Q.1

$P = \{a^n b^n \mid n > 0\}, Q = \{a^n c b^n \mid n > 0\}$

Which of the following is correct ?

(A) Only P is a DCFL
(B) Only Q is a DCFL
(C) Both P and Q are DCFL
(D) None of P or Q are DCFL

Q.2

$$L_1 = \{wxyx \mid w, x, y \in (0+1)^+\}$$

$$L_2 = \{xy \mid x, y \in (a+b)^*, |x| = |y|, x \neq y\}$$

Which one of the following is TRUE?

(A)　L_1 is regular and L_2 is context-free.

(B)　L_1 is context-free but not regular and L_2 is context-free.

(C)　Neither L_1 nor L_2 is context-free.

(D)　L_1 is context-free but L_2 is not context-free.

Q.3　Which of the following languages is/are NOT context-free ?

(A) $\{ww^R \mid w \in \{a, b\}^*\}$
(B) $\{wa^n b^n w^R \mid w \in \{a, b\}^*, n \geq 0\}$
(C) $\{wa^n w^R b^n \mid w \in \{a, b\}^*, n \geq 0\}$
(D) $\{a^n b^i \mid i \in \{n, 3n, 5n\}, n \geq 0\}$

Q.4

Which of the following languages are context free ?

(A)　$\{a^m b^n c^p d^q \mid m + p = n + q, \text{ where } m, n, p, q \geq 0\}$
(B)　$\{a^m b^n c^p d^q \mid m = n \text{ and } p = q, \text{ where } m, n, p, q \geq 0\}$
(C)　$\{a^m b^n c^p d^q \mid m = n = p \text{ and } p \neq q, \text{ where } m, n, p, q \geq 0\}$
(D)　$\{a^m b^n c^p d^q \mid mn = p + q, \text{ where } m, n, p, q \geq 0\}$

Q.5

If L_1, L_2 are context-free and R is regular then which of the following is/are necessarily context-free ?

(A) $L_1 \cup L_2$
(B) $\overline{L_1}$
(C) $L_1 \setminus R$
(D) $L_1 \cap L_2$

Q.6 Identify the language generated by the following grammar, where S is the start variable.

$$S \rightarrow XY$$
$$X \rightarrow aX \mid a$$
$$Y \rightarrow aYb \mid \epsilon$$

(A) $\{a^m b^n \mid m \geq n, \ n > 0\}$
(C) $\{a^m b^n \mid m > n, \ n \geq 0\}$

(B) $\{a^m b^n \mid m \geq n, \ n \geq 0\}$
(D) $\{a^m b^n \mid m > n, \ n > 0\}$

Q.7 **Consider the following expression grammar G :** (E is the start symbol in all the grammars)

```
E -> E - T | T
T -> T + F | F
F -> (E) | id
```

Which of the following grammars is not left recursive. but is equivalent to G?

(A)
```
E -> E - T | T
T -> T + F | F
F -> (E) | id
```

(B)
```
E -> TE'
E' -> -TE' | ε
T -> T + F | F
F -> (E) | id
```

(C)
```
E -> TX
X -> -TX | ε
T -> FY
Y -> +FY | ε
F -> (E) | id
```

(D)
```
E -> TX | (TX)
X -> -TX | +TX | ε
T -> id
```

Q.8 Consider the following languages.

$$L_1 = \{a^p \mid p \text{ is a prime number}\}$$
$$L_2 = \{a^n b^m c^{2m} \mid n \geq 0, m \geq 0\}$$
$$L_3 = \{a^n b^n c^{2n} \mid n \geq 0\}$$
$$L_4 = \{a^n b^n \mid n \geq 1\}$$

Which of the following is/are correct ?

(A) L_1 is context-free but not regular.
(B) L_2 is not context-free.
(C) L_3 is not context-free
(D) L_4 is deterministic context-free.

Q.9 Consider the following context-free grammar over the alphabet $\Sigma = \{a, b, c\}$ with S as the start symbol:

$S \to abScT \mid abcT$
$T \to bT \mid b$

Which one of the following represents the language generated by the above grammar?

(A) $\{(ab)^n (cb)^n \mid n \geq 1\}$
(B) $\{(ab)^n cb^{m_1} cb^{m_2} \ldots cb^{m_n} \mid n, m_1, m_2, \ldots, m_n \geq 1\}$
(C) $\{(ab)^n (cb^m)^n \mid m, n \geq 1\}$
(D) $\{(ab)^n (cb^n)^m \mid m, n \geq 1\}$

Q.10 G is a grammar with start symbol S and following productions

$$S \to SaS \mid aSb \mid bSa \mid SS \mid \epsilon$$

Which of the following strings is/are NOT generated by G ?

(A) abab   (B) aaab   (C) abbaa   (D) babba

Q.11 Consider the context-free grammars over the alphabet $\{a, b, c\}$ given below. S and T are non-terminals.

$G_1 : S \to aSb \mid T, \quad T \to cT \mid \epsilon$

$G_2 : S \to bSa \mid T, \quad T \to cT \mid \epsilon$

The language $L(G_1) \cap L(G_2)$ is

(A) Finite.   (B) Not finite but regular.

(C) Context-Free but not regular.   (D) Not context free

Q.12 $L_1 = \{a^n b^n c^m \mid n, m > 0\}, L_2 = \{a^n b^m c^m \mid n, m > 0\}, P = L_1 \cup L_2, Q = L_1 \cap L_2$
Which of the following is true ?
     (A) Only P is context-free.
     (B) Only Q is context-free.
     (C) Both P and Q are context-free.
     (D) None of P or Q are context-free.

Q.13 Which of the following languages is generated by the given grammar?

$$S \longrightarrow aS \mid bS \mid \varepsilon$$

(A) $\{a^n b^m \mid n,m \ge 0\}$

(B) $\{w \in \{a,b\}^* \mid w \text{ has equal number of a's and b's }\}$

(C) $\{a^n \mid n \ge 0\} \cup \{b^n \mid n \ge 0\} \cup \{a^n b^n \mid n \ge 0\}$

(D) $\{a,b\}^*$

Q.14 Consider the following context-free grammars:
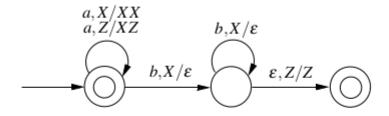
G_1: $S \to aS|B$, $B \to b|bB$

G_2: $S \to aA|bB$, $A \to aA|B|\varepsilon$, $B \to bB|\varepsilon$

Which one of the following pairs of languages is generated by G_1 and G_2, respectively?

(A) $\{a^m b^n | m > 0 \text{ or } n > 0\}$ and $\{a^m b^n | m > 0 \text{ and } n > 0\}$

(B) $\{a^m b^n | m > 0 \text{ and } n > 0\}$ and $\{a^m b^n | m > 0 \text{ or } n \ge 0\}$

(C) $\{a^m b^n | m \ge 0 \text{ or } n > 0\}$ and $\{a^m b^n | m > 0 \text{ and } n > 0\}$

(D) $\{a^m b^n | m \ge 0 \text{ and } n > 0\}$ and $\{a^m b^n | m > 0 \text{ or } n > 0\}$

Q.15 Consider the transition diagram of a PDA given below with input alphabet $\Sigma = \{a,b\}$ and stack alphabet $\Gamma = \{X,Z\}$. Z is the initial stack symbol. Let L denote the language accepted by the PDA.

Which one of the following is **TRUE**?

(A) $L = \{a^n b^n | n > 0\}$ and is not accepted by any finite automata

(B) $L = \{a^n | n \ge 0\} \cup \{a^n b^n | n \ge 0\}$ and is not accepted by any deterministic PDA

(C) L is not generated by any unrestricted grammar

(D) $L = \{a^n | n \ge 0\} \cup \{a^n b^n | n \ge 0\}$ and is deterministic context-free

Q.16 Consider a CFG G with start symbol S and following production rules:

Rule 1 : $S \to aA$
Rule 2 : $S \to a$
Rule 3 : $A \to Sb$

In which order are the rules used in the *leftmost derivation* of the string aab.

(A) 1 3 2
(B) 2 2 3
(C) 2 3 1
(D) aab cannot be derived in G.

Q.17 $\overline{L}$ is a DCFL. Which of the following is/are true ?
(A) L is generated by an unambiguous CFG.
(B) L is generated by a CSG.
(C) L is generated by a regular grammar.
(D) L is generated by an unrestricted grammar.