

1.4 DATA TYPES & STRUCTURES · 1.4.1

Binary arithmetic & two's complement — Mark scheme

30 marks · spec 1.4.1(c)(d)

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

Q	ANSWER	AO	MARKS
1(a)	Correct carrying shown (1); result 01110111 (= 119) (1). (2)	AO2	2
1(b)	Addition gives a result requiring a 9th bit (1 01000010) (1); the 8-bit answer 01000010 is incorrect (1); because an overflow has occurred (result > 255 can't fit in one byte) (1). (3)	AO2	3

Q	ANSWER	AO	MARKS
2(a)	+6 = 00000110 (1); -6 = 10000110 (MSB sign set) (1). (2)	AO2	2
2(b)	Any one: ordinary addition does not give the correct result · there are two representations of zero · arithmetic is more complex for the hardware. (1)	AO1	1
2(c)	1 mark each, max 2: only one representation of zero · standard binary addition works for signed numbers · subtraction can be done by addition. (2)	AO1	2

Q	ANSWER	AO	MARKS
3(a)	40 = 00101000, flip → 11010111, +1 (1); = 11011000 (1). (2)	AO2	2
3(b)	Uses place values -128 + 64 + 32 + 8 + 4 (1); = -20 (1). (2)	AO2	2
3(c)	The MSB's place value is made negative (-128 for 8 bits) (1); so a 1 in that position subtracts, allowing negatives to be represented and normal addition to work (1). (2)	AO1	2

Q	ANSWER	AO	MARKS
4(a)	83 = 01010011 (1); two's complement of 37 = 11011011 (1); add: 01010011 + 11011011 with carries (1); result (before discarding) 1 00101110 (1). (4)	AO2	4
4(b)	It is discarded / ignored. (1)	AO1	1
4(c)	00101110 = 46. (1)	AO2	1

Q	ANSWER	AO	MARKS
5(a)	Largest = 127 (01111111) (1); smallest = -128 (10000000) (1). (2)	AO1	2
5(b)	Largest = $2^n - 1$ with $n = 16$ (1); = 65,535 (1). (2)	AO2	2
5(c)	312 is greater than 255, the maximum for 8 bits (1); so it needs a 9th bit and cannot be stored correctly in one byte (1). (2)	AO2	2
5(d)	Overflow (error). (1)	AO1	1
5(e)	Use more bits to store the result (e.g. 16 bits). (1)	AO2	1

Total for paper: 30 marks