

KIP

2002
Higher School Certificate
Trial Examination

Physics

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Board approved calculators may be used
- Write using black or blue pen
- Draw diagrams using pencil
- A Data Sheet, Formulae Sheets and Periodic Table are provided at the back of this paper
- Write your student number and/or name at the top of every page

Total marks - 100

Section I (Pages 2 – 16)

Total marks (75)

This section has two parts, Part A and Part B

Part A

Total marks (15)

Attempt questions 1-15

Allow about 30 minutes for this part

Part B

Total marks (60)

Attempt questions 16-33

Allow about 1 hour 45 minutes for this part

Section II (Pages 17 – 24)

Total marks (25)

Attempt ONE question from Questions 34-38

Allow about 45 minutes for this section

This paper MUST NOT be removed from the examination room

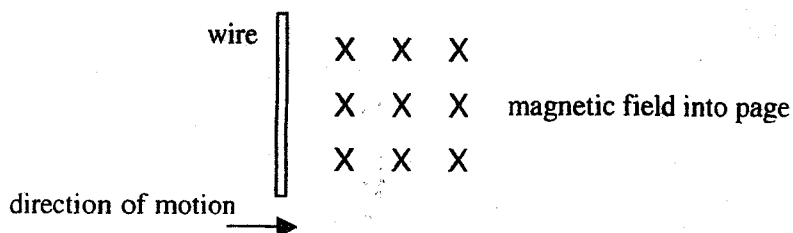
STUDENT NUMBER/NAME:

Section I**Total marks (75)****Part A****Total marks (15)****Attempt questions 1 – 15****Allow about 30 minutes for this part**

Select the alternative A, B, C or D that best answers the question and indicate your choice with a cross (X) in the appropriate space on the grid below.

	A	B	C	D
1				
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14				
15				

1. An 80 kg astronaut stands on a set of scales on a planet. The scales read 624 N. What is the acceleration due to gravity on this planet?
- (A) 8.2 ms^{-2}
(B) 7.8 ms^{-2}
(C) 7.1 ms^{-2}
(D) 7.0 ms^{-2}
2. On many overhead power lines the conducting cable is separated from the steel of the support tower by a ceramic material. The main reason for using a ceramic as the separating substance is:
- (A) to insulate the cable from the tower
(B) because ceramic is very hard
(C) ceramic material is easy to shape
(D) ceramic material is a good conductor and so makes electricity distribution cheaper
3. The invention of cathode ray tubes led to the discovery of:
- (A) electrons
(B) ions
(C) anions
(D) semiconductors
4. Why does the conductivity of silicon increase if it is doped with a Group III element?
- (A) the number of free electrons increases
(B) the number of positive holes increases
(C) the impurity decreases the energy band gap
(D) additional electrons are added to the crystal lattice structure
5. A wire is moved in a magnetic field as shown in the diagram below.



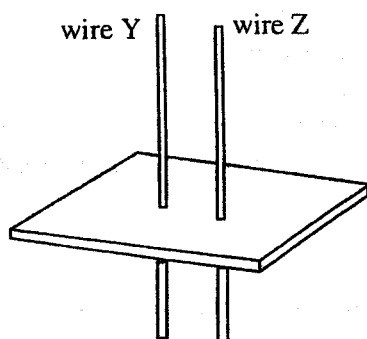
The direction of electron current flow in the wire would be:

- (A) into the page
(B) out of the page
(C) up the page
(D) down the page

6. A cricket ball is hit upwards at 125 ms^{-1} and 50° to the horizontal. What is its speed 3 seconds later?

- (A) 66.4 ms^{-1}
 (B) 80.4 ms^{-1}
 (C) 104.2 ms^{-1}
 (D) 125 ms^{-1}

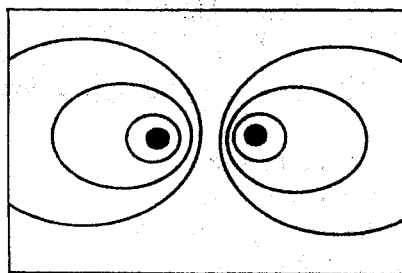
7. Two vertical parallel wires pass through a sheet of thick cardboard as shown.



Iron filings are sprinkled on the card.

When there is an electric current in each conductor, the iron filings form a pattern which indicate the illustrated magnetic field.

viewed from
above, wire Y
on left

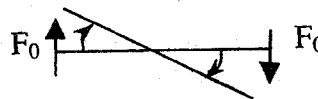
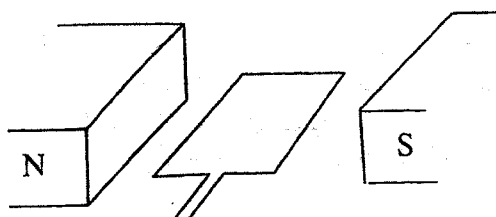


If wire Z is carrying current **downward**, then which of the following alternative statements is correct?

	Direction of current in wire Y	Direction of force between conductors
(A)	up	attraction
(B)	up	repulsion
(C)	down	repulsion
(D)	down	attraction

8. The Russian space station that was orbiting the Earth for many years eventually crashed into the Earth. This occurred mainly because of:
- (A) a reduction in its orbital velocity due to friction from the magnetosphere.
 - (B) a reduction in its orbital velocity due to friction from the atmosphere.
 - (C) an increase in its orbital velocity due to a stronger gravitational force.
 - (D) a reduction in its orbital velocity causing the gravitational force to decrease.
9. An electric field of strength E is produced between two charged plates. If the arrangement is changed so that the distance between the plates is one quarter of the original and the voltage between the plates is three times the original, what is the new electric field strength in terms of the old?
- (A) $12 E$
 - (B) $3 E$
 - (C) $0.125 E$
 - (D) $48 E$
10. Two light globes are able to be switched on simultaneously even though they are separated by a large distance. According to Einstein's theory about the relativity of simultaneity, which of the following statements is a correct description of what can happen when the lights are switched on?
- (A) all observers will see both globes light up at the same time
 - (B) one observer may see one of the globes contract and the other globe expand while another observer may see no change in the size of the globes
 - (C) no observers can see both globes light up at the same time
 - (D) one observer may see the two globes light up at the same time while another observer may see one globe light up after the other
11. Which one of the following statements is **NOT** true in regards to a hole in semiconductor theory?
- (A) holes act as a positive charge
 - (B) holes can be bound to an atomic nucleus
 - (C) holes are repelled by electrons
 - (D) holes have a drift velocity
12. A geostationary satellite that orbits the Earth in a direction from west to east in the equatorial plane will:
- (A) hover over one spot on the Earth's surface
 - (B) be orbiting in the opposite direction to the Earth's rotation
 - (C) continually move over different parts of the Earth's surface
 - (D) move over different parts of the Earth's surface but only those parts that lie on the equator

13. A rectangular coil is placed in the uniform magnetic field between two large magnets.



In the original position, a force F_0 acts on each side of the coil, producing a torque τ_0 which causes the coil to start rotating.

The coil rotates through an angle of 30° and is still within the uniform magnetic field.

The statement which correctly describes the new situation for force F and torque τ is:

- (A) $F < F_0$ and $\tau = \tau_0$
 - (B) $F < F_0$ and $\tau < \tau_0$
 - (C) $F = F_0$ and $\tau < \tau_0$
 - (D) $F < F_0$ and $\tau > \tau_0$
14. If the current in a metallic conductor was kept constant, then the drift velocity of electrons could be increased by:
- (A) increasing the length of the wire
 - (B) decreasing the length of the wire
 - (C) increasing the cross-sectional area of the wire
 - (D) decreasing the cross-sectional area of the wire
15. If you were supplied with a small unlabelled model of an AC electric motor and a similar small DC motor without being told which was which, the easiest way to distinguish them would be:
- (A) the AC motor would have commutator while the DC motor would not
 - (B) DC motors are double insulated while AC motors are not
 - (C) the DC motor would have slip rings while the AC motor would not
 - (D) the DC motor would have a commutator while the AC motor would not

Section I - continued

Part B**Total marks (60)****Attempt questions 16 – 26****Allow about 1 hour 45 minutes for this part**

Answer the questions in the spaces provided

Question 16 (8 marks)**Marks**

Science is based on experimental evidence. Theories will ultimately be supported by experimental results, or new theories that support the experimental data will replace them.

- (a) Galileo's analysis of projectile motion included one component of motion that had constant acceleration. Describe an investigation you carried out that showed that this one component did have constant acceleration..

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- (b) Michelson and Morley attempted to measure via experiment the relative velocity of the Earth with respect to the 'aether' (ether).

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- (i) Describe this experiment and its results.

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- (ii) Use Einstein's theory of relativity to explain the results of this experiment.

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Question 17 (7 marks)**Marks**

A simple electric motor can be used as a generator and a generator could be used as an electric motor. Both these machines essentially consist of a coil of wire able to turn in a magnetic field.

- (a) Who is credited with the discovery of the law that accounts for the situations outlined above?

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- (b) Describe with the aid of a diagram how EITHER of these situations could be demonstrated in the laboratory. Clearly state which situation you are describing.

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- (c) With reference to either the galvanometer or the loudspeaker, describe (using a suitable diagram) how the motor effect is used.

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Question 18 (4 marks)**Marks**

- (a) How could we distinguish between moving electrons and gamma rays?

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- (b) Calculate the energy of an X-ray that has a wavelength of 4×10^{-11} m.

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Question 19 (3 marks)

List THREE factors that cause the acceleration due to gravity on the surface of the Earth to vary.

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Question 20 (3 marks)

Outline how Einstein explained the effect of frequency on the photo current produced in the photoelectric effect.

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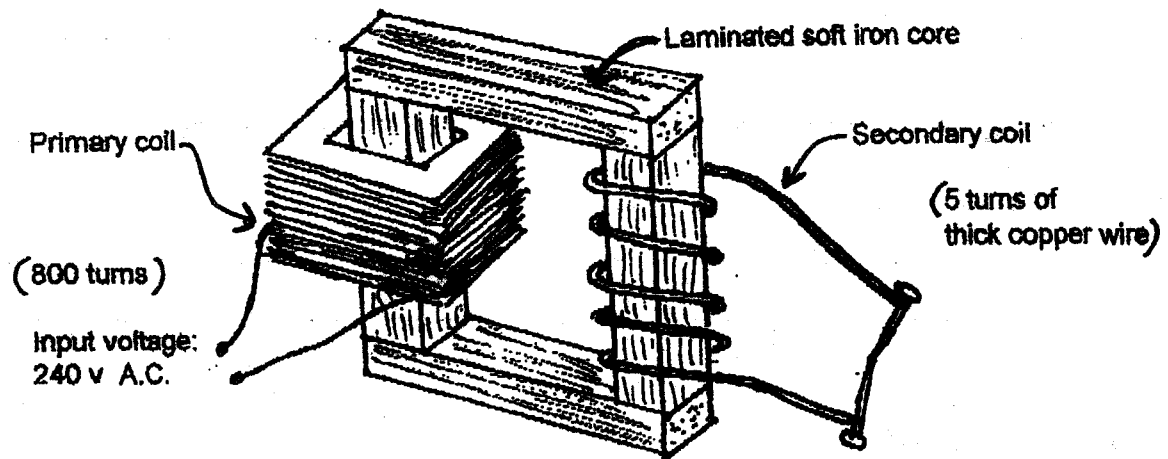
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Question 21 (6 marks)

A step-down transformer is constructed with 800 turns on the primary coil and connected to 240 V A.C. The secondary coil has 5 turns as shown:



- (a) Clearly showing your method, determine the output voltage.

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- (b) The above arrangement produces a small secondary voltage, but in spite of this, the secondary current can be so large it heats up the wiring so much that it can weld together two nails. Assuming the transformer is "ideal" (100% efficient), explain how such a small output voltage can produce such a large output current.

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- (c) Real transformers are always less than ideal, but the laminated core helps improve the operating efficiency.

Describe the structure of the laminated core and explain how it helps to reduce energy losses.

2

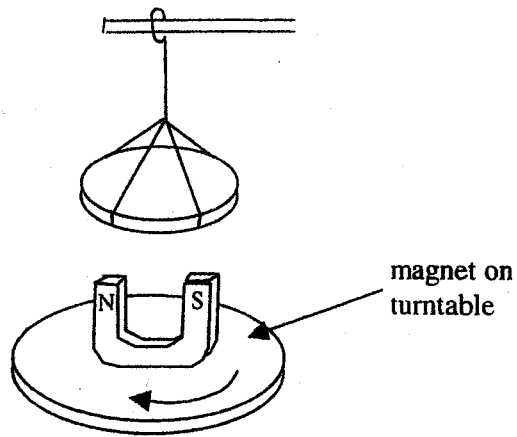
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Question 22 (3 marks)

A thick aluminium disc is suspended over a strong magnet. The magnet is mounted on a turntable, which rotates as shown.



- (a) Describe what happens to the aluminium disc when the turntable rotates.

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- (b) Use Lenz's law to explain this observation.

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STUDENT NUMBER/NAME:

Question 23 (6 marks)

Marks

Discuss differences between solid state and thermionic devices. In your answer include a discussion of why solid state devices replaced thermionic devices.

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Question 24 (4 marks)

Marks

(a) What are the van Allen belts?

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(b) Describe how sunspot activity can affect the van Allen belts.

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(c) Explain how these changes further affect communication with geostationary satellites.

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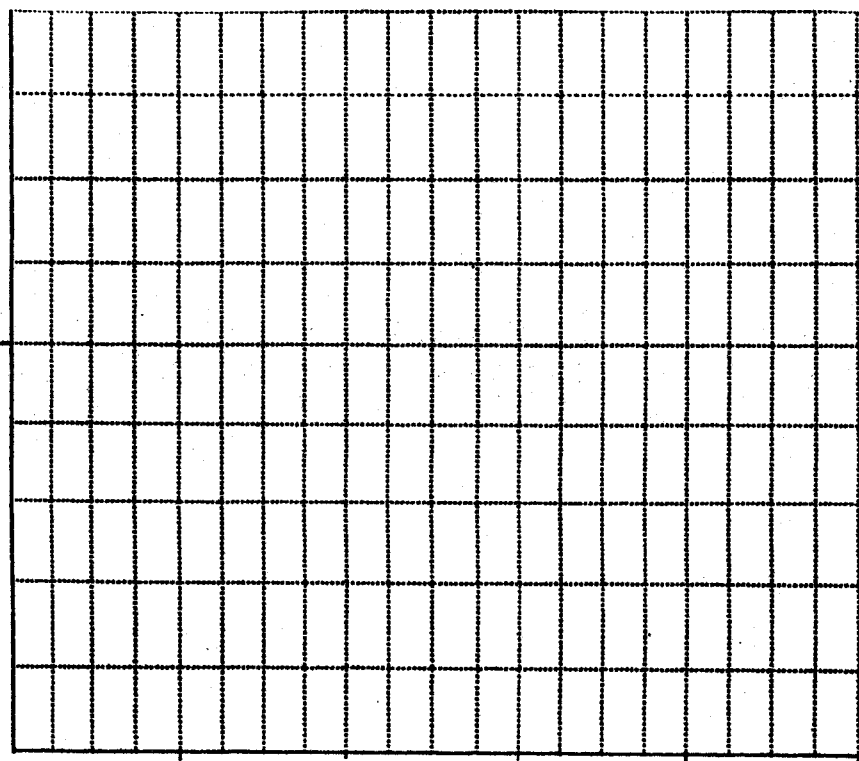
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Question 25 (4 marks)**Marks**

A student is investigating the effect of the SEPARATION of two long straight parallel wires on the FORCE between the conductors when they are carrying constant electric currents. The following results were obtained:

Separation of wires (mm)	Force per unit length (N m ⁻¹)
6.0	8.3×10^{-4}
8.0	6.2×10^{-4}
11.0	4.5×10^{-4}
14.0	3.1×10^{-4}
20.0	2.5×10^{-4}

- (a) Plot a graph of Force per unit length vs Separation of wires

3

- (b) Based on the shape of the graph you have drawn, describe the next step which the student should take in order to obtain the relationship between the variables.

1

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Question 26 (5 marks)**Marks**

The next big leap forward for humans in space travel may see extended space travel across distances outside the solar system.

Discuss the limitations and problems for such journeys on a human crew due to presently achievable speeds and present communication technologies.

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Question 27 (4 marks)

In your Physics course, you have performed a first hand investigation to demonstrate and identify the properties of cathode rays using discharge tubes.

(a) Explain how your results demonstrated that:

- (i) cathode rays travel in straight lines, and
- (ii) cathode rays transfer energy and do work.

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(b) Explain one safety precaution necessary when performing this investigation.

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Question 28 (3 marks)

Marks

Explain why a magnet is able to hover above a superconducting material that has reached the temperature at which it is superconducting.

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Section II**Total marks (25)****Attempt ONE question from Questions 29 – 33****Allow about 45 minutes for this part**

Answer the question in a separate writing booklet. Extra writing booklets are available.

Show all relevant working in questions involving calculations

		Pages
Question 29	Geophysics	18
Question 30	Medical Physics	19
Question 31	Astrophysics	20 - 21
Question 32	From Quanta to Quarks	22
Question 33	The Age of Silicon	23 - 24

Question 29 – Geophysics (25 marks)**Marks**

- (a) (i) Calculate the densities of the materials in the table below.

3

Rock /material	Dry mass (g)	Volume of water displaced (cm ³)
granite	45.1	17.0
basalt	36.4	13.0
iron	28.5	3.60

- (ii) The average density of the Earth has been calculated at 5.52 g cm
- ⁻³
- . How does the above table support the idea that the Earth has a core of iron?

1

- (iii) Using a diagram that shows the inner layers of the Earth, explain the seismic evidence for the nature of the core.

2

- (iv) A satellite of mass 500 kg orbits 400 km above the Earth and has a period of 92.7 minutes. Calculate the mass of the Earth given that its radius is
- 6.38×10^6
- m.

2

- (v) How does a seismograph from a nuclear explosion vary from that of an earthquake?

1

- (b) (i) Outline an investigation you conducted using a model to understand the Earth's magnetic field.

2

- (ii) How did this model demonstrate how the inclination of the Earth's magnetic field varies with latitude?

1

- (iii) Summarise the geophysical evidence gained from the study of the Earth's magnetic field inclination that supports the theory of plate tectonics.

3

- (c) Discuss the uses of seismic reflection and refraction in the search for oil and gas.

4

- (d) Draw a cross-section showing the nature of heat flow and seismicity at the edge of a subducting crustal plate.

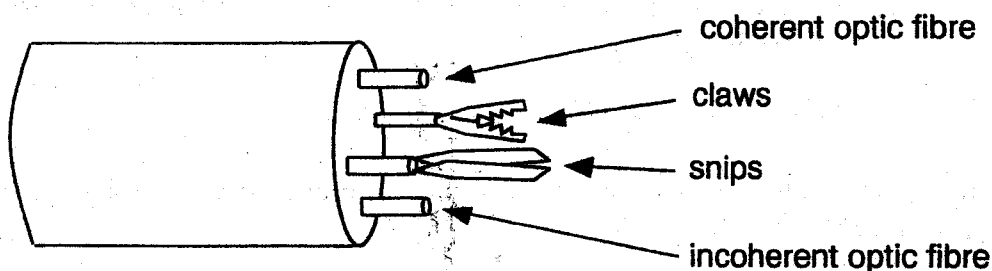
3

- (e) Outline the structure and function of a gravity meter.

3

Question 30 – Medical Physics (25 marks)**Marks**

- (a) (i) Explain what is meant by ultrasound. 1
- (ii) Describe how ultrasound is produced in a transducer. 2
- (b) (i) Describe what is meant by *acoustic impedance*. 1
- (ii) The acoustic impedance of blood is 1.61×10^6 rayls. If the speed of sound through blood 1550 ms^{-1} , determine the density of blood. 3
- (c) The following diagram shows a close up view of the end of an endoscope. Justify the inclusion of each of the labelled parts on the endoscope for medical examination. 4



- (d) A researcher wishes to use two techniques to exam the bones of a certain patient; conventional X-ray and isotopic bone scan. Compare the imaging radiation used and the usefulness of the final image from these two techniques. 6
- (e) Assess the impact of the use of new imaging techniques such as MRI and PET has had on society. 8

End of Question 30

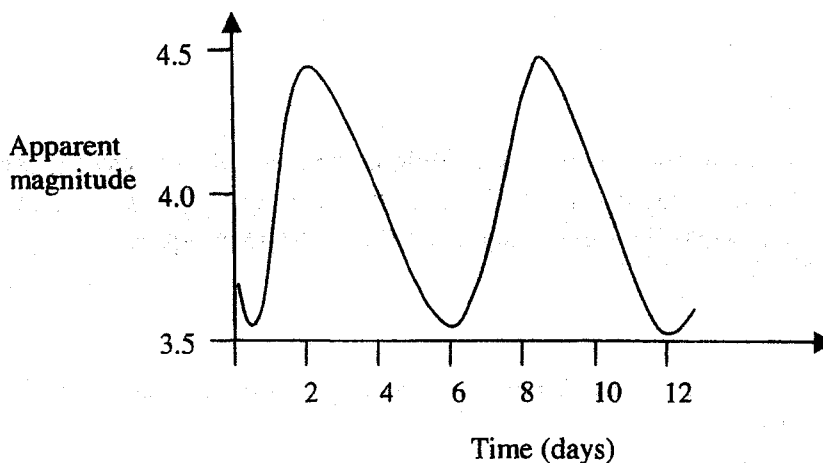
Question 31 – Astrophysics (25 marks)**Marks**

- (a) (i) Describe the difference between intrinsic and extrinsic variables. 1
- (ii) Alpha Centauri is a binary system of 2 similar stars. If the orbital period is 80 years and the average separation is 3.6×10^9 km, calculate the approximate mass of each star. 2
- (b) (i) Explain why some parts of the electromagnetic spectrum emitted by objects in space can only be detected well away from the Earth. 1
- (ii) The table shows information about several stars. 3

Star	Apparent magnitude	Absolute magnitude	Parallax
Procyon	Not given	2.8	3.27
Castor	1.58	1.4	0.05

How much brighter does Procyon appear than Castor? Explain why the absolute magnitudes of Castor and Procyon are not a valid basis for a comparison of their observed brightness.

- (c) The diagram below shows how the apparent magnitude varies with time for a Cepheid variable star.



Explain how the information contained within this diagram, along with other data relevant to Cepheid variables, can provide highly useful information to astrophysicists. 4

Question 31 – Astrophysics continues on next page

Question 31 – Astrophysics (continued)

Marks

- (d) Astronomers currently accept that stars evolve from protostars, develop through various stages and eventually "die".

Outline the key stages in a star's life cycle and justify the sequence of these stages using as evidence a typical Hertzsprung-Russell diagram for a large collection of stars such as those in our neighbourhood of space.

6

- (e) The comparison and interpretation of spectra has been very important in developing our understanding of stars and other objects in our universe.

Account for the production of emission and absorption spectra and describe how they can be used to provide a wealth of information about objects in space which are the sources of these spectra.

8

End of Question 31

Question 32 – From Quanta to Quarks (25 marks)**Marks**

- (a) (i) Calculate the speed of an electron which has a wavelength of 5×10^{-10} m. 1
- (ii) Outline the application of wave characteristics of electrons in the electron microscope. 2
- (b) (i) Describe the two groups of particles in the standard model of matter. 1
- (ii) Account for the existence of a number of lines in the hydrogen spectrum even though the hydrogen atom has only one electron. 3
- (c) In a nuclear fission reactor, it is important to maintain a balance between the production of neutrons by fission and the loss of neutrons. Justify the importance of maintaining this balance and explain how this is done. 4
- (d) Discuss the limitations of the Bohr model of the hydrogen atom in terms of its development and its inability to completely explain all experimental results. 6
- (e) Nucleons experience both attractive and repulsive forces. Explain in terms of the forces within the nucleus how it is possible for a limited number of combinations of protons and neutrons to form stable nuclei. 8

End of Question 32

Question 33 – The Age of Silicon (25 marks)**Marks**

- (a) (i) Describe the transfer characteristics of a linear amplifier in an electrical circuit. **1**
- (ii) Draw a labelled diagram to show the circuit symbol for an operational amplifier and explain how its gain can be controlled. **2**
- (b) (i) Describe the operation of a logic gate. **1**
- (ii) A house is designed to reduce the energy bills by use of a logic circuit controlling the opening and closing of the curtains depending on whether the temperature T outside is above or below 23° Celsius and whether it is daylight or dark. **3**

The truth table below uses variables:

Input variables: L = 1 represents “yes”, it is daylight

L = 0 represents “no”, it is night

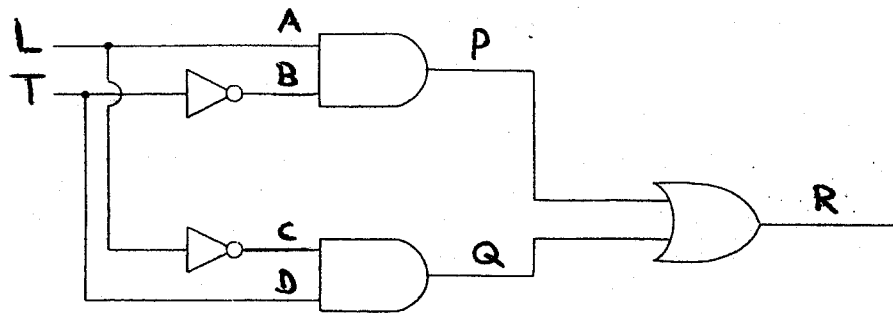
T = 1 represents “yes”, temperature above 23° Celsius

T = 0 represents “no”, temperature equal to or below 23°C

Output variable: R = 1 represents “yes”, open curtains

R = 0 represents “no”, close curtains

Copy and complete the truth table for the logic circuit shown.



L	T	A	B	C	D	P	Q	R
1	1							
0	1							
1	0							
0	0							

Question 33 – Age of Silicon continued on next page

Question 33 – The Age of Silicon (continued)

Marks

- (c) Compare the methods by which analogue and digital systems process information, giving examples of a range of devices using each type of system. **4**
- (d) Compare early computers with those available today, describing the developments in technology responsible. **6**
- (e) Explain why a thermistor is an input transducer and explain the function of thermistors in two devices currently used in the home or industry. Include a circuit diagram for one of the devices. **8**

End of Question 33