Topic 2 - Computer Organization
IB Past Paper Practice Questions

1)

The standard length of a byte to store one character is 8 bits, which can represent up to 256 different characters. Writing in the Chinese language requires over 400 characters. These can be represented in a computer by increasing the number of bits used to store a character (that is, to change the size of a byte).

(a) State the minimum number of bits required in a byte to store 400 of the Chinese characters. *[1 mark]*

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(b) Explain the implications of a change in the number of bits used in a byte on a computer system with respect to:

(i) hardware. *[3 marks]*

(ii) software. *[3 marks]*

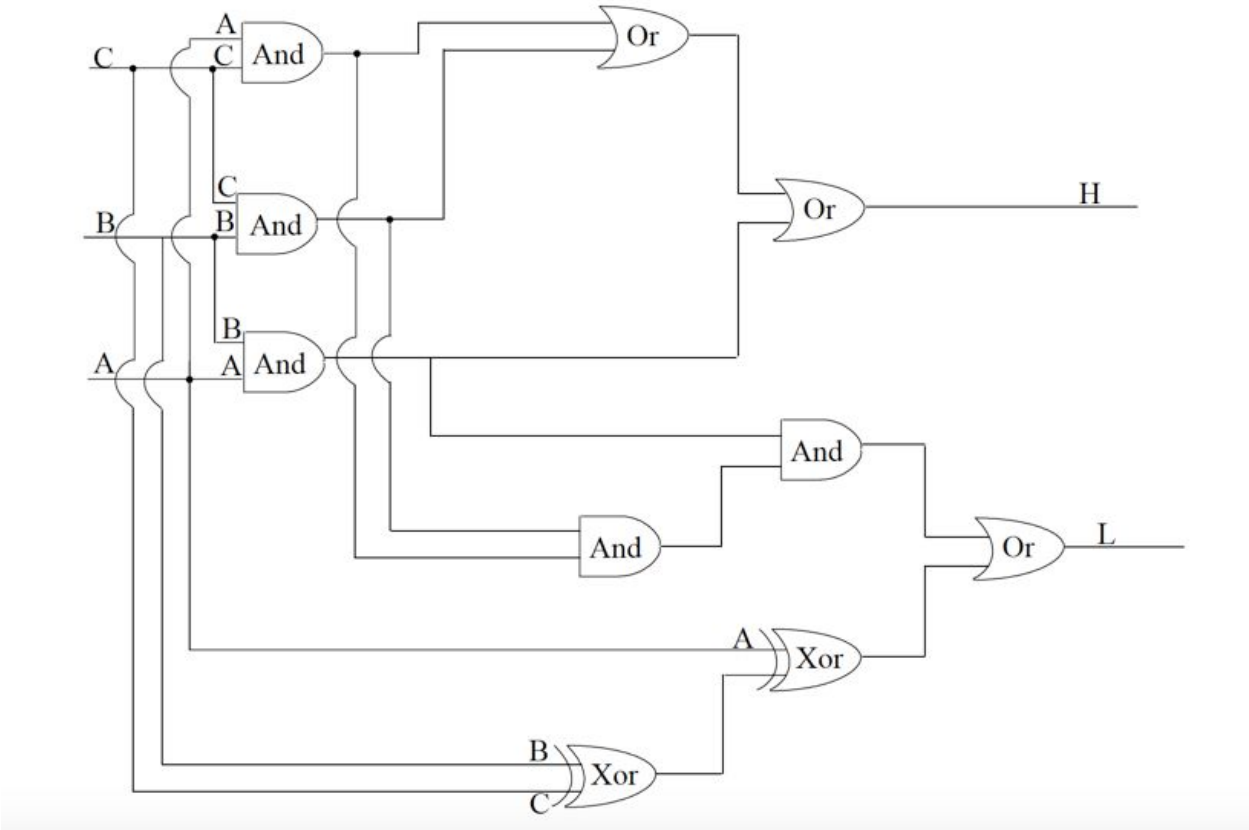
(iii) communication. *[3 marks]*

2)

State the 8 bit, two's complement of –91. Show your working. *[2 marks]*

3) *Questions b and c are optional.*

The following logic circuit has three inputs, A, B and C. It has two outputs, H and L.



(a) Copy and complete the following truth table for the circuit. *[5 marks]*

A	B	C	H	L
0	0	0	0	0
0	0	1	0	1

(b) State the name of this circuit. *[2 marks]*

(c) The boolean expression for H can be written as:

$$H = A.B.\overline{C} + A\overline{B}C + \overline{A}BC + ABC$$

Simplify this expression and show your working. *[3 marks]*

4)

With reference to number bases, explain why one kilometre is equivalent to 1000 metres whereas one kilobyte is equivalent to 1024 bytes. *[2 marks]*

5)

Describe the difference between a *multi user* and a *multi tasking* operating system, stating **one** example of each. *[4 marks]*

6)

Explain the role of the *instruction register*, the *program counter* and *buses* in the *machine instruction cycle*. *[6 marks]*

7)

A chemical factory produces three dangerous gases, A, B and C, which have to be constantly monitored to ensure that they do not exceed specific levels. If these limits are exceeded then the corresponding inputs A, B and C are set to logical true.

C is always dangerous if it exceeds its limit.
A and B neutralise one another so they are only dangerous if one or the other, but not both, exceed their limit.
A warning signal, X, is given if either A **or** C are dangerous.
A danger alarm, Y, is sounded if A **and** C are both dangerous **or** if B **and** C are both dangerous.

(a) Represent the inputs A, B and C and the corresponding outputs X and Y in a truth table. *[4 marks]*

(b) Hence, or otherwise, produce logical expressions for the outputs X and Y. *[2 marks]*

(c) Construct a logic circuit for the alarm Y from the inputs A, B and C. *[4 marks]*

8)

Calculate the value of the INTEGER represented by the following 5 bit binary number that is written in 2's complement format. *[2 marks]*

$$10111_2$$

9)

Define *virtual memory* and give an example of when it might be used. *[2 marks]*

10)

Calculate the result of the following hexadecimal addition. (Show answer in hexadecimal format.) *[2 marks]*

$$FD_{16} + AB_{16}$$

11)

The following questions **all** relate to a computer that uses 7 bits to represent integers using 2's complement.

(a) Calculate the following:

(i) minimum integer value that can be represented. *[1 mark]*

(ii) maximum integer value that can be represented. *[1 mark]*

(b) Determine the result of the addition $0111101_2 + 0111110_2$. (Show answer in binary format.) *[2 marks]*

(c) Explain the error that has occurred. *[2 marks]*

(d) Explain the likely impact on the running of a program if this general type of error occurs. *[2 marks]*

(e) Discuss how a Java programmer can prevent such errors. *[2 marks]*

12)

An automated robot is used to cut shapes from steel sheets. If the robot's cutting blade becomes both hot and blunt the robot must stop so that the blade can cool and be resharpened. Sensors S1 (hot state) and S2 (blunt state) are attached to the blade to detect these states. Water from a container is used to keep the blade cool during cutting. If the water level falls below a certain point a sensor S3 detects this state and the robot stops irrespective of the other states.

A logic circuit is required to control the robot so that it stops cutting when the appropriate states occur.

(a) Copy the following truth table and complete it to represent the above logic. *[3 marks]*

A(S1)	B(S2)	C(S3)	Stop
0	0	0	0
0			
0			
0			
1			
1			
1			
1			

(b) From the truth table write the **full** Boolean expression showing **all** terms. *[2 marks]*

(c) Simplify the above **full** Boolean expression (clearly show the method used). *[3 marks]*

(d) Draw the circuit diagram for the simplified Boolean expression in (c). *[2 marks]*

13)

(a) Calculate $DE+3C$, giving your answer in hexadecimal. *[2 marks]*

(b) State the answer to part (a) in binary. *[1 mark]*

(c) State the error that would occur when this result is stored in an 8 bit register. *[1 mark]*

14)

Outline the function of the *arithmetic and logic unit* (ALU) in the *central processing unit* (CPU). *[2 marks]*

15)

The following questions relate to the internal structure of a Central Processing Unit (CPU) and how it interacts with external requests or devices.

(a) Construct a detailed diagram of a CPU to show the following logically grouped components: *Program Counter* (PC), *Instruction Register* (IR), *Accumulator*, relevant *Buses* and connections to *Cache* and *RAM*. *[4 marks]*

(b) Outline the role of the *PC*. *[2 marks]*

(c) Explain how *hardware interrupts* are used in relation to the operation of the *CPU*. *[2 marks]*

(d) Explain an advantage of using *polling* instead of *interrupts*. *[2 marks]*

16)

Compare *magnetic tape* with *flash memory* as media for backing up data. *[4 marks]*

17)

A washing machine which has several different programs can be set to start working at a specified time. The time to start and the required program are input by a user. The washing machine is controlled by a microprocessor.

(a) Identify **two** items that would need to be held in read-only memory (ROM). *[2 marks]*

(b) Identify **two** items that would need to be held in random access memory (RAM). *[2 marks]*

The microprocessor controls water input (W), heating (H) and rotation (R). The following table shows the state of these controls for whether or not the washing machine is operating (M).

W	H	R	M
0	0	0	0
0	0	1	0
0	1	0	1
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	0
1	1	1	1

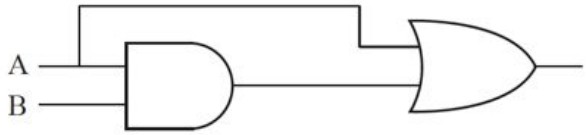
(c) Use the truth table to state the logical conditions that define when the washing machine is operating **and** simplify the expression as far as possible. *[3 marks]*

(d) Construct the logical circuit from the simplified expression you obtained in part (c). *[3 marks]*

18)

(a) Construct the truth table for a 2-input **nand** operation. *[2 marks]*

(b) State the Boolean expression that corresponds exactly (without simplification) to the following circuit. *[1 mark]*



(c) Simplify the expression from part (b). *[1 mark]*

19)

(a) Convert the decimal number 17 into 6-bit two's complement. *[1 mark]*

(b) Convert the decimal number –17 into 6-bit two's complement. *[1 mark]*

20)

Outline the following functions of an operating system.

(a) memory management *[2 marks]*

(b) security *[2 marks]*