Modula-3

Explain the purposes of the Modula-3 reserved words NIL, NULL, REFANY and TYPECASE and describe how they are used in the following program.

```
MODULE Sub EXPORTS Main;

IMPORT IO, Fmt;

TYPE
    RefLink = REF Link;
    Link = RECORD val : CARDINAL; next : RefLink := NIL END;

PROCEDURE ToText (r : REFANY) : TEXT =
BEGIN
    TYPECASE r OF
        NULL => RETURN "NIL"
    | RefLink (r1) => RETURN Fmt.Int (r1^.val) & "::" &
                       ToText(r1^.next)
    ELSE
        RETURN "** Unknown Type **"
    END
END ToText;

VAR
    jack : RefLink;
    jill := NEW (RefLink, val := 4);

BEGIN
    jill^.next := NEW (RefLink, val := 7,
                       next := NEW (RefLink, val := 11));
    IO.Put (ToText(jack) & "\n");
    IO.Put (ToText(jill) & "\n")
END Sub. [6 marks]
```

What is output by the program? Explain how this comes about. [4 marks]

Explain the use of the Modula-3 functions ISTYPE and NARROW. [4 marks]

Suppose TYPECASE were missing from Modula-3. Rewrite the procedure ToText using ISTYPE instead. Explain the operation of the revised procedure. [6 marks]