13   Types (AMP)

(*a*) Give the rules for typing the ML expressions for function abstraction and application, reference creation, dereferencing and assignment.   [5 marks]

(*b*) What is the *value-restricted* form of the typing rule for let-expressions in ML? Briefly explain what is the purpose of imposing the value restriction on the typing rule.   [5 marks]

(*c*) Which of the following typing judgements are provable in the ML type system with the value-restricted typing rule for let-expressions? Justify your answer in each case.

(*i*) $\{\} \vdash \mathtt{let}\, r = \mathtt{ref}\, (\lambda x(x\, \mathtt{true}))\, \mathtt{in}\, (r := \lambda z(\mathtt{true})) : unit$

(*ii*) $\{\} \vdash \mathtt{let}\, r = \mathtt{ref}\, (\lambda x(x\, \mathtt{true}))\, \mathtt{in}\, (!r\, (\lambda y(r := \lambda z(\mathtt{true})))) : unit$

(*iii*) $\{\} \vdash \mathtt{let}\, r = (\lambda x(\lambda y(x)))\, \mathtt{true}\, \mathtt{in}\, r\, (r\, ()) : bool$

(*iv*) $\{\} \vdash \mathtt{let}\, r = \lambda y(\mathtt{true})\, \mathtt{in}\, r\, (r\, ()) : bool$

[10 marks]