Student Number ________

A-MC /20	B-HUG /23	B-VOU /7	B-WARD /20	B-NOY /20	C-VOU ASTRO /10	C-VOU QUANTA /10	Total /100

Student Name [ ]

Sydney Technical High School

2012

TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION

Physics

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black or blue pen
- Draw diagrams using pencil
- Approved calculators may be used
- Write your student number in the space provided

Total marks – 100

Section I Pages 2 - 28

90 marks
This section has two parts, Part A and Part B

Part A – 20 marks
- Attempt Questions 1-20
- Allow about 35 minutes for this part

Part B –70 marks
- Attempt Questions 21-37
- Allow about 1 hour and 55 minutes for this part

Section II Pages 31 - 32

10 marks
- Attempt **ONE** Question from Questions 38-39
- Allow about 30 minutes for this section

Student Number ________

Section I
90 marks

Part A – 20 marks
Attempt Questions 1-20
Allow about 35 minutes for this part

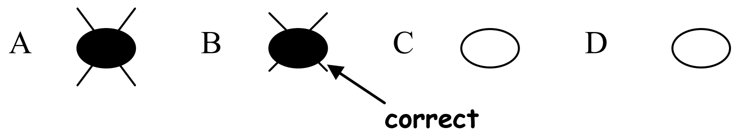
Use the multiple-choice answer sheet.

Select the alternative A,B,C or D that best answers the question. Fill in the response oval completely.

Sample: 2 + 4 = (A) 2 (B) 6 (C) 8 (D) 9

If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

If you change your mind and have crossed out what you consider to be the correct answer, then indicate the correct answer by writing the word **correct** and drawing an arrow as follows.



Student Number ________

Multiple Choice Answer Sheet

1.	A ○	B ○	C ○	D ○
2.	A ○	B ○	C ○	D ○
3.	A ○	B ○	C ○	D ○
4.	A ○	B ○	C ○	D ○
5.	A ○	B ○	C ○	D ○
6.	A ○	B ○	C ○	D ○
7.	A ○	B ○	C ○	D ○
8.	A ○	B ○	C ○	D ○
9.	A ○	B ○	C ○	D ○
10.	A ○	B ○	C ○	D ○
11.	A ○	B ○	C ○	D ○
12.	A ○	B ○	C ○	D ○
13.	A ○	B ○	C ○	D ○
14.	A ○	B ○	C ○	D ○
15	A ○	B ○	C ○	D ○
16.	A ○	B ○	C ○	D ○
17.	A ○	B ○	C ○	D ○
18.	A ○	B ○	C ○	D ○
19.	A ○	B ○	C ○	D ○
20.	A ○	B ○	C ○	D ○

1. A satellite in circular orbit around Earth has a period of 90 minutes. The satellite is then joined by a space craft having the same mass.

After the space craft docks with the satellite, the period of the orbit will be:

(A) 45 minutes

(B) 90 minutes

(C) 180 minutes

(D) 360 minutes

2. Two projectiles X and Y rise to the same height but Y has the greater range. Which of the following is identical for both X and Y?

(A) initial horizontal velocity

(B) initial vertical velocity

(C) initial speed

(D) firing angle

3. In a parallel universe where the universal gravitational constant G was greater than in our own universe, the effect on satellites, assuming that they exist in the same orbits, would be that they:

(A) have faster orbital speeds.

(B) have greater mass.

(C) have slower orbital speeds.

(D) have less mass.

4. Three astronauts of masses 50 kg, 60 kg and 70 kg are in the same rocket launched vertically from Earth.

What is the ratio of "g" forces acting on the astronauts?

(A) 5:6:7

(B) 1:1:1

(C) (5g+1) : (6g+1) : (7g+1)

(D) cannot be calculated unless launch acceleration is known.

5. A satellite with an orbital radius **r** around Earth fires its engines to change its orbit. Once in the new orbit the satellite would therefore have:

(A) increased its altitude and speed.

(B) decreased its altitude and speed.

(C) increased its speed and decreased in altitude.

(D) increased its altitude and increased in speed.

6. Which statement best summarises a basic principle of Einstein's theory of Special Relativity?

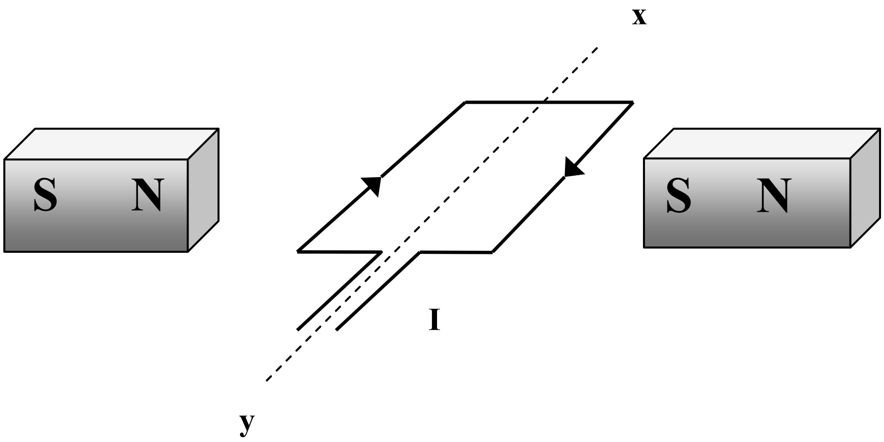
(A) the laws of physics are not always the same for all observers in uniform motion.

(B) simultaneous events in one frame of reference may not occur at the same time when viewed from another frame.

(C) there are two types of frames of reference, inertial and non-inertial.

(D) the speed of light is constant regardless of the medium through which it is travelling.

7. A rectangular loop of wire as shown has a current **I** flowing through it. The loop extends past the magnets in the direction **x**.



The torque on this loop could be increased the most by:

(A) extending the length of the loop in the direction x-y as shown.

(B) extending the width of the loop towards the magnets.

(C) decreasing the thickness of the wire in the loop.

(D) reversing the direction of the current in the loop.

8. The production of electricity in large electric generators is predominately AC.

This is because large AC electricity is:

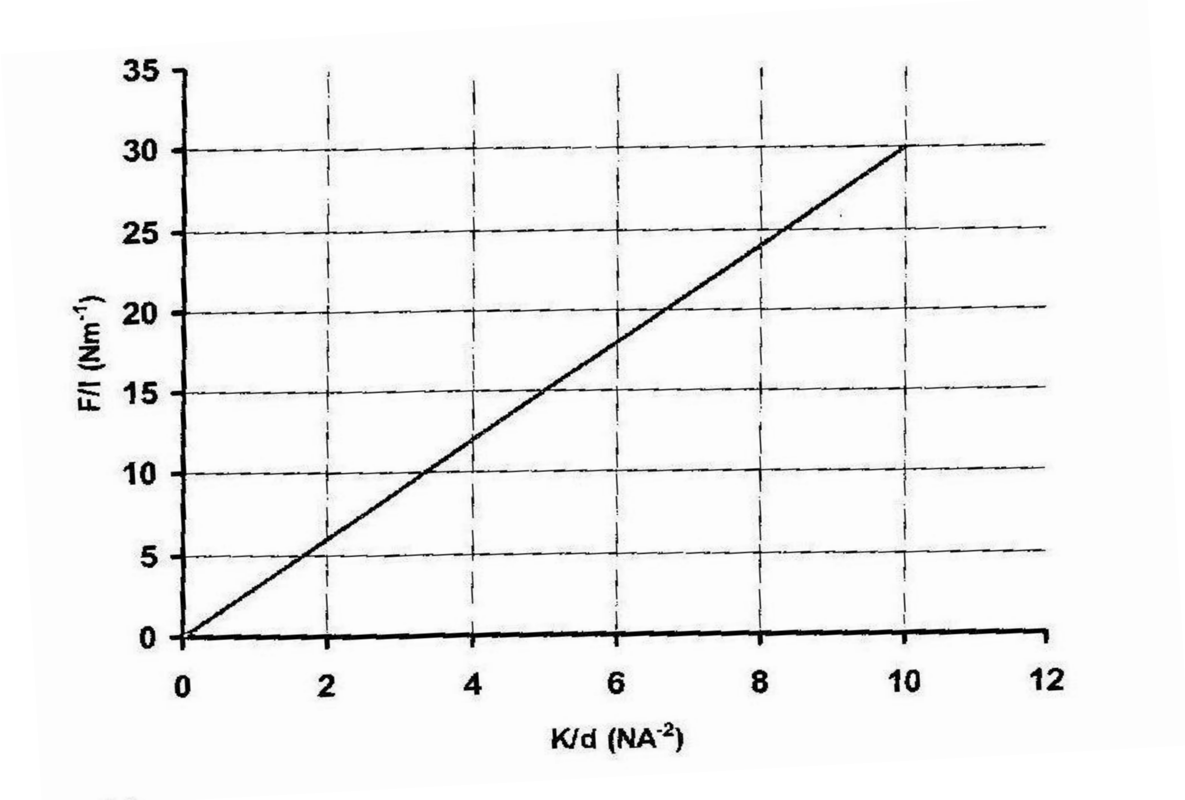
(A) more efficient than DC.

(B) less dangerous than DC.

(C) more easily adapted to particular uses than DC.

(D) transmitted faster than DC.

9. The graph shows the relationship between the force per unit length acting on two parallel current-carrying conductors and **K/d**, where **d** is the distance between the wires and **K** is the magnetic force constant.



If the current in one of the conductors is 1.5 A, what is the current in the other conductor ?

(A) 1.0 A
(B) 1.5 A
(C) 1.7 A
(D) 2.0 A

10. An AC motor is compared to a DC motor. Both motors are operating without a load on them. When the supply voltage is increased, the effect on the motors will be:

	Effect on AC motor	Effect on DC motor
(A)	no effect	no effect
(B)	speeds up	no effect
(C)	no effect	speeds up
(D)	speeds up	speeds up

11. The laminated core of a transformer is arranged so that:

(A) eddy currents are prevented from forming.

(B) eddy currents are minimised.

(C) eddy currents are changed to assist the production of the secondary current.

(D) no magnetic field is lost to the surrounding area.

12. Which statement best describes a reliable investigation?

(A) The method allows for a fair test.

(B) The method allows the results to be repeatable.

(C) The method allows for the results to be accurate.

(D) The hypothesis will be supported.

13. The concept of a "fair test" when applied to the Scientific Method is best reflected by having:

(A) a hypothesis which is supported by the results of the investigation.

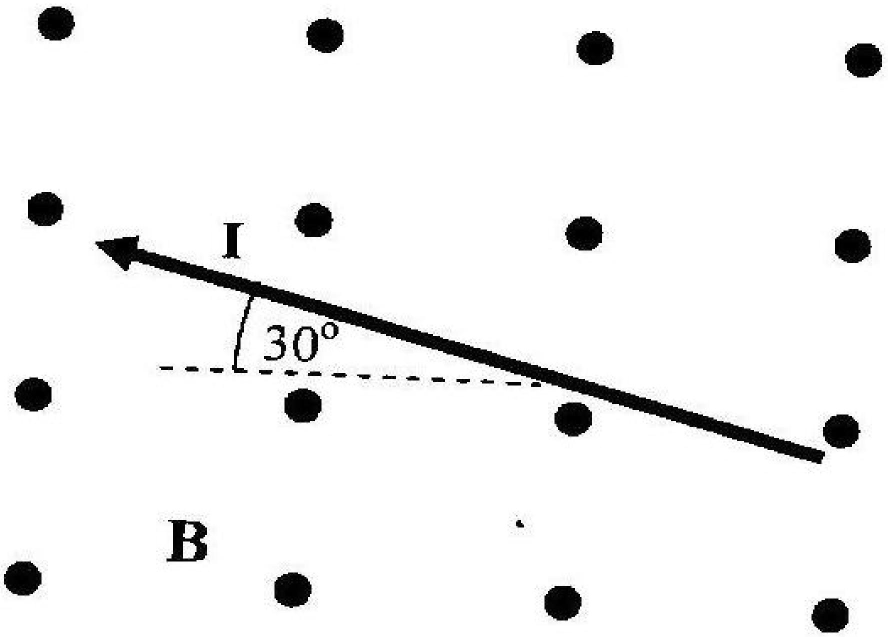
(B) only one variable being changed in the investigation.

(C) a conclusion which addresses the aim of the investigation.

(D) a method which is clearly stated in point form.

Student Number ________

14. The diagram shows a current-carrying conductor in the magnetic field, directed out of the page.



What is the direction of the force on the conductor?

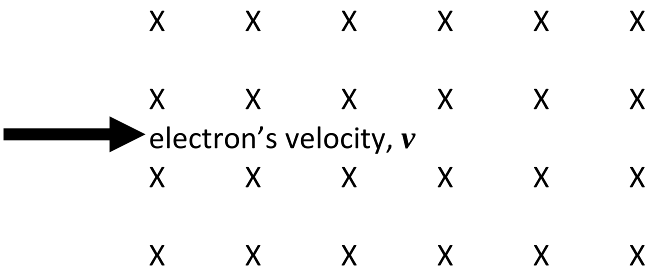
(A) 

(B) 

(C) 

(D) 

15. An electron moving at a speed ***v*** enters a uniform magnetic field perpendicular to the field, as shown. Its path while in the magnetic field is circular with a radius of 30.0 cm.



A research student then sets up two parallel charged plates separated by a distance **d**, with a voltage of **V** between them. Where the charged plates overlap with the magnetic field, the electron's path changes from circular to straight.

What is the relationship between the values of the electric field between the parallel plates **E**, the magnetic field **B**, and the speed of the electron, ***v***?

(A) $v = \frac{E}{B}$

(B) $v = BE$

(C) $B = vE$

(D) $v^2 B = E$

16. If the value of Planck's constant, *h*, was higher than it is, the effect on a photo-electric effect experiment would be:

(A) the threshold frequency, f_o would be lower for all metals.

(B) the energy of incident photons would be less.

(C) the threshold frequency would be greater for all metals.

(D) the photoelectric current would be greater.

17. X-rays, unlike light waves, are useful for investigating crystal structure because

(A) they are more powerful, so they can break apart the lattice, allowing the pieces to be studied.

(B) they have wavelength similar to the lattice spacing, so they interact with it.

(C) they have more energy per photon, so can penetrate deeper into the material than light waves.

(D) their high frequency causes the lattice to vibrate – the vibrations give information about the lattice structure.

18. Which of the following statements are correct according to the particle theory of light?

(A) All photons carry the same amount of energy.

(B) The amount of energy carried by a photon is proportional to its wavelength.

(C) The amount of energy carried by a photon is independent of its colour.

(D) Blue photons carry more energy than green ones.

19. What was the aim of the experiments done by Hertz, using a spark oscillating across a high voltage gap?

(A) To measure the frequency of light waves.

(B) To produce radio waves.

(C) To provide evidence for Planck's hypothesis.

(D) To produce electromagnetic waves with frequencies different from light

20. Electromagnetic braking is used in very fast trains as it has certain advantages over conventional braking systems. It would be true to say that electromagnetic braking:

(A) operates over the entire range of speeds just as well as conventional braking
(B) converts kinetic energy to heat energy faster than conventional brakes at all speeds.
(C) converts just as much kinetic energy to other forms of energy as conventional braking would do.
(D) has more parts to wear out than conventional braking systems.

Student Number ________

HUGHES /23

Part B – 70 marks
Attempt Questions 21-37
Allow about 1 hour and 55 minutes for this part.

Answer the questions in the spaces provided.
Show all relevant working in questions involving calculations.

Marks

Question 21 (3 marks)

An investigation was performed in which the period, **T**, of a pendulum was measured as the length, ***l***, was varied.

The student was told that, for a pendulum, $T = 2\pi\sqrt{\frac{l}{g}}$ where g is the value of gravitational acceleration.

The results are shown in the table below.

l *(m)*	**T** 1st trial (s)	**T** 2nd trial (s)	**T** 3rd trial (s)	**T** average (s)	**T²** (s²)
0.18	0.70	0.76	0.76	0.73	0.53
0.23	0.88	0.83	0.84	0.85	0.72
0.29	1.03	1.04	0.90	0.99	0.98
0.41	1.25	1.15	1.20	1.20	1.44
0.49	1.35	1.31	1.24	1.30	1.69

(a) Suggest ***one*** way in which the period, **T**, of the pendulum could have been measured to this degree of precision. **1**

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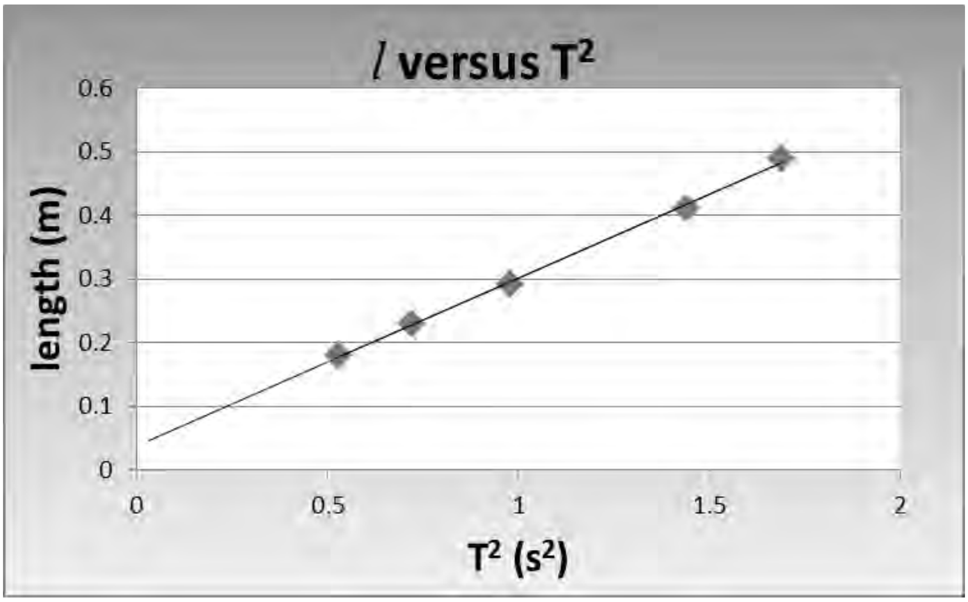
Question 21 continues on page 12.

Question 21 (continued) **Marks**

(b) The student undertaking the investigation then plotted the length, ***l***, against the period squared, $\mathbf{T^2}$, using the data from the table. The graph is shown below with a line of best fit drawn.



The line of best fit does not meet the origin of the axes.

Suggest why this might be so. **2**

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Student Number ________

Question 22 (4 marks) **Marks**

There are several reasons why the value of gravitational acceleration varies at different places on the Earth's surface.

(a) If the rotation of the Earth increased so that the length of a day became shorter, outline the effect on the value of g at a place near the equator and at the south pole. **2**

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(b) Describe how the orbit of geostationary satellites would need to change if the Earth rotated faster. **2**

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Question 23 (3 marks)

Statements made by two students are shown below:

Jo; *The Michelson-Morley experiment was reliable and valid when it was done.*
Con: *Well, it may have been reliable, but it was invalid as it failed its aim*

(a) Justify Jo's statement.

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(b) Outline how Einstein accounted for the results of the Michelson-Morley experiment.

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Marks

Question 24 (4 marks)

A large rock is dropped from a plane flying horizontally at an altitude of 4.00×10^3 m and with a speed of 900 km h^{-1}.

(a) Calculate the distance that the rock will move horizontally before hitting the ground. **2**

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(b) Find the velocity of the rock just before it hits the ground. **2**

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Question 25 (2 marks)

A 20 year old student remains on Earth while his friend aged 40 sets off on a return trip into space at relativistic speed. At journeys end both are aged 45.

Calculate the speed of the spacecraft. **2**

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Question 26 (4 marks) **Marks**

When it operated, the Space Shuttle was able to attain a low-Earth orbit at an altitude of several hundred kilometres. However, it was not considered as "escaped" from Earth's gravitational field.

Describe the conditions necessary for a spacecraft to escape Earth's gravitational field in terms of the energy required using appropriate equations and symbols. **4**

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Question 27 (3 marks)

(a) Mars has a mass of 6.6 x 10^{23} kg and a radius of 3400 km. Calculate the period of a satellite orbiting 300 km above the Martian surface. **2**

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(b) A low Earth orbit (LEO) probe at the same altitude as the Mars probe above will suffer significant orbital decay. Account for this. **1**

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Student Number ________

VOULALAS	/7

Question 28 (3 marks)

Electric motors are designed to rotate continuously, however, a galvanometer which operates using the motor effect only turns through a limited angle. **Marks**

Using an ammeter as an example, outline the operation of a galvanometer.

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Question 29 (4 marks)

An ideal transformer is one in which there is no energy loss. With reference to an ideal transformer, explain how the conservation of energy is applicable in both step-up and in step-down transformers. **4**

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Student Number ________

WARD /20

Marks

Question 30 (7 marks)

(a) (i) With the aid of a diagram, explain how electric currents can be induced in the base of a saucepan when placed on an induction cooktop. **3**

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(ii) Identify reasons why induction cooktops are more efficient than conventional or gas cook tops.

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(b) Describe one other application of producing eddy currents in a sheet of metal.

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Marks

Question 31 (5 marks)

Analyse Edison's and Westinghouse's electricity supply solutions for cities. **5**

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Question 32 (3 marks)

Outline the methods used by the Braggs to determine crystal structure. **3**

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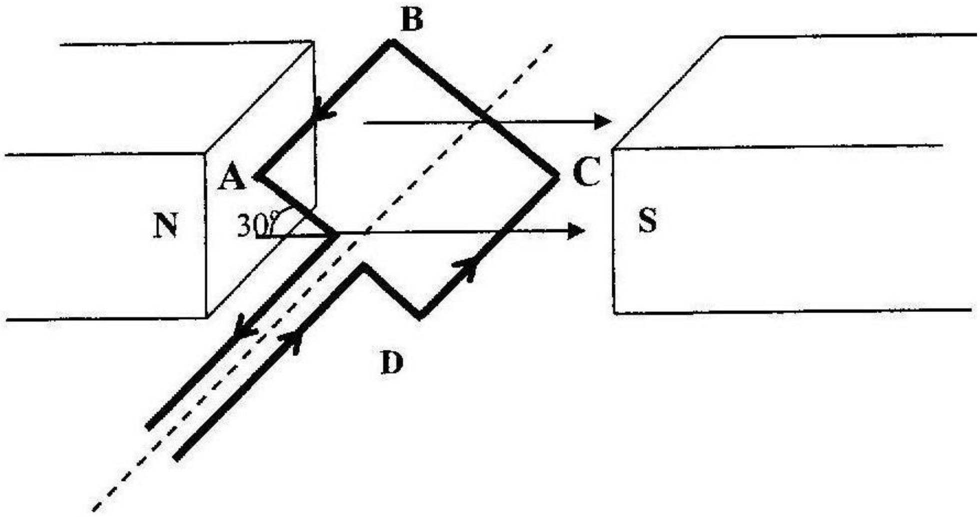
Question 33 (5 marks) **Marks**

A rectangular coil, with 250 turns, is between the poles of two bar magnets. Its plane makes an angle of 30° with the direction of the magnetic field. The side AB measures 15 cm and the side BC measures 10 cm. The magnetic field strength between the poles of the magnets is 5.0 mT and the current through the coil is 25 mA.



(a) Calculate the **magnitude** and **direction** of the force on side AB, when the coil is at an angle of 30° to the direction of the magnet field. **3**

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(b) Calculate the torque produced by the coil if the angle between the field and the plane of the coil were reduced from 30° to 10°. **2**

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Question 34 (4 marks)

NOYES /20

Marks

(a) Explain what was wrong with classical physics theory that led to Planck's hypothesis that radiation emitted by a black body was quantised. **2**

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(b) Describe how Planck's hypothesis regarding the nature of black body radiation differed from the explanation offered by classical physics. **2**

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Question 35 (4 marks)

(a) An electron of charge -1.6×10^{-19} C travelling at a speed of 2.0×10^{6} ms^{-1} enters a magnetic field of 0.1 T. **Marks**

Calculate the force on the charge as it enters the field at an angle of 30^{o}. **2**

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(b) A student is investigating the photoelectric effect using a photocell with a cobalt cathode whose work function is 2.4×10^{-19} J, and a blue LED of wavelength 450 nm (1 nm = 10^{-9} m) to illuminate the photocell. **2**

Calculate the maximum kinetic energy of any photoelectron that will be emitted .

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Student Number ________

Marks

Question 36 (7 marks)

(a) Describe the ***two*** methods of doping a semiconductor material that can change the material's electrical properties. **4**

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(b) Explain how a photovoltaic cell works. **3**

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Question 37 (5 marks) **Marks**

(a) Outline an experiment to demonstrate magnetic levitation **3**

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(b) Briefly discuss the BCS theory of superconductors. **2**

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Student Number ________

Section II

10 marks
Attempt ONE question from Questions 38-39

Allow about 30 minutes for this section

Answer the OPTION question on the writing paper supplied. Extra writing paper is available.

Show all relevant working in questions involving calculations.

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Student Number ________

Question 38 Astrophysics (10 marks) **Marks**

(a) (i) Outline the limitations of ground-based trigonometric parallax measurements. **2**

(ii) An observatory orbiting the Sun at twice the distance of Earth's orbit measures the trigonometric parallax angle of a distant star to be 0.0040 arcseconds. **1**

Calculate the distance to this star.

(b) Describe how active and adaptive optics systems can improve the resolution of images obtained by large telescopes. **4**

(c) Explain the appearance of an emission and absorption spectrum. Use a diagram to illustrate your answer. **3**

Marks

Question 39 From Quanta to Quarks (10 marks)

(a) (i) Describe an investigation in which the visible components of the hydrogen spectrum may be safely observed. **4**

A diagram should be used to illustrate your answer.

(ii) Identify TWO aspect of the hydrogen spectrum that the Bohr model of the atom could not explain. **2**

(b) Use the Rydberg equation to calculate the wavelength of the most energetic line of the visible hydrogen spectrum. **4**

PART A: Multiple Choice

1.B

2. B

3.A

4.B

5.C

6. D

7.B

8.C

9.D

10.D

11.B

12.B

13.B

14.C

15.A

16.A

17.B

18.D

19.D

20.C

PART B: HUGHES (23 marks)

Question 21 (3 marks)

21 a.

Marking Criteria	Marks
• An appropriate method described	**1**

Sample answer

e.g. measuring the time taken for 10 or 20 oscillations and dividing to find the period. OR stopwatch OR lightgates

21 b.

Marking Criteria	Marks
• An appropriate error is described that explains the graph	**2**
• An appropriate error is identified	**1**

Sample answer

The wrong measurement of the length of the pendulum is a possibility but an unlikely probability. Timing error was also minimised by doing 20 swings. Eqn for T wrt l allows a 0,0 plot. This leaves the drawing of a poor line of best fit on a graph with a poor x axis with $0.5s^2$ intervals rather than 0.1.
y axis also poor scale

Question 22 (4 marks)

22 a.

Marking Criteria	Marks
• Correct effect at both locations described	**2**
• Correct effect at either location described	**1**

Sample answer

Length of day shorter thus rotation of Earth speeds up. Centripetal acceleration of v^2/r must be subtracted from 9.8 ms^{-2} . Thus effective "g" near equator is less, say 9.7 ms^{-2}. No circular motion at south pole so no effect on value of "g". OR Faster v gives equatorial bulge so r increases so g is less and at pole r decreases so g increases.

22 b.

Marking Criteria	Marks
• Both changes described	**2**
• One change described or both changes (period and radius) identified	**1**

Sample answer

Earth rotates faster so the satellite must also travel **faster** and thus it will have a shorter period to match that of the Earth. It will do so if drops to a **lower orbit** where "g" is greater and the speed increases to compensate.

Question 23 (3 marks)

23 a.

Marking Criteria	Marks
• Correct answer reliability and validity correct	**2**
• Only one concept explained	**1**

Sample answer

M and M used the principle of interferometry to observe if light waves would be out of phase. This was a very valid method as many previous experiments on light as a wave had resulted in easily detected interference patterns. They had reliability as they repeated the experiment dozens of times and obtained the same null result.

23b.

Marking Criteria	Marks
• Correct answer	**1**

Sample answer

Einstein proposed that the speed of light was constant in all frames of reference i.e. always c never c + or - v

Question 24 (4 marks)

24 a.

Marking Criteria	Marks
• One appropriate calculation towards answer is calculated	
• Correct answer	**2**
• One appropriate calculation towards answer is calculated OR • Answer provided contains an arithmetical error	**1**

Sample answer

$$900 \text{ km h}^{-1} = 250 \text{ m s}^{-1}$$

$$\Delta y = u_y t + \frac{1}{2} a_y t^2$$

$$4000 = 4.9t^2$$

$$t = 28.57 \text{ s}$$

$$\Delta x = u_x t$$

$$= 250 \times \text{t}$$

$$= 7142.5 \text{ m}$$

$$= 7.14 \times 10^3 \text{ m}$$

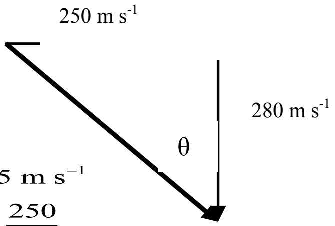
24 b.

Marking Criteria	Marks
• Correct velocity given	**2**
• Calculations performed with an arithmetic error OR • Correct speed given without angle	**1**

Sample answer

$$
\begin{aligned}
v_x &= u_x \\
&= 250 \text{ m s}^{-1} \\
v_y &= u_y + a_y t \\
&= 0 + 9.8 \times 28.57 \\
&= 280 \text{ m s}^{-1}
\end{aligned}
$$

$v_y^2 = 250^2 + 280^2$



$v_y = 375 \text{ m s}^{-1}$

$\tan \Theta = \dfrac{250}{280}$

$\theta = 42^o$ from vertical (or 48^0 from horizontal)

Question 25 (2 marks)

Marking Criteria	*Marks*
• *Correct speed given*	***2***
• *Calculations performed with an arithmetic error* *Or incorrect substitution of years*	***1***

Sample answer

t_v is 25 yrs and t_0 is 5 yrs. Sub into time dilation equation to find velocity. v= 0.98c

Question 26 (4 marks)

Marking Criteria	*Marks*
• *response provided shows evidence of proper and thorough understanding of the concepts involved,* • *presented in a logical manner* • *appropriate energy formulae used correctly*	***4***
• *sound understanding of relevant factors and relationships evident* • *appropriate energy formulae referred to*	***3***
• *basic understanding of the relevant factors and relationships evident,* • *some appropriate formulae identified*	***2***
• *Some understanding of a relevant concept evident*	***1***

Sample answer

For a spacecraft to escape Earth's gravitational field PE + KE = 0, E_K= $1/2mv^2$ and gravitational potential energy, $E_P = -Gm_1m_2/r$. This solves to give escape velocity = root 2Gm/r. It needs to propel itself with sufficient fuel so that it can "climb up" to a potential energy of zero while still having kinetic energy and thus escape and not be drawn back by Earth's gravity.

Question 27 (3 marks)

27 a.

Marking Criteria	***Marks***
• *Correct period given*	***2***
• *Calculations performed with an arithmetic error* •	***1***

Sample answer

Sub into $T^2 = 4\pi^2 R/GM \times R$ = 6739 sec NB. R=3400+300km in metres

27 b.

Marking Criteria	**Marks**
• Drag accounted for	**1**

Sample answer

At 300 km above Earth there is enough air to produce drag which will continually slow the probe which will then gradually spiral into a lower and lower orbit

PART B: VOULALAS (7 marks)

Question 28

Marking Criteria	Marks
• A thorough outline is provided that describes the relevant aspects	**3**
• A basic outline of a galvanometer is provided	**2**
• One appropriate aspect provided	**1**

Sample Answer:

A current flows through coils within a radial magnetic field. The coils are free to rotate but have a spring attached which exerts a progressively stronger restoring force when they turn. A needle is attached to the coil structure. The greater the current, the more the coils try to rotate against the spring, and the needle swings against a background scale to indicate the current flowing through the circuit.

Question 29

Marking Criteria	Marks
• The role of both types of transformers is stated clearly • The conservation of energy is related to an ideal transformer using appropriate equations for both types of transformers	**3-4**
• The role of both types of transformers is identified • The conservation of energy is related to transformers	**2**
• The role of transformers is identified OR • A limited reference to the conservation of energy is provided	**1**

Sample Answer:

Step-up transformers increase the voltage and step-down transformers decrease the voltage. For any transformer, the power in is given by $P_{in}=V_pI_p$ and the power output given by $P_{out}=V_sI_s$. So whichever type of transformer is used, an ideal transformer has $P_{in}=P_{out}$ therefore with no lost energy. It follows then that $V_pI_p=V_sI_s$ for ideal transformers. i.e. In step-up transformers, the voltage increases while the current is decreased, and vice-versa for step-down transformers.

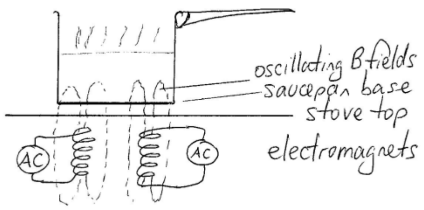
PART B: WARD (20 marks)

Question 30 a. (i) (7 marks)

Marking Criteria	Marks
• Thorough explanation is provided with either a diagram or a clear description	**3**
• A description of some of the aspects of the operation of induction cooktops provided	**2**
• A limited description of induction cooktop principles is provided	**1**

Sample Answer:

Solenoids beneath the cooktop act as sources of changing magnetic fields as they are connected to the AC mains supply. This then generates a changing magnetic flux through the base of the saucepan above, which in turn induces eddy currents in the saucepan base. The eddy currents generate heat (ohmic heating) in the saucepan base itself. The food, in contact with the saucepan, is then heated directly.



Question 30 a. (ii)

Marking Criteria	Marks
• Several appropriate reasons are identified	**2**
• One appropriate reason is identified	**1**

Sample Answer:

The heat is generated in the saucepan base quickly and stops when the power is turned off. The heat is generated in the saucepan base itself, so that the food is heated directly which lessens wasted heat.

Question 30 b.

Marking Criteria	Marks
• A relevant description of an appropriate application is provided	**2**
• An appropriate application is identified	**1**

Sample Answer:

Eddy currents can be induced in a rotating disc of metal attached to an axle by using strong electromagnets. This produces a braking force on the disc that will slow down a vehicle or train. The direction of the eddy currents is such that the magnetic field they produce makes an opposing force on the field from the electromagnet.

Question 31 (5 marks)

Marking Criteria	Marks
• Relevant aspects of both supply solutions are compared in detail • The differences between the supply solutions are outlined • Advantages and disadvantages of both solutions are described	**5**
• The supply solutions are compared • Some differences are outlined	**3-4**
• Several aspects of either supply solution are outlined OR • An aspect of both supply solutions is outlined	**2**
• An aspect of either supply solution is identified	**1**

Sample Answer:

Edison proposed a DC distribution system whereby small power stations would be necessary throughout the city, delivering 110 volts to homes, factories and shops. Westinghouse was able to propose an AC system with power stations remotely located, as transformers could be used to step up the voltage from the power station so long distance transmission could be achieved efficiently, which Edison's system could not do. AC was believed to more dangerous, so Westinghouse proposed a 110 V final voltage to match Edison's DC. The advantages of Westinghouse's system allowed Niagara Falls and other remote power sources such as coal fired power stations to be built on large scales and produce electricity much more cheaply, efficiently and with less pollution in densely populated areas.

Question 32 (3marks)

Marking Criteria	Marks
• The X-ray interference pattern reveals the arrangement and spacing of atoms in solids. • OR Explanation of a relevant equation, eg, λ=dsinΘ	3
• The X-rays were diffracted producing an interference pattern.	2
• The Braggs used X-rays in their experiments.	1

Sample answer

The Braggs diffracted X-rays through samples of different crystalline materials. The arrangement of atoms and their inter-atomic spacing act as a diffraction grating, producing diffraction of the X-rays and a measurable interference pattern.

Question 33 (5 marks)

33 a.

Marking Criteria	**Marks**
• Correct answer with direction and working	**3**
• Formula and correct magnitude or direction	**2**
• Writes correct formula **OR** • Correct answer with no working	**1**

"clockwise direction"…..1/2 mark

Sample Answer:

F = nBIl

F= 250 x 5 x 10^{-3} x 0.025 x 0.15

= 4.7 x 10^{-3} N upwards (to top of page)

Question 33 b.

Marking Criteria	Marks
• Correct formula and correct working.	2
• Correct formula or correct answer with no working.	1

Sample answer

Torque = nBIAcosϴ

= 250 x 0.005 x 0.025 x 0.015 x cos 10°

= 4.6 x 10^{-4} Nm

PART B: NOYES (20 marks)

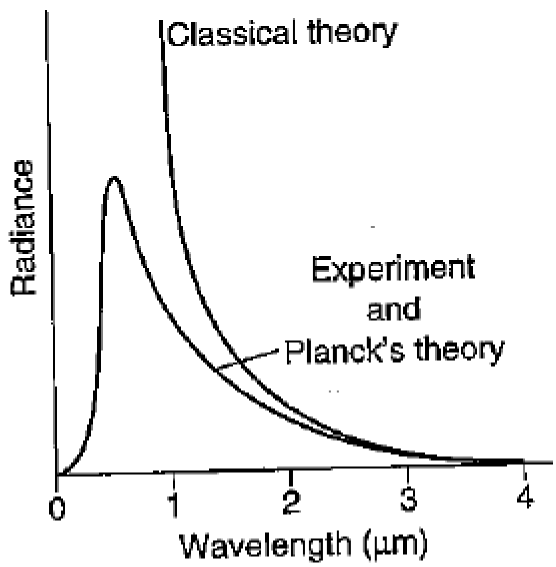
Question 34 (4 marks)

34 a

Marking Criteria	Marks
• A clear explanation is provided	**2**
• A problem with classical theory is identified	**1**

Sample Answer:

Classical physics predicted that as the temperature of the black body emitter increased, the energy radiated would increase enormously until infinite amounts would be given off – which violated the law of conservation of energy, and must therefore be incorrect as it was not consistent with observations. The experimental data showed that the radiation intensity curve had a definite peak passing through a maximum, and then declining.



34 b.

Marking Criteria	Marks
• Planck's hypothesis described clearly • Clear difference from classical outlined	**2**
• Planck's hypothesis is identified	**1**

Sample Answer:

Planck hypothesised that the radiation emitted by black bodies is quantised – i.e. given off as discrete packets of energy (quanta) , E = hf, as opposed to classical theory which stated that the energy is given of continuously with a wave nature.

Question 35 (4 marks)

35 a.

Marking Criteria	Marks
• Correct answer with working	**2**
• Correct answer with working(no negative sign)	**1.5**
• Writes correct formula & some substitution **OR** • Correct answer with no working	**1**

Sample Answer:

F = qvBsinΘ

F= - 1.6 x 10^{-19} x 2.0 x 10^{6} x 0.1 x sin 30^{0}

F = -1.6 x 10^{-14}

35 b.

Marking Criteria	Marks
• Correct answer with working	**2**
• Writes correct formula & some substitution **OR** • Correct answer with no working	**1**

Sample Answer:

$E\ k_{max}$ = hf – Φ = h x c/ λ – Φ

= (6.6 x 10^{-34} x 3.0 x 10^{8} / 450 x 10^{-9}) - 2.4 x 10^{-19}

= 2.0 x 10^{-19} J

Question 36 (7 marks)

36 a.

Marking Criteria	Marks
• Explains how semiconductors can be doped with Group 3 and 5 elements • Explains the formation of holes and electrons • Relates to increased electrical conductivity	**4**
• Explains how semiconductors can be doped with Group 3 or 5 elements **AND** • Explains the formation of holes and electrons **OR** • Relates to increased electrical conductivity	**2-3**
• Identifies semiconductors can be doped with Group 3 or 5 elements **OR** • Identifies p & n-type semiconductors.	**1**

Sample Answer:

Doping occurs when atoms of Group III or V of the periodic table replace some of the atoms of the Group IV element being doped..
To produce p-type semiconductors, atoms of Group 3 elements such as Boron replace some of the silicon atoms in the lattice. As the bonding with silicon in the lattice needs 4 electrons, there are holes created where the bonding electrons are missing.
To produce n-type semiconductors, atoms of Group V elements such as arsenic replace some of the silicon atoms in the lattice. This type of doping produces free electrons that are available for conduction.
Conduction occurs by these holes and free electrons and increases the electrical conductivity of a semiconductor.

36 b.

Marking Criteria	Marks
• Demonstrates an understanding of the structure; the electric field at the junction; the production of photoelectrons	**3**
• Demonstrates an understanding of one of the following: the structure; the electric field at the junction; the production of photoelectrons **OR** • Draws a suitable labelled diagram	**2**
• Provides information about the two layers of semiconductors.	**1**

Sample Answer:

A photovoltaic cell has a thin n-type semi-conductor layer above a p-type semi-conductor layer and is covered with a metal grid to allow light photons in and conduct electrons away. At the junction of the two semi-conductors, electrons diffuse from the n-type into the p-type and holes diffuse from the p-type into the n-type, setting up an electric field at the junction between the 2 types. When photons penetrate the cell, the energy is used to free electrons by the photoelectric effect, producing electron hole pairs near the junction. The electrons can only flow in one direction and leave the n-type layer conducted by the metal grid to return via an external circuit to the p-type layer.

Question 37 (5 marks)

37 a.

Marking Criteria	Marks
• Outlines a method including all equipment. • **OR** • Draws a labelled diagram including all equipment.	**3**
• Identifies a method **OR** • Draws a labelled diagram	**2**
• Identifies a an aspect of levitation **OR** • Draws a basic diagram	**1**

Sample Answer:

1. A superconductor (YBaCuO) was placed in a petri dish
2. It was cooled below its critical temperature using dry ice
3. A rare earth magnet was made to suspend over the superconductor by allowing induced currents in the conductor to produce magnetic fields which exert an upwards force on the magnet causing the magnet to float. This is called the Meissner effect.

37 b.

Marking Criteria	Marks
• Discusses BCS theory with mention of lattice distortion, formation of Cooper pairs.	**2**
• Identify production of Cooper pairs **OR** • Identify distortion of lattice	**1**

Sample Answer:

Electrons pass unimpeded through a crystal lattice and since they do not interact with the lattice they do not lose energy and the resistance is effectively zero. An electron passing through the lattice causes the lattice to distort. As a result of this distortion phonons are emitted forming a trough of increased positive charge density around the electron. Before the electron can pass the ion and before the lattice rebounds to its normal position, a second electron is attracted to the first and pairs up (a Cooper pair). This Cooper pair passes easily through the lattice.

PART C: OPTION-ASTROPHYSICS

Question 38 (10 marks)

(a) (i) Outlined the limitations of ground-based trigonometric parallax measurements.

Marking Criteria	Marks
• Outlines the two limitations	2
• Outlines one limitation	1

Sample answer

Ground-based measurements of parallax are hindered by:

- the „**seeing effect**‟ caused by the rapidly changing temperature of the Earth‟s atmosphere that distorts the path of the visible light and IR light (to a smaller degree) thus resulting to blurry images of stars.
- the uncertainty in the measured angles which is about 0.01 arc second, although modern telescopes can measure parallax to a precision of 0.001 arc second.

(ii) An observatory orbiting the Sun at twice the distance of the Earth‟s orbit measures the trigonometric parallax angle of a distance star to be 0.0040 arc seconds.

Calculate the distance to this star.

Marking Criteria	Marks
• Correctly calculates the distance to the star.	1
• No correct units or not realising p = half the value given	1/2

Sample answer

p = 0.0040/2 = 0.0020

d = 1/p = 1/0.0020 = 500 pc

(b) Describe how active and adaptive optics systems can improve the resolution of images obtained by large telescopes.

Marking Criteria	Marks
• Correctly describes the two systems	4
• Correctly describes one system and partially the other	3
• Correctly describes one systems or partially both	2
• Partially describes one system	1

Sample answer

Ground-based Astronomy is always hindered due to limitations imposed on it by the turbulent atmosphere that degrades and distorts images. The resolution and sensitivity of ground-based astronomy has been improved by technological advantages such as active and adaptive optics.

ACTIVE OPTICS keep the telescope at optimum performance by adjusting the shape of the mirror of the telescope every minute with the help of computer controlled actuators that push and pull on the back of the mirror. The variations in the shape of the objective mirror of the telescope are due forces of gravity, temperature changes, wind, etc.

ADAPTIVE OPTICS is a complex procedure by which the distortion in the wavelength of light caused be the atmosphere is measured with the help of wavefront sensors and then corrected many times in a second to overcome the rapidly changing „seeing effect‟. This is done using very fast computers which control a correction device, usually a flexible secondary mirror. This mirror can be adjusted to redirect the light towards the detector. Laser beams along the line of sight and beam splitters are also used in the procedure. This reduces the blurring effect of atmospheric turbulence in order to produce much clearer images and increases the resolution. Adaptive optics are widely applied now to new and modern telescopes.

(c) Explain the appearance of an emission and absorption spectrum.
Use a diagram to illustrate your answer.

Marking Criteria	Marks
• Correctly explains the two types of spectra and draws diagrams	3
• Correctly explains one type of spectra and draws diagrams of both or correctly explains both types but draws one diagram	2
• Correctly describes one type of spectra and draws diagram for one	1
• Draws correct diagrams for both spectra or partial description of both types.	1

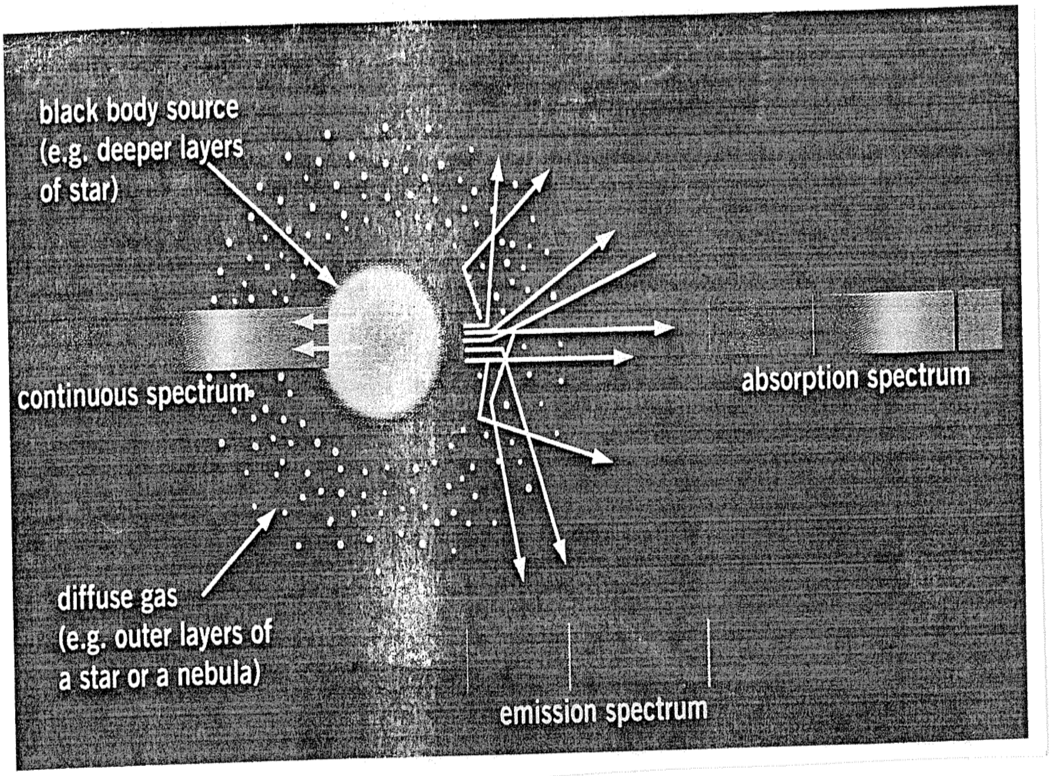
Sample answer

Absorption Line Spectra

The visible light emitted by stars is made up of a continuous spectrum of a typical black body radiation emitter characteristic of the surface temperature of the star. The hot inner surface of the star emits light of all frequencies/wavelengths which move towards the exterior of the star. Atoms of elements in the star‟s cooler outer „atmosphere‟ absorb light of particular frequencies/wavelengths that are characteristic of each element present. Such atoms subsequently re-emit these frequencies/wavelengths in all directions so that light of a particular frequency/wavelength is missing as it is viewed from Earth. These missing frequencies/wavelengths are shown as narrow absorption lines and known as Fraunhofer lines that are dark lines in the spectrum. From the patterns of these lines astronomers can determine the elements present on the star and their relative intensities are used to determine the proportion of these elements. **(See diagram below)**

Emission Line Spectra

These spectra refer to the bright emission lines of frequencies/wavelengths characteristic of the elements in low-density gases which absorb energy in the form of heat or electromagnetic radiation. This energy raises the atoms or molecules to higher energy levels. The emission spectrum lines are formed by the transition from these excited states to lower energy states, the excess energy appearing in the form of photons with characteristic frequencies that appear as bright emission lines. In stars, these emission lines are formed if the star is surrounded by a hot shell of diffused gas such as a nebula. **(See diagram below)**


black body source
(e.g. deeper layers
of star)
continuous spectrum
absorption spectrum
diffuse gas
(e.g. outer layers of
a star or a nebula)
emission spectrum

PART C: OPTION- FROM QUANTA TO QUARKS

Question 39 (10 marks)

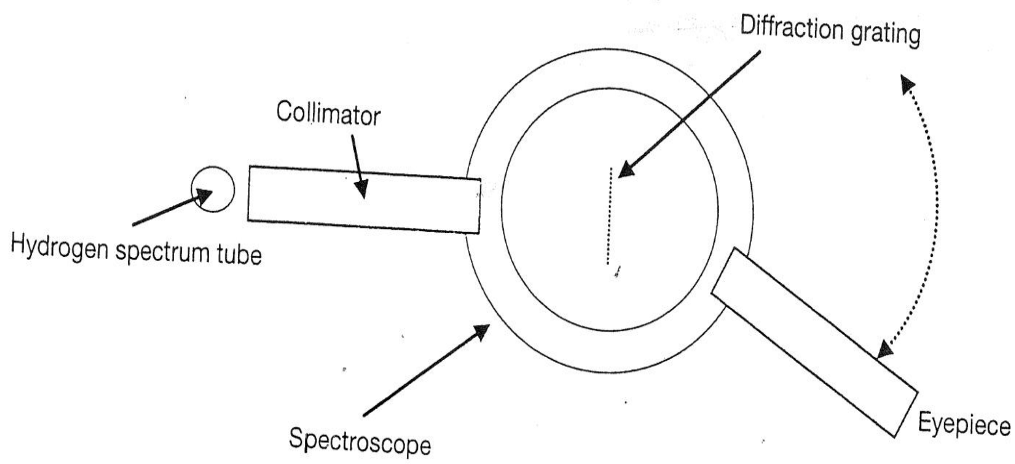
(a) (i) Describe an investigation in which the visible components of the hydrogen spectrum may be safely observed. **4**

A diagram should be used to illustrate your answer.

Marking Criteria	Marks
• Correctly describes the investigation and provides correct diagram	4
• Partially describes the investigation and provides correct diagram or correctly descries investigation with partial diagram	3
• Correctly describes the investigation without diagram	2
• Does not describe the investigation but provides correct diagram or partial description and partial diagram	2
• Partially describes the investigation without diagram	1
• Provides partly correct diagram only or partially describes the investigation.	1

Sample answer

In a darkened laboratory set up an induction coil, power supply, spectroscope and the hydrogen spectrum tube which will be emitting the reddish line as shown below.



Move the eyepiece back and forth until you see the spectrum of hydrogen then make the necessary adjustments of the slit width and focus until you obtain sharp lines.
Draw a diagram of what you see.

(ii) Identify TWO aspects of the hydrogen spectrum that the Bohr model of the atom could not explain.

Marking Criteria	Marks
• Correctly identifies the two aspects	2
• Correctly identifies one aspect only	1

Sample answer
Any TWO of the following:

- The Bohr model could not explain why some spectral lines were more intense, thicker, and sharper or diffused than others, which implied that there were more emissions of one wavelength/frequency than of others.
- The Bohr model could not explain why some spectral lines consisted of many fine, closely spaced lines (hyperfine spectral lines) suggesting that energy levels of electrons were more complex than what the model was providing.
- The Bohr model could not explain why spectral lines were split under the influence of a magnetic field, indicating that additional electron energy levels were produced in a magnetic field. (Zeeman effect)
- The Bohr model could not explain why spectral lines of species other than H, He^{+}, Li^{2+} , etc with more than one electron, as it did not account for electron-electron interactions and their effects on energy levels in the atom.

(b) Use the Rydberg equation to calculate the wavelength of the most energetic line of the visible hydrogen spectrum. **4**

Marking Criteria	Marks
• Correctly calculates the wavelength including formula, showing substitution and gives units of measurement	4
• Correctly calculates the wavelength including formula, showing substitution without/wrong units of measurement	3
• Providing the formula and correct substitution without answer	2
• Correctly calculates the wavelength including formula, showing substitution and gives units of measurement but with wrong „n" values	2
• Gives correct answer without showing working out	1
• Provides little evidence of understanding the question or shows substitution and works answer but with wrong „n" values and wrong units.	1

Sample answer
For the **visible** hydrogen spectrum: $n_f = 2$ and $n_i = 6$

$1/\lambda = R \{1/n_f^2 - 1/n_i^2\} = 1.097 \times 10^7 \text{ m}^{-1} \{1/2^2 - 1/6^2\}$
$\lambda = 4.092 \times 10^{-7} \text{ m} = 409.2 \text{ nm}$