A-LEVEL COMPUTER SCIENCE • EXERCISE SHEET

16.2 Translation Software

Name: _____ Class: _____ Date: _____ **Total: 17 marks**

KEY WORDS syntax diagram 语法图 • reverse polish notation 逆波兰表示法 • lexical analysis 词法分析 • interpreter 解释器 • machine code 机器码

Objective

Build the skills to answer exam questions on **translation software** — interpreters, the stages of compilation, BNF grammar and Reverse Polish Notation.

You must be able to:

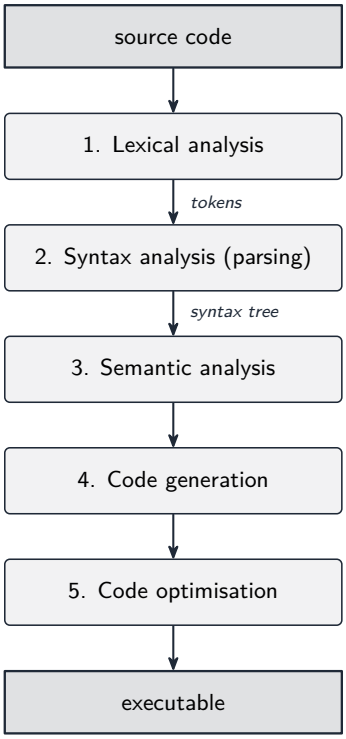
- describe how an **interpreter** runs a program and the **stages of compilation**
- read and write **BNF** production rules
- convert and evaluate **Reverse Polish Notation** (RPN)

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ Interpreter vs compiler

An **interpreter** translates and **runs each statement at once** — no executable is produced; errors stop it immediately; fast to develop, slower to run. A **compiler** translates the **whole** program to machine code first, in phases:



Each stage's job: **lexical** — group characters into **tokens** (and build the symbol table); **syntax** — check the tokens follow the grammar and build a **syntax tree**; **semantic** — check meaning (e.g. types match); **code generation** — produce the machine code; **optimisation** — make the code **faster / smaller** without changing what it does.

BNF grammar

A **BNF** rule is `<symbol> ::= alternative1 | alternative2`. Terminals are literal text; non-terminals are other rules:

```
<digit>  ::= 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9
<number> ::= <digit> | <number> <digit>
```

A **syntax diagram** shows the same rules **graphically** — any path through the diagram is a valid item. You can read a definition off either form, and check whether a given value (e.g. `42`, `4A`) is valid against it.

Reverse Polish Notation

In **RPN (postfix)** the operator follows its operands — no brackets needed: infix `(3 + 4) * 2` becomes `3 4 + 2 *`. **Evaluate** with a stack: push operands; on an operator pop two, apply, push result.

Token	Stack
`3`	3
`4`	3, 4
`2`	3, 4, 2
`*`	3, 8
`+`	11

2 Practice

Now apply the methods above.

2.1 State **one** difference between a **compiler** and an **interpreter**. [1]

2.2 Name the **first three** stages of compilation, in order. [2]

2.3 State what **lexical analysis** produces. [1]

2.4 Convert the infix expression `3 + 4` to **RPN**. [1]

3 Exam-style questions

3.1 Describe the process of executing a program using an **interpreter**. [4]

3.2 Write a **BNF** rule for `<digit>` that defines a single decimal digit (0–9). [2]

3.3 Convert the infix expression `(3 + 4) * 2` to **RPN**. [2]

3.4 Evaluate the RPN expression `5 2 - 3 *` using a **stack**. Show the stack at each step. [3]

3.5 State the purpose of the **optimisation** stage of compilation. [1]

Solutions

2.1 A **compiler** translates the **whole** program to machine code first (producing an executable); an **interpreter** translates and **runs each statement** as it goes (no executable).

2.2 Lexical analysis → Syntax analysis (parsing) → Semantic analysis.

2.3 Tokens (keywords, identifiers, operators, literals).

2.4 `3 4 +`.

3.1 Any four: it reads a statement, does **lexical** then **syntax** analysis; checks it / its types; **executes** the statement's action immediately; reports any error at once and usually stops; repeats for each statement — no executable is produced — max 4.

3.2 `<digit> ::= 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9`.

3.3 `3 4 + 2 *`.

3.4 Push `5`, push `2`; `-` → pop 2 and 5, `5 - 2 = 3`, push `3`; push `3` (stack `3, 3`); `*` → `3 * 3 = 9`, result **9**.

3.5 To make the object (machine) code run **faster** and/or use **less memory**, without changing the result it produces.