MC /20	de Rooy /21	Ward /18	Noyes /21	Voulalas /20	TOTAL /100

Student name: ……

Sydney Technical High School

2016

Trial Higher School Certificate Examination

Physics

General Instructions

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

Total marks – 100

Section I Pages 5-29

80 marks

This section has two parts, Part A and Part B

Part A – 20 marks

Attempt Questions 1-20
Allow about 30 minutes for this part

Part B – 60 marks

Attempt Questions 21-35
Allow about 1 hour 50 minutes for this section

Section II Page 31-32

20 marks

Attempt Question 36
Allow about 40 minutes for this section

Office Use Only – Do NOT write anything, or make any marks below this line.

Section I
80 marks

Part A – 20 marks
Attempt Questions 1-20
Allow about 30 minutes for this part

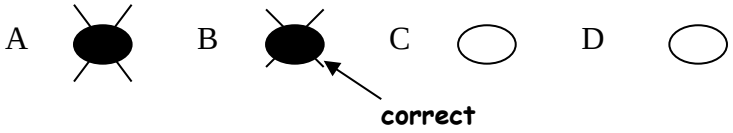
Use the multiple-choice answer sheet.

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.



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 ◯

Section I
80 marks

Part A – 20 marks
Attempt Questions 1-20
Allow about 30 minutes for this part

Use the multiple choice answer sheet for Questions 1-20

1. Which of the following components is unique to an AC generator?

(A) Armature
(B) Slip ring commutator
(C) Brushes
(D) Slip ring

2. Why would a satellite in a low orbit around Earth eventually fall to Earth?

(A) It is not in a geostationary orbit
(B) Gravity is too strong at low orbits
(C) The Sun's solar wind pushes it out of orbit
(D) The upper atmosphere gradually slows it down

3. Which of the following **is not** a role of an electrical substation?

(A) Transmission of electricity
(B) Distribution of electricity
(C) Transformation of voltage
(D) Production of electricity.

4. A critical characteristic of cathode rays that enabled J.J. Thomson to determine the charge to mass ratio of electrons was:

(A) Moving electrons can be deflected by magnetic and electric fields
(B) Electrons have a small mass
(C) Cathode rays are waves
(D) Electrons have both a wave and particle nature

5. Two massive objects X and Y, with masses 1m and 2m respectively, are placed a distance of 1d apart. How would the force of attraction on object Y be affected if the distance between them was doubled?

(A) The force would be halved

(B) The force would be quartered

(C) The force would remain the same

(D) The force would be doubled

6. Identify the main reason germanium was used in early transistors

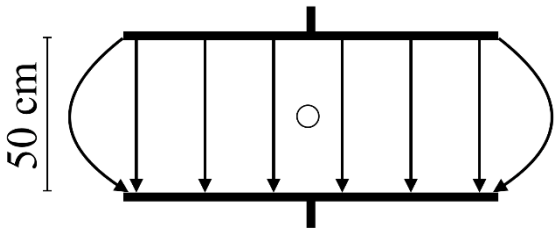
(A) Germanium was an abundantly available element

(B) The technology to obtain pure crystals of germanium was already known

(C) Germanium was a great natural semiconductor

(D) The technology to obtain pure crystals of silicon was too costly

7. An electron is placed between two parallel charged plates that are separated by 50 cm. The potential difference between the plates is 12 V and the direction of the electric field is as indicated in the diagram below.



Calculate the force acting on the electron.

(A) 3.8×10^{-18} N downwards

(B) 3.8×10^{-18} N upwards

(C) 3.8×10^{-20} N downwards

(D) 3.8×10^{-20} N upwards

8. Which observation, made during the photoelectric experiments, did Einstein explain using a particle model for light?

(A) The magnitude of the photocurrent increased as the intensity of light falling on the emitter increased, but only to a certain maximum value for each emitter.

(B) The magnitude of the photocurrent decreased as the frequency of the incident light decreased, but only to a particular frequency for each emitter, after which it fell to zero.

(C) The minimum frequency of the incident light causing a photocurrent to flow was different for each emitter.

(D) The magnitude of the photocurrent was different for different emitters even if the frequency of the incident light was identical.

9. Two parallel current-carrying conductors exert a force on each other. The current in one of the conductors is doubled and reversed so that the two currents are now flowing in opposite directions.

How is the force between the two conductors affected by the change?

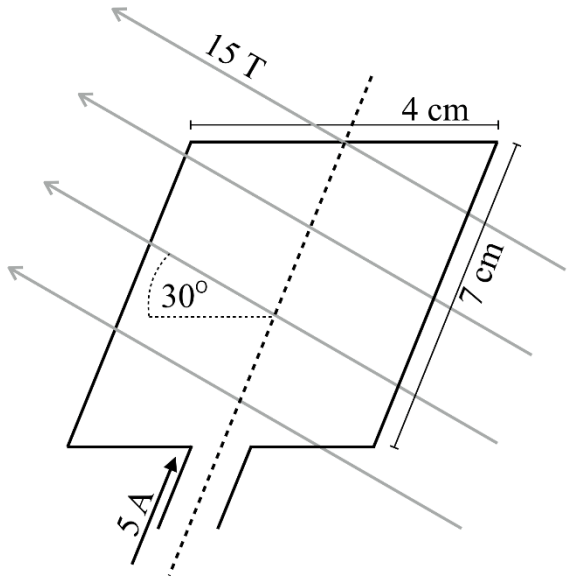
(A) It is doubled and becomes repulsive

(B) It is halved and becomes attractive

(C) It is doubled and becomes attractive

(D) It is halved and becomes repulsive

10. If the motor in the diagram experiences a torque of 2.18 Nm, calculate how many turns of the coil must be present.



(A) 1

(B) 2

(C) 12

(D) 21

11. A satellite is travelling around Mars at a velocity of 3.54×10^3 ms^{-1} at an altitude of 2000 km. If the satellite has a mass of 500 kg and Mars has a diameter of 6 779 km, determine the force of gravity acting on the satellite.

(A) 1843 N

(B) 1163 N

(C) 714 N

(D) 3128 N

12. Which statement below correctly describes a semiconductor as its temperature changes?

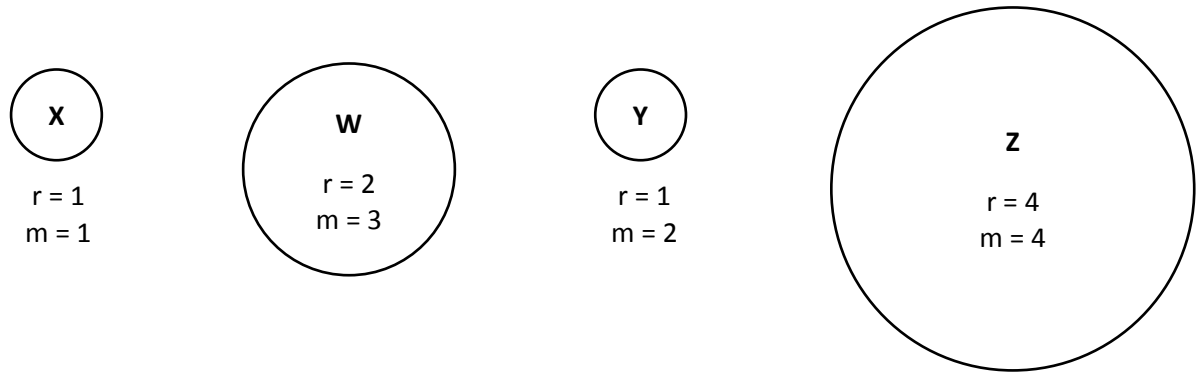
(A) As the temperature of the semiconductor increases, its conductivity increases and its resistance decreases.

(B) As the temperature of a semiconductor increases, its conductivity increases and its resistance increases.

(C) As the temperature of a semiconductor increases, its conductivity decreases and its resistance decreases.

(D) As the temperature of a semiconductor increases, its conductivity decreases and its resistance increases.

13. Four planets X, W, Y and Z have different masses and radii as indicated below.



Identify which planet has the greatest escape velocity.

(A) X

(B) W

(C) Y

(D) Z

14. A transformer in a model train reduces the 240 V supply to a much safer 12 V. The secondary coil of the transformer has 60 turns and supplies 0.6 A to the train making it 95% efficient.

Which choice shows correct values for the input coil of this transformer?

	Number of turns	*Input current (A)*
(A)	1140	3.0×10^{-2}
(B)	1140	3.2×10^{-2}
(C)	1200	3.2×10^{-2}
(D)	1200	3.0×10^{-2}

15. Two DC motors have the characteristics shown in the following table.

Characteristics	*Motor X*	*Motor Y*
Turns in the coil	400	600
Radius of the motor coil (m)	0.05	0.10
Operating current (A)	3	2
Magnetic flux from stator magnets (T)	0.30	0.15

Which statement about the torque produced by the two motors is correct if frictional effects are ignored?

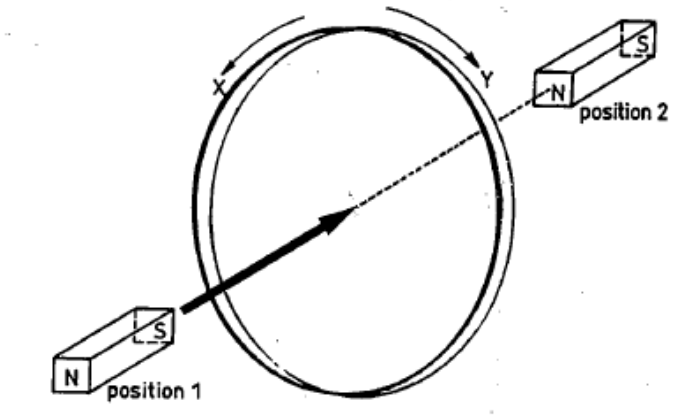
(A) X will produce twice the torque of Y

(B) X will produce half as much torque as Y

(C) X will produce one-third the torque of Y

(D) X will produce three times the torque of Y.

16. A bar magnet is moved in a straight line from position 1 to position 2 through a copper ring, as shown in the diagram below.



As the magnet moves from position 1 to position 2, the current induced in the ring flows in the direction:

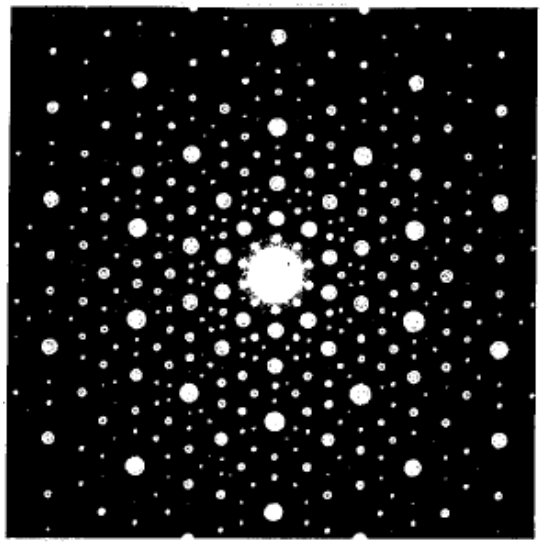
(A) X, then Y

(B) X throughout

(C) Y, then X

(D) Y throughout.

17. The diagram shows a diffraction pattern produced by a crystal.



What did diffraction patterns like this enable the Braggs to propose?

(A) The wavelengths of the various bands of electromagnetic radiation are different.

(B) The valence electrons in atoms of metals are not bonded to any particular atom but are free to move.

(C) The actual arrangement of atoms in solid bodies can be deduced from X-ray diffraction patterns.

(D) The valence band of metallic conductors is completely full.

18. A mass of 5 kg is dropped from a height of 40 m on planet X. The mass takes 3.0 seconds to reach the ground. Determine the weight of the object on planet X.

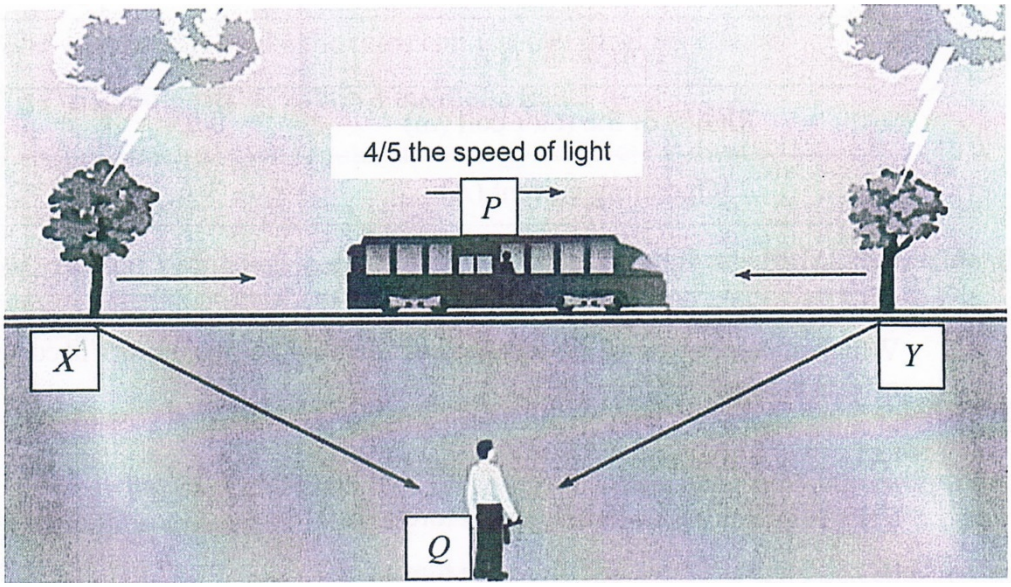
(A) 8.9 N

(B) 26.7 N

(C) 44.4 N

(D) 4.4 N

19. When observer P, in the bus travelling at 0.8c, is exactly half way between two trees X and Y, two strikes of lightning hit the trees at the same time. Observer Q is stationary, some distance away, but exactly the same distance from each tree.



Which statement about this situation is correct?

(A) P and Q will see both lightning strikes at the same time.

(B) P will see them at the same time but Q will see strike X before strike Y.

(C) Q will see them at the same time but P will see strike Y before strike X

(D) Q will see them at the same time but P will see strike X before strike Y

20. A spaceship of length 50 m travels past a space station at a relativistic speed. An observer on the space station measures the length of the spaceship to be 48 m as it travels past. Calculate the velocity of the spaceship.

(A) $8.4 \times 10^{7}\ ms^{-1}$

(B) $2.16 \times 10^{8}\ ms^{-1}$

(C) $2.356 \times 10^{7}\ ms^{-1}$

(D) $24009\ ms^{-1}$

Section I (continued)

MARKS /21 (de Rooy)

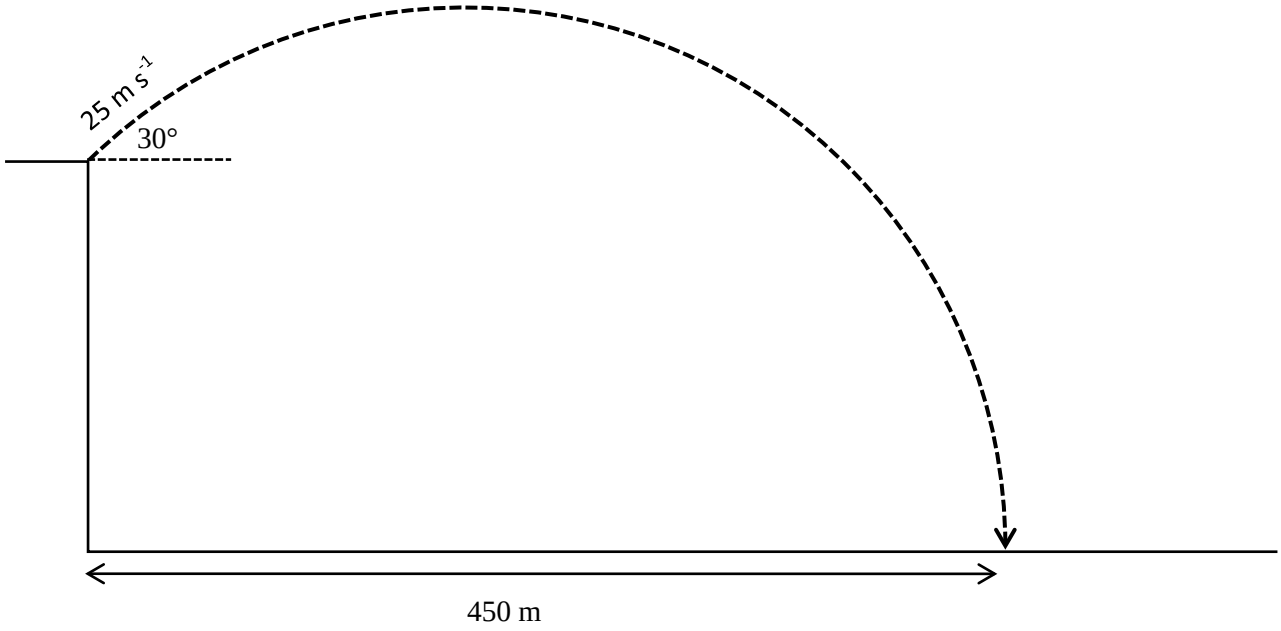
Part B –60 marks
Attempt Questions 21-35
Allow about 1 hour and 50 minutes for this part

Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.

Show all relevant working in questions involving calculation.

Question 21 (3 marks)

A projectile is launched from the edge of a cliff at a velocity of 25 ms^{-1} at 30 degrees from the horizontal. The projectile lands 450 m from the base of the cliff.



Calculate the height of the cliff. **3**

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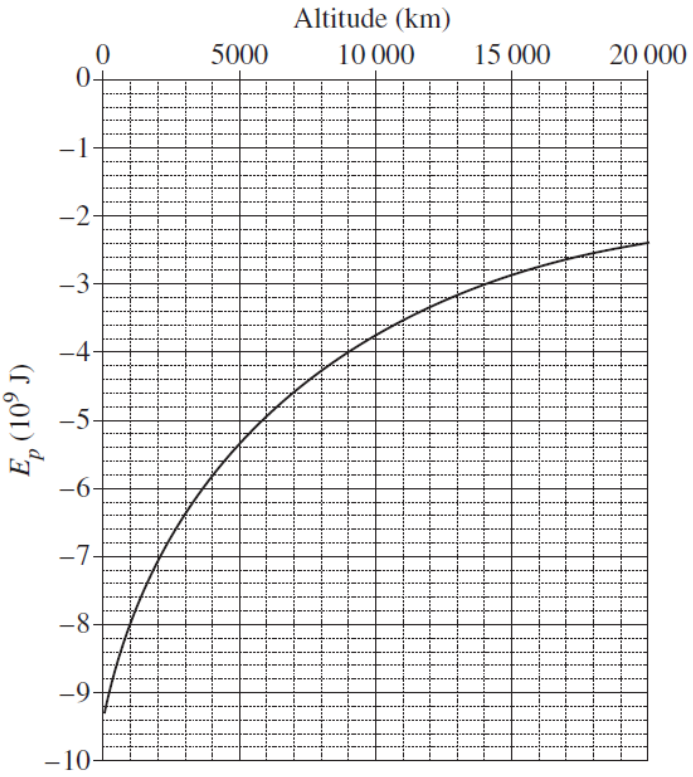
Question 22 (3 marks)

The graph shows how the gravitational potential energy (Ep) of a satellite changes with its altitude.



(a) What is the change in gravitational potential energy of the satellite when its altitude is reduced from 9000 km to 3000 km? **1**

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(b) Explain why the gravitational potential energy of a mass in a gravitational field is always a negative value. **2**

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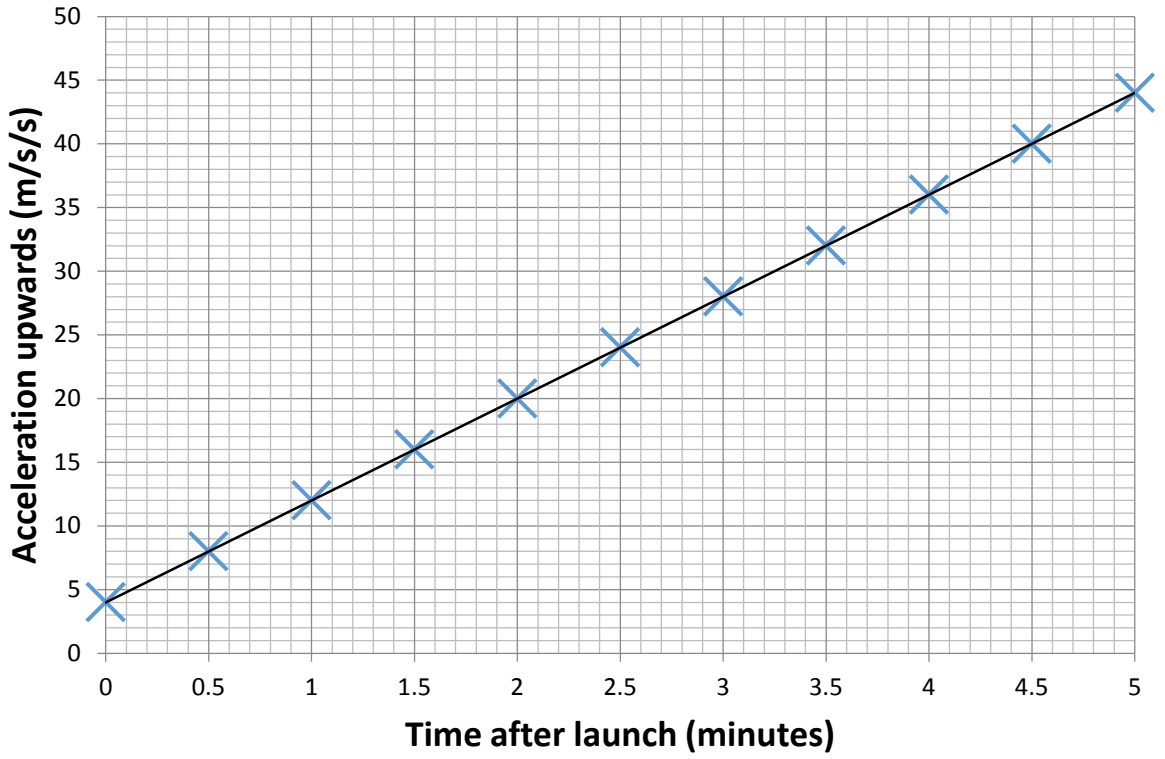
Question 23 (6 marks)

The graph below shows the acceleration of a rocket following launch.



(a) Explain the changes in momentum that occur when a rocket fires its propulsion system. **3**

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Question 23 continues on page 16

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(b) Explain why the acceleration of the rocket increases as time increases.

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(c) Calculate the g-force experienced by an astronaut on the rocket at time t = 4 minutes. **1**

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End of Question 23

Question 24 (3 marks)

A low earth satellite completes 12 orbits in the same time a geostationary orbit completes one orbit. Determine the altitude of the low earth satellite if the radius of the earth is 6.371×10^6 m. **3**

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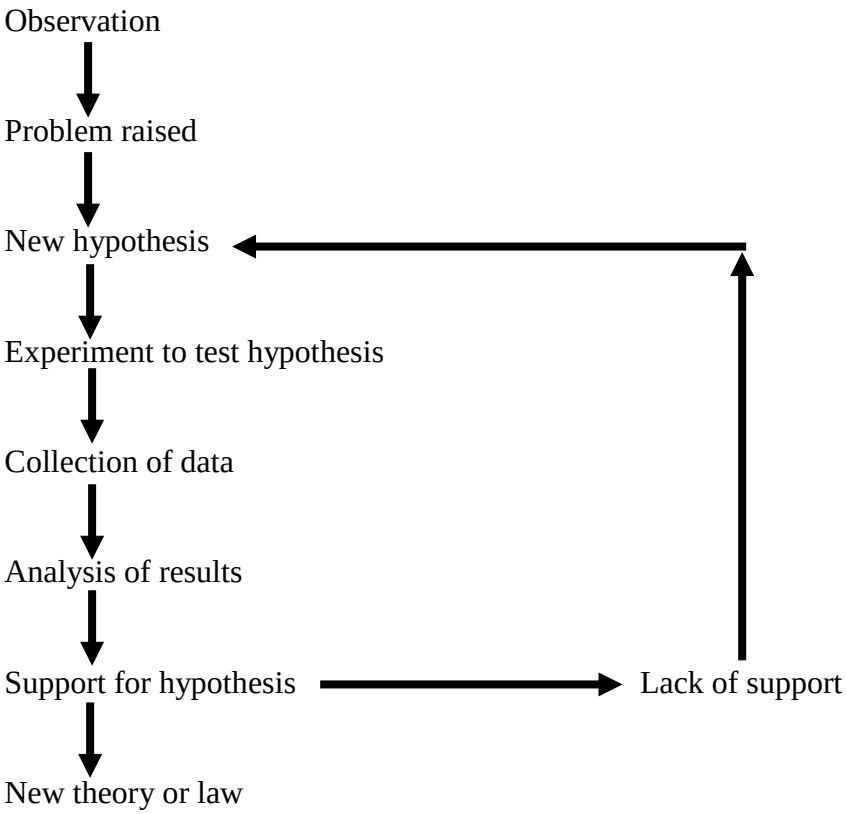
Question 25 (6 marks)

The flow chart represents one model of scientific method used to show the relationship between theory and the evidence supporting it.



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Question 25 continues on page 19

Analyse Einstein's Theory of Special Relativity and the evidence supporting it as an application of this model of scientific method. **6**

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End of question 25

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Question 26 (5 marks)

MARKS	**/18**
(Ward)	

To investigate the relationship between the force between parallel current-carrying conductors and the distance between them, students designed and carried out an experiment. Their results are shown in the table below.

Force between the conductors (N)	*Distance between the conductors (m)*
6.1×10^{-5}	0.02
3.0×10^{-5}	0.04
1.9×10^{-5}	0.06
1.2×10^{-5}	0.10

(a) Plot a graph of the force between the conductors against the distance between them on the provided grid. **3**

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(b) Outline why it is inappropriate to draw a conclusion from the graph you have drawn and identify the next step needed to analyse the results. **2**

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Question 27 (4 marks)

Electromagnetic induction is utilised in a range of applications.

(a) Explain the reason for the generation of eddy currents by electromagnetic induction when induction cooktops are used for cooking. **2**

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(b) Describe one other example of the use of electromagnetic induction. **2**

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Question 28 (6 marks)

During the late 19th Century, two electric power transmission systems competed for widespread implementation and use in homes and industry. Discuss the outcome of this competition based on the advantages and disadvantages of AC and DC generators. **6**

Do NOT write in this area.

Question 29 (3 marks)

Outline a first-hand investigation demonstrating the principle of an induction motor. Include a labelled diagram indicating all motions involved. **3**

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MARKS (Noyes)	/21

Question 30 (3 marks)

A particle enters a 0.3 T magnetic field directed to the East at 50 ms^{-1} North. Its charge is 1.6 x 10^{-18} C. The radius of the path the particle took as a result of the force was 3.33 m. Calculate the mass of the particle. **3**

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Question 31 (2 marks)

What frequency does a photon of light have if it has the same energy as an electron's kinetic energy when moving with a velocity of 0.1c? **2**

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Question 32 (4 marks)

Describe how doping can change the electrical properties of a semiconductor. **4**

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Question 33 (4 marks)

Describe the role of electrodes in the electron gun, in the cathode ray tube of a conventional TV display and explain why a transformer would be necessary for this type of TV to operate in the home. **4**

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Question 34 (4 marks)

Describe Hertz's experiments to produce and detect radio waves, and to determine the speed of radio waves. Use diagrams to support your answer. **4**

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Question 35 (4 marks)

Evaluate the use of superconductors and the limitations to their use. **4**

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Section II

MARKS /20
(Voulalas)

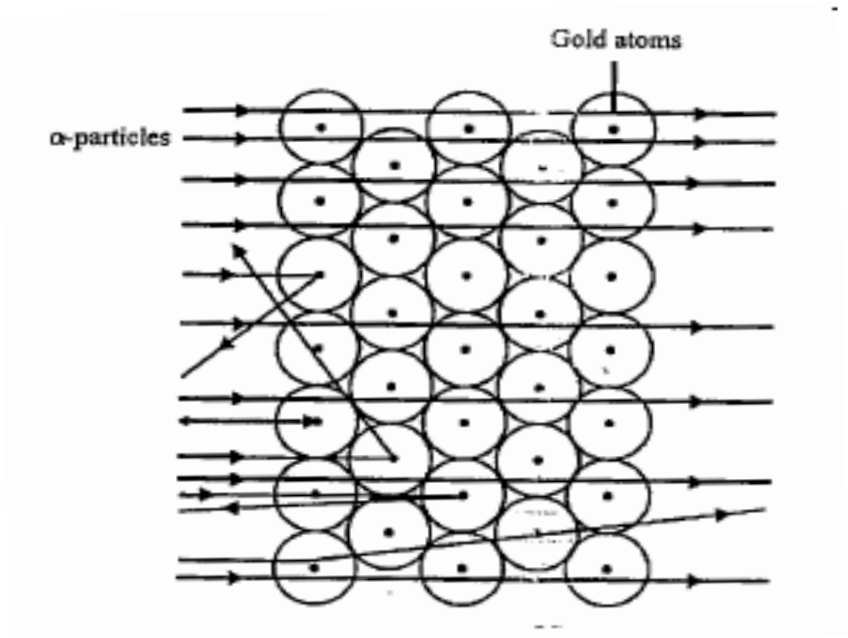
20 marks
Attempt Questions 36
Allow about 40 minutes for this section

Answer the questions in the writing booklet provided. Extra writing booklets are available.

Show all relevant working in questions involving calculation.

Question 36 – From Quanta to Quarks

(a) In 1909, Rutherford, Geiger and Marsden conducted the now famous alpha particle scattering experiments, the results of which are shown in the diagram.



(i) Outline Rutherford's explanation of these results. **2**

(ii) Explain how Bohr's model of the atom, unlike Rutherford's model, was able to account for the spectral lines of hydrogen. **2**

(b) A mathematical model can predict the wavelengths of emission spectra lines from hydrogen atoms.

(i) Use this model to predict the wavelength of emitted light when an electron falls from the fifth energy level to the second energy level. **2**

(ii) Discuss how observations of these individual spectral lines support Planck's contribution to the concept that energy is quantised. **3**

(iii) State the limitations of the Rutherford-Bohr model of the atom. **4**

Question 36 continues on page 32

(c)

(i) Describe the requirements for an uncontrolled nuclear fission chain reaction in the atomic bomb. **2**

(ii) With the aid of a diagram, describe how an uncontrolled nuclear fission chain reaction can be changed to a controlled one in a nuclear reactor. **2**

(d) The table below lists some common radioactive elements and their half-lives.

Radioisotope	**Half-life**
Carbon – 14	5930 years
Cobalt – 60	5.26 years
Iron – 59	46.3 days
Uranium – 235	710 million years
Sodium – 24	15 hours
Polonium - 216	0.16 seconds

(i) What is the main problem with using and producing radioisotopes with long half-lives? **1**

(ii) Sodium-24, an alpha emitter, is used by doctors to diagnose diseases of the circulatory system. Cobalt-60, a gamma emitter, is used to treat cancer. Suggest a reason why each of these particular radioisotopes are used for these specific purposes. **2**

End of question 36

2016 Physics Trial HSC examination. Marking Guidelines and Sample Answers.

Section I A Multiple Choice

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

DE ROOY

Section I B

Question 21

Marking Criteria	Marks
• Calculates correct height with units and full working	**3**
• Calculates correct initial horizontal and vertical velocities AND • Calculates correct time of flight	**2**
• Calculates the correct value of one unknown	**1**

Sample answer

$U_x = Ucos\theta$ $\qquad$ $U_y = Usin\theta$

$U_x = 25cos30$ $\qquad$ $U_y = 25sin30$

$U_x = 21.65\ ms^{-1}$ $\qquad$ $U_y = 12.50\ ms^{-1}$

$\Delta x = U_x t$

$t = \frac{\Delta x}{U_x} = \frac{450}{21.65} = 20.78\ s$

Let up be positive

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

$\Delta y = (12.50 \times 20.78) + (\frac{1}{2} \times -9.8 \times 20.78^2)$

$\Delta y = -1856\ m$

Therefore the height of the cliff is 1856 m.

Question 22.

(a)

Marking Criteria	Marks
• Calculates the correct value of change in gravitational energy with units	**1**

Sample answer

$$\Delta E_{GP} = E_{GP\ final} - E_{GP\ initial}$$

$$\Delta E_{GP} = (-6.4 \times 10^9) - (-4.0\ \times 10^9)$$

$$\Delta E_{GP} = -2.4\ \times 10^9\ J$$

(b)

Marking criteria	Marks
• Explains why gravitational potential energy has a negative value	**2**
• Identifies gravitational potential energy is zero at infinity OR • Defines gravitational potential energy	**1**

Sample answer

The gravitational potential energy of a mass in a gravitational field is defined as zero at an infinite distance from the centre of a larger mass. When the mass is moved towards the larger mass (that is, it is moved in the direction of the gravitational field) it gains kinetic energy and loses gravitational potential energy. It follows that the gravitational potential energy of an object anywhere in space is a negative value when compared to the gravitational potential energy at infinity.

Question 23

(a)

Marking criteria	Marks
• Identifies the changes in momentum of the rocket and of the exhaust gases AND EITHER • Indicates that these momentum changes are equal and opposite (cancel each other) OR • Indicates that the total momentum of the rocket/gases system is conserved	**3**
Any two of the following: • Identifies the changes in momentum of the rocket OR the exhaust gases • Identifies change in direction • States the total momentum is conserved	**2**
• Identifies one change in momentum OR • States that total momentum is conserved	**1**

Sample answer

Upon firing its propulsion system, the forward momentum of the rocket increases by an amount equal to the change in momentum of the exhaust gases in the opposite direction. Mathematically:

$$-\Delta p_{gases} = \Delta p_{rocket}$$

$$-\Delta(mv)_{gases} = \Delta(mv)_{rocket}$$

This means that the total momentum of the (closed) system containing the rocket and the exhaust gases remains constant.

(b)

Marking criteria	Marks
• Correct explanation with reference to both decreasing mass and decreasing weight force	**2**
• Partial explanation	**1**

Sample answer

The acceleration of a rocket is given by:

$$a = \frac{\Sigma F}{m}$$

$$a = \frac{Thrust - weight}{m}$$

$$a = \frac{T - mg}{m}$$

The acceleration of a rocket increases as time increases for two reasons:

- As fuel is burnt the mass of the rocket decreases. Since thrust remains constant, acceleration increases.
- The gravitational force between the rocket and earth decreases slightly with increasing altitude (i.e. weight decreases with increasing altitude). This causes the net force upwards on the rocket to increase with time, increasing acceleration.

Note:

- Decreasing air resistance as a consequence of a thinning atmosphere was also marked as correct.
- Many students wrote that the momentum of the rocket must be constant, and since p = mv and mass is decreasing as fuel is burnt, velocity must increase to keep the momentum of the rocket constant. This is COMPLETE RUBBISH!. The rocket accelerates (increases its velocity) because there is a non-zero net force acting on the rocket in the forward direction! The rate of acceleration increases for the reasons outlined above.

(c)

Marking criteria	Marks
• Calculates the correct g-forces	**1**

Sample answer

From the graph the acceleration of the rocket at 4 minutes is 36 ms^{-2} upwards.

If we define down as positive the g forces experienced by an astronaut is given by

$$g\ forces = \frac{g - a}{g}$$

$$g\ forces = \frac{9.8 - -36}{9.8} = 4.67$$

Question 24

Marking criteria	Marks
• Calculates correct altitude with units by substitution into relevant formula	**3**
• Calculates a correct value for r in relevant equation OR • Calculates altitude using an incorrect unit for period	**2**
• Identifies relevant equation OR • Calculates the correct period of the low earth satellite	**1**

Sample answer

The period of the low earth orbit $= \frac{24\ hrs}{12} = 2\ hrs = 2 \times 60 \times 60\ s = 7\ 200\ s$

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

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

$$r^3 = \frac{(7200)^2 \times 6.67 \times 10^{-11} \times 6.0 \times 10^{24}}{4\pi^2}$$

$$r^3 = 5.255 \times 10^{20}$$

$$r = 8\ 069\ 763\ m$$

Altitude $= r - radius\ of\ earth$

$= 8\ 069\ 763 - (6.371\ x\ 10^6)$

$$= 1\,698\,763$$

$$= 1.7 \times 10^6\ m$$

Note

- If you use a quantity given in the data sheet you must use the exact value provided on the data sheet. DO NOT ROUND IT! In this question you should have substituted 6.0 x 10^{24} not 6 x 10^{24}.

Question 25.

Marking criteria	Marks
• Demonstrates a thorough knowledge of scientific method and Einstein's Theory of Special Relativity and the evidence supporting it • Identifies the evidence to support Einstein's Theory of Special Relativity • Outlines the development and acceptance of the theory • Links the development of the theory and the evidence supporting it to the steps in the model of scientific method • Demonstrates coherence and logical progression and includes correct use of scientific principles and ideas	**5-6**
• Demonstrates knowledge of scientific method and Einstein's Theory of Special Relativity and the evidence supporting it AND EITHER • Describes the development and acceptance of the theory and evidence used to support it OR • Describes some aspects of the theory, some evidence supporting it and attempts to relate this to the steps in the model of scientific method	**3-4**
• Demonstrates a limited knowledge of scientific method and Einstein's Theory of Special Relativity AND EITHER • Describes some aspects of Einstein's theory OR • Describes some parts of the model of scientific method including 3 steps	**1-2**

Sample answer

As outlined in the presented model, the scientific method begins with observations and their associated problems. Preceding Einstein's proposal of the Theory of Special Relativity there were two main observations/problems:

- The Michelson-Morley experiment performed in 1887 provided no evidence supporting the existence of the aether. The aether was thought to be the absolute frame of reference to which all motion could be compared. Failure to detect the aether brought into question this concept of an

absolute frame of reference. The propagation of light from the sun to earth could also not be explained if the aether did not exist.

- Einstein performed several thought experiments, one of which was as follows; if I were travelling in a train at the speed of light facing forward and I held a mirror up in front of my face, would I be able to see my own reflection in the mirror? If the answer was no the principle of relativity would be violated, and if the answer was yes an observer outside of the train would see light at twice its usual speed. Both solutions caused problems.

In the presented model, following a problem a new hypothesis is proposed. In 1905, to explain the problems outlined above, Einstein proposed some new ideas (equivalent to a hypothesis) which later became known as the Theory of Special Relativity. These ideas can be summarised by the following points:

- The laws of physics are the same in all frames of reference, that is the principle of relativity holds in all situations.
- The speed of light in empty space is constant (3×10^8 ms^{-1}) regardless of the observer's frame of reference.
- The aether is not needed to explain light, and, in fact, does not exist.

These bold new ideas/hypothesis had several important implications including length contraction, time dilation, mass dilation, energy-mass equivalence and the relativity of simultaneity.

In the presented model, following a hypothesis an experiment is designed to test the hypothesis. Initially there was insufficient technology available to plan an experiment and collect and analyse data to test the implications of Einstein's ideas/hypotheses. It took years, and for some components decades, before conclusive data was collected that supported Einstein's ideas/hypotheses. Such supporting data included:

- Two atomic clocks accurate to approximately 1 nanosecond were synchronised. One clock was placed in a jet plane and flown around for 45 hours and the other left in the laboratory. On return the clock from the plane lagged slightly behind the one in the laboratory. This provided evidence of time dilation.
- Muons are subatomic particles that form high up in the atmosphere and should not be able to reach the earth due to their short lifespan. An abundance of muons are now detected striking the earth's surface. This also supports time dilation.
- Beta particles emitted from different radioactive substances were observed to have different charge to mass ratios. The greater the speed of the beta particle, the smaller was its charge to mass ratio. When the effects of mass dilation were accounted for, the beta particles were all found to have the same charge to mass ratio.

The experimental data outlined above all supported Einstein's ideas/hypotheses and have led to it being established as a scientific theory known as the Theory of Special Relativity.

Thus the development of the Theory of Special Relativity is a clear application of the presented model of scientific method.

Note:

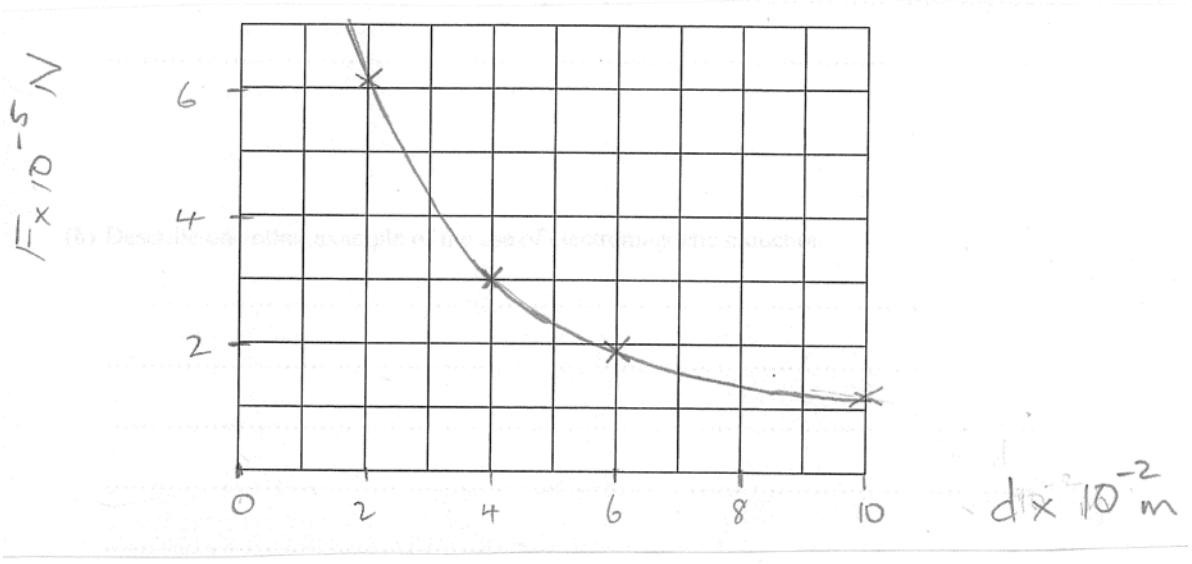
- The marking criteria dictates that if you did not discuss any supporting evidence of the Theory of Special Relativity the maximum mark you could receive is a 2.

WARD

Question 26.a.

Marking Guidelines	Marks
• 80% of the graph paper must be utilised by the data. • Curved LOBF. • Linear scales with crosses for data points. • Axes labelled with both quantities and units. • F (y axis) plotted against d.	**3**
• Four or three of the above.	**2**
• Identifies a correct aspect of the graph.	**1**

Sample answer:



b

Marking Guidelines	Marks
• Identifies a reason given below, in the sample answer, plus the appropriate next step needed, for analysis.	**2**
• Identifies a reason given below, in the sample answer, OR the appropriate next step needed, for analysis.	**1**

Sample answer:

The question says nothing about the sizes of the currents being carried, nor the mutual length of the wires, nor the medium between the wires, nor whether any of these important factors remain constant. The constancy of the factors needs to be ascertained, before analysing the results.

There are relatively few data points on the graph. More data needs to be collected, in particular for

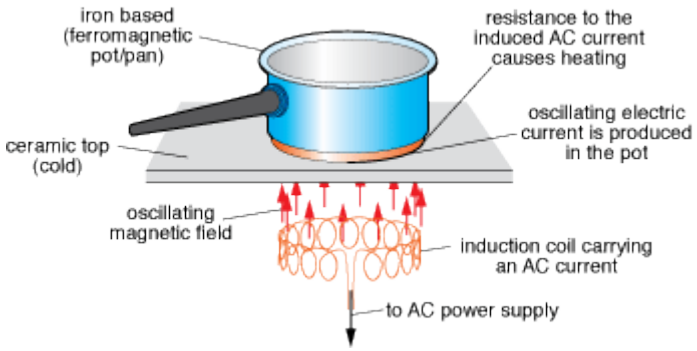
d = 0.08m, before analysing the results.

Question 27. a.

Marking Guidelines	Marks
• Thoroughly explains why eddy currents are generated in the base of the saucepan, by electromagnetic induction.	**2**
• Partially explains why eddy currents are generated in the base of the saucepan, by electromagnetic induction.	**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 metal base of the saucepan, which in turn induces voltages and 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.

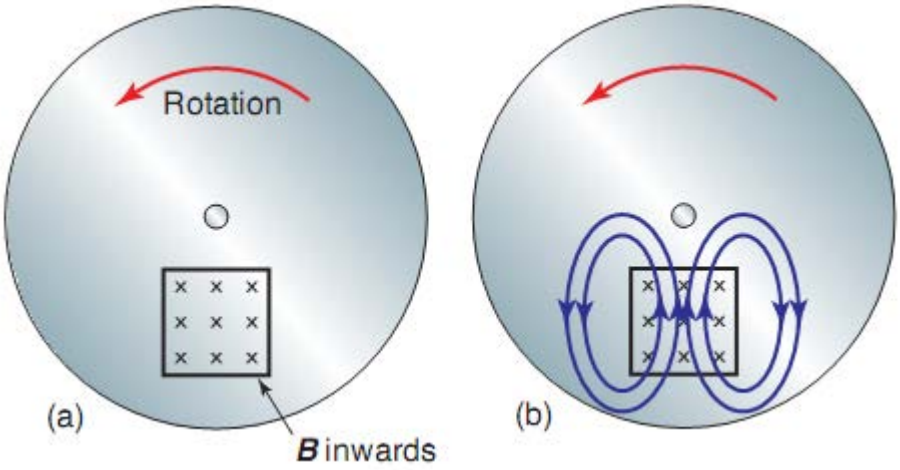


The heat is generated in the saucepan base quickly and stops when the power is turned off. Since the heat is generated in the saucepan base itself, the food is heated directly which lessens wasted heat. The ceramic top (upper surface of the cooktop) is not a good electrical conductor. Therefore, it does not receive heat from the induction process. This makes it much safer, especially for children. With extended heating, the ceramic top will become warm, from simple thermal conduction, from the hot saucepan base.

b

Marking Guidelines	Marks
• Thoroughly describes another named example of electromagnetic induction.	**2**
• Identifies another example or partially describes it.	**1**

Sample answer: ***Electromagnetic Braking….Consider the following diagrams.***



In diagram (a), we see a disc attached to a central axis. The disc is rotating in the anticlockwise direction. In the lower part of the disc, there is a region of uniform magnetic field, directed into the page.

Applying the left hand palm rule (generator), we see that twin eddy currents are generated. Through the field, the current direction is up the page, as seen in diagram (b).

If we now apply the right hand palm rule (motor) to diagram (b), we will find that a force is produced to the left, opposing the original motion, in accordance with Lenz's Law.

The current was electromagnetically induced. It provides the desired braking force.

Question 28.

Marking Guidelines	Marks
• Outlines advantages and disadvantages of AC generators • Outlines advantages and disadvantages of DC generators • Relates the advantages and disadvantages of AC and DC generators to the outcome of the competition between Edison and Westinghouse.	**5-6**
• Identifies some advantages and/or disadvantages of AC generators • Identifies some advantages and/or disadvantages of DC generators • Identifies the outcome of the competition between Edison and Westinghouse.	**3-4**
• Identifies some advantages and/or disadvantage of AC generators • Identifies some advantages and/or disadvantage of DC generators	**2**
• Identifies an advantage and/or disadvantage of AC generators OR • Identifies an advantage and/or disadvantage of DC generators	**1**

Sample answer:

During the late 19th Century George Westinghouse competed against Thomas Edison to provide the dominant power transmission systems for use in homes and industry. Edison intensely promoted the advantages of DC generators:

- Produced DC current, which some devices are solely dependent on.
- DC is typically more powerful than AC.
- Does not have to be synchronized to operate at same frequency.

DC generators however had the major disadvantage of having a split ring commutator and brushes, which wear out and are inefficient. Edison also very widely publicised the disadvantages of AC generators:

- Produced AC current at 50 Hz, which can readily cause heart fibrillation, and as such be fatal.
- The frequency of AC generators in different regions must be correctly synchronised.
- Conversion from AC to DC required rectifiers.

Despite Edison's best efforts Westinghouse's AC current became the primary power transmission systems for use in homes and industry. This outcome is based primarily on the overwhelming advantages of the AC generator:

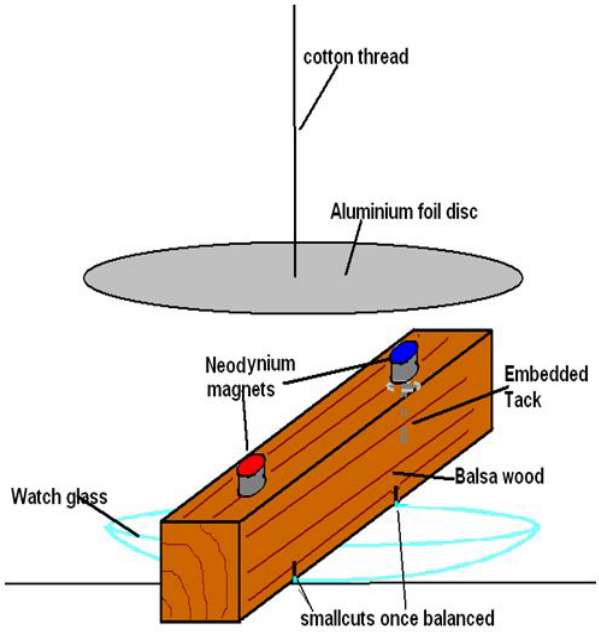
- Produced AC voltage, which can be easily stepped up/down.
- More efficient at transforming electrical energy into other useful forms of energy.
- Less moving parts – less maintenance – more reliable – simpler to construct.
- AC can be transported much more efficiently through transmission lines using transformers.

Question 29.

Marking Guidelines	Marks
• Thoroughly outlines a first hand investigation, demonstrating the principle of an induction motor, including a relevant labelled diagram.	**3**
• Partially outlines a first hand investigation, demonstrating the principle of an induction motor, including a relevant labelled diagram OR thoroughly outlines, without a relevant, labelled diagram.	**2**
• Identifies an aspect of an induction motor OR includes a relevant, labelled diagram.	**1**

Sample answer:

Demonstrating the principle of an AC induction motor



- The set-up should spin easily once it is balanced on the watch glass and small cuts are made in the Balsa to fix it in position
- The embedded tacks are there to keep the neodymium magnets in position (check that the tacks are attracted to the magnets first).
- Once the magnets are spinning on the watch glass gently lower a disc of aluminium foil and note that it starts rotating in the same direction .
- Eddy currents form in the aluminium disc that try to stop the rotation by forming poles of opposite polarity to the magnets, and hence are dragged with it. Notice that it 'lags' behind the rotation of the magnets.
- Check that the aluminium disc is not affected if there are no magnets.
- Once the experiment is over try to make cuts on the disc with a pair of scissors to reduce the circulation of eddy currents and then test your efforts by comparing it to how it behaved before you cut it.

NOYES

Questi on 30

Marking Guidelines	Marks

• Correctly calculates mass of particle with correct units and working	**3**
• Equates Magnetic force to centripetal force but makes an error in substitution	**2**
• Calculates magnetic force OR • Identifies a correct formula	**1**

Sample answer:

$$F_B = F_c$$

$$qvB\sin\theta = \frac{mv^2}{r}$$

$$m = \frac{qB\sin\theta\, r}{v}$$

$$m = \frac{1.6 \times 10^{-18} \times 0.3 \times \sin 90 \times 3.33}{50}$$

$$m = 3.2 \times 10^{-20}\ \text{kg}$$

The mass of the particle is 3.2 x 10^{-20} kg

(Make sure that you substitute all values into the equation. I know sin 90 = 1….but you get 1 mark in the HSC if you write correct formula & SUBSTITUTE into it!!)

Question 31

Marking Guidelines	**Marks**
• Calculates frequency with correct formulas and working	**2**
• Correctly calculates Ek OR • Attempts E=hf	**1.5**
• Correct substitutes into formula	**1**

Sample answer:

$E_k = \frac{1}{2}mv^2 = \frac{1}{2}\,9.109 \times 10^{-31} \times (0.1 \times 3.0 \times 10^8)^2 = 4.099 \times 10^{-16}$

$E = hf$

$4.099 \times 10^{-16} = 6.626 \times 10^{-34} \times f = 6.186 \times 10^{17}$

Question 32

Marking Guidelines	**Marks**
• Describes the meaning of doping • Describes p-type and n-type doping • Gives an example of an element used to dope in both types • Relates doping to electrical properties of both	**4**

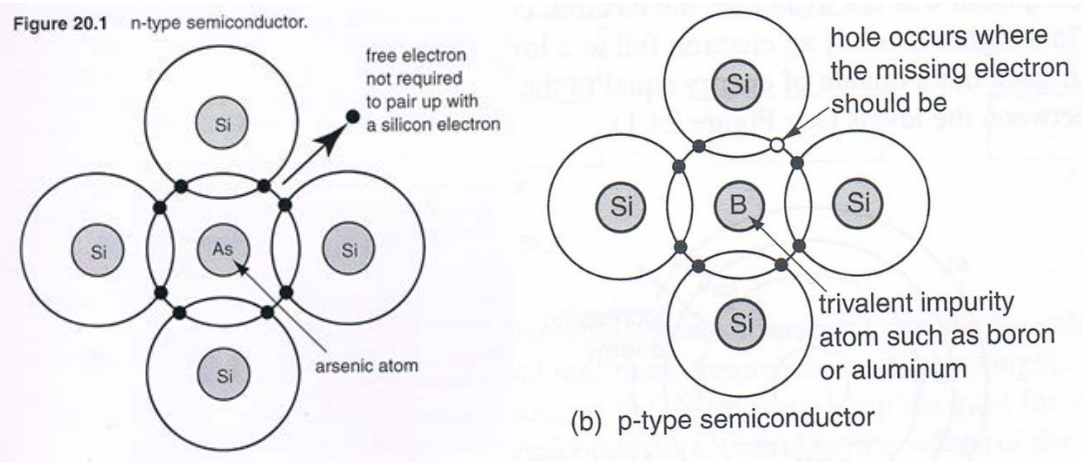
• Describes the meaning of doping • Describes p-type **and** n-type doping • Gives an example of an element used to dope in both types	**3**
• Describes p-type or n-type doping OR • Relates doping to electrical properties	**2**
• Identifies an element used to dope OR • Describes a type of doping OR • Describes the meaning of doping	**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.
Silicon is a tetravalent atom forming a lattice structure where all 4 valence electrons are bound in covalent bonds. For conduction to occur, one of these bound electrons must gain enough energy to jump into the conduction band. This electron, as well as the positive hole left behind, are free to move and act as charge carriers, thereby conducting electricity.

N-type silicon is doped with group 5 element (e.g. phosphorus) atoms that substitute for silicon atoms. The extra valence electron provided by the group 5 atom is not bonded to anything and hence can act as a charge carrier. This means n-type silicon has more charge carriers than pure silicon and hence has a lower resistivity.

P-type silicon is doped with group 3 element (e.g. boron) atoms that substitute for silicon atoms. With only three valence electrons available for covalent bonding, the boron atom effectively creates a positive hole in the lattice. This positive hole can act as a charge carrier. This means p-type silicon has more charge carriers than pure silicon and hence has a lower resistivity.



Question 33

Marking Guidelines	**Marks**

• Describes the role of the electrodes • Identifies the high voltage requirements of the electrodes • Explains that a step-up transformer is necessary to create the voltage requirements in the home.	**4**
• Describes the role of the electrodes • Identifies the voltage requirements of the electrodes OR • Identifies that a step-up transformer is necessary to create high voltages	**3**
• Describes the role of the electrodes • Identifies that a step-up transformer is necessary to create high voltages	**2**
• Describes the role of the electrodes OR • Identifies that a step-up transformer is necessary to create high voltages	**1**

Sample answer:

In simplicity, the conventional cathode ray television works by having cathode rays strike pixels on the display screen, which fluoresce and create an image. The role of the electrodes is to create a high potential difference to accelerate the electrons along the tube towards the display screen.

In order to accelerate electrons very high voltages are necessary. Households in Australia are supplied with 240 V. Typical TV's will use up to 25 KV and therefore will require a step up transformer to operate in the home.

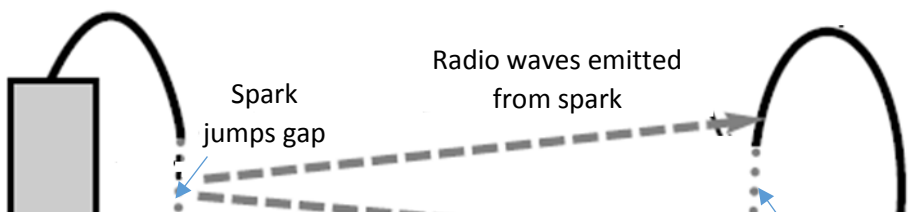
Question 34

Marking Guidelines	Marks
• Describes fully Hertz's experiment • Describes how the experiment produced and detected radio waves and determined the speed of the radio waves. • Draws a relevant diagram	**4**
• Describes Hertz's experiment • Describes how the experiment produced and detected radio waves OR determined the speed of the radio waves. • Draws a relevant diagram	**3**
• Basic outline of Hertz's experiment AND • Describes how the experiment produced and detected radio waves OR determined the speed of the radio waves OR • Draws a diagram	**2**
• Draws a diagram OR • Identifies an element of Hertz's experiment.	**1**

Sample answer:

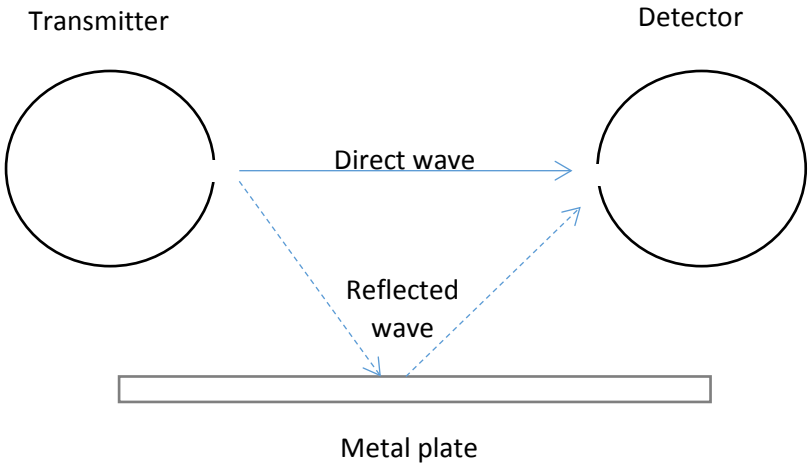
Heinrich Hertz was the first person to investigate radio waves. His most significant achievements are outlined below:

- He demonstrated the generation and detection of radio waves with the experimental set-up below.



As sparks jumped across the gap in the induction coil, sparks were also noticed jumping across the gap in the receiving loop. Hertz hypothesized that the sparks set up changing electric and magnetic fields that propagated as an electromagnetic wave. These waves, falling on the detector gap, set up electric and magnetic fields, inducing a spark.

- He determined the speed of radio waves using the experimental set-up below:



Waves of known frequency (controlled by the transmitter) were reflected from a metal plate and allowed to interfere with the direct beam from the transmitter. This produced an interference pattern from which it was possible to determine the wavelength of the waves. Knowing the frequency and the wavelength of the waves, Hertz then used $v = f\lambda$ to calculate the velocity. His value was very similar to the speed of light.

Hertz is also well known for observing but not further investigating the photoelectric effect.

In the first experiment outlined above he noticed that the gap in the receiving loop could be made greater and a spark would still occur if ultraviolet light was shone onto the loop. He also observed that the spark was larger when U.V. light was shone on the detector.

Question 35

Marking Guidelines	Marks
• Outlines three advantages of superconductors • Outlines three limitations to their use • Makes a judgement	**4**

• Outlines two advantages of superconductors OR • Outlines two limitations to their use	**3**
• Outlines one advantages of superconductors • Outlines one limitations to their use	**2**
• Outlines one advantages of superconductors OR • Outlines one limitations to their use	**1**

Sample answer:

Superconductors have the potential to completely revolutionize the efficiency of electrical energy use. At this stage in their development however, there are limitations to their use.

The whole premise of a superconductor is that they can transmit electrical energy without any resistance. Current electrical transmission is made imperfect by resistance particularly when long distances are involved. The resistance created by electron collisions with the lattice of the conductor creates heat. The energy converted to heat is essentially wasted heat, and therefore lost energy. Superconductors would allow the transmission of electrical energy with no energy losses.

Superconductors can be used to generate extremely strong electromagnets. These have many applications particularly in the transport sector that use them for maglev trains, another highly energy efficient use.

Superconductors can also increase the speed of computers. With modern civilization ever increasing their dependence on computers there is a real necessity to increase processing speed. Superconducting switches could be ten times faster than a semiconductor transistor and are therefore a major advantage to enhancing the power of computers.

The most common superconducting materials however have their drawbacks. The currently will not superconduct unless they are chilled to extremely low temperatures. This is commonly done with liquid helium. Unfortunately, in many situations this is very impractical. It is also very expensive to sustain these temperatures with a continual supply of coolant.

Newer superconductors that will superconduct at higher temperatures can be cooled with liquid nitrogen, are far more practical and cheaper coolant. The limitation with these superconductors is however, that they are made from fragile and brittle ceramics that are hard to make into wires. They therefore have a limited use. They can also be chemically unstable and have a limited life span.

Until superconductivity can be achieved at room temperature the limitations of superconductors will outweigh the advantages that they offer. But an energy revolution is ensured for when that time comes.

OPTION –VOULALAS

Question 36.a i

Marking Guidelines	Marks
• Provide correct explanation	2
• Provide a partial correct explanation	1

Sample answer:

Rutherford explained the alpha particle scattering results by proposing that the nuclear atom consists of a very small and dense nucleus in the centre of the atom, which he assumed to be positively charged, with the negatively charged electrons orbiting the nucleus. He further proposed that the most of the atom's mass is contained by the nucleus.

a ii

Marking Guidelines	Marks
• Provide correct explanation	**2**
• Provide a partial correct explanation	**1**

Sample answer:

Bohr's model explained the spectral lines of hydrogen by proposing that these lines were produced by the energy emitted by the electron of the hydrogen atom when it returned from a higher level of energy to a lower level of energy.

b. i

Marking Guidelines	Marks
• Calculates correct wavelength in meters with working	**2**
• Identifies correct formula, provides correct substitution without answer/units/wrong units	**1**

Sample answer:

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

$$\frac{1}{\lambda} = 1.097 \times 10^7 \times \left[\frac{1}{2^2} - \frac{1}{5^2}\right]$$

$$\frac{1}{\lambda} = 1.097 \times 10^7 \times \left[\frac{1}{2^2} - \frac{1}{5^2}\right]$$

$$\frac{1}{\lambda} = 2303700$$

$\lambda = 4.34 \times 10^{-7}$ m or 434.0 nm

The wavelength of the radiation emitted by a hydrogen atom when its electron falls from the fifth energy level to the second level is 4.34×10^{-7} m or 434.0 nm

b.ii.

Marking Guidelines	Marks
• Discussion refers to the nature and cause of emission spectra lines versus continuous spectrum in terms of energy photons • Nature of electron movement between allowed energy levels is referred • Planck's contribution is outlined and linked to above observations	**3**
• Reasons for discrete lines of absorption / emission spectra outlined • Planck's contribution is linked to this	**2**
• A relevant aspect of absorption / emission spectrum is identified OR • The nature of electron movement between allowed energy levels is outlined OR • Planck's contribution is outlined	**1**

Sample answer:

Electrons can exist only in allowable energy levels. They can change energy levels by absorbing or emitting photons of certain energies which must be equal to the energy difference between these allowable energy levels given by E = hf. As a result, we observe only discrete lines of certain wavelengths/frequencies for absorption and emission rather than a continuous spectrum which would indicate that photons with all or any energies are being emitted / absorbed. Therefore, the existence of individual spectra lines support Planck's hypothesis that energy is quantised.

b.iii.

Marking Guidelines	Marks
• Provide complete account of all limitations (5-4)	**4**
• Provide three limitations	**3**
• Provide two limitations	**2**
• Provide one limitation	**1**

Sample answer:

The major success of the Bohr model was its ability to explain the lines of the hydrogen spectrum and permit the calculation of the Rydberg constant. However, beside its successes there were a number of limitations. These include:

- Inability to explain the spectra of larger atoms.
- Inability to explain the different intensities of spectral lines.
- Inability to explain the existence of hyperfine spectral lines.

- Inability to account for the fact that a magnetic field splits spectral lines into several thinner lines (**the Zeeman effect).**
- It was a mixture of classical and quantum physics.

c.i.

Marking Guidelines	Marks
• Correctly describe the requirements for an uncontrolled nuclear reaction	**2**
• Provide a partial description	**1**

Sample answer:

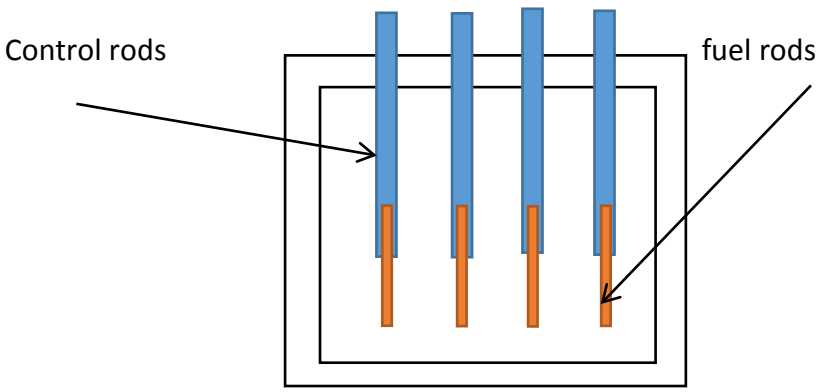
In an uncontrolled nuclear chain reaction, which takes place in a fission atomic bomb or in a nuclear reactor meltdown, the production of neutrons goes unchecked and the fission reaction increases at an accelerated rate. This process releases an enormous amount of energy in a very short time and results in a major explosion.

c.ii.

Marking Guidelines	Marks
• Correctly describe how to change an uncontrolled nuclear reaction to a controlled one with the help of a diagram	**2**
• Provide a description OR a diagram. **No marks awarded for 'control rods' without their function.**	**1**

Sample answer:

In order to change an uncontrolled nuclear reaction to a controlled one we need to regulate the available neutrons that cause the fission. This is achieved by using neutron absorbing materials such as control rods within a nuclear reactor.



d. i

Marking Guidelines	Marks
• Clearly state any one the problem. **No marks awarded for 'it is dangerous' without some explanation.**	**1**

Sample answer:

The main two problems are the risk of radioactive contamination in the working environment and subsequent danger to the people involved, and the production of non-useful waste products which need to be safely stored until their radiation counts have decreased to a minimum amount.

d.ii

Marking Guidelines	Marks
• Provide a reason for the use of **both** radioisotopes	**2**
• Provide a reason for the use of **one** radioisotope OR partial answer for both	**1**

Sample answer:

- Sodium -24 has a short half-life and therefore would not be a danger to the patients for a long period if it stayed in their bloodstream (it is also not a gamma emitter).
- Cobalt-60 is a gamma emitter and due to the high penetrating ability, it is ideal for killing cancer cells quickly (but at the same it also kills normal healthy cells).