Year 12
Physics
Trial HSC Examination
2019

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black or blue pen
- Draw diagrams using pencil
- NESA approved calculators may be used
- A data sheet, formulae sheet and Periodic Table are provided with this paper
- For questions in Section II, show all relevant working in questions involving calculations
- If extra space for writing is needed request a booklet. Clearly indicate what question is being answered.

Total marks – 100

Section I – 20 marks

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

Section II – 80 marks

- Attempt Questions 21–36
- Allow about 2 hour and 25 minutes for this part

Note: Any time you have remaining should be spent revising your answers.

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Section I

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

Use the multiple-choice answer sheet provided for Questions 1-20

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1 An investigation is designed to determine the size of the generated current when the strength of a magnet is varied. Which is the independent variable for this investigation?

(A) Speed of the magnet

(B) Strength of the magnet

(C) Size of the generated current

(D) Distance between the coil and the magnet

2 At one point on Earth's surface at a distance R from the centre of Earth, the gravitational field strength is measured as 9.76 N kg^{-1}.

Which one of the following is closest to Earth's gravitational field strength at a distance of 2R from the centre of the Earth?

(A) 1.08 N kg^{-1}

(B) 2.44 N kg^{-1}

(C) 3.25 N kg^{-1}

(D) 4.88 N kg^{-1}

3 An absorption line in a spectrum occurs at 414 nm.

Which one of the following best gives the energy of the photon for this absorption?

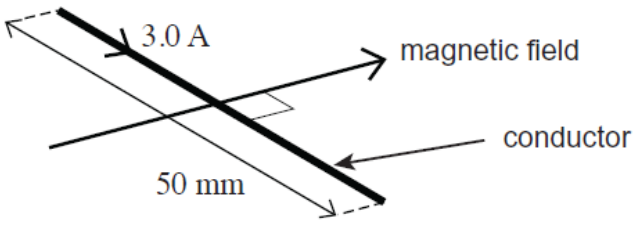
(A) 4.8×10^{-19} eV

(B) 0.33 eV

(C) 3.0 eV

(D) 4.1 eV

4 The diagram shows a horizontal conductor of length 50 mm carrying a current of 3.0A at right angles to a uniform horizontal magnetic field of flux density 0.50 T.



What is the magnitude and direction of the magnetic force on the conductor?

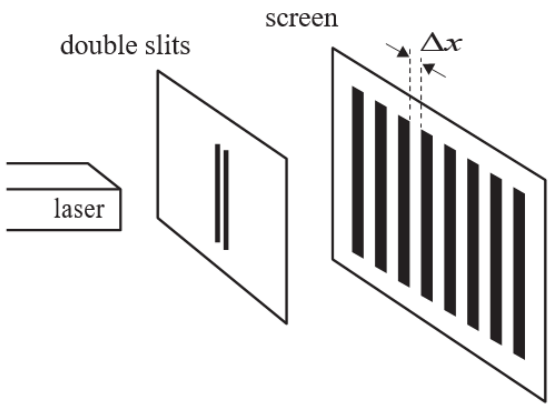
(A) 0.075 N vertically upwards

(B) 0.075 N vertically downwards

(C) 75 N vertically upwards

(D) 75 N vertically downwards

5 A teacher sets up an apparatus to demonstrate Young's double-slit experiment. A pattern of bright and dark bands is observed on the screen, as shown below.



Which one of the following actions will increase the distance, Δx, between the adjacent dark bands in this interference pattern?

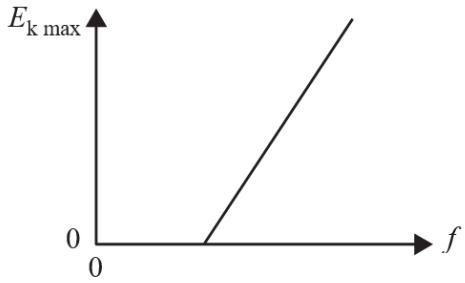
(A) Decrease the distance between the slits and the screen.

(B) Decrease the wavelength of the light.

(C) Decrease the slit separation.

(D) Decrease the slit width.

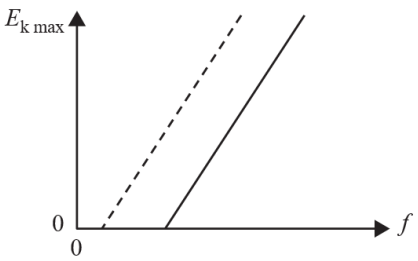
6 The results of a photoelectric experiment are displayed in the graph below. The graph shows the maximum kinetic energy ($E_{k\ max}$) of photoelectrons versus the frequency (f) of light falling on the metal surface.



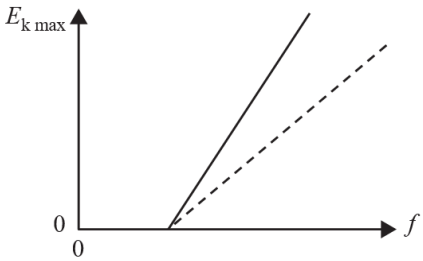
A second experiment is conducted with the original metal surface being replaced by one with a larger work function. The original data is shown with a solid line and the results of the second experiment are shown with a dashed line.

Which one of the following graphs shows the results from the second experiment?

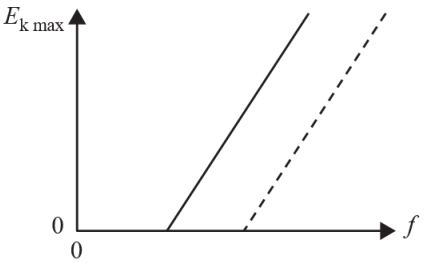
(A)



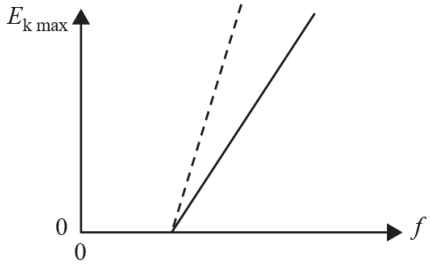
(B)



(C)



(D)



7 Which one of the following best describes the proper length of an object travelling with constant velocity?

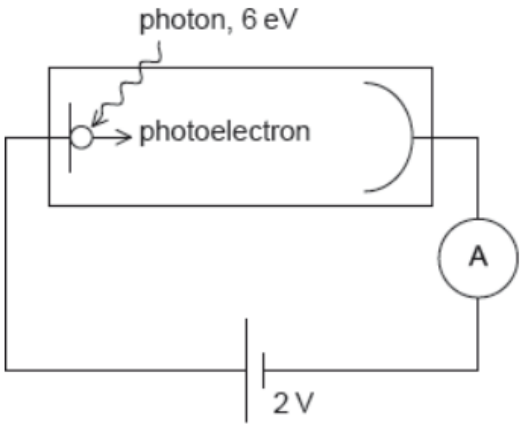
(A) the length when measured with a proper standard measuring stick

(B) the length when measured by an observer at rest relative to the object

(C) the length when both ends of the object are measured at the same time

(D) the length when measured by an observer in an inertial frame of reference

8 A photoelectric cell is connected in series with a battery of emf 2 V. Photons of energy 6 eV are incident on the cathode of the photoelectric cell. The work function of the surface of the cathode is 3 eV.



What is the maximum kinetic energy of the photoelectrons that reach the anode?

(A) 1 eV

(B) 3 eV

(C) 5 eV

(D) 8 eV

9 What is the angular speed of a car wheel of diameter 0.400 m when the speed of the car is 108 km h^{-1}?

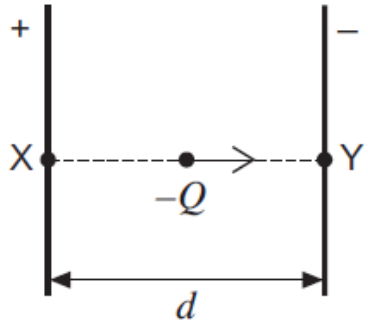
(A) 75 rad s^{-1}

(B) 150 rad s^{-1}

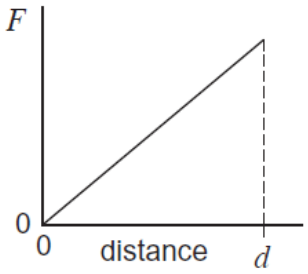
(C) 270 rad s^{-1}

(D) 540 rad s^{-1}

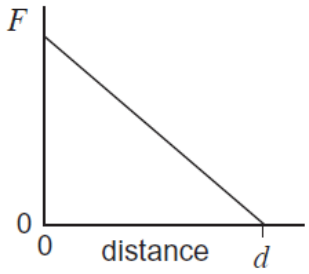
10 The diagram shows a charge – Q being moved from point X to point Y between two charged parallel plates separated by a distance d.



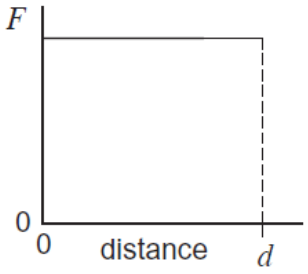
Which one of the following graphs best illustrates how the magnitude of force F on the charge varies with distance as it moves towards Y?



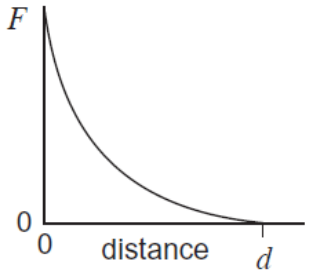
A



B



C



D

11 A scientist at the Large Hadron Collider particle accelerator observes the lifetime of a particular subatomic particle to be 1.0×10^{-5} s when it is travelling at 0.998 c. What would the lifetime of the particle be if it were stationary in the laboratory?

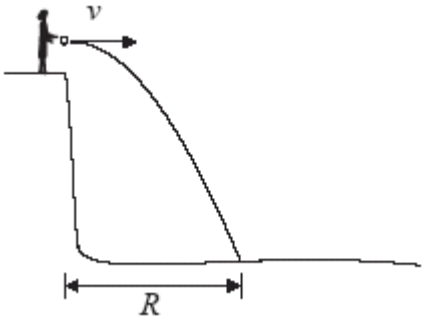
(A) 6.3×10^{-7} s

(B) 2.2×10^{-4} s

(C) 2.5×10^{-3} s

(D) 1.6×10^{-4} s

12 A stone is thrown horizontally from the top of a cliff with an initial speed v.

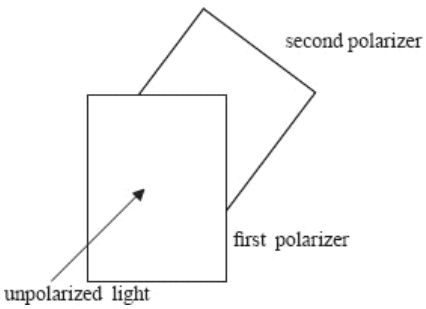


The time of flight of the stone is t and its range R. Air resistance is negligible.

For a stone that is thrown horizontally from the top of the cliff with an initial speed $3v$, which of the following is correct?

	Time of flight	Range
(A)	t	R
(B)	$3t$	$3R$
(C)	t	$3R$
(D)	$3t$	R

13 Unpolarized light of intensity I_0 is incident on a polarizer. The transmitted light is then incident on a second polarizer. The axis of the second polarizer makes an angle of 60^0 to the axis of the first polarizer.



The cosine of 60^0 is $\frac{1}{2}$. The intensity of the light transmitted through the second polarizer is:

(A) I_0

(B) $\frac{I_0}{2}$

(C) $\frac{I_0}{4}$

(D) $\frac{I_0}{8}$

14 A spacecraft orbits Earth. An astronaut inside the spacecraft feels "weightless" because

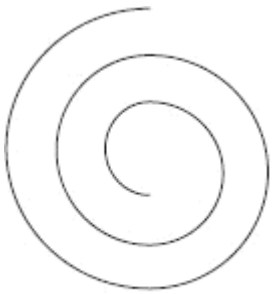
(A) the gravitational field in the spacecraft is negligible.

(B) the Earth exerts equal forces on the spacecraft and the astronaut.

(C) the spacecraft and the astronaut have the same acceleration towards the Earth.

(D) the spacecraft and the astronaut exert equal and opposite forces on each other.

15 An electron is moving in air at right angles to a uniform magnetic field. The diagram below shows the path of the electron. The electron is slowing down.



Which of the following correctly gives the direction of motion of the electron and the direction of the magnetic field?

	Direction of motion	**Direction of magnetic field**
(A)	clockwise	into plane of paper
(B)	clockwise	out of plane of paper
(C)	anti-clockwise	into plane of paper
(D)	anti-clockwise	out of plane of paper

16 An electron of mass m_e orbits an alpha particle of mass m_α in a circular orbit of radius r. Which expression gives the speed of the electron? (where e = charge on an electron)

(A) $\sqrt{\frac{2e^2}{4\pi\varepsilon_0 m_e r}}$

(B) $\sqrt{\frac{2e^2}{4\pi\varepsilon_0 m_\alpha r}}$

(C) $\sqrt{\frac{4e^2}{4\pi\varepsilon_0 m_e r}}$

(D) $\sqrt{\frac{4e^2}{4\pi\varepsilon_0 m_\alpha r}}$

17 A detector, placed close to a radioactive source, detects an activity of 260 Bq. The average background activity at this location is 20 Bq. The radioactive nuclide has a half-life of 9 hours.

What activity is detected after 36 hours?

(A) 15 Bq

(B) 16 Bq

(C) 20 Bq

(D) 35 Bq

18 A proton and an alpha particle have the same de Broglie wavelength.

Which of the following is approximately the ratio $\frac{\text{speed of alpha particle}}{\text{speed of proton}}$?

(A) $\frac{1}{4}$

(B) $\frac{1}{2}$

(C) 2

(D) 4

19 A nucleus of phosphorus (P) decays to a nucleus of silicon (Si) with the emission of particle X and particle Y.

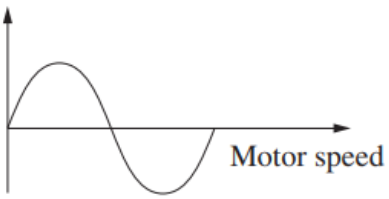
$$^{30}_{15}\mathrm{P} \rightarrow {}^{30}_{14}\mathrm{Si} + \mathrm{X} + \mathrm{Y}$$

Which line in the table correctly shows the identities of X and Y?

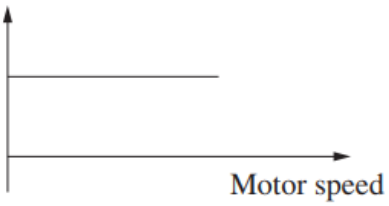
	X	Y
(A)	antineutrino	positron
(B)	antineutrino	electron
(C)	neutrino	electron
(D)	neutrino	positron

20 Which graph best represents the change in torque for a DC motor, with a radial magnetic field, from start up to operating speed?

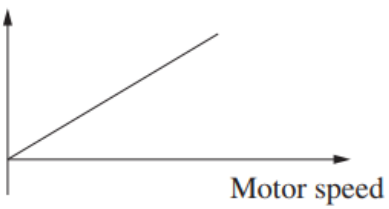
(A) Torque



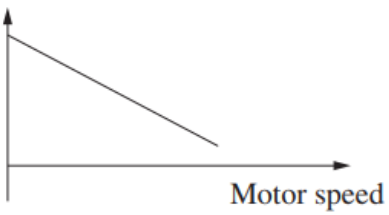
(B) Torque



(C) Torque



(D) Torque



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Exam Number

Section II – 80 marks

Attempt Questions 21–36

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. If extra space is required use an answer booklet provided. Ensure you clearly show which question you are completing in the answer booklet.

Show all relevant working in questions involving calculations.

Question 21 (4 marks) **Marks**

A generator is capable of producing 3.00×10^2 kW of electricity at 415V AC. Its output is stepped up to 11.0 kV for transmission.

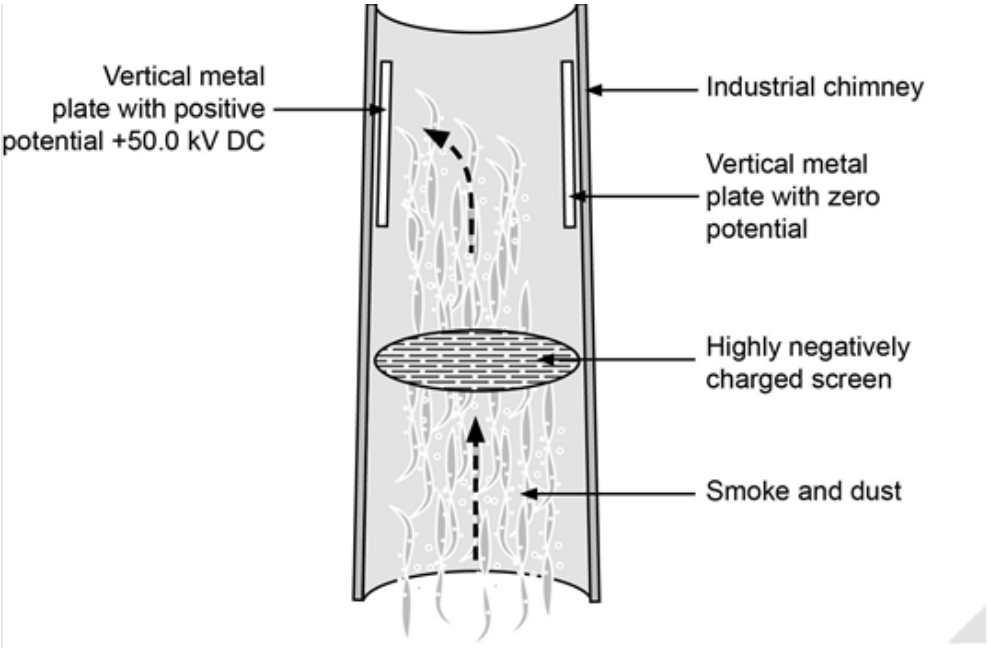
(a) Determine the primary to secondary turns ratio of the step-up transformer used at the power station. **2**

(b) Determine the current available at the output of the step-up transformer. **2**

Exam Number

Question 22 (2 marks) **Marks**

Electrostatic precipitators are used inside industrial chimneys to remove smoke and dust particles from waste gases before being released into the atmosphere. As shown in the diagram below, smoke and dust particles pass through a highly negatively charged screen where the dust particles gain electrons and are charged to -1.00×10^{-8} C. They then flow upwards between two parallel vertical metal plates. One vertical metal plate has a positive potential of +50.0 kV DC and the other is earthed at zero volts.



Calculate the force exerted on one of these dust particles by the field when it is between the parallel vertical metal plates. The horizontal distance between the plates is 47.5 cm. **2**

Exam Number

Question 23 (5 marks) **Marks**

An experiment was conducted to observe changes in colour and intensity as a bar of dull grey tungsten metal was heated from room temperature.

When heated to 200 °C the tungsten is observed as remaining grey and dull. When heated to 700 °C the tungsten is observed as red and dull, and at 2700 °C the tungsten is observed as white and bright.

(a) Describe why the colour and intensity of the tungsten changes as it is heated. **2**

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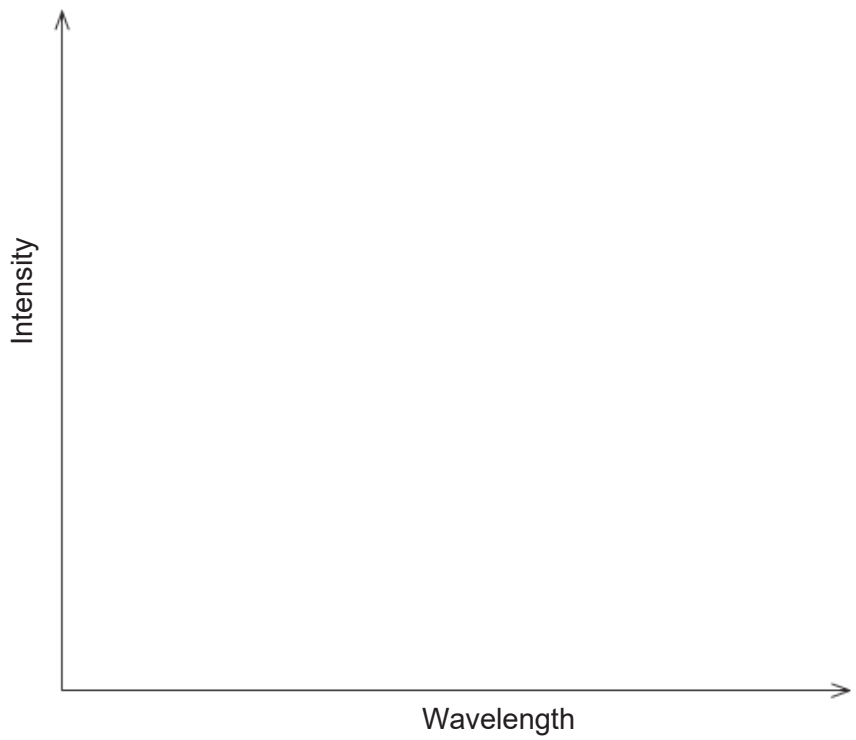
The tungsten is heated further until it starts melting at approximately 3400°C.

(b) Use the axes below to sketch labelled graphs of intensity against wavelength for the two observed spectra at 2700 °C and 3400 °C. **3**



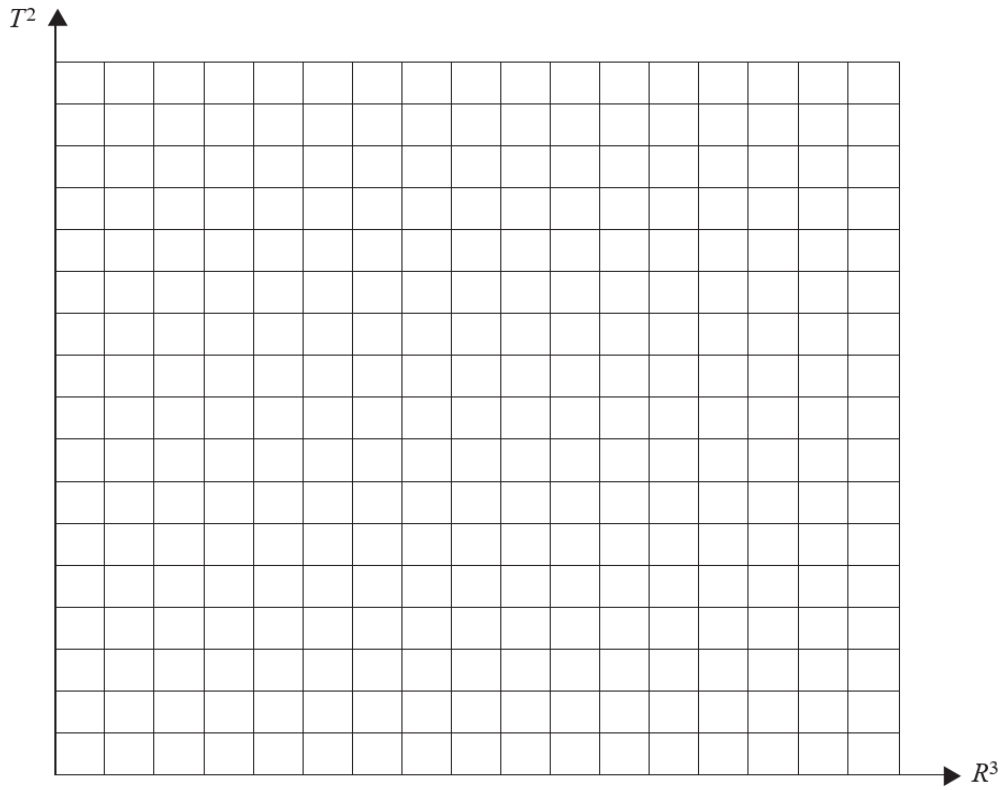
Exam Number

Question 24 (8 marks) **Marks**

Some students have collected data on the orbital period, T, and orbital radius, R, of five of Saturn's moons. The results are shown in the table below. Assume that the moons are in circular orbits.

Moon	Orbital period (s)	Orbital radius (m)	T^2 (10^{10} s^2)	R^3 (10^{24} m^3)
Mimas	8.14×10^4	1.86×10^8	0.66	6.40
Enceladus	1.18×10^5	2.38×10^8	1.39	13.5
Tethys	1.63×10^5	2.95×10^8	2.66	25.7
Dione	2.36×10^5	3.77×10^8	5.57	53.6
Rhea	3.90×10^5	5.27×10^8	15.2	146

a. On the axes provided below: **4**
- plot a graph of the observational data T^2 versus R^3
- include a scale and units on each axis
- draw a line of best fit.



Question 24 continues on the next page

Question 24 continued **Marks**

b. Calculate the gradient of the line of best fit drawn in part a. **2**

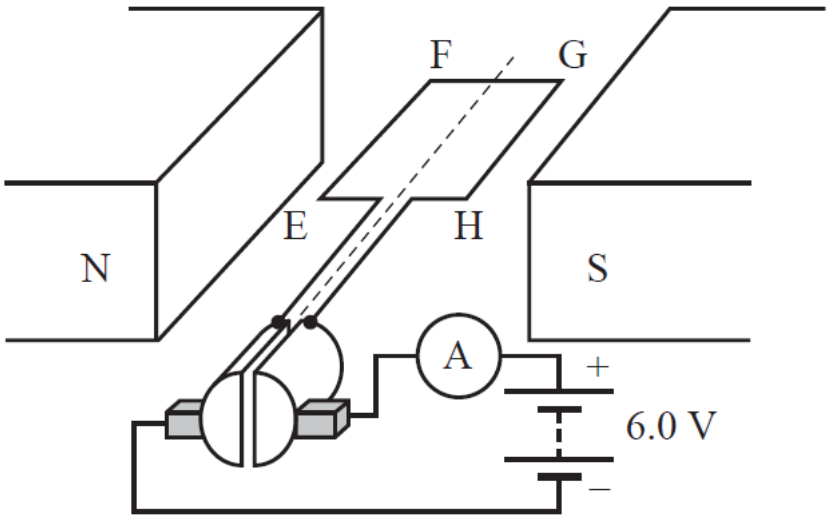
c. Use the value of the gradient calculated in part b. to determine the mass of Saturn. **2**

Exam Number

Question 25 (5 marks)

Marks

Figure below shows a DC motor consisting of a square loop of 100 turns and side length 5 cm, and a commutator. The DC motor has a uniform magnetic field of 3.0×10^{-2} T and a current of 2.0 A.



a. Find the torque on the DC motor when the rotor is in the position shown above. **2**

b. Explain the role and operation of the commutator in the DC motor shown. **3**

Exam Number

Question 26 (5 marks)

Marks

The Earth may be considered to be a sphere of radius 6.4×10^6 m with its mass of 6.0×10^{24} kg concentrated at its centre.

A satellite of mass 650 kg is to be launched from the Equator and put into geostationary orbit with period of 24 hours.

(a) Show that the radius of the geostationary orbit is 4.2×10^7 m. **2**

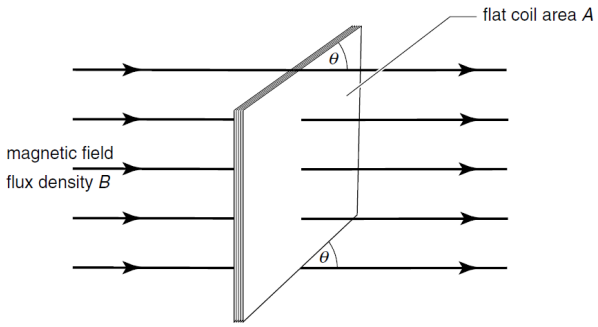
(b) Determine the increase in gravitational potential energy of the satellite during its launch from the Earth's surface to the geostationary orbit. **3**

Exam Number

Question 27 (4 marks)

Marks

A flat coil consists of N turns of wire and has area A. The coil is placed so that its plane is at an angle θ to a uniform magnetic field of flux density B, as shown in the diagram below.



(a) State Faraday's law of electromagnetic induction. **1**

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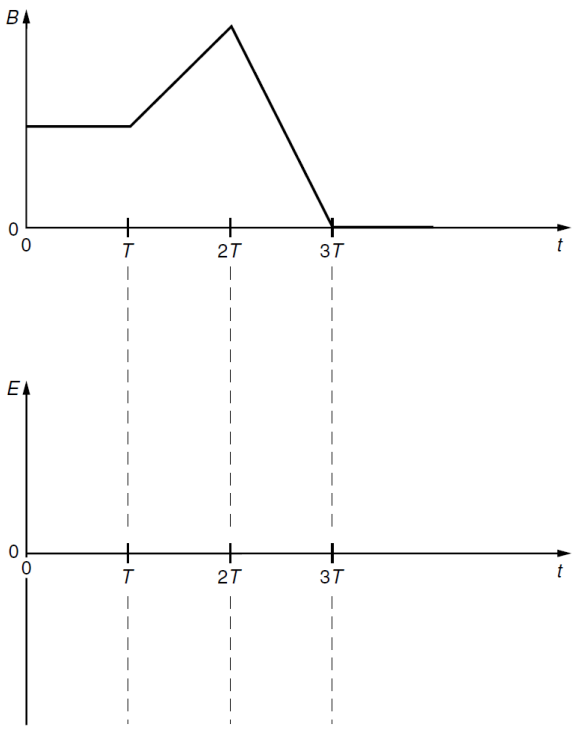
(b) The magnetic flux density *B* in the coil is now made to vary with time *t* as shown in below. **3**



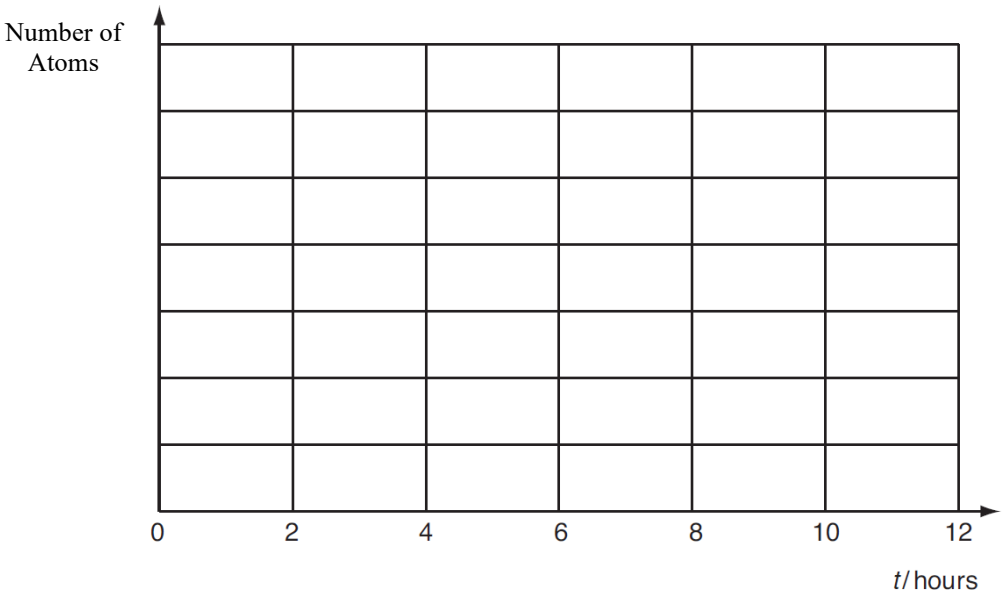
On figure above, sketch the variation with time *t* of the e.m.f. *E* induced in the coil.

Exam Number

Question 28 (5 marks) **Marks**

The isotope Manganese-56 decays and undergoes β-particle emission to form the stable isotope Iron-56. The half-life for this decay is 2.6 hours. Initially, at time $t = 0$, a sample of Manganese-56 has 1.5×10^6 atoms and there is no Iron-56.

(a) Complete figure below to show the variation with time t of the mass of Iron-56 in the sample for time $t = 0$ to time $t = 11$ hours. **2**

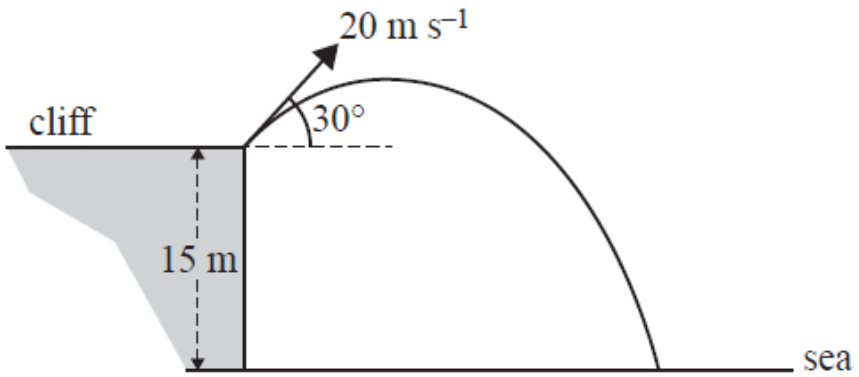


(b) For the sample of Manganese-56, use a calculation to determine the number of atoms present after 6 hours. **3**

Exam Number

Question 29 (3 marks) **Marks**

A stone of mass 2.0 kg is thrown from the top of a 15 m high cliff above the sea at an angle of 30° to the horizontal and at an initial speed of 20 m s^{-1}. Ignore air resistance.



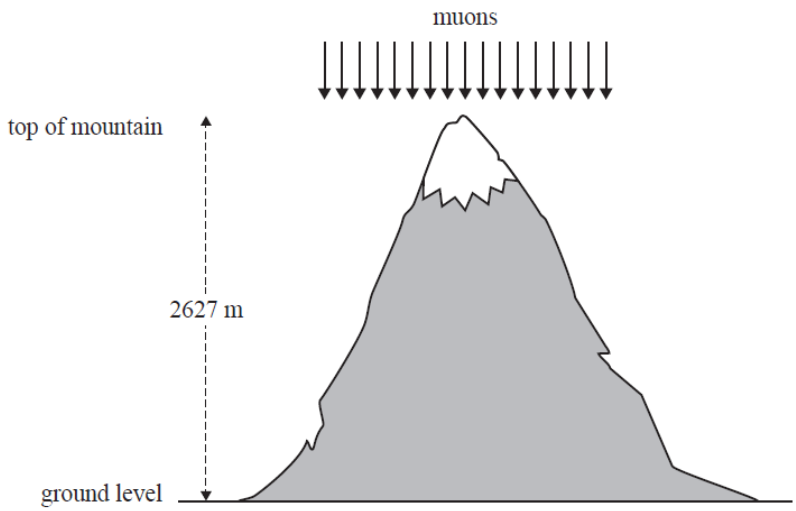
Calculate the kinetic energy of the stone immediately before it strikes the sea. **3**

Exam Number

Question 30 (6 marks) **Marks**

Muons are elementary particles created in the upper atmosphere by cosmic rays. They are unstable and decay with a half-life of 2.2 μs when measured at rest. This means that in the reference frame of the muons, half of them decay in each time interval of 2.2 μs.

In an experiment, muons with a velocity of 0.995c were observed by some scientists to pass the top of a mountain of height 2627 m, as shown below. The scientists measured the number of these muons reaching ground level.



(a) Calculate the half-life of the muons as measured by a stationary observer on the ground **2**

(b) From their reference frame, the muons see the ground rushing upwards at a speed of 0.995c. Find the height of the mountain as measured by the muons. **2**

Question 30 continues on the next page

Question 30 continued **Marks**

(c) Explain why many more muons reached the ground than would be expected according to classical physics. **2**

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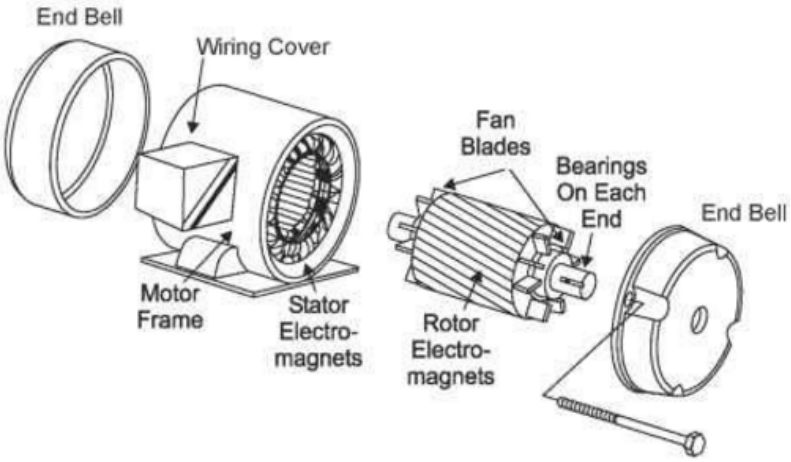
Exam Number

Question 31 (3 marks) **Marks**

The figure below shows the components of an AC induction motor.



Discuss how the stator and rotor interact to convert electrical energy into the desired form. **3**

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Exam Number

Question 32 (7 marks) **Marks**

Aldebaran is a red giant star with a peak wavelength of 740 nm and a mass of 1.7 solar masses.

(a) Show that the surface temperature of Aldebaran is about 4000 K. **1**

(b) Outline how the light from Aldebaran gives evidence of its composition. **2**

(c) Identify the element that is fusing in the greatest abundance in Aldebaran's core at this stage in its evolution. **1**

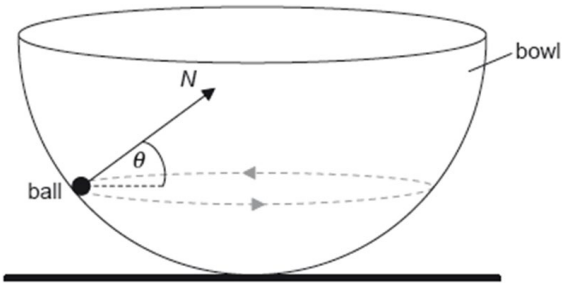
(d) Predict the likely future evolution of Aldebaran. **3**

Exam Number

Question 33 (7 marks) **Marks**

A small ball of mass m is moving in a horizontal circle on the inside surface of a frictionless hemispherical bowl.

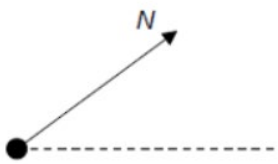
The normal reaction force N makes an angle θ to the horizontal.



(a) State the direction of the resultant force on the ball. **1**

_____

(b) On the diagram, construct an arrow of the correct length to represent the weight of the ball. **1**



(c) Show that the magnitude of the net force F on the ball is given by the following equation. **2**

$$F = \frac{mg}{tan\theta}$$

_____

_____

_____

_____

Question 33 continues on the next page

Question 33 continued **Marks**

The radius of the bowl is 8.0 m and $\theta = 22°$. Determine the speed of the ball. **3**

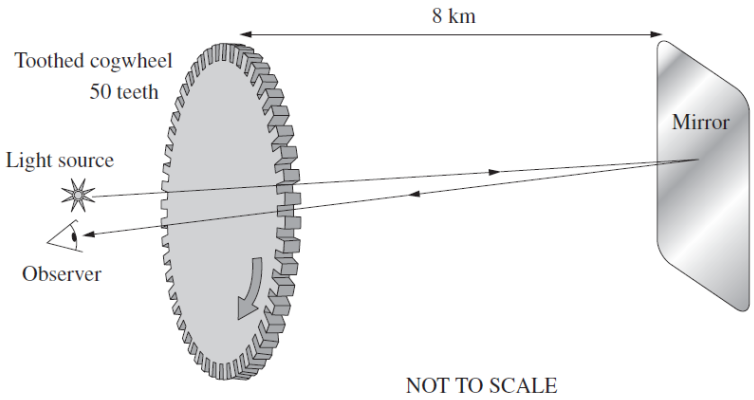
Question 34 (6 marks) **Marks**

Outline the contributions of Millikan's oil drop experiment and Schrödinger to the current model of the atom. **6**

Exam Number

Question 35 (5 marks) **Marks**

In the 1840s, French physicist, Hippolyte Fizeau performed an experiment to measure the speed of light. He shone an intense light source at a mirror 8 km away and broke up the light beam with a rotating cogwheel. He adjusted the speed of rotation of the wheel until the reflected light beam could no longer be seen returning through the gaps in the cogwheel.
The diagram shows a similar experiment. The cogwheel has 50 teeth and 50 gaps of the same width.



5

Explain why specific speeds of rotation of the cogwheel will completely block the returning light. Support your answer with calculations.

Exam Number

Question 36 (5 marks) **Marks**

Light from a sodium discharge tube is incident normally upon a diffraction grating having 8.00×10^5 lines per metre. The spectrum contains a double yellow line of wavelengths 589 nm and 590 nm.

(a) Determine the angular separation of the two lines when viewed in the second order spectrum. **4**

(b) State why it is more difficult to observe the double yellow line when viewed in the first order spectrum. **1**

END OF EXAM

SHORE PHYSICS

2019 TRIAL

ANSWERS AND SUGGESTED MARKING SCHEME

Section I

QUESTION	1	2	3	4	5	6	7	8	9	10
ANSWER	B	B	C	A	C	C	B	A	B	C

QUESTION	11	12	13	14	15	16	17	18	19	20
ANSWER	A	C	D	C	D	A	D	A	D	D

Section II

Question 21 (a)

Criteria	Mark
Valid method with correct substitutions to calculate correct ratio of turns	**2**
Valid method with one error of logic or substitution **OR** Correctly identifies the Primary and Secondary voltage.	**1**

Sample Answer

$V_{\mathrm{p}} = 415\ V, V_{\mathrm{s}} = 11.0\ kV$

$$\frac{N_{\mathrm{p}}}{N_{\mathrm{s}}} = \frac{V_{\mathrm{p}}}{V_{\mathrm{s}}} = \frac{415\ V}{11.0\ x\ 10^3\ V} = \frac{2}{53} = \frac{1}{26.5}$$

Question 21 (b)

Criteria	Mark
Valid method with correct substitutions to calculate secondary current.	**2**
Valid method with one error of logic or substitution **OR** Correctly identifies the $P_{\mathrm{IN}} = P_{\mathrm{OUT}}$	**1**

Sample Answer

$P_{\mathrm{IN}} = P_{\mathrm{OUT}} = 3.00 \times 10^2\ kW = V_{\mathrm{s}} I_{\mathrm{s}}$, $I_{\mathrm{s}} = \frac{P_{\mathrm{OUT}}}{V_{\mathrm{s}}} = \frac{3.00\ x\ 10^2\ x\ 10^3}{11.0\ x\ 10^3} = 27.3A$

Question 22

Criteria	Mark
Valid method with correct substitutions to calculate F.	**2**
Valid method with one error of logic or substitution to calculate F. **OR** Correctly calculates E field.	**1**

$d = 0.475\ m, V = +50.0\ kV,\ q = -1.0\ x\ 10^{-8}\ C$

$$F = \frac{V}{d}q = \frac{50.0\ x\ 10^{3}\ V}{0.475\ m} x\ 1.0\ x\ 10^{-8}\ C = 1.1x\ 10^{-3}\ N$$

Question 23 (a)

Criteria	Mark
Describes Wien's Law and the relationship between Wavelength of maximum intensity and Temperature AND relates intensity to temperature.	**2**
Describes Wien's Law and the relationship between Wavelength of maximum intensity and Temperature **OR** Relates intensity to temperature.	**1**

Sample Answer

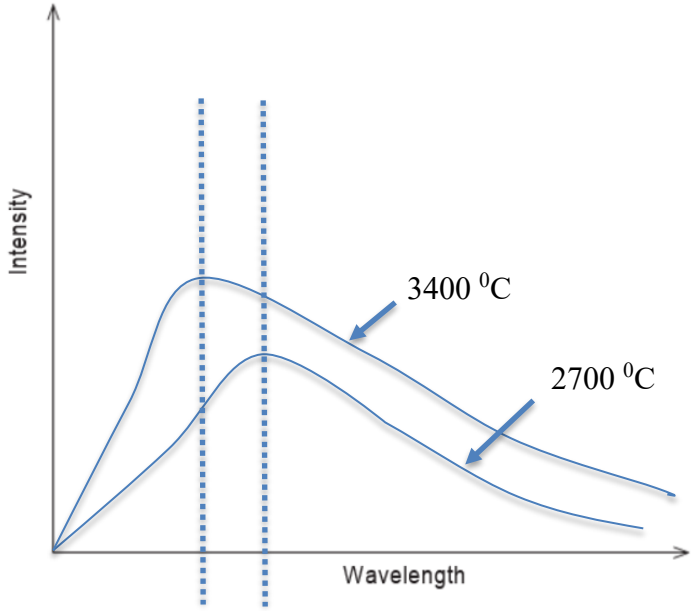
Wein's Law states that $\lambda_{\max} = \frac{\mathrm{b}}{\mathrm{T}}$, where b is Wein's displacement constant. The wavelength of the maximum intensity of a hot body is only dependent on the temperature, T, of the body and decrease as T increases. Therefore, we see a change in colour as the temperature of the body increases.

Hotter objects also emit more energy per second and thus appear brighter/increased intensity is observed.

Question 23 (b)

Criteria	Mark
Intensity at all wavelengths is greater for spectra of 3400 ^{0}C **AND** Wavelength of maximum intensity is shorter for 3400 ^{0}C **AND** Temperature correctly labelled for both curves.	**3**
Any TWO of the above.	**2**
Any ONE of the above.	**1**

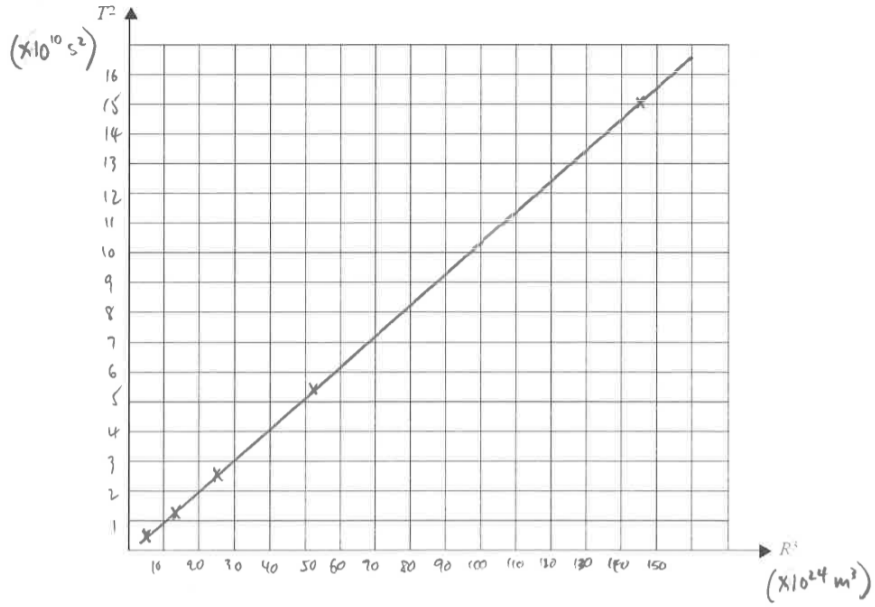
Sample Answer



Question 24 (a)

Criteria	Mark
Correctly included scales on each axis AND Correct included units on each axis AND Correctly plotted points AND draw a straight line of best fit through the points.	**4**
Any THREE of the above.	**3**
Any TWO of the above.	**2**
Any ONE of the above.	**1**

Sample Answer



Question 24 (b)

Criteria	Mark
Valid method with correct substitutions to calculate gradient **AND** Correct Units	**2**
Valid method with correct substitutions to calculate gradient **OR** Correct Units	**1**

Sample Answer

$$gradient = \frac{{T_2}^2 - {T_1}^2}{{R_2}^3 - {R_1}^3} = \frac{(16-0)\ x\ 10^{10}\ s^2}{(155-0)\ x\ 10^{24}\ m^3} = 1.03\ x\ 10^{-15}\ s^2\ m^{-3}$$

Question 24 (c)

Criteria	Mark
Identify gradient in part b. is equal to $\frac{GM}{4\pi^2}$ **AND** Valid method with correct substitutions to calculate mass of Saturn.	**2**
Valid method with one error in substitutions to calculate mass of Saturn.	**1**

Sample Answer

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

$T^2 = \frac{4\pi^2}{GM} x\ R^3$ now in the form $y = mx + b$

$$\frac{4\pi^2}{GM} = 1.03\ x\ 10^{-15}\ s^2\ m^{-3}$$

$$M = 5.7\ x\ 10^{26}\ kg$$

Question 25 (a)

Criteria	Mark
Correct calculation of the area of the coil **AND** Valid method with correct substitutions to calculate torque.	**2**
Correct calculation of the area of the coil **OR** Valid method with one error in substitutions to calculate torque.	**1**

Sample Answer

$\tau = nIA_{\perp}B = 100\ x\ 2.0\ x\ (0.05)^2\ x\ 3.0x10^{-2} = 0.015\ Nm$

Question 25 (b)

Criteria	Mark
Describes the split-ring commutator as a form a mechanical switch **AND** causes the change the direction of the current through the coil every half turn **AND** allows the coil continues rotating in the same direction.	**3**
Any TWO of the above.	**2**
Any ONE of the above.	**1**

Sample Answer

The split-ring commutator and the brushes form a mechanical switch that change the direction of the current through the coil every half turn so that the coil continues rotating in the same direction.

Question 26 (a)

Criteria	Mark
Correct calculation of period of orbit **AND** Valid method with correct substitutions to calculate radius of orbit.	**2**
Correct calculation of period of orbit **OR** Valid method with correct substitutions to calculate radius of orbit.	**1**

Sample Answer

$T = 24\ hrs = 24\ x\ 60\ x\ 60 = 86400\ s$

$$R^3 = \frac{GM}{4\pi^2}\, x\, T^2 = \frac{6.67\ x\ 10^{-11}\ x\ 6.0\ x\ 10^{24}}{4\pi^2}\, x\ (86400)^2 = 7.57\ x10^{22}\ m^3$$

$R = 4.2\ x10^7\ m$

Question 26 (b)

Criteria	Mark
Correctly identify initial and final radius **AND** Valid method with correct substitutions to calculate the both the initial of final potential energy **AND** Valid method with correct substitutions to calculate the increase in GPE.	**3**
Correctly identify initial and final radius **AND** Valid method with correct substitutions to calculate the both the initial of final potential energy.	**2**
Correctly identify initial and final radius **OR** Valid method with correct substitutions to calculate the **either** the initial of final potential energy.	**1**

Sample Answer

$$\Delta U = \Delta U_f - \Delta U_i = -\frac{GMm}{r_f} - \left(-\frac{GMm}{r_i}\right) = GMm\left(\frac{1}{r_i} - \frac{1}{r_f}\right)$$

$$\Delta U = 6.67\ x\ 10^{-11} x\ 6.0\ x\ 10^{24} x\ 650\ x\ \left(\frac{1}{6.4\ x\ 10^{6}} - \frac{1}{4.2\ x\ 10^{7}}\right) = 3.45\ x\ 10^{10} J$$

Question 27 (a)

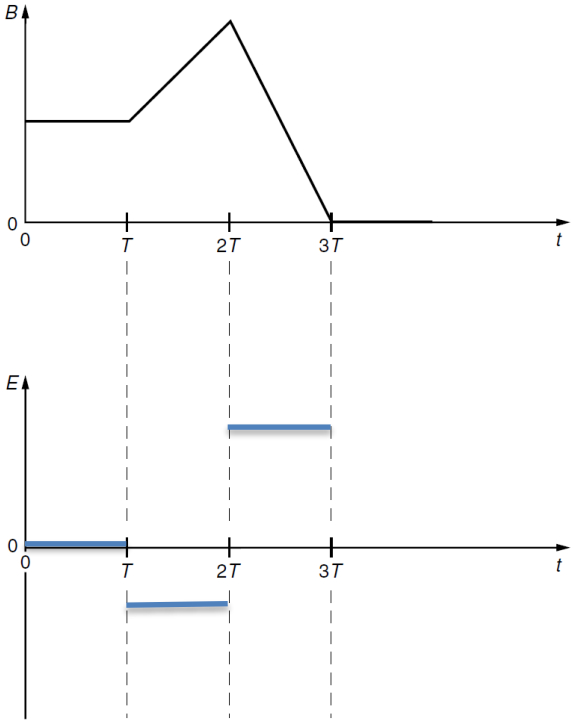
Criteria	Mark
Correctly states Faraday's law of Induction.	**1**

Sample Answer

The induced emf in a coil or circuit is equal in magnitude to the rate at which the magnetic flux through the coil or circuit is changing with time.

Question 27 (b)

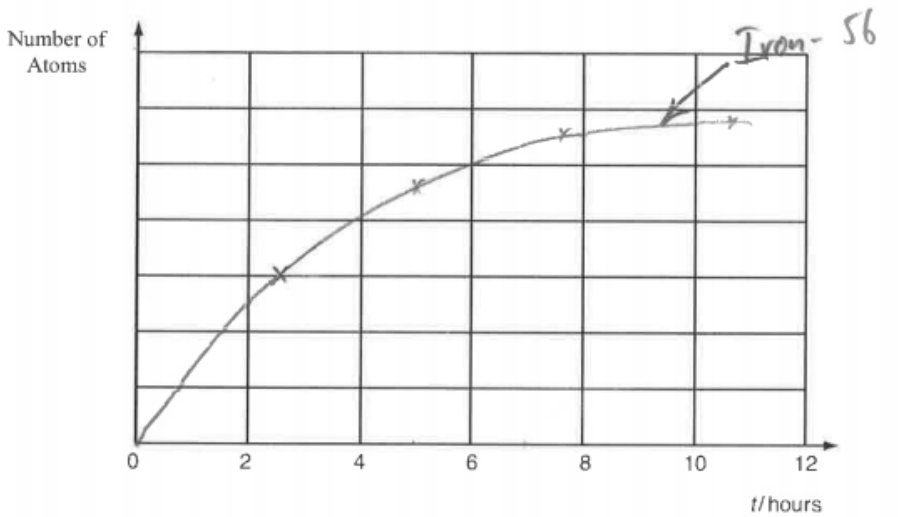
Criteria	Mark
Emf correctly drawn on graph for all time periods. One mark each.	**3**
Emf correctly drawn on graph for TWO time periods. One mark each.	**2**
Emf correctly drawn on graph for ONE period.	**1**



Question 28 (a)

Criteria	Mark
Correctly draws a curve for Iron - 56	**2**
Correctly draws a decay curve for Manganese - 56	**1**

Sample Answer



Question 28 (b)

Criteria	Mark
Correctly calculates half-life seconds **AND** Valid method with correct substitutions to calculate the decay constant **AND** Valid method with correct substitutions to calculate the number of atoms	**3**
Correctly calculates half-life seconds AND Valid method with correct substitutions to calculate the decay constant **OR** Valid method with ONE error in substitution to calculate the number of atoms	**2**
Correctly draws a decay curve for Manganese - 56 **OR** Exponential growth curve	**1**

Sample Answer

$t = 6\ hrs = 6\ x\ 60\ x\ 60 = 21600\ s$

$T_{1/2} =\ 2.6\ hrs =\ 2.6\ x\ 60\ x\ 60\ =\ 9360\ s$

$\lambda = \frac{ln2}{t_{1/2}} = \frac{ln2}{9360} = 7.4\ x\ 10^{-5} s^{-1}$

$N_t = N_o e^{-\lambda t} = 1.5\ x\ 10^6 e^{-(7.4\ x\ 10^{-5}\ x\ 21600)} = 3.0\ x\ 10^5 atoms$

Question 29

Criteria	Mark
Valid method with correct substitutions to calculate the both the K and U at launch **AND** Valid method with correct substitutions to calculate E_T **AND** Correctly identifies U immediately before impact to be zero **AND** Correctly calculates K immediately before impact. *Please also accept suitable alternative method to calculate K.*	**3**
Valid method with correct substitutions to calculate the both the K and U at launch **AND** Valid method with correct substitutions to calculate E_T **OR** Valid method with correct substitutions to calculate the both the K and U at launch **AND** Correctly identifies U immediately before impact to be zero	**2**
Valid method with correct substitutions to calculate the both the K and U at launch **OR** Correctly identifies U immediately before impact to be zero	**1**

Sample Answer

From conservation of energy, $E_T = K + U$

At launch

$$E_T = K + U = \frac{1}{2}mv^2 + mgh = \frac{1}{2}x\ 2\ x\ (20)^2 + 2\ x\ 9.8\ x\ 15 = 694\ J$$

Immediately before impact

$E_T = K + U = 694\ J$, but since $U = 0$ at impact.

Therefore, $K = 694\ J$

Question 30 (a)

Criteria	Mark
Correctly identifies t_0 **AND** Valid method with correct substitutions to calculate half-life of muons.	**2**
Valid method with ONE error to calculate half-life of muons.	**1**

Sample Answer

$$t_0 = 2.2\mu s,\ t = \frac{t_0}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{2.2\mu s}{\sqrt{1-(0.995)^2}} = 22\mu s$$

Question 30 (b)

Criteria	Mark
Correctly identifies l_0 **AND** Valid method with correct substitutions to calculate height of the mountain as measured by the muons.	**2**
Valid method with ONE error to calculate height of the mountain as measured by the muons.	**1**

Sample Answer

$l_0 = 2627\ m$

$$l = l_0\sqrt{\left(1 - \frac{v^2}{c^2}\right)} = 2627\ x\ \sqrt{1 - (0.995)^2} = 262\ m$$

Question 30 (c)

Criteria	Mark
Describes the absolute nature of length and time according to "classical mechanics" **AND** Describes the consequences for time/length of moving at relativistic speeds.	**2**
Describes the absolute nature of length and time according to "classical mechanics" **OR** Describes the consequences for time/length of moving at relativistic speeds.	**1**

Sample Answer

According to classical mechanics 'time' and 'length' are absolute qualities, that is, the same for all observers. This would predict very few muons reaching the ground. However, many muons are observed on the ground since the muons are moving at high speed, and their life time is longer because of time dilation.

Question 31

Criteria	Mark
The stator produces a rotating magnetic field **AND** The rotor experiences a changing magnetic field which induces an emf between the ends of the induction bars causing current to flow **AND** The current in the induction bars experience a force, the rotor turns.	**3**
Any TWO of the following: States Lenz's Law **OR** Describes a rotating magnetic field **OR** The rotor experiences a changing magnetic field **OR** The current in the induction bars experience a force.	**2**
States Lenz's Law **OR** Describes a rotating magnetic field **OR** The rotor experiences a changing magnetic field **OR** The current in the induction bars experience a force.	**1**

Sample Answer

A rotating magnetic field is produced by the coils in the stator. The rotor experiences a changing magnetic field which induces an emf between the ends of the induction bars in the rotor. This causes a current to flow in the induction bars. The current in the induction bars experience a force due to the external magnetic field produced by the stator. The force on the induction bars cause the rotor turn in the same direction as the rotating magnetic field.

Question 32 (a)

Criteria	Mark
Valid method with correct substitutions to calculate temperature OR correct exact value for T	**1**

Sample Answer

$\lambda_{max} = 740 \text{ nm}$

$\lambda_{max} = \dfrac{b}{T}$

$T = \dfrac{b}{\lambda_{max}} = \dfrac{2.898\ x\ 10^{-3}}{740\ x\ 10^{-9}} = 3916\ K \approx 4000K$

Question 32 (b)

Criteria	Mark
Clearly states that Aldebaran will emit a spectrum that can be compared to spectra of known elements	**2**
States that Aldebaran will emit a spectrum **OR** States that elements have distinct spectra	**1**

Sample Answer

When the light from Aldebaran is separated by a prism/diffraction grating, an absorption spectrum is observed. The dark lines on the absorption spectrum represent the absorption of light of specific wavelengths by specific elements in the star. The spectrum can thus be used to determine elements present in the outer layers and atmosphere of Aldebaran.

Question 32 (c)

Criteria	Mark
Identifies Helium	**1**

Sample Answer

Helium

Question 32 (d)

Criteria	Mark
• Identifies Aldebaran will become a white dwarf • Outlines TWO subsequent stages or properties of the star due to its evolution from a red giant to a white dwarf (may include formation of planetary nebula) • Identifies that dwindling heat energy will result in evolution to cooler dwarf(s)	**3**
Any two of the above	**2**
Any one of the above	**1**

Sample Answer

As the helium supply dwindles, the energy producing reactions at the core of Aldebaran will decrease. Gravitational forces will cause the core to collapse. The outer layers of the star will be shed and form a planetary nebula. The core will remain as a dense hot mass known as a white dwarf, very hot but with low luminosity due to its small size. There will be no more energy producing reactions so the star will gradually cool becoming a red, brown and, eventually, a black dwarf.

Question 33 (a)

Criteria	Mark
Correctly describes the direction of the resultant force.	**1**

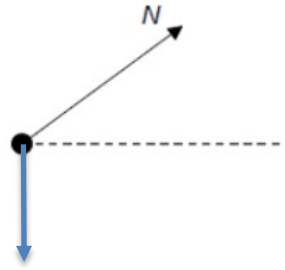
Sample Answer

Towards the centre of the circle OR horizontally to the right.

Question 33 (b)

Criteria	Mark
Arrow drawn vertically downwards of approximately the correct length (must be less than the length of N)	**1**

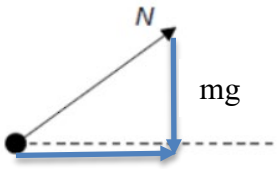
Sample Answer



Question 33 (c)

Criteria	Mark
Derives a correct expression for F by appropriate trigonometry as applied to the student's answer to part (b)	**2**
Resolves N in terms of θ **OR** Shows some correct working in terms of vector addition or resolving of forces	**1**

Sample Answer



F

$tan\,\theta = \frac{O}{A} = \frac{mg}{F},\ F = \frac{mg}{tan\,\theta}$

Question 33 (d)

Criteria	Mark
A valid method with correct substitutions to calculate velocity	**3**
One error of logic or substitution	**2**
Equates net force with centripetal force **OR** Makes correct substitutions into an invalid but logical equation	**1**

Sample Answer

$r = Rcos\,\theta\,, \mathrm{F_{NET}} = \mathrm{F_C},\ \frac{\mathrm{m}v^2}{r} = \frac{\mathrm{m}g}{\tan\theta}$

$$v = \sqrt{\frac{gr}{\tan\theta}} = \sqrt{\frac{g\,Rcos\,\theta}{\tan\theta}} = \sqrt{\frac{9.8\ x\ 8.0\ x\ cos\,22}{\tan 22}} = 13.4\ ms^{-1}$$

Question 34

Criteria	Mark
Clearly describes how the MOD experiment enabled the calculation of the unit charge and the mass of the electron. Identifies one other subsequent advance in knowledge of the atom. Describes Schrodinger's work regarding the wave function and outlines a subsequent advance in understanding of the motion of electrons or of quantum mechanics in general.	**6**
Makes a good description of the MOD experiment and outlines how the calculation of the unit charge increased understanding of the atom. Outlines Schrodinger's work and an aspect of how it applied to understanding the atom.	**5**
Outlines the MOD experiment and the calculation of the unit charge. Identifies Schrodinger developed a wave model for describing the motion of electrons. **OR** Makes a good description of the MOD experiment and outlines how the calculation of the unit charge increased understanding of the atom AND identifies one aspect of Schrodinger's work	**4**
Outlines multiple aspects of the MOD experiment AND outlines an aspect of Schrodinger's work **OR** Makes a good description of the MOD experiment and outlines how the calculation of the unit charge increased understanding of the atom	**3**
Outlines multiple aspects of the MOD experiment AND/OR Schrodinger's work	**2**
Any valid information regarding the MOD experiment or Schrodinger's work	**1**

Sample Answer

Millikan fired charged droplets of oil into an electric field and, by observing their motion due to the field and gravity, calculated the charge on each droplet. He noticed the charge occurred in multiples of a quantum amount and was able to use his results to calculate the quantum, this arriving at a value for the unit charge or charge on one electron. As Thomson had previously calculated the charge to mass ratio of the electron, the mass of the electron was also able to be determined. This then led to other experimental work and calculations being made regarding the nature of the nucleus and positive charge in the atom.

Schrodinger built on the work of Bohr and de Broglie in developing a wave model for the motion of electrons in atoms. His wave function was able to be used to successfully predict many aspects of the motion of electrons and resulted in the idea of the electron orbit as being a "shell" or "cloud". Schrodinger was also a pioneer of the use of quantum principles to increase understanding of the nature and motion of sub atomic particles in general.

Question 35

Criteria	Mark
• Clearly identifies that the light must travel to the mirror and back and that rotation of the wheel must occur such that a tooth blocks the return path. • Provides valid, correct calculations to show that a specific speed of rotation will result in blockage. • Clearly shows that multiples of that speed will also block the path.	**5**
• Clearly describes how the path of the light can be blocked by the rotating wheel. • Provides valid calculations with one error of logic or substitution.	**4**
• Outlines how the path of the light could be blocked by the rotating wheel. • Identifies the calculations that need to be made. **OR** • Clearly identifies that the light must travel to the mirror and back and that rotation of the wheel must occur such that a tooth blocks the return path. • Clearly shows that multiples of that speed will also block the path.	**3**
• Outlines how the path of the light could be blocked by the rotating wheel. **OR** • Identifies the calculations that need to be made.	**2**
• Identifies that the path of the light could be blocked by the rotating wheel. **OR** • Identifies a correct equation.	**1**

Sample answer

Light travels at 3.00×10^8 m s^{-1}, so for an 8 km journey to the mirror and 8 km back, the time taken will be:

$$t = \frac{s}{v} = \frac{2 \times 8000}{3 \times 10^8} = 5.33 \times 10^{-5}\ s$$

If the wheel is stationary, the light travelling through a gap will return completely through the gap, but if the wheel is rotating, a cog (tooth) will begin to block the returning light. If a tooth moves exactly the width of a gap in the time it takes the light to return, it will completely block the light.
It takes 5.33×10^{-5} seconds for the light to travel to the mirror and back. To completely block the light, the tooth will have moved into the path of a gap in this time. Since there are 50 teeth and 50 gaps, the wheel will have rotated 1/100th of a rotation in this time. This is equal to $2\pi/100$ radians.
The rotational speed of the wheel is given by $\omega = \frac{\Delta\theta}{\Delta t}$

$$\omega = \frac{\Delta\theta}{\Delta t} = \frac{\frac{2\pi}{100}}{5.33 \times 10^{-5}} = 1180 \text{ rad } s^{-1}$$

Spinning the cogwheel at 3, 5 and 7 times this rate (or any odd multiple) would also completely block the returning light, as the light will be blocked by subsequent teeth.

Question 36 (a)

Criteria	Mark
A valid method with correct substitutions	**4**
One error of logic or substitution	**3**
Identifies the correct equation to use AND that the angles must be subtracted	**2**
Identifies the correct equation to use **OR** Correct separation given incorrect values for θ.	**1**

Sample Answer

$d\sin\theta = m\lambda, \quad \sin\theta = \frac{m\lambda}{d}, \ \theta = \sin^{-1}\left(\frac{m\lambda}{d}\right)$

Where $m = 2$

$d = \frac{1}{8.00 \text{ x } 10^5} = 1.25 \text{ x } 10^{-6}\ m$

589 nm $\theta_1 = sin^{-1}\left(\frac{2 \text{ x } 589 \text{ x } 10^{-9}}{1.25 \text{ x } 10^{-6}}\right) = 70.4586\ degrees$

590 nm $\theta_2 = sin^{-1}\left(\frac{2 \text{ x } 590 \text{ x } 10^{-9}}{1.25 \text{ x } 10^{-6}}\right) = 70.7345\ degrees$

Angular Separation = $70.4586 - 70.73.45 = 0.276\ degrees$

Question 36 (b)

Criteria	Mark
Identifies there will be a smaller angle of separation (or distance between lines on a screen).	**1**

Sample Answer

The angular separation is smaller for 1st order spectrum compared to other orders of spectrum. Therefore, it is easier to distinguish between double yellow lines in higher orders of spectrum.