**wjec cbac**

## GCSE

## 4162/01

S18-4162-01

## ELECTRONICS

### UNIT E2: Paper replacement test

FRIDAY, 15 JUNE 2018 – AFTERNOON

1 hour

**ADDITIONAL MATERIALS**

A calculator and a ruler.

**INSTRUCTIONS TO CANDIDATES**

Use black ink or black ball-point pen.

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

Answer **all** questions 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.

## INFORMATION SHEET FOR UNIT E2

This information may be of use in answering the questions.

1. **Resistor Colour Codes**

| BLACK | 0 | GREEN | 5 |
|---|---|---|---|
| BROWN | 1 | BLUE | 6 |
| RED | 2 | VIOLET | 7 |
| ORANGE | 3 | GREY | 8 |
| YELLOW | 4 | WHITE | 9 |

The fourth band colour gives the tolerance as follows:

GOLD ± 5%

SILVER ± 10%
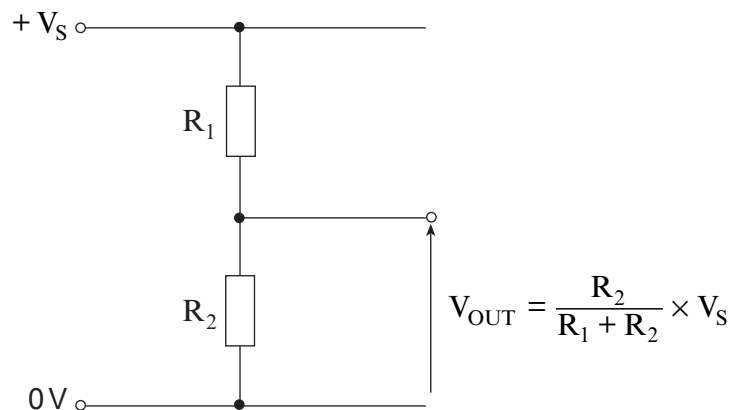
2. **Preferred Values for Resistors – E24 series**

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

3. **Resistance =** $\dfrac{\text{voltage}}{\text{current}}$ ; $R = \dfrac{V}{I}$.

4. **Effective resistance,** $R$, of two resistors $R_1$ and $R_2$ in series is given by $R = R_1 + R_2$.

5. **Effective resistance,** $R$, of two resistors $R_1$ and $R_2$ in parallel is given by $R = \dfrac{R_1 R_2}{R_1 + R_2}$ .

6. **Voltage Divider**



$$V_{OUT} = \frac{R_2}{R_1 + R_2} \times V_S$$

7. **Power** = voltage × current;    $P = VI = I^2 R = \dfrac{V^2}{R}$.

8. **LED** The forward voltage drop across a LED is 2 V.

9. **NPN Transistors**    (i)    Current gain $= \dfrac{\text{Collector current}}{\text{Base current}}$ ; $h_{FE} = \dfrac{I_C}{I_B}$ .

   (ii)    The forward voltage drop across the base emitter junction is 0.7 V.

**10. Amplifiers**

Voltage gain:

$$A = \frac{V_{OUT}}{V_{IN}}$$

Non-inverting amplifier:

$$A = 1 + \frac{R_F}{R_1}$$

Inverting amplifier:

$$A = -\frac{R_F}{R_{IN}}$$

Summing amplifier:

$$V_{OUT} = -R_F \left( \frac{V_1}{R_1} + \frac{V_2}{R_2} + ... \right)$$

(4162-01) **Turn over.**

*Answer **all** questions.*

**1.** *(a)* The boxes on the left give the names of three sub-systems.
The boxes on the right give descriptions of four applications.
For each sub-system, draw **one** line to link it to its correct application. [3]

**Sub-systems**                    **Applications**

| A car indicator flashes on and off repeatedly. |

Monostable

| A security light outside a house comes on for a short time when triggered. |

Astable

| The light inside a fridge comes on when the door is opened and goes off when it is closed. |

Latch

| A burglar alarm stays on when triggered until a reset switch is pressed. |

*(b)* Which **one** of the following statements about a monostable circuit is true?
(Tick (✓) the correct answer.)
When triggered, its output changes from logic 0 to logic 1… : [1]
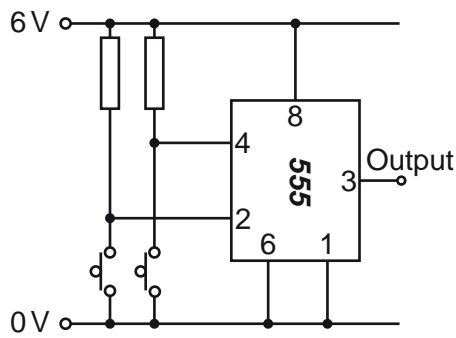
☐ … instantly, and then stays there.

☐ … for a certain time, and then resets automatically.

☐ … and then changes back again, repeatedly.

☐ … slowly, and then stays there.

*(c)* Which **one** of the following shows the circuit diagram for a monostable circuit based on a 555 timer?
(Tick (✓) the correct answer.) [1]

© WJEC CBAC Ltd. (4162-01) **Turn over.**
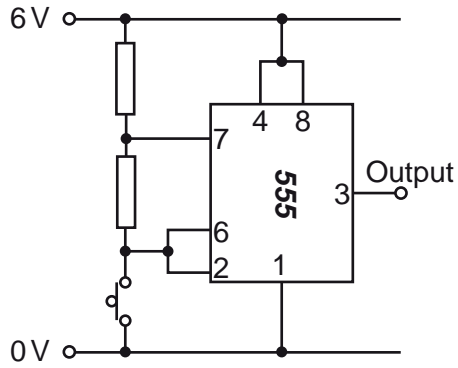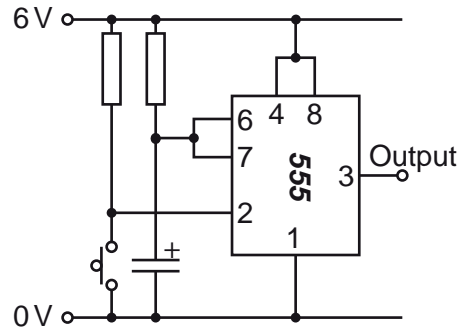
**2.** *(a)* Here are four signals produced by astable circuits:

Voltage / V

**A**

Voltage / V

**B**

Voltage / V

**C**

Voltage / V

**D**
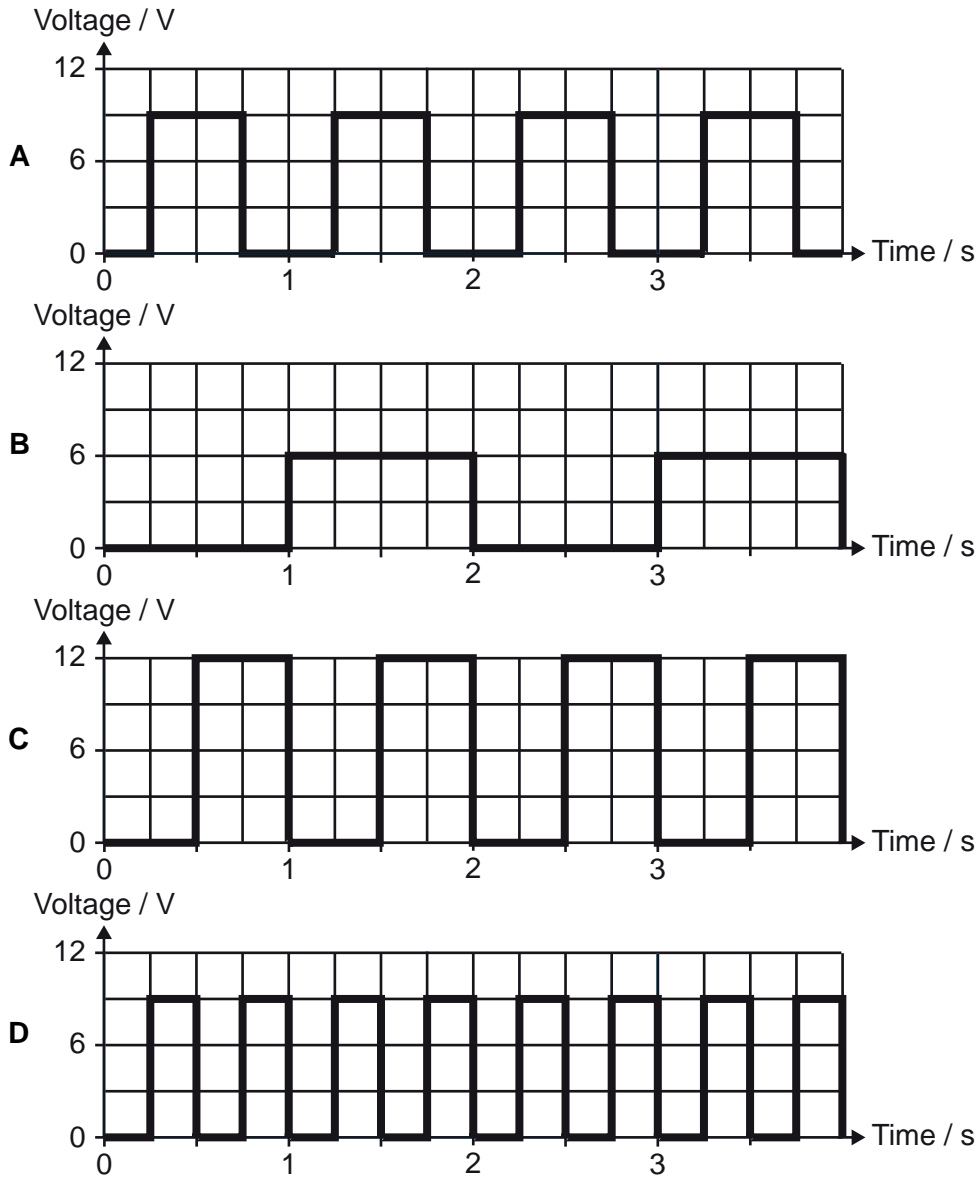
(i) Which **two** signals have the same amplitude? [1]

Answer: ☐ and ☐

(ii) Which **two** signals have the same period? [1]

Answer: ☐ and ☐

*(b)* An astable sub-system has a period of ten seconds.
Calculate its frequency in Hz. [1]

Answer = ......................................... Hz

**3.** *(a)* The LED segments of a 7-segment display light when they receive logic 1 signals.
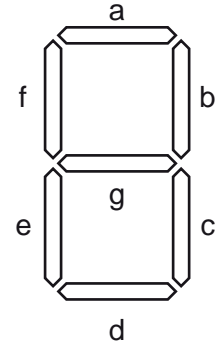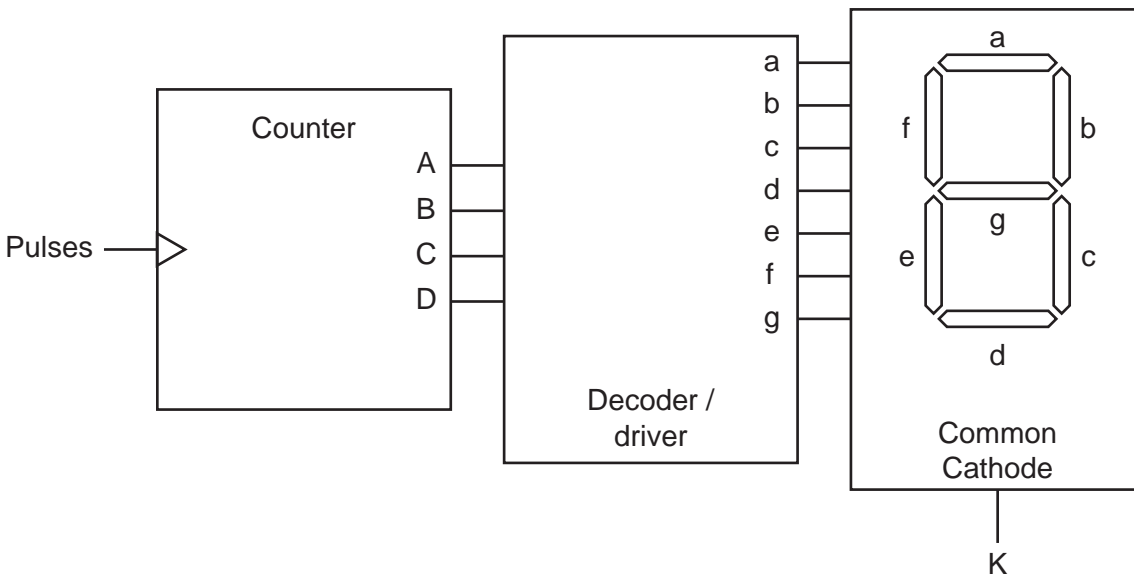The display needs to show the letter 'H'.
Complete the truth table by selecting **0** or **1** for each segment to make the display. [1]

| Segments | | | | | | | Character |
|---|---|---|---|---|---|---|---|
| **a** | **b** | **c** | **d** | **e** | **f** | **g** | |
| | | | | | | | H |

*(b)* The display is used in the single digit decimal counting system, shown in the diagram.

(i) Which row in the table produces '7' on the display?
(Tick (✓) the correct answer.) [1]

| Decoder / driver outputs | | | | | | |
|---|---|---|---|---|---|---|
| **a** | **b** | **c** | **d** | **e** | **f** | **g** |
| 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| 1 | 1 | 0 | 0 | 0 | 1 | 1 |
| 0 | 0 | 1 | 1 | 1 | 0 | 0 |

(ii) What connection must be made to the common cathode pin to make the display
work? Circle the correct answer. [1]
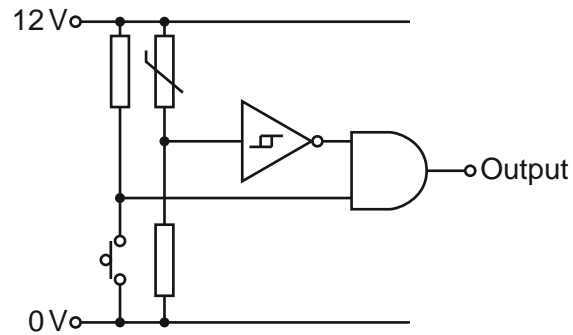
Connect pin K to

0 V        5 V        Reset        Clock

**4.** A temperature controller has two input sub-systems – a switch unit and a temperature-sensing unit.
The output of the temperature-sensing unit is interfaced to the logic gate by a Schmitt inverter.
[4]



Write either 'Analogue' or 'Digital' in the box next to the signals listed in the table.

| Signal | Analogue or digital? |
|---|---|
| Output of temperature-sensing unit | ............................................ |
| Output of switch unit | ............................................ |
| Output of Schmitt inverter | ............................................ |
| Output of logic gate | ............................................ |

**5.** The pinout for a decade counter is shown below.

| | | | | |
|---|---|---|---|---|
| output 5 | 1 | 4017B | 16 | supply + |
| output 1 | 2 | | 15 | reset |
| output 0 | 3 | | 14 | clock |
| output 2 | 4 | | 13 | enable |
| output 6 | 5 | | 12 | carry |
| output 7 | 6 | | 11 | output 9 |
| output 3 | 7 | | 10 | output 4 |
| supply - | 8 | | 9 | output 8 |
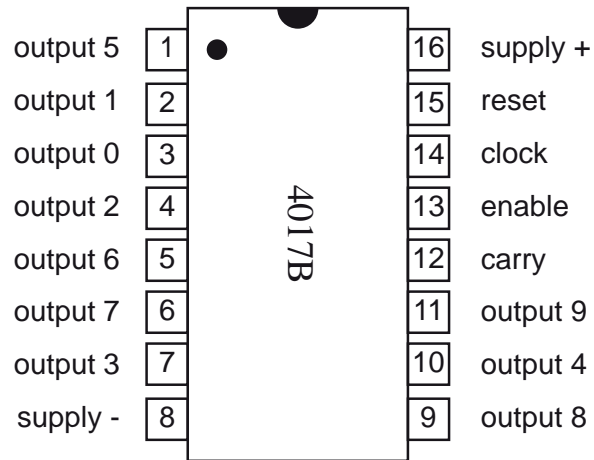
*(a)* Which statement best describes the function of the decade counter?
(Tick (✓) the correct answer.) [1]

☐ It counts up in tens, not in units.

☐ It resets automatically on the sixteenth pulse.

☐ Each output goes high in turn.

☐ Every tenth count, it outputs a pulse from its clock pin.

*(b)* The diagram shows part of a lighting sequence, controlled by a decade counter.
Outputs W, X, Y and Z are connected to LEDs.
The counter resets when the Reset pin receives a logic 1 signal.
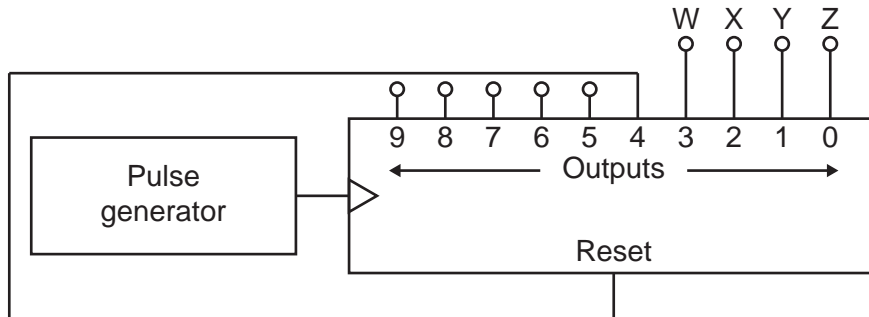
Complete the table by writing **On** or **Off** for each LED to show the sequence.   [2]

| Pulse | LEDs | | | |
|---|---|---|---|---|
| | **Z** | **Y** | **X** | **W** |
| 0 | On | Off | Off | Off |
| 1 | Off | On | Off | Off |
| 2 | Off | Off | On | Off |
| 3 | Off | Off | Off | On |
| 4 | On | Off | Off | Off |

**6.** *(a)* Which of the following statements best describes the behaviour of a D-type flip-flop?
(Tick (✓) the correct answer.) [1]
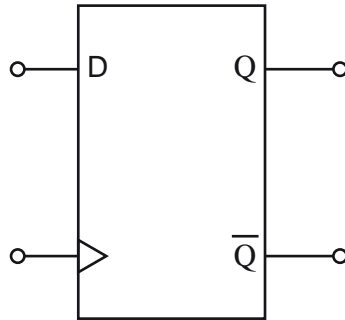


☐ The $\overline{Q}$ pin changes state every time a clock pulse triggers the flip-flop.

☐ The clock is triggered when the D pin changes state.

☐ The Q pin copies the logic level on the D pin when the flip-flop is triggered.

☐ The D pin copies the logic level on the clock pin when the flip-flop is triggered.

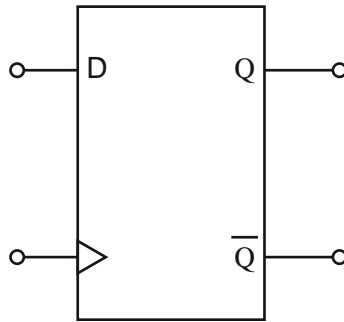*(b)* A D-type flip-flop is rising-edge triggered.
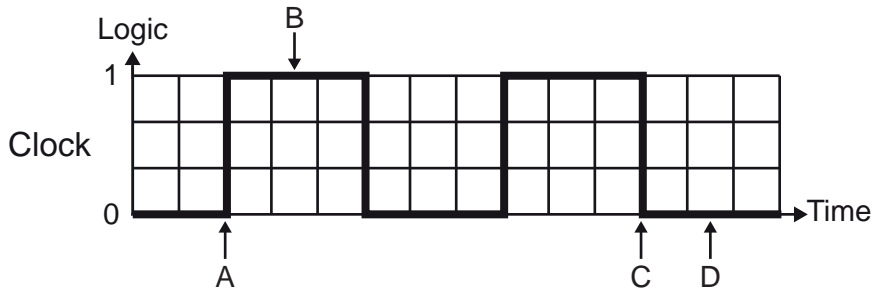


On the graph, which arrow identifies a rising-edge of a clock pulse?
Circle the correct answer. [1]

A     B     C     D

**7.** A **rising-edge triggered** D-type flip-flop can be made into a one-bit counter.

```
      ┌───────────────┐
 o────┤ D           Q ├────o
      │               │
      │               │
      │              ___│
 o────┤▷           Q ├────o
      └───────────────┘
```

(a) Which connection should be made to create a one-bit counter?          [1]
(Tick (✓) the correct answer.)

☐    Q output to the D input.

☐    $\overline{Q}$ output to the D input.

☐    Q output to the clock input.

☐    $\overline{Q}$ output to the clock input.

(b) Initially, the one-bit counter is reset.
Use the axes provided to draw the corresponding signals on the Q and $\overline{Q}$ outputs.    [3]



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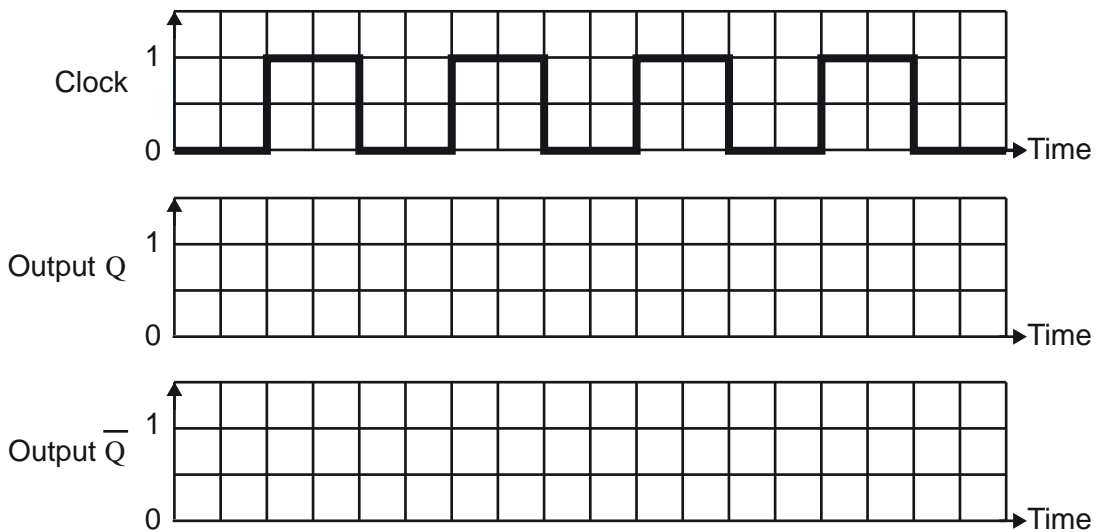
**8.** The diagram shows a 2-bit up-counter connected to a pulse generator.
The counter is **rising-edge triggered** and is initially **reset**.
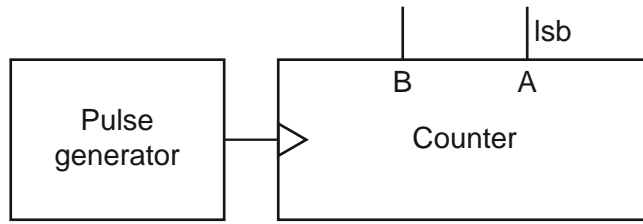
The top graph shows pulses received from the pulse generator.
The middle graph shows the signal at output A, the least-significant bit.

*(a)* Complete the bottom graph to show the corresponding signal at output B. [1]
(Initially, it is at logic 0.)
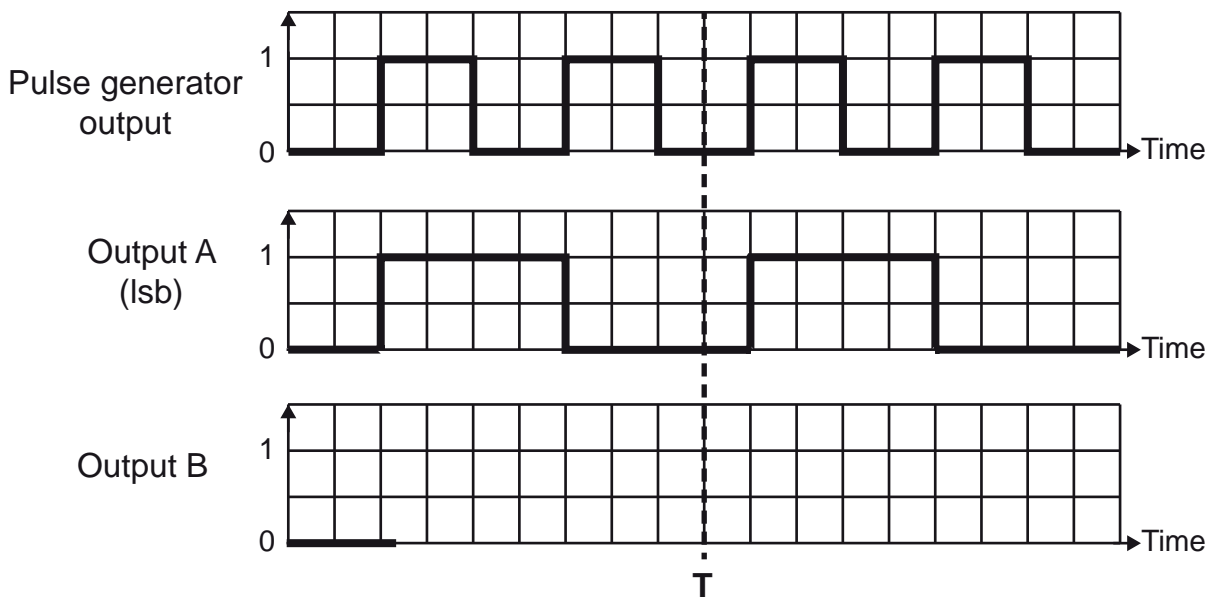
*(b)* What binary number does the counter output at time **T**?
Circle the correct answer. [1]

00        01        10        11

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010013

Examiner only

**9.** A microcontroller is used to operate a lamp in a dark corridor, using two push-switches **P** and **Q** located at the ends of the corridor.

When switch **P** OR switch **Q** is pressed for a moment, the light comes on for ten seconds.

Complete the flowchart by writing the correct letter in the boxes. [4]

A = | Switch lamp on

B = | Is switch **Q** on?

C = | Wait 10s

D = | Is switch **P** on?

E = | Switch lamp off
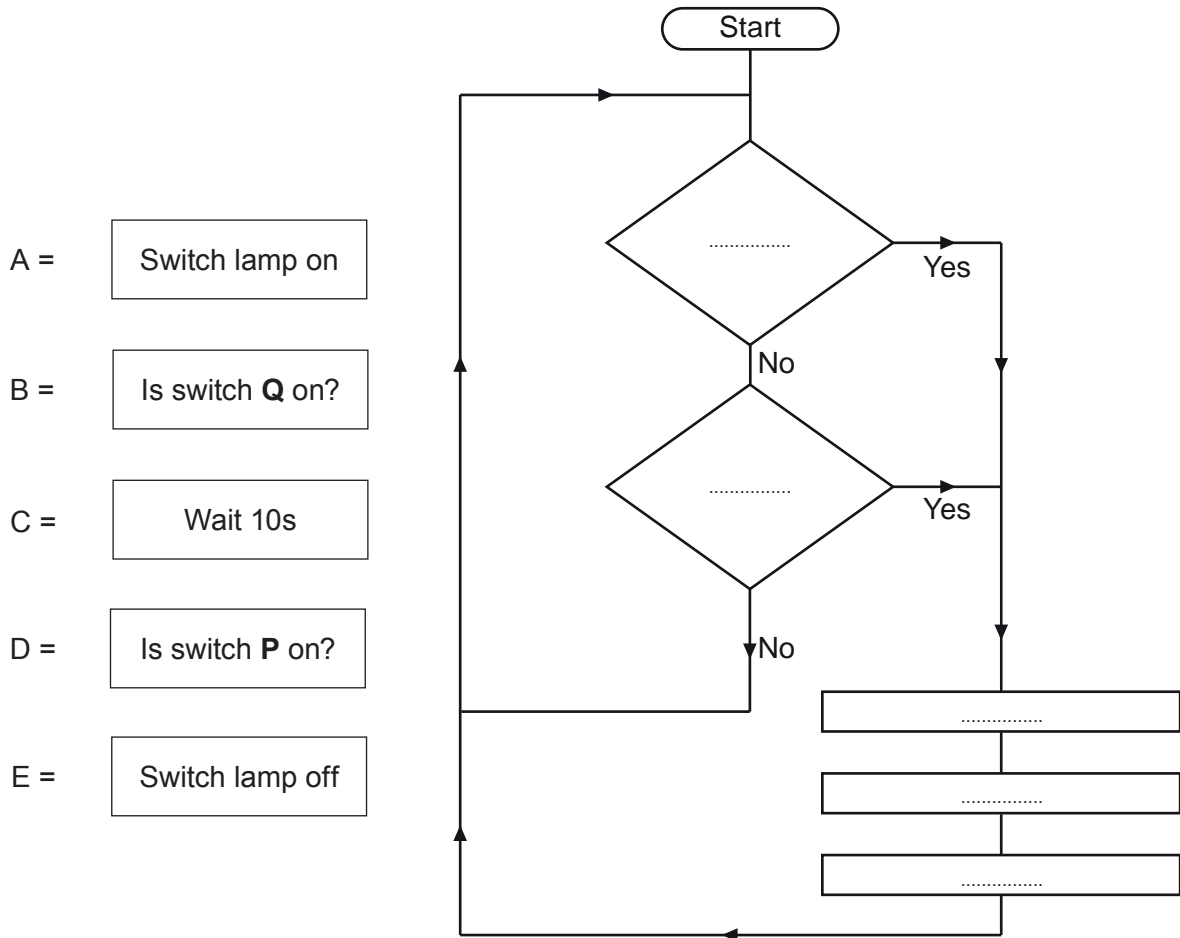
**10.** Comparators and Schmitt inverters can be used to interface a light-sensing unit to a logic system.

*(a)* Which statement about the comparator is correct? [1]
(Tick (✓) the correct answer.)

☐ It has a single switching threshold fixed at 0.7 V.

☐ It has a single switching threshold at a voltage which can be varied.

☐ It has two fixed switching thresholds.

☐ It has two switching thresholds at voltages which can be varied.

*(b)* Which statement gives the advantage of a Schmitt inverter over the comparator in this application? [1]
(Tick (✓) the correct answer.)

☐ It stops contact bounce in the light sensor.

☐ It stops rapid output switching when the light level fluctuates slightly.

☐ It works better in the dark.

☐ It boosts the current to the logic system.

**11.** The block diagram represents a typical public address system. It consists of different sub-systems, labelled **A** to **E**.
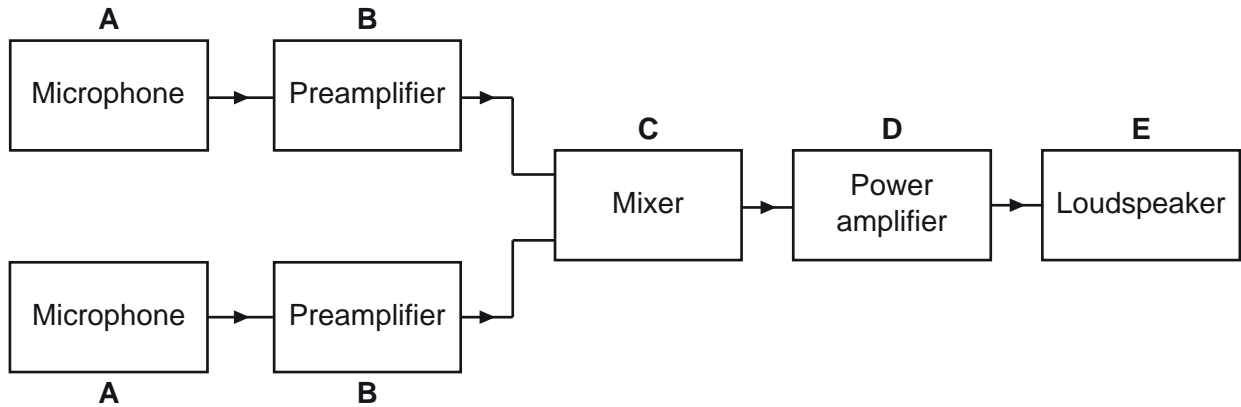


*(a)* Which sub-system:

(i) converts electrical signals into sound; [1]

A     B     C     D     E

(ii) is designed specifically to boost the signal **current**; [1]

A     B     C     D     E

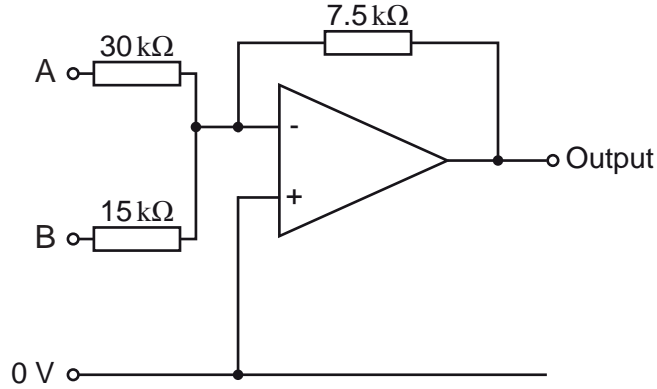(iii) is designed specifically to boost the signal **voltage**? [1]

A     B     C     D     E

*(b)* The mixer, shown in the diagram, combines signals from the two microphones.
It is tested by applying the following voltages.

Input A = 2.0 V
Input B = 1.0 V



(i) Which **one** of the following shows the correct equation to calculate the output voltage, $V_{OUT}$? [1]
(Tick (✓) the correct answer.)

☐ $V_{OUT} = -15\left(\dfrac{1}{30} + \dfrac{2}{7.5}\right)$

☐ $V_{OUT} = -30\left(\dfrac{1}{15} + \dfrac{2}{7.5}\right)$

☐ $V_{OUT} = -7.5\left(\dfrac{2}{30} + \dfrac{1}{15}\right)$

☐ $V_{OUT} = -7.5\left(\dfrac{1}{30} + \dfrac{2}{15}\right)$

(ii) Calculate the output voltage. [1]

................................................................................................................................................................

................................................................................................................................................................
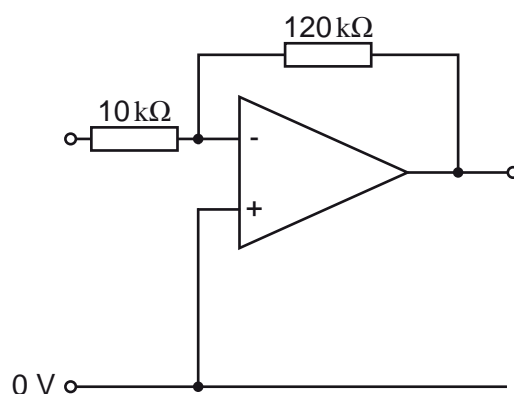
Output voltage = ............................... V

**12.** **A**, **B** and **C** are different voltage amplifiers.

*(a)* When the input signal has an amplitude of 4 mV, amplifier **A** produces an output signal with an amplitude of 40 mV.
What is the voltage gain of amplifier **A**? Circle the correct answer. [1]
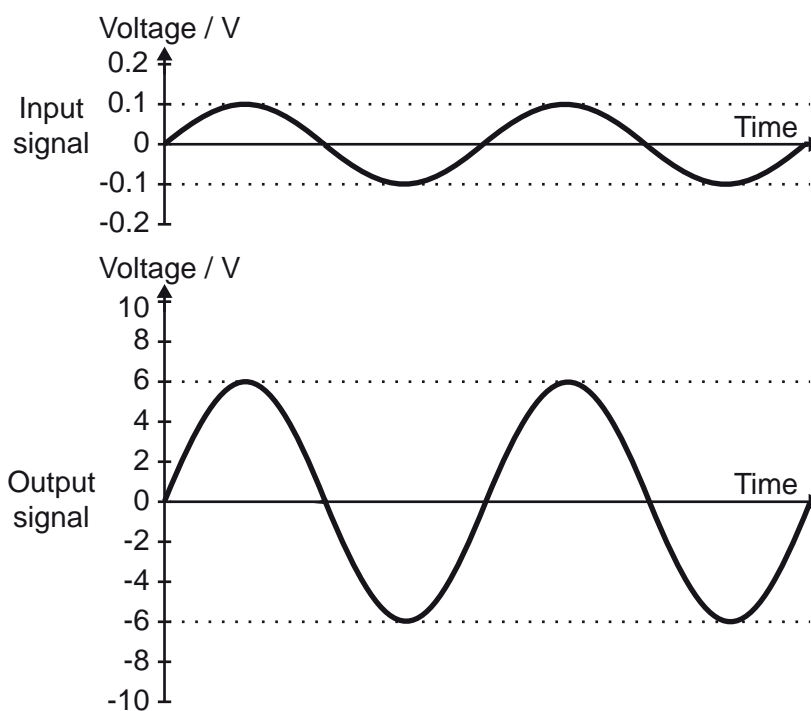
10          36          44          160

*(b)* The circuit diagram for amplifier **B** is shown below.
What is its voltage gain? Circle the correct answer. [1]

−13          −12          12          13

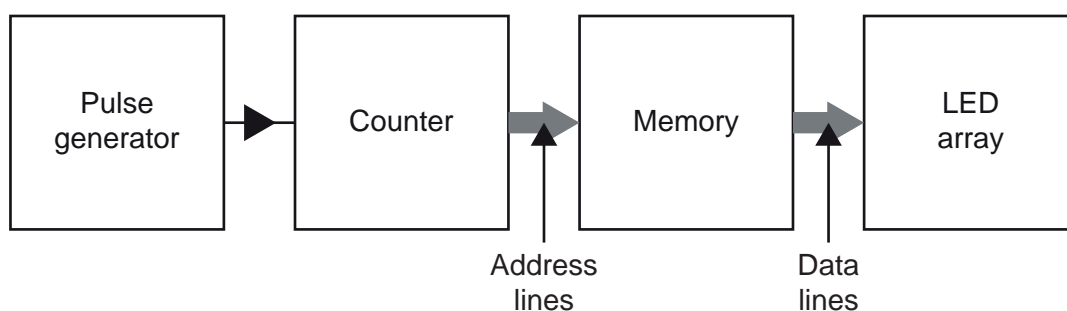$$120\,\text{k}\Omega$$

$$10\,\text{k}\Omega$$

- 

+

0 V

*(c)* The top graph shows the signal applied to the input of amplifier **C**.
The bottom graph shows the corresponding output signal.
What is the voltage gain of amplifier **C**? Circle the correct answer. [1]

6.0          6.1          12.2          60.0          120.0

Voltage / V

0.2
Input   0.1
signal    0                                    Time
-0.1
-0.2

Voltage / V

10
8
6
4
2
Output   0                                    Time
signal  -2
-4
-6
-8
-10

(4162-01)

**13.** The block diagram for a sequence controller is shown below.



The contents of the memory are given in the following table:

| Address | | | Data | | | |
|---|---|---|---|---|---|---|
| $A_2$ | $A_1$ | $A_0$ | $D_3$ | $D_2$ | $D_1$ | $D_0$ |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| 0 | 1 | 0 | 0 | 1 | 0 | 0 |
| 0 | 1 | 1 | 0 | 0 | 1 | 0 |
| 1 | 0 | 0 | 0 | 0 | 0 | 1 |

*(a)* What is the minimum number of bits that the counter must have?
Circle the correct answer. [1]

1    2    3    4    5

*(b)* Each output is connected to a single LED.
How many LEDs are required in total?
Circle the correct answer. [1]

1    2    3    4    5

*(c)* Initially, the counter is reset.
How many pulses are then needed to produce the output '0100'?
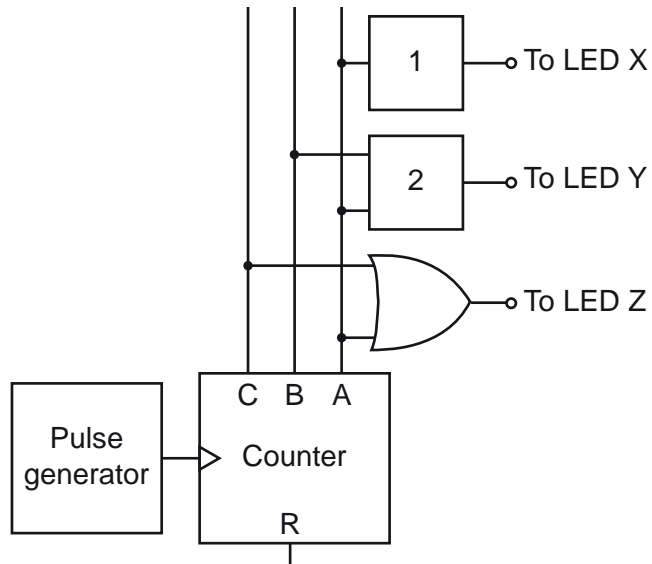Circle the correct answer. [1]

1    2    3    4    5

**14.** The diagram shows part of a control system for a LED lighting sequence.

A LED lights when it receives a logic 1 signal.

The behaviour of LEDs X and Y is shown in the table.



| Pulses | Counter outputs | | | LEDs | |
|---|---|---|---|---|---|
| | C | B | A | X | Y |
| 0 | 0 | 0 | 0 | On | On |
| 1 | 0 | 0 | 1 | Off | On |
| 2 | 0 | 1 | 0 | On | On |
| 3 | 0 | 1 | 1 | Off | Off |
| 4 | 1 | 0 | 0 | On | On |
| 5 | 1 | 0 | 1 | Off | On |
| 6 | 1 | 1 | 0 | On | On |
| 7 | 1 | 1 | 1 | Off | Off |

*(a)* Box 1 must contain the ........................... logic gate.
Insert the correct answer from the list below. [1]

NOT     AND     NAND     OR     NOR
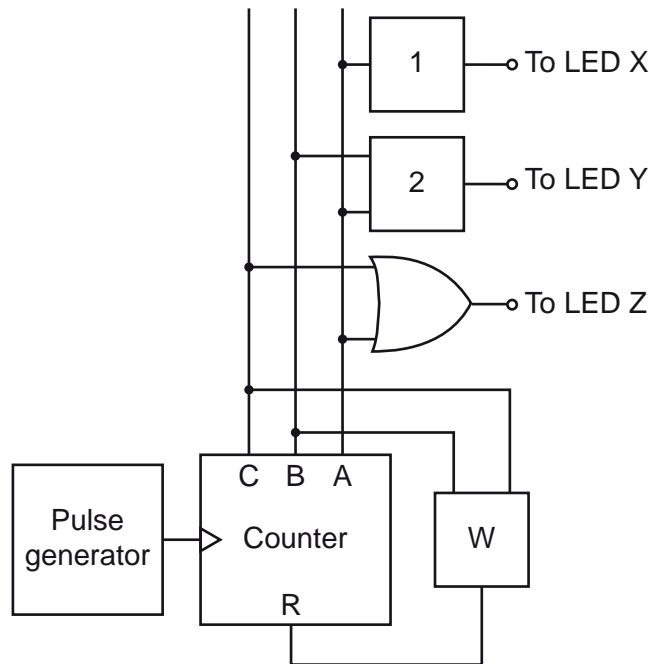
*(b)* Box 2 must contain the ........................... logic gate.
Insert the correct answer from the list below. [1]

NOT     AND     NAND     OR     NOR

*(c)* Which two pulses cause LED Z to switch **off**?

Pulses ........................... and ........................... cause LED Z to switch **off**.
Insert the correct answers from the list below. [2]

0     1     2     3     4     5     6     7

*(d)* The next diagram includes the reset sub-system.



The counter resets when the reset pin **R** receives a logic 1 signal.
The logic gate in box **W** makes the counter reset on pulse 6.

Box **W** must contain the ........................... logic gate.
Insert the correct answer from the list below. [1]

NOT     AND     NAND     OR     NOR

**15.** A Schmitt Inverter is tested using the input signal shown in the upper graph.
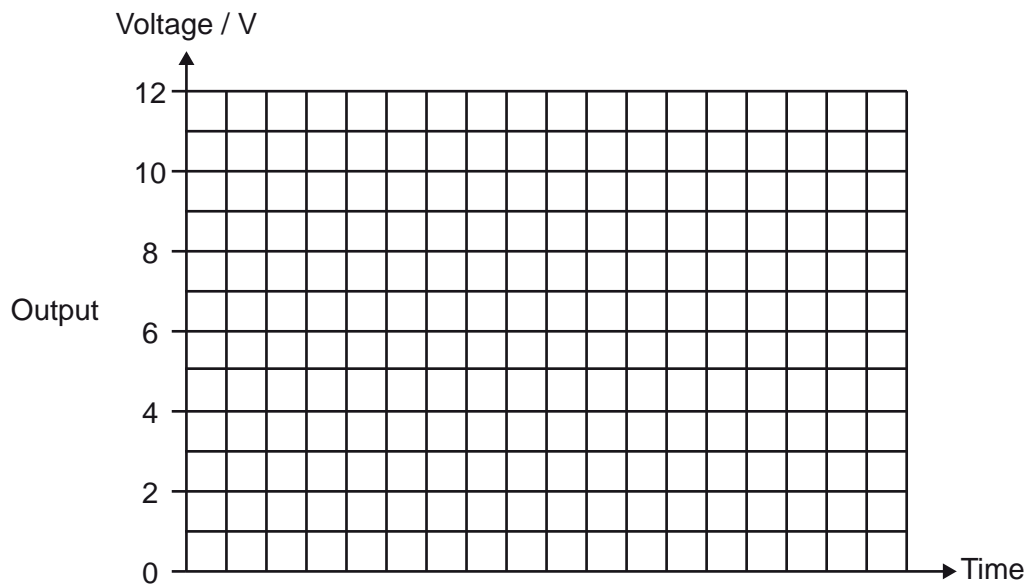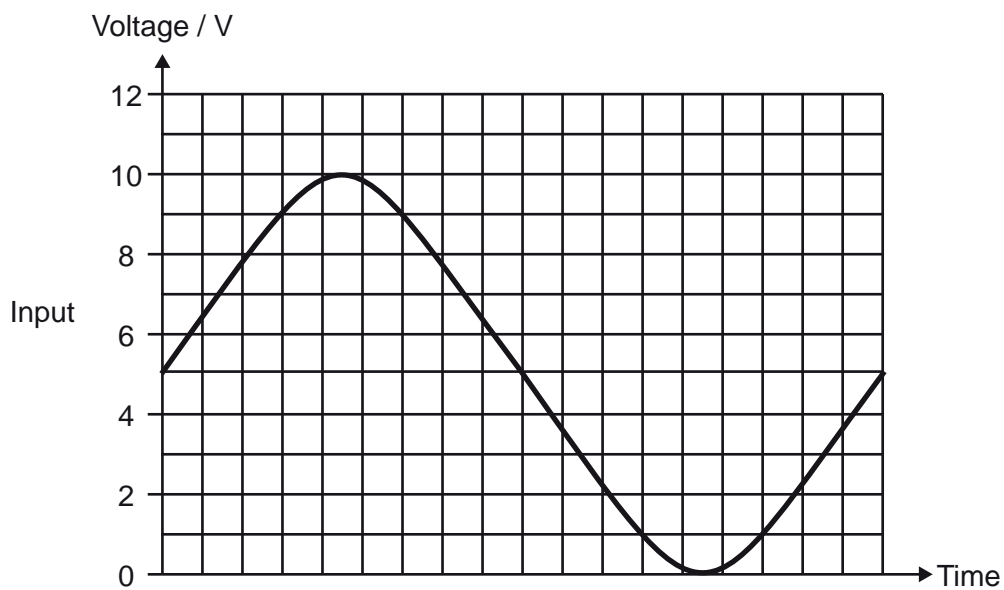
**Schmitt Inverter Information:**

The output:

- changes from logic 1 to logic 0 when a **rising** input voltage reaches 9 V;
- changes from logic 0 to logic 1 when a **falling** input voltage reaches 6 V.

A signal at 1 V represents logic 0 and one at 10 V represents logic 1.

Use the axes provided in the lower graph to draw the expected output signal. [4]
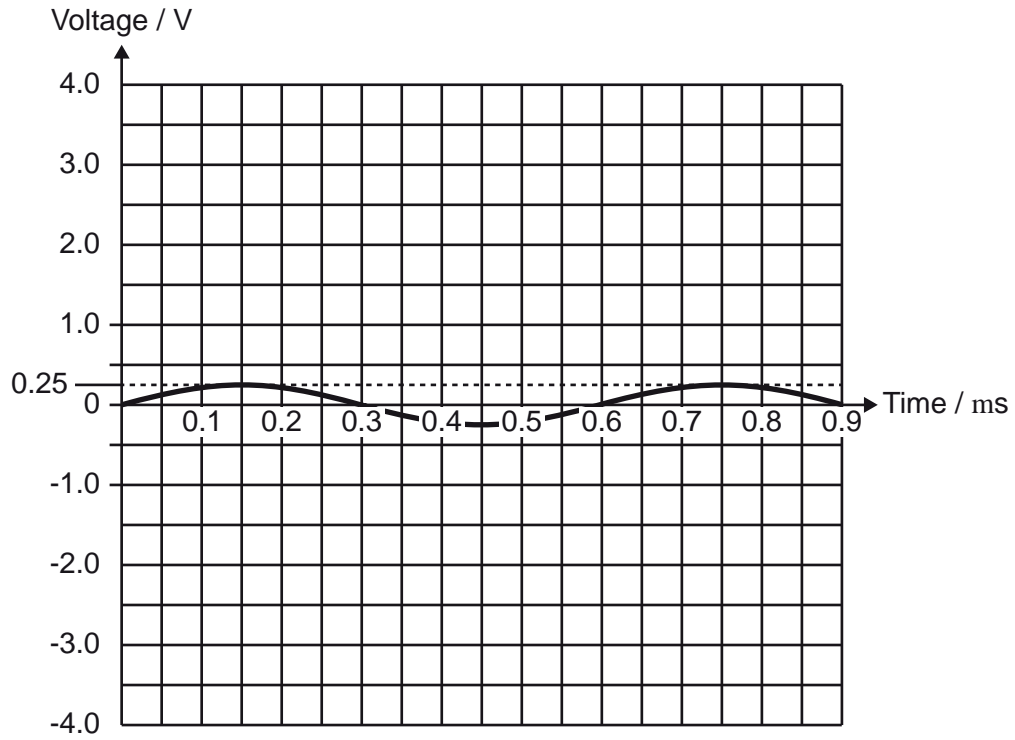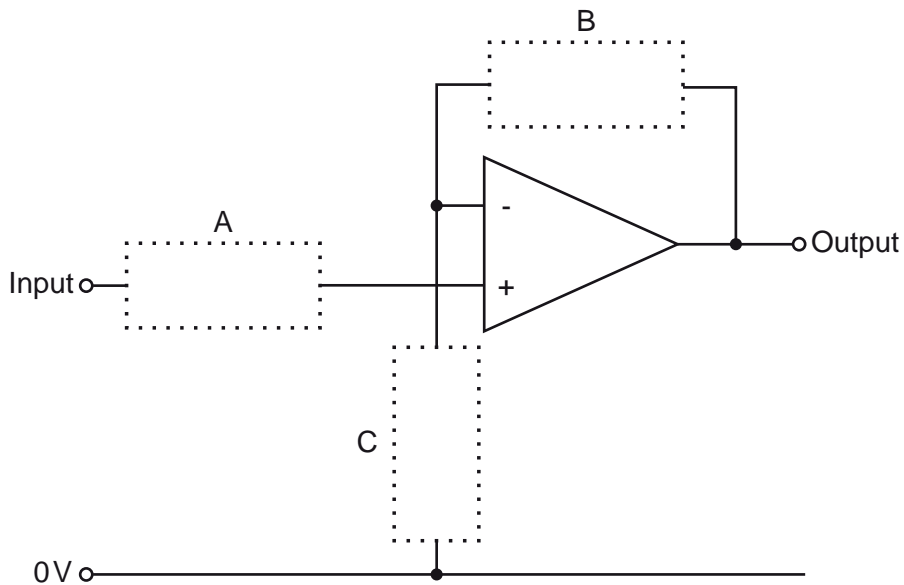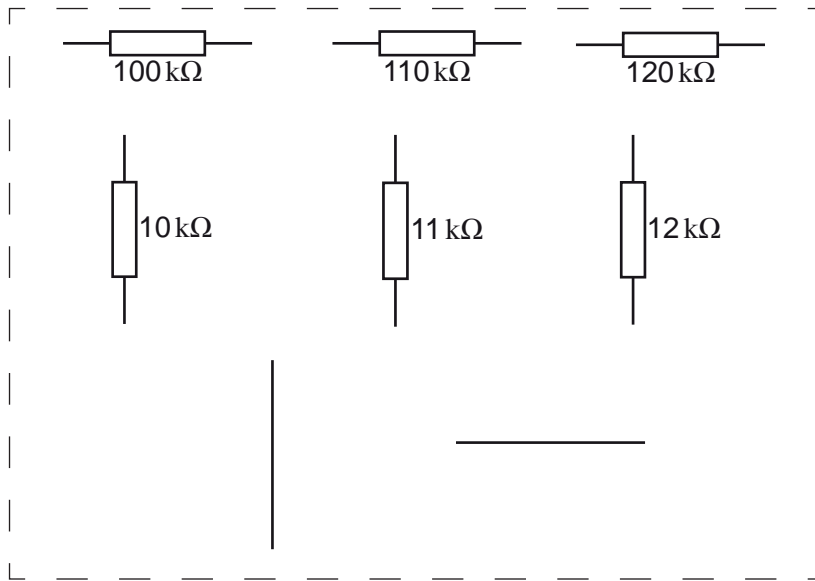
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 **Turn over.**

**16.** A **non-inverting** amplifier has a voltage gain of 12.

*(a)* The graph shows the input signal of peak value 0.25 V.
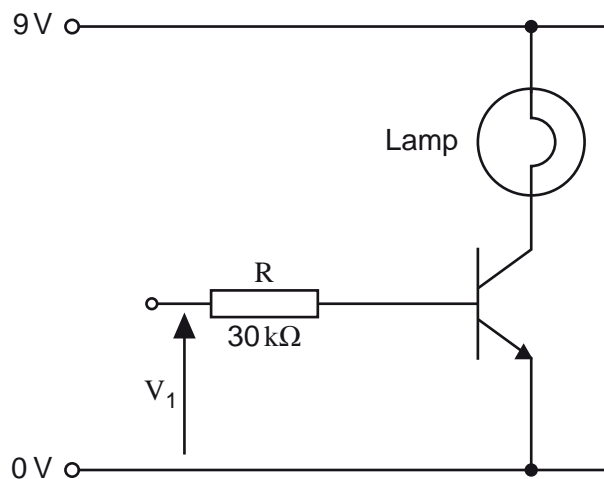Draw the wave that shows the corresponding output signal in the graph below. [2]

*(b)* Draw the correct components in the circuit diagram for the non-inverting amplifier shown below having a voltage gain of 12. [3]

**17.** A transistor switch is used to interface a logic system to a lamp.
The transistor has a current gain of 50.
The current through $R$ is 0.2 mA.



*(a)* What current flows through the lamp if the transistor is not saturated? [1]

Current through the lamp = ........................... mA.

*(b)* (i) Calculate the voltage across resistor, $R$. [1]

...................................................................................................................................................................

...................................................................................................................................................................

Voltage across $R$ = ........................... V.

(ii) What is the voltage $V_1$? [1]

$V_1$ = ........................... V.

**END OF PAPER**

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