Cambridge Assessment International Education

Cambridge International AS & A Level

COMPUTER SCIENCE **9618/32**

Paper 3 Advanced Theory **May/June 2023**

MARK SCHEME

Maximum Mark: 75

Published

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

Cambridge International will not enter into discussions about these mark schemes.

Cambridge International is publishing the mark schemes for the May/June 2023 series for most Cambridge IGCSE, Cambridge International A and AS Level and Cambridge Pre-U components, and some Cambridge O Level components.

This document consists of **12** printed pages.

Generic Marking Principles

These general marking principles must be applied by all examiners when marking candidate answers. They should be applied alongside the specific content of the mark scheme or generic level descriptors for a question. Each question paper and mark scheme will also comply with these marking principles.

GENERIC MARKING PRINCIPLE 1: Marks must be awarded in line with: • the specific content of the mark scheme or the generic level descriptors for the question • the specific skills defined in the mark scheme or in the generic level descriptors for the question • the standard of response required by a candidate as exemplified by the standardisation scripts.
GENERIC MARKING PRINCIPLE 2: Marks awarded are always **whole marks** (not half marks, or other fractions).
GENERIC MARKING PRINCIPLE 3: Marks must be awarded **positively**: • marks are awarded for correct/valid answers, as defined in the mark scheme. However, credit is given for valid answers which go beyond the scope of the syllabus and mark scheme, referring to your Team Leader as appropriate • marks are awarded when candidates clearly demonstrate what they know and can do • marks are not deducted for errors • marks are not deducted for omissions • answers should only be judged on the quality of spelling, punctuation and grammar when these features are specifically assessed by the question as indicated by the mark scheme. The meaning, however, should be unambiguous.
GENERIC MARKING PRINCIPLE 4: Rules must be applied consistently, e.g. in situations where candidates have not followed instructions or in the application of generic level descriptors.
GENERIC MARKING PRINCIPLE 5: Marks should be awarded using the full range of marks defined in the mark scheme for the question (however; the use of the full mark range may be limited according to the quality of the candidate responses seen).
GENERIC MARKING PRINCIPLE 6: Marks awarded are based solely on the requirements as defined in the mark scheme. Marks should not be awarded with grade thresholds or grade descriptors in mind.

Mechanics of Marking:

Every mark given should have a corresponding tick on the script. The number of ticks on each (part) question should match the number of marks awarded for that (part) question. If giving Benefit of Doubt, **the BOD must be accompanied by a tick**.

If a candidate has not given a response or the response is in no way related to the question, such as 'don't know', NR (the Hash key) should be awarded rather than zero.

Every part question must be annotated to show that it has been read even if awarding NR. Please ensure that all part questions that are marked as NR are also annotated with the SEEN icon. This is a requirement of RM3.

There are **two** blank pages at the start of each script and a page of syntax diagrams on page 4 (question 3) that must be annotated with the SEEN icon. ☹

NEW: Words or phrases that are <u>underlined</u>, must be present in the candidate's answer. Words or phrases that are <u>emboldened</u> indicate that the idea represented by the bold text must be included.

Even though the comments box is visible at the bottom of the screen, please do not put comments or question marks on the scripts. When scripts are returned to centres all the annotations including comments, are visible.

If work has been crossed out and something written in its place, the replacement work is marked even if the crossed-out work is correct. If the crossed-out work has not been replaced, mark the crossed-out answer. Please also annotate the unmarked work as SEEN, especially if the replacement answer is on a separate sheet.

For single mark answers, mark the first answer on the line, unless there is a note to the contrary on the mark scheme.

If a candidate writes something that is not enough (NE) for a mark, but is not actually incorrect, continue reading, even if the mark scheme says, for example, mark first two answers.

Question	Answer	Marks
1(a)	**One** mark per mark point • correct mantissa • correct exponent **with** associated working Answer **Mantissa**: 0 1 0 1 0 1 0 1 1 1 **Exponent**: 0 0 0 1 1 0 Working exponent = 6 (movement of 6 bicimal places seen to find what exponent should be) calculation of denary 6 to binary (000)110	**2**
1(b)	**One** mark per mark point (**Max 3**) MP1 the mantissa of the number would need to be 0.101011111001 / 13 bits / digits MP2 … it can only store 10 bits / digits MP3 The **3** least significant digits would be truncated MP4 …causing a loss of precision	**3**

Question	Answer	Marks
2(a)	**One** mark per mark point (**Max 3**) MP1 **records** are stored in a particular **order** MP2 the order is determined based on the value in a key field MP3 **records** are accessed one after the other MP4 **records** can be found by searching from the beginning of the file, record by record, MP5 … until the required **record** is found <u>or</u> key field value is exceeded.	**3**
2(b)	**One** mark for each correct hash value (**Max 2**) **Record key** / **Hash value** 3003 / 3 1029 / 4 7630 / 0	**2**

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>3(a)</td><td>One mark per correct valid/invalid and reason combination (Max 2)

9SW – Invalid
Reason - This begins with a digit and a variable must begin with a letter

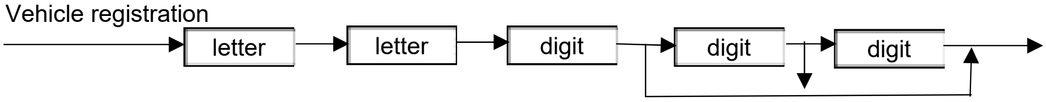
UWY – Valid
Reason – This begins with a letter and is followed by two other letters.</td><td>2</td></tr>
<tr><td>3(b)</td><td>One mark per mark point (Max 3)
• <word> ::= <letter>|
• …<word><letter>
• <variable> ::= <word>|<word><digit>

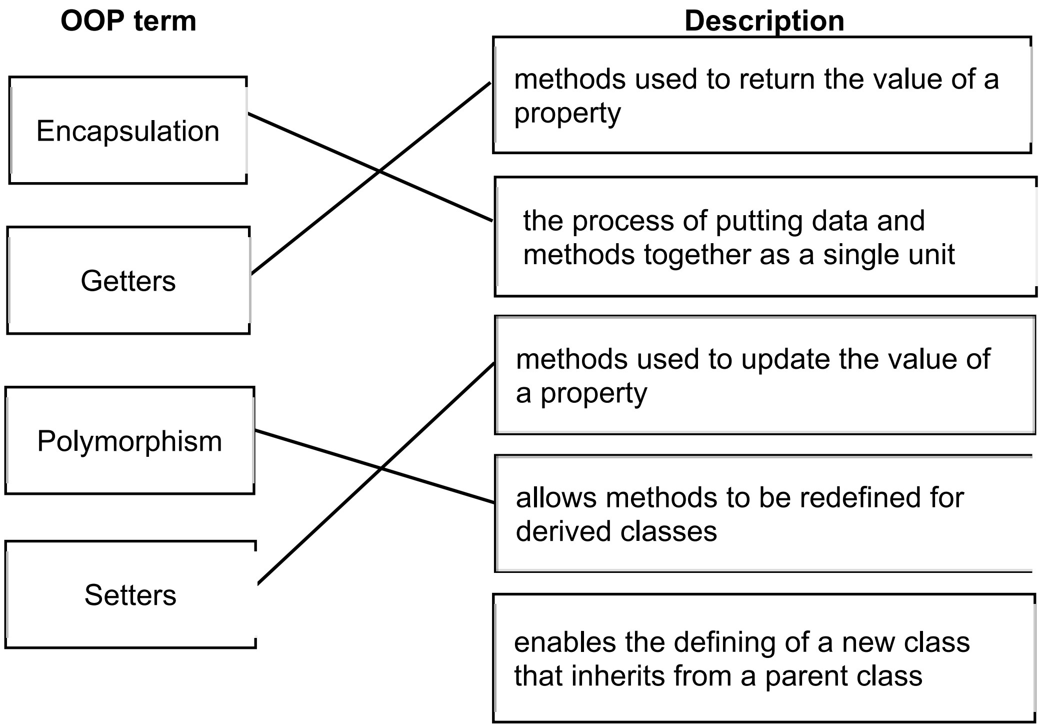
Example answers
<word> ::= <letter>|<word><letter>
<word> ::= <letter><word>|<letter>

<variable> ::= <word>|<word><digit>
<variable> ::= <word><digit>|<word></td><td>3</td></tr>
<tr><td>3(c)(i)</td><td>Answer must be two letters followed by one, two or three digits using the letters and digits on the syntax diagram.

Example answer
AC768</td><td>1</td></tr>
<tr><td>3(c)(ii)</td><td>One mark per mark point (Max 3)
• always has only two letters
• one, two or three digits possible
• correct arrows, boxes and name of syntax diagram

Example answer

Vehicle registration

</td><td>3</td></tr>
</table>

Question	Answer	Marks
4	**One** mark for each correct line connecting an OOP term to its description **(Max 4)**.  	**4**

Question	Answer	Marks
5(a)	**One** mark per mark point (**Max 2**) MP1 to produce a **virtually unbreakable** encryption system / send **virtually un-hackable** secure messages … MP2 …using the laws / principles of quantum mechanics / properties of photons MP3 detects **eavesdropping** … MP4 …because the properties of photons change MP5 to protect security of data transmitted over **fibre optic cables** MP6 to **enable** the use of longer keys.	**2**
5(b)	**One** mark per mark point (**Max 3**) MP1 Symmetric cryptography uses a single key to encrypt and decrypt messages, Asymmetric cryptography uses two. MP2 The symmetric key is shared, whereas with asymmetric, only the public key is shared (and the private key isn't). MP3 … the risk of compromise is higher with symmetric encryption and asymmetric encryption is more secure. MP4 Symmetric cryptography is a simple process that can be carried out quickly, but asymmetric is much more complex, so slower. MP5 The length of the keys in symmetric encryption are (usually) shorter than those for asymmetric (128/256 bits v 2048 bits).	**3**

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>6(a)</td><td>One mark for <code>TYPE TAppointments</code> and <code>ENDTYPE</code> correct
One mark for every two correct declarations (Max 3)

Example answer<pre>TYPE TAppointments
    DECLARE Name : STRING
    DECLARE DateOfBirth : DATE
    DECLARE Telephone : STRING
    DECLARE LastAppointment : DATE
    DECLARE NextAppointment : DATE
    DECLARE TreatmentsComplete : BOOLEAN
ENDTYPE</pre></td><td>4</td></tr>
<tr><td>6(b)</td><td>One mark for each correctly completed line (Max 5)<pre>DECLARE DentalRecord : ARRAY[1:250] OF TAppointments
DECLARE DentalFile : STRING
DECLARE Count : INTEGER
DentalFile ← "DentalFile.dat"
OUTPUT "The file ", DentalFile, " contains these records:"
OPENFILE DentalFile FOR RANDOM
Count ← 1
REPEAT
   SEEK DentalFile, Count
   GETRECORD DentalFile, DentalRecord[Count]
   OUTPUT DentalRecord[Count]
   Count ← Count + 1
UNTIL EOF(DentalFile)
CLOSEFILE DentalFile</pre></td><td>5</td></tr>
</table>

Question	Answer	Marks
7(a)	**One** mark per mark point (**Max 2**) MP1 Packet switching is most commonly used on data networks such as the internet to send large data files that don't need to be live streamed MP2 Packet switching is used when it is necessary to be able to overcome failed/faulty lines by rerouting. MP3 Packet switching is used when it is necessary for the communication to be more secure. MP4 Packet switching is used for high volume data transmission. MP5 Packet switching is used when it isn't necessary to use all the bandwidth. MP6 Specific examples e.g. email, text messages, documents, VOIP etc. (up to **two** marks).	2

Question	Answer	Marks
7(b)	**One** mark per mark point (**Max 4**) MP1 Circuit switching uses a dedicated channel to make communication, whereas packet switching forms data into packets to transmit over a digital network. MP2 The dedicated path for circuit switching must be established before the transfer of data can commence, which is not the case with packet switching (as it doesn't require a dedicated path). MP3 Data in packet switching is split into packets, in circuit switching the message remains intact. MP4 All of the transmission in circuit switching follows the same path whereas different packets in packet switching can take different routes. MP5 The message is received in the same order in which it is sent with circuit switching, but with packet switching, the packets can be received out of order (for assembly at the destination). MP6 Circuit switching is implemented at the physical layer while packet switching is implemented at the network layer. MP7 Circuit switching uses the whole bandwidth of the channel used, packet switching can share bandwidth. MP8 Circuit switching communication ends with an error but packet switching allows packets to be re-sent. MP9 Circuit switching is a simpler process than packet switching.	**4**

Question	Answer	Marks
8(a)	**One** mark per mark point (**Max 2**) MP1 Pipelining allows several **instructions** to be processed simultaneously / concurrently. MP2 … therefore, increasing the CPU **instruction** throughput / the number of **instructions** completed per unit of time. MP3 Each **instruction** stage / subtask is completed during one clock cycle MP4 No two **instructions** can execute their same stage of instruction / subtask at the same clock cycle. MP5 … e.g., while one **instruction** is being decoded, the next **instruction** can be fetched, etc.	**2**

Question	Answer	Marks
8(b)	**One** mark per mark point (**Max 4**) • First stage of first instruction in first clock cycle • First instruction successfully completed over five clock cycles • Remaining instructions completed over ten clock cycles … • … with no extra instruction sections added on any row.	4

Example answer 1

Clock cycles

Processor stages	1	2	3	4	5	6	7	8	9	10	11	12
IF	1.1	2.1	3.1	4.1	5.1	6.1						
ID		1.2	2.2	3.2	4.2	5.2	6.2					
OF			1.3	2.3	3.3	4.3	5.3	6.3				
IE				1.4	2.4	3.4	4.4	5.4	6.4			
WB					1.5	2.5	3.5	4.5	5.5	6.5		

Example answer 2

Clock cycles

Processor stages	1	2	3	4	5	6	7	8	9	10	11	12
IF	A	B	C	D	E	F						
ID		A	B	C	D	E	F					
OF			A	B	C	D	E	F				
IE				A	B	C	D	E	F			
WB					A	B	C	D	E	F		

Question	Answer	Marks
9(a)	**One** mark for every two correct products (**Max 3**) (Z =) $\bar{A}\bar{B}\bar{C}\bar{D} + \bar{A}\bar{B}\bar{C}D + \bar{A}\bar{B}C\bar{D} + \bar{A}\bar{B}CD + \bar{A}BC\bar{D} + \bar{A}BCD$	3
9(b)	**Two** marks if no errors present **One** mark if one error present	2

CD \ AB	00	01	11	10
00	1	0	0	0
01	1	0	0	0
11	1	1	0	0
10	1	1	0	0

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>9(c)</td><td>One mark for each correct loop (Max 2)
<table>
<tr><td>CD \ AB</td><td>00</td><td>01</td><td>11</td><td>10</td></tr>
<tr><td>00</td><td>1</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>01</td><td>1</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>11</td><td>1</td><td>1</td><td>0</td><td>0</td></tr>
<tr><td>10</td><td>1</td><td>1</td><td>0</td><td>0</td></tr>
</table></td><td>2</td></tr>
<tr><td>9(d)</td><td>One mark for each mark point (Max 2)
• Any correct Boolean term
• Boolean terms and operator correct and no other terms present

(Z =) $\bar{A}\bar{B} + \bar{A}C$</td><td>2</td></tr>
<tr><td>9(e)</td><td>One mark for simplest form (Max 1)

(Z =) $\bar{A}\,(\bar{B} + C)$</td><td>1</td></tr>
</table>

Question	Answer	Marks
10(a)	**One** mark from: Supervised (learning) Unsupervised (learning) Reinforcement (learning) Deep (learning)	1

Question	Answer	Marks
10(b)	**One** mark for each correct calculation as follows **(Max 2)**: • Node B (from Begin) (Line 3 in table) • Node C (from Begin) (Line 4 in table) • Node D (from Begin) (Line 5 in table) **One** mark for each correct calculation as follows **(Max 2)**: • Node G (from C) (Line 6 in table) • Node F and Node End (from G) (Lines 7 and 8 in table) • Node End (from F) (Line 9 in table) **One** mark for correct path **(Max 1)**: • Begin ⇨ C ⇨ G ⇨ F ⇨ End	**5**

Start node	**Destination node**	**Cost from start node (g)**	**Heuristic (h)**	**Total (f = g + h)**
Begin	Begin	0	12	12
Begin	A	5	8	13
Begin	B	6	7	13
Begin	C	5	7	12
Begin	D	4	11	15
C	G	5 + 2 = **7**	5	12
G	F	5 + 2 + 4 = **11**	1	12
G	End	5 + 2 + 7 = **14**	0	14
F	End	5 + 2 + 4 + 1 = **12**	0	12

Final Path	Begin ⇨ C ⇨ G ⇨ F ⇨ End

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>11(a)(i)</td><td>One mark for every two correct identifiers (Max 2)
<table>
<tr><th>Identifier</th><th>Data type</th><th>Description</th></tr>
<tr><td>Queue</td><td>STRING</td><td>An array to store the contents of the queue.</td></tr>
<tr><td>RearPointer</td><td>INTEGER</td><td>Points to the last term of the queue.</td></tr>
<tr><td>Length</td><td>INTEGER</td><td>Indicates the number of items in the queue.</td></tr>
<tr><td>FrontPointer</td><td>INTEGER</td><td>Points to the first term of the queue.</td></tr>
</table></td><td>2</td></tr>
<tr><td>11(a)(ii)</td><td>One mark for each correctly completed line (Max 5)
<pre>
CONSTANT MaxLength = 50
DECLARE FrontPointer : INTEGER
DECLARE RearPointer : INTEGER
DECLARE Length : INTEGER
DECLARE Queue : ARRAY[0:MaxLength - 1] OF STRING
// Initialisation of queue
PROCEDURE Initialise
   FrontPointer ← -1
   RearPointer ← -1
   Length ← 0
ENDPROCEDURE
// Adding a new item to the queue
PROCEDURE Enqueue(NewItem : STRING)
   IF Length < MaxLength THEN // IF Length <= MaxLength -
      1 THEN
      RearPointer ← RearPointer + 1
      IF RearPointer > MaxLength - 1 THEN
         RearPointer ← 0
      ENDIF
      Queue[RearPointer] ← NewItem
      Length ← Length + 1
   ENDIF
ENDPROCEDURE
</pre></td><td>5</td></tr>
<tr><td>11(b)</td><td>One mark per mark point (Max 3)

Print jobs are expected to be actioned by the printer in the order they are received
… because the printer queue is a queue, the first job to be sent to the printer would be the first job printed.
If the printer queue was on a stack, the first job the printer received would not be printed until all the other jobs have been printed.
</td><td>3</td></tr>
</table>