|aT7T4B’

C🡪a

D🡪b

R1🡪T5R1|T5

R2🡪T4R1T6R2|T4T6R2|T4R1T6|T4T6

Now for T4:

S🡪A’T1

T1🡪 AT2

T2🡪 B’T3

T3🡪BA’

A🡪BT4R1|BT4

A’🡪a

T4🡪 aT7R2B’|aT7B’

T5🡪 aB’

B🡪 aT7R2|aT7

B’🡪b

T6🡪 bA’

T7🡪 aT7R2T4R1B’|aT7T4R1B’|aT7R2T4B’|aT7T4B’

C🡪a

D🡪b

R1🡪T5R1|T5

R2🡪T4R1T6R2|T4T6R2|T4R1T6|T4T6

Now for A:

S🡪A’T1

T1🡪 AT2

T2🡪 B’T3

T3🡪BA’

A🡪aT7R2T4R1| aT7T4R1|aT7R2T4|aT7T4

A’🡪a

T4🡪 aT7R2B’|aT7B’

T5🡪 aB’

B🡪 aT7R2|aT7

B’🡪b

T6🡪 bA’

T7🡪 aT7R2T4R1B’|aT7T4R1B’|aT7R2T4B’|aT7T4B’

C🡪a

D🡪b

R1🡪T5R1|T5

R2🡪T4R1T6R2|T4T6R2|T4R1T6|T4T6

Now for T1, T2, and T3 and S:

S🡪aT1

T1🡪 aT7R2T4R1T2| aT7T4R1T2| aT7R2T4T2| aT7T4T2

T2🡪 bT3

T3🡪 aT7R2A’| aT7A’

A🡪aT7R2T4R1| aT7T4R1|aT7R2T4|aT7T4

A’🡪a

T4🡪 aT7R2B’|aT7B’

T5🡪 aB’

B🡪 aT7R2|aT7

B’🡪b

T6🡪 bA’

T7🡪 aT7R2T4R1B’|aT7T4R1B’|aT7R2T4B’|aT7T4B’

C🡪a

D🡪b

R1🡪T5R1|T5

R2🡪T4R1T6R2|T4T6R2|T4R1T6|T4T6

Now for the recursive steps:

S🡪aT1

T1🡪 aT7R2T4R1T2| aT7T4R1T2| aT7R2T4T2| aT7T4T2

T2🡪 bT3

T3🡪 aT7R2A’| aT7A’

A🡪aT7R2T4R1| aT7T4R1|aT7R2T4|aT7T4

A’🡪a

T4🡪 aT7R2B’|aT7B’

T5🡪 aB’

B🡪 aT7R2|aT7

B’🡪b

T6🡪 bA’

T7🡪 aT7R2T4R1B’|aT7T4R1B’|aT7R2T4B’|aT7T4B’

C🡪a

D🡪b

R1🡪 aB’R1| aB’

R2🡪 aT7R2B’R1T6R2| aT7B’R1T6R2| aT7R2B’T6R2| aT7B’T6R2| aT7R2B’R1T6| aT7B’R1T6| aT7R2B’T6| aT7B’T6

And that is our final rule replacement. The grammar is now in Greibach Normal Form.