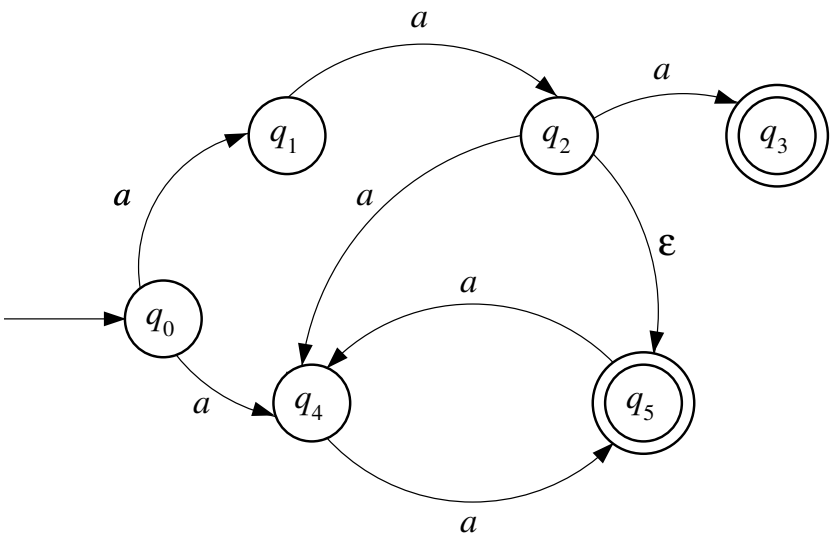
2011 Paper 2 Question 8

Regular Languages and Finite Automata

(*a*) Give a regular expression r over the alphabet $\Sigma = \{a, b, c\}$ such that the language determined by r consists of all strings that contain at least one occurrence of each symbol in Σ. Briefly explain your answer. [5 marks]

(*b*) Let L be the language accepted by the following non-deterministic finite automaton with ε-transitions:



(*i*) Draw a deterministic finite automaton that accepts L.

(*ii*) Write down a regular expression that determines L.

Briefly explain your answers. [5 marks]

(*c*) Show that if a deterministic finite automaton M accepts any string at all, then it accepts one whose length is less than the number of states in M. [5 marks]

(*d*) Is the language

$$\left\{ a^n b^\ell a^k \in \{a, b\}^* \mid k \geq n + \ell \right\}$$

regular? Justify your answer. [5 marks]