1.4 DATA TYPES & STRUCTURES · 1.4.1 · A-LEVEL

Floating point — Mark scheme

30 marks · spec 1.4.1(g)(h) · 8-bit mantissa, 4-bit exponent, two's complement

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

Q	ANSWER	AO	MARKS
1(a)	value = mantissa × 2^(exponent). (1)	AO1	1
1(b)	The mantissa. (1)	AO1	1
1(c)	The exponent. (1)	AO1	1
1(d)	It is taken to be immediately after the (sign) first bit of the mantissa. (1)	AO1	1

Q	ANSWER	AO	MARKS
2(a)	Exponent 0010 = +2; move point right 2 → `011.00000` (1); = `3` (or 3.0) (1). (2)	AO2	2
2(b)	Exponent 0011 = +3; `0101.1000` (1); = `5.5` (1). (2)	AO2	2
2(c)	Mantissa negative (two's complement); move point right 2 → `101.10000` (1); = `−2.5` (1). (2)	AO2	2

Q	ANSWER	AO	MARKS
3(a)	6.5 = `110.1` (1); move point 3 left, exponent = 3 (1); = mantissa `0.1101000` exp `0011` (1). (3)	AO2	3
3(b)	Find two's complement for −6.5 / mantissa must start `1.0` (1); exponent = 3 (1); = mantissa `1.0011000` exp `0011` (1). (Check: −0.8125 × 2^3 = −6.5.) (3)	AO2	3

Q	ANSWER	AO	MARKS
4(a)	It gives the maximum precision for the given number of mantissa bits (1); by removing leading bits that carry no information / using the bits for significant digits (also gives a single standard representation) (1). (2)	AO1	2
4(b)	Shift mantissa left 2 (first bit after point becomes 1), reduce exponent by 2 (1); = mantissa `0.1101000` exp `0010` (1). (Both equal 3.25.) (2)	AO2	2
4(c)	Greater precision (numbers can be represented more accurately). (1)	AO1	1

Q	ANSWER	AO	MARKS
5(a)	A = 2.5, B = 1.5 (sum should be 4.0). Mark the method: • raise B to exponent 0010: mantissa `0.0110000` exp `0010` (1) • add mantissas: `0.1010000 + 0.0110000 = 1.0000000` (1) • recognise mantissa overflow into the sign bit (1) • renormalise: shift right 1, exponent → `0011` (1) • answer: mantissa `0.1000000` exp `0011` (= 4.0) (1). (5)	AO2	5
5(b)	Adding the mantissas overflowed into the sign bit, so the result was not in normalised form. (1)	AO2	1

Q	ANSWER	AO	MARKS
6(a)	Most negative mantissa `1.0000000` (= −1) with largest exponent `0111` (= 7) (1); $-1 \times 2^{7} =$ `−128` (1). (2)	AO2	2
6(b)	When a number is too small (close to zero) to be represented in the available bits. (1)	AO1	1

Total for paper: 30 marks