

3 An alarm system sensor embedded in a baby's clothing is used to measure its heart rate.

a) A digital display shows the baby's heart rate in beats per minute (bpm).

Each digit in the display is represented as a 4-bit binary code.

For example:

1	0
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0	0	0	1		0	0	0	0
1					0			

(i) Complete the table to show how a heart rate of 95 bpm is represented.

9					5			

(ii) Complete the table to show what heart rate is being displayed. (1)

0	1	1	1		0	0	1	0

(1)

b) Assembly code is used to program a microcontroller.

Here is part of an assembly code instruction set showing the commands and a description of each command.

Command	Description
ADD Rd, Rn, Rm	Adds the contents of Register m to the contents of Register n and stores the result in Register d
CMP Rn, Rm	Compares the value in Register m with the value in Register n and updates the result status flags according to the result
LDR Rd, [Rm]	Loads the contents of the memory address stored in Register m into Register d
MOV Rd, #<value>	Moves <value> into Register d
MOVGT Rd, #<value>	Moves <value> into Register d if result status flags indicate that the 'greater than' condition is true

(i) The assembly code makes use of registers.

Describe the role of registers in a processor.

(2)

The microcontroller monitors the input from the sensor using a subprogram. Here is a subprogram, in assembly code, for the microcontroller:

Register 0 holds the maximum safe heart rate.

Register 1 holds the address of the current heart rate reading.

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LDR R3, [R1]
MOV R2, #0
CMP R3, R0
MOVGT R2, #1
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(ii) Describe how the subprogram processes the heart rate data.

(4)

The table shows the binary values stored in two registers, R4 and R5.

Register	Binary value
R4	0100 1001
R5	0010 1010

(iii) The microcontroller's processor executes the command ADD R6, R4, R5.

State the binary value that would be stored in register R6 when this command is executed.

(1)

c) The processor has a 32-bit address bus.

(i) State the function of the address bus.

(1)

(ii) Describe how the size of the address bus affects the maximum amount of memory available to the microcontroller's processor.

(2)

(iii) The binary number 0110 1110 is stored in a memory location.

State the hexadecimal representation of this binary number.

d) The baby alarm system monitors heart rate, temperature and movement. These are Boolean variables that are set to 0 when the values are within safe limits and 1 when they are outside safe limits.

The microcontroller monitors the readings and sounds an alarm if any two of the readings are outside safe limits.

- (i) Give the logic statement the microcontroller uses to determine if the alarm should be sounded.

(2)

- (ii) Complete the truth table for this logic statement.

INPUTS			OUTPUT
Heart Rate	Temperature	Movement	Alarm

(2)

Total for Question 3 = 17 marks

3 a)(i)	1001 0101		1 (1)
3 a)(ii)	72		1 (1)
3 b)(i)	Provides small amount of storage (in the processor)(1) holds an instruction/memory address/data value (1)		2 (1,1)
3 b)(ii)	Any four of: <ul style="list-style-type: none"> • Puts the heart rate into register 3 (1) • Sets value/flag/register 2 to 0 (1) • Compares heart rate with maximum safe level (1) • If heart rate too high sets value/flag/register 2 to 1 (1) • Returns a value 0 if heart rate is within safe region or 1 if heart rate is too high (1) 		4 (1,1,1,1)
3 b)(iii)	0111 0011 (1)		1 (1)
3 c)(i)	Specifies a memory address/uniquely identifies a memory location (1)		1 (1)
3 c)(ii)	The more lines/wires/bits the address bus has (1) the more memory locations can be uniquely identified (1)	A valid example that demonstrates understanding is acceptable, e.g. 8-bit address bus generates 256 different addresses, a 16-bit address book generates 65,536 different addresses	2 (1,1)
3 c)(iii)	6E		1 (1)
3 d)(i)	Alarm = (Heart Rate AND Temperature) OR (Heart Rate AND Movement) OR (Temperature AND Movement)		2 (2/1)

3 d)(ii)	INPUTS			OUTPUT	2 (2/1)
	HeartRate	Temp	Movement	Alarm	
	0	0	0	0	
	0	0	1	0	
	0	1	0	0	
	0	1	1	1	
	1	0	0	0	
	1	0	1	1	
	1	1	0	1	
1	1	1	1		
Award a maximum of 1 mark if input values for three sensors are not all correct but Alarm values are correct for stated inputs.					
					17 marks