Surname		Other Names	
Centre Number			Candidate Number				
Candidate Signature									

For Examiner's Use

General Certificate of Education
June 2008
Advanced Subsidiary Examination

AQA
ASSESSMENT and QUALIFICATIONS ALLIANCE

ELECTRONICS **ELE2**
Unit 2 Further Electronics

Friday 16 May 2008 9.00 am to 10.30 am

For this paper you must have:
- a pencil and a ruler
- a calculator.

Time allowed: 1 hour 30 minutes

Instructions
- Use black ink or black ball-point pen. Use pencil only for drawing.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Answers written in margins or on blank pages will not be marked.
- Do all rough work in this book. Cross through any work you do not want to be marked.
- A *Data Sheet* is provided on pages 3 and 4. Detach this perforated sheet at the start of the examination.

Information
- The maximum mark for this paper is 72.
- The marks for questions are shown in brackets.
- You are expected to use a calculator where appropriate.
- Any correct electronic solution will gain credit.
- You are reminded of the need for good English and clear presentation in your answers.

For Examiner's Use			
Question	Mark	Question	Mark
1		5	
2		6	
3		7	
4			
Total (Column 1) →			
Total (Column 2) →			
TOTAL			
Examiner's Initials			

Data Sheet

- A perforated *Data Sheet* is provided as pages 3 and 4 of this question paper.
- This sheet may be useful for answering some of the questions in the examination.
- You may wish to detach this sheet before you begin work.

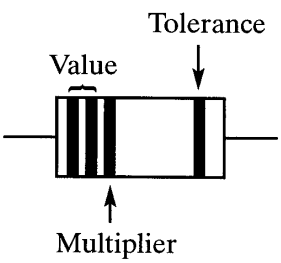
Data Sheet

Resistors Preferred values for resistors (E24) series:
1.0, 1.1, 1.2, 1.3, 1.5, 1.6, 1.8, 2.0, 2.2, 2.4, 2.7, 3.0, 3.3, 3.6, 3.9, 4.3, 4.7, 5.1, 5.6, 6.2, 6.8, 7.5, 8.2, 9.1 ohms and multiples that are ten times greater.

Resistor Printed Code (BS 1852) This code consists of letters and numbers:
R means × 1
K means × 1000 (i.e. 10^3)
M means × 1 000 000 (i.e. 10^6)
Position of the letter gives the decimal point
Tolerances are given by the letter at the end of the code, F = ± 1%, G = ± 2%, J = ± 5%, K = ± 10%, M = ± 20%.

Resistor Colour Code

Number	Colour
0	Black
1	Brown
2	Red
3	Orange
4	Yellow
5	Green
6	Blue
7	Violet
8	Grey
9	White



Tolerance, gold = ± 5%, silver = ± 10%, no band ± 20%.

Silicon diode $V_F = 0.7\,V$

Silicon transistor $V_{be} \approx 0.7\,V$ in the on state
$V_{ce} \approx 0.2\,V$ when saturated

Resistance

$$R_T = R_1 + R_2 + R_3 \quad \text{series}$$

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \quad \text{parallel}$$

Capacitance

$$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} \quad \text{series}$$

$$C_T = C_1 + C_2 + C_3 \quad \text{parallel}$$

Time constant $T = CR$

A.C. theory

$$I_{rms} = \frac{I_o}{\sqrt{2}}$$

$$V_{rms} = \frac{V_o}{\sqrt{2}}$$

$$X_C = \frac{1}{2\pi fC} \quad \text{reactance}$$

$$X_L = 2\pi fL \quad \text{reactance}$$

$$f = \frac{1}{T} \quad \text{frequency, period}$$

$$f_o = \frac{1}{2\pi\sqrt{LC}} \quad \text{resonant frequency}$$

Operational amplifier

$$G_V = \frac{V_{out}}{V_{in}} \quad \text{voltage gain}$$

$$G_V = -\frac{R_f}{R_1} \quad \text{inverting}$$

$$G_V = 1 + \frac{R_f}{R_1} \quad \text{non-inverting}$$

$$V_{out} = -R_f\left(\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3}\right) \quad \text{summing}$$

Astable and Monostable using NAND Gates

$$f \approx \frac{1}{2RC} \quad \text{astable}$$

$$T \approx RC \quad \text{monostable}$$

555 Astable and Monostable

$$T = 1.1RC \quad \text{monostable}$$

$$\left.\begin{aligned} t_H &= 0.7(R_A + R_B)C \\ t_L &= 0.7R_BC \end{aligned}\right] \quad \text{astable}$$

$$f = \frac{1.44}{(R_A + 2R_B)C} \quad \text{two resistor circuit}$$

Electromagnetic Waves

$c = 3 \times 10^8 \text{ m s}^{-1}$ speed in vacuo

List of BASIC Commands

DIM variable [(subscripts)]

DO [{**WHILE** | **UNTIL**} condition]
    [statement block]
LOOP

DO
    [statement block]
LOOP [{**WHILE** | **UNTIL**} condition]

FOR counter = start **TO** end [**STEP** increment]
    [statement block]
NEXT counter

GOSUB [label | line number]
    [statement block]
RETURN

IF condition **THEN**
    [statement block 1]
ELSE
    [statement block 2]

INKEY$

INP (port %)

INPUT [;] ["prompt" {;1, }] variable list (comma separated)

LPRINT [expression list] [{ ;1, }]

OUT port%, data%

PRINT [expression list] [{;1,}]

REM remark

Answer **all** questions in the spaces provided.

1 Temporary traffic lights are used to control the traffic at roadworks. The traffic lights have a 16-step binary sequence as shown in the table below where R = red, Y = amber, G = green.

D	C	B	A	traffic lights 1	traffic lights 2
0	0	0	0	R	G
0	0	0	1	R	G
0	0	1	0	R	G
0	0	1	1	R	G
0	1	0	0	R	G
0	1	0	1	R	G
0	1	1	0	R	Y
0	1	1	1	R, Y	R
1	0	0	0	G	R
1	0	0	1	G	R
1	0	1	0	G	R
1	0	1	1	G	R
1	1	0	0	G	R
1	1	0	1	G	R
1	1	1	0	Y	R
1	1	1	1	R	R, Y

1 (a) State the value of the step, in hexadecimal, when only the amber lamp is illuminated in **traffic lights 1**.

.....

(1 mark)

Question 1 continues on the next page

1 (b) Explain why the Boolean expression when the green lamp of **traffic lights 1** is illuminated is given by

$$\mathbf{G = D \cdot \overline{C} \cdot \overline{B} \cdot \overline{A} + D \cdot \overline{C} \cdot \overline{B} \cdot A + D \cdot \overline{C} \cdot B \cdot \overline{A} + D \cdot \overline{C} \cdot B \cdot A + D \cdot C \cdot \overline{B} \cdot \overline{A} + D \cdot C \cdot \overline{B} \cdot A}$$

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(2 marks)

1 (c) Show that the expression in part (b) simplifies to:

$$\mathbf{G = D \cdot \overline{B \cdot C}}$$

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(3 marks)

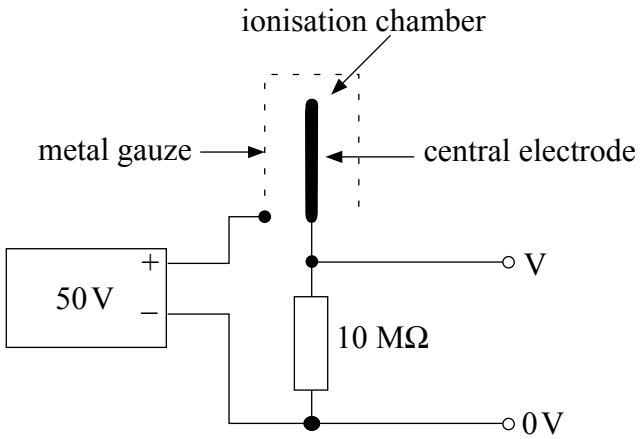
1 (d) Draw a circuit diagram to show how you would implement the simplified logic expression using several 2-input NAND gates.

(3 marks)

9

Turn over for the next question

2 An ionisation chamber for detecting radioactivity consists of a metal gauze cylinder surrounding a central electrode. The metal gauze is held at a voltage of +50 V with respect to the central electrode. When radiation enters the chamber the gas is ionised and a very small current flows which is directly related to the strength of the radiation. This small current passes through a 10 MΩ resistor.



2 (a) (i) The maximum current that the detector can produce is 2×10^{-10} A. Calculate the corresponding voltage across the 10 MΩ resistor.

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2 (a) (ii) The voltage is to be displayed on a digital meter which has a maximum sensitivity of 200 mV. Calculate the voltage gain required for an amplifier to interface the digital meter to the ionisation chamber.

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(4 marks)

2 (b) It is decided to use a non-inverting op-amp amplifier to provide this gain. State and explain what important property makes a non-inverting amplifier a suitable choice.

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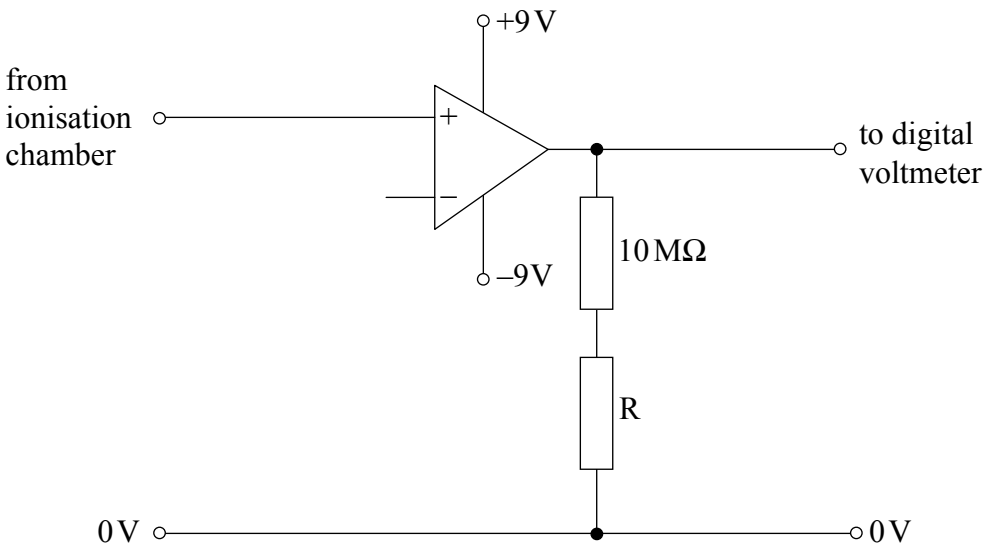
(2 marks)

The partly drawn circuit diagram for a non-inverting amplifier is shown below.



2 (c) (i) Complete the circuit diagram by adding the missing connection.

2 (c) (ii) Calculate the value of R needed to produce the voltage gain you have calculated in part (a)(ii).

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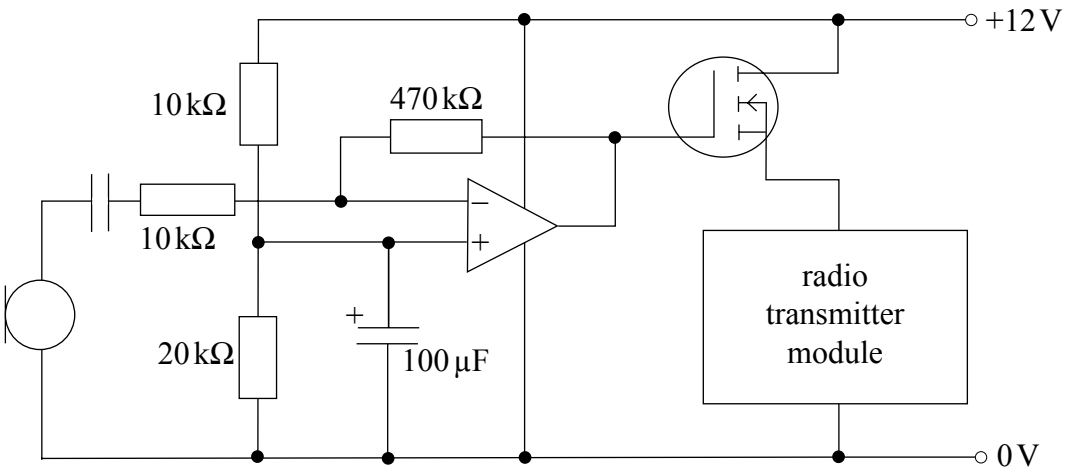
(3 marks)

9

Turn over for the next question

3 Part of the circuit diagram for a low power radio transmitter is shown below.

The audio amplifier controls the current through the radio transmitter module.



3 (a) (i) Label the source connection of the MOSFET with an S.

3 (a) (ii) What is the name for the circuit arrangement in which the MOSFET is being used?

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(2 marks)

3 (b) (i) Show that the voltage at the non-inverting input of the op-amp is 8 V.

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3 (b) (ii) With no input signal from the microphone, explain why the voltage on the gate of the MOSFET is also 8 V.

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3 (b) (iii) If the turn on value of V_{gs} for the MOSFET is 2 V, what is the voltage across the radio transmitter module, when there is no signal from the microphone?

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(4 marks)

3 (c) (i) Calculate the voltage gain of the op-amp amplifier.

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3 (c) (ii) If the microphone gives an output of 40 mV, estimate the voltage change that occurs across the radio transmitter module, showing your working.

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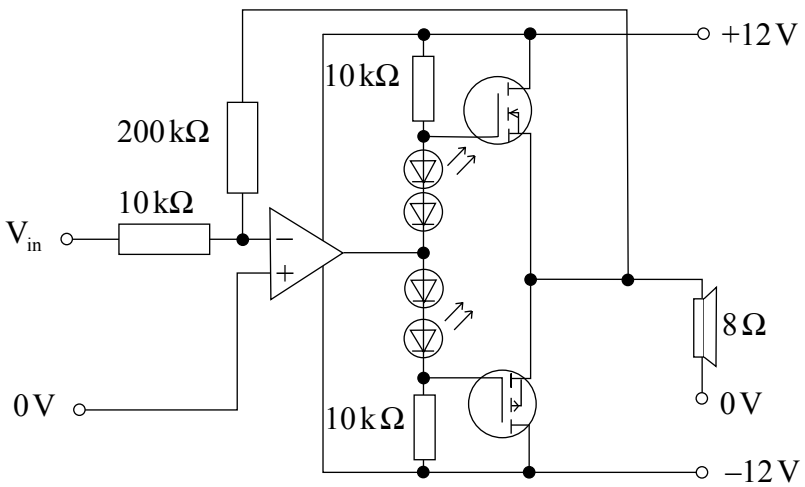
(3 marks)

9

Turn over for the next question

4 A student wants to amplify the output from the sound card on his computer so that he can use loudspeakers instead of headphones. His sound card gives a maximum peak output voltage of 500 mV. He wants to use an amplifier circuit that he has found on a website, but needs to decide if it will be suitable.
The circuit diagram is shown below.



4 (a) Show that the peak voltage developed across the loudspeaker will be approximately 10 V when there is an input of 500 mV.

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(2 marks)

4 (b) Calculate the rms output power into the loudspeaker under these conditions.

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(2 marks)

The student is concerned that the amplifier will suffer from *cross-over distortion*.

4 (c) (i) Explain what is meant by cross-over distortion.

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4 (c) (ii) State what measures have been taken to reduce cross-over distortion in the circuit.

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(3 marks)

4 (d) With the circuit constructed and working, the student finds that the MOSFETs become very hot. His teacher recommends that he should bolt each MOSFET to a heatsink.

State **two** important features of an efficient heatsink.

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(2 marks)

9

Turn over for the next question

5 All of the electrical activity of the brain occurs at low frequencies, the alpha rhythm having the highest frequency of 8 – 13 Hz. In order to isolate this electrical activity from that of the muscles, which occurs at a higher frequency, the electrical signals are passed through a *low pass filter* with a *break point frequency* of 20 Hz.

5 (a) (i) What is meant by the term low pass filter?

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5 (a) (ii) What is meant by the term break point frequency?

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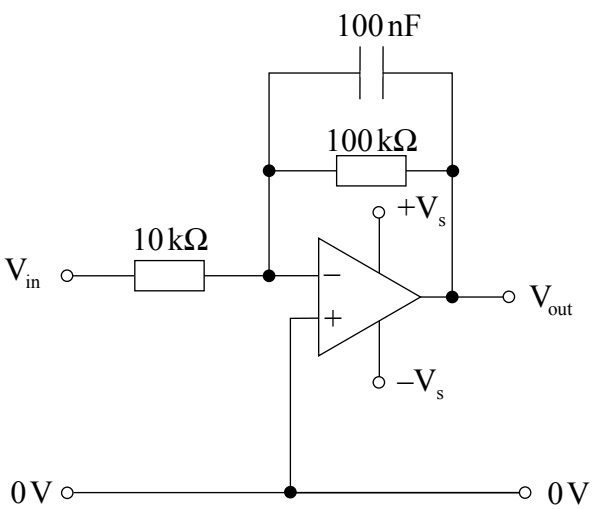
(3 marks)

5 (b) The circuit diagram of the low pass filter is shown below.



Calculate the reactance of the 100 nF capacitor at a frequency of 20 Hz.

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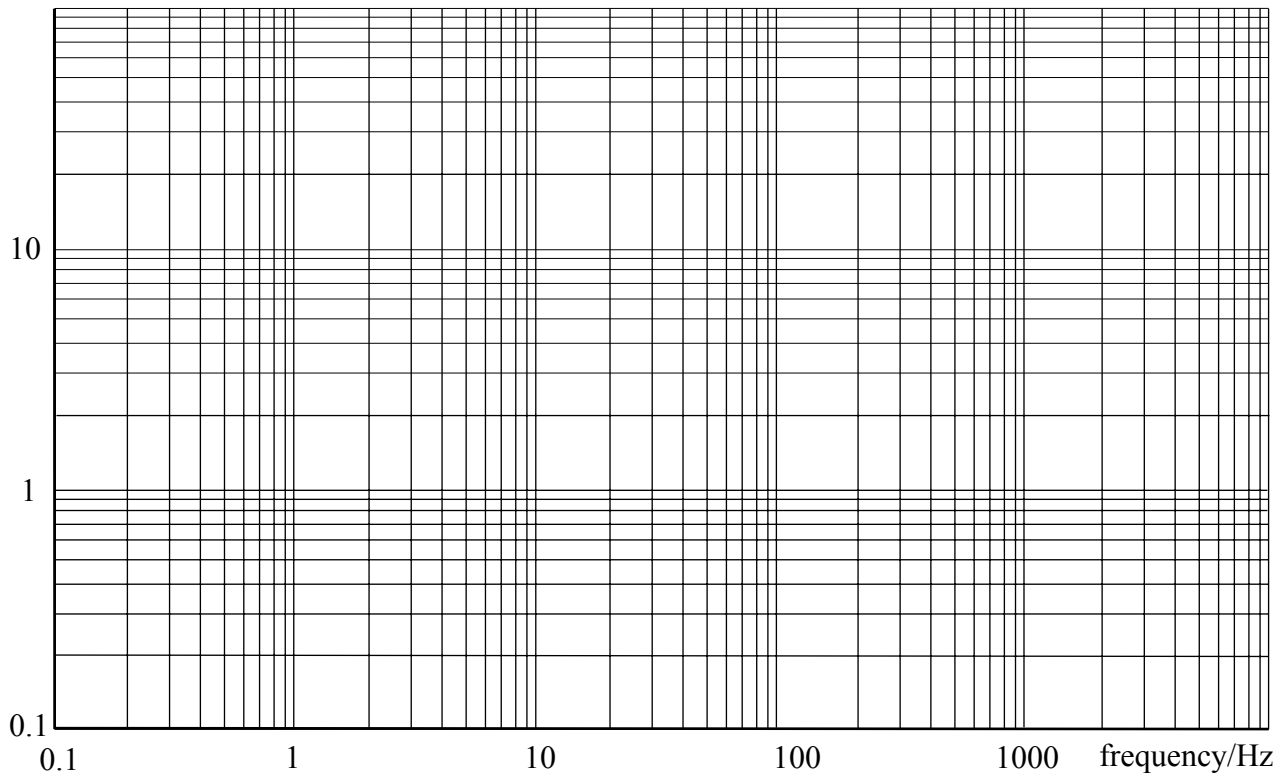
(3 marks)

5 (c) Sketch onto the grid below how the voltage gain of this filter circuit varies with frequency.

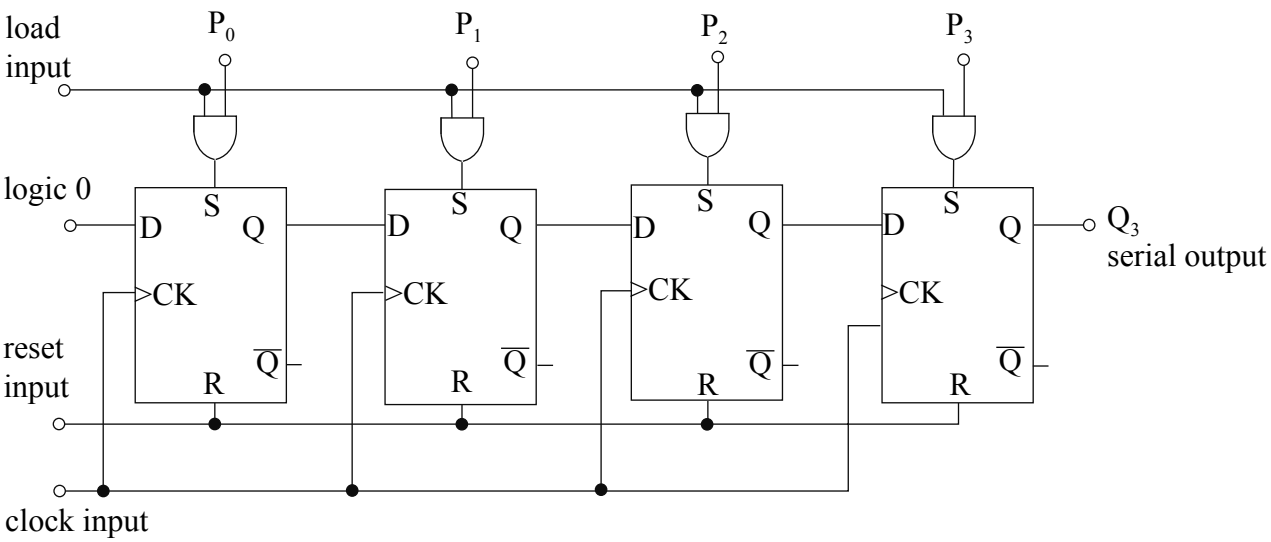


(3 marks)

9

Turn over for the next question

6 The shift register circuit below is used by a student to convert parallel data to serial data. The parallel data is sent to P_0, P_1, P_2 and P_3 and the serial output is taken from Q_3.



6 (a) Explain how a shift register works.

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(3 marks)

6 (b) (i) Explain why it is necessary in this circuit to reset the shift register before loading new parallel data.

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6 (b) (ii) State the logic level of the load input for parallel data to be loaded into the shift register.

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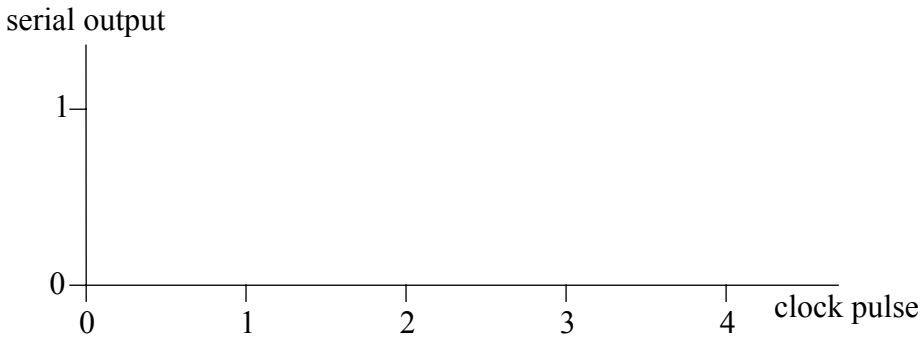
(2 marks)

6 (c) The hexadecimal number **B** is loaded into the shift register. Sketch onto the diagram below the serial output.

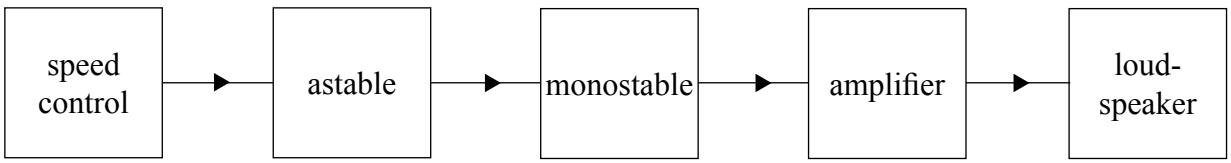


(4 marks)

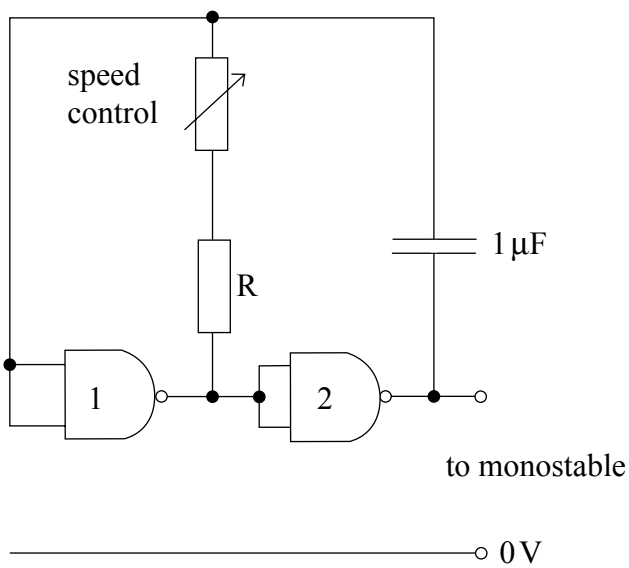
9

Turn over for the next question

7 A metronome is a device used by musicians to help keep in time. It produces a click to time the beat of the music. The system diagram of a simple metronome is shown below.



The circuit diagram for the astable is shown below.



7 (a) (i) The metronome produces a maximum rate of 240 clicks per minute. What is the required frequency of the astable?

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7 (a) (ii) Calculate a suitable value for R using the formula on the Data Sheet.

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(3 marks)

7 (b) If the minimum number of clicks per minute is 30, calculate a suitable value for the speed control variable resistor.

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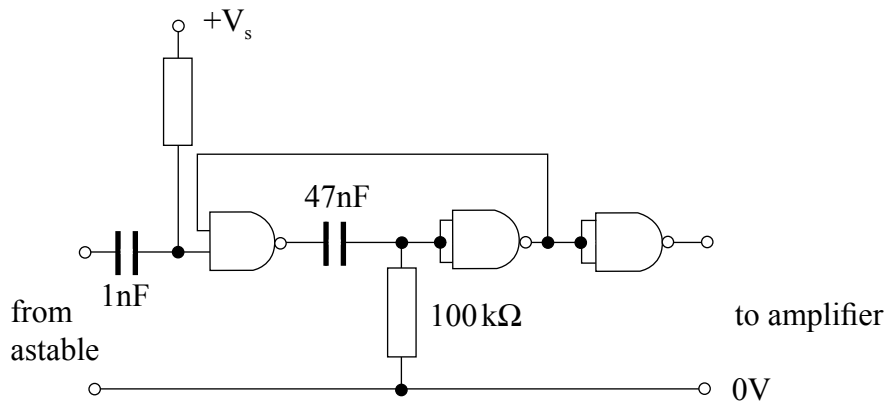
(2 marks)

The circuit diagram for the monostable is shown below.



7 (c) (i) Calculate the time period of the pulse from the monostable using the formula on the Data Sheet.

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7 (c) (ii) Explain how the monostable circuit operates once it has been triggered.

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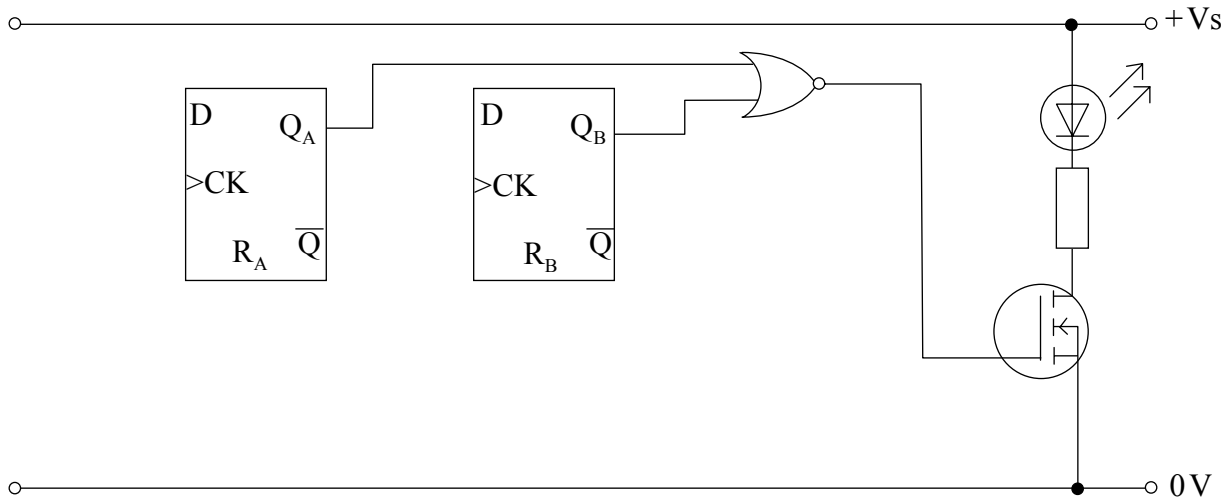
(6 marks)

Question 7 continues on the next page

Having built the metronome, a student decides to modify it so that it flashes a LED every two, three or four clicks. He decides to build a 2-bit counter using D-type flip-flops. The diagram below shows two D-type flip-flops and the LED flashing circuit.



7 (d) (i) Add the connections necessary to make the two flip-flops into a 2-bit up-counter and show where the output from the monostable would be connected in order to make them count.

7 (d) (ii) Explain under what conditions the LED will light.

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(4 marks)

7 (e) In order to make the LED flash every two, three or four clicks, it is necessary to design a logic circuit to control the reset terminals, R, of the flip-flops. Complete the table below for the logic states that must be applied to each of the reset pins. Choose from **0**, **1** or $\mathbf{Q_A \cdot Q_B}$

No of clicks	R_A	R_B
2	0	1
3		
4		

(3 marks)

18

END OF QUESTIONS