Newington College

2013 Year 12
TRIAL HSC 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 a sharp pencil and ruler
- A Data and Formula Sheet is provided.
- Write your Student Number at the top of each page.

Total marks – 100

Section I

80 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 – 60 marks

- Attempt Questions 21-34
- Allow about 1 hour and 50 minutes for this part

Section II

20 marks

- Candidates are to answer ONE elective question. Answer in the spaces provided.

Allow about 35 minutes for this section

Section I

80 marks

Part A – 20 marks

Attempt Questions 1-20

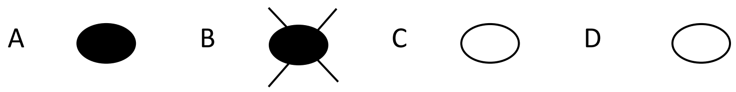
Allow about 35 minutes for this part

Use the multiple-choice answer sheet.

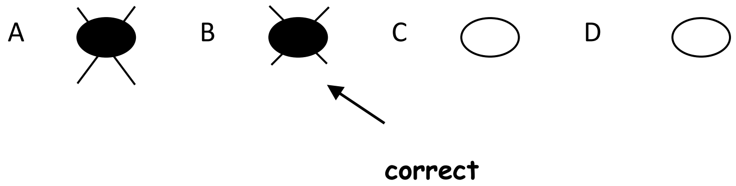
Select the alternative A,B,C or D that best answers the question. Fill in the response oval completely.

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.



Part A: Multiple Choice

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1. The gravitational potential energy of an object near Earth's surface is changed when you:

(A) apply a horizontal net force on the object.

(B) allow the object to fall down 5 metres.

(C) hold the object stationary in the air.

(D) ensure the net force on the object remains zero.

2. A material becomes a superconductor when:

(A) all atomic motion ceases in the material except for electrons.

(B) the electrons cease moving in the lattice structure.

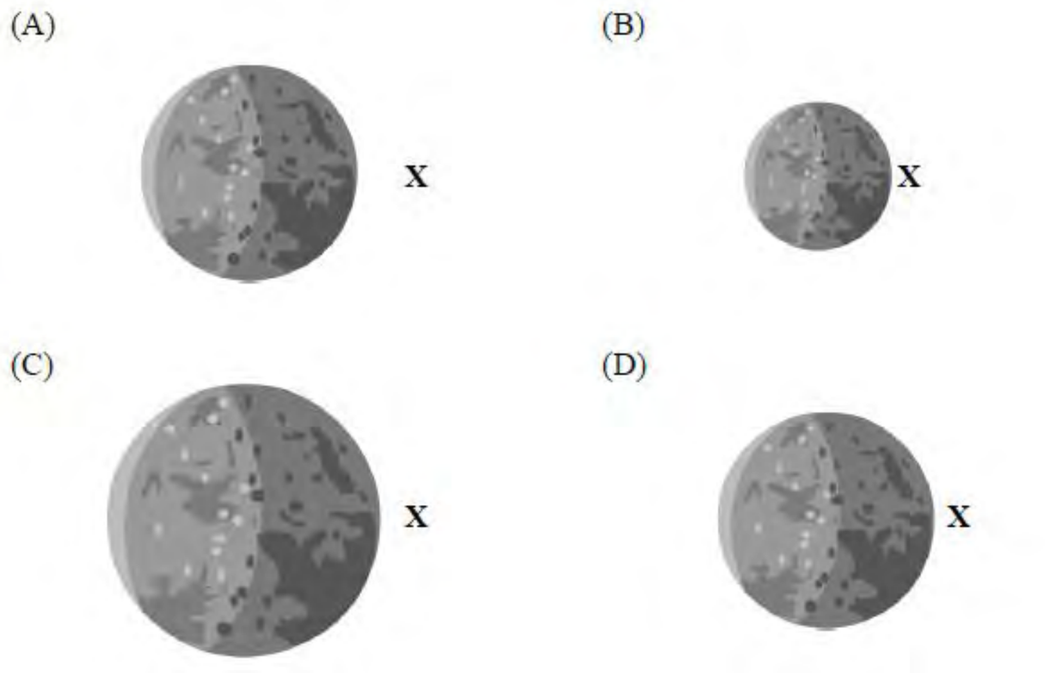
(C) the electrons all line up and move in one line through the material.

(D) electrons pair up and move unimpeded through the material.

3. A gaseous planet expands and contracts in size while maintaining the same mass.

In which diagram is the object at "**X**" experiencing the greatest gravitational force?

The diagrams are to scale.



4. The aether model for the transmission of light was popular in the 19th century. Such a model was developed because it was believed:

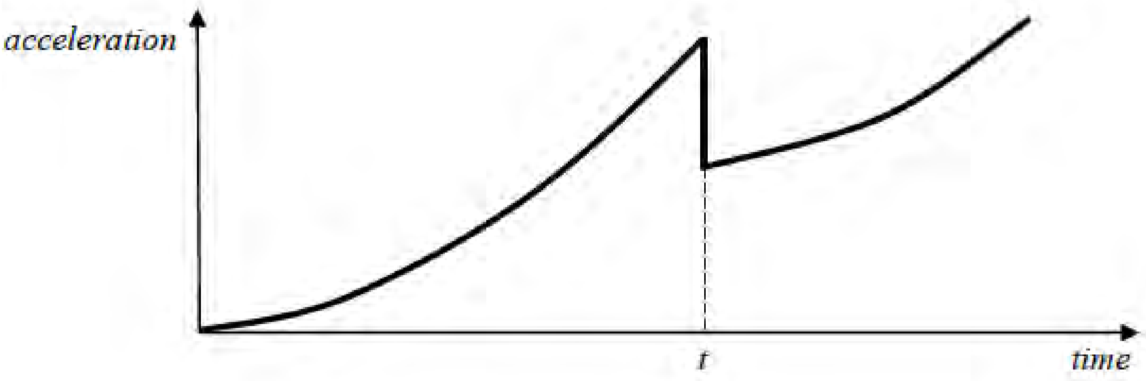
(A) particles could not travel through solids.

(B) the Earth would otherwise move away from the Sun.

(C) light travelled at a constant speed.

(D) all waves needed a medium to travel through.

5. The acceleration of a rocket being used to transport astronauts to the International Space Station is shown for the minutes just after launch:



At time *t*, the astronauts:

(A) feel momentarily weightless.

(B) feel a sudden increase in their apparent weight.

(C) feel no effect as they are still in Earth's gravity.

(D) feel a reduction in their apparent weight.

6. The concept of time dilation is a direct consequence of

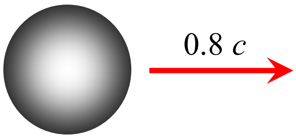
(A) the constancy of the speed of light in a vacuum.

(B) the equivalence of mass and energy.

(C) the aether effect

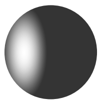
(D) nothing being able to exceed the speed of light.

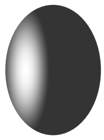
7. .

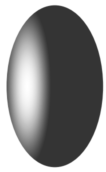


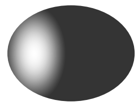
Consumed by his implacable hatred for Earthlings the Zaxxon Warlord launched a solid metal sphere at 0.8 *c* directly at our planet. It missed. However, a photograph was taken by one of Earth's space cameras as evidence for the Intergalactic Court.

Which of the following diagrams would most closely resemble the photographic image?

(A) 

(B) 

(C) 

(D) 

8. Hertz observed the photoelectric effect in his experiments with radio waves but he did not investigate this phenomenon further.

What did Hertz observe in relation to the photoelectric effect?

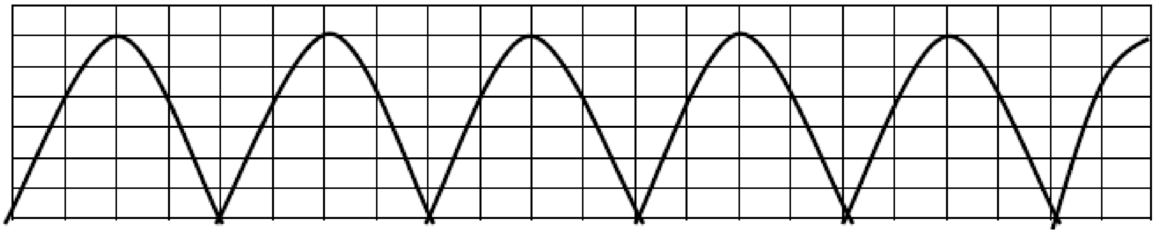
(A) Sparks could be made to jump a gap in another coil at a distance.

(B) The gap that sparks could jump across is larger when exposed to light.

(C) The radio waves producing the spark carried energy.

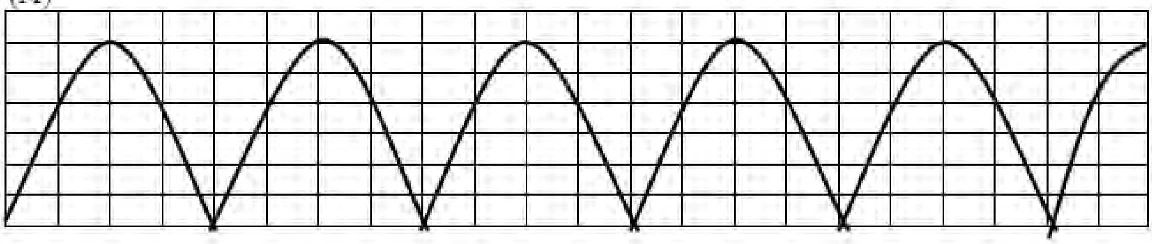
(D) The radio waves travelled at the speed of light.

9. A hand-turned generator has its outputs connected to a cathode ray oscilloscope (CRO). The CRO screen appears below:

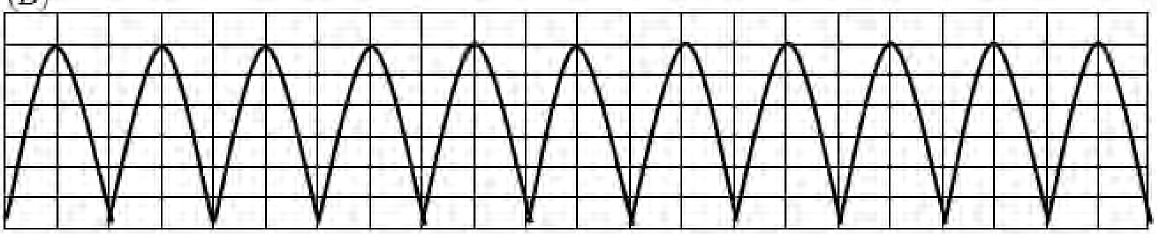


When the same generator is turned at a faster rate, the CRO output with the same settings would appear most similar to:

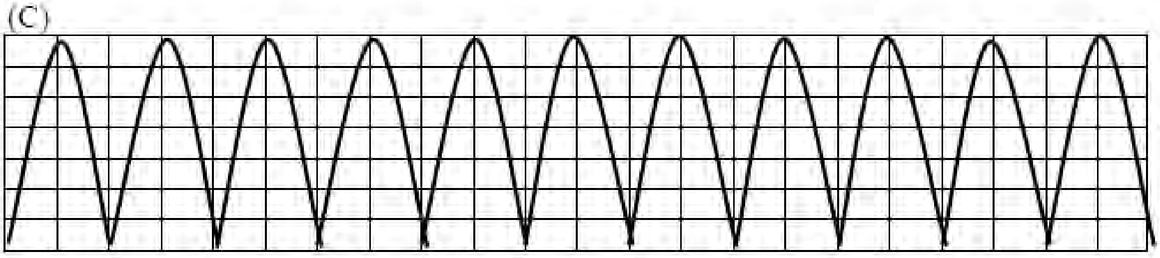
(A)



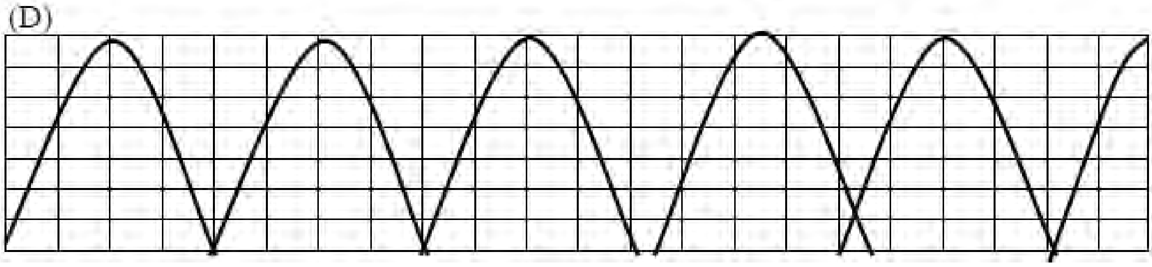
(B)



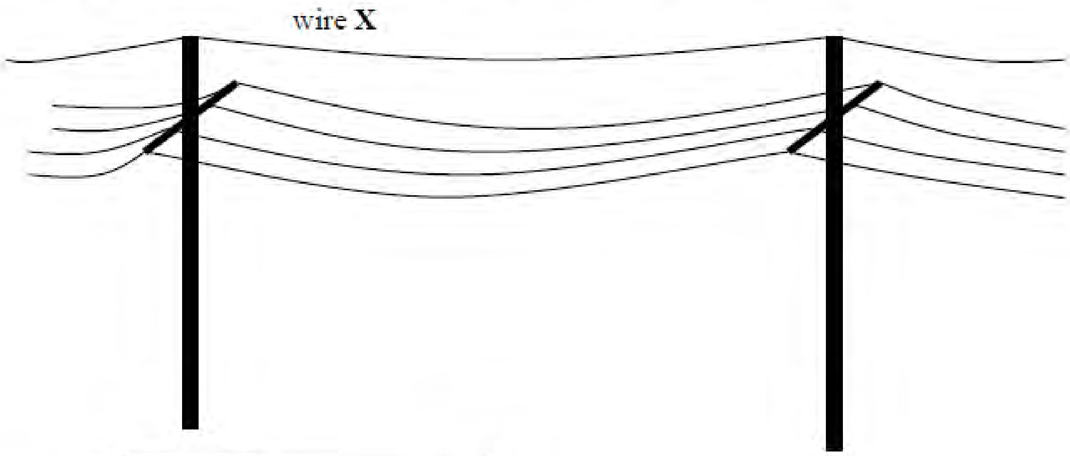
(C)

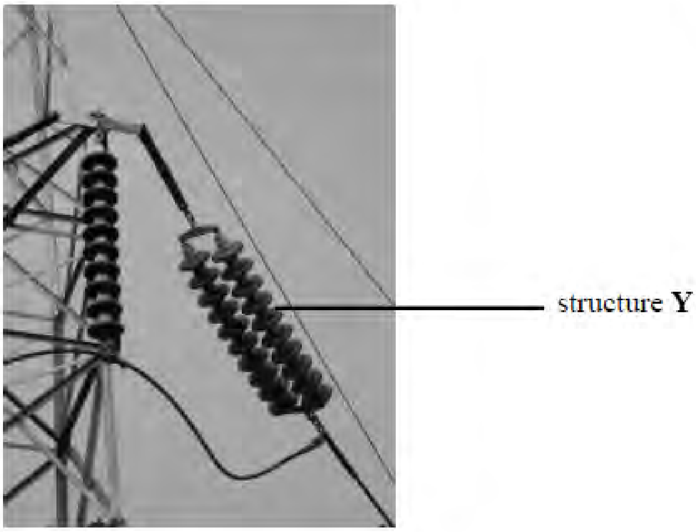


(D)



10. Wire **X** and structure **Y** are shown in the illustrations below:





The purposes of the wires and structure are:

	Purpose of Wire X	Purpose of structure Y
(A)	protect wires from lightning	insulate supporting tower from wires
(B)	insulate supporting tower from wires	protect wires from lightning
(C)	returns the current in the wires to the power station	insulate supporting tower from wire
(D)	attracts lightning to the wire	prevents surges in voltage in wires

11. The maximum torque produced by a single-coil DC motor is 2.8 N m.

This torque could be produced if the motor had 200 turns on the coil and:

	Magnetic field intensity (T)	Current in coil (A)	Dimensions of rectangular coil (cm x cm)
(A)	0.10	5.0	10 x 20
(B)	1.0×10^{-3}	0.07	10 x 20
(C)	2.0×10^{-4}	0.5	10 x 15
(D)	0.10	7.0	10 x 20

12. An ideal transformer has 4000 turns on the primary coil and 250 turns on the secondary coil.

The input and output voltages for this transformer could be:

	Input voltage (volts)	Output voltage (volts)
(A)	2 000	32 000
(B)	1 600	10
(C)	32 000	2 000
(D)	20	100 000

13. A piece of silicon is doped with an element from group V of the periodic table.

Which statement below is most correct?

(A) The material becomes positively charged

(B) The material becomes negatively charged

(C) The material has no overall charge

(D) The material is now classified as a *conductor*.

14. In an experiment to demonstrate the photoelectric effect, it was found that when light with a frequency f and an intensity I was shone on the cathode, the voltage needed to completely stop the photoelectric current was V volts.

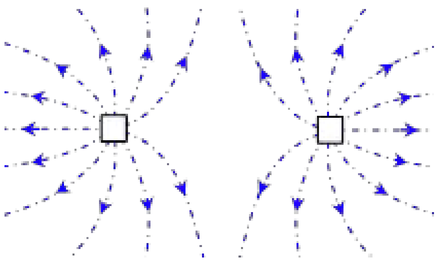
The effect of increasing the incident light **intensity** shining on the cathode is that the voltage V needed to be:

(A) dropped to zero.

(B) increased.

(C) kept the same.

(D) decreased.

15. 

This diagram shows a rough 2-dimensional representation of a 3-dimensional field.

Which of the following alternatives best identifies which type of field it could be?

(A) An electric field around two objects carrying equal like charges

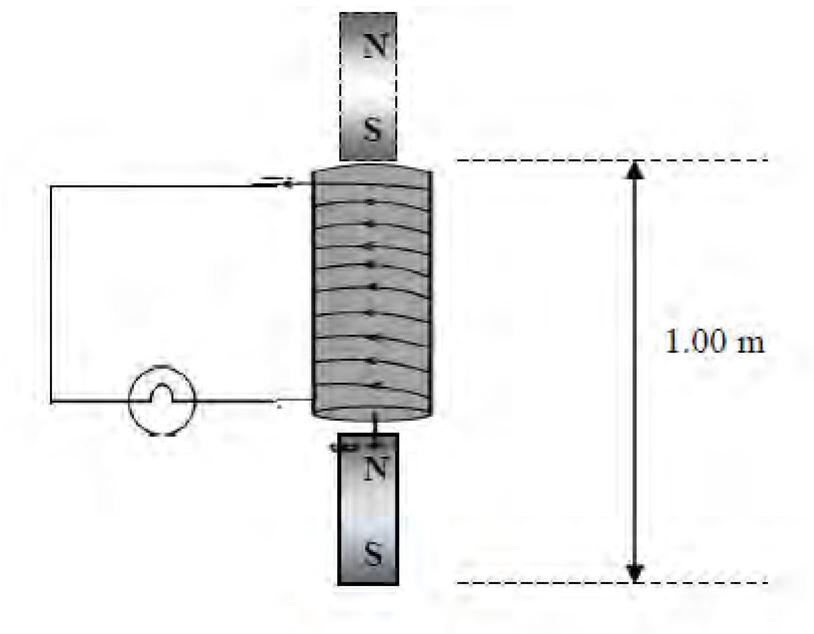
(B) A magnetic field around two like magnetic poles of equal strength

(C) A gravitational field around two objects in space with identical masses

(D) The field shown here would correctly represent two of these alternatives.

16. A 100 g bar magnet is released from rest and falls vertically through a small coil connected to a light globe, as shown. The wires have negligible resistance.

After falling through a height of 1.00 m, the bar magnet is moving at 3.8 m s^{-1}.



How much electrical energy was converted to other forms of energy by the light globe?

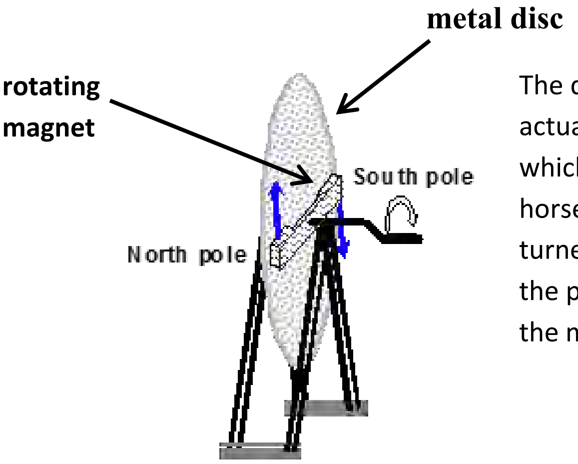
(A) 0.38 J

(B) 3.7 J

(C) 0.72 J

(D) 0.26 J

Questions 17 and 18 refer to the information below:



The device shown in this diagram is called an Aragó disc. The actual disc is a circular plate made of aluminium or copper, which can rotate freely on a crank handle. There is a long horseshoe magnet attached to the crank handle, so when it is turned the poles of the magnet move across the surface of the plate, which is observed to rotate in the same direction as the magnet is moving.

17. Why does the copper or aluminium disc turn while the magnet continues to rotate as the handle is turned?

(A) The metal of the disc is attracted by the moving magnet

(B) Since the crank handle cannot be frictionless, the disc turns by the friction

(C) The changing field induces an emf that opposes the motion of the magnets

(D) The magnet's poles attract or repel electrons as they move across the metal.

18. The Arago disc is an excellent example of a significant principle of physics.

Which of the following principles does it show?

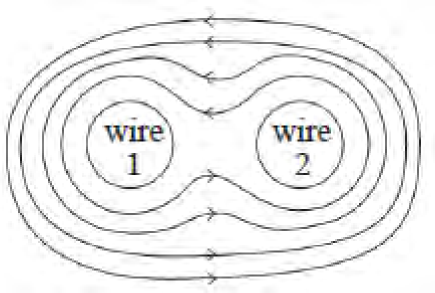
(A) Ohm's Law

(B) The motor effect

(C) The law of conservation of momentum

(D) The principle of an AC induction motor

19. The following diagram shows magnetic field lines around two current-carrying wires.



Which statement describes the direction of the current AND the force between the wires?

(A) The currents are flowing in the same direction; the force between them is attractive

(B) The currents are flowing in the same direction; the force between them is repulsive

(C) The currents are flowing in opposite directions; the force between them is attractive

(D) The currents are flowing in opposite directions; the force between them is repulsive

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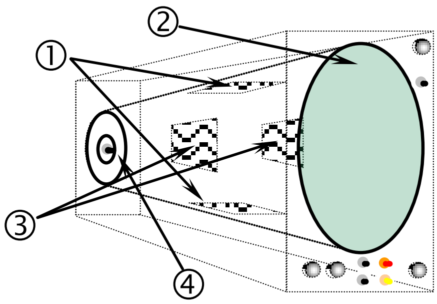


This diagram shows the fundamental components of an oscilloscope. Arrows point to these various components, numbered from ① to ④.

Which of the following answers correctly identifies what the numbers refer to?

	①	②	③	④
(A)	horizontal sweep	fluorescent screen	vertical sweep	electron-gun
(B)	vertical sweep	fluorescent screen	horizontal sweep	electron-gun
(C)	horizontal sweep	fluorescent screen	electron-gun	vertical sweep
(D)	electron-gun	horizontal sweep	fluorescent screen	vertical sweep

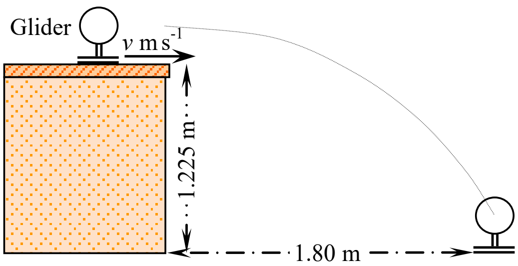
PART B (Questions 21 to 34)

ANSWER ALL QUESTIONS.

Show all working, including the appropriate formulae. Full marks may not be awarded if working is insufficient.

Marks

Question 21 (4 marks)



A frictionless glider is moving at a uniform speed v m s^{-1} across a smooth horizontal table 1.225 m high when it reaches the edge, and falls to the floor and lands 1.8 m away from the table.

(a) How long after leaving the table does it take to strike the floor? **2**

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(b) Calculate the speed, v, of the glider as it leaves the table. **2**

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Question 22 (7 marks) **Marks**

A 4.00 x 10^2 kg satellite completes one orbit around Earth in 2 hours exactly.

(a) Calculate the radius of this satellite's orbit. **2**

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(b) Calculate the gravitational force acting on the satellite. **2**

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(c) Explain the nature of the force (ie, its important characteristics) in relation to the motion of the satellite. **2**

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(d) Explain one important advantage of using multi-stage rockets to launch vehicles into space and beyond. **1**

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Question 23 (2 marks)

Calculate the gravitational potential energy of a binary star system consisting of two stars, each of mass 2×10^{30} kg, separated by a mean distance 150×10^{6} km.

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Question 24 (2 marks)

The half-life of a certain radioactive isotope is known to be 1 second when measured in a laboratory on Earth. However, when a stream of these isotopes is accelerated to a very high speed, the number of particles arriving at a particle detector reveals that their half-life is now measured as being 2 seconds.

If external influences and effects can be ignored, what is the speed of these particles? **2**

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Question 25 (5 marks) **Marks**

(a) Explain why a radial magnetic field improves the performance of a DC motor. **2**

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(b) Name a device that uses the motor effect (other than an electric motor), and with the aid of a diagram, describe how the motor effect is used. **3**

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Question 26 (3 Marks)

With the aid of a diagram, describe the concept of magnetic flux. Include an appropriate mathematical expression as part of your answer. **2**

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(b) With reference to the diagram you drew in part (a), describe one way how the size of the magnetic flux can be made to vary in magnitude. **1**

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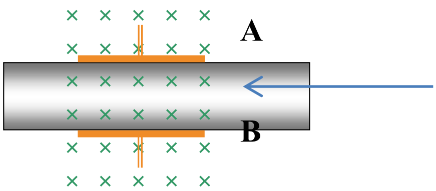
Question 27 (5 marks) **Marks**

A technique called magnetohydrodynamics, MHD, was trialled as a means of producing electricity directly from a nuclear reactor. Sodium, a metal that normally melts at 97.7^{0}C, is used as the coolant for the reactor core. It is trapped inside pressurised pipes, and forced through the reactor core. It heats up, turns to liquid, expands and forces its way through a powerful magnetic field (directed into the plane of the page, as shown in the diagram). **In other words, a liquid metal is moving relative to a magnetic field.** As a consequence**,** a potential difference is then generated between the plates.



(a) Identify the physics principle involved in MHD. **1**

(b) In the diagram above, identify which of the plates **A** or **B** would become charged negatively as the sodium flows in the direction marked. **1**

(c) Unfortunately the efficiency of MHD for generating electricity in this way is far too low to make it viable. However, applications of the principle described here, involving the forcing of a metal through a magnetic field to produce a potential difference are very common.
With the use of at least one labelled diagram to support your answer *explain* one example of using a magnetic field and a metal to produce electricity. Your answer must include how you would demonstrate that a current in an external circuit is produced. **3**

Question 28 (4 marks) **Marks**

Early investigations using cathode rays resulted in uncertainty as to their nature.
Explain how the behaviour of cathode rays indicates their properties. Include specific observations and why early observations made their nature uncertain. **4**

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Question 29 (4 Marks)

(a) Calculate the energy of a single photon having a wavelength of 550 nm. **2**

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Question 29 is continued on the next page -------------------->

Question 29 continued. **Marks**

(b) The Einstein photoelectric equation can be written as:

$$qV = E_k = hf - W$$

Where: E_k = maximum kinetic energy of the electron, 'q' is the charge on the electron, 'V' is the stopping voltage, and 'W' is the work function.

In a photoelectric effect experiment, the stopping voltage required of this wavelength of light (550 nm) was measured to be 0.46 V.

Calculate the work function for the metal being used in this experiment. **2**

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Question 30 (4 marks)

Early electronic appliances such as radios used thermionic devices which had severe limitations. The invention of the transistor resulted in the development of solid state devices that overcome these limitations.

Evaluate the advantages of solid state devices over thermionic devices in improving communication technologies. **4**

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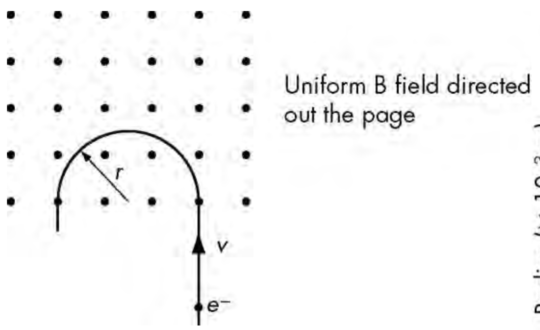
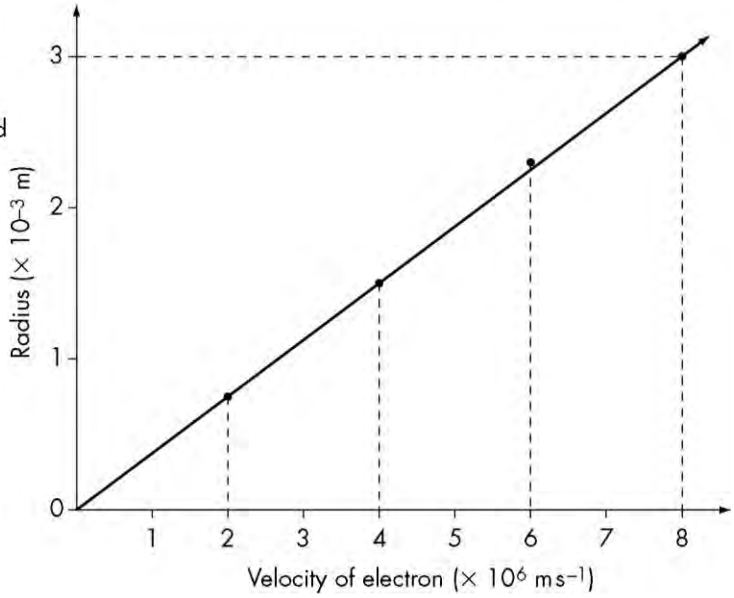
Question 31 (6 marks) **Marks**

A student uses a cathode gun to accelerate electrons to different velocities and then measures the radius of curvature of the path the electrons take in a magnetic field. The electrons enter the magnetic field at right angles to the field. A diagram of the experiment and a graph of the results obtained by the student are shown below.





(a) By equating the centripetal force and magnetic force on a charge moving at right angles to a magnetic field at a constant speed (v) **derive** a general expression for the radius of curvature of the charge in the field. **2**

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(b) Calculate the gradient and its units. Show all working. **2**

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(c) Calculate the strength of the magnetic field used in the experiment. **2**

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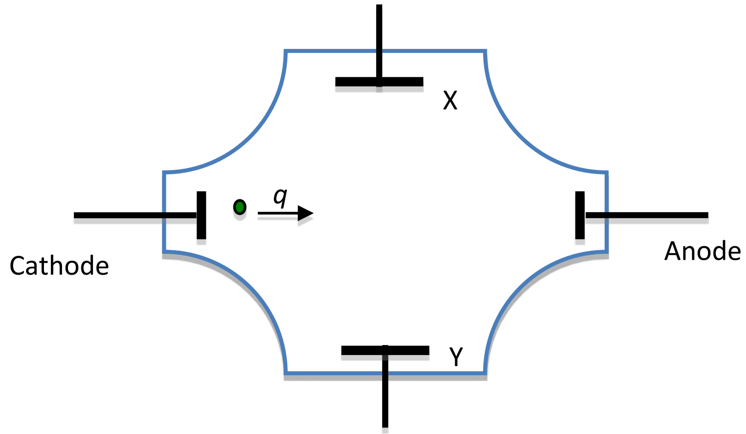
Question 32 (4 marks) **Marks**

(a) Discuss the effects of future applications of superconductivity on **either** generators or motors. **2**

(b) With reference to your answer in (a), explain giving TWO different reasons why such superconductivity applications have yet to be made on a large scale. **2**

Question 33 (5 marks)

A particle *q* with charge -2*e* is travelling from a cathode to anode inside the vacuum tube shown below. There are charged plates set up at X and Y.



(a) Describe and explain the path taken by *q* if a voltage of 24 000 V is put across **XY**, with **X** being positive. **2**

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(b) Calculate the electric field strength from XY given that 24 000 V is put across XY and the plate separation is 18 cm. **1**

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(c) *q is* travelling at 7×10^5 ms^{-1} . The experimenter then produces a uniform magnetic field ***B*** that is perpendicular to the electric field in such a way that makes *q* travel in a straight line between the electric plates. Calculate the required ***B**, including direction,* that achieves this. **2**

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Question 34 (5 marks) **Marks**

Section 9.4.2, column-3, dot-point 5 of the HSC Physics syllabus requires students to *"process information to discuss Einstein and Planck's differing views about whether science research is removed from social and political forces"*.

In order to obtain the financial support necessary to carry out research, scientists have three principal sources – government grants, industry and the military.

Discuss the potential limitations to scientists' freedom to research and publish their results posed by each of these sources. Your answer should include appropriate references to Einstein and Planck's differing views on this matter, and should also consider the work of some other scientists' and areas of research. **5**

END OF SECTION 1

Section II

20 marks
Attempt ONE question from Questions 35-40

Allow about 35 minutes for this section

Answer the question in a writing booklet.
Show all relevant working in questions involving calculations.

Marks

Question 35 Geophysics (20 marks)

(a) (i) Identify two uses of remote sensing of radiation in mineral exploration. **2**

(ii) Explain why remote sensing is often the preferred method over other methods when mineral exploration is undertaken. **2**

(b) The value of the gravitational acceleration on the surface of a newly discovered planet is 13.4 m s^{-2}. The diameter of the planet is 5.89 x 10^3 km.

Calculate the mass of this planet. **4**

(c) (i) Describe an investigation which models the way in which the inclination of Earth's magnetic field varies with latitude. **4**

Include a diagram to illustrate your answer.

(ii) Assess the validity of the model referred to in part (i). **3**

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(d) Describe the use of GPS in the providing on information about seafloor spreading. Then relate this to the use of satellites and GPS in mineral exploration. **5**

Marks

Question 36 Medical Physics (20 marks)

(a) (i) Compare the two types of beta emission that may occur when a radioactive isotope decays. **2**

(ii) Explain what happens to positrons when they are emitted within a human. **2**

(b) By selecting two suitable materials from the table provided, show how the reflected ultrasound signal has a low intensity compared to the incident signal intensity when the acoustic impedance of the two materials is similar. **3**

Material	**Acoustic impedance ($\times 10^6$ kg m^{-2} s^{-1})**
fat	1.38
tissue	1.63
blood	1.61
muscle	1.70
bone	5.6

(c) (i) Compare and contrast images produced by an endoscope with images produced by an X-ray. **3**

(ii) Describe the advantages of using an endoscope to obtain images of internal body organs. **2**

(d) Describe how the composition of the nuclei and the strength of the applied external magnetic field determine the frequency of precesssing of the nuclei. **3**

(e) Account for the use of Doppler ultrasound in the examination of patient heart valves. Then discuss a heart valve disease that can be examined using Doppler ultrasound and MRI. **5**

Marks

Question 37 Astrophysics (20 marks)

(a) (i) Describe the difference between intrinsic and extrinsic variable stars, giving examples of each. **2**

(ii) Identify the type of variable star that can have its light used to photometrically measure its distance and outline how this is done. **2**

(b) A pair of binary stars, "alpha" and "beta" have visual magnitudes of +12.5 and +15.7 respectively.

(i) How much is "alpha" brighter than "beta"? **2**

(ii) Explain why it is not possible to tell if "alpha" is closer than "beta" using this information alone. **2**

(c) (i) Describe a suitable method used for an investigation that would demonstrate why it is desirable to have a telescope with a large diameter objective lens or mirror. **3**

Use a diagram to illustrate your answer.

(ii) Outline how the validity of such an investigation could be ensured. **2**

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

(e) Why is the colour index of a star useful? **2**

(f) Assess the impact of moving from photographic film to computer technology in gathering astronomical data **3**

Question 38 From Quanta to Quarks (20 marks) **Marks**

(a) Rutherford and his colleagues conducted scattering experiments to help determine the structure of the atom.

(i) Describe important features of the atom that they identified from such scattering experiments. **1**

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(ii) Outline an important limitation of the Rutherford model of the atom. **1**

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(b) The **visible** colour of one of the Balmer spectral lines in the hydrogen spectrum is blue. Using this information alone, what must be its n_f in the Rydberg formula? **1**

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(c) Calculate the wavelength and frequency of light emitted when an electron moves from the n = 5 level to the n = 2 level of a Bohr hydrogen atom. **2**

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Question 38 continued:

(d) Describe how the concept of quantised energy fitted in with Bohr's postulates and how this in turn led to the mathematical model that he produced to account for the observed spectrum of hydrogen. **4**

(e) Explain how de Broglie's matter wave hypothesis was able to help explain the stability of electron orbits in the Bohr atomic model. **2**

This question continues on the next page ------------->

Question 38 continued.

(f) (i) de Broglie proposed that an electron moving with velocity of 2×10^8 m/s has wave properties. Calculate the value of the wavelength of such an electron. **1**

(ii) Account for why the effects of de Broglie's hypothesis about the wave nature of matter is not observed with larger objects (such as people). **1**

(g) Compare and contrast the properties of nucleons **2**

(h) Large unstable nuclei can become more stable by undergoing radioactive decay.

(i) Write a nuclear equation for the alpha decay of Americium- 241 **2**

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(ii) Is the above reaction an example of transmutation? Why or why not? **1**

(i) The neutrino was suggested by Pauli to account for an unsolved problem. Outline this problem and explain how the neutrino solves it. **2**

END OF QUESTION 38

Question 39 The Age of Silicon (20 marks)

(a) Write the truth table for the logical expression **Marks**

C = NOT (A OR B) **2**

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(b) Explain, giving examples, situations in which the use of an LED would be preferable to using an ordinary light source. **3**

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(c) (i) Draw a circuit diagram that could be used as a potential divider so that a potential of 2.5 mV is made available from a supply voltage of 10 V. **2**

(ii) Describe the role of transducers as an interface between the Environment and an electronic system. Include examples in your answer. **3**

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Question 39 continued on next page --------------->

Question 39 Continued. **Marks**

(d) With the use of an example to illustrate your answer, discuss how feedback can be used in a control system. **4**

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(e) The ability to manipulate and store large quantities of data has increased dramatically over the past two decades. Describe the advances in semiconductor production and technology that has allowed for this increased ability and explain how these changes have led to new consumer electronic devices. **6**

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END OF QUESTION 39

 Student Number

Newington College

IN FIDE SCIENTIAM

2013 PHYSICS TRIAL EXAMINATION

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 ◯

DATA SHEET

Charge on electron, q_e	-1.602×10^{-19} C
Mass of electron, m_e	9.109×10^{-31} kg
Mass of neutron, m_n	1.675×10^{-27} kg
Mass of proton, m_p	1.673×10^{-27} kg
Speed of sound in air	340 m s^{-1}
Earth's gravitational acceleration, g	9.8 m s^{-2}
Speed of light, c	3.00×10^{8} m s^{-1}
Magnetic force constant, $\left(k \equiv \frac{\mu_0}{2\pi}\right)$	2.0×10^{-7} N A^{-2}
Universal gravitational constant, G	6.67×10^{-11} N m^2 kg^{-2}
Mass of Earth	6.0×10^{24} kg
Planck constant, h	6.626×10^{-34} J s
Rydberg constant, R (hydrogen)	1.097×10^{7} m^{-1}
Atomic mass unit, u	1.661×10^{-27} kg 931.5 MeV/c^2
1 eV	1.602×10^{-19} J
Density of water, ρ	1.00×10^{3} kg m^{-3}
Specific heat capacity of water	4.18×10^{3} J kg^{-1} K^{-1}

FORMULAE SHEET

$$v = f\lambda$$

$$I \propto \frac{1}{d^2}$$

$$\frac{v_1}{v_2} = \frac{\sin i}{\sin r}$$

$$E = \frac{F}{q}$$

$$R = \frac{V}{I}$$

$$P = VI$$

$$\text{Energy} = VIt$$

$$v_{\text{av}} = \frac{\Delta r}{\Delta t}$$

$$a_{\text{av}} = \frac{\Delta v}{\Delta t} \text{ therefore } a_{\text{av}} = \frac{v-u}{t}$$

$$\Sigma F = ma$$

$$F = \frac{mv^2}{r}$$

$$E_k = \frac{1}{2}mv^2$$

$$W = Fs$$

$$p = mv$$

$$\text{Impulse} = Ft$$

$$E_p = -G\frac{m_1 m_2}{r}$$

$$F = mg$$

$$v_x{}^2 = u_x{}^2$$

$$v = u + at$$

$$v_y{}^2 = u_y{}^2 + 2a_y \Delta y$$

$$\Delta x = u_x t$$

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

$$\frac{r^3}{T^2} = \frac{GM}{4\pi^2}$$

$$F = \frac{Gm_1 m_2}{d^2}$$

$$E = mc^2$$

$$l_v = l_0\sqrt{1-\frac{v^2}{c^2}}$$

$$t_v = \frac{t_0}{\sqrt{1-\frac{v^2}{c^2}}}$$

$$m_v = \frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}}$$

FORMULAE SHEET

$$\frac{F}{l} = k\frac{I_1 I_2}{d}$$

$$F = BIl\sin\theta$$

$$\tau = Fd$$

$$\tau = nBIA\cos\theta$$

$$\frac{V_p}{V_s} = \frac{n_p}{n_s}$$

$$F = qvB\sin\theta$$

$$E = \frac{V}{d}$$

$$E = hf$$

$$c = f\lambda$$

$$Z = \rho v$$

$$\frac{I_r}{I_0} = \frac{\left[Z_2 - Z_1\right]^2}{\left[Z_2 + Z_1\right]^2}$$

$$d = \frac{1}{p}$$

$$M = m - 5\log\left(\frac{d}{10}\right)$$

$$\frac{I_A}{I_B} = 100^{(m_B - m_A)/5}$$

$$m_1 + m_2 = \frac{4\pi^2 r^3}{GT^2}$$

$$\frac{1}{\lambda} = R\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$$

$$\lambda = \frac{h}{mv}$$

$$A_0 = \frac{V_{\text{out}}}{V_{\text{in}}}$$

$$\frac{V_{\text{out}}}{V_{\text{in}}} = -\frac{R_{\text{f}}}{R_{\text{i}}}$$

PERIODIC TABLE OF THE ELEMENTS

KEY

Atomic Number Atomic Weight	79 Au 197.0 Gold	Symbol of element Name of element

1 H 1.008 Hydrogen																	2 He 4.003 Helium
3 Li 6.941 Lithium	4 Be 9.012 Beryllium											5 B 10.81 Boron	6 C 12.01 Carbon	7 N 14.01 Nitrogen	8 O 16.00 Oxygen	9 F 19.00 Fluorine	10 Ne 20.18 Neon
11 Na 22.99 Sodium	12 Mg 24.31 Magnesium											13 Al 26.98 Aluminium	14 Si 28.09 Silicon	15 P 30.97 Phosphorus	16 S 32.07 Sulfur	17 Cl 35.45 Chlorine	18 Ar 39.95 Argon
19 K 39.10 Potassium	20 Ca 40.08 Calcium	21 Sc 44.96 Scandium	22 Ti 47.87 Titanium	23 V 50.94 Vanadium	24 Cr 52.00 Chromium	25 Mn 54.94 Manganese	26 Fe 55.85 Iron	27 Co 58.93 Cobalt	28 Ni 58.69 Nickel	29 Cu 63.55 Copper	30 Zn 65.41 Zinc	31 Ga 69.72 Gallium	32 Ge 72.64 Germanium	33 As 74.92 Arsenic	34 Se 78.96 Selenium	35 Br 79.90 Bromine	36 Kr 83.80 Krypton
37 Rb 85.47 Rubidium	38 Sr 87.62 Strontium	39 Y 88.91 Yttrium	40 Zr 91.22 Zirconium	41 Nb 92.91 Niobium	42 Mo 95.94 Molybdenum	43 Tc [97.91] Technetium	44 Ru 101.1 Ruthenium	45 Rh 102.9 Rhodium	46 Pd 106.4 Palladium	47 Ag 107.9 Silver	48 Cd 112.4 Cadmium	49 In 114.8 Indium	50 Sn 118.7 Tin	51 Sb 121.8 Antimony	52 Te 127.6 Tellurium	53 I 126.9 Iodine	54 Xe 131.3 Xenon
55 Cs 132.9 Caesium	56 Ba 137.3 Barium	57–71 Lanthanoids	72 Hf 178.5 Hafnium	73 Ta 180.9 Tantalum	74 W 183.8 Tungsten	75 Re 186.2 Rhenium	76 Os 190.2 Osmium	77 Ir 192.2 Iridium	78 Pt 195.1 Platinum	79 Au 197.0 Gold	80 Hg 200.6 Mercury	81 Tl 204.4 Thallium	82 Pb 207.2 Lead	83 Bi 209.0 Bismuth	84 Po [209.0] Polonium	85 At [210.0] Astatine	86 Rn [222.0] Radon
87 Fr [223] Francium	88 Ra [226] Radium	89–103 Actinoids	104 Rf [261] Rutherfordium	105 Db [262] Dubnium	106 Sg [266] Seaborgium	107 Bh [264] Bohrium	108 Hs [277] Hassium	109 Mt [268] Meitnerium	110 Ds [271] Darmstadtium	111 Rg [272] Roentgenium							

Lanthanoids

57 La 138.9 Lanthanum	58 Ce 140.1 Cerium	59 Pr 140.9 Praseodymium	60 Nd 144.2 Neodymium	61 Pm [145] Promethium	62 Sm 150.4 Samarium	63 Eu 152.0 Europium	64 Gd 157.3 Gadolinium	65 Tb 158.9 Terbium	66 Dy 162.5 Dysprosium	67 Ho 164.9 Holmium	68 Er 167.3 Erbium	69 Tm 168.9 Thulium	70 Yb 173.0 Ytterbium	71 Lu 175.0 Lutetium

Actinoids

89 Ac [227] Actinium	90 Th 232.0 Thorium	91 Pa 231.0 Protactinium	92 U 238.0 Uranium	93 Np [237] Neptunium	94 Pu [244] Plutonium	95 Am [243] Americium	96 Cm [247] Curium	97 Bk [247] Berkelium	98 Cf [251] Californium	99 Es [252] Einsteinium	100 Fm [257] Fermium	101 Md [258] Mendelevium	102 No [259] Nobelium	103 Lr [262] Lawrencium

For elements that have no stable or long-lived nuclides, the mass number of the nuclide with the longest confirmed half-life is listed between square brackets.

The International Union of Pure and Applied Chemistry Periodic Table of the Elements (October 2005 version) is the principal source of data. Some data may have been modified.

Newington College

150TH ANNIVERSARY 1863–2013

IN FIDE SCIENTIAM

2013 Year 12
TRIAL HSC Examination

PHYSICS SOLUTIONS

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 a sharp pencil and ruler
- A Data and Formula Sheet is provided.
- Write your Student Number at the top of each page.

Total marks – 100

Section I

80 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 – 60 marks

- Attempt Questions 21-34
- Allow about 1 hour and 50 minutes for this part

Section II

20 marks

- Candidates are to answer ONE question only. Write answers in the space provided.

Allow about 35 minutes for this section

Section I

80 marks

Part A – 20 marks

Attempt Questions 1-20

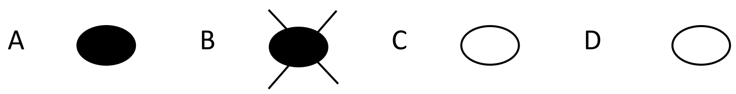
Allow about 35 minutes for this part

Use the multiple-choice answer sheet.

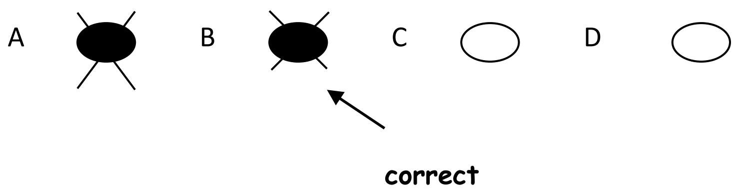
Select the alternative A,B,C or D that best answers the question. Fill in the response oval completely.

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.



Part A: Multiple Choice

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1. The gravitational potential energy of an object near Earth's surface is changed when you:

(A) apply a horizontal net force on the object.

(B) allow the object to fall down 5 metres.

(C) hold the object stationary in the air.

(D) ensure the net force on the object remains zero.

2. A material become a superconductor when:

(A) all atomic motion ceases in the material except for electrons.

(B) the electrons cease moving in the lattice structure.

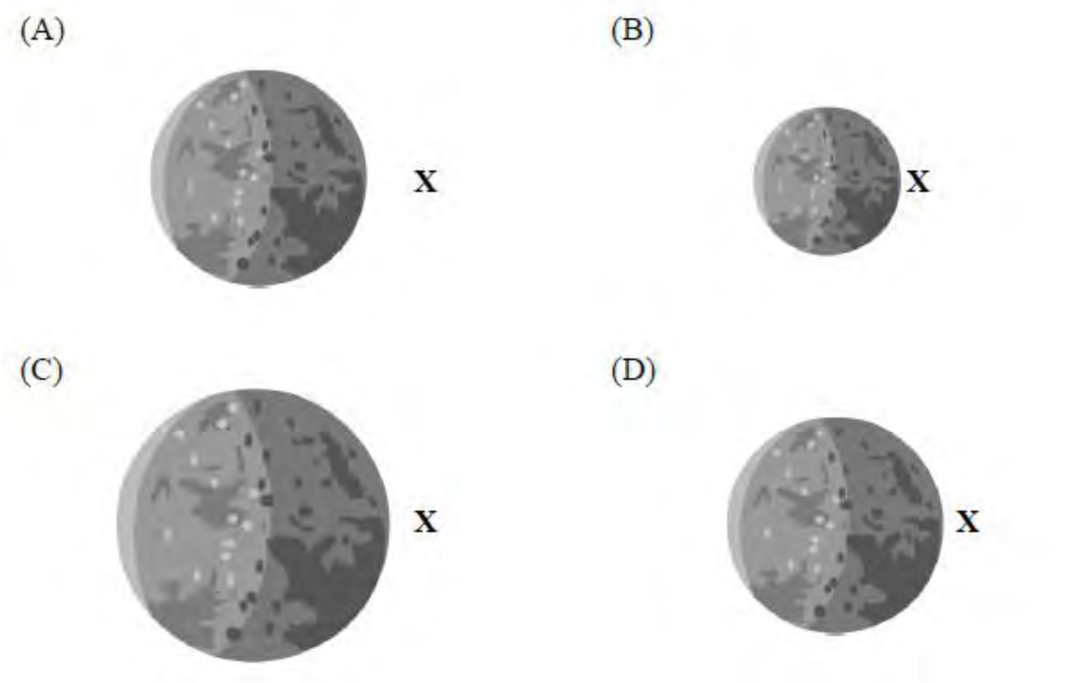
(C) the electrons all line up and move in one line through the material.

(D) electrons pair up and move unimpeded through the material.

3. A gaseous planet expands and contracts in size while maintaining the same mass.

In which diagram is the object at "**X**" experiencing the greatest gravitational force?

The diagrams are to scale. **CORRECT ANSWER IS B**



4. The aether model for the transmission of light was popular in the 19^{th} century. Such a model was developed because it was believed:

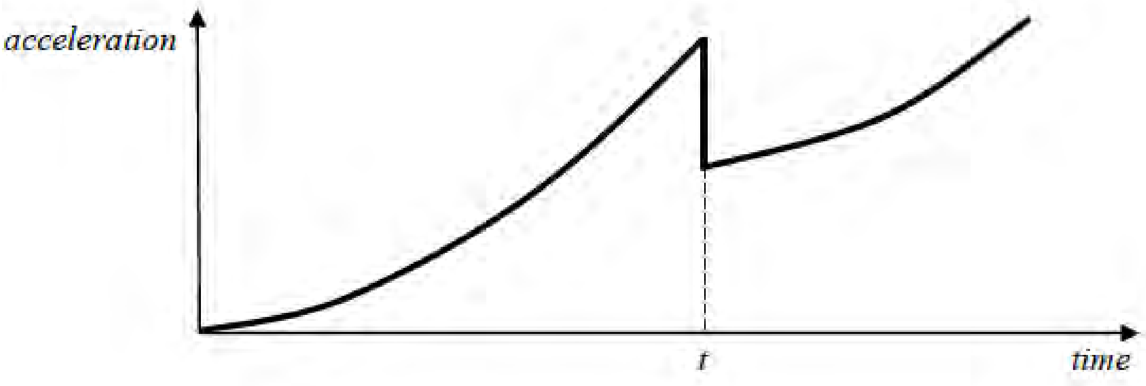
(A) particles could not travel through solids.

(B) the Earth would otherwise move away from the Sun.

(C) light travelled at a constant speed.

(D) all waves needed a medium to travel through.

5. The acceleration of a rocket being used to transport astronauts to the International Space Station is shown for the minutes just after launch:



At time *t*, the astronauts:

(A) feel momentarily weightless.

(B) feel a sudden increase in their apparent weight.

(C) feel no effect as they are still in Earth's gravity.

(D) feel a reduction in their apparent weight.

6. The concept of time dilation is a direct consequence of

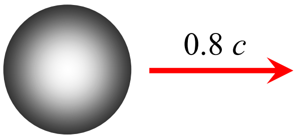
(A) the constancy of the speed of light in a vacuum.

(B) the equivalence of mass and energy.

(C) the aether effect

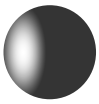
(D) nothing being able to exceed the speed of light.

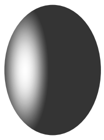
7. .

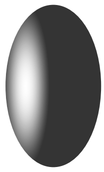


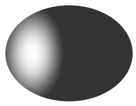
Consumed by his implacable hatred for Earthlings the Zaxxon Warlord launched a solid metal sphere at 0.8 *c* directly at our planet. It missed. However, a photograph was taken by one of Earth's space cameras as evidence for the Intergalactic Court.

Which of the following diagrams would most closely resemble the photographic image?

(A) 

(B) 

(C) 

(D) 

CORRECT ANSWER TO Q 7 IS B

8. Hertz observed the photoelectric effect in his experiments with radio waves but he did not investigate this phenomenon further.

What did Hertz observe in relation to the photoelectric effect?

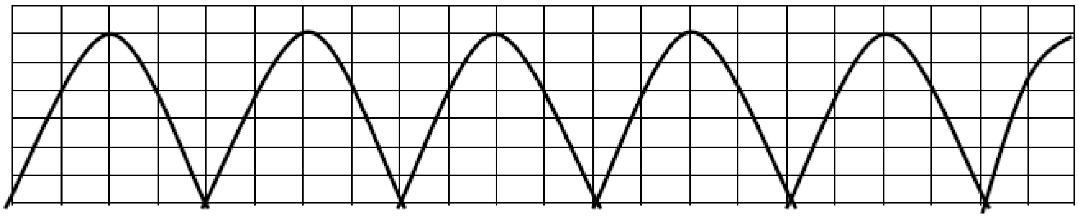
(A) Sparks could be made to jump a gap in another coil at a distance.

(B) The gap that sparks could jump across is larger when exposed to light.

(C) The radio waves producing the spark carried energy.

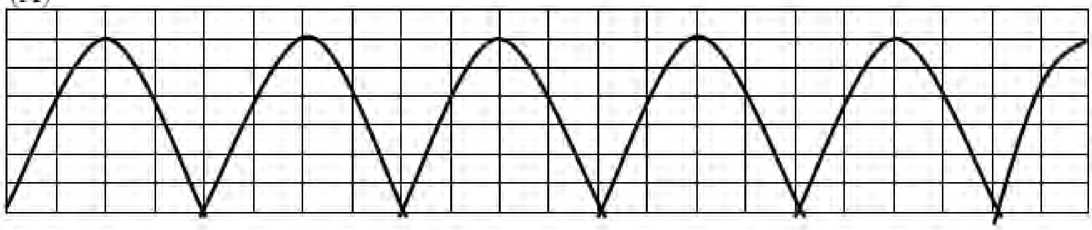
(D) The radio waves travelled at the speed of light.

9. A hand-turned generator has its outputs connected to a cathode ray oscilloscope (CRO). The CRO screen appears below:

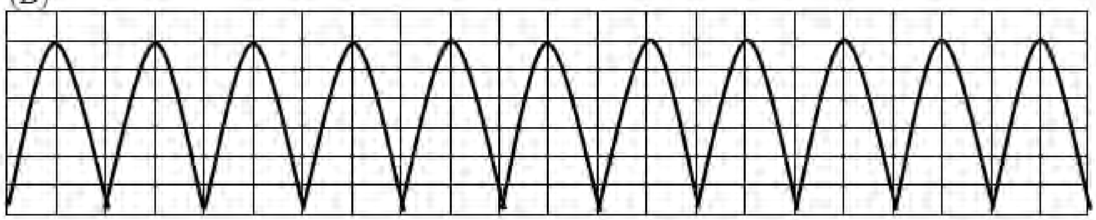


When the same generator is turned at a faster rate, the CRO output with the same settings would appear most similar to:

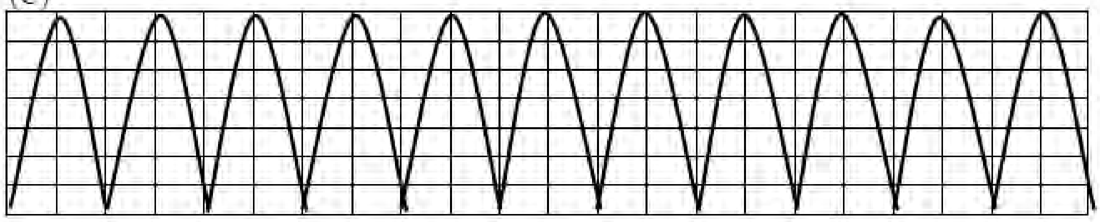
(A)



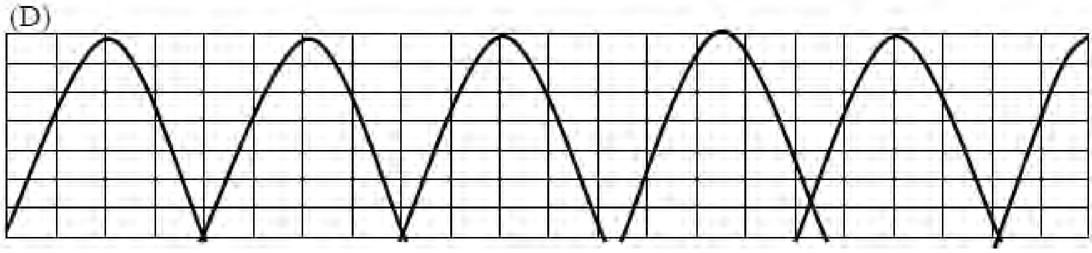
(B)



(C)

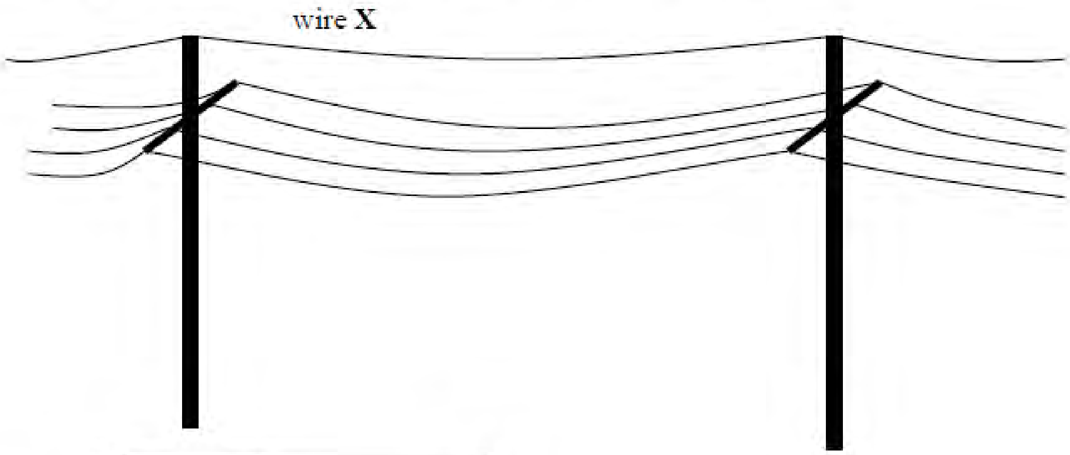


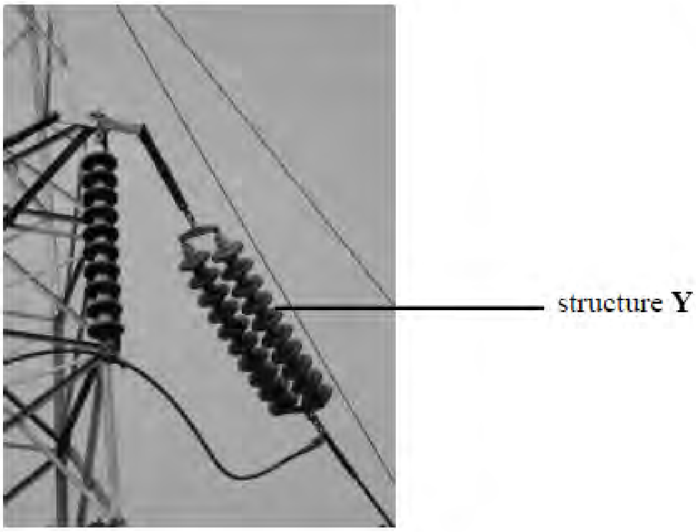
(D)



ANSWER TO Q 9 IS C

10. Wire **X** and structure **Y** are shown in the illustrations below:





The purposes of the wires and structure are:

	Purpose of Wire X	Purpose of structure Y
(A)	protect wires from lightning	insulate supporting tower from wires
(B)	insulate supporting tower from wires	protect wires from lightning
(C)	returns the current in the wires to the power station	insulate supporting tower from wire
(D)	attracts lightning to the wire	prevents surges in voltage in wires

11. The maximum torque produced by a single-coil DC motor is 2.8 N m.

This torque could be produced if the motor had 200 turns on the coil and:

	Magnetic field intensity (T)	**Current in coil (A)**	**Dimensions of rectangular coil (cm x cm)**
(A)	0.10	5.0	10 x 20
(B)	1.0×10^{-3}	0.07	10 x 20
(C)	2.0×10^{-4}	0.5	10 x 15
(D)	0.10	7.0	10 x 20

12. An ideal transformer has 4000 turns on the primary coil and 250 turns on the secondary coil.

The input and output voltages for this transformer could be:

	Input voltage (volts)	**Output voltage (volts)**
(A)	2 000	32 000
(B)	1 600	10
(C)	32 000	2 000
(D)	20	100 000

13. A piece of silicon is doped with an element from group V of the periodic table.

Which statement below is most correct?

(A) The material becomes positively charged

(B) The material becomes negatively charged

(C) The material has no overall charge

(D) The material is now classified as a *conductor*.

14. In an experiment to demonstrate the photoelectric effect, it was found that when light with a frequency f and an intensity I was shone on the cathode, the voltage needed to completely stop the photoelectric current was V volts.

The effect of increasing the incident light **intensity** shining on the cathode is that the voltage V needed to be:

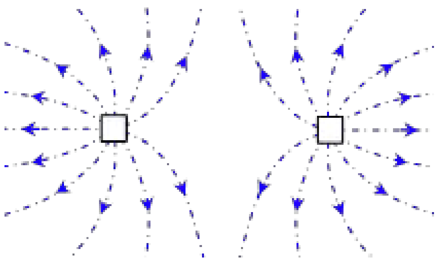
(A) dropped to zero.

(B) increased.

(C) kept the same.

(D) decreased.

15.



This diagram shows a rough 2-dimensional representation of a 3-dimensional field.

Which of the following alternatives best identifies which type of field it could be?

(A) An electric field around two objects carrying equal like charges

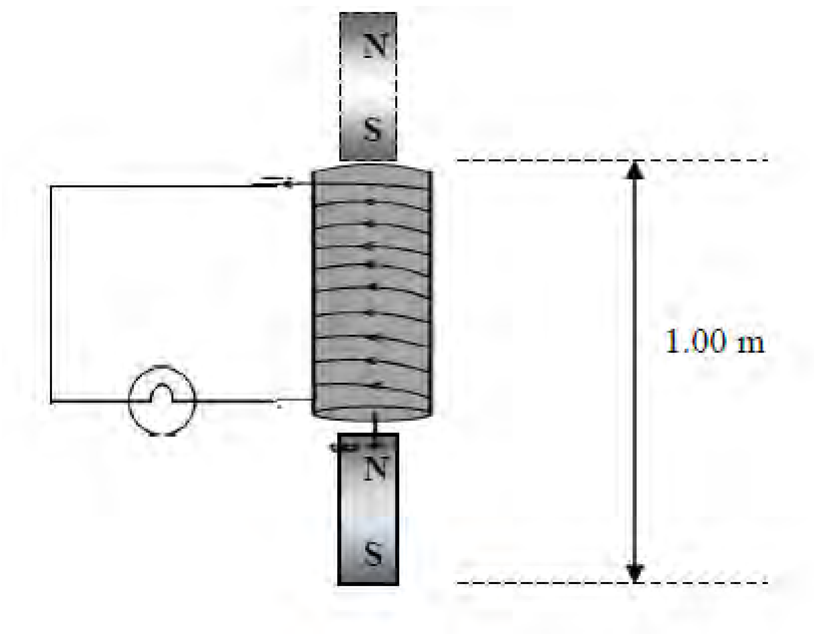
(B) A magnetic field around two like magnetic poles of equal strength

(C) A gravitational field around two objects in space with identical masses

(D) The field shown here would correctly represent two of these alternatives.

16. A 100 g bar magnet is released from rest and falls vertically through a small coil connected to a light globe, as shown. The wires have negligible resistance.

After falling through a height of 1.00 m, the bar magnet is moving at 3.8 m s^{-1}.



How much electrical energy was converted to other forms of energy by the light globe?

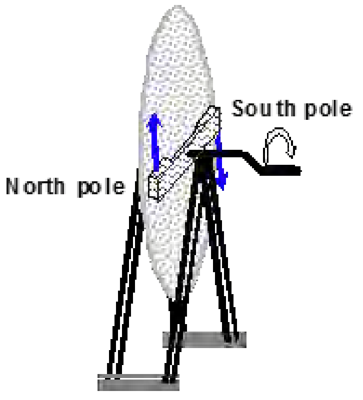
(A) 0.38 J

(B) 3.7 J

(C) 0.72 J

(D) 0.26 J

Questions 17 and 18 refer to the information below:



The device shown in this diagram is called an Aragó disc. The actual disc is a circular plate made of aluminium or copper, which can rotate freely on a crank handle. There is a long horseshoe magnet attached to the crank handle, so when it is turned the poles of the magnet move across the surface of the plate, which is observed to rotate in the same direction as the magnet is moving.

17. Why does the copper or aluminium disc turn while the magnet continues to rotate as the handle is turned?

(A) The metal of the disc is attracted by the moving magnet

(B) Since the crank handle cannot be frictionless, the disc turns by the friction

(C) The changing field induces an emf that opposes the motion of the magnets

(D) The magnet's poles attract or repel electrons as they move across the metal.

18. The Arago disc is an excellent example of a significant principle of physics.

Which of the following principles does it show?

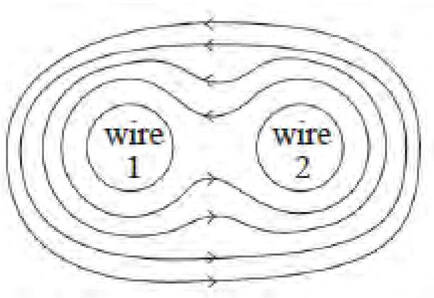
(A) Ohm's Law

(B) The motor effect

(C) The law of conservation of momentum

(D) The principle of an AC induction motor

19. The following diagram shows magnetic field lines around two current-carrying wires.



Which statement describes the direction of the current AND the force between the wires?

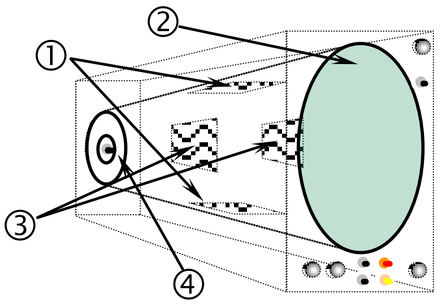
(A) The currents are flowing in the same direction; the force between them is attractive

(B) The currents are flowing in the same direction; the force between them is repulsive

(C) The currents are flowing in opposite directions; the force between them is attractive

(D) The currents are flowing in opposite directions; the force between them is repulsive

20.



This diagram shows the fundamental components of an oscilloscope. Arrows point to these various components, numbered from ① to ④.

Which of the following answers correctly identifies what the numbers refer to?

	①	②	③	④
(A)	horizontal sweep	fluorescent screen	vertical sweep	electron-gun
(B)	vertical sweep	fluorescent screen	horizontal sweep	electron-gun
(C)	horizontal sweep	fluorescent screen	electron-gun	vertical sweep
(D)	electron-gun	horizontal sweep	fluorescent screen	vertical sweep

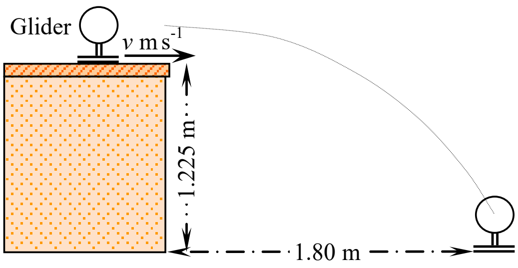
PART B (Question 21 to 34)

ANSWER ALL QUESTIONS.

Show all working, including the appropriate formulae. Full marks may not be awarded if working is insufficient.

Marks

Question 21 (4 marks)



A frictionless glider is moving at a uniform speed v m s^{-1} across a smooth horizontal table 1.225 m high when it reaches the edge, and falls to the floor and lands 1.8 m away from the table.

(a) How long after leaving the table does it take to strike the floor? **2**

Vertical motion: $\Delta y = -1.225\ m \quad u_y = 0 \quad a_y = -9.8\ m\,s^{-2} \quad \Delta y = u_y t + ½ a_y t^2$

$\therefore -1.225 = 0 - 4.9\,t^2 \qquad \therefore t = 0.5\ s.$

(1 mark for correct substitution into formula, 1 mark for correct answer. Units not penalised)

NOTE: acceleration due to gravity does not have to be negative, as there is only one direction in this particular problem.

(b) Calculate the speed, v, of the glider as it leaves the table. **2**

Horizontal motion: $\Delta x = 1.8\ m \quad u_y = ? \quad a_y = 0\ m\,s^{-2} \quad \Delta x = u_x t$

$\therefore 1.8 = u_x\, 0.5 \qquad u_x = 3.6\ m\,s^{-1}.$

(1 mark for correct substitution, 1 mark for correct answer)

Question 22 (8 marks) **Marks**

A 4.00 x 10^2 kg satellite completes one orbit around Earth in 2 hours exactly.

(a) Calculate the radius of this satellite's orbit. **2**

T = 2 x 60 x 60 = 7200 s

$$\frac{r^3}{T^2} = \frac{GM}{4\pi^2}$$
$$r = \sqrt[3]{\frac{GM}{4\pi^2} \times T^2}$$
$$= \sqrt[3]{\frac{(6.67\times10^{-11})\times(6.0\times10^{24})}{4\pi^2} \times (7200^2)}$$
$$= 8.1\times10^6 \text{ m}$$

Marking Criteria	Marks
• Correct answer calculated. (units not graded)	2
• Correct substitution or error made with metric conversion	1

(b) Calculate the gravitational force acting on the satellite. **2**

$$F = G\frac{m_1 m_2}{d^2}$$
$$= 6.67\times10^{-11} \frac{(4.00\times10^2)\times(6.0\times10^{24})}{(8.07\times10^6)^2}$$
$$= 2.46\times10^3 \text{ N}$$

Note: allow carry-over error from part (a).

(1 mark for correct formula selection and substitution, and one mark for correct answer. Direction not necessary to gain full marks)

(c) Explain the nature of the force (ie, its important characteristics) in relation to the motion of the satellite. **2**

Marking Criteria	Marks
• All appropriate reasons given	2
• One appropriate reason given	1

Sample answer: Satellite's orbit is circular and the net force (gravitational force) is always perpendicular to the direction of motion and directed to the centre of the Earth, i.e. the centre of the orbital path. (ie, the gravitational force provides the necessary centripetal force, directed towards the centre of the Earth)

Question 22 continued **Marks**

(d) Explain one important advantage of using multi-stage rockets to launch vehicles into space and beyond. **1**

Criteria	*Marks*
• ***Describing that an empty stage can be abandoned and less mass to carry***	***1***

Sample answer

Once the fuel inside a rocket motor is exhausted, the motor is 'dead-weight', and a great deal of energy would be wasted to carry it further, so the 'stage' is allowed to drop away.

Question 23 (2 marks)

Calculate the gravitational potential energy of a binary star system consisting of two stars, each of mass 2×10^{30} kg, separated by mean distance 150×10^{6} km. **2**

$$E_p = \frac{-GM_1M_2}{r}$$
$$= 1.78 \times 10^{39} \text{ J}$$

Criteria	**Marks**
Uses formula correctly **Correct answer found** **Units correct**	**2**
Correct substitution and units	**1**

Question 24 (2 marks)

The half-life of a certain radioactive isotope is known to be 1 second when measured in a laboratory on Earth. However, when a stream of these isotopes is accelerated to a very high speed, the number of particles arriving at a particle detector reveals that their half-life is now measured as being 2 seconds.

If external influences and effects can be ignored, what is the speed of these particles? **2**

criteria	marks
Correct answer obtained	2
Correct values of t_v and t_0 Correct formula Mathematical error in answer	1

This is an example of time dilation.

$$t_v = \frac{t_0}{\sqrt{1 - \frac{v^2}{c^2}}}$$

t_v = 2 seconds ***t_0 = 1 second***

substitute into time dilation formula to obtain v = 0.866 c

Question 25 (5 marks) **Marks**

(a) Explain why a radial magnetic field improves the performance of a DC motor. **2**

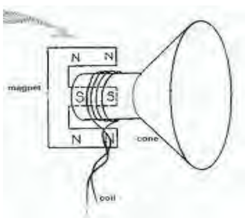
Marking Criteria	*Marks*
• *Explanation refers to the interaction of the field and current* *AND* • *Reference to maximum torque being extended*	*2*
• *One of the above*	*1*

Sample answer: With a radial magnetic field, the field lines are perpendicular to the current in the coil for a greater part of one whole revolution of the coil rather than at only one instance every half turn. This allows for the maximum torque to be produced for a greater percentage of the time the motor is operating.

(b) Name a device that uses the motor effect (other than an electric motor), and with the aid of a diagram, describe how the motor effect is used. **3**

Marking Criteria	**Marks**
• An appropriate device is identified AND • reference is made to the application of the motor effect AND • diagram is provided that assists in explanation	**3**
• An appropriate device is identified AND • reference is made to the application of the motor effect OR • diagram is provided that assists in explanation	**2**
• Appropriate device is identified	**1**

Sample answer:



e.g. loudspeaker : a coil that is connected to the output signal is wrapped around a magnet. Current in the coil causes motion of the coil due to the interaction with the magnetic field from the magnet, as shown. The coil is attached to the cone which vibrates with the coil and produces sound waves in the air. (NB other loudspeaker types also accepted.)

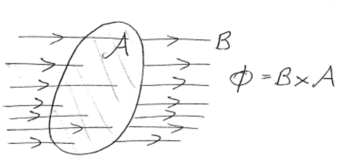
Other possible answer: galvanometer

Question 26 (3 Marks)

With the aid of a diagram, describe the concept of magnetic flux. Include an appropriate mathematical expression as part of your answer. **2**

Marking Criteria	Marks
• Magnetic flux related to flux density and surface area clearly • Diagram used correctly	2
• Magnetic flux related to flux density and surface area OR • Diagram used to show flux concept of magnetic flux	1

Sample answer:



Magnetic flux can be visualised as the number of magnetic field lines passing through an area. It is the product of the magnetic flux density B and the cross-sectional area, A: Φ = BA

(b) With reference to the diagram you drew in part (a), describe ONE way how the size of the magnetic flux can be made to vary in magnitude. **1**

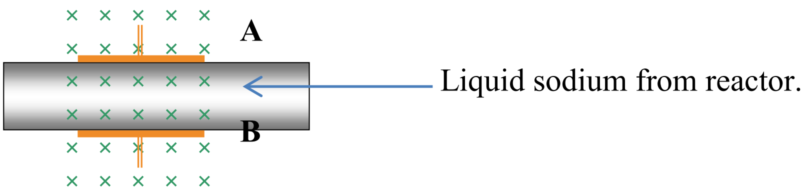
The number of magnetic field lines passing through the area could be increased, which would then increase the flux.

OR

The size of the area could also be increased, which would increase the flux.

Question 27 (5 marks) **Marks**

A technique called magnetohydrodynamics, MHD, was trialled as a means of producing electricity directly from a nuclear reactor. Sodium, a metal that normally melts at 97.7^0C, is used as the coolant for the reactor core. It is trapped inside pressurised pipes, and forced through the reactor core. It heats up, turns to liquid, expands and forces its way through a powerful magnetic field (directed into the plane of the page as shown in the diagram). **In other words, a liquid metal is moving relative to a magnetic field.** As a consequence potential difference is then generated between the plates.



(a) Identify the physics principle involved in MHD. **1**

EM induction or Faradays' Law or Lenz's Law (1 mark)

(b) In the diagram above, identify which of the plates **A** or **B** would become charged negatively as the sodium flows in the direction marked. **1**

The plate A becomes negative (1 mark)

(c) Unfortunately the efficiency of MHD for generating electricity in this way is far too low to make it viable. However, applications of the principle described here, involving the forcing of a metal through a magnetic field to produce a potential difference is very common.

With the use of at least one labelled diagram to support your answer *explain* one example of using a magnetic field and a metal. Your answer must include how you might demonstrate that a current in an external circuit is produced. **3**

Criteria	*Marks*
• ***An appropriate labelled diagram*** • ***A clear identification that the conductor must move relative to the field*** • ***An explanation of how the current is demonstrated (eg: use of galvanometer or a globe in external circuit)***	*3*
• ***One of the above required outcomes is missing***	*2*
• ***A reasonable, appropriate diagram, labelled or otherwise, <u>or</u>*** • ***A correct statement about generating electricity, apart from 'Faraday's law'***	*1*

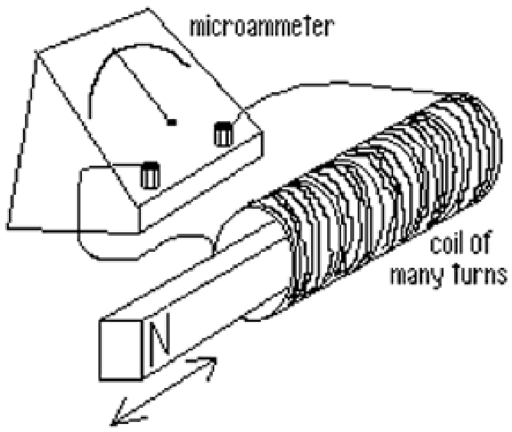
<u>Sample answer:</u>

A magnet is moved in and out of a solenoid coil.

If the solenoid is then connected to a galvanometer to make a full circuit, a current will be recorded on this device.

This occurs due to there being relative motion between the (metal) coil and the magnet.

Diagram:



Another acceptable answer would be to draw and label a generator, and explain how the rotating coil undergoes a change in mag flux to generate PD (and a current if in a complete circuit).

Other options also include: electromagnetic braking, induction cooktops (AC), transformers(AC)

Question 28 (4 marks) **Marks**

Early investigations using cathode rays resulted in uncertainty as to their nature.

Explain how the behaviour of cathode rays indicates their properties. Include specific observations and why early observations made their nature uncertain. **4**

Marking Criteria	*Marks*
• *Appropriate observations linked and related to explain the properties of cathode rays thoroughly* • *There must be four such appropriate observations with the associated conclusions drawn from them* • *Reasons for early uncertainty of nature outlined clearly* • *Response is in a logical and sequential manner*	*4*
• *Appropriate observations related to properties of cathode rays* • *Reasons for early uncertainty of nature identified*	*3*
• *An observation linked to a property of cathode rays*	*2*
• *A characteristic or property of cathode rays identified*	*1*

Observation of behaviour of cathode rays	*Property responsible for behaviour and conclusion drawn*
Travelled in straight lines/cast a shadow	*Particle nature and also wave nature – so no conclusion drawn*
Were deflected by a magnetic field	*Possessed a charge (and therefore must be particles)*
Were not deflected by an electric field in early investigations	*Must be a wave without a charge*
Were deflected by an electric field in later studies with better vacuums in the CRT	*Possessed a charge and must be particles*
Were able to rotate a paddle wheel	*Possessed momentum – must have mass and therefore be particles*

NOT: 'travels slower than light', as this is not an observation per se (it is a calculation based on data obtained)

Also, many candidates confused Hertz and Rutherford with regard to penetration of metal foils and various scattering experiments. Be very careful!

Question 29 (4 Marks)

(a) Calculate the energy of a single photon having a wavelength of 550 nm. **2**

Marking Criteria	*Marks*
• *Correct answer provided*	*2*
• *A correct step in the calculation is performed or a single error made*	*1*

$$E = hf \quad \text{and as} \quad v = f\lambda;\ f = \frac{v}{\lambda} = \frac{c}{\lambda}$$

$$\text{so: } E = hf$$
$$= h\frac{c}{\lambda}$$
$$= 6.626\times10^{-34}\times\frac{3.00\times10^{8}}{550\times10^{-9}}$$
$$= 3.61\times10^{-19}\ \text{J}$$

(b) The Einstein photoelectric equation can be written as:

$$qV = E_k = hf - W$$

Where: E_k = maximum kinetic energy of the electron, 'q' is the charge on the electron, 'V' is the stopping voltage, and 'W' is the work function.

In a photoelectric effect experiment, the stopping voltage required of this wavelength of light was measured to be 0.46 V.

Calculate the work function for the metal being used in this experiment. **2**

Marking Criteria	*Marks*
• *Correct answer calculated with appropriate unit given*	*2*
• *Appropriate equation used with an error made or incorrect units or no units given*	*1*

$$E_{k\ \max} \text{ of photoelectron} = hf - \Phi$$
$$\Phi = hf - E_{k\ \max}$$
$$= 3.61\times10^{-19} - (0.46\times1.6\times10^{-19})$$
$$= 2.87\times10^{-19}\ \text{J}$$

Several candidates made errors with metric conversions.

Also note: do not include the negative sign for the electron when using W = qV. This will lead you to make errors when you then use your answer in the final calculation for work function.

Question 30 (4 marks)

Early electronic devices used thermionic devices which had severe limitations. The invention of the transistor resulted in the development of solid state devices that overcome these limitations.

Evaluate the advantages of solid state devices over thermionic devices in improving communication technologies. **4**

Marking Criteria	*Marks*
• *Advantages of solid state devices evaluated thoroughly* • *response is in a logical, coherent and sequential style* • *a clear and separate evaluation statement made*	*4*
• *Advantages of solid state devices outlined* • *Evaluation attempted*	*3*
• *Several aspects of solid state devices identified*	*2*
• *An advantage of solid state devices identified*	*1*

Sample answer:

Thermionic devices	*Solid state devices*
bulky and heavy – hard to carry around	*much smaller and lighter – miniaturisation possible*
delicate glass vacuum tubes easily broken	*robust – can withstand impacts*
high power requirement with high voltage	*much lower power needed and lower voltages*
much heat emitted	*little heat emitted*
take some time to warm up before being used	*work instantly*
unreliable – "valves" have short working life	*very reliable – long life of devices*

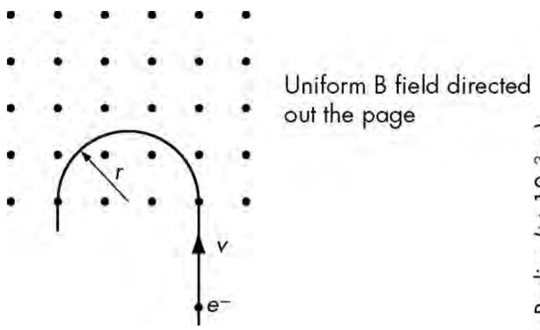
Thus on the grounds of energy efficiency, portability, and durability, solid devices are to be preferred over thermionic devices.

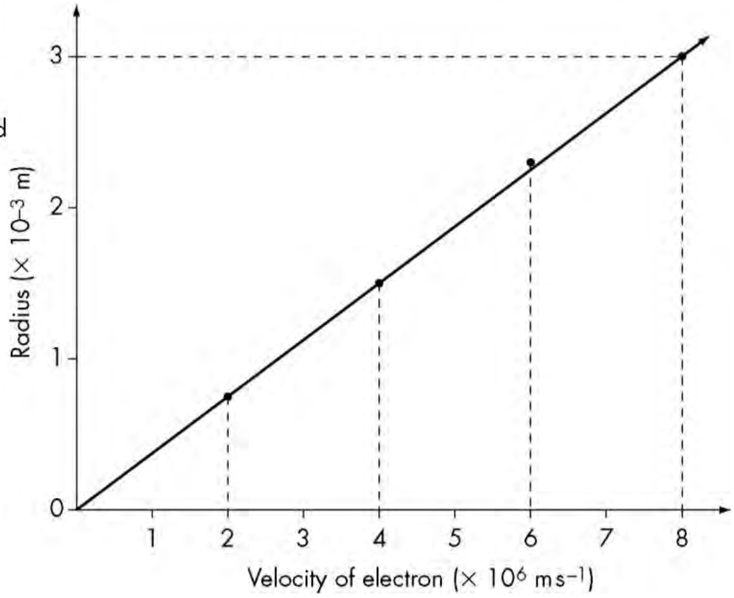
Many candidates did not include a definitive statement making their evaluation.

Ie, the solid state devices have many advantages and are therefore better overall (ie, making a judgement is necessary).

Question 31 (6 marks) **Marks**

A student uses a cathode gun to accelerate electrons to different velocities and then measures the radius of curvature of the path the electrons take in a magnetic field. The electrons enter the magnetic field at right angles to the field. A diagram of the experiment and a graph of the results obtained by the student are shown below.





(a) By equating the centripetal force and magnetic force on a charge moving at right angles to a magnetic field at a constant speed (v) **derive** a general expression for the radius of curvature of the charge in the field. **2**

Criteria	*Marks*
• *Correct derivation, including showing how the final expression was obtained*	*2*
• *States the centripetal force equation and magnetic force equations correctly but fails to correctly derive the radius equation*	*1*

Suggested answer:

$$F_C = F_B \text{ or } \frac{mv^2}{r} = qvB \text{ or } r = \frac{mv^2}{qvB}$$

Therefore: *r = mv / qB*

(b) Calculate the gradient and its units. Show all working. **2**

Criteria	**Marks**
• Correct numerical value and units	2
• Correct numerical value OR units	1

Suggested answer:

$$\text{Gradient} = \frac{\text{rise}}{\text{run}} = \frac{0.003\ \text{m}}{8 \times 10^{6}\ \text{m s}^{-1}}$$ = **3.75 × 10^{-10} s**

(c) Calculate the strength of the magnetic field used in the experiment. **2**

Criteria	***Marks***
• *Correct numerical answer*	*2*
• *Correctly states equation or uses gradient, but fails to obtain correct answer*	*1*

Suggested answers:

$\frac{mv^2}{r} = qvB$ and hence $B = \frac{mv}{qr} = \frac{9.1 \times 10^{-19} \times 8 \times 10^{6}}{1.6 \times 10^{-19} \times 0.003}$ = 0.015 Tesla

OR

Gradient = $\frac{r}{v} = \frac{m}{qB}$ = 3.75 × 10^{-10} and hence $B = \frac{m}{q(3.75 \times 10^{-10})}$ = 0.015 Tesla

Question 32 (4 marks) **Marks**

(a) Discuss the effects of future applications of superconductivity on **either** generators or motors. **2**

Marking Criteria	*Marks*
• *Effects of the applications of superconductivity discussed thoroughly for EITHER motors or generators.* • *Response shows evidence of deep understanding of the application. As it **specifically relates to either motor or generator.*** • *Weaker responses made statements that could really apply to almost any application of superconductors, rather than the specific parts and functions of motors or generators that would benefit from using superconductors in various named components.* • *For two marks, answer will be coherent and contain no errors of fact, with appropriate examples of applications.*	*2*
An outline of an application wrt either motor or generator	*1*

Sample answers

Superconducting wires in the coils of a generator would allow the generator to be much smaller as thinner wire could be used to carry the same amount of current. Hence the generator could be made smaller and lighter (aids portability and miniaturisation)

OR

The rotating electromagnet used in large generators (to induce the current in the coil) could also be much smaller (and less heavier) yet still produce an intense magnetic field. This also aids portability

OR

Likewise, motors with superconducting coils could be made smaller and be made to produce much greater torque as superconducting electromagnets could produce the magnetic field in which the coils rotate.

(b) With reference to your answer in (a), explain giving TWO different reasons why such superconductivity applications have yet to be made on a large scale. **2**

the conducting wires could be made from ceramic high temperature superconducting materials, but these still need to be cooled with liquid nitrogen and the materials are very expensive to produce. This need for cooling systems limits their economic efficiency.

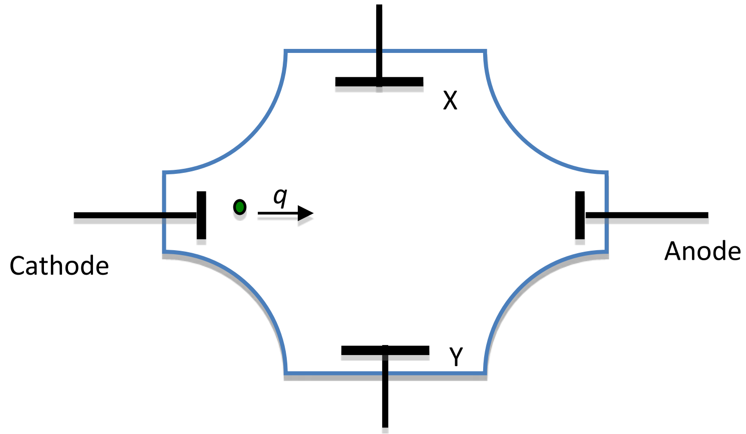
- *ceramic high temperature superconductors or quite fragile (brittle, not malleable or ductile) and difficult to make into wires, and not suitable for use in moving applications.*

1 mark for each reason <u>explained</u>. (need two DIFFERENT reasons, not just an extended explanation on all things to do with issues surrounding cooling difficulties).

Many candidates made very general statements that did not show a deep understanding of the specific limitations of superconductors (as required by this course!)

Question 33 (5 marks)

A particle *q* with charge -2*e* is travelling from a cathode to anode inside the vacuum tube shown below. There are charged plates set up at X and Y.



(a) Describe and explain the path taken by *q* if a voltage of 24 000 V is put across **XY**, with **X** being positive. **2**

It will curve upwards towards plate X. (note: not a circular path, it will be more parabolic)

This is because the negative charge will be attracted to the oppositely charged positive plate

(b) Calculate the electric field strength from XY given that 24 000 V is put across XY and the plate separation is 18 cm. **1**

E = V / D

= 24 000 / 0.18 = 1.3 x 10^5 V/m

(note the units, even though units not marked in this question)

(c) *q is* travelling at 7 x 10^5 ms^{-1} . The experimenter then produces a uniform magnetic field ***B*** that is perpendicular to the electric field in such a way that makes *q* travel in a straight line between the electric plates. Calculate the required ***B,*** *including direction* that achieves this. **2**

Bqv = Eq

B = E / v = 0.19 tesla (1 mark)

Direction is into the plane of the page (use palm rule to determine this, remembering that it is a negative charge we are dealing with in this question).

Question 34 (5 marks) **Marks**

Section 9.4.2, column-3, dot-point 5 of the HSC Physics syllabus requires students to *"process information to discuss Einstein and Planck's differing views about whether science research is removed from social and political forces"*.

In order to obtain the financial support necessary to carry out research, scientists have three principal sources – government grants, industry and the military.

Discuss the potential limitations to scientists' freedom to research and publish their results posed by each of these sources. Your answer should include appropriate references to Einstein and Planck's differing views on this matter, and should also consider the work of some other scientists' and areas of research. **5**

Criteria	***Marks***
• *Correctly describes both Planck's and Einstein's views about scientific research* • *describes a limitation to freedom to publish with respect to government funding* • *describes a limitation to freedom to publish with respect to industrial funding* • *describes a limitation to freedom to publish with respect to military funding (the above three limitations all had specific examples attached to them)* • *Carefully constructed answer. Logically structured and historically accurate.*	*4-5*
• *Describes two or three significant challenges to freedom to publish with respect government, military or industry funding, with some specifics provided.* *OR: discusses the Einstein –Planck 'debate' correctly in some detail* *NOTE:* • *3 marks is maximum grade for those who only discuss Einstein/Planck or only refer to other scientists, no matter how well it is done.*	*3*
• *Some relevant and correct statements about Einstein-Planck differing views* *And/or a relevant but limited discussion of another restriction to publish in context of either military, industry or government.* • *The answer possibly also has significant errors of fact.*	*2*
• *One true and significant comment about Planck, Einstein or freedom to publish.*	*1*

NOTE: many students made significant errors of fact regarding Einstein or Planck. This cannot be ignored. At best, many candidates were misleading. Be careful with your history!! Eg: Einstein did NOT make the atom bomb, Planck did NOT work on war weapons for the Nazis in WWII

Also, many answers were not logically structured and bounced all over the place.

Some answers did not neatly fit the above criteria, and so had to be marked holistically. The better of these gave specific examples of either named scientists or specific areas of research that might be impacted by research or publication limitations.

Too many candidates essentially re-stated info' given in the question. For example, the question <u>already</u> tells you that there are going to be pressures from military/government with respect to the work of scientists as they are funding their work. It is your job to now give specific pieces of evidence around this. Many possible valid examples, either current or historical (the rocket scientists studied in the Space module are possible candidates).

Sample answer

From the early part of the 20th century, the military leadership of Germany received support from most of their scientific establishment in a wave of patriotic fervour. Planck was noted as being a strong German patriot and he organised a petition among fellow scientists asking them to support the German war effort in WWI. He believed that scientists should conduct research to serve the interests of the state. Albert Einstein was a pacifist. He did NOT support Germany's World War I effort. He signed a document (petition) stating his views, which is in direct opposition to Planck's petition of German scientists supporting the war. He believed that scientists should be able to publish their work without regard to the needs to the military or state. Einstein opposed any form of censorship of knowledge, keeping his beliefs public throughout his life. However, in 1939 Einstein wrote a letter to the US President (Franklin Roosevelt) urging that the Allies consider the development of a nuclear bomb, as he feared that Nazi Germany would otherwise make a bomb first. Einstein though was not a part of the Manhattan Project that developed the atomic bomb. (Max Planck was NOT involved in the German war effort in World War 2, as he was by then nearing the end of his career and had no real love of Nazism).

The days of scientists working on their own out of interest, purchasing their own materials and equipment, and publishing their findings to interest others to pursue the next discovery have largely passed. Research is just too expensive or multi-disciplinary to do on your own.

Government grants: With so many demands on the public purse, the available grants are limited. There is pressure to regularly publish findings so as to justify the public funding. Specifically, researchers try to publish work that is viewed as having practical importance in the eyes of politicians (such as, say, a breakthrough in superconductivity with room temperature superconductors).

Industry: Consider the world of semiconductors and computing. Researchers are typically not free to publish their work at their own behest, as there are likely to be commercial contracts they have signed that prohibit the dissemination of results in case the company be put at risk of a commercial disadvantage from a rival computing firm.

The military: In such a case there is usually some type of 'Official Secrets Act' that restrains publication by threat of imprisonment , which is rather more serious for the researcher than simple loss of funding or dismissal from employment for researchers insisting on their personal right to publish their findings. Consider Wernher Von Braun who had no freedom to openly publish his rocket weapons research in WWII. His research also had to have an immediate war focus

Hint: writing in dot points is allowed. It can make following your argument easier!

NOTE: I got the strong feeling that many candidates di not really know how to approach this question. It was marked as generously as possible, and I often overlooked small errors. BUT, HSC examiners will harshly treat misleading or contradictory or just plain wrong 'facts'. Scores of 'zero' are not unknown for such essay questions, even if the candidate has written several pages!

Question 38 From Quanta to Quarks (20 marks) **Marks**

(a) Rutherford and his colleagues conducted scattering experiments to help determine the structure of the atom.

(i) Describe important features of the atom that they identified from such scattering experiments. **1**

The atom had most of its mass concentrated in a positive nucleus.

Note: The positive nature of the nucleus is a vital part of their findings and must be explicitly mentioned.

(ii) Outline an important limitation of the Rutherford model of the atom. **1**

It could not explain why the positive charges in the nucleus held together OR

The orbiting electrons should have spiralled into the nucleus, emitting a continuous stream of EMR as they did so OR

It did not explain the discrete line emission spectra of hydrogen

Note: Answers to both (i) and (ii) must be not mix up the work of other scientists. For example, the scattering experiment did NOT 'discover neutrons' or discover protons' or 'put electrons in orbiting energy levels'.

By the way: Rutherford himself apparently did not say anything really about the orbiting electrons. He essentially left the issue unaddressed.

(b) The **visible** colour of one of the Balmer spectral lines in the hydrogen spectrum is blue. Using this information alone, what must be its n_f in the Rydberg formula? **1**

For the Balmer series, $n_f = 2$

(c) Calculate the wavelength and frequency of light emitted when an electron moves from the n = 5 level to the n = 2 level of a Bohr hydrogen atom. **2**

$$\frac{1}{\lambda} = R\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right) = 1.097 \times 10^7\left(\frac{1}{2^2} - \frac{1}{5^2}\right) = 2.3 \times 10^6$$

$$\lambda = 4.34 \times 10^{-7}\ \text{m}$$

$c = f\lambda$ Therefore: $f = 3 \times 10^8 / 4.34 \times 10^{-7}$ <u>*= 6.9 x10^14 Hz*</u>

1 mark if correct wavelength found. Award the second mark for converting wavelength to frequency (allow error carried forward). Units not graded in this question.

Question 38 continued:

(d) Describe how the concept of quantised energy fitted in with Bohr's postulates and how this in turn led to the mathematical model that he produced to account for the observed spectrum of hydrogen. **4**

Marking Criteria	Marks
• Concept of quantised energy discussed • Bohr's postulates identified (must include the first two) and a link made to the discrete lines of the hydrogen spectrum • Mathematical model referred to in its relation to H spectrum • **Bohr able to derive the Balmer- Rydberg equation and give a physical reason for its existence.**	**4**
• Concept of quantised energy outlined. *E = h f* is good to state and explain!!! • Bohr's postulates identified (must include the first two) and a link made to the discrete lines in the hydrogen spectrum • Mathematical model referred to in its relation to H spectrum	**3**
• An aspect of quantised energy identified (eg: he borrowed Planck's *E = h f* expression) **AND** • Bohr's postulates identified (including the first two) OR Features of the H spectrum identified	**2**
• An aspect of quantised energy identified • OR • One of Bohr's postulates identified • OR • Features of the H spectrum identified	**1**

Sample answer:

The concept of quantised energy – where energy exists in discrete amounts (E = h f) – can be applied to Bohr's postulates, as Bohr proposed that electrons can only exist with certain energy levels in the H atom. When changing energy levels, electron transitions result in either a) the absorption of energy in the form of a photon by the electron when it moves up energy levels or b) the emission of a photon of energy with E = hf when the electron moves down an energy level. The energy of the photon absorbed or emitted equals the change in the energy level of the electron orbital. The pattern of wavelengths observed in the H spectrum was used to derive the empirical Rydberg equation: $\frac{1}{\lambda} = R\left(\frac{1}{n^2_f} - \frac{1}{n^2_i}\right)$ *where n_f and n_i are the final and initial allowed orbitals and R is Rydberg's constant. This formula matches the observed discrete emission spectral lines from hydrogen. The observed wavelength, λ can be associated with transitions between n_f and n_i emitting photons as the electron moves down to a lower energy level. If energy was not quantised then the H spectrum would be a continuous one. In fact it only has lines at certain wavelengths.*

(e) Explain how de Broglie's matter wave hypothesis was able to help explain the stability of electron orbits in the Bohr atomic model. **2**

Marking Criteria	Marks
• de Broglie's proposal is linked to the Bohr model, including stationary states existing because these levels had circumferences that were integral (whole number) wavelengths of the electrons. • The electrons formed standing waves, and as they did not propagate and no interference, therefore no energy loss/emr emitted	2
• A feature of de Broglie's hypothesis described (but no marks just for repeating information implied in the question) • AND/OR • States that Bohr's model had electrons orbiting in allowed stationary states (energy levels) without emitting EMR.	1

Sample answer:

The Bohr model of the atom had electrons only in allowed energy levels, or orbits about the nucleus. These allowed energy levels had orbital circumferences that were integer multiples of the wavelength of the electrons – thus making them stable. The electrons formed standing waves, therefore no propagation and energy (emr) emitted by the electron. In-between levels were thus not allowed – and this matched the observations from the H atom at the time.

This question continues on the next page ------------→

Question 38 continued.

(f) (i) de Broglie proposed that an electron moving with velocity of 2 x 10^8 m/s has wave properties. Calculate the value of the wavelength of such an electron. **1**

$$\lambda = \frac{h}{mv} =$$

Therefore: 6.626 x 10^{-34} / 9.1 x 10^{-31} x 2 x 10^8 = 3.64 x 10-^{12} m

1 mark for correct answer. (units not penalised)

(ii) Account for why the effects of de Broglie's hypothesis about the wave nature of matter is not observed with larger objects (such as people). **1**

The wavelengths are far too small for observable wave behaviour (such as diffraction) to be observed.

(g) Compare and contrast the properties of nucleons **2**

One mark for each correct and important statement:

Protons are positive, neutrons have no charge.

Protons and neutrons have similar mass, and are assigned mass numbers of '1'.

Note: electrons are not classified as nucleons. NO marks just for identifying that protons and neutrons are nucleons.

Note: this question surprisingly poorly done. It is one of the easiest dot points in the whole module!

(h) Large unstable nuclei can become more stable by undergoing radioactive decay.

Write a nuclear equation for the alpha decay of Americium- 241 **2**

$${}^{241}_{95}Am \rightarrow {}^{237}_{93}Np + {}^{4}_{2}\alpha$$

or

$${}^{241}_{95}Am \rightarrow {}^{237}_{93}Np + {}^{4}_{2}He$$

Two marks for correct equation . One mark if there is a minor error or omission.

(ii) It is an example of transmutation as a new chemical element has been produced. One chemical element has 'transmuted' into another. (1 mark)

Question 38 continued:

(i) The neutrino was suggested by Pauli to account for an unsolved problem. Outline this problem and explain how the neutrino solves it. **2**

Criteria	Marks
Outlines the problem and explains the neutrino solution in some detail. *Answer includes:* the beta particles not emitted with same energies implied that energy conservation laws were not being obeyed. The neutrino was to be a (massless) and high speed particle that carried off the missing energy.	2
Identifies or briefly outlines the problem: beta particles were not emitted with same energies (as shown by their velocity measurements) or 'to satisfy energy conservation laws he proposed a neutrino'	1

Sample answer:

Pauli proposed the existence of the neutrino to solve the issue of the 'missing' energy and momentum in beta decay. Unlike alpha emissions, beta particles emitted from a particular isotope have a range of velocities. This is a problem because the amount of energy (and momentum) carried by each beta particle should be identical. The proposed neutrino possessed both energy and momentum and could therefore account for the 'missing' amounts.

NOTE: must explicitly address BETA decay.

END OF QUESTION 38

Question 39 The Age of Silicon (20 marks)

(a)

Marking Criteria	Marks
• Table written correctly	**2**
• Table provided has an error	**1**

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

(b)

Marking Criteria	Marks
• Several situations explained	**3**
• Several situations identified OR • A situation explained	**2**
• A situation identified	**1**

Answer may include

- when low power consumption is a requirement – e.g. on boats, caravans etc

- when rapid response time is important – e.g. car brake lights; fibre optic applications

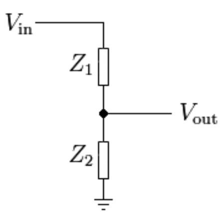
- where long and reliable life expectancy is needed –e.g. remote operations

- where low heat generation is a requirement – e.g. near flammable sources

(c)

Marking Criteria	Marks
• Circuit drawn correctly	**2**
• Circuit drawn with an error or omission	**1**

Using values of: Z_1 = 750 ohms and Z_2 = 2.5 ohms



(c) (ii)

Marking Criteria	Marks
• Role of transducers described thoroughly • Examples are relevant	**3**
• Role of transducers outlined • An example provided	**2**
• Role of transducers in general is identified	**1**

Transducers are input or output devices that are designed to measure some aspect of the environment and transform it into a signal that can be read:

e.g. a light meter – converts light intensity into an electrical voltage that is then fed into a digital read-out – the input transducer is the LDR, the output the digital

e.g. a sound level meter – similar to the above but generates a voltage in proportion to the intensity of the sound

(d)

Marking Criteria	Marks
• Feedback is discussed thoroughly • An example of a relevant control system is used to illustrate answer • Example is relevant	**4**
• Feedback is outlined • An example of a relevant control system is provided	**3**
• Feedback is identified AND • An example of a control system is provided	**2**
• Feedback is identified OR • An example of a control system is provided	**1**

A thermostat is an example of an on-off control system that uses feedback. The temperature of the system is monitored and this is fed back into the control electronics to turn on or switch off the heater or pump when the desired temperature is reached. Without feedback, the system would not know when to switch off and the desired temperature would be overshot. A car's cruise control constantly feeds information from the car's speedometer into the computer chip that controls the throttle setting so that a constant speed is maintained, even going up hills.

(e)

Marking Criteria	Marks
• Advances described thoroughly and linked to data storage • Semiconductor production techniques described • Examples of new consumer devices provided • Response is in a logical, sequential style	**6**
• Advances outlined and linked to data storage • Semiconductor production techniques outlined • Examples of new consumer devices provided	**4-5**
• An advance in semiconductor production identified • Example of a new device with large storage of data identified	**2-3**
• An advance in semiconductor production identified OR • Example of a new device with large storage of data identified	**1**

Semiconductor production has advanced by being able to etch a greater number of transistors onto smaller areas of silicon chip so that now, many millions of individual transistors can exist on a chip the size of a pinhead. This has been achieved using shorter wavelength lasers to etch the connections along with better quality silicon chips. Thus a large quantity of data can be stored in RAM chips so that cameras, phones and computers can store images, movies and other information. Phones now have small and powerful CPUs to run the complex operating systems that exceed the computing power of computers only a few years old.