Ans. 2

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CFG is in Chomsky Normal Form if all production rules satisfy one of the following conditions

(1). Non-terminal generating terminal

$$X \to x$$

(2) Non-terminal generating two terminal

$$X \to YZ$$

(3). Start Symbol generating ε.

$$S \to \varepsilon$$

$$\Rightarrow \quad S \to ASA \mid aB, \; A \to B \mid S, \; B \to b \mid \varepsilon$$

$\Rightarrow$ (1) S appears in RHS, we add a new state S_0 & $S_0 \to S$ is added to production set & it becomes

$$S_0 \to S, \; S \to ASA \mid aB, \; A \to B \mid S, \; B \to b \mid \varepsilon$$

(2). we will remove the null productions

$$B \to \varepsilon \quad \& \quad A \to \varepsilon$$

$\to$ After removing $B \to \varepsilon$, production set becomes

$\to \quad S_0 \to S, \; S \to ASA \mid aB \mid a, \; A \to B \mid S \mid \varepsilon, \; B \to b$

After removing A→e, productions set becomes

$S_0 \to S$, $S \to ASA \mid aB \mid a \mid AS \mid SA \mid S$, $A \to B \mid S$, $B \to b$

(3). Now, ~~we too~~ Remove the unit productions.

After removing S→S, production becomes

$S_0 \to S$, $S \to ASA \mid aB \mid a \mid AS \mid SA$, $A \to B \mid S$, $B \to b$

After removing $S_0 \to S$ production becomes

$S_0 \to ASA \mid aB \mid a \mid AS \mid SA$, $S \to ASA \mid aB \mid a \mid AS \mid SA$
$A \to B \mid S$, $B \to b$

After removing A→B, production becomes,
$S_0 \to ASA \mid aB \mid a \mid AS \mid SA$, $S \to ASA \mid aB \mid a \mid AS \mid SA$

$A \to S \mid b$
$B \to b$

→ After removing A→S, production becomes
$S_0 \to ASA \mid aB \mid a \mid a \mid AS \mid SA$, $S \to ASA \mid aB \mid a \mid AS \mid SA$
$A \to b \mid ASA \mid aB \mid a \mid AS \mid SA$, $B \to b$

(4), we will find out more than two variables in RHS

$S_0 \to ASA$, $S \to ASA$, $A \to ASA$
violate two Non-terminals in RHS.

→ The we used Replace each $A \to B_1 - B_n$
$\qquad n > 2$

with $A \to B_1 C \quad C \to B_2 - B_n$.

& if RHS of any production is
$A \to aB$; terminal & A, B are
non-terminal, ∴ then replaced by
$A \to xB$ & $x \to a$.

→ $S_0 \to AX | aB | a | AS | SA$
$S \to AX | aB | a | AS | SA$
$A \to b | AX | aB | a | AS | SA$
$B \to b$
$X \to SA$

(5)   Change production $S_0 \to aB$,
$\qquad\qquad\qquad\qquad S \to aB$
$\qquad\qquad\qquad\qquad A \to aB$

Final production set becomes

$S_0 \to AX | YB | a | AS | SA$
$S \to AX | YB | a | AS | SA$
$A \to bA \to b | AX | YB | a | AS | SA$
$B \to b$
$X \to SA$
$Y \to a$.