Question 2b:

i) $\neg p \rightarrow r$

This means, in that particular state, p is false, r is true. For M, s0 |= φ, there is no p and there is r. So it holds. (s0 = r)

For M, s2 |= φ, there is no p and there is r. So it holds. (s2 = q,r)

ii) Ft

This means, any state where t is true will be reached in future. For M, s0 |= φ, s0 doesn't have t and it has a self loop. If it always stays on state s0, then a state with t will never be reached. So it doesn't hold.

For M, s2 |= φ, there is no t, but in the next step to s1(p,t,r) has t. So it holds.

iii) Fq

This means, any state where q is true will be reached in future. For M, s0 |= φ, s0 doesn't have q and it has a self loop. If it always stays on state s0, then a state with q will never be reached. So it doesn't hold.

For M, s2 |= φ, there is q in s2(q,r). So it holds.

iv) G (r ∨ q)

This means, for every state starting from initial state, there is r or q. For M, s0 |= φ, every state is reachable from s0 and each of them has r or q in it(s0(r), s1(p,t,r), s2(q,r), s3(p,q)). So it holds.

For M, s2 |= φ, s1 and s2 is reachable from s2. Both of them have r or q in them. So it holds.