1 (a)

$S \rightarrow AACD$

$A \rightarrow aAb \mid ac \mid \varepsilon$

$C \rightarrow aC \mid a$

$D \rightarrow aDa \mid bDb \mid d \mid \varepsilon$

Step-1: The null variables are A and D.

After removing ε-productions,

$S \rightarrow AACD \mid ACD \mid CD \mid AAC \mid AC \mid C$

$A \rightarrow aAb \mid ac \mid ab$

$C \rightarrow aC \mid a$

$D \rightarrow aDa \mid bDb \mid d \mid aa \mid bb$

Step-2: After removing ~~unit~~ unit production, we get,

$S \rightarrow AACD \mid ACD \mid CD \mid AAC \mid AC \mid aC \mid a$

$A \rightarrow aAb \mid ac \mid ab$

$C \rightarrow aC \mid a$

$D \rightarrow aDa \mid bDb \mid d \mid aa \mid bb$

All the variables are reachable and have terminal productions.

Step-3: After converting to CNF,

$S \rightarrow XY \mid ZD \mid CD \mid XC \mid AC \mid PC \mid a$

$A \rightarrow MQ \mid PR \mid PQ$

$C \rightarrow PC \mid a$

$D \rightarrow NP \mid OQ \mid PP \mid QQ \mid d$

$X \rightarrow AA$

$Y \rightarrow CD$

$Z \rightarrow AC$

$P \rightarrow a$

$Q \rightarrow b$

$R \rightarrow C$

$M \rightarrow PA$

$N \rightarrow PD$

$O \rightarrow QD$

(Ans)

1(b)

$S \rightarrow XSB \mid \varepsilon$

$X \rightarrow pXS \mid p$

$B \rightarrow SbS \mid X \mid bb$

Step-1: Adding new state,

$S' \rightarrow S$

$S \rightarrow XSB \mid \varepsilon$

$X \rightarrow pXS \mid p$

$B \rightarrow SbS \mid X \mid bb$

Step-2: Variable S is nullable.

Removing ε-productions,

$S' \rightarrow S$

$S \rightarrow XSB \mid XB$

$X \rightarrow pXS \mid p \mid pX$

$B \rightarrow SbS \mid X \mid bb \mid bS \mid Sb \mid b$

Step-3: Removing unit productions,

$S' \rightarrow XSB \mid XB$

$S \rightarrow XSB \mid XB$

$X \rightarrow pXS \mid p \mid pX$

$B \rightarrow SbS \mid pXS \mid p \mid pX \mid bb \mid bS \mid Sb \mid b$

Step-4: Removing unnecessary variables,

$S' \rightarrow$ ~~XSB~~ XB

$X \rightarrow pX \mid p$

$B \rightarrow pX \mid p \mid bb \mid b$

Step-5: Converting to CNF,

$S' \rightarrow XB$

$X \rightarrow YX \mid p$

$B \rightarrow YX \mid p \mid WW \mid b$

$W \rightarrow b$

$Y \rightarrow p$

(Ans.)

1(c)

$S \rightarrow aAa \mid bBb \mid \varepsilon$

$A \rightarrow C \mid a$

$B \rightarrow C \mid b$

$C \rightarrow CD \mid \varepsilon$

$D \rightarrow A \mid B \mid ab$

Step-1: Removing ε-productions.

$S \rightarrow aAa \mid bBb \mid aa \mid bb$

$A \rightarrow C \mid a$

$B \rightarrow C \mid a$

$C \rightarrow CD \mid D$

$D \rightarrow A \mid B \mid ab$

Step-2: Removing unit productions

$S \rightarrow aAa \mid bBb \mid aa \mid bb$

$A \rightarrow CD \mid a \mid b \mid ab$

$B \rightarrow CD \mid a \mid b \mid ab$

$C \rightarrow CD \mid a \mid b \mid ab$

$D \rightarrow CD \mid a \mid b \mid ab$

All the variables are reachable and have terminal productions.

Step-3: Converting to CNF,

$S \rightarrow YM \mid ZN \mid YY \mid ZZ$

$A \rightarrow CD \mid YZ \mid a \mid b$

$B \rightarrow CD \mid YZ \mid a \mid b$

$C \rightarrow CD \mid YZ \mid a \mid b$

$D \rightarrow CD \mid YZ \mid a \mid b$

$Y \rightarrow a$

$Z \rightarrow b$

$M \rightarrow AY$

$N \rightarrow BZ$

(Ans)

2 (a)

{S,X,Y,Z}			
{X,Z}	{S,X,Z}		
{Z}	{S,X}	{S,X,Y}	
{X}	{X}	{Y,Z}	{Y,Z}
a	a	b	b

We can see that (1,4) contains S variable.

∴ "aabb" ∈ L(G)

2 (b)

{S,Z}				
{S,X,Z}	{Y,Y}			
{Y}	{Y}	{S,Z}		
{Y}	{S,Z}	{S,X}	{S,Z}	
{X,Z}	{X,Z}	{Y}	{X,Z}	{X}
a	a	b	a	b

(1,5) contains S variable.

∴ "aabab" ∈ L(G)

2 (c)

{S, R}				
{S, R}	{S, X}			
∅	{S, X}	{S}		
∅	{X}	{S, X, Y, R}	∅	
{S, Z, T}	{X, Y, Z}	{S, Z, T}	{S, Z, T}	{X, Y, Z}
a	b	a	a	b

(1,5) contains S variable.

∴ "abaab" ∈ L(G)