

1.4 DATA TYPES & STRUCTURES · 1.4.1 · A-LEVEL

Bitwise manipulation & masks — Mark scheme

30 marks · spec 1.4.1(i)

AO key: AO1 = knowledge · AO2 = application. Award method marks for correct working even where a slip gives a wrong final value. Do not award the same point twice.

Q	ANSWER	AO	MARKS
1(a)	00110100 (1); the value is doubled / multiplied by 2 (1). (2)	AO2	2
1(b)	00011010 (1); the value is divided by 4 (1). (2)	AO2	2
1(c)	Multiplies the value by $2^3 = 8$. (1)	AO1	1
1(d)	Bits shifted off the right-hand end are lost, so a remainder is discarded (rounds down). (1)	AO1	1

Q	ANSWER	AO	MARKS
2(a)	00000110 (1)	AO2	1
2(b)	Clears (zeroes) the top four bits / keeps (isolates) the bottom four bits. (1)	AO1	1
2(c)	10111111 (1)	AO2	1
2(d)	Sets the bottom four bits to 1 / keeps the top four bits. (1)	AO1	1
2(e)	01001001 (1)	AO2	1
2(f)	It inverts / flips every bit (one's complement). (1)	AO1	1

Q	ANSWER	AO	MARKS
3(a)	AND with mask 00001111 (1); result 00000111 (1). (2)	AO2	2
3(b)	OR with mask 11110000 (1); result 11110111 (1). (2)	AO2	2
3(c)	AND the byte with the mask 10000000 (a single 1 in bit 1's position) (1); if the result is non-zero (the bit was 1), light 1 is on (1). (2)	AO2	2

Q	ANSWER	AO	MARKS
4(a)	OR (1); mask 00100000 (sets bit 6 / adds 32) (1); result 01100010 = 'b' (1). (3)	AO2	3
4(b)	$\times 6 = \times 4 + \times 2$: shift left 2 $\rightarrow$ 00010100 (20) (1); shift left 1 $\rightarrow$ 00001010 (10) (1); add $\rightarrow$ 00011110 (30) (1). (3)	AO2	3

Q	ANSWER	AO	MARKS
5(a)	OR. (1)	AO1	1
5(b)	XOR. (1)	AO1	1
5(c)	OR (1) with mask 10000000 (1 in the MSB, 0s elsewhere) (1). (2)	AO2	2
5(d)	XOR with 1 flips a bit; flipping the same bit again returns it to its original state (1); mask 0 positions are unchanged throughout, so the whole value is restored (1). (2)	AO1	2

Total for paper: 30 marks