# 2009 Electronic and Electrical Fundamentals

# Intermediate 2

# Finalised Marking Instructions

## Section A

### Attempt all the questions in this section (50 marks)

**1.** Convert the following numbers.

(*a*) $10001101_2$ binary to decimal

(*b*) $171_{10}$ decimal to hexadecimal

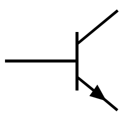
*(c)* $B7_{16}$ hexadecimal to binary

**Answers**

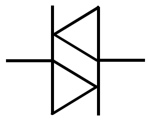
| | | |
|---|---|---|
| (*a*) | $141_{10}$ | **2** |
| (*b*) | $AB_{16}$ | **2** |
| (c) | $10110111_2$ | **2** |
| | <u>(base numbers not required in answers)</u> | **(6)** |

**2.** Identify the following circuit symbols.

(*a*)



(*b*)



**Answers**

| | | |
|---|---|---|
| (*a*) | Bipolar Transistor or npn transistor | **2** |
| (*b*) | Diac | **2** |
| | | **(4)** |

**3.** For the circuit shown in Figure Q3 below, determine:

(*a*) the voltage $V_{CD}$;

(*b*) the voltage $V_{BC}$.

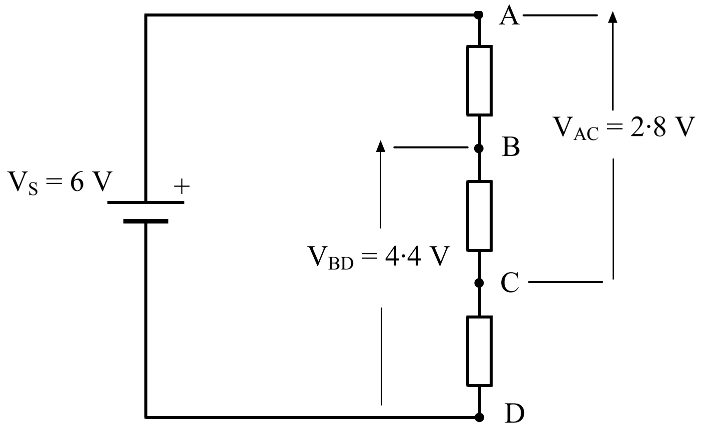



Figure Q3

**Answers**

| | | | | |
|---|---|---|---|---|
| (*a*) | $V_{CD}$ | = | 3·2 V | **2** |
| (*b*) | $V_{BC}$ | = | 1·2 V | **2** |
| | | | | **(4)** |

**4.** Referring to Figure Q4 shown below,

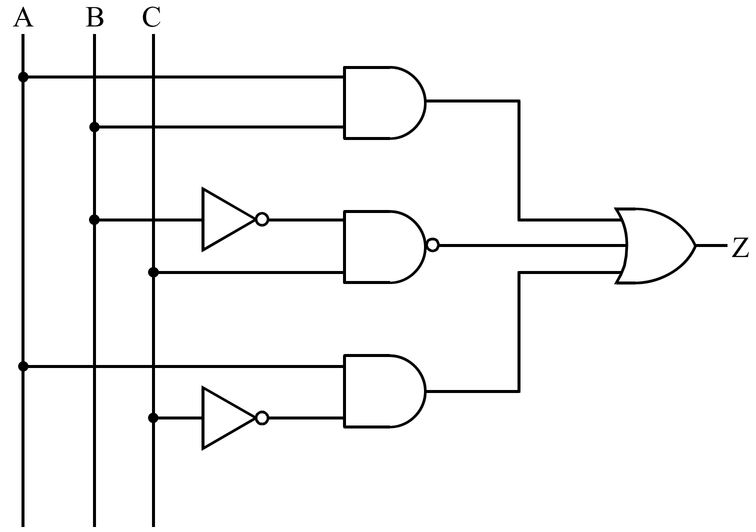



Figure Q4

*(a)* determine the Boolean expression for output Z;

*(b)* draw the truth table for the circuit.

**Answers**

(*a*) $Z = A.B + \overline{\overline{B}.C} + A.\overline{C}$ **3**

*(b)*

| | | | 1 | 2 | 3 | 1+2+3 |
|---|---|---|---|---|---|---|
| A | B | C | A.B | $\overline{\overline{B}.C}$ | $A.\overline{C}$ | Z |
| 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 0 | 1 | 0 | 0 | 1 | 0 | 1 |
| 0 | 1 | 1 | 0 | 1 | 0 | 1 |
| 1 | 0 | 0 | 0 | 1 | 1 | 1 |
| 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| 1 | 1 | 0 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 | 0 | 1 |

**4**

**(7)**

**5.** For the circuit shown in Figure Q5 below:

*(a)* identify the circuit configuration;

*(b)* state the circuit voltage gain in terms of input and output voltages;

*(c)* state the circuit voltage gain in terms of resistors $R_1$ and $R_2$;

*(d)* state the phase relationship between input and output voltage.

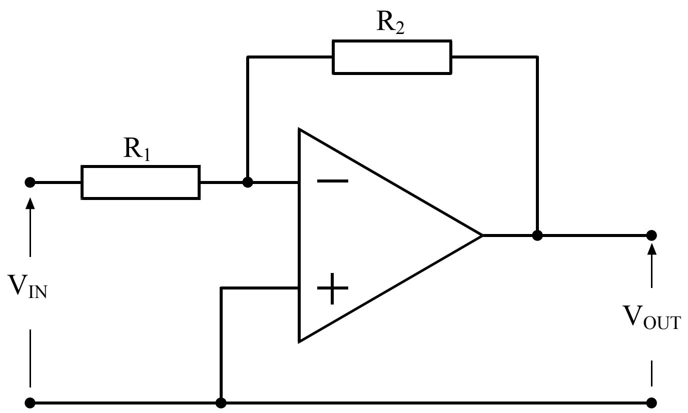



Figure Q5

**Answers**

| | | |
|---|---|---|
| *(a)* | Inverting amplifier | **1** |
| *(b)* | Gain = $-V_{OUT}/V_{IN}$ | **2** |
| *(c)* | Gain = $-R_2/R_1$<br>For *(b)* and *(c)* both minuses, or one minus and one positive are acceptable but not two positive | **2** |
| *(d)* | 180º | **1**<br>**(6)** |

**6.** Figure Q6(*a*) and Figure Q6(*b*) show a current carrying conductor placed between the poles of a magnet. For each Figure, sketch the resultant magnetic field around each conductor.

State whether you are using ‘conventional’ or ‘electron’ current flow.


Figure Q6(*a*)

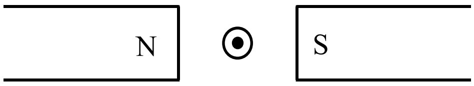



Figure Q6(*b*)

**Answer**

For both figures, magnetic field lines drawn for both N → S field and field around the conductor. Resultant field to show closer field lines where fields strengthen and weaker field should show field lines further apart. **2, 2**

**(4)**

**7.** With reference to the circuit shown in Figure Q7,

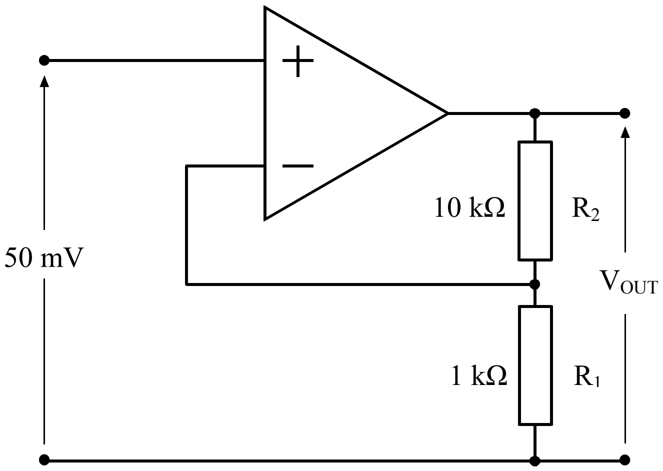



Figure Q7

(*a*) identify the circuit configuration;

(*b*) calculate the circuit gain;

(*c*) calculate the output voltage;

(*d*) state the phase relationship between input and output voltages.

**Answers**

(*a*) Non inverting amplifier **1**

(*b*) gain = $\dfrac{R_1 + R_2}{R_2} = \dfrac{10+1}{1} = 11$ **2**

(*c*) $V_{OUT}$ = 50 mV × 11 = 550 mV **2**

(*d*) In-phase or 0º phase shift **1**

**(6)**

**8.** (*a*) For the Boolean expression,

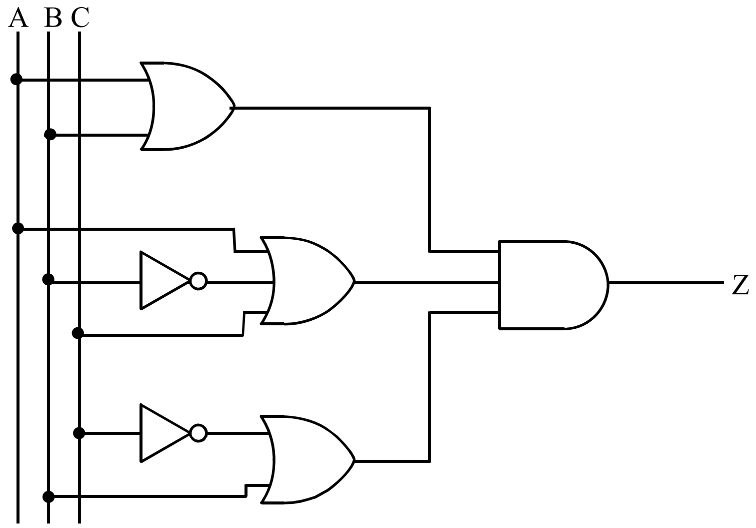
$$Z = (A + B).(A + \overline{B} + C).(B + \overline{C})$$

draw the logic circuit diagram.

(*b*) Show by diagram, how two 2-input AND gates can be connected to perform the logic function of a 3-input AND gate.

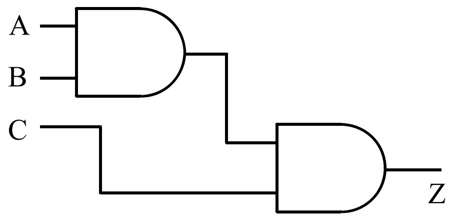
**Answers**

(*a*)




**3**

(*b*)




**2**
**(5)**

**9.** For the circuit shown in Figure Q9, determine:

(*a*) the voltage across resistor $R_2$;

(*b*) the current through resistor $R_2$;

(*c*) the value of resistor $R_1$;

(*d*) the voltage across resistor $R_4$;

(*e*) the value of resistor $R_4$;

(*f*) the supply current.

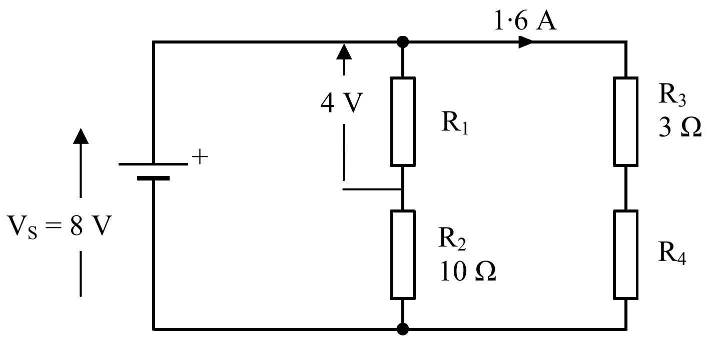



Figure Q9

**Answers**

(*a*) $V_{R2} = 8 - 4 = 4$ V **1**

(*b*) $I_{R2} = \dfrac{4}{10} = 0{\cdot}4$ A **1**

(*c*) $R_1 = \dfrac{V}{I} = \dfrac{4}{0 \cdot 4} = 10\ \Omega$ **1**

(*d*) $V_{R2} = 8 - (1{\cdot}6 \times 3) = 3{\cdot}2$ V **2**

(*e*) $R_2 = \dfrac{3 \cdot 2}{1 \cdot 6} = 2\ \Omega$ **1**

(*f*) $I_S = 0{\cdot}4 + 1{\cdot}6 = 2$ A **2**

**(8)**

## Section B

**Attempt any TWO questions in this section (50 marks)**
**Each question is worth 25 marks**

**10.** (*a*) For the circuit shown in Figure Q10(*a*),

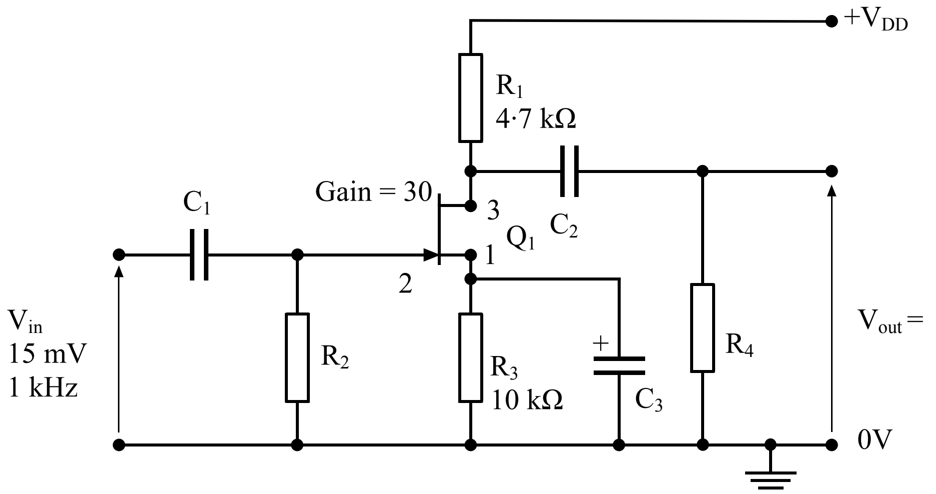



Figure Q10(*a*)

(i) name the circuit and its configuration;

(ii) name the terminals 1, 2 and 3 of component $Q_1$;

(iii) calculate the output voltage;

(iv) sketch the input and output waveforms to show the phase relationship between them (numerical values are not required);

(v) state the purpose of capacitors $C_1$ and $C_2$.

**Answers**

(*a*) (i) Common source amplifier. **2**

(ii)
1 Source
2 Gate
3 Drain **3**

(iii) $V_{out}$ = Gain × $V_{in}$ = $300 \times 15 \times 10^{-3} = 4{\cdot}5$ V **2**

(iv) Sketch of waveforms should show output and input waveforms are 180º out of phase. **2**

(v) Coupling capacitor (block dc (1 mark) voltage let ac signal pass through). **2** (*b*) With reference to the circuit shown in Figure Q10(*b*).

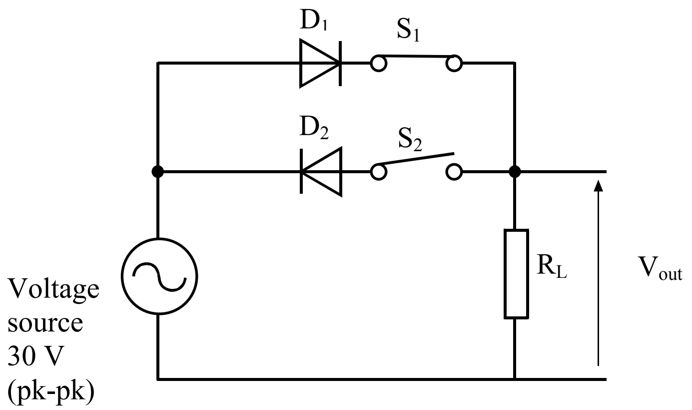



Figure Q10(*b*)

(i) what is the purpose of the diode $D_1$?

(ii) explain the operation of the circuit when switch $S_1$ is closed and switch $S_2$ is open.

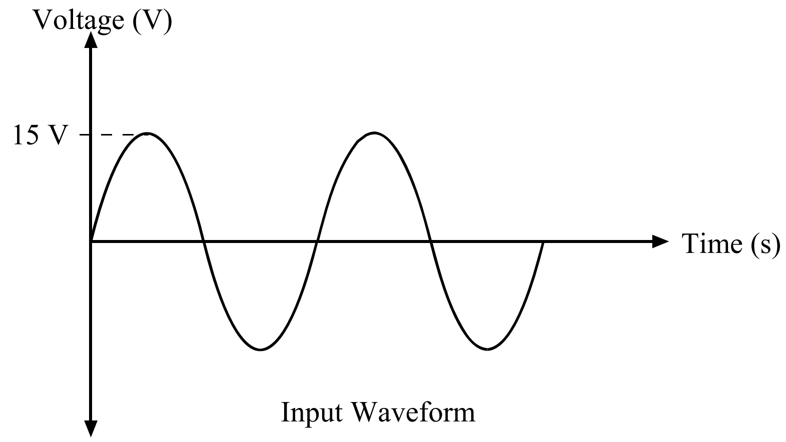
(iii) the forward voltage drop of diodes $D_1$ and $D_2$ is 0·7 V. Sketch the input and output waveforms showing peak values for each.

**Answers**

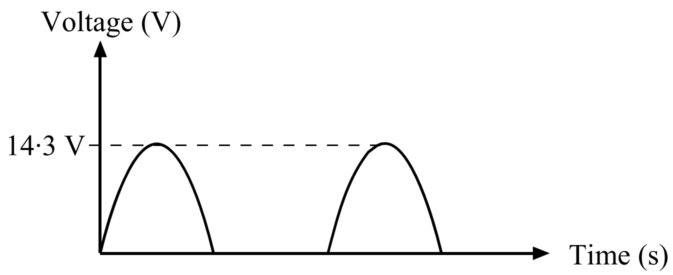
(*b*) (i) Half wave rectification. **1**

(ii) When the input waveform is positive the current flows through the forward biased diode $D_1$, through $R_L$ and returns to the load $R_L$. When the input waveform is negative the diode is reversed biased and there is no current flow. **2**

(iii)




Input Waveform




**4**

(*c*) The waveform shown in Figure Q10(*c*) is fed into the input of the circuit shown in Figure Q10(*d*).

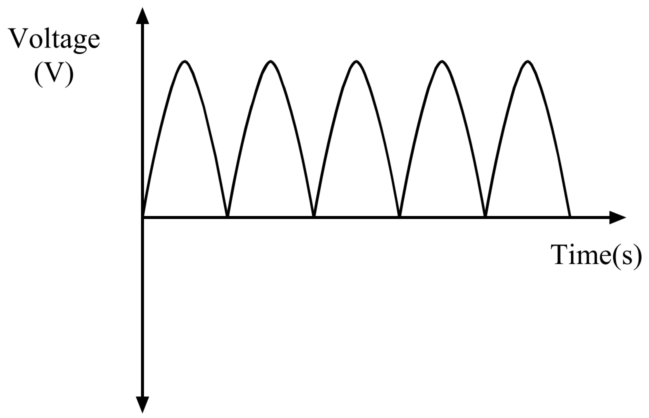



Figure Q10(*c*)

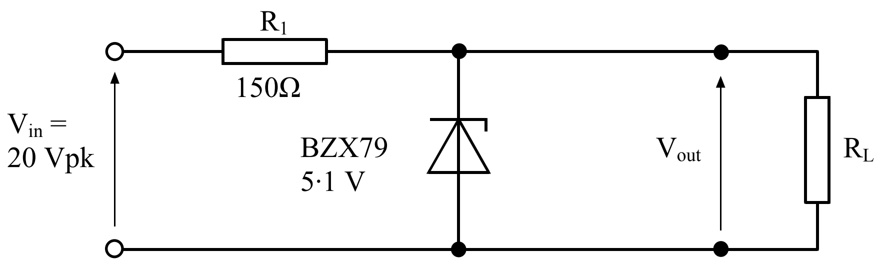



Figure Q10(*d*)

(i) State the operating voltage of the zener diode.

(ii) Sketch the output waveform across the load resistor $R_L$.

(iii) Using the data sheet provided:

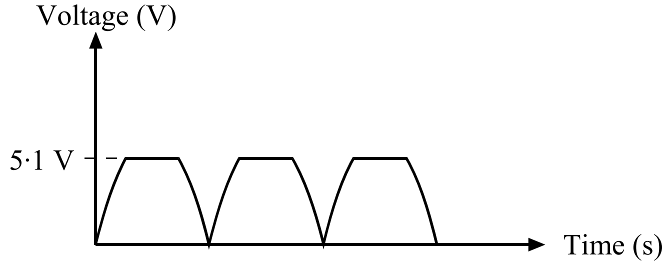
(A) determine the maximum power rating of the zener diode;

(B) calculate the maximum current of the zener diode.

**Answers**

(*c*) (i) 5·1 V **1**

(ii)




**3**

(iii) (A) 500 mW **1**

(B) Maximum Current Rating = $\dfrac{500\times10^{-3}}{5\cdot1}$

$= 98$ mA **2**

**(25)**

*Marks*

**11.** (*a*) An a.c. sinusoidal voltage is given by $e = 20 \sin\Theta$ mV.

(i) State the maximum value of this voltage.

(ii) Calculate the rms value of the voltage.

(iii) Calculate the instantaneous value of the voltage when $\Theta = 45^\circ$.

(*b*) The coil AB shown on Figure Q11(*b*) has an effective length of 4·5 m. The conductor moves at a constant speed of 6 $m\,s^{-1}$ through a uniform magnetic field of flux density 0·45T.

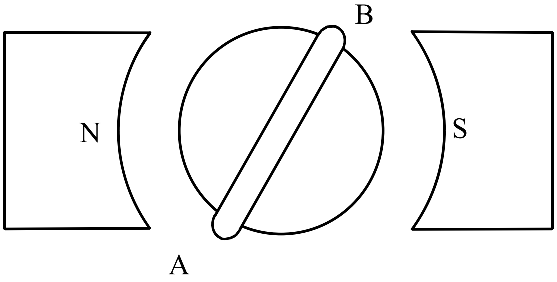



Figure Q11(*b*)

(i) Determine the induced emf when the coil cuts the magnetic field at 45º.

(ii) State the angle relative to the vertical at which the minimum voltage will occur.

**Answers**

(*a*) (i) 20 mV **1**

(ii) rms = 0·707 × 20 = 14·14 mV **2**

(iii) e = 20 sin 45
= 14·14 mV **2**

(*b*) (i) e = Blv sin Θ
= 0·45 × 4·5 × 6 sin 45
= 8·6 V **2**

(ii) 0 V **1**

*Marks*

(*c*) For the circuit diagram in Figure Q11(*c*),

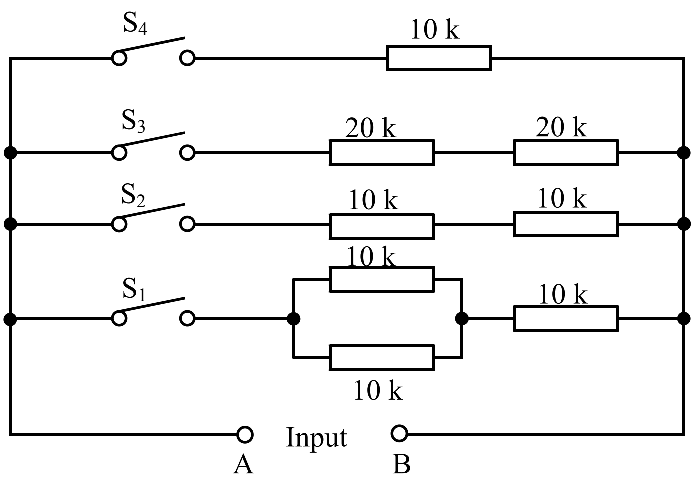


Figure Q11(*c*)

(i) Calculate the total resistance of the circuit when switches $S_1$ and $S_2$ are closed and switches $S_3$ and $S_4$ are open.

(ii) Calculate the total resistance when switches $S_2$ and $S_3$ are closed and switches $S_1$ and $S_4$ are opened.

(iii) Which switches should be left open to give the highest resistance between A and B?

(iv) Which switches should be closed to give the lowest resistance between A and B?

(v) If only one switch can be closed, which switch would give the lowest current?

**Answers**

| | | | |
|---|---|---|---|
| (*c*) | (i) | (10k + 10k) / / 15k = 8·57 kΩ | **2** |
| | (ii) | (20k + 20k) / / (10k + 10k) = 13·3 kΩ | **2** |
| | (iii) | All switches open | **1** |
| | (iv) | All switches closed | **2** |
| | (v) | $S_3$ closed | **2** |

(*d*) (i) Calculate the power dissipated in a 15 kΩ resistor when the current is 2 mA.

(ii) Calculate the energy used, in joules, if this current continues for 45 minutes.

(iii) The power rating of the resistor is 0·125 W. Calculate the maximum current that can flow through the resistor without exceeding the power rating.

**Answers**

(*d*) (i)

$$\begin{aligned} \text{Power} = I^2R &= (2 \times 10^{-3})^2 \times 15 \times 10^3 \\ &= 4 \times 10^{-6} \times 15 \times 10^3 \\ &= 60 \times 10^{-3} \\ &= 0{\cdot}06\ \text{W} \\ &= 60\ \text{mW} \end{aligned}$$

**2**

(ii)

$$\begin{aligned} \text{Energy} &= P \times t \\ &= 60 \times 10^{-3} \times 45 \times 60 \\ &= 162\ \text{J} \end{aligned}$$

**2**

(iii)

$$\begin{aligned} P_{max} &= I_{max}^2\, R \\ I_{max}^2 &= \frac{P_{max}}{R} \\ &= \frac{0 \cdot 125}{15 \times 10^3} \\ I_{max} &= \sqrt{\frac{0 \cdot 125}{15 \times 10^3}} \\ &= 2{\cdot}9\ \text{mA} \end{aligned}$$

**4**

**(25)**

*Marks*

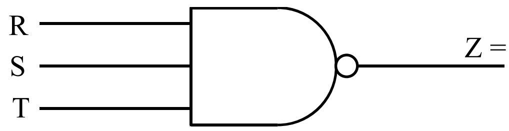
**12.** (*a*) Add the following binary numbers.

(i) $1011_2 + 1001_2$

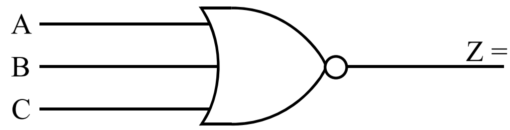
(ii) $0101_2 + 0011_2$

(*b*) State the Boolean expression and construct the truth table for the following logic gates.

(i)




(ii)




**Answers**

(*a*) (i) $10100_2$ **2**

(ii) $1000_2$ **2**

(*b*) (i) $Z = \overline{R.S.T}$

| R | S | T | Z |
|---|---|---|---|
| 0 | 0 | 0 | **1** |
| 0 | 0 | 1 | **1** |
| 0 | 1 | 0 | **1** |
| 0 | 1 | 1 | **1** |
| 1 | 0 | 0 | **1** |
| 1 | 0 | 1 | **1** |
| 1 | 1 | 0 | **1** |
| 1 | 1 | 1 | **0** |

**4**

(ii) $Z = \overline{A + B + C}$

| A | B | C | Z |
|---|---|---|---|
| 0 | 0 | 0 | **1** |
| 0 | 0 | 1 | **0** |
| 0 | 1 | 0 | **0** |
| 0 | 1 | 1 | **0** |
| 1 | 0 | 0 | **0** |
| 1 | 0 | 1 | **0** |
| 1 | 1 | 0 | **0** |
| 1 | 1 | 1 | **0** |

**4**

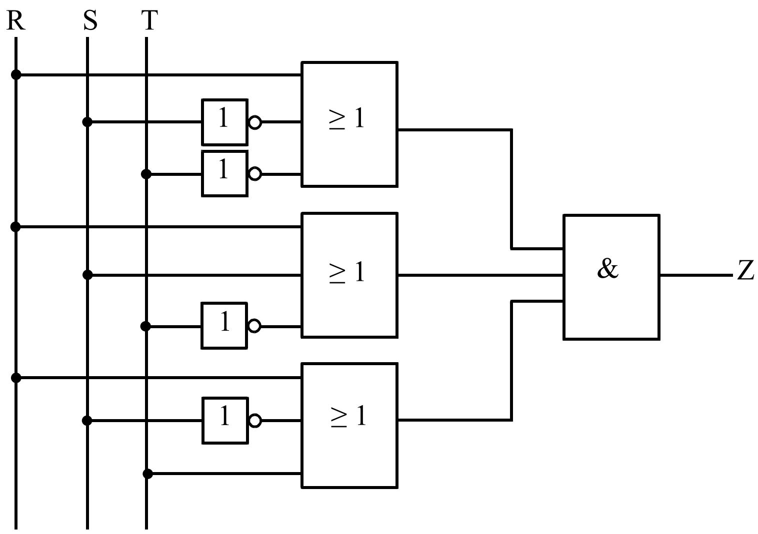
*Marks*

(*c*) Draw, using BS symbols, the logic diagram for the following Boolean expression.

$Z = (R+\overline{S}+\overline{T}).(R+S+\overline{T}).(R+\overline{S}+T)$

**Answers**

(*c*)




**4**

*Marks*

(*d*) The circuit shown in Figure Q12(*d*) is used to control a warning lamp, which operates when the output of the circuit is on.

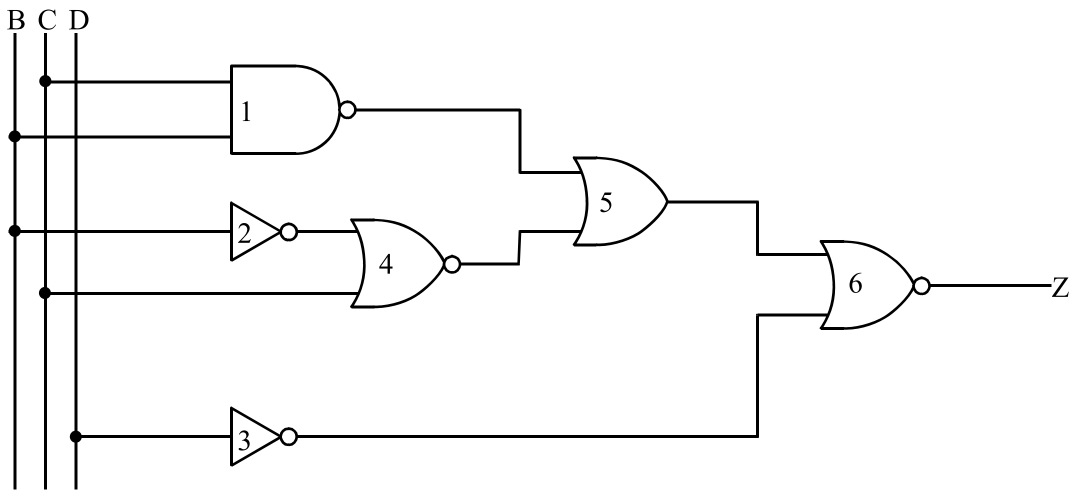



Figure Q12(*d*)

(i) Determine the Boolean expression for the circuit.

(ii) Construct the truth table for the circuit.

(iii) Use the truth table to determine an alternative Boolean expression.

**Answers**

(*d*) (i) $Z = \overline{((\overline{B.C}) + (\overline{\overline{B} + C})) + \overline{D}}$ **3**

½ mark for each correct gate output

(ii)

| B | C | D | $\overline{B.C}$ | $\overline{\overline{B}+C}$ | $\overline{D}$ | Z |
|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| 0 | 1 | 0 | 1 | 0 | 1 | 0 |
| 0 | 1 | 1 | 1 | 0 | 0 | 0 |
| 1 | 0 | 0 | 1 | 1 | 1 | 0 |
| 1 | 0 | 1 | 1 | 1 | 0 | 0 |
| 1 | 1 | 0 | 0 | 0 | 1 | 0 |
| 1 | 1 | 1 | 0 | 0 | 0 | 1 |

**4**

(iii) Z = B.C.D **2**

**(25)**

[END OF MARKING INSTRUCTIONS]