Student Number

2020

TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION

PEM

Physics

General Instructions

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

Total marks – 100

100 marks
This exam has two parts, Part A and Part B

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

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

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

Use the multiple choice answer sheet for Questions 1-20

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1 What does the deflection of cathode rays by magnetic fields suggest about their nature?

(A) They are electromagnetic waves because electromagnetic waves produce magnetic fields that interact with the applied magnetic field.

(B) They are electromagnetic waves because electromagnetic waves carry a charge that can be attracted or repelled by the applied magnetic field.

(C) They are charged particles because moving charged particles produce a magnetic field that interacts with the applied field.

(D) They are charged particles because the charges are repelled or attracted by the magnetic field causing deflection.

2 Which of the following was NOT observed about the photoelectric effect?

(A) It only happens if the EMR used has a frequency above a certain value.

(B) The maximum kinetic energy of the photoelectrons emitted depends on the intensity of the EMR.

(C) The emission of photoelectrons is instantaneous

(D) Photocurrent has a max value with increasing light intensity

3 Bohr's model of the atom differed from Rutherford's model of the atom by:

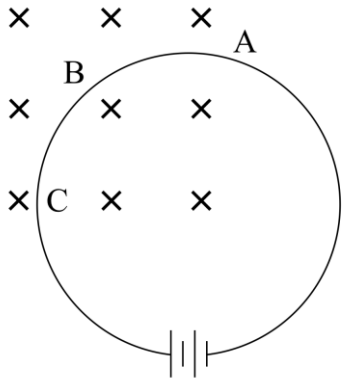
(A) allowing for the existence of subshells.

(B) assuming electrons have a constant speed and constant acceleration.

(C) explaining the spectrum of the visible lines in the hydrogen spectrum.

(D) making firm predictions as to the location of the electron around the nucleus.

4 A length of wire labelled ABC in a uniform magnetic field is connected to an external circuit as shown below.

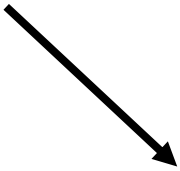


What is the direction of the force acting on the wire at point B?

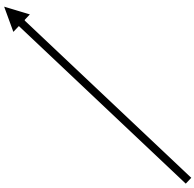
(A)

(B)

(C)



(D)



5 A low earth orbit satellite has its altitude doubled in order to reduce orbital decay. What effect would this have on the Force of gravity acting on the satellite.

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

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

(C) $2F_g$

(D) $4F_g$

6 In an experiment, an electron gun with a voltage between its cathode and anode of 100 V was observed to have electrons travelling at a speed of 6.2 X 10^6 ms^{-1}.

Calculate the de Broglie wavelength of these electrons.

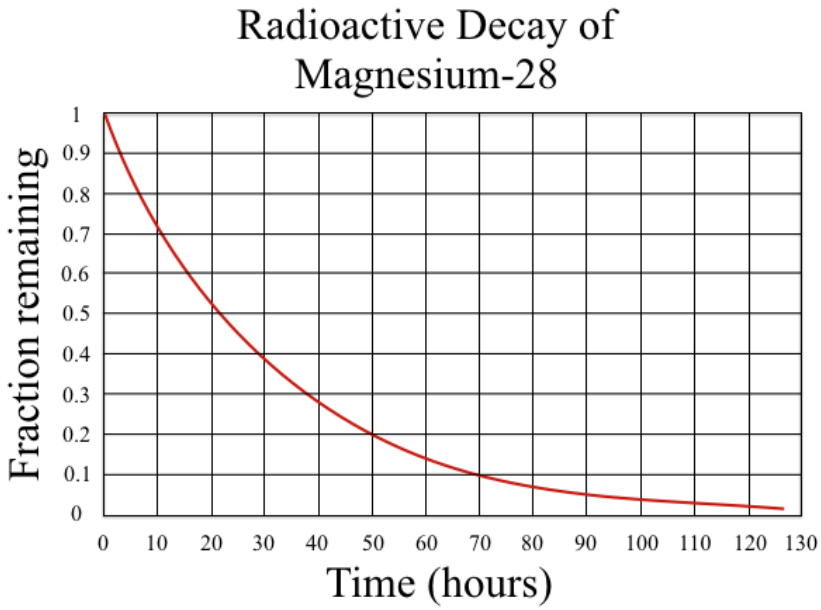
(A) 0.12 nm

(B) 0.22 nm

(C) 11.7 nm

(D) 221 nm

7 The radioactivity of a sample of Magnesium-28 was measured over time and the results plotted on the axes shown.



Which of the values below is the radioactive decay constant?

(A) 40

(B) 20

(C) 0.5

(D) 0.035

8 An unstable isotope of Strontium-90 has a mass of 89.907737 u before it undergoes beta decay to Yttrium-90 which has a mass of 89.907151 u.

$^{90}_{38}Sr \longrightarrow {}^{90}_{39}Y + e^{-} + \bar{\nu}_e$

What is the energy released in the decay?

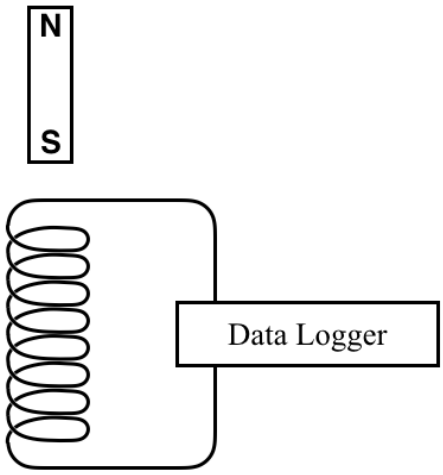
(A) 112 keV

(B) 0.546 MeV

(C) 1.2 MeV

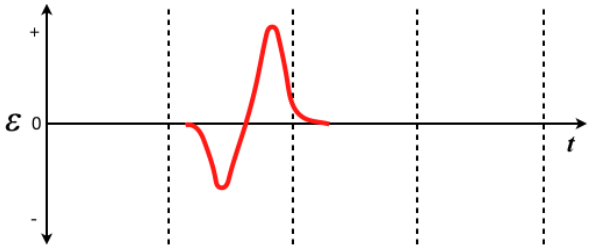
(D) 1.8 MeV

9 A bar magnet is dropped through a coil connected to a data logger as shown below.

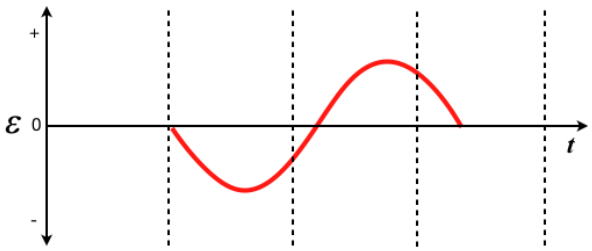


The emf trace produced by the data logger would look like:

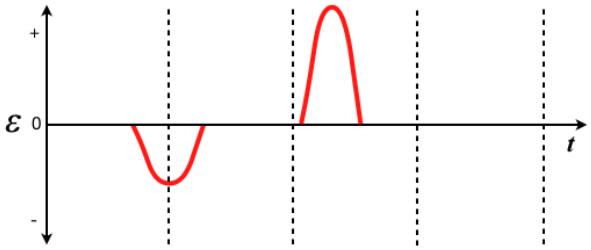
(A)



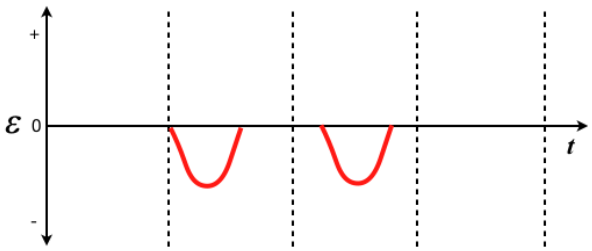
(B)



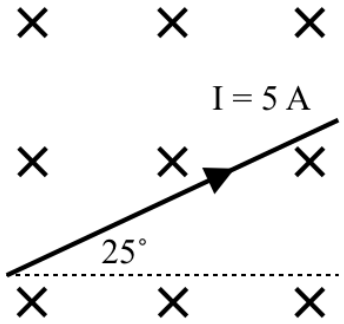
(C)



(D)



10 A current carrying conductor of length *l* is placed in a 0.12 T magnetic field as shown below.



The magnitude of the force on the wire can be determined by:

(A) $F = (0.12)(5)(l)$

(B) $F = (0.12)(5)(l)sin250$

(C) $F = (0.12)(5)(l)cos250$

(D) $F = (0.12)(5)(l)cos450$

11 Two parallel current carrying wires are shown below.

If the current in wire 1 is reduced by 75% and the current in wire 2 is reduced by 50%, Deduce the magnitude of the force between the wires.

(A) 8F

(B) F

(C) F/8

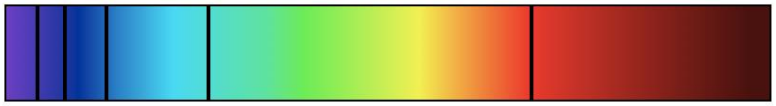
(D) F/4

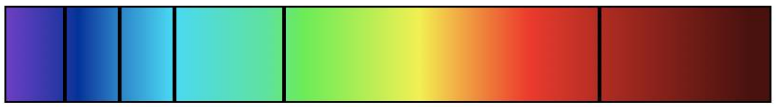
12 The transformer for an electric guitar tuner has an input voltage of 230 V and an output voltage of 6 V.

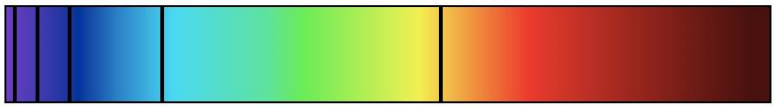
Which of the following options could achieve this transformation?

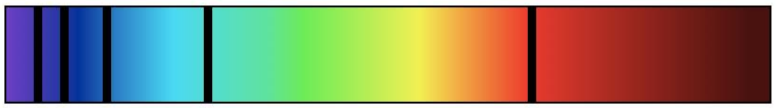
	Number of turns Primary	Number of turns Secondary
(A)	690	12
(B)	12	690
(C)	2760	72
(D)	72	2760

13 Which of the following spectra was most likely emitted from a star with a high rotational velocity?

(A) 

(B) 

(C) 

(D) 

14 Light from a laser is directed through a pair of slits that are 40 mm apart. If the laser light has a wavelength of 600 nm, calculate the distance between three sequential bright fringes that would be produced if projected onto a screen 1 m from the slits.

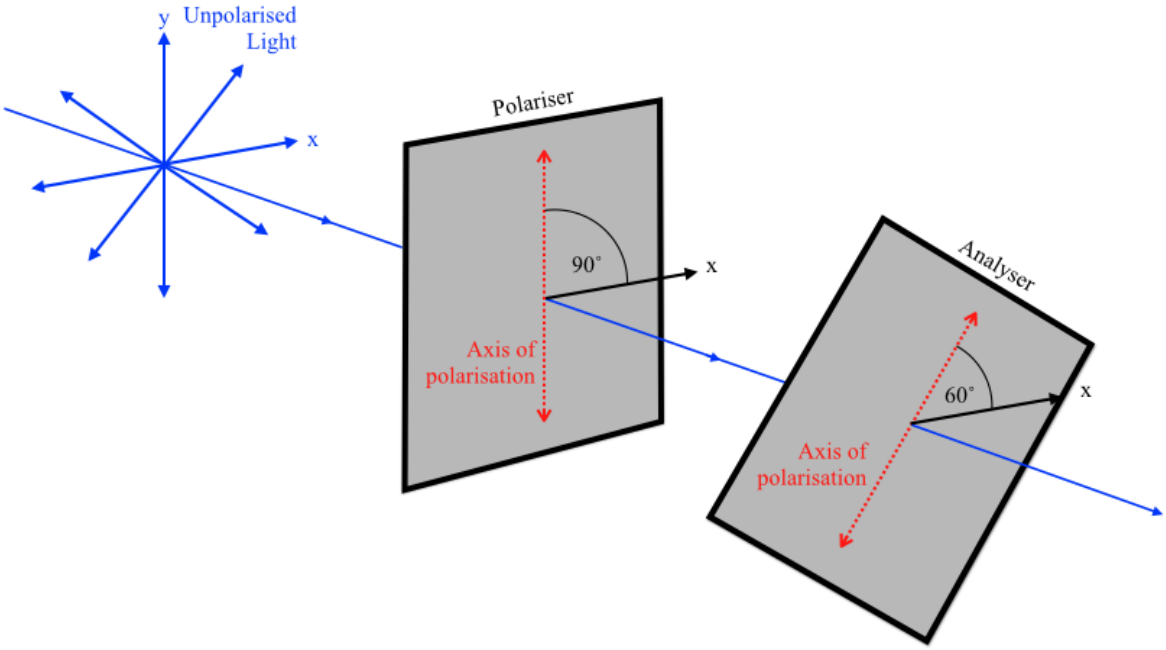
(A) 3.0 cm

(B) 1.5 cm

(C) 0.5 cm

(D) 1.0 cm

15 Unpolarised light is passed through a polariser followed by an analyser as shown in the diagram below.



Calculate the intensity of the light transmitted by the analyser.

(A) 0.125 I_O

(B) 0.375 I_O

(C) 0.25 I_O

(D) 0.75 I_O

16 A very long train is travelling close to the speed of light. An observer on a platform watches the train travel past.

Which of the following statements is true?

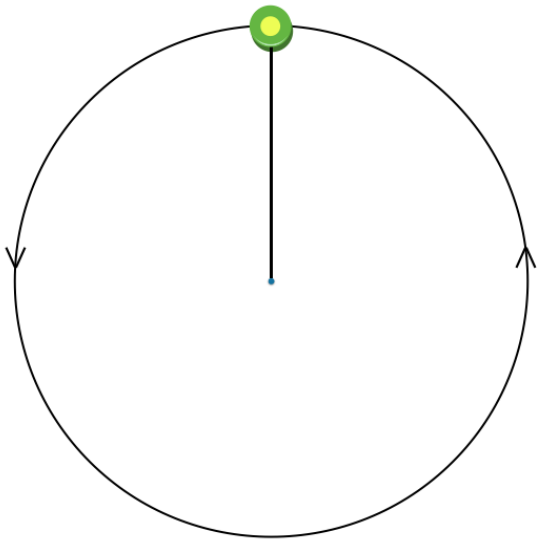
(A) Time will appear to be running faster in the train according to the observer on the platform.

(B) A passenger on the train and the observer on the platform both measure time slowing in the other frame of reference.

(C) The platform will appear longer to the passenger on the train.

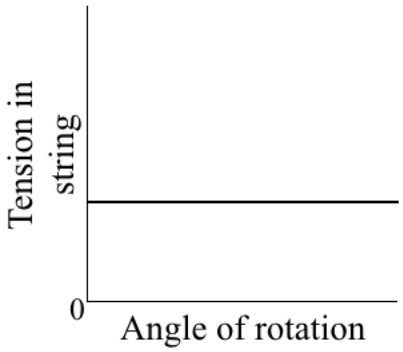
(D) The observer on the platform will observe a longer train.

17 A yo-yo is undergoing circular motion on a vertical plane as shown below.

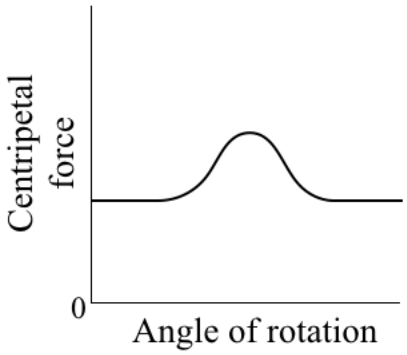


Which graph below correctly describes the forces acting on the yo-yo as it completes one revolution from the point shown?

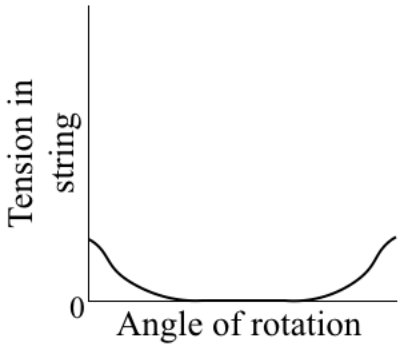
(A)



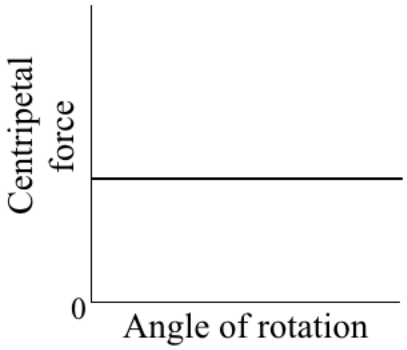
(B)



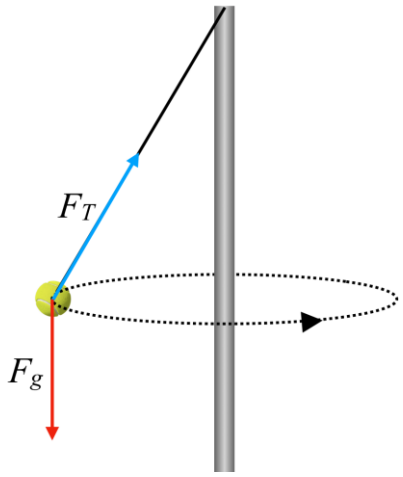
(C)



(D)



18 A tether ball is swinging around a pole in uniform circular motion on a horizontal plane as shown below.



Which of the following expression would correctly determine the mass of the ball?

(A) $m = \sqrt{\frac{F_c r}{v}}$

(B) $m = \frac{gr \tan \theta}{v^2}$

(C) $m = \frac{F_c g}{\tan \theta}$

(D) $m = \frac{F_T \cos \theta}{g}$

19 Calculate the mass of the Comet Churyumov–Gerasimenko if has an average radius of 2 km and an escape velocity of 1 m s^{-1}.

(A) 1.5 x 10^{13} kg

(B) 1.5 x 10^{10} kg

(C) 7.5 x 10^{6} kg

(D) 7.5 x 10^{13} kg

20 It takes a satellite 5 days to complete one full orbit around a planet, at a distance of 3.0 units. A second satellite orbits in 3.5 days. How far is the second satellite from the planet.

(A) 1.2 units

(B) 1.5 units

(C) 2.1 units

(D) 4.7 units

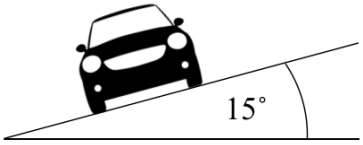
Part B – 80 marks
Attempt questions 21-35
Allow about 2 hour and 25 minutes for this part

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

Show all relevant working in questions involving calculations.

Question 21 (5 marks)

(a) A car is travelling at the design speed of a banked track with a turning radius of 30.0 m, as shown in the diagram. The mass of the car is 1000 kg. **2**



Determine the design speed of the track.

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(b) If the car was to increase its speed by 5 m s^{-1} and maintain the same radius, what friction force would be required by the tyres. **3**

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Question 22 (5 marks)

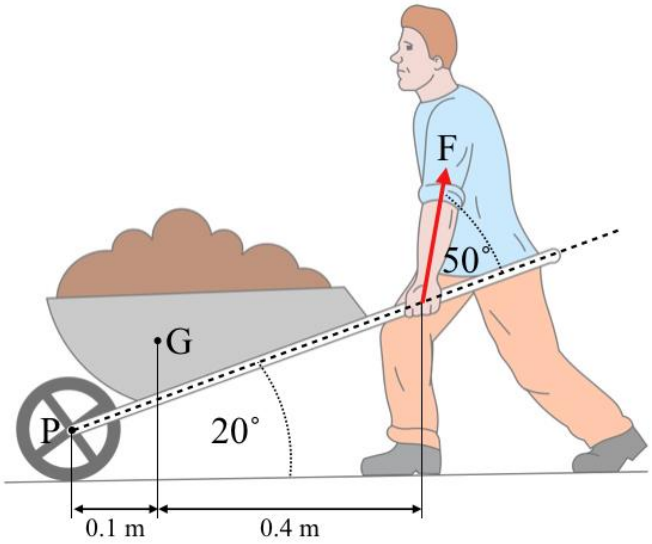
During a game of cricket, the batsman hits a six (the ball clears the fence boundary on the full). The cricket ball is hit at an angle of 35˚ from the horizontal at 28 m s^{-1}, 1.1 m above the ground. Air resistance is negligible.

(a) If the ball just clears the fence 74 m from where it was hit, calculate the height of the fence. **3**

(b) Determine the speed of the ball when it reaches the fence. **2**

Question 23 (4 marks)

The combined mass of a wheelbarrow and its load is 60 kg with the centre of mass located at G, as shown below.



(a) What force must the man apply to the wheelbarrow arm in order to create a net torque of zero at point P. **3**

(b) Identify two ways in which the man could decrease the required force and maintain a zero-net torque at P. **1**

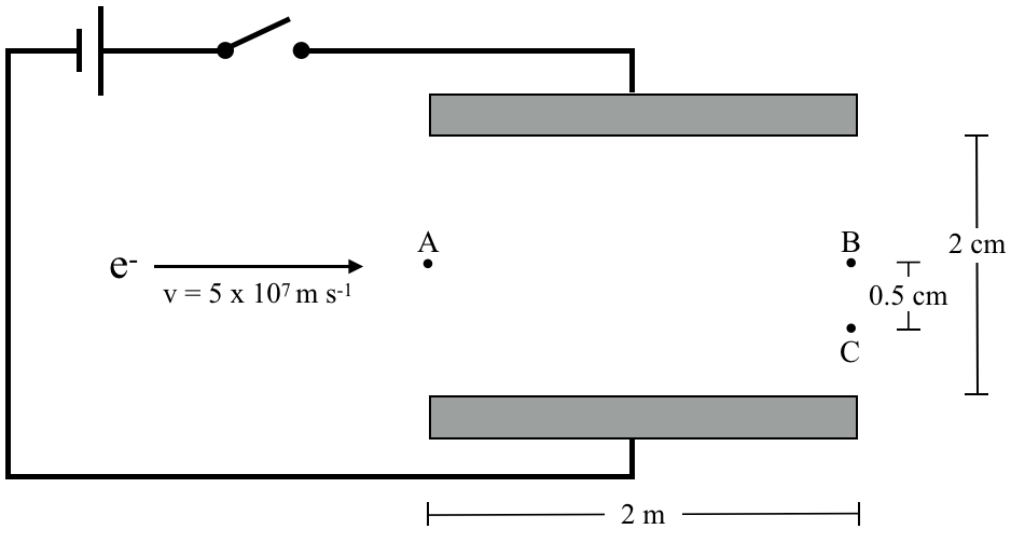
Question 24 (6 marks)

(a) Calculate the altitude of a geosynchronous satellite orbiting the Earth. **3**

(b) Determine the total mechanical energy of the same satellite if it has a mass of 2000 kg. **3**

Question 25 (5 marks)

Two parallel electric plates are connected to a power source as shown in the diagram below.



(a) Determine the time taken for the electron to get from point A to point B when the switch is open. **1**

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(b) Determine the voltage required so that the electron exits the field at C when the switch is closed. **4**

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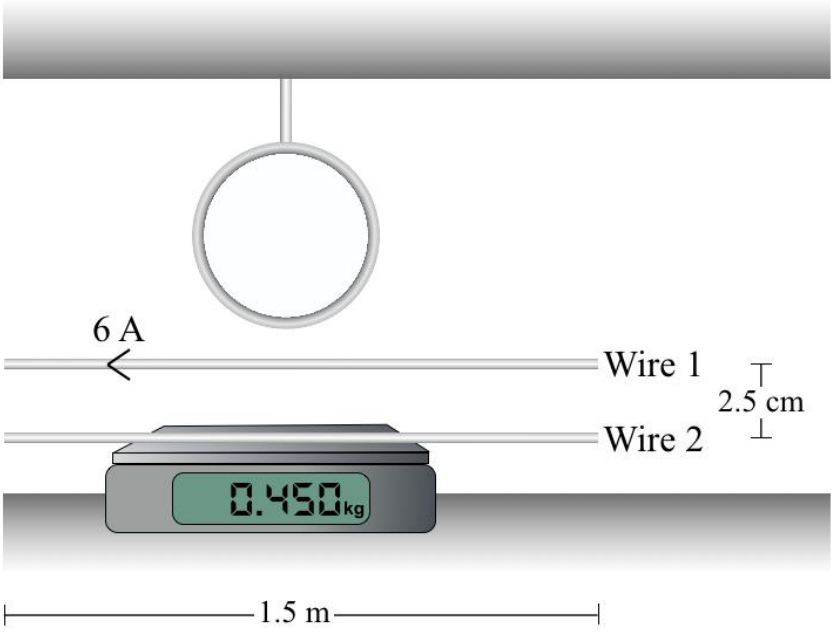
Question 26 (4 marks)

A vehicle can be propelled using an electric motor. If the motor is used as a generator when the vehicle is moving there is a braking effect on the vehicle.

Explain the physics principles involved in the propulsion and braking of this vehicle.

Question 27 (7 marks)

An iron ring is suspended over two wires in a laboratory as shown below. Wire 1 is suspended 25 cm above wire 2 which rests on a scale. Wire 1 has a 6 A current running through it. Wire 1 and 2 are each 1.5 m in length.



(a) Determine the magnitude and direction of the current required through wire 2 so that a reading of 0.20 kg is achieved on the scale. **3**

Question 27 continues on page 18

(b) Explain why there is an induced emf in the iron ring when wire 2 is turned on. **3**

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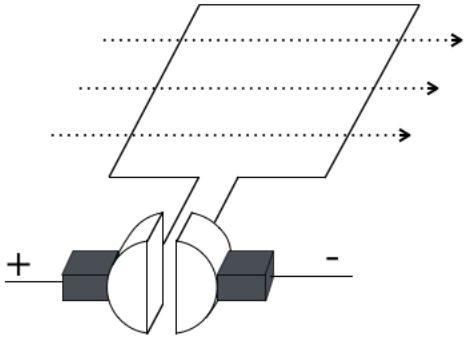
(c) Indicate the direction of the induced emf in the iron ring on the diagram on the previous page. **1**

Question 28 (4 marks)

A motor has a square coil with side length 3 cm in a magnetic field of 0.15 T as shown below. The coil rotates at 240 rpm when a 3A current flows to the coil.



(a) Determine the torque on the coil at the position shown. **2**

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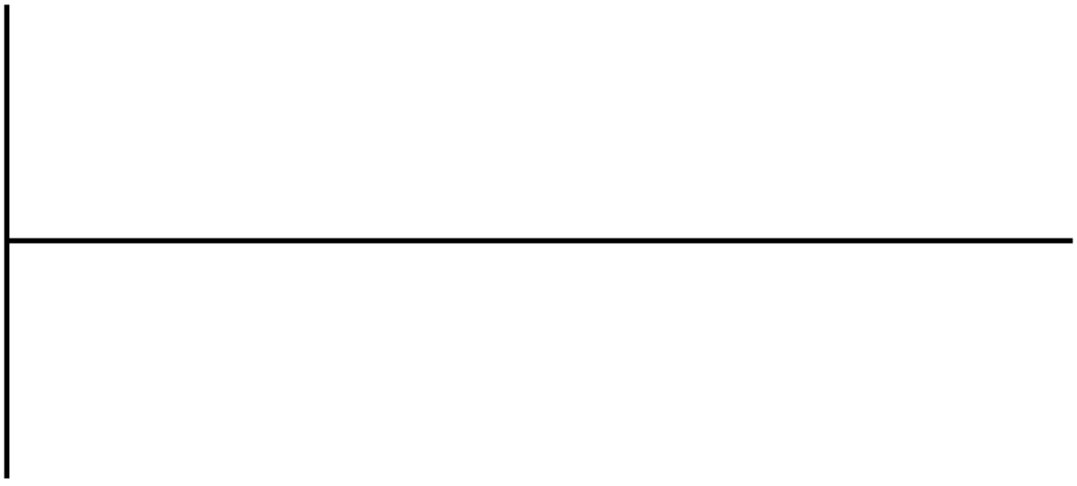
(b) Draw a torque vs time graph on the axis below for one revolution of the coil from the position shown. **2**



Question 29 (7 marks)

In the early 17th century Galileo Galilei made a notable attempt to measure the speed of light. He and his assistant stood 1km apart atop two tall hills at night-time. Galileo opened a lantern and began a timing device. His assistant opened his lantern when he saw the light from Galileo's lantern. Galileo stopped his timing device when he saw the light form his assistants' lantern.

(a) What type of error is present in Galileo's method as a result of human reaction times? **1**

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(b) If the average human reaction time to visual stimulus is at approximately 0.25 s, what is the fastest speed Galileo could have measured? **3**

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(c) Based on your answer to the previous question assess the validity of Galileo's method. **3**

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Question 30 (7 marks)

Explain how new evidence over time necessitated change in the model of light.

Question 31 (6 marks)

(a) Compare the production of emission and absorption spectra. **3**

(b) Explain how spectra can be used to identify elements. **3**

Question 32 (6 marks)

Max Planck, Albert Einstein, Niels Bohr, and Louis de Broglie made inspired guesses about how nature works.

'The limitations of classical physics gave birth to Quantum Physics.'

With reference to TWO of these scientists discuss TWO theories and ONE piece of evidence for this statement.

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Question 33 (2 marks)

The rest mass of ${}^{7}_{4}Be$ is 1.16519 X 10^{-26} kg. Calculate the binding energy of the Beryllium isotope in MeV.

Question 34 (3 marks)

An excited electron in a hydrogen atom emits a photon of wavelength 410.1 nm whilst transitioning into the Balmer series. Calculate the initial energy level of the electron.

Question 35 (9 marks)

Explain how the dominant nucleosynthesis reaction occurring in the core of main sequence stars is related to where they are located on the HR diagram. Compare these reactions to those occurring in the core of red giant and supergiant stars and explain the differences. In your answer you should include descriptions of relevant nucleosynthesis reactions.

END OF EXAM

PEM

2020 Trial HSC Physics Marking Guidelines

Section I, Part A

Multiple-choice Answer Key

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

Section I, Part B

Question 21 (a)

Criteria	Marks
Correctly determines design speed.	2
Attempts to derive correct equation	1

Sample answer:

$v = \sqrt{\tan\theta\ gr}$

$v = \sqrt{\tan 15 \times 9.8 \times 30}$

$v = 8.88$ m s^{-1}

Question 21 (b)

Criteria	Marks
Calculates correct friction force down the slope	3
Calculates x component of friction force	2
Calculates the difference in centripetal force	1

Sample answer:

$F_{c2} = \frac{mv_2{}^2}{r}$ $\qquad$ $F_{c1} = \frac{mv_1{}^2}{r}$

$F_{c2} = \frac{1000\times 13.9^2}{30}$ $\qquad$ $F_{c1} = \frac{1000\times 8.9^2}{30}$

$F_{c2} = 6417$ N $\qquad$ $F_{c1} = 2626$ N

The difference in centripetal force is the horizontal force provided by the friction.

$\Delta F_c = F_{c2} - F_{c1}$

$\Delta F_c = 3792$ N

$f = \frac{\Delta F_c}{\cos 15}$

$f = \frac{3792}{\cos 15}$

$f = 3926$ N down the slope

Question 22 (a)

Criteria	Marks
Calculates the height of the fence correctly	3
Calculates the change in vertical displacement	2
Shows relevant working out	1

Sample answer:

$\Delta x = u_x t$

$t = \frac{\Delta x}{u \cos \theta}$

$t = \frac{74}{28 \cos 35}$

$t = 3.27 \text{ s}$

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

$\Delta y = (28 \sin 35 \times 3.27) - 4.9(3.27)^2$

$\Delta y = 0.81 \text{ m}$

$h_f = \Delta y + 1.1$

$h_f = 1.92 \text{ m}$

Question 22 (b)

Criteria	Marks
Calculates correct speed	2
Calculates correct y component of the speed	1

Sample answer:

$v_y = u_y + at$

$v_y = 16.1 - 9.8 \times 3.27$

$v_y = -15.6 \text{ m s}^{-1}$

$v = \sqrt{{v_y}^2 + {v_x}^2}$

$v = 27.7 \text{ m s}^{-1}$

Question 23 (a)

Criteria	Marks
Calculates applied force correctly	3
Calculates perpendicular force correctly	2
Calculates perpendicular force with incorrect radius value	1

Sample answer:

$\Sigma\tau = 0 = \tau_{F\perp} + \tau_g$

$F_\perp r = -mgr$

$F_\perp \frac{0.5}{\cos 20} = 60 \times 90 \times \frac{0.1}{\cos 20}$

$F_\perp = 117.6$

$F = \frac{F_\perp}{\cos 40}$

$F = 153.5 \text{ N}$

Question 23 (b)

Criteria	Marks
Identifies two modifications that will decrease the force	1

Sample answer:

The man could hold the wheelbarrow arm further from the pivot point or increase the angle between the wheelbarrow arm and the horizontal.

Question 24 (a)

Criteria	Marks
Calculates correct altitude of satellite	3
Calculates correct radius of orbit	2
Attempts to use Kepler's third law	1

Sample answer:

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

$r = \sqrt[3]{\frac{6.67\times10^{-11}\times6\times10^{24}\times86400^2}{4\pi^2}}$

$r = 4.2 \times 10^7$ m

$Altitude = r - r_{earth}$

Question 24 (b)

Criteria	Marks
Calculates correct energy	3
Calculates kinetic and gravitational potential energy	2
Attempts to use relevant equations	1

Sample answer:

$E = -\frac{GMm}{2r}$

$E = -9.46 \times 10^{9}$ J

Question 25 (a)

Criteria	Marks
Correctly calculates time	1

Sample answer:

$s = \frac{d}{t}$

$t = \frac{d}{s}$

$t = \frac{2}{5 \times 10^{7}}$

$t = 4 \times 10^{-8}$ s

Question 25 (b)

Criteria	Marks
Correctly calculates the voltage	4
Attempts to substitute correct formulae to determine the acceleration of the electron AND/OR the voltage supplied	2-3
Attempts to provides relevant information	1

Sample answer:

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

$-0.005 = \left(\frac{1}{2}\right)(a)(4 \times 10^{-8})^2$

$a = -6.25 \times 10^{12}$ m s^{-1}

$F = qE$

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

$a = \frac{qE}{m}$

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

So $a = \frac{qV}{dm}$

$\therefore V = \frac{dam}{q}$

$V = \frac{(0.02)(-6.25\times10^{12})(9.109\times10^{-31})}{-1.602\times10^{-19}}$

$V = 0.71$ V

Question 26

Criteria	Marks
Demonstrates a sound understanding of the physics principles involved in a motor and a generator AND considers the energy changes and relates these to the motion of the vehicle both in propulsion and in braking AND clearly explains the physics principles involved in the propelling and braking of the vehicle	4
Demonstrates an understanding of the physics principles involved in a motor and a generator AND describes relevant energy changes	3
Demonstrates an understanding of the physics principles involved in a motor or generator OR shows some understanding of how a motor can act as a generator	2
Identifies some relevant information	1

Sample answer:

When acting as a motor, the vehicle converts electrical energy to kinetic energy due to the motor effect, thus propelling the vehicle. A motor consists of a rotating coil in a magnetic field.

When power is cut, the rotating coil in the magnetic field induces an emf to due to a change in magnetic flux. This allows the motor to act as a generator, which has essentially the same parts as a motor. When it acts as a generator, kinetic energy is converted to electrical energy, and so by Lenz's law, the motion of the rotor is opposed. This acts to slow the vehicle.

Question 27 (a)

Criteria	Marks
Correctly calculates the current	3
Attempts to substitute into correct formulae to determine the upward force required on wire 2 AND/OR the current through wire 2	1-2

Sample answer:

$mass\ of\ wire\ 2 = 0.45$ kg

$W = mg$

$W = 0.45 \times 9.8$

$W = 4.41$ N

If the reading is 0.2 kg

Then $W = 0.20 \times 9.8$

$W = 1.96$ N

$Upward\ force = 4.41 - 1.96$

$Upward\ force = 2.45$ N

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

$\frac{2.45}{1.5} = \frac{4\pi \times 10^{-7}}{2\pi} \times \frac{6 \times I_2}{0.025}$

$1.63 = 4.8 \times 10^{-5} \times I_2$

$I_2 = 34027$ A to the left

Question 27 (b)

Criteria	Marks
Explains the relationship between current carrying wire AND magnetic field produced AND induced current in the coil according to Lenz's Law.	3
Explains the relationship between current carrying wire AND/OR magnetic field produced AND/OR induced current in the coil according to Lenz's Law.	2
Attempts to explain any relevant information.	1

Sample answer:

When wire 2 is turned on there is an increase in magnetic flux through the coil and into the page. This is because a magnetic field flows around a current carrying conductor. An emf is induced in the coil to oppose this rate of change of flux (Lenz's Law).

Question 27 (c)

Criteria	Marks
Correctly indicates direction on coil	1

Sample answer:

This induced emf will be in a clockwise direction.

Question 28 (a)

Criteria	Marks
Correctly calculates the torque (clockwise)	2
Attempts to substitute correct information into a relevant equation	1

Sample answer:

$\tau = nIA_{\perp}B$

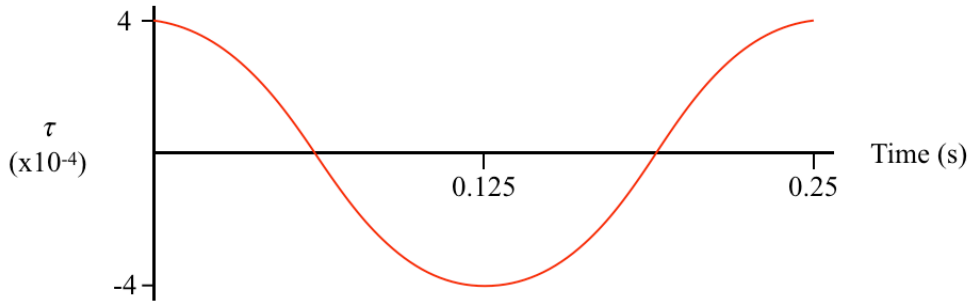
$\tau = 3 \times 0.0009 \times 0.15$

$\tau = 4.05 \times 10^{-4}$ Nm

Question 28 (b)

Criteria	Marks
Graph correctly drawn including correct scale on both axes	2
As above with error or exclusion	1

Sample answer:



Question 29 (a)

Criteria	Marks
Identifies correct error type. Human error not an error type.	1

Sample answer:

Observational systematic error.

Question 29 (b)

Criteria	Marks
Calculates correctly Galileo's fastest possible speed measurement showing correct working	3
Calculates the correct speed but does not include the time taken for light in working	2
Correctly calculates the time light would take to travel 2 km	1

Sample answer:

$t = \frac{2d}{c}$

$t = \frac{2\times1000}{3\times10^8} = 7 \times 10^{-6}$ s

$v = \frac{2d}{t}$

$v = \frac{2\times1000}{7\times10^{-6}+0.5}$

$v = 4000$ m s^{-1}-

Question 29 (c)

Criteria	Marks
Makes a judgment of the validity based on the predicted measurement from the previous answer.	3
Makes a judgment of the validity	2
Provides relevant information in regard to validity	1

Sample answer:

Comparing the above value to the known value of the speed of light Galileo's result would have been wildly inaccurate. Due to the incredibly fast speed of light the time it took light to travel 2 km was an insignificant amount of time compared to the reaction time. His method therefore could not practically measure the speed of light. It therefore was a very invalid method as it cannot fulfil the aim.

Question 30

Criteria	Marks
• Describes three models of light over time • Describes new evidence and explains why it necessitated change to a new model • Answer is coherent, logical and sequential	3
• Describes three models of light over time • Describes new evidence and explains why it necessitated change to a new model	5-6
• Describes two models of light over time • Describes new evidence and explains why it necessitated change to a new model	3-4
• Describes one models of light and Describes new evidence and explains why it necessitated change to a new model	1-2

Sample answer:

Isaac Newton's particle model of light described light made of corpuscles which varied in size depending on the colour of the light. In the 18th century, young's double slit experiment showed that light diffracts when passing through a slit. This was evident in the interference patterns produce which are consistent with wave nature. This supported a wave model of light and thus Newton's particle model was replaced with the classical wave model.

In the 19th century the photo-electric effect was observed and was not explainable using the classical model of light. The photo-electric effect is the emission of electrons from a metal when light above a certain frequency is incident upon the metal. A classical model would suggest that intensity, not frequency, is relate to electron ejection. Also, electron emission was almost spontaneous, where the classical wave model would predict that emission should occur after some time so as to allow energy to build up.

In 1905, Albert Einstein was able to explain the photo-electric effect by using a particle model of light, where light was made up of packets of energy called photons. These photons would collide with electrons and would eject the electrons if they possessed enough energy, where energy is proportional to frequency.

The new evidence supported the particle model of light but since a wave model was appropriate to describe other light phenomenon, such as diffraction, a new particle-wave model was adopted. This model indicates that light can behave as both a particle and a wave depending on the scenario. Thus, over time the emergence of new evidence regarding the nature of light has forced the scientific community to continually reassess the model of light.

Question 31 (a)

Criteria	Marks
Describes absorption and emission spectra production and how they are similar.	3
Describes absorption and emission spectra production	2
Describes absorption or emission spectra production	1

Sample answer:

Both the absorbed and emitted lines correspond to the electron energy levels of atoms. Photons of precise frequency/wavelength corresponding to those energy levels are absorbed or emitted.

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

The coloured lines in the emission spectra are produced by photons being emitted by electrons from 'excited' atoms as they fall from higher energy levels. Each 'fall' involves a precise 'quantum' of energy, which produces a precise frequency and wavelength.

Question 31 (b)

Criteria	Marks
Explains unique energy levels of atoms and therefore spectra to analyse chemical composition	3
Describes unique spectra of elements to identify chemical composition	2
Identifies unique spectra of elements	1

Sample answer:

Lines produced in absorption and emission spectra are characteristic of the atoms that were heated or that light passed through. Every element has different energy levels to which electrons can move to. This corresponds to photons with different frequencies/wavelengths. Because no two elements produce the same spectrum and all atoms of the same element produce the same spectrum, the chemical composition can be deduced from analysing spectra.

Question 32

Criteria	Marks
Provides correct characteristics and features of two theories proposed by two scientists AND correctly relates one of these theories to the experimental evidence that supports the statement.	5-6
Provides correct characteristics and features of one OR two theories proposed by two scientists AND/OR correctly relates one of these theories to the experimental evidence that supports the statement.	3-4
Provides relevant information related to the theory of the scientists AND/OR provides relevant information related to a relevant experiment	2
Provides relevant information related to the theory of the scientists OR provides relevant information related to a relevant experiment	1

Sample answer:

The failure of classical Physics to adequately explain blackbody radiation, the photoelectric effect and the hydrogen atom ultimately demolished the foundations of classical Physics.

Max Planck explained the deviation of experiment to classical prediction for blackbody radiation. This is known as the left-hand catastrophe. He stated that the energy of electrons comes in clumps – he named a clump of energy a quantum.

Louis de Broglie proposed that wave-particle duality not only applied to light (as described by Einstein) but to everything in nature. De Broglie rewrote Einstein's equation. The evidence that electrons propagate like a wave came when electrons were passed through a double slit and counted as they hit a screen. If the electrons travelled like a stream of particles, they would have simply piled up at two locations behind the two slits. But they didn't. They showed a double-slit interference pattern, bright bands and dark bands just like the ones produced by light waves. Davisson and Germer experimentally confirmed de Broglie's prediction in 1927 when they bombarded the surface of a piece of nickel with electrons which were then scattered and detected by a moveable electron detector. They found the electrons were interfering with one another to produce a diffraction pattern. This evidence was ground-breaking in that it showed the limitations of classical physics in describing the nature of moving particles.

Question 33

Criteria	Marks
Correctly calculates the binding energy of $^{7}_{4}Be$ in MeV	2
Attempts to calculate binding energy using any correct method	1

Sample answer:

$^{7}_{4}Be$ has 4 protons and 3 neutrons

$mass\ defect = (3 \times 1.675 \times 10^{-27}) + (4 \times 1.673 \times 10^{-27}) - (1.16519 \times 10^{-26})$

$mass\ defect = 6.51 \times 10^{-29}$ kg

$E = mc^2$

$E = 6.51 \times 10^{-29} \times (3 \times 10^{8})^2$

$E = 5.859 \times 10^{-12}$ J

$E = \frac{5.859 \times 10^{-12}}{1.602 \times 10^{-19}}$

$E = 36573033.71$ eV

$E = 36.573$ MeV

Question 34

Criteria	Marks
Correctly calculates the initial energy level (n=6)	3
Substitutes correct information into the Rydberg equation.	2
Attempts to substitute the correct information into the Rydberg equation	1

Sample answer:

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

$\frac{1}{410.1\times10^{-9}} = 1.097 \times 10^7 \left(\frac{1}{4} - \frac{1}{n^2}\right)$

$\frac{1}{410.1\times10^{-9}} = 2742500 - \frac{1.097\times10^7}{n^2}$

$\frac{1.097\times10^7}{n^2} = 2742500 - \frac{1}{410.1\times10^{-9}}$

$\frac{1.097\times10^7}{n^2} = 304070$

$\frac{n^2}{1.097\times10^7} = \frac{1}{304070}$

$n = \sqrt{\frac{1.097\times10^7}{304070}}$

$n = 6$

Question 35

Criteria	Marks
• Provides detailed descriptions of the correct nucleosynthesis reactions occurring at all three star types • Relates mass to dominant nucleosynthesis reaction and position on the diagram • Thoroughly compares the nucleosynthesis reactions of main sequence stars with the reactions occurring within Giant and super giant stars. • Answer is logical, coherent, and well structured	7-9
3 of the above	4-6
Provides some relevant information	1-3

Sample answer:

There are three main nucleosynthesis reactions occurring in the core of main sequence stars; Proton-proton chain, CNO cycle and the Triple Alpha process.

The Proton-proton chain fuses four protons to form one helium nucleus plus energy. The CNO cycle fuses four protons with larger nuclei to form one helium nucleus plus energy. The triple alpha process fuses helium nuclei with increasingly large nuclei up to oxygen.

All three of the nucleosynthesis reactions follow a series of reactions shown below.

P-P chain	**CNO cycle**	**Triple Alpha**
${}_1^1H + {}_1^1H \rightarrow {}_2^2He$	${}_6^{12}C + {}_1^1H \longrightarrow {}_7^{13}N + \gamma$	${}_2^4He + {}_2^4He \longrightarrow {}_4^8Be + \gamma$
${}_2^2He \rightarrow {}_1^2H + {}_1^0e + \upsilon$	${}_7^{13}N \rightarrow {}_6^{13}C + {}_1^0e + \upsilon$	${}_4^8Be + {}_2^4He \longrightarrow {}_6^{12}C + \gamma$
${}_1^2H + {}_1^1H \rightarrow {}_2^3He + \gamma$	${}_6^{13}C + {}_1^1H \rightarrow {}_7^{14}N + \gamma$	
${}_2^3He + {}_2^3He \rightarrow {}_2^4He + {}_1^1H + {}_1^1H$	${}_7^{14}N + {}_1^1H \rightarrow {}_8^{15}O + \gamma$	
	${}_8^{15}O \rightarrow {}_7^{15}N + {}_1^0e + \upsilon$	
	${}_7^{15}N + {}_1^1H \rightarrow {}_6^{12}C + {}_2^4He$	

The ratio of these reactions is dependent on mass, as larger gravitational forces are required for the CNO cycle and even larger for the triple alpha process.

Stars are positioned on the main sequence according to their surface temperature and luminosity. Luminosity has a directly proportional relationship to mass on the main sequence, such that stars in the upper left of the HR diagram are high mass with large gravitational forces, and stars in the bottom right are small mass with relatively small gravitational forces.

Because the dominant nucleosynthesis reaction is dependent on gravitational forces the dominant reaction in the largest main sequence stars will be the CNO cycle. The ratio of CNO cycle to P-P chain reactions

decreases as the mass decreases, to a point where the dominant reaction of the bottom half of the main sequence is the P-P chain.

The dominant nucleosynthesis reaction occurring at the core of red giants is the triple Alpha reaction. The triple alpha reaction is similar to the P-P chain and CNO cycle in that it fuses smaller nuclei into larger nuclei and releases larger amounts of energy. It differs in that it produces nuclei larger than Helium up to Oxygen and requires much larger gravitational forces to sustain in large quantities. It also uses helium nuclei as the basic building block rather than hydrogen nuclei.

The dominant nucleosynthesis reaction occurring at the core of a super-giant star depends on how long it has been at this position. The core nuclei increase in size up to Iron as the star ages. The fusion of heavy nuclei is once again similar to the previously mentioned nucleosynthesis reactions in that it fuses smaller nuclei to create larger nuclei and releases energy. It differs in that it does not always use a specific small nucleus to build larger ones. Rather the gravitational forces are so large that it is able to overcome the large repulsive electric charges of two heavy nuclei and fuse them together.

Physics

2020 Trial HSC Examination Mapping Grid

Part A

Question	Marks	Outcome
1	1	PH12-15
2	1	PH12-14
3	1	PH12-15
4	1	PH12-13
5	1	PH12-12
6	1	PH12-15
7	1	PH12-15
8	1	PH12-15
9	1	PH12-13
10	1	PH12-13
11	1	PH12-13
12	1	PH12-13
13	1	PH12-14
14	1	PH12-14
15	1	PH12-14
16	1	PH12-14
17	1	PH12-12
18	1	PH12-12
19	1	PH12-12
20	1	PH12-12

Part B

Question	Marks	Outcome
21 (a)	2	PH12-12
21 (b)	3	PH12-12
22 (a)	3	PH12-12
22 (b)	2	PH12-12
23 (a)	3	PH12-12
23 (b)	1	PH12-12

Question	Marks	Content
24 (a)	3	PH12-12
24 (b)	3	PH12-12
25 (a)	1	PH12-13
25 (b)	4	PH12-13
26	4	PH12-13
27 (a)	3	PH12-13
27 (b)	3	PH12-13
27 (c)	1	PH12-13
28 (a)	2	PH12-13
28 (b)	2	PH12-13
29 (a)	1	PH12-14
29 (b)	3	PH12-14
29 (c)	3	PH12-14
30	7	PH12-14
31 (a)	3	PH12-14
31 (b)	3	PH12-14
32	6	PH12-15
33	2	PH12-15
34	3	PH12-15
35	9	PH12-15