DATA REPRESENTATION

Papers Dock

COMPUTER SCIENCE 9618 PAPER 1

DATA REPRESENTATION

Data representation refers to the form in which data is stored, processed and transmitted.

Number Systems

Binary (Base 2)	0 and 1
Denary (Base 10)	0 1 2 3 4 5 6 7 8 9
Hexadecimal (Base 16)	0 1 2 3 4 5 6 7 8 9 A B C D E F

Understanding A Bit

A bit is the smallest unit of data in computing, representing a binary state of 0 or 1. 8 bits are known as a Byte. Each bit has a value and it depends how many combination of 0 and 1 can be made by using bits. For our questions we will be using a list which you are suppose to memorize.

Memorized List

128	64	32	16	8	4	2	1

Case 1 : Positive Denary Number To Binary Conversion

Question : Convert 65 into 8 bit Binary

Step 1 : Write down the memorized list

Step 2 : Put 1 on numbers which will be added to fulfil Question Requirement and the rest will be 0

Ans : 0 1 0 0 0 0 0 1

Exam Style Question

2 (a) Convert the following denary integer into 8-bit binary.

55

[1]

Case 2 : Binary To Denary Conversion

Question : Convert the 8 bit binary number into denary

0	1	0	0	0	0	0	1

Step 1 : Write down the memorized list

0	1	0	0	0	0	0	1
128	64	32	16	8	4	2	1

Step 2 : Add only the numbers with 1

0	1	0	0	0	0	0	1
128	64	32	16	8	4	2	1

= 64 + 1 (Ans) 65

Exam Style Question

2 **(a)** Convert the following 8-bit binary integer into denary.

01001101

.....[1]

1 **(a)** **(i)** Convert the unsigned binary integer into denary.

00100111

Answer ..... [1]

1(a)(i)	39	**1**

Hexadecimal

Why Do We Need Hexadecimal?

Computers operate using binary (base-2) number systems, where all data is represented as a series of 0s and 1s. However, binary numbers can become very long and hard to read for humans. Hexadecimal is more compact and easier to understand

Uses of Hexadecimal

Color Codes in Web Design #FFFFFF
Machine Code and Assembly Language
MAC Address

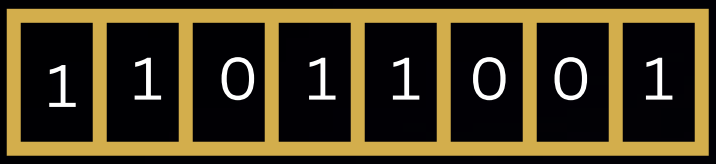
Hexadecimal (Base 16) 0 1 2 3 4 5 6 7 8 9 A B C D E F

Value Box

A	**10**
B	11
C	12
D	13
E	14
F	15

Case 3 : Binary Conversion To HexaDecimal

Question : Convert the 8 bit binary number into Hexadecomal



Step 1 : From right side, divide binary number into groups of 4

Step 2 : Write the memorized list separately for each group

Step 3 : Add the number with and if the sum is greater than 9 then use Value Box

13 9

13

9

Value Box

A	10
B	11
C	12
D	13
E	14
F	15

According to value box the value 13 is D so the Final Answer would be

D9

Exam Style Question

(b) The current contents of a general purpose register (X) are:

X	1	1	1	1	0	0	1	0

(i) The contents of X represent an unsigned binary integer.

Convert the value in X into denary.

.....[1]

Ans = F2

(iii) Convert the positive binary integer 11110010 into hexadecimal.

.....

..... [1]

3(d)(iii)	F2	**1**

Case 4 : Denary To HexaDecimal

Question : Convert 195 to HexaDecimal.

Step 1 : First convert the denary number to Binary

128	64	32	16	8	4	2	1

1	1	0	0	0	0	1	1
128	64	32	16	8	4	2	1

Step 2 : Repeat the steps in Case 3

1	1	0	0	0	0	1	1
8	4	2	1	8	4	2	1
12				3			

C3

Exam Style Question

(d) Convert the following hexadecimal number into denary.

4E

.....[1]

Note : For Hexadecimal to Denary just consider each as group of 4 and reverse the steps in case 4

4				E			
0	1	0	0	1	1	1	0
8	4	2	1	8	4	2	1

0 1 0 0 1 1 1 0

After using the complete memorized link you will get 78

Binary Coded Decimal

Binary Coded Decimal (BCD) is a class of binary encodings where each digit of a decimal number is represented by its own binary sequence. In the most common form of BCD, each of the decimal digits (0-9) is represented by a four-bit binary number:

Uses of BCD

Any scenario where a single digit need to be transmitted / displayed e.g Calculator and Digital Clocks.

0	**0000**
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001

Note : Any number greater than 9 can not be represented as BCD 4bits

Case 1 : Denary to BCD

Question : Convert 54 into BCD

Step 1 : Each digit should be considered as an individual digit and convert each digit into BCD format

5 4

0 1 0 1 0 1 0 0

Final answer would be 0101 0100

Exam Style Question

(b) (i) Convert the following denary integer into Binary Coded Decimal (BCD).

653

.....[1]

Final answer would be 0110 0101 0011

(ii) Convert the denary number 964 into Binary Coded Decimal (BCD).

.....

..... [1]

3(d)(ii)	1001 0110 0100	**1**

Case 2 : BCD to Denary

Question : Convert 0101 0100 into Denary

Step 1 : Make groups of 4

0 1 0 1 0 1 0 0

Step 2 : Write down the memorized list for each group and add

0	1	0	1	0	1	0	0
8	4	2	1	8	4	2	1

5 4

Final answer would be 54

Exam Style Question

(b) Convert the following Binary Coded Decimal (BCD) number into denary.

10000011

.....[1]

Final answer would be 83

Question : Describe how denary integers larger than 9 can be converted into BCD. Give an example in your answer.

Answer : Each denary digit is written as 4-Bit binary number
example 46 0100 0110

Question : Describe how an 8 bit BCD can be converted into a denary integer. Give an example in your answer.

Answer : Binary Number is split into groups of 4 bits starting from right. Each group of 4 bits is converted to a denary digit.
example 0100 0110 will be 46

Question : Identify practical application where BCD is used.

Answer : Any scenario where a single digit needs to be transmitted / displayed
Example Caluclator and Digital Clocks

Binary Addition

Addition	Sum	Carry
0 + 0	**0**	**0**
0 + 1	1	0
1 + 0	1	0
1 + 1	0	1
1 + 1 + 1	1	1

Questions

```
  0 1        1 1        1 1 1 0
  1 0        1 1          1 1 1
-----      -----      ---------

1 1 0 0      1 1 1 0      1 1 1 1 1
  1 1 0    0 1 1 1 1      1 1 1 0 1
-----      ---------    -----------
```

Exam Style Question

(ii) The amount of green in binary is `00100011`. This has the denary number `15` added to it to create a second colour.

Add the denary number `15` to the binary number `00100011` and give your answer in binary.

Perform the addition in binary. Show your working.

Working .....

.....

.....

.....

.....

Answer (in binary) .....

[3]

Ans : 00110010

(b) (i) Perform the following binary addition. Show your working.

$$\begin{array}{r} 10101010 \\ +\ 00110111 \\ \hline \end{array}$$

[2]

Ans : 11100001

Binary Magnitude

0 represents “Positive” 1 represents “Negative”

Binary Representation

Unsigned Binary Numbers : In this all bits contribute to the magnitude of the number, and there is no concept of negative numbers.

Signed Binary Numbers (Sign and Magnitude) : In a signed binary number system 0 indicates a positive number. 1 indicates a negative number.

Two’s Compliment

To represent negative numbers we use a method Known as Two’s compliment.

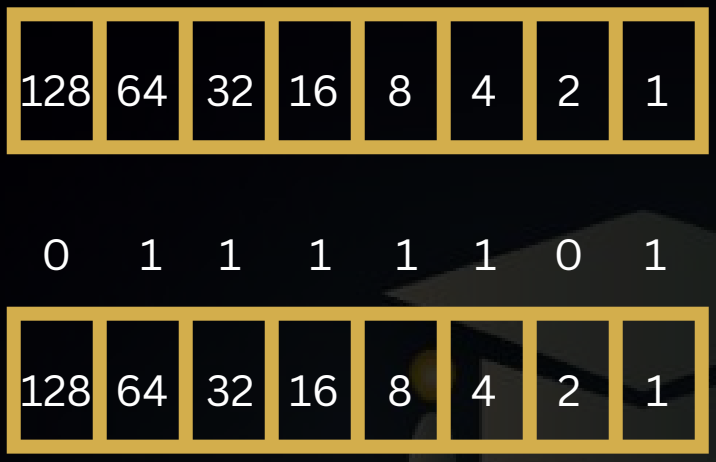
Positive Numbers : In two's complement, positive numbers are represented just like unsigned binary numbers

Negative Numbers : Negative numbers are represented by inverting all the bits of the positive number (known as finding the one's complement) and then adding 1 to the result.

Case 1 : Negative Denary Number To Binary Conversion

Question : Convert -125 to Binary Form

Step 1 : Ignore negative sign and convert it to Binary



Step 2 : Apply Two's Compliment

Steps to Find Two's Complement

1. **Invert All Bits: Change all 0s to 1s and all 1s to 0s.**
2. **Add Binary 1**

0 1 1 1 1 1 0 1

One's Compliment

Two's Compliment

	0 1 1 1 1 1 0 1
One's Compliment	1 0 0 0 0 0 1 0
Two's Compliment	1
	1 0 0 0 0 0 1 1

Exam Style Question

(b) Convert the denary number −194 into 12-bit two's complement.

..... [1]

Ans : 1111 0011 1110

Note : All Two's Compliment numbers that starts with 1 are negative numbers.

Case 2 : Negative Two's Compliment Binary To Denary Conversion

Apply Two's compliment and then use your memorized list but make sure to put negative sign.

Exam Style Question

(c) H is a register. The current contents of H are:

1	1	0	0	0	0	0	1

The current contents of register H represent an unsigned binary integer.

(i) Convert the value in register H into denary.

.....[1]

(ii) Convert the value in register H into hexadecimal.

.....[1]

(iii) The current contents of register H represent a two's complement binary integer.

Convert the value in register H into denary.

.....[1]

(iv) State why register H does not currently contain a Binary Coded Decimal (BCD).

.....

.....[1]

Ans
(i) 193
(ii) C1
(iii) -63
(iv) The first 4 bits would be 12 which is greater than 9 which is not a valid BCD

(c) The current contents of a general purpose register (X) are:

(i) The contents of X represent an unsigned binary integer.

Convert the value in X into denary.

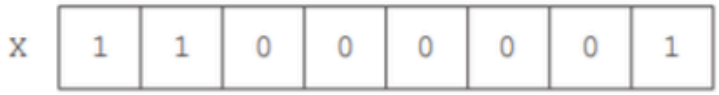
.....[1]

(ii) The contents of X represent an unsigned binary integer.

Convert the value in X into hexadecimal.

.....[1]

(3c) the current contents of a general purpose register (X) are:



(i) The contents of X represent an unsigned binary integer.

Convert the value in X into denary.

..... [1]

(ii) The contents of X represent an unsigned binary integer.

Convert the value in X into hexadecimal.

..... [1]

(iii) The contents of X represent a two's complement binary integer.

Convert the value in X into denary.

..... [1]

Binary Subtraction

10 - 5 = 10 + (-5)

Note : Apply Two's Compliment and then same working as Binary Addition.

Exam Style Question

(iii) Hexadecimal `23` in two's complement representation is `00100011`. The denary number `10` needs to be subtracted from this value.

Subtract the denary number `10` from the two's complement representation `00100011`.

Give your answer in binary. Show your working.

Working .....

.....

.....

.....

.....

Answer (in binary) .....

[3]

Converting 10 to -10 : 11110110
Adding : 00100011
11110110
Answer : 00011001

(e) Convert the denary numbers 127 and 12 to 8-bit binary and then perform the subtraction 12 − 127 in binary.

Show your working.

127 in binary .....

12 in binary .....

12 − 127 in binary .....

.....

.....

.....

.....

[3]

3(e)	**1 mark** per point • Correct conversion to binary 01111111 (127) and 00001100 (12) • Working e.g. turning 01111111 into two's complement 10000001 • Answer: 1000 1101	**3**

Concept Of Overflow

Computers have fixed memory spaces for eg 32 bits or 64 bit so sometimes after calculation or after any arithmetic operation the number of bits exceeds the maximum bits that can be stored.

1 0 1 0 1 0 1 0

1 0 1 1 0 1 1 1

---

1 0 1 1 0 0 0 0 1

Question : State how an overflow can occur when adding two binary integers

Answer : The result after adding two integers is larger number than can be stored in the given number of bits

ASCII EXTENDED ASCII UNICODE

67	01000011
A	?
B	?
[ ]	?

Note : The numbers could easily be represented into Binary Form but there was no way to represent alphabets / character

In the early days of computing, different manufacturers used different character encodings, which made it difficult for computers and devices from different companies to communicate effectively. ASCII was developed to standardize the encoding of text characters

ASCII Table

Dec	Hex	Oct	Char	Dec	Hex	Oct	Char	Dec	Hex	Oct	Char	Dec	Hex	Oct	Char
0	0	0		32	20	40	[space]	64	40	100	@	96	60	140	`
1	1	1		33	21	41	!	65	41	101	A	97	61	141	a
2	2	2		34	22	42	"	66	42	102	B	98	62	142	b
3	3	3		35	23	43	#	67	43	103	C	99	63	143	c
4	4	4		36	24	44	$	68	44	104	D	100	64	144	d
5	5	5		37	25	45	%	69	45	105	E	101	65	145	e
6	6	6		38	26	46	&	70	46	106	F	102	66	146	f
7	7	7		39	27	47	'	71	47	107	G	103	67	147	g
8	8	10		40	28	50	(	72	48	110	H	104	68	150	h
9	9	11		41	29	51	)	73	49	111	I	105	69	151	i
10	A	12		42	2A	52	*	74	4A	112	J	106	6A	152	j
11	B	13		43	2B	53	+	75	4B	113	K	107	6B	153	k
12	C	14		44	2C	54	,	76	4C	114	L	108	6C	154	l
13	D	15		45	2D	55	-	77	4D	115	M	109	6D	155	m
14	E	16		46	2E	56	.	78	4E	116	N	110	6E	156	n
15	F	17		47	2F	57	/	79	4F	117	O	111	6F	157	o
16	10	20		48	30	60	0	80	50	120	P	112	70	160	p
17	11	21		49	31	61	1	81	51	121	Q	113	71	161	q
18	12	22		50	32	62	2	82	52	122	R	114	72	162	r
19	13	23		51	33	63	3	83	53	123	S	115	73	163	s
20	14	24		52	34	64	4	84	54	124	T	116	74	164	t
21	15	25		53	35	65	5	85	55	125	U	117	75	165	u
22	16	26		54	36	66	6	86	56	126	V	118	76	166	v
23	17	27		55	37	67	7	87	57	127	W	119	77	167	w
24	18	30		56	38	70	8	88	58	130	X	120	78	170	x
25	19	31		57	39	71	9	89	59	131	Y	121	79	171	y
26	1A	32		58	3A	72	:	90	5A	132	Z	122	7A	172	z
27	1B	33		59	3B	73	;	91	5B	133	[	123	7B	173	{
28	1C	34		60	3C	74	<	92	5C	134	\	124	7C	174	|
29	1D	35		61	3D	75	=	93	5D	135	]	125	7D	175	}
30	1E	36		62	3E	76	>	94	5E	136	^	126	7E	176	~
31	1F	37		63	3F	77	?	95	5F	137	_	127	7F	177	

Note : You are not suppose to memorize the list.

A = 65

a = 97

ASCII

7 bits
128 characters can be represented 0-127
American Standard Code For Information Interchange

Extended ASCII

8 bits
ASCII codes were 7 bit long but then it was extended to have bit length of 8
256 characters can be represented

UNICODE

Problem which occurred after Extended ASCII was that we had more characters which needed to be represented for Example Arabic, Chinese, Greek Character as we had no representation for these characters. It uses 16, 24, 32 Bits.

Question : What are the disadvantages if using ASCII codes ?

Answer :

- **Only 128 characters can be represented**
- **uses value 0 to 127**
- **Many characters used in other languages can not be represented**
- **In extended ASCII the characters from 128 to 255 may be coded differently in different systems.**

Question : How Unicode is designed to overcome the disadvantages of ASCII ?

Answer :

- **Uses 16, 24, 32 bits**
- **Unicode is designed to be superset of ASCII**
- **Designed so the most characters in other languages can be represented.**

Exam Style Question

6 A computer uses the ASCII character set.

(a) State the number of characters that can be represented by the ASCII character set and the extended ASCII character set.

ASCII 128

Extended ASCII 256

[2]

(b) Explain how a word such as 'HOUSE' is represented by the ASCII character set.

Each character has its ASCII codes. Those codes are converted in binary format and are stored together

[2]

(c) Unicode is a different character set.

The Unicode value for the character '1' is denary value 49.

(i) Write the hexadecimal value for the Unicode character '1'.

[1]

(ii) Write the denary value for the Unicode character '5'.

[1]

Note : Binary Prefixes will be covered in multimedia

Data Representation

Question 1

(c) One of the colours used in the image has the hexadecimal colour code:

`#FC238A`

`FC` is the amount of red, `23` is the amount of green and `8A` is the amount of blue in the colour.

(i) Convert the hexadecimal code `FC` into denary.

..... [1]

(ii) The amount of green in binary is `00100011`. This has the denary number `15` added to it to create a second colour.

Add the denary number `15` to the binary number `00100011` and give your answer in binary.

Perform the addition in binary. Show your working.

Working .....

.....

.....

.....

.....

Answer (in binary) .....

[3]

(iii) Hexadecimal `23` in two's complement representation is `00100011`. The denary number `10` needs to be subtracted from this value.

Subtract the denary number `10` from the two's complement representation `00100011`.

Give your answer in binary. Show your working.

Working .....

.....

.....

.....

.....

Answer (in binary) .....

[3]

Question 2

6 A computer uses the ASCII character set.

(a) State the number of characters that can be represented by the ASCII character set and the extended ASCII character set.

ASCII .....

Extended ASCII .....

[2]

(b) Explain how a word such as 'HOUSE' is represented by the ASCII character set.

.....

.....

.....

..... [2]

(c) Unicode is a different character set.

The Unicode value for the character '1' is denary value 49.

(i) Write the hexadecimal value for the Unicode character '1'.

..... [1]

(ii) Write the denary value for the Unicode character '5'.

..... [1]

Question 3

(b) **(i)** Perform the following binary addition. Show your working.

10101010

+ 00110111

[2]

(ii) State how an overflow can occur when adding two binary integers.

.....

..... [1]

(c) Convert the hexadecimal value F0 into denary.

.....

..... [1]

Question 4

4 A register stores the following binary number:

1	1	0	0	1	1	0	1

(a) The binary value in the register represents an unsigned binary integer.

Convert the unsigned binary integer into denary.

..... [1]

(b) The binary value in the register represents a two's complement binary integer.

Convert the two's complement binary integer into denary.

..... [1]

(c) The binary value in the register represents a hexadecimal number.

Convert the binary number into hexadecimal.

..... [1]

(d) State why the value in the register cannot be interpreted as a Binary Coded Decimal (BCD).

.....

..... [1]

(e) The binary contents of **two** registers are:

Register 1	0	0	1	1	1	1	0	1
Register 2	0	0	1	0	1	1	0	1

(i) Add the contents of **Register 1** and **Register 2**. Show your working.

Answer .....
[2]

(ii) Subtract the contents of **Register 2** from the contents of **Register 1**. Show your working.

Answer .....
[2]

Question 5

(b) Convert the signed denary value –100 into an 8-bit two's complement binary integer.

Working .....

.....

Answer ..... [1]

(c) Convert the denary number 251 into hexadecimal. Show your working.

Working .....

.....

.....

.....

Answer .....

[2]

(d) Add the following unsigned binary integers.

```
  01010000
+ 00111110
```

[1]

Question 6

(c) Convert the following positive binary integer into hexadecimal.

0 1 1 1 1 1 1 0

..... [1]

(d) A **three-place logical shift** to the **left** is performed on the following positive binary integer.

Show the result of this logical shift.

0 1 1 1 1 1 1 0

..... [1]

(e) Convert the denary numbers 127 and 12 to 8-bit binary and then perform the subtraction 12 − 127 in binary.

Show your working.

127 in binary .....

12 in binary .....

12 − 127 in binary .....

.....

.....

.....

.....

[3]

Question 7

1 Text and numbers are examples of data stored in a computer.

(a) A character set is used to represent characters in a computer.

(i) Describe what is meant by a **character set**.

.....

.....

.....

.....

.....

..... [2]

(ii) Identify **two** character sets and state **one** difference between them.

Character set 1 .....

Character set 2 .....

Difference .....

.....

[3]

(b) A computer can represent numerical data in different forms.

Complete the table by writing the answer to each statement.

Statement	Answer
The hexadecimal value 11 represented in denary	
The smallest denary number that can be represented by an unsigned 8-bit binary integer	
The denary number 87 represented in Binary Coded Decimal (BCD)	
The denary number 240 represented in hexadecimal	
The denary number –20 represented in 8-bit two's complement binary	

[5]

Working space

Question 8

1 (a) (i) Convert the unsigned binary integer into denary.

00100111

Answer ..... [1]

(ii) Convert the Binary Coded Decimal (BCD) into denary.

00100111

Answer ..... [1]

(iii) Convert the 8-bit two's complement binary integer into denary.

11100111

Answer ..... [1]

(b) Perform the following binary subtraction. Show your working.

$$\begin{array}{rr} & 1\ 0\ 1\ 1\ 0\ 0\ 1\ 1 \\ - & 0\ 1\ 1\ 1\ 0\ 1\ 0\ 1 \\ \hline \end{array}$$

[2]

(c) Give **one** similarity and **two** differences between the ASCII and Unicode character sets.

Similarity .....

.....

Difference 1 .....

.....

Difference 2 .....

.....

[3]

Question 9

2 **(a)** **(i)** Convert the two's complement binary integer into denary.

10010110

Answer ..... [1]

(ii) Convert the unsigned binary integer into hexadecimal.

10010110

Answer ..... [1]

(iii) Convert the unsigned binary integer into Binary Coded Decimal (BCD). Show your working.

10010101

Working .....

.....

.....

Answer .....

[2]

(b) Perform the following binary addition.

```
  1 0 0 0 1 1 0 0
+ 0 1 0 0 0 1 1 0
-----------------
```

[1]

Question 10

9 **(a)** **(i)** Convert the unsigned binary value into hexadecimal.

10010011

Answer ..... [1]

(ii) Convert the unsigned binary value into denary.

10010011

Answer ..... [1]

(b) State **two** benefits of using Binary Coded Decimal (BCD) to represent values.

Benefit 1 .....

.....

Benefit 2 .....

.....

[2]

Question 11

(ii) Convert the denary number 964 into Binary Coded Decimal (BCD).

.....

..... [1]

(iii) Convert the positive binary integer 11110010 into hexadecimal.

.....

..... [1]

(iv) Give the smallest **and** largest two's complement binary number that can be represented using 8 bits.

Smallest .....

Largest .....

[2]

(v) Add the following two binary integers using binary addition. Show your working.

```
  10110000
+ 00011011
```

[2]

Question 12

4 Data in a computer is stored in binary form.

(a) State the number of unique binary values that can be represented in 16 bits.

..... [1]

(b) Give the 8-bit one's complement representation of the denary number −120.

Show your working.

Working .....

.....

.....

.....

Answer .....

[2]

(c) Convert the hexadecimal number A04 into denary.

Show your working.

Working .....

.....

.....

.....

Answer .....

[2]

Question 13

7 A computer stores data in binary form.

(a) Draw **one** line from each description to its matching denary value.

Description	Denary value
	–127
The smallest integer that can be represented in 8-bit two's complement.	127
	–255
The largest integer that can be represented in 8-bit two's complement.	–128
	–256
The largest unsigned integer that can be represented in 8 bits.	256
	128
	255

[3]

Question 14

3 **(a)** State **one** difference between a kibibyte and a megabyte.

.....

..... [1]

(b) **(i)** Convert the denary value into a 12-bit two's complement binary integer.

−196

Answer ..... [1]

(ii) Convert the Binary Coded Decimal (BCD) into denary.

100001100101

Answer ..... [1]

(iii) Convert the unsigned binary integer into denary.

000111010110

Answer ..... [1]

(c) Identify **one** practical application of BCD **and** justify why BCD is used in this application.

Application .....

.....

Justification .....

.....

.....

.....

[2]

Question 15

7 Complete the binary addition. Show your working.

$$\begin{array}{r} 10011110 \\ 01100001 \\ +\ 00011001 \\ \hline \end{array}$$

[3]

Question 16

(b) Subtract the denary number 10 from the denary number 100 using binary subtraction.

Show your working.

Working .....

.....

.....

.....

.....

.....

Answer .....

[3]

(c) Convert the hexadecimal number C0F into denary.

Show your working.

Working .....

.....

.....

Answer .....

[2]

Question 17

(b) Convert the denary number 241 to hexadecimal.

.....

..... [1]

(c) State what is meant by an **overflow in binary addition**.

.....

..... [1]

(d) Computers use character sets when representing characters in binary.

(i) Complete the table by identifying the number of bits each of the character sets allocates to each character.

Character set	Number of bits
ASCII	
extended ASCII	
Unicode	

[1]

(ii) Explain how the word 'Clock' is represented by a character set.

.....

.....

.....

..... [2]

Question 18

(d) The hexadecimal colour value of the background of Xiaoming's website is:

913C8E

Complete the following table by converting each hexadecimal value to denary value.

	Red	Green	Blue
Hexadecimal value	91	3C	8E
Denary value			

[2]

Question 19

5 (a) The bit depth of an image dictates how many different colours can be represented by each pixel.

(i) State the number of different colours that can be represented by a bit depth of 8 bits.

..... [1]

(ii) One binary colour is represented by 0100 1110

Convert the unsigned binary number 0100 1110 into denary.

..... [1]

(b) Convert the denary number −194 into 12-bit two's complement.

..... [1]

(c) (i) Convert the Binary Coded Decimal (BCD) value 0110 1001 into denary.

..... [1]

(ii) Identify one practical application where BCD is used.

.....

.....[1]

(d) One example of a character set used by computers is ASCII.

Describe how one character is represented in a character set.

.....

.....

.....

..... [2]

Question 20

(c) H is a register. The current contents of H are:

1	1	0	0	0	0	0	1

The current contents of register H represent an unsigned binary integer.

(i) Convert the value in register H into denary.

.....[1]

(ii) Convert the value in register H into hexadecimal.

.....[1]

(iii) The current contents of register H represent a two's complement binary integer.

Convert the value in register H into denary.

.....[1]

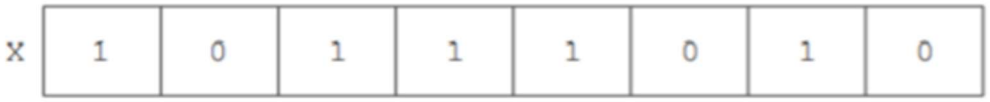
(iv) State why register H does not currently contain a Binary Coded Decimal (BCD).

.....

.....[1]

Question 21

(c) The current contents of a general purpose register (X) are:



(i) The contents of X represent an unsigned binary integer.

Convert the value in X into denary.

.....[1]

(ii) The contents of X represent an unsigned binary integer.

Convert the value in X into hexadecimal.

.....[1]

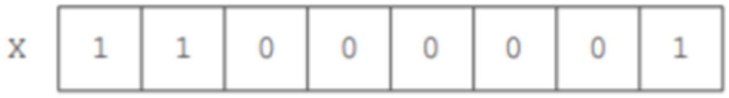
(iii) The contents of X represent a two's complement binary integer.

Convert the value in X into denary.

.....[1]

Question 22

(3c) the current contents of a general purpose register (X) are:



(i) The contents of X represent an unsigned binary integer.

Convert the value in X into denary.

..... [1]

(ii) The contents of X represent an unsigned binary integer.

Convert the value in X into hexadecimal.

..... [1]

(iii) The contents of X represent a two's complement binary integer.

Convert the value in X into denary.

..... [1]

Question 23

(b) The current contents of a general purpose register (X) are:

X	1	1	1	1	0	0	1	0

(i) The contents of X represent an unsigned binary integer.

Convert the value in X into denary.

.....[1]

(ii) The contents of X represent an unsigned binary integer.

Convert the value in X into hexadecimal.

.....[1]

(iii) The contents of X represent a two's complement binary integer.

Convert the value in X into denary.

.....[1]

Question 24

1 **(a)** Each of the following bytes represents an integer in two's complement form.

State the denary value.

(i) `0111 0111` Denary ..... [1]

(ii) `1000 1000` Denary ..... [1]

(iii) Express the following integer in two's complement form.

`-17`

[1]

(iv) State in denary, the range of integer values that it is possible to represent in two's complement integers using a single byte.

Lowest value .....

Highest value ..... [1]

(b) **(i)** Convert the following denary integer into Binary Coded Decimal (BCD).

`653`

.....[1]

(ii) A 3-digit BCD representation has been incorrectly copied. It is shown as:

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

State how you can recognise that this is not a valid BCD representation.

.....

.....[1]

(iii) Describe a practical application where BCD is used.

.....

.....[1]

Question 25

2 **(a)** Convert the following denary integer into 8-bit binary.

55

[1]

(b) Convert the following Binary Coded Decimal (BCD) number into denary.

10000011

.....[1]

(c) Convert the following denary integer into 8-bit two's complement.

-102

[2]

(d) Convert the following hexadecimal number into denary.

4E

.....[1]

Question 26

2 **(a)** Convert the following 8-bit binary integer into denary.

01001101

.....[1]

(b) Convert the following denary number into Binary Coded Decimal (BCD).

82

.....[1]

(c) Convert the following two's complement integer number into denary.

11001011

.....

.....

.....[2]

(d) Convert the following denary number into hexadecimal. Show your working.

198

.....[2]

Question 27

3 **(a)** **(i)** Convert the denary number 46 to an 8-bit binary integer.

.....

.....[1]

(ii) Convert the denary integer –46 to an 8-bit two's complement form.

.....

.....[1]

(iii) Convert the denary number 46 into hexadecimal.

.....

.....[1]

(b) Binary Coded Decimal (BCD) is another way of representing numbers.

(i) Describe how denary integers larger than 9 can be converted into BCD.
Give an example in your answer.

.....

.....

.....

.....[2]

(ii) Describe how an 8-bit BCD representation can be converted into a denary integer.
Give an example in your answer.

.....

.....

.....

.....[2]

Question 28

4 Hexadecimal, Binary Coded Decimal (BCD) and binary values are shown below.

Draw a line to link each value to its correct denary value.

Hexadecimal, BCD, binary	Denary
	93
Hexadecimal: 3A	
	−65
BCD representation: 0100 1001	
	58
	−63
Binary integer: 01011101	
	73
Two's complement binary integer: 11000001	
	49
	−93

[4]

Question 29

1 (i) Convert the following binary number into hexadecimal.

1 0 1 1 1 0 0 0

.....[1]

(ii) Convert the following denary number into BCD format.

9 7

.....[1]

(iii) Using two's complement, show how the following denary numbers could be stored in an 8-bit register:

114 | | | | | | | | |

- 93 | | | | | | | | |

[2]

Question 30

1 (a) (i) Using two's complement, show how the following denary numbers could be stored in an 8-bit register:

124 | | | | | | | | |

–77 | | | | | | | | |

[2]

(ii) Convert the two numbers in **part (a) (i)** into hexadecimal.

124 .....

–77 .....

[2]

(b) Binary Coded Decimal (BCD) is another way of representing numbers.

(i) Write the number 359 in BCD form.

..... [1]

(ii) Describe a use of BCD number representation.

.....

..... [2]

Question 31

3 A touch screen has three squares where a selection can be made:

(a) The x-coordinate of the centre of the three squares is held in three memory locations:

	Address	Memory contents
S	40	0000 1011 0100
T	41	0010 0101 0100
U	42	0100 0110 1100

(i) Give the hexadecimal value of the memory contents for U.

.....

.....[1]

(ii) Convert the denary number 40 into binary.

.....

.....[1]

Question 32

(c) The program used the ASCII coding system for character codes. An alternative coding system is Unicode.

(i) Give **two** disadvantages of using ASCII code.

1 .....

.....

2 .....

.....[2]

(ii) Describe how Unicode is designed to overcome the disadvantages of ASCII.

.....

.....

.....

.....[2]

Answer

Answer 1

1(c)(ii)	**1 mark** per bullet point
	
	• Converting 15 to binary `0000 1111`
	• Method for addition
	• Final answer
	`0010 0011`
	`+ 0000 1111`
	`0011 0010`
	`1 111`
		3

1(c)(iii)	**1 mark** per bullet point
	
	• Converting −10 to two's complement binary `1111 0110`
	• Adding values
	• Final answer `0001 1001`
	10 = `0000 1010`
	–10 = `1111 0110`
	
	`0010 0011`
	`+ 1111 0110`
	`0001 1001`
	`11 11`
		3

Answer 2

6(a)	1 mark for each correct answer ASCII = 128 // 2^7 Extended ASCII = 256 // 2^8	**2**
6(b)	**1 mark** per bullet point to **max 2** • Each character has its own **unique** code • Each character in the word is **replaced** by its code • The codes are stored **in the order in the word**	**2**

6(c)(i)	31	**1**
6(c)(ii)	53	**1**

Answer 3

1(b)(i)	**1 mark** for answer **1 mark** for working e.g. 1010 1010 0011 0111 **1110 0001** 1 1 1 1 1 1	**2**
1(b)(ii)	The result is a larger number than can be stored in the given number of bits. // The result is greater than 255	**1**
1(c)	240	**1**

Answer 4

4(a)	205	**1**
4(b)	–51	**1**
4(c)	CD	**1**
4(d)	**1 mark** for: The denary value in each group of 4 bits is greater than 9 // the denary value in each nibble is greater than 9	**1**
4(e)(i)	**1 mark** for working, **1 mark** for answer 0011 1101 +0010 1101 **0110 1010** 111 1 1	**2**
4(e)(ii)	**1 mark** for working, **1 mark** for answer 0011 1101 +1101 0011 (two's complement) **0001 0000** 1111 111	**2**

Answer 5

1(b)	1001 1100	**1**
1(c)	**1 mark** for working e.g. • Dividing by 16 // converting to binary (11111011) **1 mark** for answer FB	**2**
1(d)	1000 1110	**1**

Answer 6

3(c)	7E	**1**
3(d)	11110000	**1**
3(e)	**1 mark** per point • Correct conversion to binary 01111111 (127) and 00001100 (12) • Working e.g. turning 01111111 into two's complement 10000001 • Answer: 1000 1101	**3**

Answer 7

1(a)(i)	**1 mark** per point to **max 2** • **All** of the characters/symbols that the computer can use/represent • Each character has a **unique** number/binary number/hexadecimal number	**2**
1(a)(ii)	**1 mark** for each character set to **max 2**, **1 mark** for difference • ASCII • Extended ASCII • UNICODE • ASCII has 7 bits whereas UNICODE has 16 bits • Extended ASCII has 8 bits whereas UNICODE has 16 bits • ASCII has 7 bits whereas extended ASCII has 8 bits • Unicode can represent more characters than ASCII/Extended// by example • Extended ASCII can represent more characters than ASCII	**3**

1(b)	**1 mark** for each correct value **Statement** / **Answer** The hexadecimal value 11 represented in denary — 17 The smallest denary number that be represented by an unsigned 8-bit binary integer — 0 The denary number 87 represented in Binary Coded Decimal (BCD) — 1000 0111 The denary number 240 represented in hexadecimal — F0 The denary number –20 represented in 8-bit two's complement binary — 1110 1100	**5**

Answer 8

1(a)(i)	39	**1**
1(a)(ii)	27	**1**
1(a)(iii)	–25	**1**
1(b)	**1 mark** for working, **1 mark** for answer (0011 1110) Working using borrowing: 1 10 10 1 0 ~~10~~ 0 0 ~~10~~ 10 ~~1~~ 0 ~~1~~ ~~1~~ 0 0 1 1 0 1 1 1 0 1 0 1 – 0 0 1 1 1 1 1 0 Working using two's complement: 1 0 1 1 0 0 1 1 Two's complement 1 0 0 0 1 0 1 1 + (1) 0 0 1 1 1 1 1 0 1 1	**2**

1(c)	**1 mark** for similarity, **2 marks** for differences Similarity (**max 1**): • both **can** use 8 bits • both represent each character using a **unique** code • Unicode will contain all the characters that ASCII contains // ASCII is a subset of Unicode Differences (**max 2**): • Unicode can go up to 32 bits per character whereas ASCII is 7 or 8 bits Unicode can represent a wider range of **characters** than ASCII • different **languages** are represented using Unicode, ASCII is only for one language	**3**

Answer 9

2(a)(i)	–106	**1**
2(a)(ii)	96	**1**
2(a)(iii)	**1 mark** for each bullet point: • 149 decimal • 0001 0100 1001	**2**
2(b)	1101 0010	**1**

Answer 10

9(a)(i)	93	**1**
9(a)(ii)	147	**1**
9(b)	**1 mark** for each correct benefit (**max 2**) Examples: • straightforward to convert to / from BCD and denary • ... so it is less complex to encode and decode for programmers • easier for digital equipment use BCD to display output information • can represent monetary values exactly	**2**

Answer 11

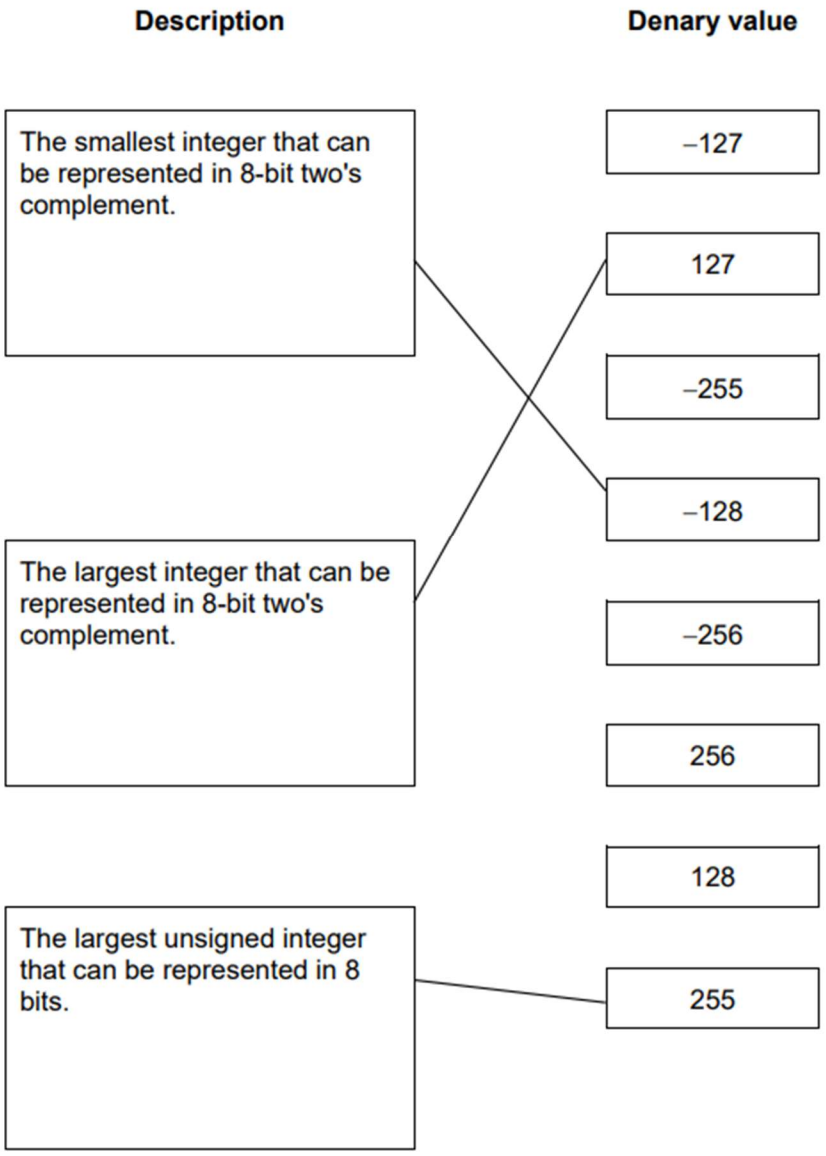
3(d)(ii)	1001 0110 0100	**1**
3(d)(iii)	F2	**1**
3(d)(iv)	Smallest: 10000000 Largest: 01111111	**2**
3(d)(v)	**1 mark** for working **1 mark** for answer 1 0 1 1 0 0 0 0 + 0 0 0 1 1 0 1 1 1 1 0 0 1 0 1 1 1 1	**2**

Answer 12

4(a)	2^{16} // 65536	**1**
4(b)	**1 mark** for working; **1 mark** for answer • Working: +120 = 0111 1000 • Answer: 1000 0111	**2**

4(c)	**1 mark** for working; **1 mark** for answer
	
	• Working: A04 = (10 * 16^2) + 4
	// A04 = (10 * 256) + 4
	// A04 = 1010 0000 0100
	
	• Answer: 2564
		2

Answer 13

7(a)	**1 mark** for each correct line 	**3**

Answer 14

3(a)	**1 mark** for: Either • kibibyte = 1,024 bytes // 2^{10} bytes **and** megabyte = 1000 kilobytes //1 000 000 bytes // 10^3 kilobytes // 10^6 bytes Or • kibi is binary prefix **and** mega is denary prefix	**1**
3(b)(i)	1111 0011 1100	**1**
3(b)(ii)	865	**1**
3(b)(iii)	470	**1**
3(c)	**1 mark** for a correct application **1 mark** for a corresponding justification • An application that performs financial / banking calculations • ... because it is difficult to represent decimal values exactly in normal binary and financial transactions use only two decimal places and must be accurate, no accumulating errors Or • Electronic displays, e.g. calculators, digital clocks • ... because visual displays only need to show individual digits • ... because conversion between denary and BCD is easier Or • The storage of the date and time in the BIOS of a PC • ... because conversion with denary is easier	**2**

Answer 15

7	**1 mark** each: • Working – carried values clearly indicted • Correct answer 0001 1000 • Overflow clearly indicated as overflow Example: 1 0 0 1 1 1 1 0 0 1 1 0 0 0 0 1 + 0 0 0 1 1 0 0 1 (1) 0 0 0 1 1 0 0 0 1 1 1 1 1 1 1.....(carries)	**3**

Answer 16

7(b)	**1 mark** each: • Converting 100 to binary **0110 0100 and** 10 to binary **0000 1010** • Subtraction method - converting 10 to – 10 and adding // direct subtraction … • … correct answer **0101 1010** Method 1: Converting to -10 and adding: Binary for +10 is 0000 1010 Binary for –10 is 1111 0110 Binary for 100 is 0110 0100 100 + (-10): 0 1 1 0 0 1 0 0 +1 1 1 1 0 1 1 0 (1) 0 1 0 1 1 0 1 0 Carries: 1 1 0 0 1 0 0 0 Method 2: Direct Subtraction Borrows: 0 0 0 1 1 0 1 0 0 1 1 0 0 1 0 0 – 0 0 0 0 1 0 1 0 0 1 0 1 1 0 1 0	**3**
7(c)	**1 mark** for working: 1100 0000 1111 // 2048 + 1024 + 8 + 4 + 2 + 1 // (12 * 16^2) + 15 // (12 * 16 * 16) + 15 // 3072 + 15 **1 mark** for correct answer: 3087	**2**

Answer 17

<table>
<tr><td>1(b)</td><td>1 mark for correct answer:
F1</td><td>1</td></tr>
<tr><td>1(c)</td><td>1 mark for a correct answer:

The answer is too long to be represented in the same number of bits as the binary numbers being added</td><td>1</td></tr>
<tr><td>1(d)(i)</td><td>1 mark for all 3 answers correct:
<table><tr><th>Character set</th><th>Number of bits</th></tr><tr><td>ASCII</td><td>7</td></tr><tr><td>extended ASCII</td><td>8</td></tr><tr><td>Unicode</td><td>16/32</td></tr></table></td><td>1</td></tr>
<tr><td>1(d)(ii)</td><td>1 mark each:

• Each character has a unique binary code
• The binary code for each character is stored in sequence</td><td>2</td></tr>
</table>

Answer 18

<table>
<tr><td>7(d)</td><td>1 mark for 1 or 2 correct answers
2 marks for 3 correct answers

<table><tr><th></th><th>Red</th><th>Green</th><th>Blue</th></tr><tr><td>Hexadecimal value</td><td>91</td><td>3C</td><td>8E</td></tr><tr><td>Denary value</td><td>145</td><td>60</td><td>142</td></tr></table></td><td>2</td></tr>
</table>

Answer 19

5(a)(i)	256	**1**
5(a)(ii)	78	**1**
5(b)	1111 0011 1110	**1**
5(c)(i)	69	**1**
5(c)(ii)	Any scenario where a single digit needs to be transmitted / displayed e.g. calculator / digital clock	**1**
5(d)	**1 mark** per bullet to **max 2** • Each character is represented by a **unique** • … denary / hexadecimal / binary number	**2**

Answer 20

3(c)(i)	193	**1**
3(c)(ii)	C1	**1**
3(c)(iii)	− 63	**1**
3(c)(iv)	The first 4 bits / first nibble (would give 12 which) is > 9 / 2 digits (which is not valid for BCD)	**1**

Answer 21

4(c)(i)	186	**1**
4(c)(ii)	BA	**1**
4(c)(iii)	–70	**1**

Answer 22

3(c)(i)	193	**1**
3(c)(ii)	C1	**1**
3(c)(iii)	–63	**1**

Answer 23

2(b)(i)	**242**	**1**
2(b)(ii)	**F2**	**1**
2(b)(iii)	**–14**	**1**

Answer 24

1(a)(i)	119	**1**
1(a)(ii)	–120	**1**
1(a)(iii)	1 1 1 0 1 1 1 1	**1**
1(a)(iv)	Lowest value: −128 Highest value: +127	**1**
1(b)(i)	0110 0101 0011	**1**
1(b)(ii)	The second block of four binary digits represents a digit larger than 9 // 14	**1**
1(b)(iii)	A string of digits on any electronic device displaying numeric values	**1**

Answer 25

2 **(a)** 00110111 **[1]**

(b) 83 **[1]**

(c) 10011010 **[2]**

Marks allocated as follows:

1 mark for the most significant bit
1 mark for the remaining 7 bits

(d) 78 **[1]**

Answer 26

2 **(a)** 77 **[1]**

(b) 1000 0010 **[1]**

(c) −53 **[2]**

One mark for '**53**' and **one** mark for '**–**'

(d) C6 **[2]**

One mark for the answer, <u>one</u> mark for the method

- Working e.g. 198 / 16 = 12, 198 − (12*16) = 6

Answer 27

3 (a) (i) 0 0 1 0 1 1 1 0 [1]

(ii) 1 1 0 1 0 0 1 0 [1]

(iii) 2 E [1]

(b) (i) **One mark** for the explanation and **one mark** for the example

- Each denary digit is written as a 4-bit binary number
- Example: 46 = 0100 0110

[2]

(ii) **One mark** for the explanation and **one mark** for the example

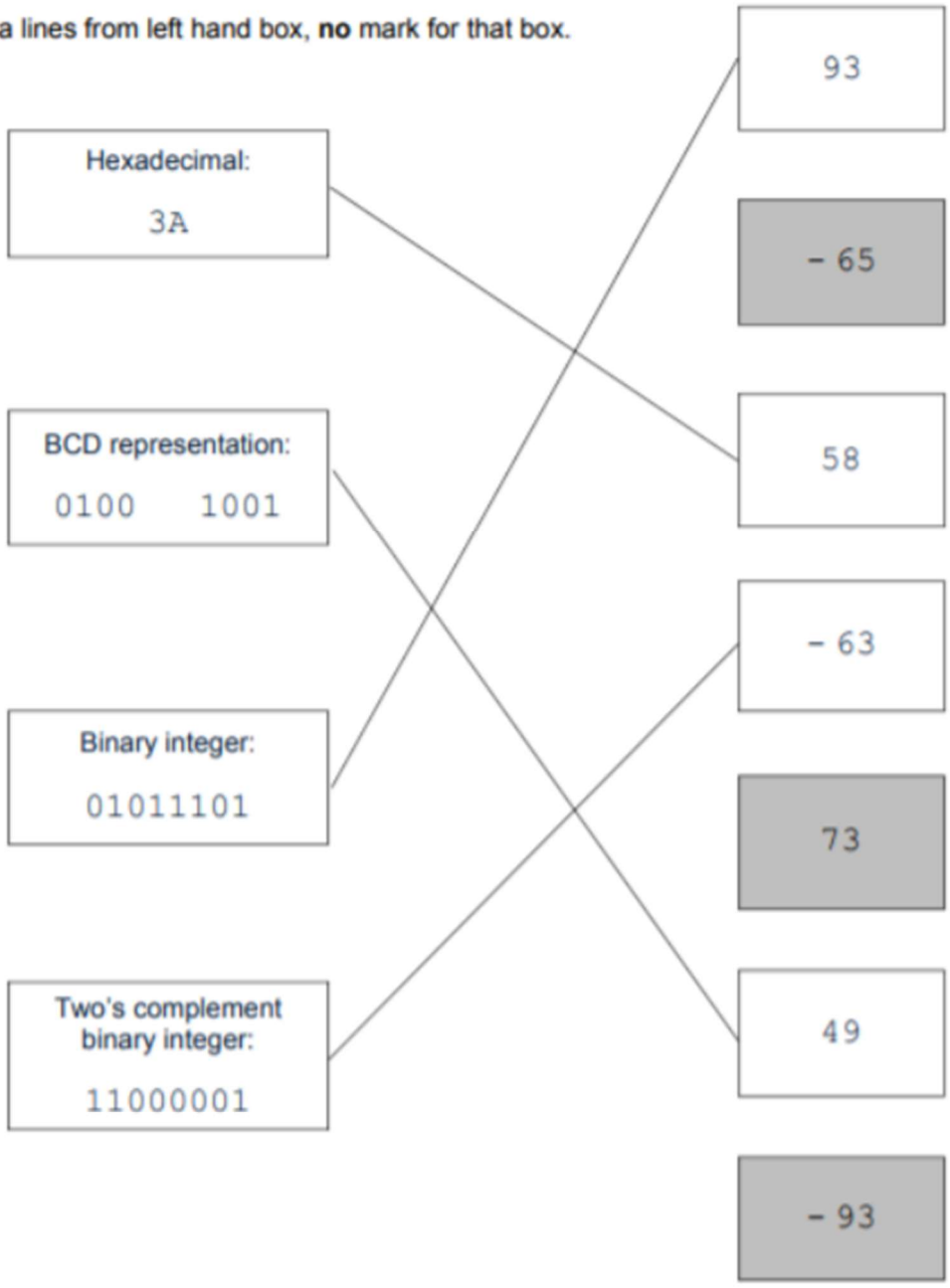
- Binary number is split up into groups of 4 bits (starting from the right) // Each group of 4 bits is converted to a denary digit
- Example: 0011 0111 = 37

[2]

Answer 28

4 **ONE** mark for each correct line.

Extra lines from left hand box, **no** mark for that box.



[4]

Answer 29

1 (i) B 8

(ii) 1 0 0 1 0 1 1 1

(iii)

114	0	1	1	1	0	0	1	0
– 93	1	0	1	0	0	0	1	1

Answer 30

1(a) (i)

124 = 0 1 1 1 1 1 0 0

-77 = 1 0 1 1 0 0 1 1

(ii) 124: 7 C

–77: B 3 [2]

(b) (i) 0 0 1 1 0 1 0 1 1 0 0 1 [1]

(ii)
- when denary numbers need to be electronically coded
- e.g. to operate displays on a calculator where each digit is represented
- decimal fractions can be accurately represented [2]

Answer 31

3 (a) (i) 4 6 C [1]

(ii) 1 0 1 0 0 0 [1]

Answer 32

(c) (i) Any **two** from:

- Only 128 / 256 characters can be represented
- Uses values 0 to 127 (or 255 if extended form) / one byte
- Many characters used in other languages cannot be represented
- In extended ASCII the characters from 128 to 255 may be coded differently in different systems

[2]

(ii) Any **two** from:

- Uses 16, 24 or 32 bits / two, three or four bytes
- Unicode is designed to be a superset of ASCII
- Designed so that most characters (in other languages) can be represented

[2]