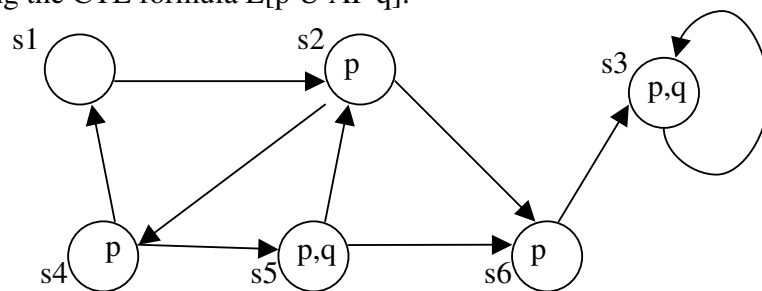


1. **[1 point]** Translate each of the following sentences in a linear time temporal logic formula:
  - a) property P eventually becomes false;
  - b) eventually property P becomes invariantly true;
  - c) as long as the property Q does not hold, the property P will hold;
  - d) if property P holds now and it is always the case that if property P holds at a certain time then property P holds also at the next instant in time, then P always holds.
2. **[2 points]** Use the labelling algorithm to give the set of all states of the following transition system satisfying the CTL formula  $E[p \cup AF q]$ :



3. **[1 point]** Give a CTL model with a state  $s_0$  satisfying the formula  $AFp \wedge AFq$  but not satisfying  $AF(p \wedge q)$ .
4. **[2 points]** Give a derivation for calculating the final state  $\sigma'$  of the following command

if  $x < 3$  then  $x := 3 + y$  else  $x := 3$  fi

when starting from an initial state  $\sigma$  with  $\sigma(x) = 2$  and  $\sigma(y) = 1$ .

5. **[2 points]** Calculate the weakest precondition of the following command

$a[j] := a[i]; a[a[j]] := i$

with respect to the postcondition  $a[j] = i$ , where  $a$  is an array of positive integers, and  $i, j$  are two positive integers.

6. **[2 points]** Give a proof outline for the total correctness of the following Hoare triple:

```

{ 0 ≤ n }
x := 1;
y := n;
while y ≠ 0 do
  y := y-1;
  x := 2*x
od
{ x = 2n }
  
```

The final score is given by the sum of the points obtained.