

Questions 1-5 are multiple choice, circle the best answer.

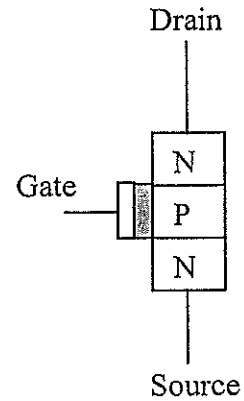
1. [4 marks] Using 7-bit binary plus a sign bit, the base-10 number -97 is represented by:

- (a) 10011110
- (b) 11100001
- (c) 00011110
- (d) 01100001

2. [4 marks] The result of the binary addition (all numbers are 7 bit binary plus a sign bit)  $00101010 + 0001011 + 00011101$  is:

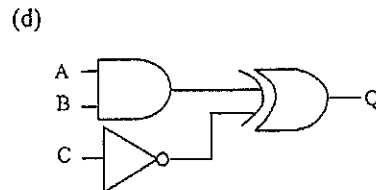
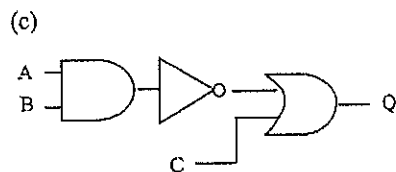
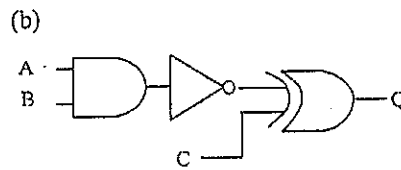
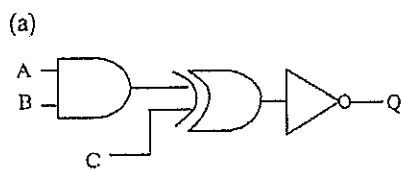
- (a) 01100010
- (b) 11010010
- (c) 01010010
- (d) 01110001

3. [2 marks] The diagram at right represents an NPN MOSFET (Metal Oxide Semiconductor Field Effect Transistor). If a voltage of 5V (a high voltage) is applied to the gate terminal,



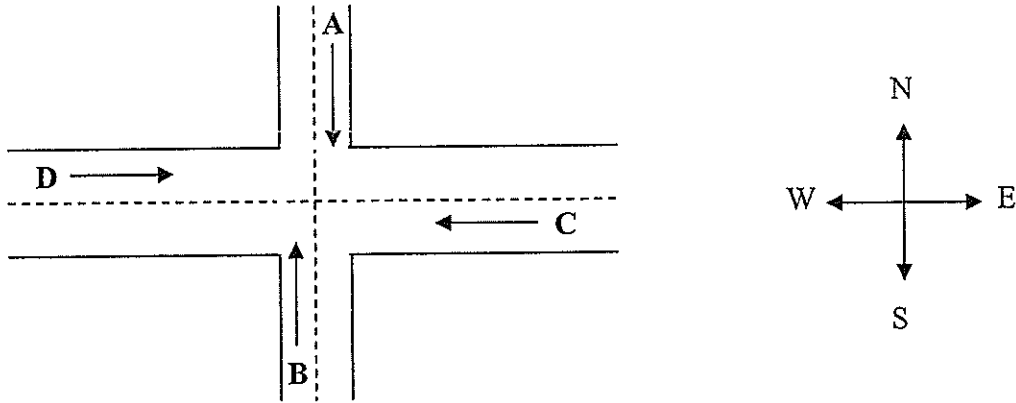
- (a) the resistance between the drain and source terminals is very high.
- (b) the MOSFET is turned off.
- (c) a current passes between the gate and source terminals.
- (d) an N-type channel is induced between the 2 N-type regions.

4. [2 marks] Select the logic gate combination which represents the Boolean expression  $\overline{A} \cdot B \oplus C = Q$ .



Questions 6-11 are long answer questions, write your answers in the provided boxes, make sure that you include working and explain it.

6. [10 marks] The diagram below shows the intersection of a main highway with a secondary access road. Vehicle detection sensors are placed along lanes C and D (main road) and lanes A and B (access road). These sensor outputs are LOW (0) when no vehicle is present and high (1) when a vehicle is present.



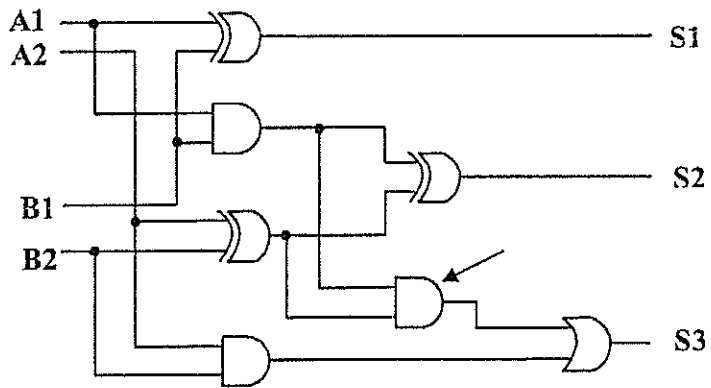
The intersection traffic light is to be controlled according to the following logic:

- 1) The East-West (E-W) traffic light will be green whenever both lanes C and D are occupied.
- 2) The E-W light will be green whenever either C or D is occupied but lanes A and B are not both occupied.
- 3) The E-W light will be green when no vehicles are present.

Using the sensor outputs A, B, C, and D as inputs, design a logic circuit to control the traffic light. There should be two outputs, N-S and E-W that go HIGH when the corresponding light is green. Explain your working.

5. [2 marks] In the adder circuit below the purpose of the AND gate indicated by the arrow is:

- (a) to determine if there is a carried bit from the first column to the second column of the sum.
- (b) to determine if there is a carried bit from the second column to the third column of the sum.
- (c) to add a carried bit from the first column to the second column.
- (d) to add a carried bit from the second column to the third column.

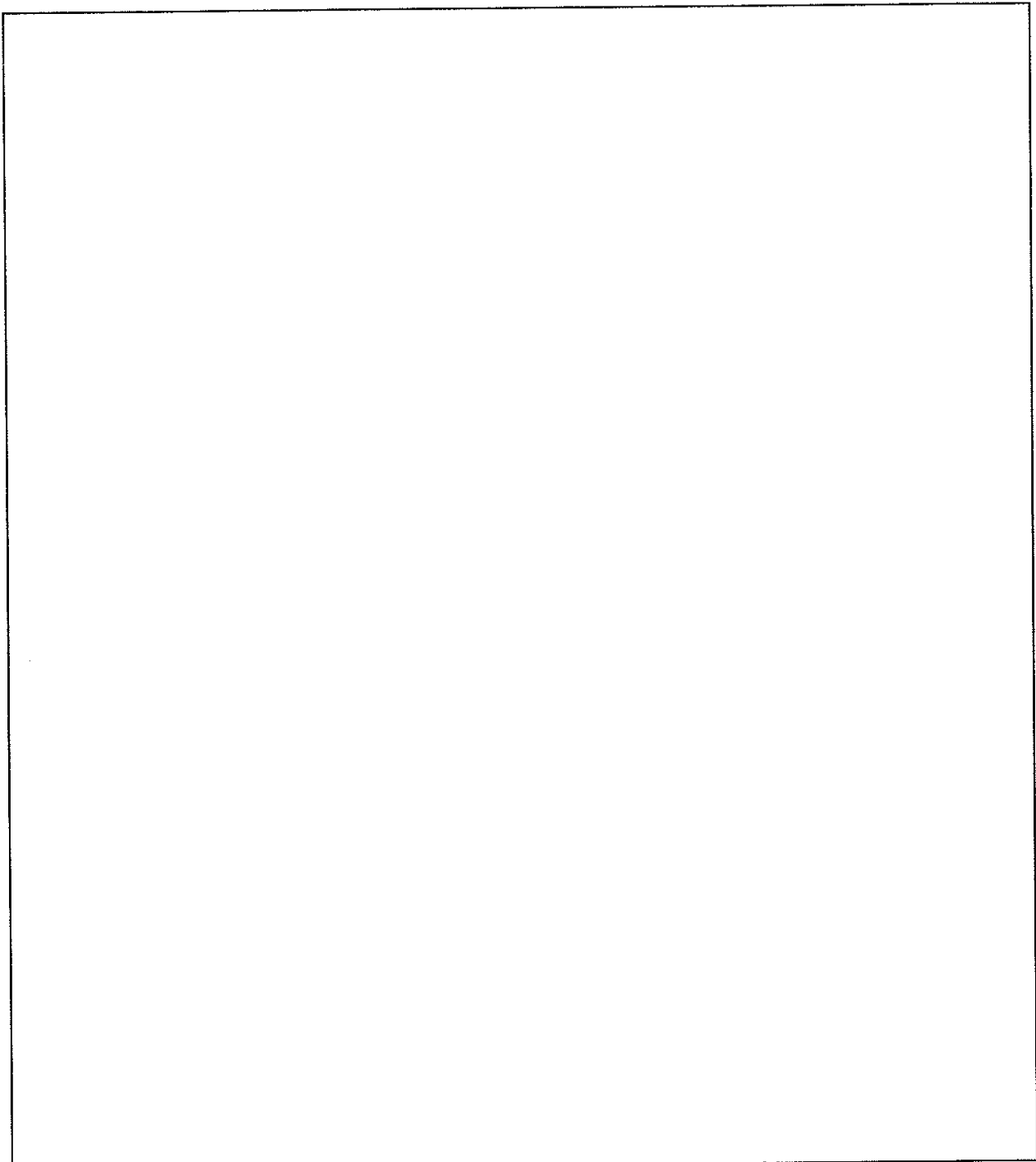


7. [10 marks] A car alarm circuit has three inputs which detect the following conditions:

- (i) whether the door is CLOSED (0) or OPEN (1);
- (ii) whether the ignition is turned ON (1) or OFF (0);
- (iii) whether the headlights are ON (1) or OFF (0).

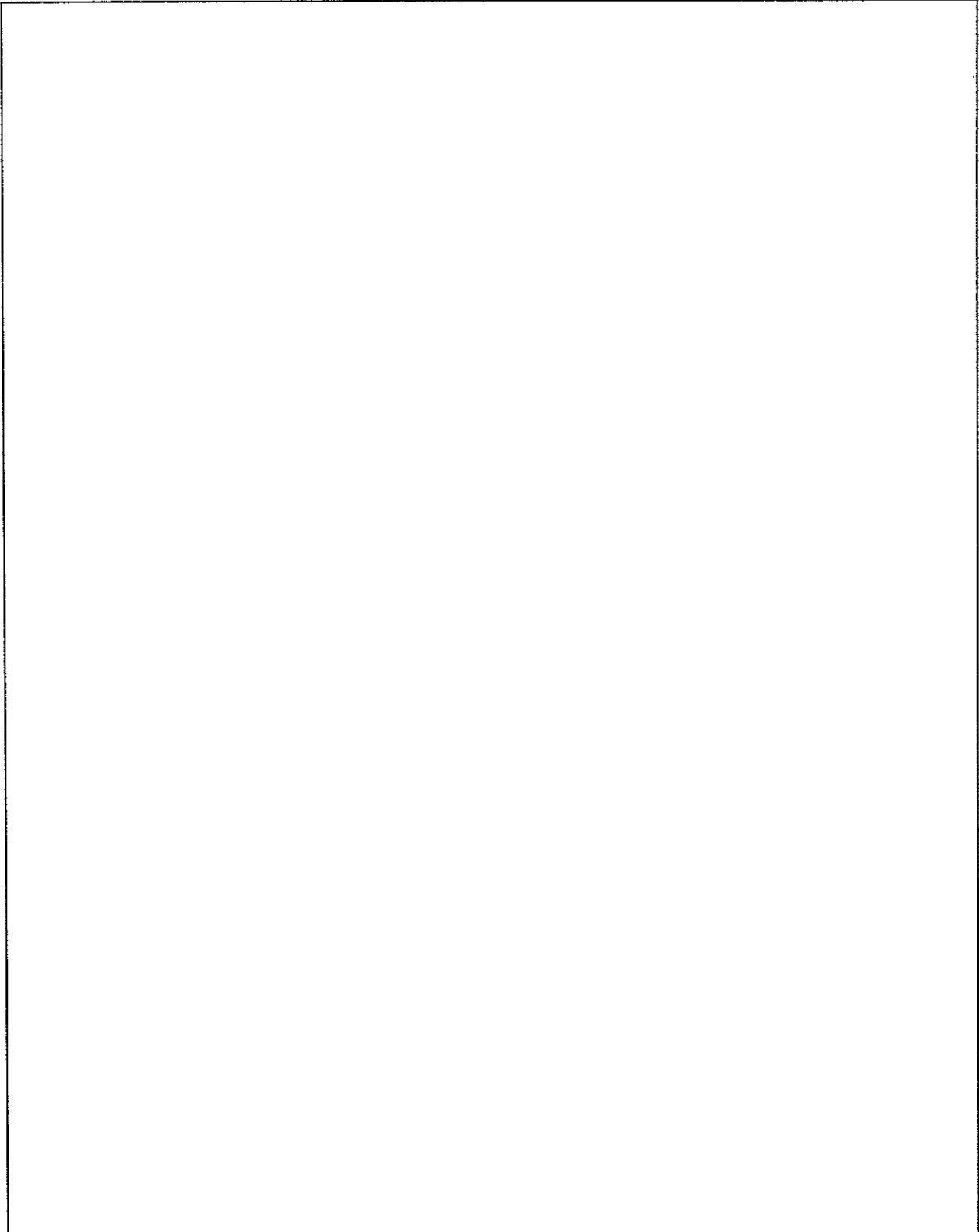
Design a logic circuit which uses these three inputs and sounds the alarm if either:

- (a) the headlights are ON while the ignition is OFF; or
- (b) the door is OPEN when the ignition is ON.



8. [6 marks] Making integrated circuits (2 marks each part)

- (a) Describe briefly how lithography can be used to make integrated circuits.
- (b) What is Moore's Law?
- (c) Give one reason why the limitations of lithography might slow the continued improvement in the performance of integrated circuits.

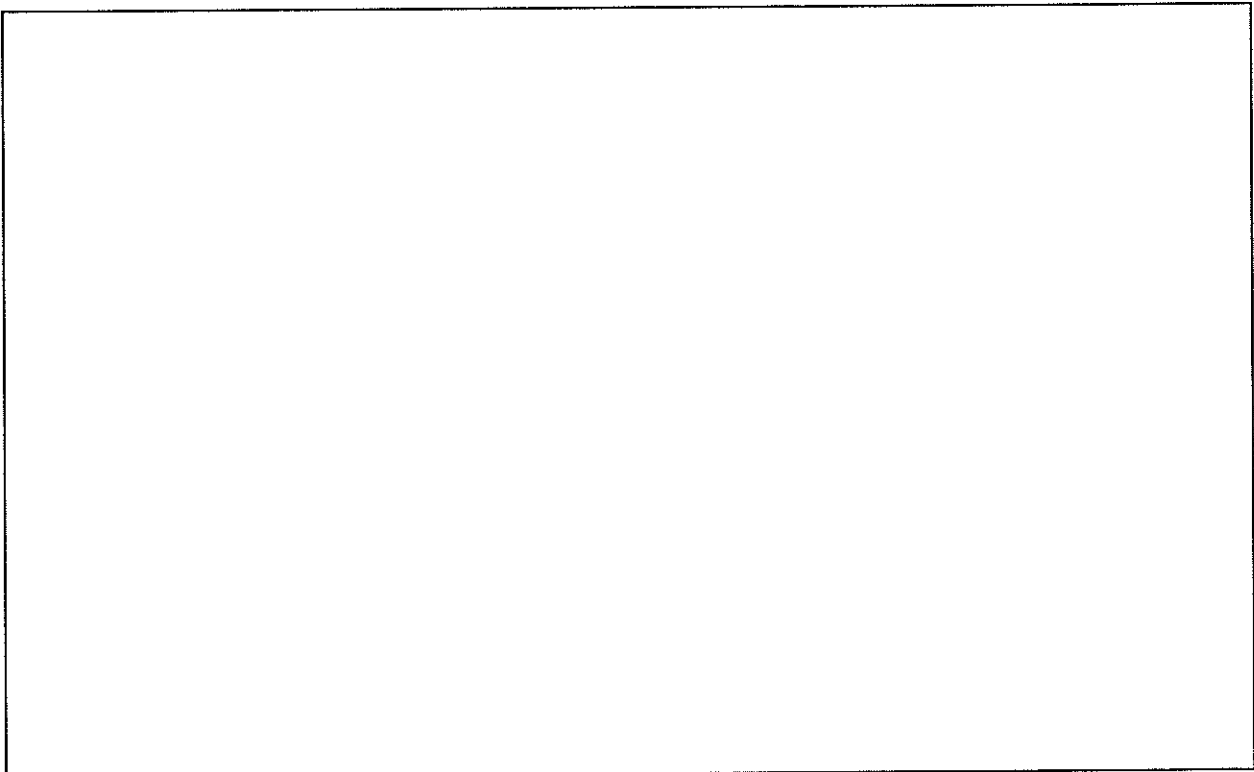
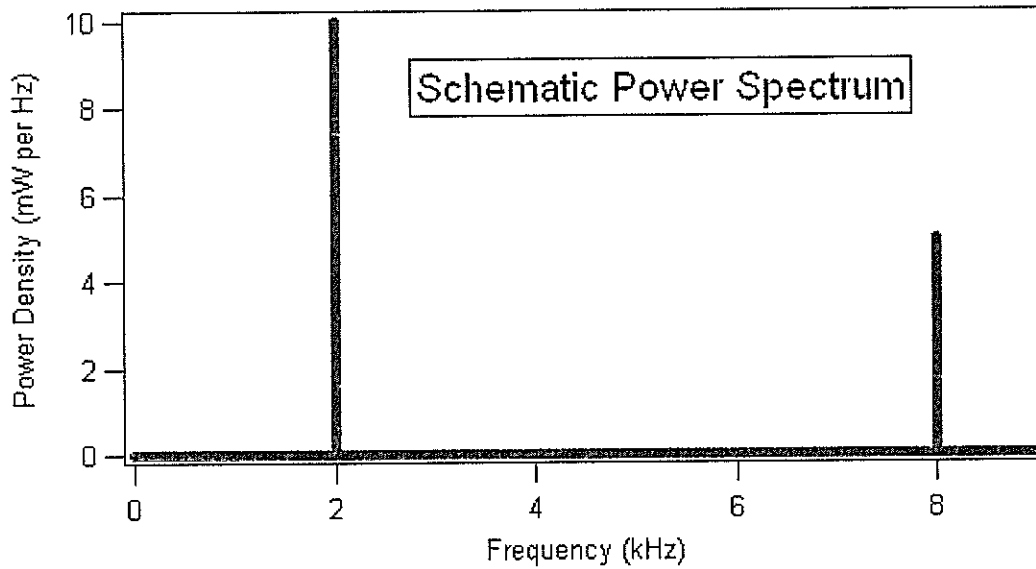


9. [10 marks] Waves (1 mark each of parts a – f, 4 marks for part g)

Consider a wave described by the equation  $y = 10\text{metres} \sin(5x + 7t)$

The variable  $x$  is position in metres and  $t$  is time in seconds.

- Find the amplitude of the wave.
- Find the wavelength of the wave.
- Find the period of the wave.
- Find the frequency of the wave.
- Find the speed of the wave.
- Write a function that describes a wave that would cancel this wave.
- Consider the following power spectrum. Sketch roughly what the signal would look like.



10. [10 marks] Your friend has just bought a computer with a 2GHz processor(CPU) that doesn't support pipelining. You have a computer with a 1.5Ghz processor (CPU) that does support pipelining, more RAM and a larger on-board cache. Explain why he may find that some of his programs still do not run any faster on his machine than on yours despite having a faster processor.

11. [10 marks] You are working in small office with five standalone PCs and a single PC that is connected to the Internet. At the moment people take turns using the PC that can access the Internet and they share files by passing around flash drives (6 marks for a, 4 marks for b).

(a) Identify the advantages and disadvantages for this office if a local area network is installed.

(b) Recommend an appropriate network topology for the local area network that will make it easier to find and fix breakages in network cabling. Make sure that you justify your answer.

