SECTION A

Answer ALL questions.

You MUST write your answers in the spaces provided in this answer booklet.

1. (a) Define magnetic flux density, B, in terms of the force on a current-carrying wire.

$B = \frac{F}{IL}$

The magnetic flux density is defined as the force exerted per unit current per unit length ~~of~~ on a current carrying wire that is placed in the magnetic field.

$B = \frac{F}{IL}$ where F= force exerted, I-current and L is length of conductor (wire).

[2 marks]

(b) Figure 1 (b) shows a wire, P, carrying a current perpendicular to the plane of the paper, between two flat permanent magnets which have poles on their faces as shown in Figure 1 (a). Draw the resultant magnetic field pattern between the two magnets. Indicate on the figure, with an arrow labelled M, the direction of motion of the wire.

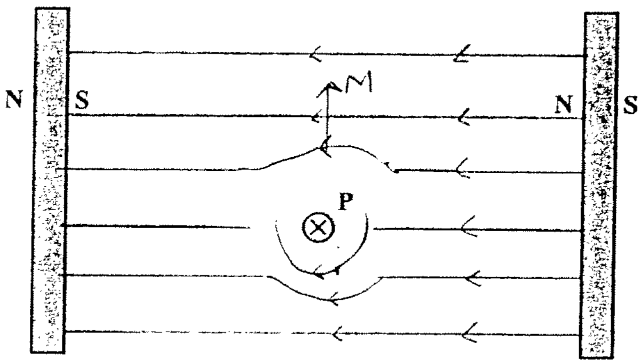


Figure 1 (b)

Field around ~~coil~~ wire predicted using Right hand grip rule

Field ~~around~~ between magnets in from N to S

The field due to wire above it is cancelled by other field

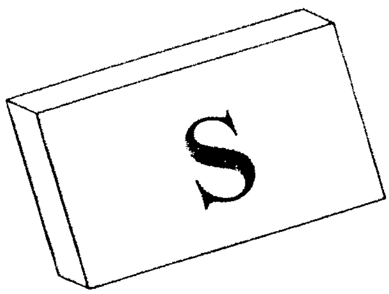


Figure 1 (a)

[4 marks]

(c) Figure 1 (c) shows a narrow beam of electrons travelling at a speed, v, and directed into a uniform electric field between two oppositely charged parallel plates placed a distance, d, apart. The top plate is at a positive potential, V, relative to the lower plate. A magnetic field is now applied perpendicularly to the direction of the electric field between the plates and the deflection of the beam is cancelled.

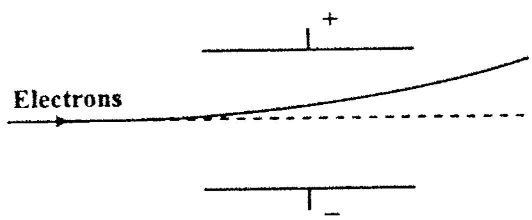


Figure 1 (c)

(i) State the direction of the magnetic field.

The magnetic field is applied into the plane of the paper, i.e, perpendicular to plane of paper

[1 mark]

(ii) By considering the forces on EACH electron, show that the magnetic flux density is given by

$$B = \frac{V}{vd}.$$

$F_B = F_E$
$Bqv = Eq$
$Eqv = \frac{Vq}{d}$
$B = \frac{Vq}{qvd}$
$= \frac{V}{vd}$

The magnetic force on each electron, $F_b = Bqv$
$= Bev$ (where e is charge on e

The electric force on each electron, $F_{el} = Eq$
$= Ee$ (where E: electric field s

Recall for an electric field between parallel plates, $E = \frac{V}{d}$
$= \frac{V}{d}$

$\therefore$ Electric force $= \frac{Ve}{d}$

When there is no deflection, $F_b = F_{el}$ which indicates that the force produced by magnetic field opposes that of electric field.

$$Bev = \frac{Ve}{d}$$

$$B = \frac{Ve}{evd} \Rightarrow B = \frac{V}{vd}$$

[4 marks]

(iii) Given that $V = 3500$ V, $v = 2.8 \times 10^7$ m s^{-1}, and $d = 50$ mm, calculate the magnetic flux density of the magnetic field.

Recall: $B = \frac{V}{vd}$

Substituting given values

$$B = \frac{(3500)V}{(2.8\times10^{7})ms^{-1} \times (50\times10^{-3})m}$$

$$= \frac{3500V}{1.4\times10^{6} m^{2}s^{-1}}$$

$$= 2.5\times10^{-3}\ Vm^{-2}s$$

[2 marks]

(iv) The magnetic flux density is now doubled. The distance between the plates is then adjusted so that no deflection occurs. Calculate the new distance.

$B = \frac{V}{vd}$ holds and is valid for when there is no deflection

$\therefore$ If B is doubled,

$2B = \frac{V}{vd_2}$ where d_2 is new distance

$$d_2 = \frac{V}{2vB}$$

$$= \frac{3500V}{(2)(2.8\times10^{7})ms^{-1}(2.5\times10^{-3})Vm^{-2}s}$$

[2 marks]

$d_2 = 2.5\times10^{-2}m$

Total 15 marks

CAPE PHYSICS 2011
Paper 02 - UNIT 2 EXEMPLARS

MODULE 1

Question 1

Although this candidate showed a very good understanding of the material necessary to answer this question, the response could have been improved in the following areas:

- In part (a)(i), the candidate should have provided a more complete definition of the magnetic flux density by including that the field and current must be perpendicular.

- In part (b), the 'catapult' could have been drawn more accurately. The field lines from N -> S between the magnets below the wire should have been more concentrated and have a more pronounced 'dip'.

- In part (c), had the candidate recalled the relationship $B \propto \frac{1}{d}$, and recognised that if B is doubled then d has to be halved, the solution could have been more succinctly presented in one or two lines.

2. (a) (i) What does the term 'bistable' mean when used in reference to an electronic circuit?

A bistable is a device which can exist in one of two stable states dependent on the ~~op~~ input voltages of the circuit

[1 mark]

(ii) Figure 2 (a) shows a quad NOR circuit board with l.e.d.'s to show the output of each gate. It is connected to a 6 V battery.

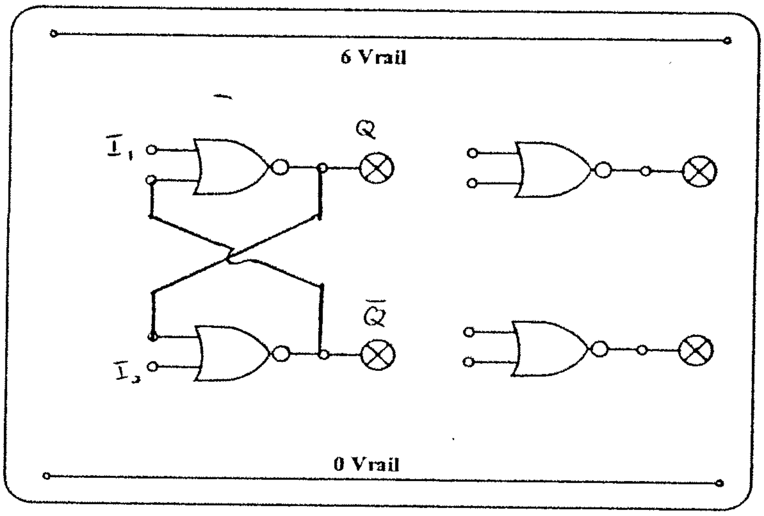


Figure 2 (a)

Draw connecting wires on the diagram to show the construction of an S-R flip-flop with clearly marked inputs I_1 and I_2 and outputs Q and $\overline{Q}$.

A friend asks you to demonstrate how this circuit acts as an electronic latch, perhaps as part of a burglar alarm. Complete the sequential truth table on the right and use it to assist you in describing the connections you would need to make to show this feature to your friend.

	sequence of inputs		outputs	
Row No.	I_1	I_2	Q	$\overline{Q}$
1	0	1	1	0
2	0	0	1	0
3	1	0	0	1
4	0	0	0	1
5	1	0	0	1
6	0	0	0	1

An ~~alarm~~ buzzer can be connected to $\overline{Q}$ along with the led. In Row No 1 $I_1 = 0$, $I_2 = 1$ the alarm is set. Row No 2 $I_1 = I_2 = 0$ the output remains the same and the circuit is latched. If a high ~~lo~~ logic level is sent by a burglar opening a window $I_1 = 1$, $I_2 = 0$, $\overline{Q} = 1$ the ~~alarm is~~ buzzer and led are triggered (Row No 3) hence acting as a burgler alarm

[5 marks]

GO ON TO THE NEXT PAGE

(b) Figure 2 (b) shows two wave forms A and B as inputs to a logic circuit. The resulting output waveform, D, is shown.

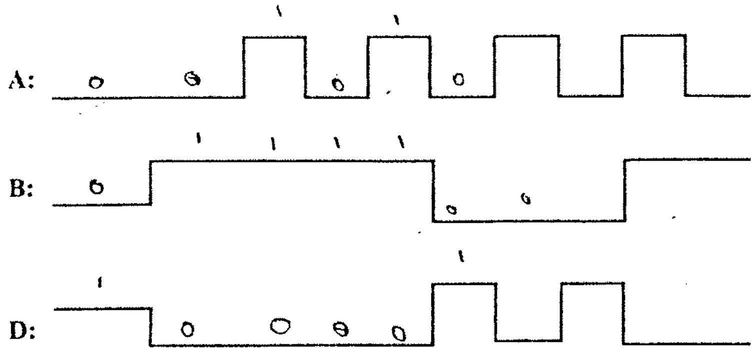


Figure 2 (b)

Draw the truth table for the circuit and hence state the equivalent logic gate for the circuit.

Truth table:

A	B	D
1	1	0
1	0	0
0	1	0
0	0	1

Equivalent logic gate:

NOR GATE

[4 marks]

(c) A 1 kHz square wave of amplitude 5 V is input into one input of an XOR gate while the other input is grounded. An oscilloscope is used to view the output waveform.

(i) What is the frequency of the XOR output?

1 KHz

[1 mark]

(ii) If the same frequency is input but the other input to the XOR is tied to 5 V, what is the frequency of the output?

1 KHz
~~0Hz~~ ~~the XOR~~ ~~will have a constant 0V output~~

[1 mark]

(iii) The same square wave is applied to one input of logic gate P while the other input is grounded (See Figure 2 (c) below). The output waveform is a flat line at 0 V. State the name of logic gate P and use a truth table to explain your answer.

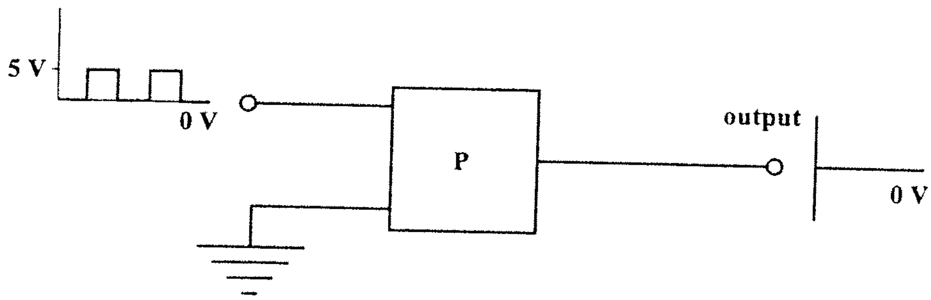


Figure 2 (c)

the logic gate, P is an AND gate

truth table for AND

A	B	C
1	1	1
0	1	0
1	0	0
0	0	0

the table shows that as long as an input is zero the output is zero ~~the~~ in figure 2(c) this is caused by the grounded input. thus explaining the output waveform at 0V.

[3 marks]

Total 15 marks

CAPE PHYSICS 2011

Paper 02 - UNIT 2 EXEMPLARS

MODULE 2

Question 2

Overall, this candidate provided a good response, however, no marks were awarded for part (a) , since the candidate failed to define the term 'bistable' as a circuit having two different stable outputs for one particular input state.

In part (a) (ii), the candidate correctly connected two of the four NOR-gates although $I_1$and I_2 inputs could have been drawn to indicate connections to the 6 V and 0 V rails as well.

The sequential truth table was correctly drawn but the description of the burglar alarm features could have been expanded to describe what would happen if the burglar tried to close the window after the alarm was turned on. This should have been related to the table and the fact that I_2 needed to be changed to reset the alarm and that changes to I_1would not affect the alarm (rows 3, 4, 5, 6) so the alarm remains ON.

Part (b) was correctly done.

For parts (c)(i) and (ii), the candidate correctly stated the frequencies as 1 KHz regardless of which input the 1 KHz square wave was applied to. Part (c)(iii) was clearly explained and the candidate correctly identified the logic gate P as an AND gate.

6. (a) (i) Explain what is meant by 'nuclear fission'.

(ii) Sketch a graph to show how the binding energy per nucleon varies with the mass number of the nucleus. Show on the graph the approximate positions of carbon-12 and uranium-235.

(iii) Use your graph to explain why energy is released when a heavy nucleus undergoes fission.

[6 marks]

(b) The fission of 1 kg of uranium-235 releases as much thermal energy as 50 000 kg of oil. 30 MJ of energy is released when 1 kg of oil is burned.

Calculate the mass of fuel used per day, in EACH case, in a 1 000 MW power station which is only 25% efficient and which uses

(i) oil

(ii) uranium. **[8 marks]**

(c) Hence comment on the sustainability of using oil as an energy source for the next century.

[1 mark]

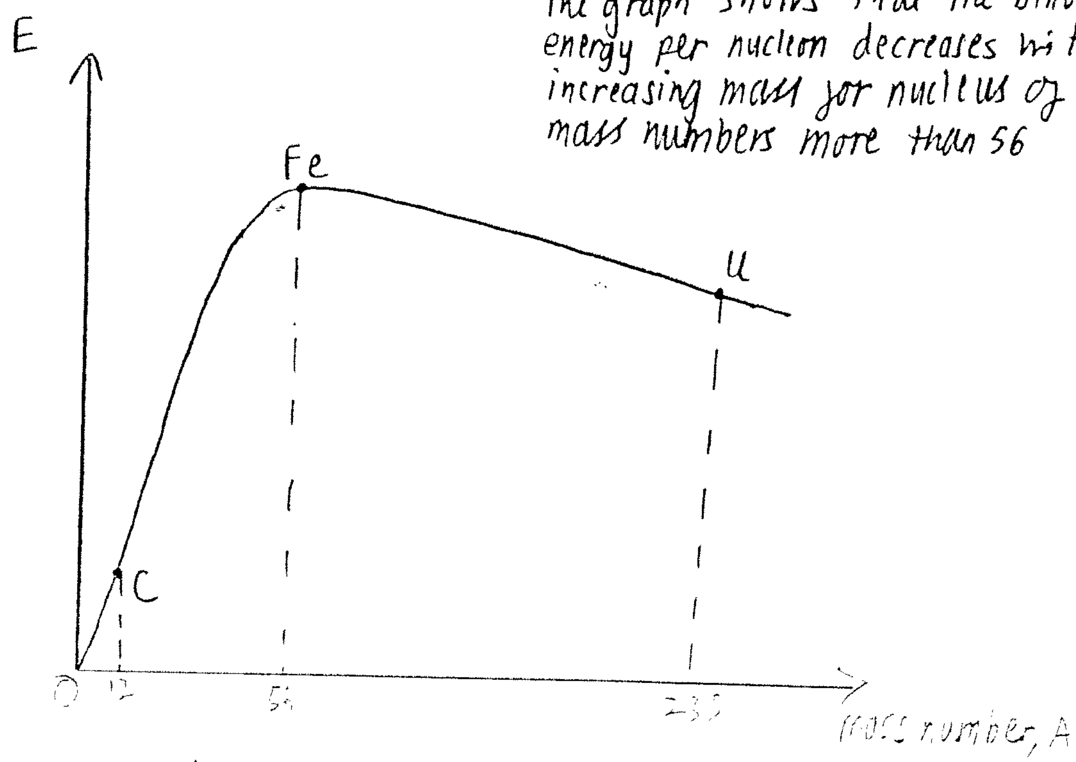
Total 15 marks

You MUST write the answer to Question 6 here.

6. (a) Nuclear fission is the splitting of a heavy nucleus into 2 smaller nuclei of approximately the same mass with the release of binding energy.

The graph shows that the binding energy per nucleon decreases with increasing mass for nucleus of mass numbers more than 56.

(a)(ii)



E - binding energy per nucleon

C - Carbon 12

U - Uranium 235

Fe - Iron 56

(a) (iii) When a heavy nucleus (mass # greater than 56) undergoes fission the smaller nuclei obtained has higher binding ~~energy~~ energies per nucleon and is more stable. (from graph)

The heavy nucleus must give up some of its energy to increase its binding energy per nucleon.
∴ Energy is release when a heavy nucleus undergoes fission

(b) (i) let the power needed by the station be P

$\frac{25}{100} \times P = 1000\,MW$.

$\Rightarrow P = 4000\,MW = 4 \times 10^9\,W$

- 1kg of oil produces $30\,MJ = 3 \times 10^7\,J$
- Energy need in one day $= P \times t = (4 \times 10^9) \times (24 \times 3600)$

$E_d = 3{,}456 \times 10^{14}\,J$

Mass of oil needed to power station $= \frac{E_d}{3 \times 10^7} = \frac{3.456 \times 10^{14}}{3 \times 10^7}$

$= 1.152 \times 10^7\,kg$.

$\Rightarrow$ The power station needs about 1.2×10^7 kg of oil each day

(ii) 1 kg of Ur produces : $(5 \times 10^4) \times (3 \times 10^7)$ J of energy

$E_{ur} = 15 \times 10^{11}\,J = 1.5 \times 10^{12}\,J$

Mass of Ur needed to power the station for one day $= \frac{E_d}{E_{ur}}$.

$m = \frac{3.456 \times 10^{14}}{1.5 \times 10^{12}} = 230.4\,kg$

$\Rightarrow$ 230.4 kg of Uranium will be needed per day to power the stat

(c)

- The demand for oil is to high to provide energy for a very long time and is not very sustainable. 1.2×10^7 kg of oil is need to provide the energy that 230.4 kg of Uranium can produce. The large amount of oil needed to produce energy means that this resource will be depleted and not act as a sustainable energy provider.

END OF TEST

CAPE PHYSICS 2011
Paper 02 - UNIT 2 EXEMPLARS

MODULE 3

Question 6

While the description of 'nuclear fission' in part (a) (i) is clear, the candidate incorrectly stated that during this process 'binding energy' is released rather than 'energy'.

Overall, the candidate provided a good sketch of the graph is good. However, one small error was that the point representing carbon – 12 was positioned too low on the curve.

Although the candidate provided a comprehensive explanation to part (a) (iii), the response could have been improved if the candidate had specifically stated that during the fission of a heavy nucleus, less mass energy is released. Additionally, had the candidate included the equation $E = \Delta m\, c^2$ in the explanation, this would also have strengthened the response.

The calculations in part (b) were well laid out and used the correct substitutions, hence the candidate, was awarded maximum marks for this portion of the question.

In part (c), the candidate correctly used the values from the calculations in justifying why it was not sustainable to use such a large amount of oil on a daily basis.