MODULE C DATA REPRESENTATION · C7

Two's complement: mark scheme

22 marks · Cambridge 0478 syllabus 1.1.6

How to use. One mark per creditworthy point up to the maximum shown. **/** separates alternative words; **//** separates alternative answers. Words in (brackets) are not needed for the mark. All patterns are 8-bit two's complement (place values −128, 64, 32, 16, 8, 4, 2, 1). A binary answer must have exactly 8 bits in the correct order. A correct final answer with no working gets full marks, including where the question says "Show your working".

QUESTION	ANSWER	MARKS	GUIDANCE
1(a) 0478 1.1.6	−128	**1**	Do not accept 128 (the minus sign is needed).
1(b) 0478 1.1.6	Smallest: −128 Largest: 127 // +127	**2**	1 mark each. Do not accept 128 or 255 as largest, or −127 as smallest.
2(a) 0478 1.1.6	90	**1**	64 + 16 + 8 + 2 = 90.
2(b) 0478 1.1.6	−128 + 32 + 16 + 4 + 1 // −128 + 53 −75	**2**	1 mark working (MSB taken as −128 with the correct positive headings), 1 mark answer. Correct answer with no working = 2. 181 = 0. 75 (no minus sign) = 0.
2(c) 0478 1.1.6	−1	**1**	−128 + 127 = −1. Do not accept 255.
3(a) 0478 1.1.6	01001101	**1**	64 + 8 + 4 + 1 = 77. Must be 8 bits (the leading 0 is needed).
3(b) 0478 1.1.6	Working: 77 = 01001101, flipped to 10110010, then + 1 // −128 + 51 (51 = 32 + 16 + 2 + 1) 10110011	**2**	1 mark working, 1 mark answer. Correct answer alone = 2. 10110010 (1 not added; this is −78) = 1. 11001101 (first bit switched on; this is −51) = 0.
3(c) 0478 1.1.6	Working: 19 = 00010011, flipped to 11101100, then + 1 // −128 + 109 (109 = 64 + 32 + 8 + 4 + 1) 11101101	**2**	1 mark working, 1 mark answer. Correct answer alone = 2. 11101100 (1 not added; this is −20) = 1. 10010011 (first bit switched on) = 0.

QUESTION	ANSWER	MARKS	GUIDANCE
4(a) 0478 1.1.6	Any two from: In two's complement the most significant bit is worth −128 (not +128) // 246 is the value read as binary with no sign The MSB is 1 so the reading is negative The correct reading is −10 (°C)	**2**	max 2. Working: −128 + 64 + 32 + 16 + 4 + 2 = −10.
4(b) 0478 1.1.6	Any two from: The largest value that can be stored is 127 150 is greater than 127 // 150 is out of range The MSB is worth −128, so only 7 bits have positive place values // a 1 in the MSB would make the value negative	**2**	max 2. Do not credit "8 bits store up to 255".
5(a) 0478 1.1.6	Row 1: True Row 2: False Row 3: True	**3**	1 mark per correct row. More than one tick in a row = 0 for that row. Row 2: 10000000 = −128; 0 is 00000000. Row 3: positive integers 0 to 127 have MSB 0 and the same pattern.
6(a) 0478 1.1.6	Any three from: Write the positive value (of the number) in 8-bit binary Flip / invert every bit // change 1s to 0s and 0s to 1s (then) add 1 (to the flipped pattern) (using binary addition) carrying where needed // check that the MSB is 1 Alternative: put a 1 in the −128 column // MSB = 1 Alternative: work out (number + 128) and write it in the remaining 7 bits	**3**	max 3. Steps must be in the correct order: adding 1 before flipping = max 1. Do not credit "put a 1 in front of the positive number" on its own.

Total: 22 marks