1993 Paper 12 Question 9

Introduction to Functional Programming

Consider the ML definitions

```
fun N f x = x;
fun P a k f x = f a (k f x);
fun Q k l f x = k f (l f x);
fun W a k = Q k (P a N);
fun R k = k W N;
```

Suppose further that K and L have ML definitions of the form

```
val K = P a₁ (P a₂ ... (P aᵢ N) ...);
val L = P b₁ (P b₂ ... (P bⱼ N) ...);
```

In parts (b) to (d) below, assume that f and x are arbitrary ML identifiers of suitable type for the expression containing them.

(a) State the ML types of N and P.   [3 marks]

(b) What does the expression K f x evaluate to?   [3 marks]

(c) What does the expression Q K L f x evaluate to?   [4 marks]

(d) What does the expression R K f x evaluate to?   [10 marks]

1