BOOKLET 1 (of 4)

Student Number

2019

TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION

Physics

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black or blue pen
  Black pen is preferred
- Draw diagrams using pencil
- Approved calculators may be used
- A data sheet, formulae sheets and Periodic Table are provided at the back of this paper
- Write your student number in the space provided
- SHOW ALL WORKING. Marks are allocated to working.

Total marks – 100

100 marks
This exam has two parts, Part A and Part B,
Split into 4 booklets (1 to 4).

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

Part B – 80 marks
- Attempt Questions 21-34
- Allow about 2 hour and 25 minutes for this part

2019 SBHS Physics Trial. Multiple choice answer sheet

You may separate this sheet from the rest of the paper.

Student Number | | | | | | | | | |

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

Use the multiple choice answer sheet for Questions 1-20

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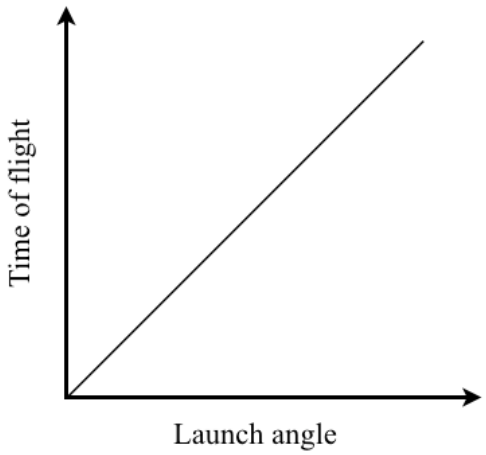
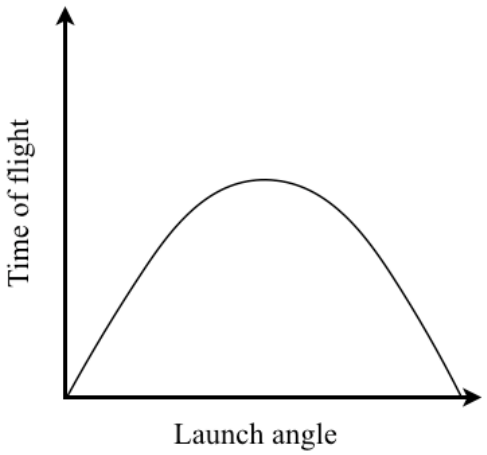
1. Which graph below correctly represents the relationship between launch angle and time of flight for a projectile?

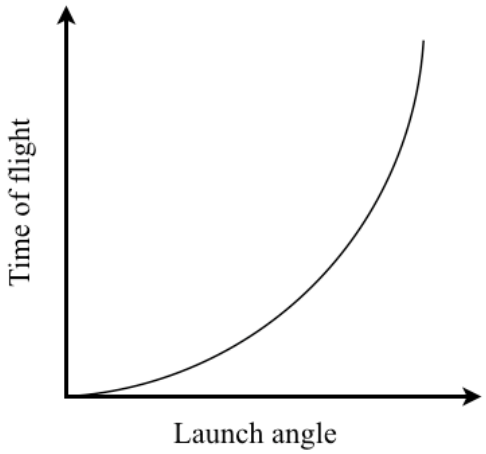
(A)



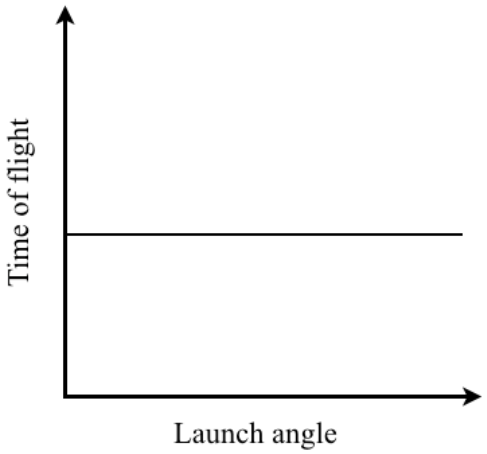
(B)



(C)



(D)



2. Using a homemade projectile launcher a student undertook a depth study to analyse projectile motion.

The student determined that the launcher did not produce a consistent initial velocity.

The type of error this produced would be best defined as:

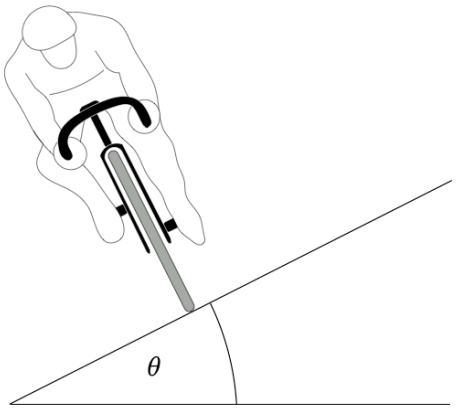
(A) Instrumental error

(B) Human error

(C) Systematic error

(D) Random error

3. The diagram below shows a cyclist turning on a banked track.



Which of the following statements about the forces acting on the cyclist are correct?

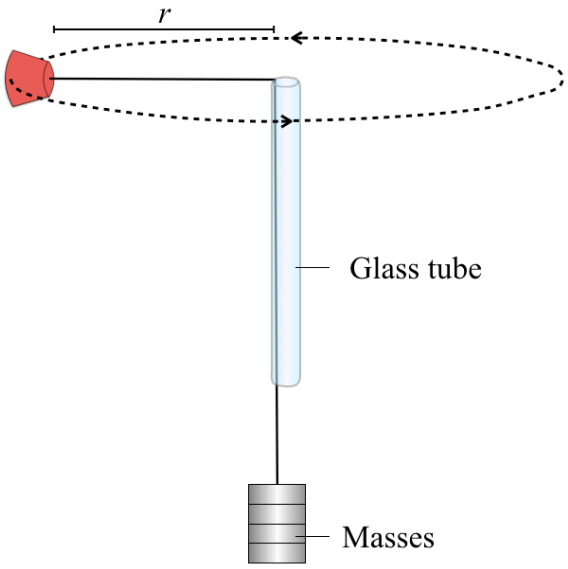
(A) All the forces are balanced, allowing him to travel at a constant speed.

(B) The net force acting on the cyclist creates a centripetal force.

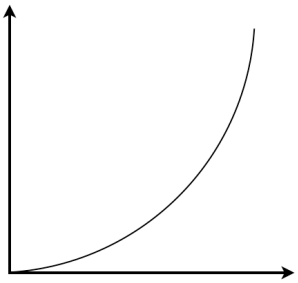
(C) The force acting on the cyclist parallel to the bank is balanced by the centripetal force.

(D) The component of the normal force perpendicular to the slope is equal to the weight force.

4. A class undertook a depth study in pairs to investigate centripetal force using the apparatus below.



One day a student was sick and their partner had to interpret their results. The lab partner found a graph with unlabelled variables as shown below.



Which pair of variables was most likely graphed?

(A) F and v

(B) F and r

(C) m and r

(D) a and v/r

5. Thompson's charge-to-mass experiment:

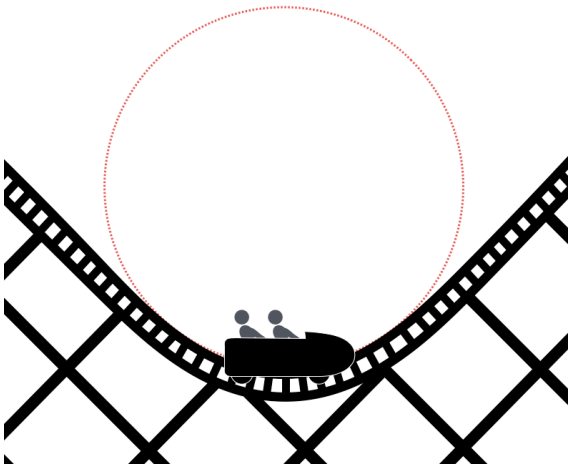
(A) calculated the mass of the electron.

(B) measured the charge of an electron.

(C) provided evidence that cathode rays had mass.

(D) Supported Hertz's claims about cathode rays.

6. The rollercoaster trolley shown has a constant speed through the dip. The curvature of the dip is circular.



Which of the following descriptions best analyses the forces acting on the trolley?

(A) The normal force acting on the trolley is less than when travelling on a flat surface.

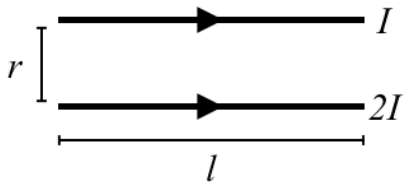
(B) The centripetal force is equal to the normal force.

(C) The sum of the normal force and the gravitational force is equal to the centripetal force.

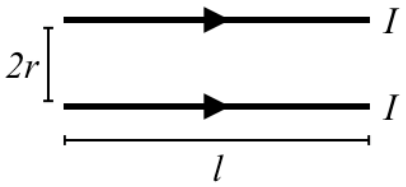
(D) None of the above are correct.

7. Which of the following pairs of current carrying conductors has the weakest force acting between them?

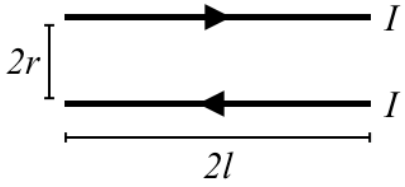
(A)



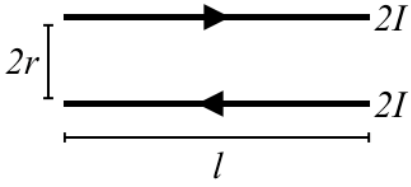
(B)



(C)

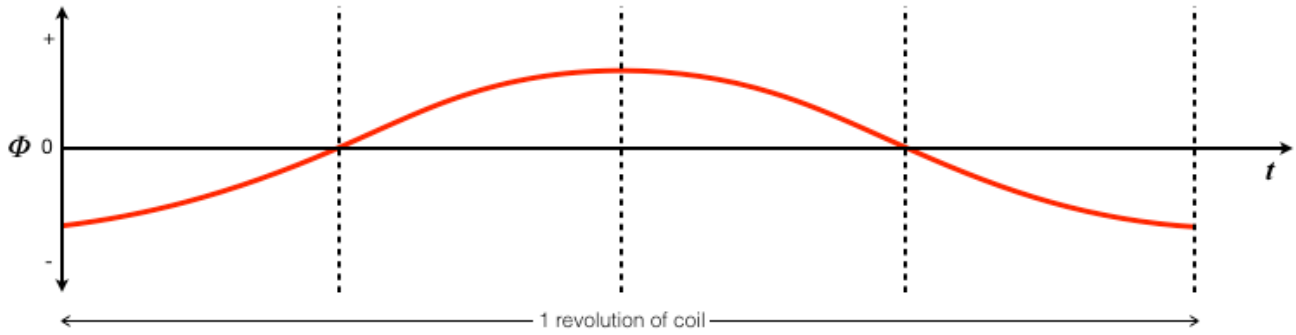


(D)



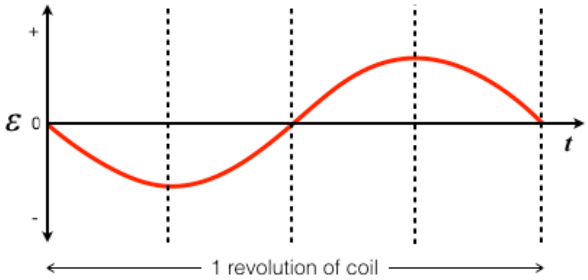
Use the following information to answer Question 8 and Question 9

The graph below shows the variation of flux of a generator coil as it completes a single revolution.

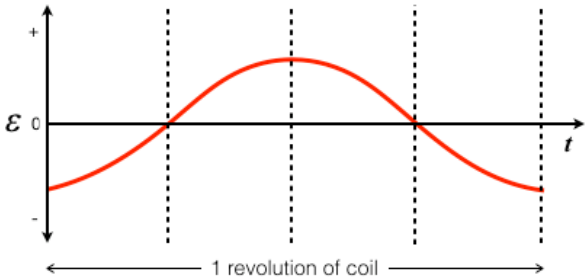


8. Which of the following graphs shows the corresponding EMF in the generator?

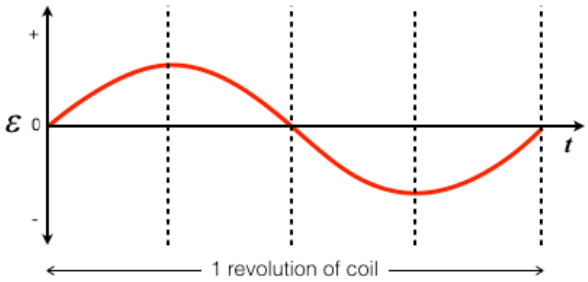
(A)



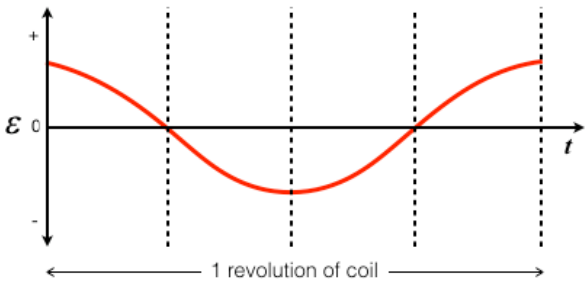
(B)



(C)

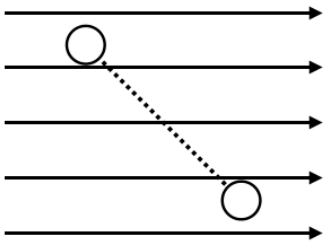


(D)

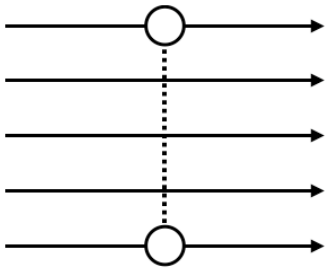


9. The following diagrams represent a cross section of the generator coil. Which position was the coil in at the beginning of the graph?

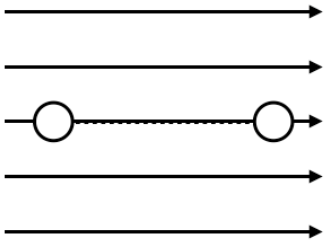
(A)



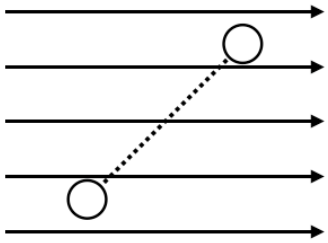
(B)



(C)



(D)



10. The main difference between a controlled and an uncontrolled nuclear chain reaction is:

(A) the number of neutrons released at each fission.

(B) the amount of energy released at each fission.

(C) the mass defect per fission is greater in uncontrolled reactions.

(D) the rate of fission reactions.

11. Which of the following formulas shows the correct decay of Cobalt-60 to Nickel-60?

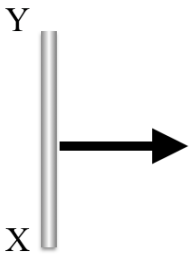
(A) ${}^{60}_{27}Co \longrightarrow {}^{60}_{28}Ni + {}^{0}_{-1}\beta + \bar{v}$

(B) ${}^{60}_{27}Co \longrightarrow {}^{56}_{25}Ni + {}^{4}_{2}He + energy$

(C) ${}^{60}_{27}Co \longrightarrow {}^{60}_{28}Ni + {}^{0}_{+1}\beta + v$

(D) ${}^{60}_{27}Co \longrightarrow {}^{60}_{27}Ni + {}^{0}_{+1}\beta + \bar{v}$

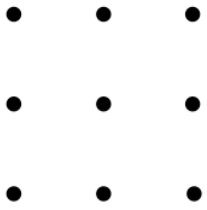
12. A wire conductor is moving to the right as shown below.



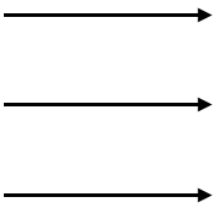
Which of the following magnetic fields would the conductor need to pass through (in the direction shown) in order to induce a net positive charge at position Y on the conductor?

(A)

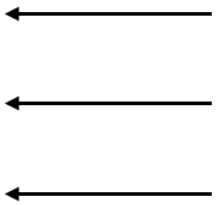
(B)



(C)



(D)



13. Foucault measured the speed of light by focusing a light onto a rotating mirror which reflected it onto a fixed mirror which in turn reflected it back. Whilst the light travelled to the fixed mirror and back, the rotating mirror rotated through an angle. By measuring the angle with a known angular velocity of the mirror, Foucault was able to calculate a value for the speed of light.

The smaller the measured angle the more uncertainty there was in the measurement.

What would be the easiest adjustment to make to the experimental design to increase the size of the angle and reduce the uncertainty in measurement?

(A) Increase the distance between the mirrors.

(B) Decrease the distance between the mirrors.

(C) Increase the rotational velocity of the rotating mirror.

(D) Decrease the rotational velocity of the rotating mirror.

14. Calculate the energy released from an electron-positron annihilation.

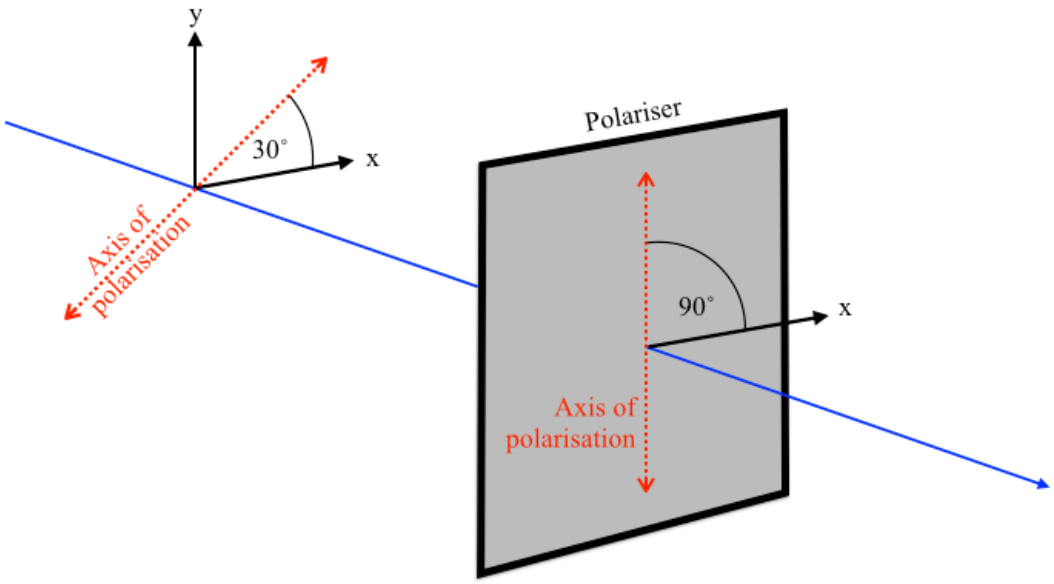
(A) 1.638×10^{-13} eV

(B) 8.19×10^{-14} eV

(C) 0.51 MeV

(D) 1.02 MeV

15. A polarised light source is entering a polarising filter as shown below.



What adjustment would produce the greatest reduction in light intensity?

(A) Rotating the light source clockwise 10˚

(B) Rotating the light source counter clockwise 70˚

(C) Rotating the filter clockwise 140˚

(D) Rotating the filter counter-clockwise 110˚

16. Calculate the work function for copper, which has a threshold frequency of 1.0×10^9 MHz.

(A) 4.1 eV

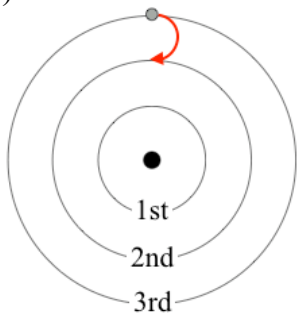
(B) 4.1 MeV

(C) 3.9 eV

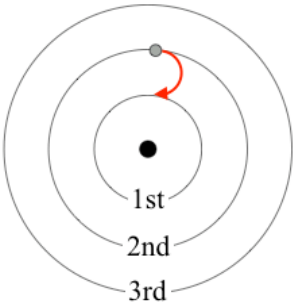
(D) 3.9 MeV

17. Which of the following examples below of an electron moving energy levels in a Hydrogen atom would emit the shortest wavelength?

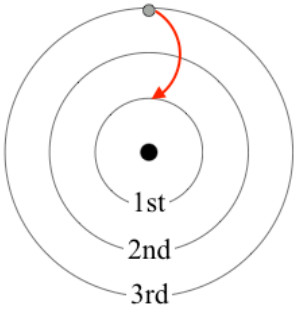
(A)



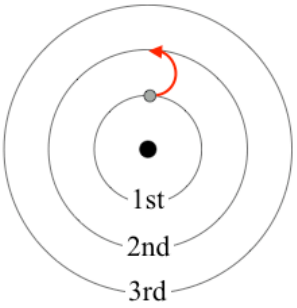
(B)



(C)



(D)



18. What significant change to the atomic model did the Rutherford Gold foil experiment lead to?

(A) All atoms contained negative electrons.

(B) Electrons existed in energy shells surrounding the nucleus.

(C) The nucleus was a positive space.

(D) The atom is mostly empty space.

19. Calculate the wavelength of a tennis ball of mass 59.4g travelling at 170 km h^{-1}.

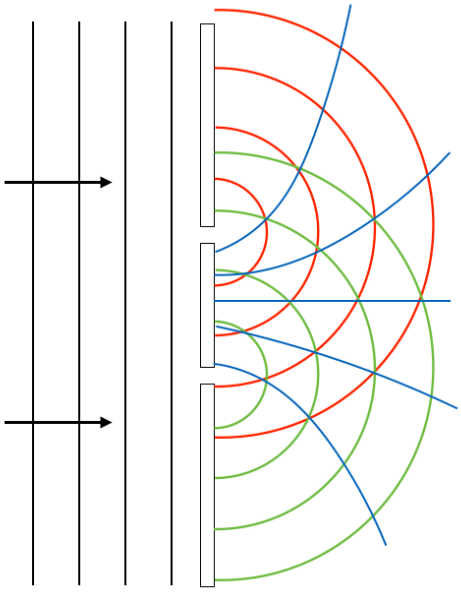
(A) 6.56×10^{-38} m

(B) 2.36×10^{-37} m

(C) 6.56×10^{-35} m

(D) 2.36×10^{-34} m

20. What wave phenomena are shown in the experiment shown in the diagram below?



(A) Diffraction and dispersion

(B) Interference and diffraction

(C) Refraction and interference

(D) Interference and dispersion

Part B – 80 marks
Attempt questions 21-40

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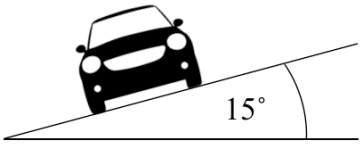
Allow about 2 hour and 25 minutes for this part
Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.
Show all relevant working in questions involving calculations.

Question 21. (2 marks)

Low Earth orbit satellites experience significant orbital decay, have a low life span and are difficult to monitor and troubleshoot. Explain why low Earth orbit satellites are still used extensively despite the above points. **2**

Question 22. (6 marks)

(a) A car is travelling at a constant speed on a frictionless banked track with a turning radius of 26.0 m, as shown in the diagram. The car maintains a constant height on the track. The centripetal force acting on the car is 3040 N. **2**



Determine the mass of the car.

(b) Determine the minimum coefficient of friction required if the car was to travel around an unbanked track of the same radius at half the speed from part (a). **4**

Question 23. (2 marks)

In terms of mechanical energy, explain why the work done on a satellite moving in a constant circular orbit around the Earth is equal to zero. **2**

Question 24. (3 marks)

Explain why the mass of an object is not a factor in determining its escape velocity. **3**

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Question 25. (5 marks)

Maverick's F14 plane is flying at a constant altitude of 200.0 m and a speed of 300.0 ms^{-1} when he fires his missile. The missile's engine creates an acceleration of 25.0 ms^{-2} for 10.0 seconds in a straight line and maintains the same altitude. The missile then follows normal projectile motion to hit the target on the ground.

(a) Calculate the distance travelled by the missile during the first 10 seconds. **2**

(b) Determine the horizontal distance from the target that Maverick should fire his missile in order to hit it. **3**

Question 26. (2 marks)

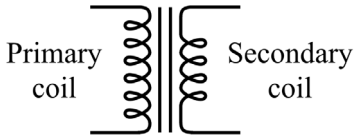
The Earth's average distance from the Sun is 1.00 AU. The average distance of Saturn from the Sun is 9.00 AU. Calculate the period of Saturn in Earth Years. **2**

Question 27. (3 marks)

Justify Lenz's Law. **3**

Question 28. (3 marks)

Identify and explain how the device shown in the diagram below works. **3**



Question 29. (4 marks)

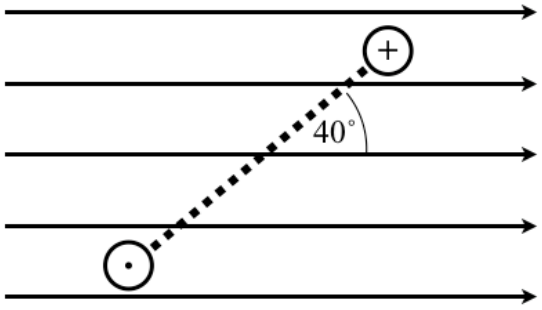
A power plant generates 150 MW of electricity for a town 20 km away. The transmission wires have a resistance of 0.01 ohms per km. The voltage drop between the plant and the town is 50 V.

(a) Calculate the power loss between the plant and the town **2**

(b) Calculate the voltage transmitted to the town. **2**

Question 30. (5 marks)

Below is a diagram of a cross section of a coil in a magnetic field. The square coil of side length 12.00 cm has 8 turns, and a current of 3.00 A. The magnetic field has a strength of 2.50×10^4 T.



(a) Calculate the torque on the coil shown in the diagram. **1**

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(b) Determine the change in flux if the coil rotates 30˚ from the position shown. **2**

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(c) Calculate the rate of coil rotation in revolutions/minute if a maximum voltage output (peak to peak) of 2400 volts is required. **2**

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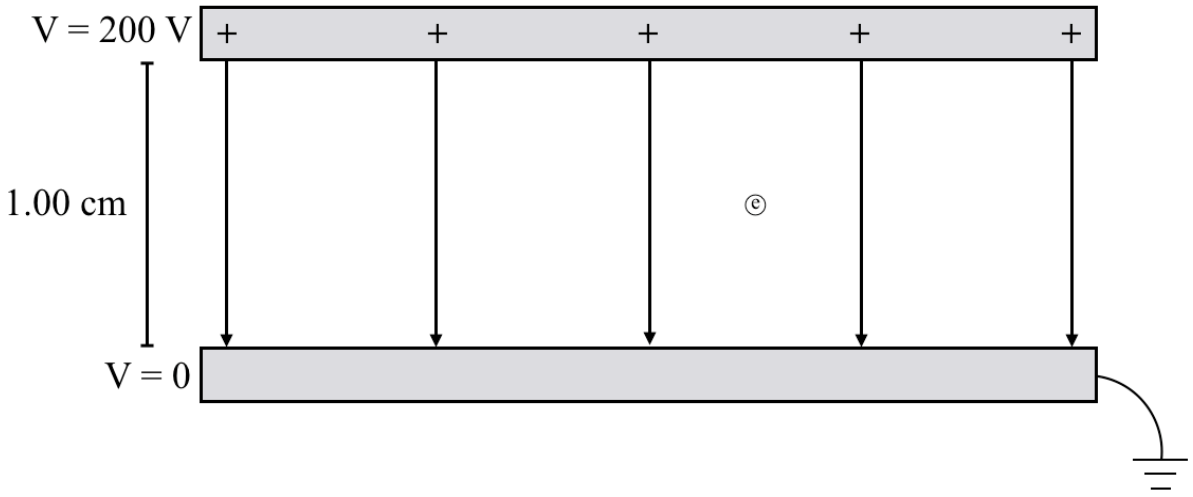
Question 31. (5 marks)

Two parallel plates are set up as shown in the diagram below so that the positive plate is above the earthed plate.



An electron is placed exactly midway between the plates so that it is allowed to fall.

(a) Calculate the net force acting on the electron. **2**

(b) Determine how long it takes for the electron to touch a plate. **3**

Question 32. (6 marks)

Discuss the significance of Maxwell's contribution to the development of our current understanding of electromagnetism and the development of wireless communication. **6**

Question 33. (4 marks)

(a) A spaceship pilot travelling through a spaceport observes that it takes 2.00 s to pass through. A person viewing the spaceship from the spaceport records the ship taking 4.39 s. Determine the speed of the ship as a percentage of the speed of light. **2**

(b) Outline an experimental validation of time dilation. **2**

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Question 34. (8 marks)

We currently have two models of light. One is from Classical Physics and the other is a Quantum model. Explain the need for two models of light. **8**

Question 35. (6 marks)

(a) Contrast the processes that lead to the production of absorption and emission spectra from stars. **3**

(b) Explain how rotational velocity of a star can be deduced from spectra. **3**

Question 36. (6 marks)

A student carried out an experiment on the photoelectric effect. The frequency of the incident radiation and the kinetic energy of the photoelectrons were both determined from measurements taken during the experiment. The results are shown in the table:

Frequency of incident radiation ($\times 10^{14}$ Hz)	**Maximum Kinetic Energy of photoelectrons** ($\times 10^{-19}$ J)	**Maximum Kinetic Energy of** *Photoelectrons* ***(eV)***
7.0	0.8	0.50
7.5	1.2	
9.0	2.2	
9.9	3.5	2.2
11	3.5	
12	4.2	2.6

(a) Complete the third column of the table. **1**

(b) Graphing the data. Use appropriate columns and scaling on the graph below so that the gradient of the LOBF gives a value for Planck's constant in S.I. units and the y intercept shows the work function. **2**

From the graph calculate the following values. Show all working.

i) Planck's constant **2**

ii) Threshold frequency **1**

Question 37. (5 marks)

(a) Explain how the emission spectra of hydrogen provided evidence for Bohr's model of the hydrogen atom with reference to one of his postulates. **2**

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(b) Calculate the second longest wavelength of the Balmer series in hydrogen. **3**

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Question 38. (3 marks)

A sample of Iodine-131 has a half-life of 8 days and contains 1.2×10^{13} nuclei.

(a) Calculate the decay constant for Iodine-131. **2**

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(b) Determine how many Iodine-131 nuclei will remain after 76 days. **1**

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Question 39. (2 marks)

In the Standard Model, protons and neutrons are composite particles. Compare the composition of a proton and a neutron. **2**

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2019 Trial HSC Physics Marking Guidelines

Section I, Part A

Multiple-choice Answer Key

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

Section I, Part B

Question 21

Criteria	Marks
Explains property of orbit ***and*** links to use	2
Explains property of orbit ***or*** describes use	1

Sample answer:

Because LEO's have a short period, they complete multiple passes off the Earth's surface every day. This makes it ideal for mapping or monitoring of the surface.

Shorter period → surface mapping/monitoring
Lower GPE → Cheaper to launch
Below Van Allen Belt→ Safer for astronauts/iss
Closer orbit → satellite communication (Iridium)/low latency (N.B. NOT mobile phone communication! Telecom companies use satellites in GTO)

GPS/Navigation ≠ LEO!!

Question 22 (a)

Criteria	Marks
Calculates correct mass of the car (1.2×10^3kg)	2
Attempts to find an expression for centripetal force	1

Sample answer:

$F_c = F_{N_x} = mg \sin\theta$

$3040 = m \times 9.8 \times \sin 15$

$m = \frac{3040}{9.8 \sin 15}$

$m = 1.2 \times 10^3$ kg (1158kg)

Question 22 (b)

Criteria	Marks
Correct working and answer to **2 SF** Coeff of friction $\mu = 0.067$	4
Some working, Coeff of friction $\mu = 0.067$	3
Answer wrong but correct use of equations and calculation of centripetal force of 760 N **or** derivation of correct new velocity $v_1 = 4.13ms^{-1}$	2
Some correct working	1

Sample answer:

$$F_c = 3040N = \frac{mv^2}{r}$$

$$v = \sqrt{\frac{3040 \times 26}{1158}}$$

$$= 8.26ms^{-1}$$

$$\frac{v_1}{2} = 8.26ms^{-1}$$

$$v_1 = 4.13ms^{-1}$$

$$F_C = \frac{mv_1^2}{r} = \frac{1158 \times 4.13}{26} = 760N$$

$$F_f = \mu F_N = 3040$$

$$= \mu mg = 3040 \times \tfrac{1}{4}$$

$$\mu = \frac{3040 \times {}^1\!/_4}{1158 \times 9.8}$$

$$= 0.067 = 6.7 \times 10^{-2}$$

Question 23

Criteria	Marks
Describes constant kinetic energy **and** gravitational potential energy, and relates work to change in energy	2
Describes constant kinetic energy and gravitational potential energy Or Describes constant kinetic energy **or** gravitational potential energy, and relates work to change in energy	1

Sample answer:

When an object is undergoing uniform circular motion its speed is constant, so its kinetic energy is constant. The gravitational potential energy of an object in uniform circular motion on a horizontal plane is always constant because its height above the Earth does not change.

Work done is equal to the energy transferred to the object. Because the total energy of an object in uniform circular motion remains constant, no work is done and thus equal to zero.

Question 24

Criteria	Marks
Defines escape velocity (including derivation of v_{esc}) **and** explains how mass is not a factor in determining its magnitude	3
Equates Kinetic energy with GPE to show escape velocity (derivation of v_{esc})	2
Identifies escape velocity (including formula)	1

Sample answer:

Escape velocity is defined as the kinetic energy required for a body to escape a gravitational field. Therefore, an escape velocity is reached when the kinetic energy is equal to the gravitational potential energy.

$K = U$

$\frac{1}{2}mv^2 = G\frac{Mm}{r}$

$v^2 = \frac{2GM}{r}$

$v_{esc} = \sqrt{\frac{2GM}{r}}$

By equating the kinetic energy and potential energy of the object, the object's mass has been cancelled and is not a factor in determining escape velocity.

Question 25

Criteria	Marks
Calculates correct distance	2
Uses correct formula	1

Sample answer:

$s = ut + \frac{1}{2}at^2$

$s = (300 \times 10) + \frac{1}{2} \times 25 \times 10^2$

$s = 4250$ m

Question 25

Criteria	Marks
Calculates correct distance of rocket launch	3
Calculates distance of projectile	2
Calculates time for projectile to fall (6.39s) **or** Initial velocity of ballistic flight ($550 ms^{-1}$)	1

Sample answer:

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

$-200 = 0 - \frac{9.8}{2}(t^2)$

$t = 6.39$ s

$v = u + at$

$v = 300 + 25 \times 10$

$v = 550$ m s^{-1}

$\Delta x = u_x t$

$\Delta x = 550 \times 6.39$

$\Delta x = 3513.8$ m

$s_{total} = 4250 + 3513.8$

$s_{total} = 7760$ m

Question 26

Criteria	Marks
Calculates correct period of Saturn	2
Attempts to use Kepler's law of periods	1

Sample answer:

$\frac{r_E^3}{T_E^2} = \frac{r_S^3}{T_S^2}$

$\frac{1}{1} = \frac{9^3}{T^2}$

$T = \sqrt{9^3}$

$T = 27$ Earth years *or* $T = 8.52 \times 10^8$ s

Question 27

Criteria	Marks
States Lenz's law and **explains** how it prevents a violation of conservation laws	3
States Lenz's law **and** identifies its affirmation of conservation laws	2
States Lenz's law **or** identifies its affirmation of conservation laws	1

Sample answer:

Lenz's law states that an induced **current** will flow in the direction that produces a magnetic field that opposes the change in flux through the conductor.

If it did not oppose the change in flux it would affirm it, creating a larger change in flux which would increase the induced current leading to an infinite source of energy. This would violate the conservation of energy.

Question 28

Criteria	Marks
. Identifies the device is a step down transformer. . Explains magnetic flux in primary coil induces an EMF in the secondary coil that is lower in voltage **and** uses correct terminology - primary coil and secondary coil. . Applies Faraday's Law as part of the explanation	3
2 points from above	2
1 point from above	1

Sample answer:

The primary coil supplied with an AC current produces a constantly changing magnetic flux as the current alternates. The soft iron core links the two coils and amplifies the changing flux. The changing flux induces an EMF in the secondary coil. Because there are less turns in the secondary coil a smaller voltage is induced.

Question 29 (a)

Criteria	Marks
Calculates correct power loss	2
Uses correct power loss formula	1

Sample answer:

$P_{loss} = \frac{{v_{drop}}^2}{r}$

$P_{loss} = \frac{50^2}{20 \times 0.01}$

$P_{loss} = 12500 \text{ W}$

Question 29 (b)

Criteria	Marks
Calculate the correct voltage	2
Calculates current	1

Sample answer:

$P_{loss} = I^2R = 12500$

$I = \sqrt{\frac{12500}{20 \times 0.01}}$

$I = 250$ A

$P = VI$

$150 \times 10^6 = V \times 250$

$V = 600$ kV

Question 30 (a)

Criteria	Marks
Calculates correct torque	2

Sample answer:

$\tau = nIAB \sin\theta$

$\tau = 8 \times 3 \times 0.0144 \times 2.5 \times 10^4 \times \sin 50$

$\tau = 6620$ Nm

Question 30 (b)

Criteria	Marks
Calculates correct change in flux (1351 or 169 Wb/loop)	2
Identifies the formula for change in flux	1

Sample answer:

$\Delta\Phi = \Phi_f - \Phi_i$

$\Delta\Phi = n\text{BA}\cos\theta_f - n\text{BA}\cos\theta_i$

$\Delta\Phi = (8\ x\ 2.5 \times 10^4 \times 0.0144 \times \cos 80) - (8\ x\ 2.5 \times 10^4 \times 0.0144 \times \cos 50)$

$\Delta\Phi = 1351$ Wb (this is actually Flux Linkage or total flux accounting for loops) or 169 Wb/loop

Question 30 (c)

Criteria	Marks
. Faraday's law equation line . 6.25 rpm (will accept 12.5 rpm)	2
. One of the above	1

$$\in = -n\frac{\Delta\Phi}{\Delta t}$$

$$1200 = \frac{8\ x\ 2.5\ x\ 10^4\ x\ 0.0144}{\frac{\Delta t}{4}}$$

$$\Delta t = \frac{8\ x\ 2.5\ x\ 10^4\ x\ 0.0144}{1200}\ x\ 4$$

= 9.6 s (ie per rotation)

$rpm = 6.25$ (will accept 12.5 if all working shown)

Question 31 (a)

Criteria	Marks
Calculates the net force acting on the electron	2
Calculates the force acting on the electron by the plates	1

Sample answer:

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

$E = \frac{200}{0.01}$

$E = 20000$ Vm^{-1}

Note: must include weight in answer or make a statement that weight is negligible therefore not included.
If said e- moved towards the negative plate (ie wrong direction) then lost 1mark.

$\Sigma F = qE + mg$

$\Sigma F = 3.2 \times 10^{-15}$ N

Question 31 (b)

Criteria	Marks
Calculates correct time	3
Calculate correct acceleration and attempts to find time	2
Calculate correct acceleration	1

Sample answer:

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

$a = \frac{3.2 \times 10^{-15}}{9.109 \times 10^{-31}}$

$a = 3.52 \times 10^{15}$ m s^{-2}

$s = ut + \frac{1}{2}at^2$

$0.005 = 0 + \frac{1}{2}3.52 \times 10^{15} \times t^2$

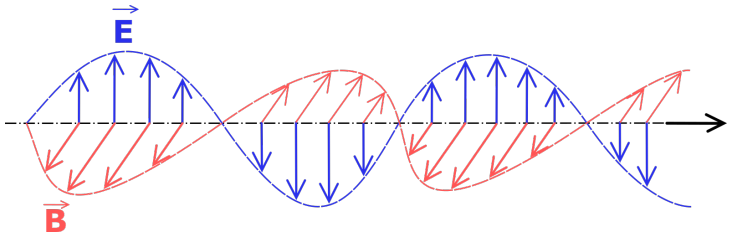
$t = 1.7 \times 10^{-9}$ s

Question 32

Criteria
✓ describes Maxwell's combination of electricity & magnetism
✓ describes Maxwell's model of EM waves
✓ identify one of Maxwell's predictions
✓ outline Hertz's confirmation of Maxwell
✓ describes one use of EMR for wireless communication
✓ describes significance of Maxwell's contribution

Sample answer:

Maxwell used the work of previous scientists (Gauss, Faraday and Ampere) to unify electricity and magnetism, and develop his four equations of electromagnetic theory. He used this theory to develop a model for electromagnetic waves, the basis for electromagnetic radiation (EMR). His model for EMR incorporated oscillating electric and magnetic fields that were perpendicular to each other and in phase.



Maxwell also used the equations of electromagnetic theory to predict the speed with which EMR would propagate. The calculated speed was approximately 3×10^8 m s^{-1}, very close to the measured speed of light. Thus, he reasoned that light was a form of EMR, and predicted that there could be EMR of other wavelengths outside the range of the visible spectrum. This prediction was confirmed by Hertz when he used an induction coil to produce sparks, thereby emitting EMR of very long wavelengths. He used reflection, refraction, polarisation and interference to confirm the properties of the EMR.

The EMR produced by Hertz are now used for wireless communication around the world. Radio waves are readily produced by oscillating electrons in antennae, allowing radio and TV signals to be broadcast around cities, countries and the world. This only became possible due to the development of Maxwell's electromagnetic theory. Thus, Maxwell made a significant contribution to our current understanding of electromagnetism and the development of wireless communication.

Marker's notes:

The only EMR known before Maxwell's theory was visible light, infrared (discovered by William Herschel in 1800) and ultraviolet (discovered by Johann Ritter in 1801). He did not study radio waves. Hertz first produced them in 1886, 7 years after Maxwell died! Likewise, Maxwell did not study x-rays (discovered by Wilhelm Röntgen in 1895) or gamma rays (discovered by Paul Villard in 1900).

Question 33 (a)

Criteria	Marks
Calculates the speed of the ship as a percentage of the speed of light	2
Attempts to use the correct formula	1

Sample answer:

$$t_v = \frac{t_0}{\sqrt{\left(1-\frac{v^2}{c^2}\right)}}$$

$$\sqrt{\left(1-\frac{v^2}{c^2}\right)} = \frac{t_0}{t_v}$$

$$1-\frac{v^2}{c^2} = \left(\frac{t_0}{t_v}\right)^2$$

$$\frac{v^2}{c^2} = 1-\left(\frac{t_0}{t_v}\right)^2$$

$$\frac{v}{c} = \sqrt{1-\left(\frac{t_0}{t_v}\right)^2} = \sqrt{1-\left(\frac{2.00}{4.39}\right)^2} = 0.890$$

The ship is travelling at 89.0% the speed of light.

Question 33 (b)

Criteria	Marks
✓ outline an appropriate experiment	2
✓ relates results to validation of time dilation	1

Sample answer:

Muons in the upper atmosphere have a very short resting lifetime. So short that they would not be able to reach the surface of the Earth after their creation. However, because they reach relativistic speeds, their lifetimes are dilated long enough to be detected on the surface. This provides evidence for Einstein's time dilation.

Marker's notes:
The use of Hafele–Keating experiment is not recommended as evidence for Special Relativity (despite inclusion in syllabus). The results are a combination of both Special and General Relativity (so you need distinguish between the two contributions). This also applies to atomic clocks on satellites. In addition, in the Hafele–Keating experiment, the clocks lost time when travelling east, but *gained* time when travelling west, and this needs to be described to get full marks.

Question 34

Criteria	Marks
Clearly states that the CLASSICAL model is based on WAVES Clearly states that the QUANTUM model is based on PARTICLES	2
Support for the wave model: (a minimum of **4** egs from the list below is required) REFRACTION DISPERSION POLARISATION INTERFERENCE DIFFRACTION DOUBLE SLIT EXPERIMENT POISSON SPOT EXPERIMENT	2
Support for the particle model: (a minimum of **2** from the list below is required) PHOTOELECTRIC EFFECT AND PHOTONS EXPLAINS THRESHOLD FREQUENCY EXPLAINS KE_{max} v FREQ data LAW OF CONSERVATION OF MOMENTUM CAN BE APPLIED TO P/E EFFECT EMISSION SPECTRA can be explained PLANCKS SOLUTION TO BLACK BODY RADIATION AND THE IDEA OF QUANTA.	2
Concluding statement: BOTH MODELS ARE NEEDED TO EXPLAIN ALL OBSERVATIONS	1
AT LEAST 2 EGS OF WAVE AND 1 EG OF PARTICLE BEHAVIOUR GIVEN	1

Sample answer:

Question 35 (a)

Criteria	Marks
. Absorption spectrum- when light passes through a cool gas, photons of **particular wavelengths are absorbed as electrons in the gas atoms are excited to higher energy levels.** . **Dark lines appear** on a continuous spectrum background. . Emission spectrum. In excited gases **electrons drop to lower energy levels**. Photons are emitted giving a spectrum with coloured lines on a black background.	1 1 1

Sample answer:

Absorption spectra are produced when a continuous spectrum of light passes through a cloud of cool gas, such as in stars. Atoms in the gas absorb photons of wavelength corresponding to the quanta of energy involved in transitions of electrons to higher energy levels. The wavelengths absorbed correspond to the dark lines of the absorption spectrum.

Emission Spectra on the other hand occur when the electrons in excited atoms drop to lower energy levels emitting a photon of light energy equal to the energy difference between the initial and final energy levels according to Bohr's second postulate ($hf = E_f - E_i$). The spectra produced shows coloured lines on a black background.

Question 35 (b)

Criteria	Marks
• Emission Spectra is measured • A Red Shift indicates the velocity is moving away. • A Blue Shift indicates the velocity is towards us. • The magnitude of the velocity is determined from the amount of Red or Blue shift	3
OR. Some students wrote their answer in terms of rotational velocity of a star. The answer is similar to above except explains how emission lines become wider with more angular velocity.	

Sample answer:

The velocity of a star can be determined by studying its emission spectra.
The spectra of a star moving away from the observer will have its spectra shifted towards the red end of the spectrum.
The spectra of a star moving towards an observer will be shifted towards the blue end.
The magnitude to the velocity can be determined from the extent of the red or blue shift.

Question 36

(a)

Criteria	Marks
Correctly calculates the missing data: 0.75eV, 1.4eV, 2.2eV.	1

(b)

Criteria	Marks
GRAPHING. . KE plotted on the Y axis in joules and frequency plotted on X – both with correct units. . Correct scaling so that the Y intercept occurs within the printed area of the graph. . A straight line of best fit is drawn	2
. 2 points from above	1

Criteria	Marks
(i) Calculate Planck's constant to be between 6.5 and 6.9 X 10^{-34} Js with units (2 sig figs) OR If outside that range but between 6.3 and 7.1 with correct units	2 1
(ii) Threshold Frequency = 5.7 x 10^{14} Hz (5.5-6.0) 2 sig fig.	1

Question 37
(a)

Criteria	Marks
. **States <u>ONE</u> of the following postulates** *-Electrons in an atom exist in stable circular orbits which do not emit radiation* *-Electrons absorb or emit a specific quanta of energy when they move from one stable energy level to another. The energy absorbed or emitted is* $hf = E_f - E_i$. **CLEARLY EXPLAINS how the postulate is supported by the H emission spectra**	1 1
NB. Many students stated that the emission spectra supported the postulate they listed but did not clearly explain WHY the emission spectra provided the support	

Sample answer:

Bohr's second postulate states that when orbiting electrons move between stable energy states they absorb or emit a photon of energy. The emission spectra of Hydrogen supported this idea because it showed that only particular frequencies were emitted from excited H atoms and their energies corresponded to the energy differences between energy states as modelled by Bohr.

(b)

Criteria	Marks
. Correct equation line . Correctly substitutes $N_f = 2$ (not $n_i = 2$) . Correct answer with units (4.86×10^{-7} m)	3
. 2 of the above points	2
. 1 of the above points	1

Question 38 (a)

Criteria	Marks
Calculates correct decay constant with unit	2
Attempts to use correct formula	1

Sample answer:

$\lambda = \frac{\ln(2)}{t_{1/2}}$

$\lambda = \frac{\ln(2)}{8}$

$\lambda = 0.087 \text{ day}^{-1}$

Question 38 (b)

Criteria	Marks
Calculates correct number of atoms (carry over error only allowed if full working is shown.)	1

Sample answer:

$N_t = N_0 e^{-\lambda t}$

$N_t = 1.2 \times 10^{13} \times e^{-0.087 \times 76}$

$N_t = 1.6 \times 10^{10}$ nuclei

Question 39

Criteria	Marks
. At least one similarity stated explicitly (eg. Both are baryons) . At least one difference stated explicitly	2
. 1 point from above	1

.Protons and neutrons are similar in that they both consist of 3 quarks but their quark composition is different. Protons consist of 2 Up quarks and a Down quark whereas neutrons consist of 2 Down quarks and 1 Up quark

Nb. A list or table of features is not enough.