Context Free Grammar

I. Write a CFG for each of the following languages

1) $L = \{a^n b^m a^n \mid m, n > 0\}$

$S \rightarrow aSa \mid aAa$

$A \rightarrow bA \mid b$

2) $L = \{a^n b^m c^m d^{2n} \mid m, n \geq 0\}$

$S \rightarrow aSdd \mid A$

$A \rightarrow bAc \mid \varepsilon$

3) Odd length palindromes over {a, b}

$S \rightarrow a \mid b \mid aSa \mid bSb$

4) $L = \{a^n b^m \mid 0 \leq n \leq m \leq 2n\}$

$S \rightarrow aSb \mid aSbb \mid \varepsilon$

5) $L = \{a^+ b^*\}$

$S \rightarrow aS \mid aA$

$A \rightarrow bA \mid \varepsilon$

6) Strings over {a, b} that contain exactly 2 b's

$S \rightarrow AbAbA$

$A \rightarrow aA \mid \varepsilon$

7) Strings over {a, b} that contain at least 2 b's

$S \rightarrow AbAbA$

$A \rightarrow aA \mid bA \mid \varepsilon$

8) Even length strings over {a, b}

$S \rightarrow aA \mid bA \mid \varepsilon$

$A \rightarrow aS \mid bS \mid \varepsilon$

9) Strings over {a, b} with even number of b's

$S \rightarrow aS \mid bA \mid \varepsilon$

$A \rightarrow aA \mid bS$

10) Strings with even number of a's and b's

$S \rightarrow aA \mid bB \mid \varepsilon$

$A \rightarrow aS \mid bC$

$B \rightarrow aC \mid bS$

$C \rightarrow aB \mid bA$

11) Strings with even number of a's and odd number of b's

S → aA | bB

A → aS | bC

B → aC | bS | ε

C → aB | bA

12) Strings with odd number of a's and even number of b's

S → aA | bB

A → aS | bC | ε

B → aC | bS

C → aB | bA

13) Strings with odd number of a's and b's

S → aA | bB

A → aS | bC

B → aC | bS

C → aB | bA | ε

14) Strings over {a, b, c} that do not contain abc as substring

S → aA | bS | cS | ε

A → aA | bB | cS | ε

B → aA | bS | ε

15) Strings with $n_a(w) = n_b(w)$

S → aSb | bSa | SS | ε OR

S → aSbS | bSaS | ε OR

S → aA | bB | ε

A → aAA | bS

B → aS | bBB

16) Strings without ba as substring

S → aS | bA | ε

A → bA | ε OR

S → aS | Sb | ε

17) L = {0*1(0+1)*}

S → 0S | 1A

A → 0A | 1A | ε

18) L = {(011+1)*(01)*}

S → 011S | 1S | S01 | ε

19) $L = \{a^n b^n \mid n > 0\}$

$S \rightarrow aSb \mid ab$

20) $L = \{a^n b^n c^m \mid m, n > 0\}$

$S \rightarrow AB$

$A \rightarrow aAb \mid ab$

$B \rightarrow cB \mid c$

21) $L = \{a^n b^n c^m d^m \mid m, n > 0\}$

$S \rightarrow AB$

$A \rightarrow aAb \mid ab$

$B \rightarrow cBd \mid cd$

22) $L = \{a^n b^m \mid n > m > 0\}$

$S \rightarrow aSb \mid aAb$

$A \rightarrow aA \mid a$

23) $L = \{wcw^r \mid w \in \{a, b\}^*\}$

$S \rightarrow aSa \mid bSb \mid c$

24) $L = \{a^n \mid n > 0\}$

$S \rightarrow aS \mid a$

25) $L = \{a^n b^m \mid m, n > 0\}$

$S \rightarrow aS \mid aA$

$A \rightarrow bA \mid b$

26) $L = \{a^{2n} \mid n > 0\}$

$S \rightarrow aaS \mid aa$

27) $L = \{(ab)^n \mid n > 0\}$

$S \rightarrow abS \mid ab$

28) $L = \{0^i 1^j 0^k \mid j > i + k\}$

$S \rightarrow ABC$

$A \rightarrow 0A1 \mid \varepsilon$

$B \rightarrow 1B \mid 1$

$C \rightarrow 1C0 \mid \varepsilon$

29) $L = \{a^i b^j \mid i \leq 2j\}$

$S \rightarrow aSb \mid aaSb \mid Sb \mid \varepsilon$

30) $L = \{w \mid n_a(w) = n_b(w) + 1\}$

$S \rightarrow AaA$

$A \rightarrow aAb \mid bAa \mid AA \mid \varepsilon$

31) Strings of even length such that the two symbols in the middle are same

$S \rightarrow aSa \mid aSb \mid bSa \mid bSb \mid aa \mid bb$