Candidate Name	Centre Number	Candidate Number

WELSH JOINT EDUCATION COMMITTEE
General Certificate of Education
Advanced

WJEC CBAC

CYD-BWYLLGOR ADDYSG CYMRU
Tystysgrif Addysg Gyffredinol
Uwch

385/01

ELECTRONICS

ET5

P.M. TUESDAY, 12 June 2007

($1\frac{3}{4}$ hours)

ADDITIONAL MATERIALS

In addition to this examination paper you will need a calculator.

INSTRUCTIONS TO CANDIDATES

Write your name, centre number, and candidate number in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

You are reminded of the necessity for good English and orderly presentation in your answers.

Your attention is drawn to the Information for the Use of Candidates on page 2 and 3 of this paper.

No certificate will be awarded to a candidate detected in any unfair practice during the examination.

For Examiner's use only.	
1	
2	
3	
4	
5	
6	
7	
Total	

INFORMATION FOR THE USE OF CANDIDATES

Preferred Values for resistors
The figures shown below and their decade multiples and sub-multiples are the E24 series of preferred values.

10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82, 91.

RC networks	$V_C = V_O\,(1 - e^{-t/RC})$	for a charging capacitor
	$V_C = V_O\,e^{-t/RC}$	for a discharging capacitor
	$t = -RC\ 1n\left(1 - \frac{V_c}{V_o}\right)$	For a charging capacitor
	$t = -RC\ 1n\left(\frac{V_c}{V_o}\right)$	For a discharging capacitor
Alternating Voltages	$V_o = V_{rms}\sqrt{2}$	
	$X_C = \frac{1}{2\pi fC}$	Capacitive reactance
	$X_L = 2\pi fL$	Inductive reactance
	$f_0 = \frac{1}{2\pi\sqrt{LC}}$	Resonant frequency
	$f_{co} = \frac{1}{2\pi RC}$	Cut-off frequency for high pass and low pass filters
	$\phi = \tan^{-1}\frac{R}{X_C}$	Phase shift between V_R and V_c.
Silicon Diode	$V_F \approx 0{\cdot}7$ V	
Bipolar Transistor	$h_{FE} = \frac{I_C}{I_B}$	Current gain
	$V_{BE} \approx 0{\cdot}7$ V	in the on state
MOSFETs	$I_D = g_M V_{GS}$	

Operational amplifier

$$G = -\frac{R_F}{R_{IN}}$$ Inverting amplifier

$$G = 1 + \frac{R_F}{R_1}$$ Non-inverting amplifier

$$V_{OUT} = -R_F\left(\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3}\right)$$ Summing amplifier

$$\text{Slew Rate} = \frac{\Delta V_{OUT}}{\Delta t}$$ Slew rate

$$V_{OUT} = V_{DIFF}\left(\frac{R_F}{R_1}\right)$$ Difference amplifier

$$V_L \approx V_Z\left(1 + \frac{R_F}{R_1}\right)$$ Stabilised power supply

Power Amplifier

$$P_{MAX} = \frac{V_S^2}{8R_L}$$ where V_S is rail-to-rail voltage

555 Monostable

$$T = 1{\cdot}1\ RC$$

555 Astable

$$t_H = 0{\cdot}7\ (R_A + R_B)C$$

$$t_L = 0{\cdot}7\ R_B C$$

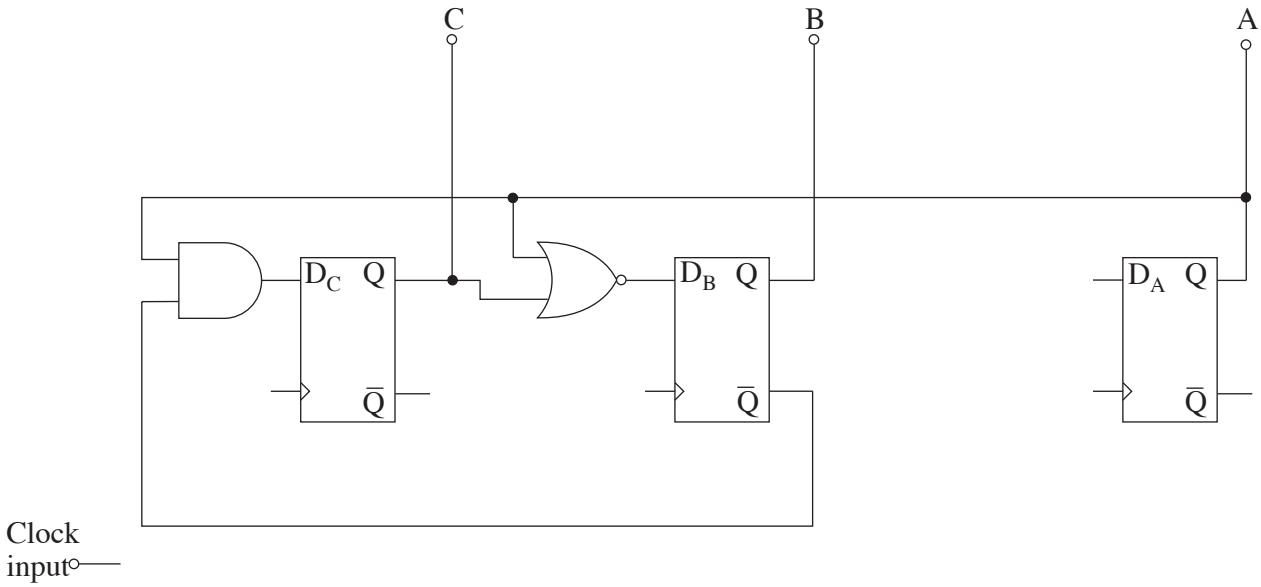
$$f = \frac{1 \cdot 44}{(R_A + 2R_B)C}$$

Schmitt Astable

$$f \approx \frac{1}{RC}$$

Turn over.

1. *(a)* The diagram shows the partly completed circuit of a synchronous counter.



(i) Modify the circuit diagram by adding the correct connections for the clock inputs of the D-type flip-flops. [1]

(ii) Write down the Boolean expressions for the inputs D_C and D_B in terms of the outputs C, B and A. [2]

D_C = ...

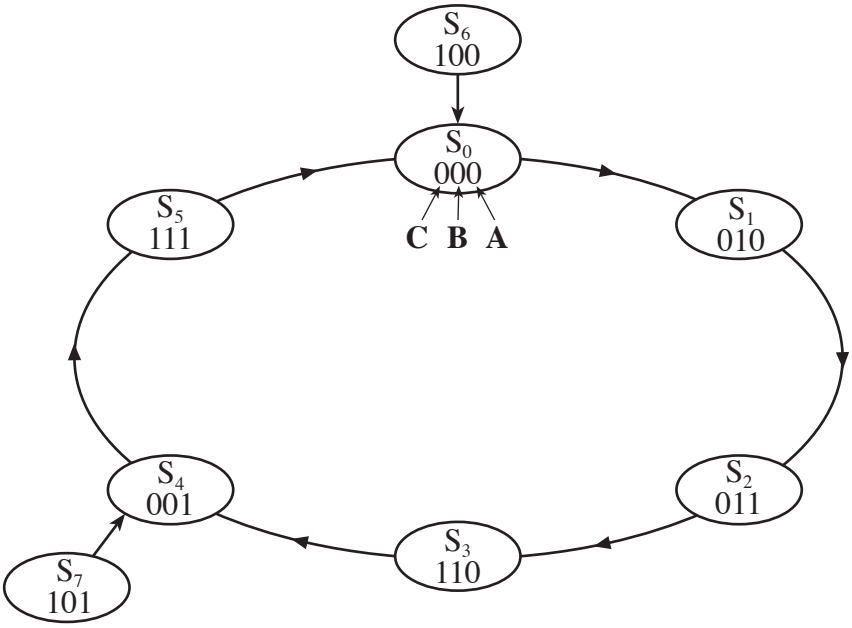
D_B = ...

(iii) The Boolean expression for D_A is:

$D_A = C \cdot B + \overline{C} \cdot \overline{B}$

Complete the circuit diagram by adding appropriate logic gates to provide the correct signal to input D_A. *(Extra credit will be given for using the smallest number of gates possible.)* [2]

(b) Here is the state diagram for a **different** synchronous counter, which uses three D-type flip-flops.



(i) Complete the following table to show the D-type outputs and corresponding inputs. [2]

State	C	B	A	D_C	D_B	D_A
S_0						
S_1						
S_2						
S_3						
S_4						
S_5						
S_6						
S_7						

(ii) Write down the unused states in this sequence. [1]

.....

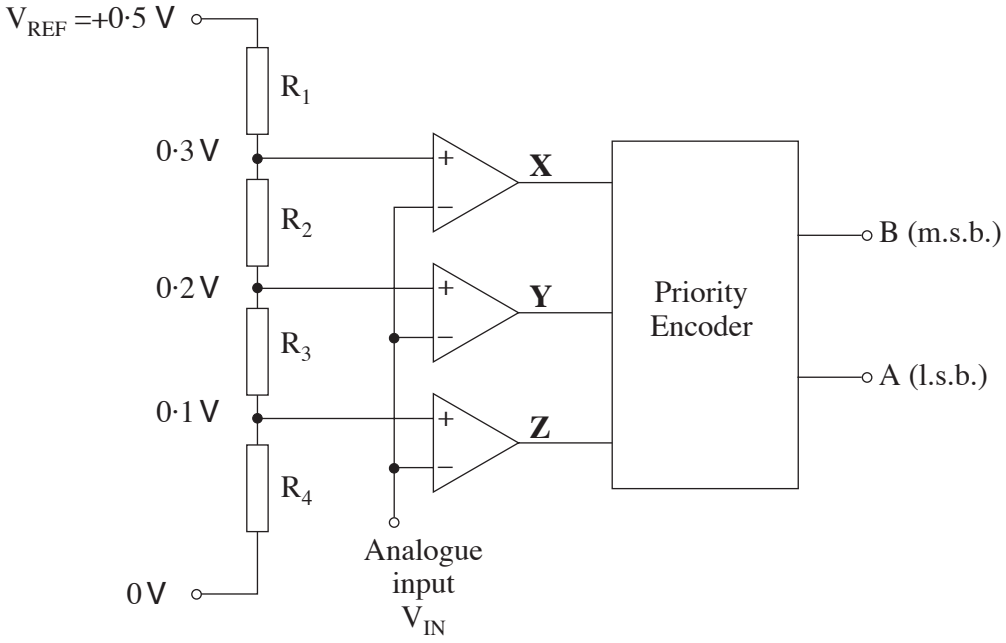
(iii) Use the table to generate **simplified** Boolean expressions for the inputs D_C, D_B and D_A in terms of outputs C, B and A. [4]

D_C = ...

D_B = ...

D_A = ...

2. Here is the circuit diagram for a 2-bit analogue-to-digital converter (ADC).



(a) Calculate suitable resistor values for resistors R_1, R_2, R_3 and R_4 to provide voltages of 0·3V, 0·2V and 0·1V at the non-inverting inputs of the op-amps. [3]

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R_1 = ... R_2 = ... R_3 = ... R_4 = ...

(b) Complete the table to show the output voltages of the op-amps X Y and Z for the given values of analogue input voltage V_{IN}. The op-amps saturate at +10 V and 0 V. [3]

V_{IN}	Output of X	Output of Y	Output of Z
0·05 V			
0·12 V			
0·39 V			

(c) What is the minimum voltage change guaranteed to produce a change in the binary output (i.e. what is the resolution of ADC)? [1]

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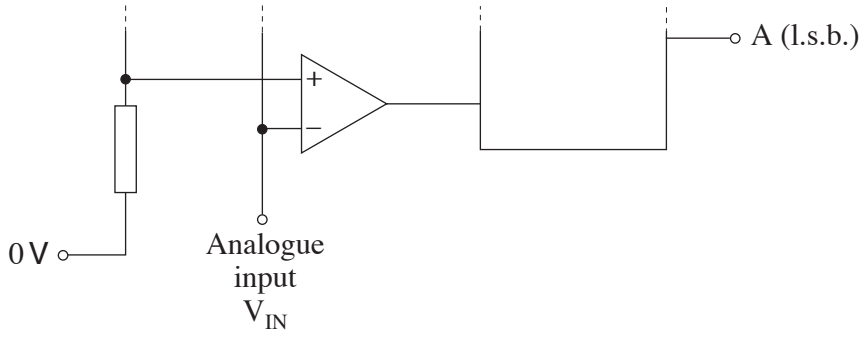
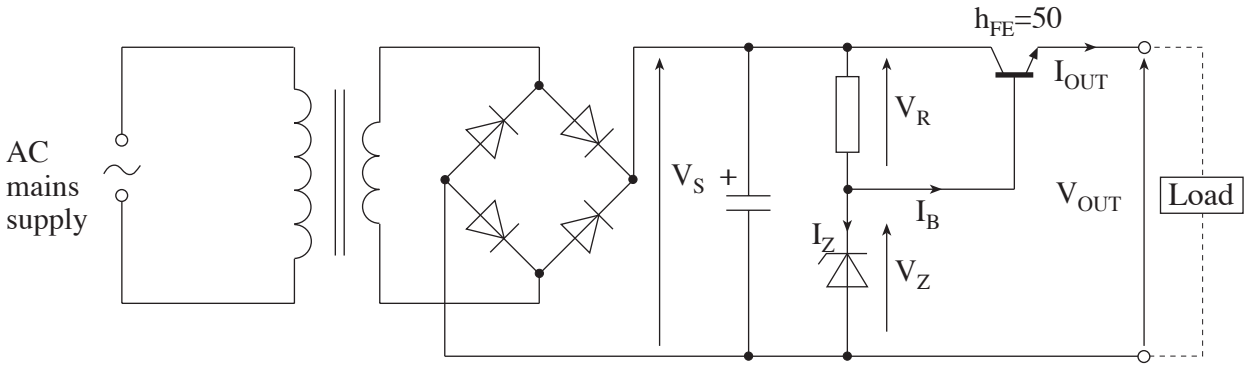
(d) Complete the circuit diagram to show how the circuit is modified to give a 3-bit output **for the same input voltage range**. [4]



3. The diagram shows the circuit for a power supply, which incorporates some *line* and *load regulation*.



(a) Explain what is meant by the terms:

(i) line regulation; [1]

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.....

(ii) load regulation; [1]

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(b) In this circuit, the zener diode provides line regulation. Explain how it does this. Your answer should refer to some of the labels shown on the diagram. [2]

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(c) The output current I_{OUT} starts to increase. Explain how the circuit provides (limited) load regulation. Your answer should refer to some of the labels shown on the diagram. [2]

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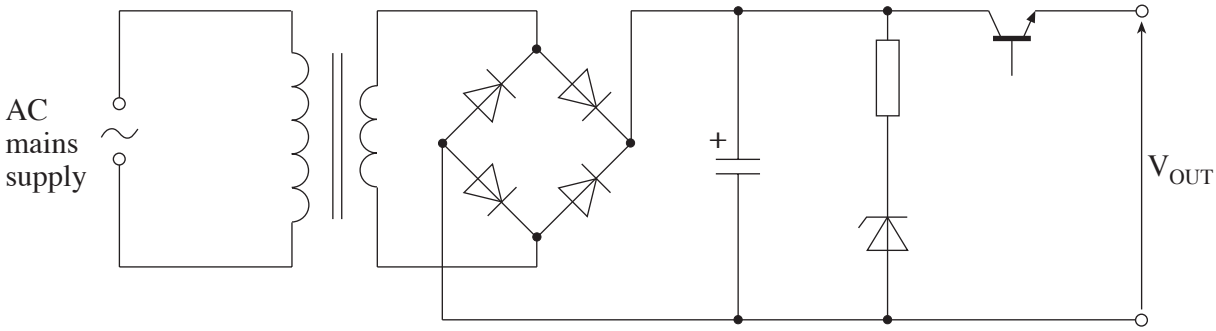
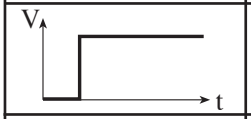
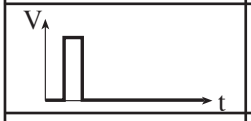
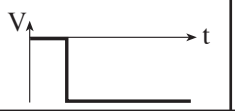
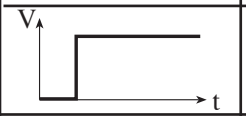
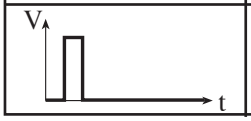
(d) Load regulation can be improved by adding an op-amp non-inverting amplifier to the circuit. Show how this is done by completing the following circuit diagram. [3]

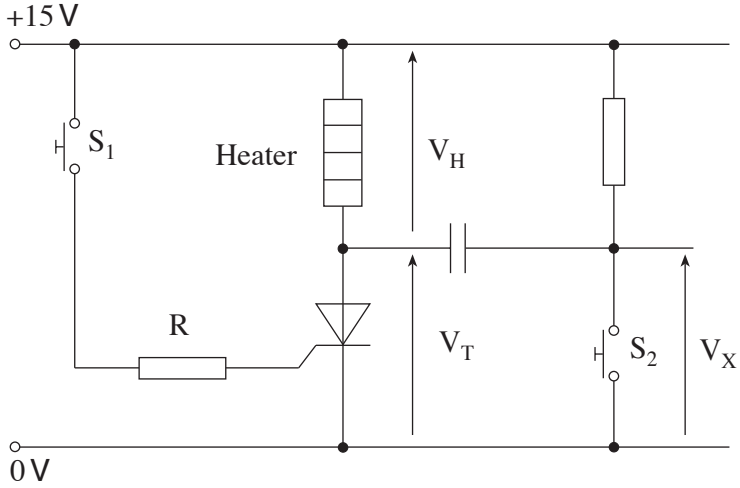


4. *(a)* The behaviour of a thyristor depends on the signal applied to the gate terminal and the voltage bias applied between its anode and cathode.
The table lists various combinations of these conditions.

Input to gate	Bias	Thyristor on/off?
	Reverse biased	
	Reverse biased	
	Reverse biased	
	Forward biased	
	Forward biased	
	Forward biased	

Complete the third column of the table to show whether the thyristor will be switched on or off under each of the conditions shown. [3]

(b) In the circuit, a thyristor is used to switch a heater on and off.



(i) Here is some data for the thyristor.
Minimum gate voltage = 1·2 V
Holding current = 200 mA
Minimum gate current = 100 mA

Calculate the maximum resistance for the resistor R. [2]

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(ii) The thyristor is initially switched off. Switch S_1 is pressed and then released. Complete the table to show the corresponding voltages across the thyristor (V_T) and across the heater (V_H). [2]

Switch S_1	V_T	V_H
Off (thyristor switched off)		
On		
Off		

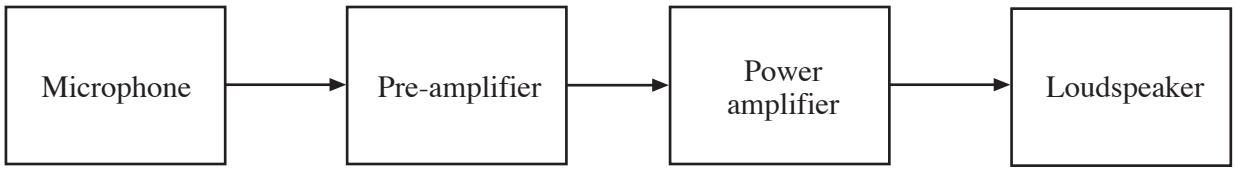
(iii) The thyristor is on.
Switch S_2 is pressed.
Estimate the following voltages at the instant S_2 is pressed: [3]

V_X = ...

V_T = ...

V_H = ...

5. *(a)* When designing an audio system, care must be taken over impedance matching so that a sub-system efficiently transfers a voltage signal, or transfers power to the subsystem which follows.



The microphone has an impedance of 80 kΩ.
The loudspeaker has an impedance of 8 Ω.
The aim is to maximize **voltage** transfer from the microphone to the pre-amplifier, and to maximise **power** transfer from the power amplifier to the loudspeaker.

(i) Which of these is the best choice of input impedance for the pre-amplifier? [1]

8 Ω 800 Ω 8 kΩ 80 kΩ 800 kΩ

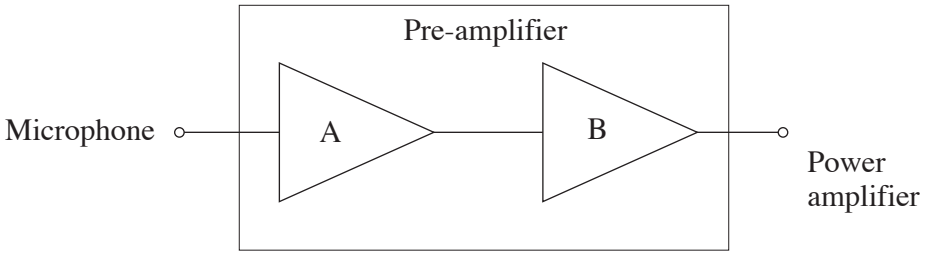
Answer = ...

(ii) Which of these is the best choice of output impedance for the power amplifier? [1]

8 Ω 800 Ω 8 kΩ 80 kΩ 800 kΩ

Answer = ...

(b) The pre-amplifier has a voltage gain of 900.
It consists of a *2-stage amplifier*, made up to two non-inverting amplifiers A and B, represented in the following diagram.



(i) Why is a non-inverting amplifier more suitable than an inverting amplifier in this situation? [1]

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(ii) In order to maximise the bandwidth of the pre-amplifier, what is the gain of

Amplifier A? .....

Amplifier B? ..... [2]

(iii) The table gives some data on the op-amps used in the circuits for amplifiers A and B.

Parameter	Typical Value
Open-loop voltage gain	2×10^5
Input resistance	$10^{12}\ \Omega$
Gain bandwidth product	1 MHz
Slew-rate	$12\ V\ \mu s^{-1}$
Common mode rejection ratio	90 dB

What is the resulting bandwidth of the pre-amplifier? [2]

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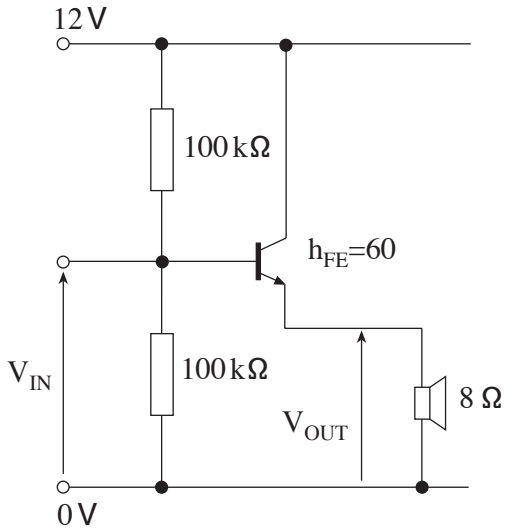
(c) The emitter follower circuit, shown below, is used for the power amplifier.



(i) Estimate the input impedance of the emitter follower. [1]

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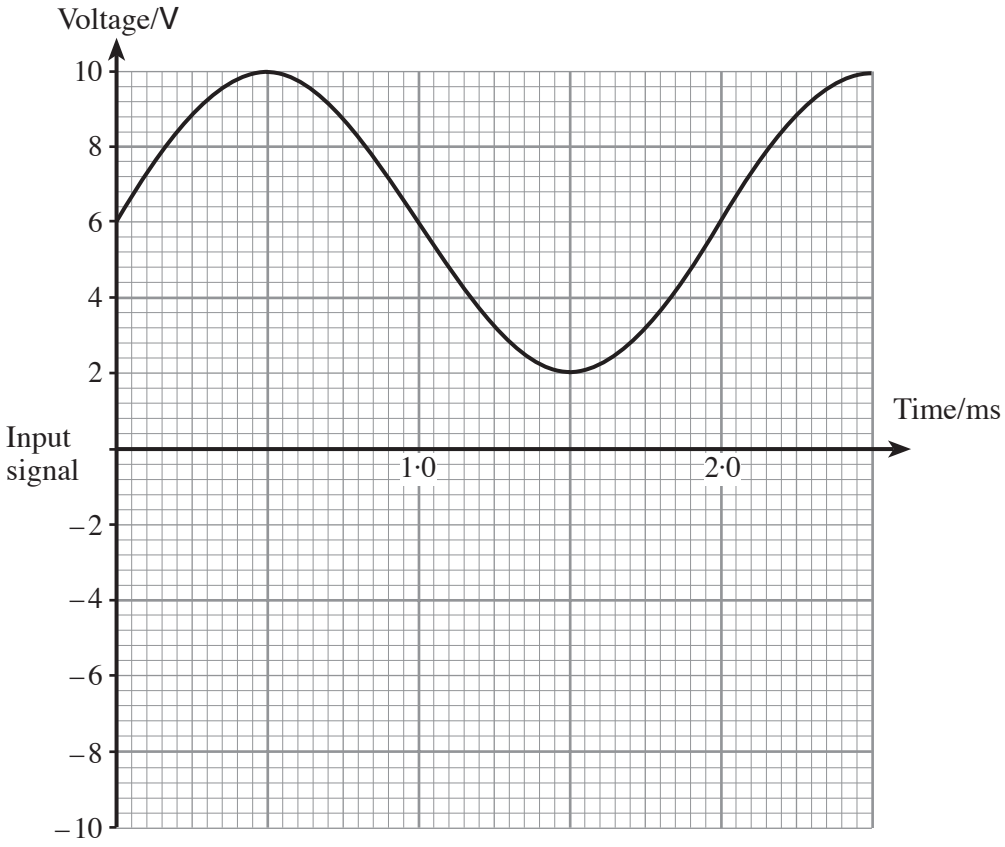
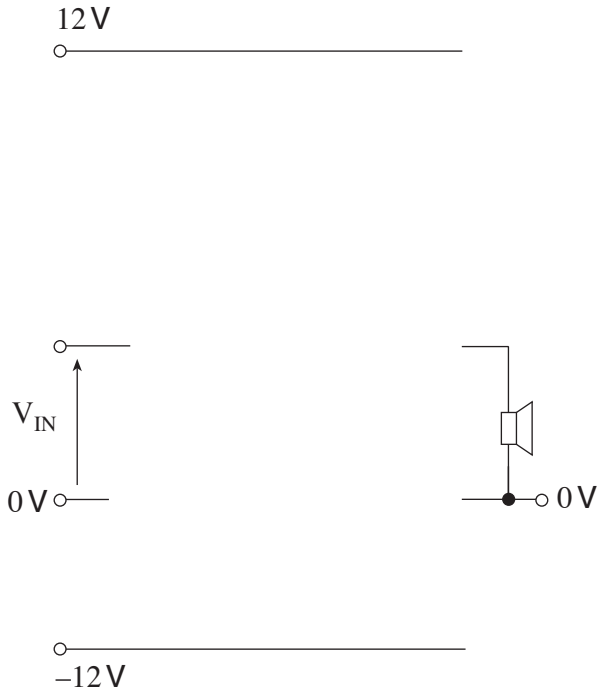
(ii) The AC signal shown in the graph is applied to the input. Using the same axes, draw the output signal. [2]



(iii) A push-pull power amplifier is an alternative to the emitter follower. Complete the following diagram to show the circuit for a push-pull power amplifier. [2]



(iv) Describe **one** advantage of a push-pull power amplifier over an emitter follower power amplifier. [1]

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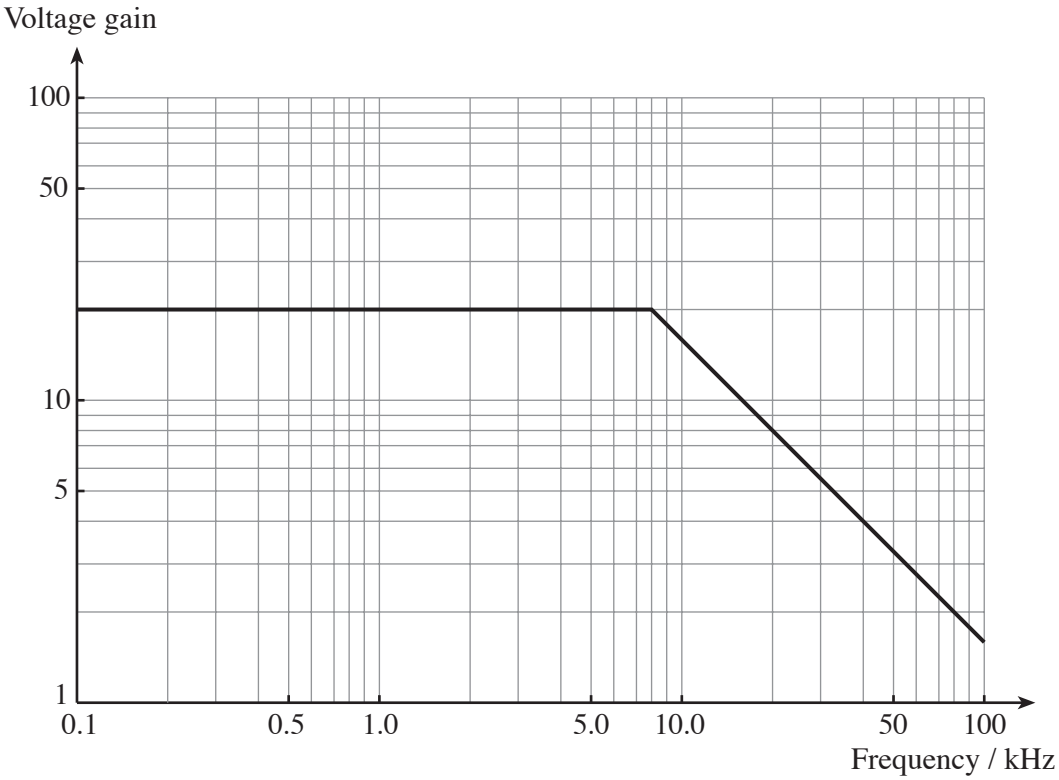
6. An audio system contains a tone control active filter that has the following frequency response.



(a) What type of active filter is this – bass cut, bass boost, treble cut or treble boost? [1]

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(b) What is the break frequency for this filter? [1]

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(c) A signal with a frequency of 1 kHz and amplitude of 1 mV is applied to the input of this filter.

What is the amplitude of the resulting output signal? [1]

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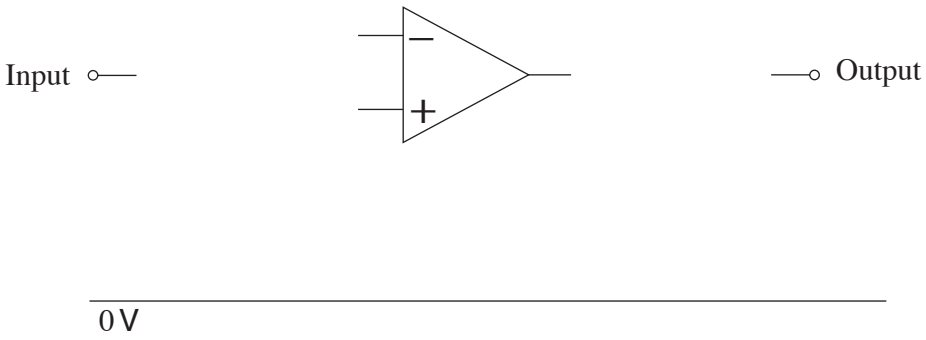
(d) (i) Complete the circuit diagram for the type of active filter you chose in part *(a)*. [3]



(ii) The active filter uses a 0·1 nF capacitor. Calculate suitable values for any resistors used in the circuit, and mark them on the circuit diagram. [2]

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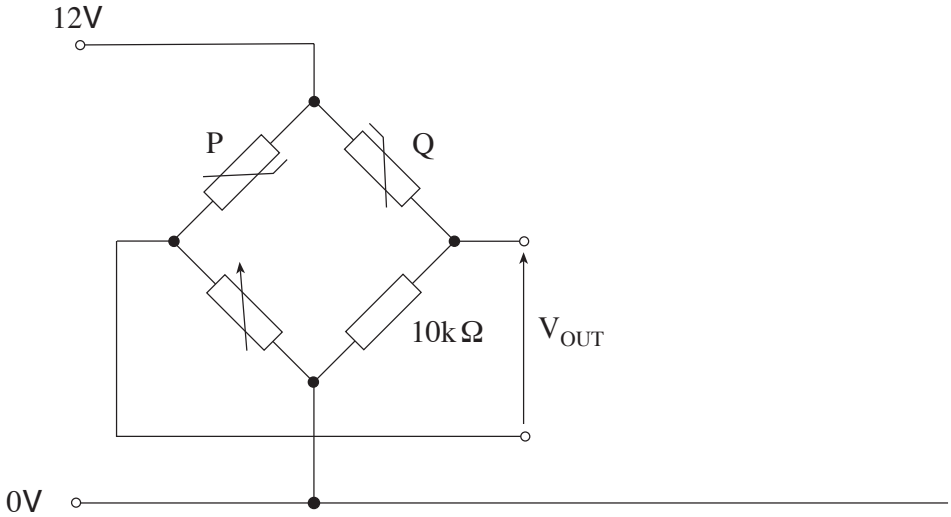
THE QUESTION PAPER CONTINUES ON THE NEXT PAGE.

7. A system is required to show which thermistor, P or Q, is hotter.

(a) The two thermistors are connected in the sensing sub-system shown below. When P and Q are at the same temperature, V_{OUT} must be zero volts.



(i) Explain the purpose of the variable resistor. [1]

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(ii) Calculate V_{OUT} under the following conditions:

Resistance of P = 19·7 kΩ
Resistance of Q = 20·0 kΩ
Resistance of variable resistor = 10·3 kΩ [2]

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(b) The output of this sensing sub-system is applied to a difference amplifier. Modify the diagram above by adding the circuit for a difference amplifier connected to the sensing unit. [3]

(c) Name a suitable output device for this system, and describe how it would indicate which thermistor is hotter. [1]

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FOR USE ONLY IF YOU HAVE MADE SUBSTANTIAL DELETIONS IN PARTS OF YOUR ANSWERS OR NEED MORE SPACE TO COMPLETE THEM. BE SURE TO INDICATE THE QUESTIONS CONCERNED.

Examiner only
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