Regular Expressions

Write a regular expression for each of the following questions

I. $\Sigma = \{a, b\}$

1) Strings with odd number of b's
   a*(ba*ba*)*ba*
2) Strings that do not end with aaa
   (ε+(a+b)*b)(ε+a+aa)
3) Strings that contain both aa and bab as substrings
   (a+b)*(aa(a+b)*bab+bab(a+b)*aa)(a+b)*
4) Strings with number of a's divisible by 3
   (b*ab*ab*ab*)*
5) $L = \{a^{2n}b^{2m} \mid n \geq 0, m \geq 0\}$
   (aa)*(bb)*
6) Strings that contain aa or bb
   (a+b)*(aa+bb)(a+b)*
7) Strings that contain exactly 2 b's
   a*ba*ba*
8) Strings that contain at least 2 b's
   (a+b)*b(a+b)*b(a+b)*
9) Strings that contain even number of b's
   (a*ba*ba*)*
10) Strings that do not contain aa
    (b+ab)*(ε+a)
11) Strings that begin with ba and end with ab and contain aa
    ba(ε+(a+b)*aa(a+b)*+a(a+b)*+(a+b)*a)ab
12) Length divisible by 6
    ((a+b)(a+b)(a+b)(a+b)(a+b)(a+b))*
13) At most one pair of consecutive a's
    (b+ab)*(ε+aa)(b+ba)*
14) Fifth last symbol is a
    (a+b)*a(a+b)(a+b)(a+b)(a+b)
15) $L = \{a^n b^m \mid n \geq 1, m \geq 1, mn \geq 3\}$
    a*(aaab+aabb+abbb)b*

16) L = $\{a^n b^m \mid n \geq 4, m \leq 3\}$

aaaaa*(ε+b+bb+bbb)

17) Strings with exactly 1 a

b*ab*

18) Strings with not more than 3 a's

b*(ε+a)b*(ε+a)b*(ε+a)b*

19) Strings with no run of a's greater than two

((ε+a+aa)b)*(ε+a+aa)

20) L = {a, ab, abb, abbb, …}

ab*

21) Strings that start and end with one or more a's and have nothing but b's inside

aa*b*a*a

22) Strings that have all a's before all b's

a*b*

II. Σ = {a, b, c}

1) Strings with at least one a and one b

c*(a(a+c)*b+b(b+c)*a)(a+b+c)*

2) Strings that do not contain bc

(c+b*a)*b*

3) Strings that have a, b and c occurring only once

a(bc+cb)+b(ac+ca)+c(ab+ba)

III. Σ = {0, 1}

1) Strings with odd number of 1's followed by even number of 0's

1(11)*(00)*

2) Strings that end with 1 and do not contain 00

(1+01)*(0+ε)1

3) Strings that end with 00 or 11

(0+1)*(00+11)

4) Strings that do not contain 101 as substring

(0+11*00)*1*(ε+10)

5) Strings containing both 11 and 010

(0+1)*(11(0+1)*010+010(0+1)*11)(0+1)*

6) Strings having at most two 0's

   $1^*(\varepsilon+0)1^*(\varepsilon+0)1^*$

7) Strings having at most one pair of consecutive 1's

   $(\varepsilon+1)(0+01)^*(\varepsilon+1)(0+01)^*$

8) Strings with alternating 0's and 1's

   $(\varepsilon+1)(01)^*(\varepsilon+0)$

9) Strings that do not have 11

   $(0+10)^*(\varepsilon+1)$

10) Strings in which all consecutive 0's come before all consecutive 1's

    $(\varepsilon+1)(0+01)^*(1+10)^*$

11) Strings that begin with 1 and do not contain 00

    $1(1+01)^*(0+\varepsilon)$

12) Strings with exactly two occurrences of 00

    $(1+01)^*00(\varepsilon+1(1+01)^*0)0(1+10)^*$

13) Strings with at most two occurrences of 00

    $(1+01)^*(\varepsilon+00+000+001(1+01)^*00)(1+10)^*$

14) Strings that end with 01

    $(0+1)^*01$

15) Strings that do not end with 01

    $\varepsilon+1+(0+1)^*(0+11)$

16) Strings with even number of 0's

    $(1^*01^*01^*)^*$

17) $L = \{(11)^n \mid n \geq 0\}$

    $(11)^*$

18) Strings ending with 011

    $(0+1)^*011$

IV. $\Sigma = \{0, 1, 2\}$

1) Strings with any number of 0's followed by any number of 1's followed by any number of 2's

   $0^*1^*2^*$

2) $L = \{0^i1^j2^k \mid i, j, k > 0\}$

   $00^*11^*22^*$