2020

HIGHER SCHOOL CERTIFICATE
TRIAL EXAMINATION

Physics

General Instructions	• Reading time – 5 minutes • Working time – 3 hours • Write using black pen • Draw diagrams using pencil • NESA approved calculators may be used • A data sheet, formulae sheet and Periodic Table are provided at the back of this paper • For questions in Section II, show all relevant working in questions involving calculations • Write your Student ID at the bottom of this page and at the top of page 9
Total marks: 100	**Section I — 20 marks (**pages 2-8) • Attempt Questions 1–20 • Allow about 35 minutes for this section **Section II — 80 marks (**pages 9-24) • Attempt Questions 21–35 • Allow about 2 hours and 25 minutes for this section

STUDENT ID: ________________________________

Section I

20 marks
Attempt Questions 1–20
Allow about 35 minutes for this section

Use the multiple-choice answer sheet for Questions 1–20.

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1 Which statement does not relate to evidence that validated Einstein's thought experiments for time dilation and length contraction?

A. Evidence from particle accelerators

B. The results of the Hafele–Keating experiment

C. Early experiments with cathode rays operating in a vacuum

D. Observations of the life of muons that enter the Earth's atmosphere

2 Which experiment directly helped develop a model for light?

A. Millikan's oil drop experiment

B. Einstein's thought experiments

C. Malus' polarisation experiment

D. The Hafele–Keating experiment

3 A far-off star has been found to have three planets orbiting it. The periods and orbital radii of two of the planets is set out below.

Planet	*Radius in metres*	*Period is seconds*
PK1	**?**	4.2×10^{4}
PK2	9.84×10^{8}	8.4×10^{4}
PK3	1.56×10^{9}	1.68×10^{5}

Scientists had to determine the nearest planet's orbital radii mathematically.

What would the calculated radii of PK1 be?

A. 2.46×10^{7} m

B. 4.92×10^{7} m

C. 4.92×10^{8} m

D. 6.20×10^{8} m

4 A 100 g mass is swung in a horizontal circle with a diameter of 1.5 m. It completes ten revolutions in three seconds.

Calculate the magnitude of the centripetal force, correct to two decimal points.

A. 6.58×10^3 N

B. 3.23×10^1 N

C. 3.23×10^3 N

D. 6.58×10^1 N

5 Which bank would allow the car to round a tight bend with the greatest safety?

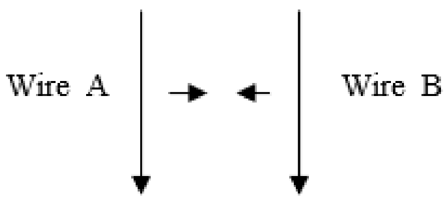
A.

C.

B.

D.

6 Two parallel wires experience a force, F, as shown in the diagram.



What would the new resultant force be, if the current in Wire A was doubled and the length of Wire B was halved?

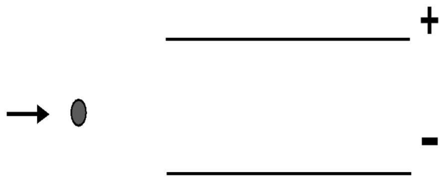
A. $\frac{1}{2}$ F

B. F

C. 2 F

D. 4 F

7 A charged particle travels at constant velocity as it passes through two parallel, oppositely charged plates. The particle's path is not deflected in any way.



Which relationship would best explain this?

A. $qE = mg$

B. $v^2 r = qE$

C. $F = qE$

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

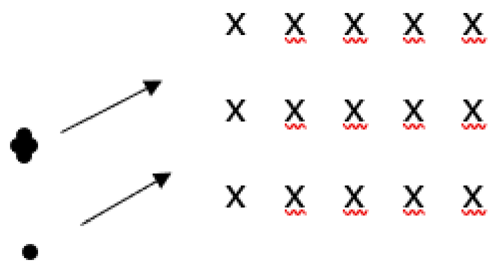
8 A rocket propelled racing car speeds around a very large diameter circular track. It consumes its rocket fuel at a constant rate.

Half the mass of the racing car is fuel, which is ejected out the rear at a constant rate.

Which group has the most correct description of the propelling force and centripetal force as the car rounds the track?

	Propelling Force	*Centripetal force*
A.	Constant	Increasing
B.	Constant	Constant
C.	Increasing	Increasing
D.	Increasing	Constant

9 A proton and a helium nucleus both enter a strong uniform magnetic field at an angle as shown below.



Which statement best compares the pathways of these particles?

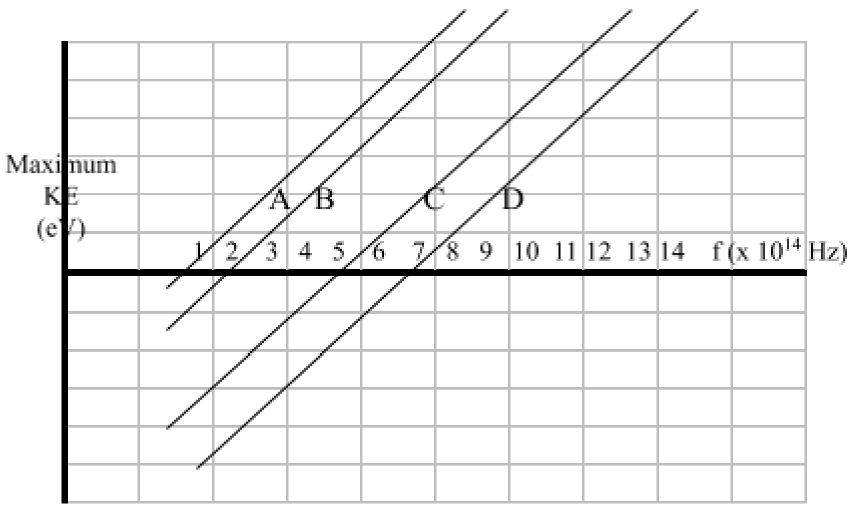
A. Neither the proton nor the helium nucleus will change its path.

B. The proton will turn to its left, but the helium nucleus will turn to its right.

C. Both particles will turn to their left and have the same radius of curvature.

D. Both particles will turn to their left, but each with different radii of curvature.

10 The graph below shows the relationship between the frequency and kinetic energy of electrons emitted by four different metals (A, B, C and D) when they were exposed to light.



What is the wavelength of a photon of light that supplied the threshold frequency for Metal D?

A. 3.75×10^{-7} m

B. 8.00×10^{-14} m

C. 2.66×10^{-7} m

D. 1.8×10^{-14} m

11 Which nuclear equation accurately shows the alpha decay of Radium 223?

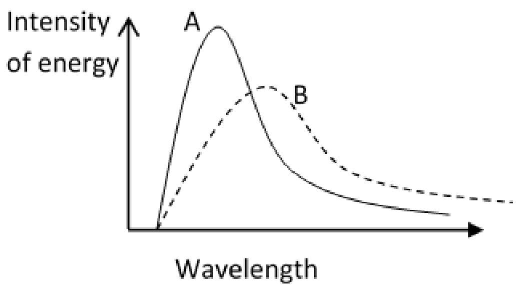
A. $^{223}_{88}Ra \rightarrow ^{219}_{86}Rn + 24He$

B. $^{219}_{86}Rn \rightarrow ^{223}_{80}Ra + 24He$

C. $^{223}_{86}Ra \rightarrow ^{219}_{87}Fr + -10e$

D. $^{223}_{88}Ra \rightarrow ^{210}_{89}Ac + -10e$

12 Why is there a drop in the intensity at very short wavelengths for the typical black body radiation traces shown in the graph below?



A. The energy of each photon is reduced at very short wavelengths

B. There are fewer photons with high energy at very short wavelengths

C. Only photons of very short wavelengths are reabsorbed by the black body

D. Photons of very short wavelengths interact, causing destructive interference

13 Which group contains all the quantities that are required to calculate escape velocity?

A. Mass of the rocket and the planet

B. Mass of the rocket and the planet, and the radius

C. Mass of the planet, radius and universal gravitational constant

D. Mass of the rocket and the planet and universal gravitational constant

14 What are the respective units for magnetic flux and magnetic flux density?

	Magnetic flux	*Magnetic flux density*
A.	Tesla	Weber
B.	Weber	Faraday
C.	Weber	Tesla
D.	Faraday	Weber

15 The fusion reaction of hydrogen nuclei to produce helium nuclei in our Sun produces the energy that is radiated to Earth.

Which amount of energy would be the closest to that released by the production of just 10×10^6 Helium nuclei?

A. 1.1×10^7 MeV

B. 2.8×10^7 MeV

C. 1.1×10^8 MeV

D. 2.8×10^8 MeV

16 An up quark (*u*) has a charge of $+\frac{2}{3}$ and a down quark (*d*) has a charge of $-\frac{1}{3}$.

What is the respective quark make up of a proton and a neutron?

	Proton	Neutron
A.	*uud*	*ddu*
B.	*udd*	*ddd*
C.	*uuu*	*uud*
D.	*uud*	*ddd*

17 A planet is discovered with the same mass as the Earth but with only half the diameter.

If we consider the gravity on the surface of the Earth to be *g*, what would the gravity on the surface of the newly discovered planet be?

A. $\frac{1}{4}g$

B. $\frac{1}{2}g$

C. $2g$

D. $4g$

18 Which group of particles do leptons belong to?

A. Bosons

B. Hadrons

C. Baryons

D. Fermions

19 Which of the fundamental forces are W and Z bosons responsible for?

A. Strong

B. Weak

C. Gravity

D. Electromagnetic

20 Two projectiles are both fired from a rifle at the same speed. The first, **A** has an elevation of 40° while the second, **B** has an elevation of 50°.

Which statement is most correct when comparing the projectiles?

A. Projectile **A** has the same range when compared to **B** projectile.

B. Projectile **A** has a shorter range when compared to **B** projectile.

C. Projectile **B** has a lower maximum height when compared to Projectile **A**.

D. Projectile **B** has the same time of flight when compared to Projectile **A**.

Student ID: ______________________________

2020 HIGHER SCHOOL CERTIFICATE TRIAL EXAMINATION

Physics

Section II
Answer Booklet

80 marks
Attempt Questions 21–35
Allow about 2 hour 25 minutes for this part

Instructions

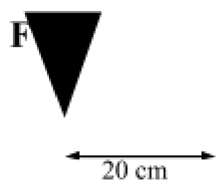
- Write your Student ID at the top of this page
- Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.
- Show all relevant working in questions involving calculations.
- Extra writing space is provided at the back of this booklet. If you use this space, clearly indicate which question you are answering.

Please turn over

Question 21 (5 marks)

A driver had a flat tyre. She struggled to remove the wheel until she used her foot, rather than her hands, to push down on the very end of the spanner.

The diagram below models the set up she was using.



(a) Use physics principles to explain why she was only successful when using her foot. **2**

(b) Use a sample calculation to show why it was important for her to apply the force to the very end of the spanner. **3**

Question 22 (6 marks)

Lenz's Law is used to account for the production of back emf in motors.

(a) Use a model to help explain Lenz's Law. **3**

(b) Explain how the production of back emf relates to Lenz's Law and to the law of conservation of energy? **3**

Question 23 (6 marks)

Observations of the hydrogen spectra were significant to the development of the model of the atom.

(a) Explain the importance of these observations to the development of Bohr's model of the atom. **3**

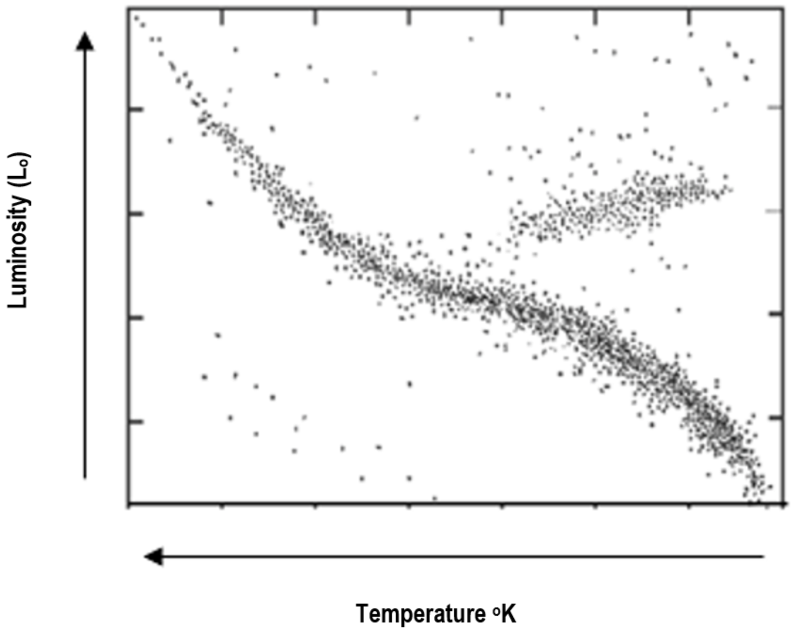
(b) Describe TWO characteristics of the hydrogen spectra that could not be explained by Bohr's model? **3**

Question 24 (7 marks)

Two stars can be compared on a Hertzsprung-Russell diagram. Both stars, A and B, come from the same cluster of stars.

Star A is a very large white star about ten times bigger than our Sun, while Star B is an orange star, similar in size to our Sun.

(a) Indicate, by using an A and a B on the Hertzsprung-Russel diagram below, where Stars A and B would most likely be positioned. **1**



(b) Sketch in the most likely pathways for each star's life cycle. **2**

(c) Compare the main nuclear reactions occurring in Stars A and B. **4**

Question 25 (5 marks)

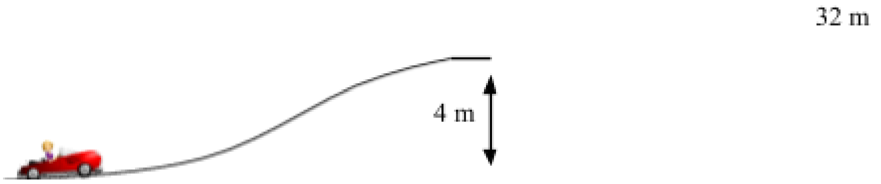
A train passes a station at 88% of the speed of light. According to a passenger on the train, the length of the train carriage is 30 m from front to rear.

(a) As the train is passing the platform of the station, a light in the carriage is switched on.

Use Einstein's postulates to compare the velocity of the light beam as seen by the passenger, to that seen by an observer waiting on the platform. **3**

(b) Calculate the length of the carriage as observed by the observer waiting on the platform. **2**

Question 26 (5 marks)



A daredevil driver accelerates along a runway and then up a ramp. The intention is to have enough launch velocity to clear all the cars and land safely on the other side of the them.

The ramp's launch height is four metres above the ground and the launch position is horizontal to the ground.

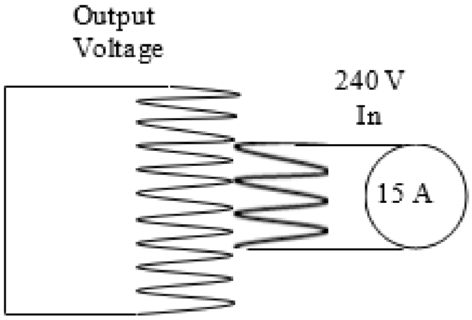
(a) Calculate the minimum launch velocity needed to clear the 32 m needed to land safely. **2**

(b) The sports car can accelerate at 17.6 ms^{-2} on the runway. **3**

Explain why the runway is needed before the ramp for the car to gain the required launch velocity. Support your answer with calculations.

Question 27 (6 marks)

A transformer is modelled below.



(a) Calculate the output current. **2**

(b) Describe TWO strategies used to improve the energy efficiency of transformers. **4**

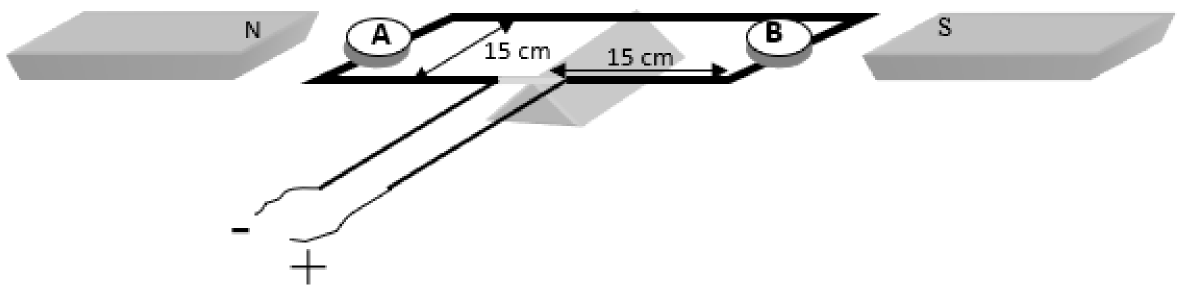
Question 28 (2 marks)

Calculate the velocity of an electron that has a wavelength of 1.84 $\times 10^{-11}$ m. **2**

Question 29 (9 marks)

A space traveller constructs a delicate balance to determine the acceleration, due to gravity, on a planet he encounters.

He does this by using a pivoting conducting loop placed in a magnet field of 25 mT. It is connected to a DC transformer.



He carries out the experiment with a range of small masses and then adjusts the current to balance the torque produced.

His results are set out below.

Mass in grams	*Current required in Amps*
1	2.55
2	5.02
4	7.55
6	15.03
8	20.00

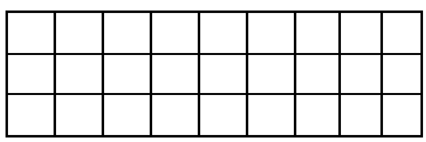
(a) For this experiment to work, were the masses added on Disc A or Disc B? Justify your answer. **1**

....

....

....

(b) Plot the results in the table below and draw in a line of best fit. **2**



Question 29 (continued)

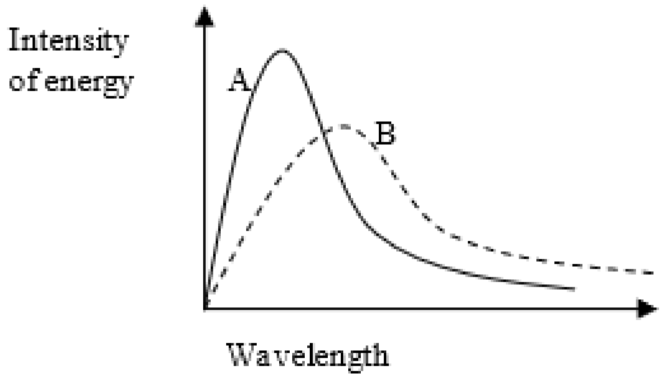
(c) Suggest a reason why the space traveller conducted the experiment using several different masses, rather than repeating the same mass many times. Use the results to help justify your answer. **2**

(d) Calculate the force produced by the current when balancing the 2 g mass. **2**

(e) Calculate the acceleration, due to gravity, on the alien planet. **2**

Question 30 (5 marks)

When a black body is heated, it produces the typical shape set out below.



Explain the relationship between the shape of this graph and the particle theory of light. **5**

Question 31 (7 marks)

Spectroscopy is a key tool in identifying the characteristics of stars. **7**

Justify this statement by explaining how spectroscopy is used to gain a range of information about the characteristics of stars.

Question 31 continues on page 21

Question 31 (continued)

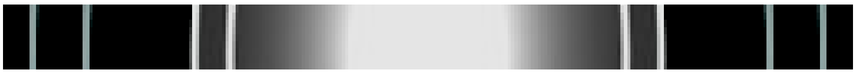
End of Question 31

Question 32 (3 marks)

Calculate the wavelength of the spectral line produced when an electron undergoes transition from energy level n = 4 to energy level n = 2. **3**

Question 33 (3 marks)

Below is a diffraction pattern showing light and dark bands.

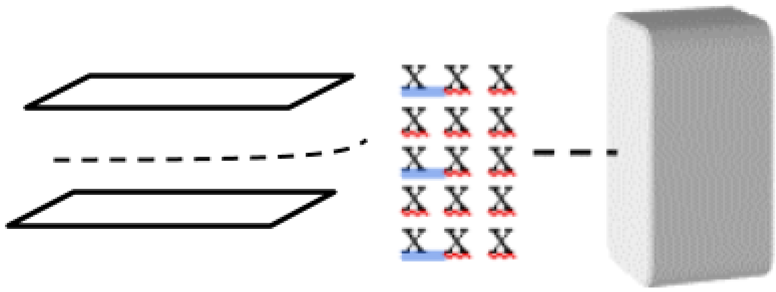


Explain, using a diagram, how diffraction produces this series of light and dark bands. **3**

Question 34 (5 marks)

An electron beam is fired towards a screen at 2.2×10^{7} ms^{-1}. It is deflected by an electric field produced by two parallel plates which are separated by 1.0 cm.

A uniform magnetic field of 5.0×10^{-3} T then straightened the beam, causing it to hit the screen perpendicularly.



(a) Calculate the voltage applied to the parallel plates. **3**

(b) What acceleration would the electron experience as it enters the magnetic field? **2**

Question 35 (6 marks)

The energy of orbiting planets, moons and satellites allow them to maintain their orbits in radial gravitational fields.

Assess this statement with specific reference to the energy changes that occur as the orbits of these bodies decay. Include quantitative examples in your answer. **6**

Section II extra writing space

If you use this space, clearly indicate which question you are answering.

Section II extra writing space

If you use this space, clearly indicate which question you are answering.

2020 TRIAL HSC EXAMINATION

Physics

DATA SHEET

Charge on electron, q_e	-1.602×10^{-19} C
Mass of electron, m_e	9.109×10^{-31} kg
Mass of neutron, m_n	1.675×10^{-27} kg
Mass of proton, m_p	1.673×10^{-27} kg
Speed of sound in air	340 ms^{-1}
Earth's gravitational acceleration, g	9.8 m s^{-2}
Speed of light, c	3.00×10^{8} m s^{-1}
Electric permittivity constant, ϵ_o	8.854×10^{-12} $\text{A}^2\text{s}^4\text{kg}^{-1}\text{m}^{-3}$
Magnetic permeability constant, μ_o	4Л $\times 10^{-7}$ N A^{-2}
Universal gravitational constant, G	6.67×10^{-11} N m^2kg^{-2}
Mass of Earth, M_E	6.0×10^{24} kg
Radius of the Earth, r_E	6.371×10^{6} m
Planck constant, h	6.626×10^{-34} J s
Rydberg constant, R (hydrogen)	1.097×10^{7} m^{-1}
Atomic mass unit, u	1.661×10^{-27} kg 931.5 MeV/c^2
1 eV	1.602×10^{-19} J
Density of water, ϱ	1.00×10^{3} kg m^{-3}
Specific heat capacity of water	4.18×10^{3} J kg^{-1} K^{-1}
Wein's displacement constant	2.898×10^{-3} mK

FORMULAE SHEET

Motion, forces and gravity

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

$$v = u + at$$

$$v^2 = u^2 + 2as$$

$$\vec{F}_{\text{net}} = m\vec{a}$$

$$\Delta U = mg\Delta h$$

$$W = F_{\parallel}s = Fs\cos\theta$$

$$P = \frac{\Delta E}{\Delta t}$$

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

$$P = F_{\parallel}v = Fv\cos\theta$$

$$\sum\frac{1}{2}mv_{\text{before}}^2 = \sum\frac{1}{2}mv_{\text{after}}^2$$

$$\sum m\vec{v}_{\text{before}} = \sum m\vec{v}_{\text{after}}$$

$$\Delta\vec{p} = \vec{F}_{\text{net}}\Delta t$$

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

$$\omega = \frac{\Delta\theta}{t}$$

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

$$\tau = r_{\perp}F = rF\sin\theta$$

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

$$v = \frac{2\pi r}{T}$$

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

$$U = -\frac{GMm}{r}$$

Waves and thermodynamics

$$v = f\lambda$$

$$f_{\text{beat}} = \left|f_2 - f_1\right|$$

$$f = \frac{1}{T}$$

$$f' = f\frac{(v_{\text{wave}} + v_{\text{observer}})}{(v_{\text{wave}} - v_{\text{source}})}$$

$$d\sin\theta = m\lambda$$

$$n_1\sin\theta_1 = n_2\sin\theta_2$$

$$n_x = \frac{c}{v_x}$$

$$\sin\theta_c = \frac{n_2}{n_1}$$

$$I = I_{\max}\cos^2\theta$$

$$I_1r_1^2 = I_2r_2^2$$

$$Q = mc\Delta T$$

$$\frac{Q}{t} = \frac{kA\Delta T}{d}$$

FORMULAE SHEET

Electricity and magnetism

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

$$V = \frac{\Delta U}{q}$$

$$W = qV$$

$$W = qEd$$

$$B = \frac{\mu_0 I}{2\pi r}$$

$$B = \frac{\mu_0 NI}{L}$$

$$\Phi = B_{||}A = BA\cos\theta$$

$$\varepsilon = -N\frac{\Delta\Phi}{\Delta t}$$

$$\frac{V_p}{V_s} = \frac{N_p}{N_s}$$

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

$$F = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}$$

$$I = \frac{q}{t}$$

$$V = IR$$

$$P = VI$$

$$F = qv_{\perp}B = qvB\sin\theta$$

$$F = lI_{\perp}B = lIB\sin\theta$$

$$\frac{F}{l} = \frac{\mu_0}{2\pi}\frac{I_1 I_2}{r}$$

$$\tau = nIA_{\perp}B = nIAB\sin\theta$$

$$V_p I_p = V_s I_s$$

Quantum, special relativity and nuclear

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

$$K_{\max} = hf - \phi$$

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

$$E = mc^2$$

$$E = hf$$

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

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

$$l = l_0\sqrt{\left(1 - \frac{v^2}{c^2}\right)}$$

$$p_v = \frac{m_0 v}{\sqrt{\left(1 - \frac{v^2}{c^2}\right)}}$$

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

$$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$$

PERIODIC TABLE OF THE ELEMENTS

1 **H** 1.008 Hydrogen	**KEY** Atomic number Chemical symbol Relative atomic mass Name of element											
3 **Li** 6.941 Lithium	4 **Be** 9.012 Beryllium											5 **B** 10.81 Boron
11 **Na** 22.99 Sodium	12 **Mg** 24.31 Magnesium											13 **Al** 26.98 Aluminium
19 **K** 39.10 Potassium	20 **Ca** 40.08 Calcium	21 **Sc** 44.96 Scandium	22 **Ti** 47.87 Titanium	23 **V** 50.94 Vanadium	24 **Cr** 52.00 Chromium	25 **Mn** 54.94 Manganese	26 **Fe** 55.85 Iron	27 **Co** 58.93 Cobalt	28 **Ni** 58.69 Nickel	29 **Cu** 63.55 Copper	30 **Zn** 65.38 Zinc	31 **Ga** 69.72 Gallium
37 **Rb** 85.47 Rubidium	38 **Sr** 87.61 Strontium	39 **Y** 88.91 Yttrium	40 **Zr** 91.22 Zirconium	41 **Nb** 92.91 Niobium	42 **Mo** 95.96 Molybdenum	43 **Tc** Technetium	44 **Ru** 101.1 Ruthenium	45 **Rh** 102.9 Rhodium	46 **Pd** 106.4 Palladium	47 **Ag** 107.9 Silver	48 **Cd** 112.4 Cadmium	49 **In** 114.8 Indium
55 **Cs** 132.9 Caesium	56 **Ba** 137.3 Barium	Lanthanoids 57-71 * -	72 **Hf** 178.5 Hafnium	73 **Ta** 180.9 Tantalum	74 **W** 183.9 Tungsten	75 **Re** 186.2 Rhenium	76 **Os** 190.2 Osmium	77 **Ir** 192.2 Iridium	78 **Pt** 195.1 Platinum	79 **Au** 197.0 Gold	80 **Hg** 200.6 Mercury	81 **Tl** 204.4 Thallium
87 **Fr** Francium	88 **Ra** Radium	Actinoids 89-103 ** -	104 **Rf** Rutherfordium	105 **Db** Dubnium	106 **Sg** Seaborgium	107 **Bh** Bohrium	108 **Hs** Hassium	109 **Mt** Meitnerium	110 **Ds** Darmstadtium	111 **Rg** Roentgenium	112 **Cn** Copernicium	113 **Uut** Unutrium

***Lanthanoids**

57 **La** 138.9 Lanthanum	58 **Ce** 140.1 Cerium	59 **Pr** 140.9 Praseodymium	60 **Nd** 144.2 Neodymium	61 **Pm** Promethium	62 **Sm** 150.4 Samarium	63 **Eu** 152.0 Europium	64 **Gd** 157.3 Gadolinium	65 **Tb** 158.9 Terbium	66 **Dy** 162.5 Dysprosium	67 **Ho** 164.9 Holmium

****Actinoids**

89 **Ac** Actinium	90 **Th** 232.0 Thorium	91 **Pa** 231.0 Protactinium	92 **U** 238.0 Uranium	93 **Np** Neptunium	94 **Pu** Plutonium	95 **Am** Americium	96 **Cm** Curium	97 **Bk** Berkelium	98 **Cf** Californium	99 **Es** Einsteinium	100 **Fm** Fermiu

Standard atomic weights are abridged to four significant figures.
Elements with no reported values in the table have no stable nuclides.
Information on elements with atomic numbers 113 and above has been updated to match BOS HSC Physics and Chemistry ame

STUDENT ID________________________

2020 Physics HSC Trial Examination

Section I – Answer Sheet

20 marks
Attempt Questions 1–20
Allow about 35 minutes for this section

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

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 ○

2020 HSC Trial
Physics Marking Guidelines

Section I

Multiple-choice Answer Key

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

Section II

Question 21 (5 marks)

(a)

Criteria	Marks
• Explains with reference to physics principals why she was only successful when using her foot	2
• Provides some relevant information	1

Sample answer:
Using her hands meant she could only use part of her weight force and her upper muscles. Pushing with her foot allowed her to stand and focus all her weight force onto the spanner, this would increase the applied force.

(b)

Criteria	Marks
• Explains why force had to be on the end • Uses a sample calculation to support answer	3
• States why force had to be on the end • Uses a sample calculation to support answer	2
• Provides some relevant information	1

Sample answer:
The equation:

$$\tau = rF\,sin\theta$$

shows us that the greater the force and the greater the radius the more torque is applied to turn an object. As the relationship is directly proportional then, if she applied the force to the spanner halfway along, it would halve the torque.

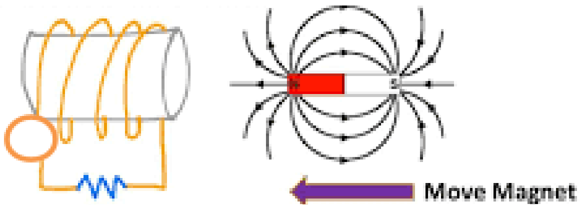
Question 22 (6 marks)

(a)

Criteria	Marks
● Describes fully an appropriate model ● Describes Lenz's Law ● Links description of Law to described model	3
● Describes an appropriate model ● Links model in some way to Lenz's Law	2
● Identifies a model that is linked in some way to Lenz's Law	1

Sample answer:

Lenz's Law states that an induced electric current flows in a direction such that the current opposes the change that induced it. This can be modelled by using a coil connected to a galvanometer and then moving a magnet in and out of the coil. As the magnet below is moved into the coil, the coil will experience an induced current due to the changing magnetic field produced by the moving magnet. This current will flow in a direction that will produce a magnetic field that opposes the changing field that produced it. As the magnet is moved out again the current will flow in the opposite direction. This can be viewed by seeing the needle of the galvanometer move and change directions with the changes in motion of the magnet.



(b)

Criteria	Marks
● Describes the Law of Conservation of Energy ● Uses Lenz's Law to describe the production of back emf and how it opposes the motion of the motor ● Relates this in some way to obeying the Law of Conservation of Energy	3
● Uses Lenz's Law to outline how back emf is produced and relates its production in some way to the Law of Conservation of Energy	2
● Uses Lenz's Law to outline how back emf is produced OR relates its production in some way to the Law of Conservation of Energy	1

Sample answer:

Lenz's Law states that an induced current will always oppose the direction of the of the changed circuit or magnetic field that produces it. The law of conservation of energy states that energy cannot be created or destroyed but can only change from one form to another. Thus, a closed system has a set amount of energy that cannot change unless added to from outside the system. The production of back emf, to obey the conservation of energy, must oppose the system producing it. Otherwise, you would have a constantly increasing amount of energy within the system.

Question 23 (6 marks)

(a)

Criteria	Marks
• Explains the importance of these observations to the development of Bohr's model of the atom • Outlines clearly how he related these	3
• Describes briefly the spectrum produced by excited hydrogen atoms • Outlines how he related spectral lines to orbiting electrons	2
• Links the occurrence of spectral lines in some way to orbiting electrons	1

Sample answer:
The observed spectrum produced by excited hydrogen atoms were a few specific lines at very specific frequencies. This supported Bohr's theory of electrons in set stable obits that could move from one orbit to another by absorbing and releasing energy thus producing these unique spectral lines.

(b)

Criteria	Marks
• Describes two characteristics of the hydrogen spectra that could not be explained by Bohr's model	3
• Describes one characteristic of the hydrogen spectra that could not be explained by Bohr's model OR • Identifies two characteristics	2
• Identifies ONE characteristic	1

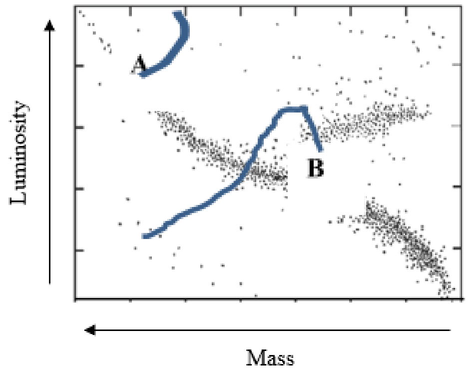
Sample answer:
Bohr's model could not explain why each band, when viewed closely, was not a solid line of emitted light or a narrow range of frequencies emitted from the atom but were, in fact, made up of a number of hyperfine spectral lines. Also, his model could not explain why some spectral lines in the hydrogen spectra were brighter than others.

Question 24 (7 marks)

(a)

Criteria	Marks
● Correctly places A and B on the Hertzsprung-Russel diagram provided	1

Sample answer:



(b)

Criteria	Marks
● Correctly sketches the most likely pathways for each star's life cycle	2
● Correctly sketches the most likely pathways for one star's life cycle	1

Sample answer:
See above diagram

(c)

Criteria	Marks
● Explains similarities of the main nuclear reactions occurring in Stars A & B ● Explains differences in the main nuclear reactions occurring in Stars A & B	4
● Describes similarities of the main nuclear reactions occurring in Stars A & B ● Describes differences in the main nuclear reactions occurring in Stars A & B	3
● Explains either similarities or differences in the main nuclear reactions occurring in Stars A & B OR ● Describes some similarities and differences of the main nuclear reactions occurring in Stars A & B	2
● Provides some relevant information	1

Sample answer:
Both stars use fusion reactions to produce energy. Star A is much hotter than Star B and would have carbon present. It could, therefore, have the high temperature needed to produce energy predominantly via the CNO cycle this uses a cycle to produce helium nuclei from 4 hydrogen nuclei :

$$^{12}C + {}^{1}H \rightarrow {}^{13}N + \gamma$$
$$^{13}N \rightarrow {}^{13}C + \beta^{+} + \nu$$
$$^{13}C + {}^{1}H \rightarrow {}^{14}N + \gamma$$
$$^{14}N + {}^{1}H \rightarrow {}^{15}O + \gamma$$
$$^{15}O \rightarrow {}^{15}N + \beta^{+} + \nu$$
$$^{15}N + {}^{1}H \rightarrow {}^{12}C + {}^{4}He$$

Star B would not have the temperature needed for the CNO cycle to dominate, so, while it also uses 4 hydrogen nuclei to produce helium nuclei it does so using the proton-proton chain reaction:

$$H_1^1 + H_1^1 \rightarrow H_1^2 + \bar{e}_1^0 + \nu_0^0$$
$$H_1^2 + H_1^1 \rightarrow He_2^3 + \gamma_0^0$$
$$He_2^3 + He_2^3 \rightarrow He_2^4 + H_1^1 + H_1^1$$

Question 25 (5 marks)

(a)

Criteria	Marks
• Describes that the speed of light is the same for both the observer and the passenger • Linking this to Einstein's postulate relating to the constancy of the speed of light regardless of the relative motion	3
• Identifies that the speed of light is the same for both the observer and the passenger • Identifies Einstein's postulate relating to the constancy of the speed of light	2
• Identifies that the speed of light is the same for both the observer and the passenger	1

Sample answer:
The speed of light is constant in all inertial reference frames, and, as such, is independent of the relative speed of the source and the observer. The principal of relativity states that if you are moving at a constant velocity, you cannot conduct an experiment to prove you are moving within your frame of reference.

(b)

Criteria	Marks
• Uses correct equation and substitutes correctly to get correct answer including units	2
• Correct substitution with minor calculation error	1

Sample answer:
$L_v = L_O \sqrt{1-0.88c^2/c^2}$
$L_v = 30 \sqrt{1-0.88}$

$L_v = 14.2$ m

Question 26 (5 marks)

(a)

Criteria	Marks
• Uses correct equations and substitutes correctly to get correct answer including units	2
• Correct substitution with minor calculation error	1

Sample answer:
Time to fall 4 m
t = $\sqrt{2s}/a$
t = $\sqrt{8}/9.8$
= 0.9 s
v = s/t
= 32/0.9
= 35.6 ms^{-1}

(c)

Criteria	Marks
• Explains why the runway is needed before the ramp for the car to gain the required launch velocity • Relates the reduction of acceleration/velocity due to ramp climb to the need for the runway	3
• Describes how the required launch velocity needs the runway	2
• Provides some relevant information	1

Sample answer:
The car will lose velocity climbing the ramp so it needs to have a runway of sufficient length to gain a velocity above the launch velocity needed and clear the cars.

On the flat, the car can accelerate at 17.6 ms^{-2} if all goes perfectly. To ensure a velocity above the launch velocity is achieved before the climb, the car needs more than 2 seconds on the flat. In 3 seconds, the accelerating car can travel about 53 m. So again, to ensure some room for error, a runway of at least 70-80 metres would be needed.

Question 27 (6 marks)

(a)

Criteria	Marks
• Uses correct equation and substitutes correctly to get correct answer including units	2
• Correct substitution with minor calculation error	1

Sample answer:
Correctly calculates the current as 2 Amps
$n_p/n_s = 240/V_s$ 3/9 = 0.33
therefore V_s = 727; I_p = 1; and 1 x 240 = 240
therefore I_s = 0.33 A

(b)

Criteria	Marks
• Describes two different strategies • Relates each strategy to improved energy efficiency	4
• Identifies two different strategies • Relates each in some way to improved energy efficiency	3
• Identifies one strategy • Relates in some way to improved efficiency	2
• Either of above	1

Sample answer:
Most energy is lost due to the transformer heating up. This is caused by the production of eddy currents.

One way to reduce heat production is to reduce the production of eddy currents by using a laminated iron core. This is many thin sheets of iron pressed together but separated by thin insulating layers. This limits the circulation of any eddy currents to the thickness of one lamina, rather than the whole core, thus reducing the overall heating effect. Other ways involve cooling the transformer down to stop the heat building up and overheating the transformer. Various methods such as having transformers in well ventilated surroundings, using cooling systems and/or fans are used to dissipate the heat.

Question 28 (2 marks)

Criteria	Marks
• Uses correct equation and substitutes correctly to get correct answer including units	2
• Correct substitution with minor calculation error	1

Sample answer:
Correct Substitution
$\lambda = h/mv$
$v = h/m\lambda$
$v = 6.63 \times 10^{-34} / (9.31 \times 10^{-31})(1.84 \times 10^{-11})$

Question 29 (9 marks)

(a)

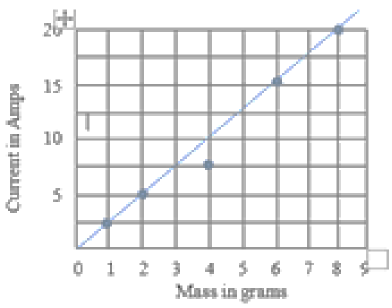
Criteria	Marks
● Provides the correct disc with justification	1

Sample answer:
Disc A by using the right hand rule the coil will experience clockwise force so the weights need to oppose this force.

(b)

Criteria	Marks
● Labels axes and plots all points correctly ● Draws in an appropriate line of best fit	2
● One of above	1

Sample answer:



(c)

Criteria	Marks
● Provides a valid reason why the experiment was conducted using several different masses ● Uses the results to help justify your answer	2
● Provides a valid reason why the experiment was conducted using several different masses	1

Sample answer:
Looking at the graph, the 4 gram mass was an outrider when compared to the other masses. While repeats are important by using a range of masses, you must take into account any errors in one of the masses. By graphing the results it is easier to see the relationship and pick up any outriders.

(d)

Criteria	Marks
• Uses correct equation and substitutes correctly to get correct answer including units	2
• Correct substitution with minor calculation error	1

Sample answer:

$I = 5.02\ A$

$B = 25 \times 10^{-3}\ T$

$l = .15\ m$

$F = BIl$

$= 25 \times 10^{-3} \times 5.02 \times .15$

$= 1.9 \times 10^{-2}$ N

(e)

Criteria	Marks
• Uses correct concept • Calculates correct answer including units	2
• Makes a minor calculation error or omits units	1

Sample answer:

Concept $F = BIl = mg$

$g = 1.9 \times 10^{-2} \div 2 \times 10^{-3}$

$= 9.5\ ms^{-2}$

Question 30 (5 marks)

Criteria	Marks
• Describes fully the relationship shown in the graph between energy and frequency relating the maxima to temperature • Describes clearly the particle theory of light in terms of photons of energy with specific frequencies and hence energy • Clearly links the concept of the wavelength maxima and Wien's Law to temperature – the shorter the wavelength (thus the higher the frequency) the greater the total energy radiated (for a given temperature)	5
• Describes the relationship shown in the graph between energy and frequency relating the maxima to temperature • Describes the particle theory of light • Links the concept of the wavelength maxima temperature	4
• Describes very briefly the relationship shown in the graph between energy and frequency relating the maxima to temperature • Describes very briefly the particle theory of light • Links the concept of the wavelength maxima temperature	3
• Generalises about the relationship and/or the theory and/or the concept	2
• Provides some relevant information	1

Sample answer:
The particle theory of light is explained if light is considered to consist of a stream of particles, or discrete bundles of energy, called photons. A photon carries an amount of energy that is proportional to the frequency of the radiation (light). The higher the frequency of the light, the more energy the photon possesses. Thus, photons of ultraviolet light have higher energy than those of blue light, which in turn have higher energy than photons of red light.

A black body radiation curve shows the relationship between the wavelength and the intensity of the energy emitted for bodies at different temperatures. The hotter the temperature, the higher the energy intensity is at the shorter wavelengths (or higher frequency). Wein's Law states that as temperature increases, wavelength maxima moves to the left on the graph. According to the particle theory, a photon cannot transfer part of its energy and the energy possessed by a photon is proportional to its frequency, in relation to black body radiation, that the shorter the wavelength (thus the higher the frequency) the greater the total energy radiated (for a given temperature).

Question 31 (7 marks)

Criteria	Marks
• Explains, showing comprehensive understanding, links between spectroscopy and information about the characteristics of stars • Provides a range of information possible through different types of spectroscopy • Provides a justification	6-7
• Explains links between spectroscopy and information about the characteristics of stars	4-5
• Describes some links between spectroscopy and information about the characteristics of stars	2-3
• Provides some relevant information	1

Sample answer:
A stellar spectrum emitted by a star consists of an approximate black body radiation spectrum for the temperature of the stellar surface, superimposed with absorption lines characteristic of the elements present in the stellar atmosphere.

The shape of the curve of intensity against wavelength across a star's black-body spectrum, and particularly the position of the intensity maximum, using Wein's Law, identifies the surface temperature of the star. Thus, the spectral radiation can be used to classify visible stars into their spectral class: O, B, A, F, G, K, and M, from hottest to coolest. Each spectral class has a characteristic colour and surface temperature range, and each is characterised by specific absorption line patterns, indicating the elements in the star's atmosphere.

Further analysing shifts in specific spectral lines can give information about rotational and translational velocity. Rotational velocity can be measured by looking at the degree of broadening of spectral lines due to both blue and red shift occurring as the star rotates on its axis. Translational velocity can be determined by the amount of shift of the spectral lines.

Broadening of spectral lines can also give information about the density of a star.

Question 32 (3 marks)

Criteria	Marks
• Uses correct equation and substitutes correctly to get correct answer including units	3
• Correct substitution with minor calculation error or incorrect units	2
• Correct substitution	1

Sample answer:

$\frac{1}{\lambda} = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$

$\frac{1}{\lambda} = 1.097\times10^7\left(\frac{1}{2^2} - \frac{1}{4^2}\right)$

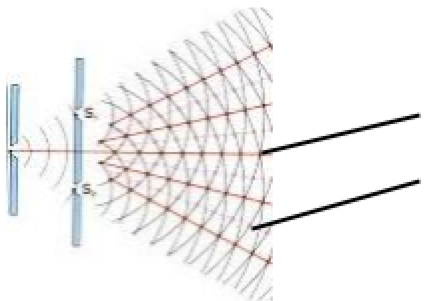
$\frac{1}{\lambda} = 2.05\times10^6$

$\lambda = 4.86\times10^{-7}\ m$

Question 33 (3 marks)

Criteria	Marks
• Defines diffraction and uses a diagram to describe how diffracted waves interfere with each other to produce light and dark bands on a screen	3
• Uses a diagram to describe how diffracted waves interfere with each other to produce light and dark bands on a screen	2
• Identifies that bands are produced by diffracted waves interfering with each other	1

Sample answer:



Two sets of waves initiated at each slit constructively and destructively interfere with each other.

Where two crests meet constructive interference occurs.

Where a crest and trough meet destructive interference occurs.

On a screen this interference is represented with a series of bright (constructive) and dark (destructive) bands.

Question 34 (5 marks)

(a)

Criteria	Marks
• Correctly derives equation and substitutes correctly to calculate correct answer including units	3
• Correctly derives equation and substitutes with minor calculation error	2
• Substitutes correctly with minor mistake in rearranging equation	1

Sample answer:

For straight line:

$F = qvB = qE$

Therefore $E = vB$

$= 2.2 \times 10^{7} \times 5.0 \times 10^{-3} = 11.0 \times 10^{4}$

and $V = Ed = 11.0 \times 10^{4} \times 1.0 \times 10^{-2} = 11.0 \times 10^{2}$ V

(b)

Criteria	Marks
• Uses correct equation and substitutes correctly to calculate correct answer including units	2
• Correct substitution with minor calculation error	1

$F = qE = 11.0 \times 10^{4} \times 1.602 \times 10^{-19}$

$= 1.76 \times 10^{-14}$ N

$F = ma$

$a = F/m$

$= 1.76 \times 10^{-14} / 9.109 \times 10^{-31}$

$= 1.93 \times 10^{16}$ ms^{-1}

Question 35 (6 marks)

Criteria	Marks
• Describes, using relevant equations, the requirements for orbiting objects to remain in their respective orbits and relates this to their energy • Describes the process of orbital decay • Uses equations to explain kinetic and gravitational potential energy changes that occur during orbital decay	5-6
• Describes the requirements for orbiting objects to remain in their respective orbits • Outlines the process of orbital decay • Relates energy changes in some way to orbital decay	3-4
• Identifies the requirements for orbiting objects to remain in their respective orbits • Relates energy changes in some way to orbital decay	1-2

Sample answer:
An object that is orbiting a body in a radial gravitational field is basically falling but doing so with a velocity that ensures it keeps orbiting rather than falling closer to the body. It can be seen by looking at the equation for orbital velocity that the smaller the radius, the greater the velocity needed to stay in orbit, and as KE = ½ mv^2 the greater the velocity the greater its KE

$$v = \sqrt{\left(\frac{GM_{\odot}}{r}\right)}$$

To remain in orbit therefore, the orbiting body must have enough KE to maintain its orbital radius but not too much that it escapes. If the body comes in contact with something that causes it to lose some KE, it will start to fall closer to the central body, though it does not fall directly down. As can be seen in the above equation, a lower orbit actually requires more KE to maintain it than a higher orbit. Using the above equations, if the radius of orbit is halved, the velocity increases by approximately 1.4 thus doubling the KE. The gained KE comes from the loss in GPE due to the changed radius via equation:

$$U = -\frac{GMm}{r}$$

This all means that energy is key to maintaining an orbit. If a loss of energy is a one off, such as a collision with a small asteroid, the body may have enough KE to remain in its new orbit if nothing else happens for it to lose more KE. In the case of orbiting satellites, lower orbits often mean more and more contact with atmospheric particles so the decay process continues as the satellite slowly spirals back to Earth.

2020 HSC Trial
Physics
Mapping Grid

Question	Marks	Content	Syllabus outcomes
Section I			
1	1	7.4.2	PH12-12, PH12-5
2	1	7.2.4	PH12-12, PH12-6
3	1	5.3.4.2	PH12-12, PH12-6
4	1	5.2.3	PH12-12, PH12-6
5	1	5.2.2	PH12-12, PH12-4
6	1	6.2.3	PH12-13, PH12-6
7	1	6.1.1	PH12-13, PH12-5
8	1	5.2.2,3	PH12-12, PH12-6
9	1	6.1.4	PH12-13, PH12-5
10	1	7.3.3	PH12-14, PH12-4
11	1	8.4.1	PH12-15, PH12-7
12	1	7.3.1	PH12-14, PH12-7
13	1	5.3.5.1	PH12-12, PH12-7
14	1	6.3.1	PH12-12, PH12-6
15	1	8.4.6	PH12-15, PH12-5
16	1	8.5.2.1	PH12-15, PH12-7
17	1	5.3.1	PH12-12, PH12-6
18	1	8.5.2.2	PH12-15, PH12-7
19	1	8.5.2.3	PH15-12, PH12-7
20	1	5.1.1	PH12-12, PH12-5
Section II			
21 (a)	2	5.2.5	PH12-12, PH12-7
21 (b)	3	5.2.5	PH12-12, PH12-4
22 (a)	3	6.3.2.1	PH12-13, PH12-4
22 (b)	3	6.4.3	PH12-13, PH12-7
23 (a)	3	8.3.1,2	PH12-15, PH12-1
23 (b)	3	8.3.1,3	PH12-15, PH12-4
24 (a)	1	8.1.6.3,4	PH12-15, PH12-4

24 (b)	2	8.1.6.2	PH12-15, PH12-4
24 (c)	4	8.1.7	PH12-15, PH12-7
25 (a)	3	7.4.1	PH12-14, PH12-3,7
25 (b)	2	7.4.2	PH12-14, PH12-5,6
26 (a)	2	5.1.4	PH12-12, PH12-5
26 (b)	3	5.1.4	PH12-12, PH12-4
27 (a)	2	6.3.3	PH12-13, PH12-4
27 (b)	4	6.3.4,5	PH12-13, PH12-7
28	2	8.3.3	PH12-15, PH12-4
29 (a)	1	6.2.1.1	PH12-13, PH12-3
29 (b)	2	ACSPH004	PH12-13, PH12-2
29 (c)	2	ACSPH005	PH12-13, PH12-2
29 (d)	2	6.2.1.2	PH12-13, PH12-5,6
29 (e)	2	5.3.1	PH12-13, PH12-4
30	5	7.3.1	PH12-14, PH12-7
31	7	7.1.5,6	PH12-15, PH12-4,5,6,7
32	3	8.3.3	PH12-15, PH12-5
33	3	7.2.1,2	PH12-14, PH12-2,3,7
34 (a)	3	6.1.1.1; 6.1.3.2	PH12-13, PH12-5,6
34 (b)	2	6.1.3.1	PH12-13, PH12-5,6
35	6	5.3.5	PH12-15, PH12-1,2,3,7