Topics in Concurrency: Problem sheet 3

- 1. Prove briefly that the CTL formula $A[B \cup C] \equiv \neg E[\neg C \cup \neg B \land \neg C] \land \neg EG \neg C$ is statisfied in a state *s* iff for all paths from *s* it is the case that *B* holds until *C* holds.
- 2. Given any Petri net, there is a transition system in which states correspond to reachable markings of the net from the drawn initial marking and transitions are given by the token game.

Draw the transition system of the following *basic* Petri net, explicitly writing down its set of states (recall that in a basic Petri net, all conditions implicitly have capacity 1).



3. Draw the transition system of the following general Petri net, explicitly writing down its set of states (i.e. markings, which are multisets: these can be written as e.g. $\{x, x, y\}$ for the multiset in which x occurs twice).



4. Why in general do we not allow the multiset of pre-conditions of any transition to be an ∞ -multiset?

- 5. Considering *basic* Petri nets, prove that if $\mathcal{M} \xrightarrow{e_1} \mathcal{M}_1 \xrightarrow{e_2} \mathcal{M}'$ and e_1 and e_2 are independent in the sense that $(\bullet e_1 \cup e_1 \bullet) \cap (\bullet e_2 \cup e_2 \bullet) = \emptyset$ then there exists a marking \mathcal{M}_2 such that $\mathcal{M} \xrightarrow{e_2} \mathcal{M}_2 \xrightarrow{e_1} \mathcal{M}'$.
- 6. Attempt the following three past exam questions:
 - 2005 Paper 9 Question 16
 - 2011 Paper 9 Question 13
 - 2013 Paper 9 Question 13