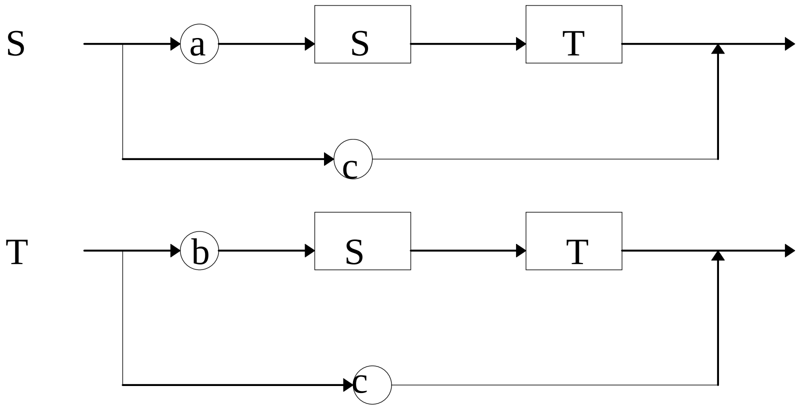
Problem 1. A syntax chart is given as follows:



(1) Write a recursive descent parser for this chart in C, Pascal, or Java. A pseudo code notation is allowed, similar to the notes. 6 marks

(2) The trace for the string acc! where ! is an end marker is given as follows:

History	Input string	Comment
S	acc!	Consume a
S	cc!	Enter S
SS	cc!	Consume c
SS	c!	Exit from S
S	c!	Enter T
ST	c!	Consume c
ST	!	Exit from T
S	!	Exit from S
empty	!	Accept

Following this example, trace your parser with the string aaccbcc! 6 marks

Problem 2. The following PL/0 program multiplies a and b and stores the result in z.

```
const a=4, b=3;
var x,y,z;
procedure P;
begin
  if y>0 then begin
    y:=y-1;  z:=z+x;
    call P;
  end;
end;
begin
  x:=a; y:=b;
  call P;
  write(z);
end.
```

The corresponding object code is given as follows:

```
 0   jmp 0 17
 1   jmp 0 2
 2   inc 0 3
 3   lod 1 4
 4   lit 0 0
 5   opr 0 12
 6   jpc 0 16
 7   lod 1 4
 8   lit 0 1
 9   opr 0 3
10  sto 1 4
11  lod 1 5
12  lod 1 3
13  opr 0 2
14  sto 1 5
15  cal 1 2
16  opr 0 0
17  inc 0 6
18  lit 0 4
19  sto 0 3
20  lit 0 3
21  sto 0 4
22  cal 0 2
23  lod 0 5
24  wrt 0 0
25  opr 0 0
```

(1) Copy this code onto the answer sheet and give a comment to each instruction describing the meaning in the source program. 8 marks

(2) After procedure P is entered twice and the machine instruction at address 12 is executed the stack becomes as follows: 7 marks

```
0   0   0   4   1   4   1   1   23   1   7   16   4   4
```

Explain the meaning of each element.

(3) Show the contents of the stack after you execute instruction 12 for the third time. 7 marks