Name: ________________
Class: ________________

2020 TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION

Physics

Weighting: 30%

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 at the back of this paper
- For questions in Section II, show all relevant working in questions involving calculations
- Write your name at the top of pages 13 and 35

Total Marks: 100

Section I – 20 marks (pages 2-12)

- Attempt Questions 1-20
- Allow about 35 minutes for this section

Section II – 80 marks (pages 13-30)

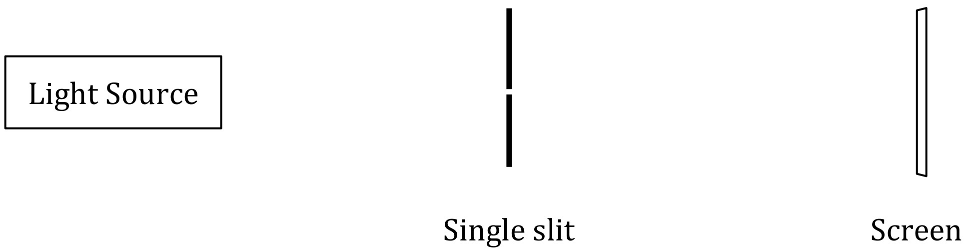
- Attempt Questions 21 - 35
- Allow about 2 hours and 25 minutes for this section

Section I

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

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

1 A student set up the apparatus shown to investigate a property of light.



What property of light was the student investigating?

A. Diffraction

B. Polarisation

C. Reflection

D. Refraction

2 What did Chadwick discover?

A. The neutron

B. The atomic nucleus

C. The charge of an electron

D. The charge-to-mass ratio of an electron

3 Which of the following is an example of uniform circular motion?

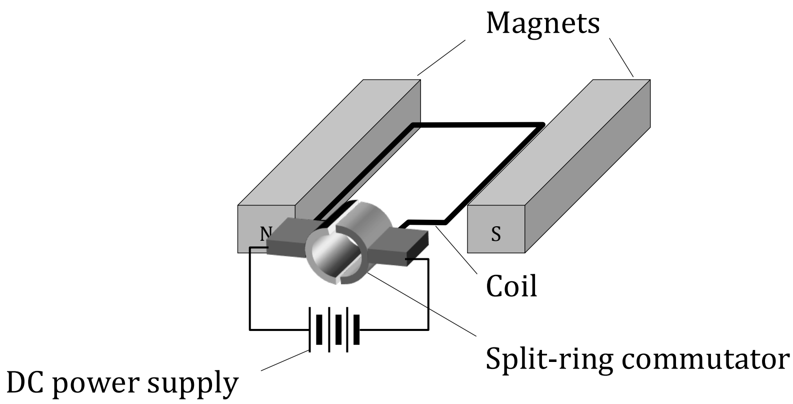
A. A ball thrown horizontally off a cliff

B. A proton moving parallel to a magnetic field

C. A mass swinging horizontally on the end of a string

D. An electron moving perpendicularly to an electric field

4 The diagram shows a simple DC motor. The components of the motor are labelled.



Which component changes the direction of the current in the motor?

A. Coil

B. Magnets

C. DC power supply

D. Split-ring commutator

5 What type of nucleosynthesis reaction takes place in the Sun?

A. CNO cycle

B. Proton-proton chain

C. Triple alpha process

D. Positron-electron annihilation

6 Which row of the table correctly identifies the orbital properties of a satellite that is in a geostationary orbit?

	Orbital Period (hours)	*Orbit*
A.	1.5	Equatorial
B.	1.5	Polar
C.	24	Equatorial
D.	24	Polar

7 Which of the following shows how the law of conservation of energy applies to magnetic braking?

A. $\boxed{\text{Electrical}} \rightarrow \boxed{\text{Heat}} \rightarrow \boxed{\text{Kinetic}}$

B. $\boxed{\text{Electrical}} \rightarrow \boxed{\text{Kinetic}} \rightarrow \boxed{\text{Heat}}$

C. $\boxed{\text{Kinetic}} \rightarrow \boxed{\text{Electrical}} \rightarrow \boxed{\text{Heat}}$

D. $\boxed{\text{Kinetic}} \rightarrow \boxed{\text{Heat}} \rightarrow \boxed{\text{Electrical}}$

8 When compared to a laboratory source, a star's spectrum was observed to be redshifted.

What information does this observation provide about the star?

A. Its density

B. Its rotational velocity

C. Its surface temperature

D. Its translational velocity

9 A Ferris wheel has a diameter of 40 metres. It takes 40 s to make one revolution.

What is the centripetal acceleration of a carriage on the Ferris wheel?

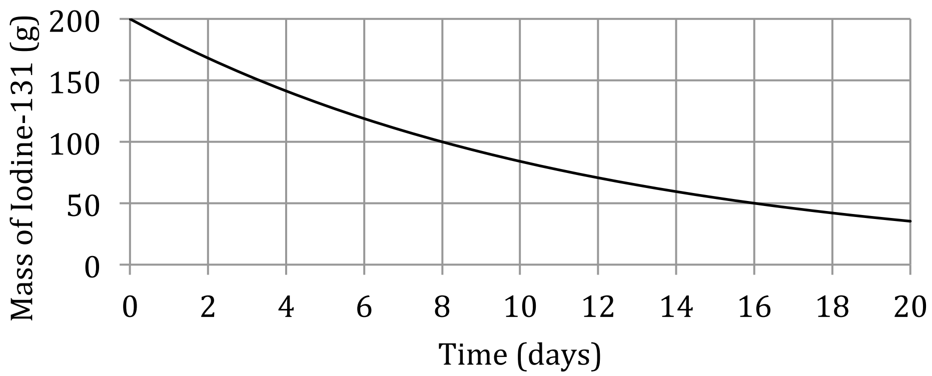
A. $0.5\ ms^{-2}$

B. $1.0\ ms^{-2}$

C. $3.1\ ms^{-2}$

D. $6.3\ ms^{-2}$

10 The graph shows how the mass of a radioactive sample of Iodine-131 changes over time.



What will the mass of Iodine-131 be after 32 days?

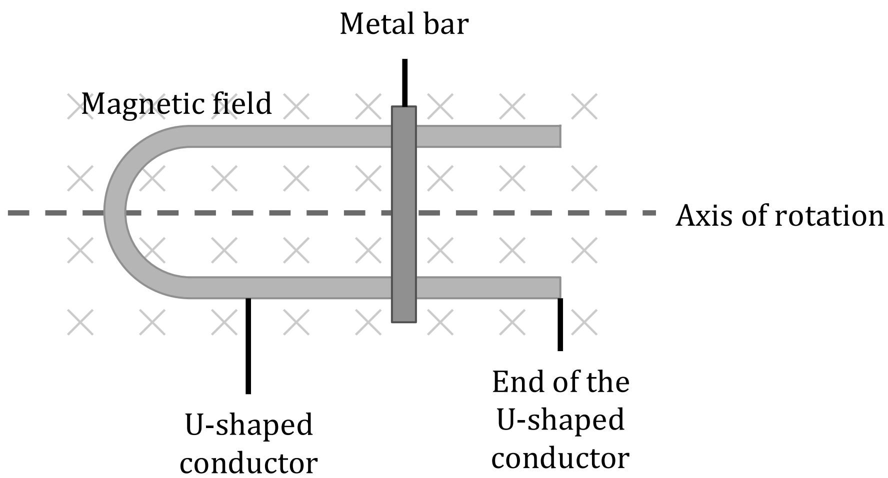
A. 0 g

B. 13 g

C. 18 g

D. 35 g

11 A U-shaped conductor is in a magnetic field. A metal bar is used to make a complete circuit.



Which of the following will produce an anticlockwise current in the circuit?

A. Decreasing the strength of the magnetic field

B. Moving the metal bar to the end of the U-shaped conductor

C. Moving the U-shaped conductor and metal bar out of the magnetic field

D. Rotating the U-shaped conductor and metal bar around the axis of rotation

12 Two polaroid filters were aligned so they transmitted the maximum amount of light. The intensity of the transmitted light was measured to be 50 lux.

The second polaroid filter was then rotated 60°.

What was the intensity of the light after the polaroid filter was rotated?

A. 12.5 lux

B. 25 lux

C. 100 lux

D. 200 lux

13 A projectile is launched over flat ground at an angle of 45°.

Which variable will decrease if the launch angle of the projectile is increased?

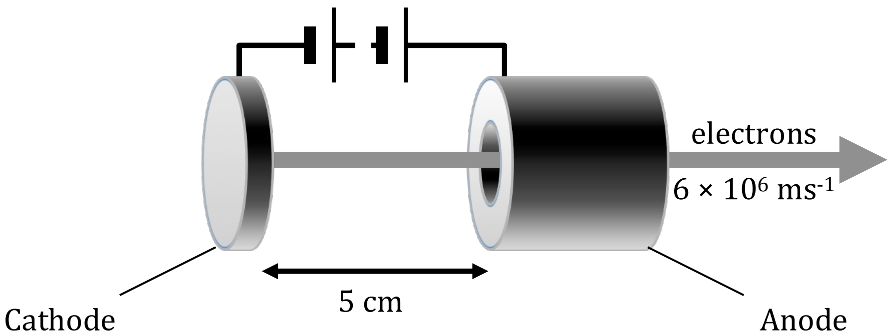
A. Final velocity

B. Horizontal range

C. Maximum height

D. Time of flight

14 An electron gun uses an electric field to accelerate electrons.



The electron gun accelerates an electron from rest to a velocity of 6×10^6 ms^{-1}.

What is the electric field between the cathode and the anode?

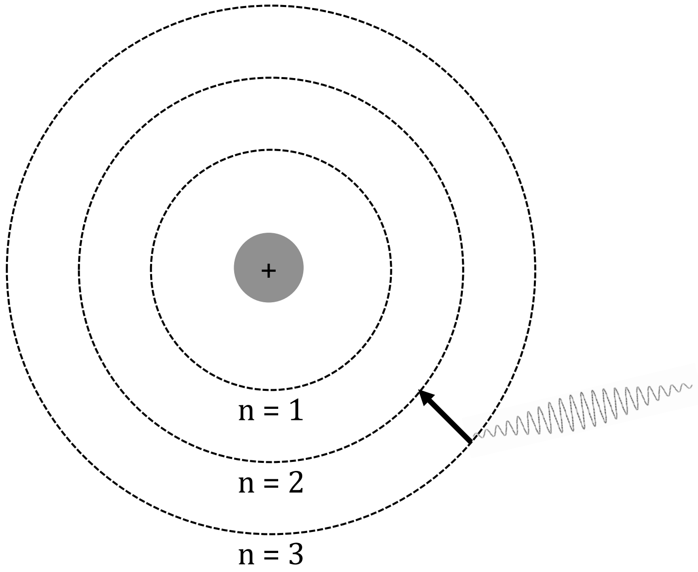
A. 2×10^1 NC^{-1}

B. 4×10^1 NC^{-1}

C. 2×10^3 NC^{-1}

D. 4×10^3 NC^{-1}

15 A hydrogen atom emits a photon as an electron moves into a lower energy level.



What is the frequency of the photon emitted?

A. 1.03×10^{-7} Hz

B. 6.56×10^{-7} Hz

C. 4.57×10^{14} Hz

D. 2.93×10^{15} Hz

16 A proton enters a particle accelerator with a velocity of 0.31 c. The particle accelerator accelerates the particle to a velocity of 0.92 c.

By how much does the momentum of the proton increase while it's in the particle accelerator?

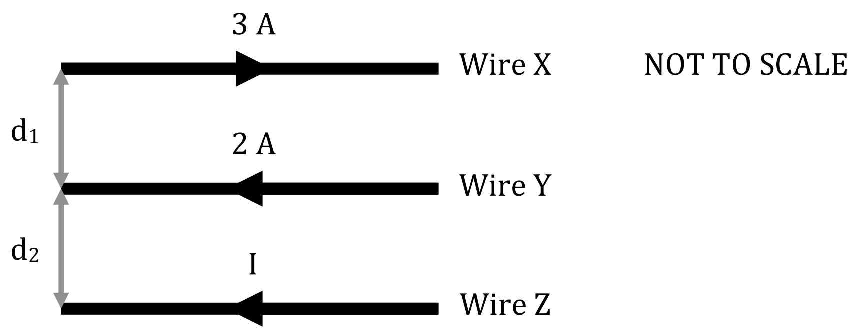
A. 3.0×10^{-19} Ns

B. 4.6×10^{-19} Ns

C. 1.0×10^{-18} Ns

D. 1.2×10^{-18} Ns

17 Three parallel current-carrying wires are shown. All wires are the same length.



There is no net force on Wire Z.

What is the ratio of d_1 to d_2?

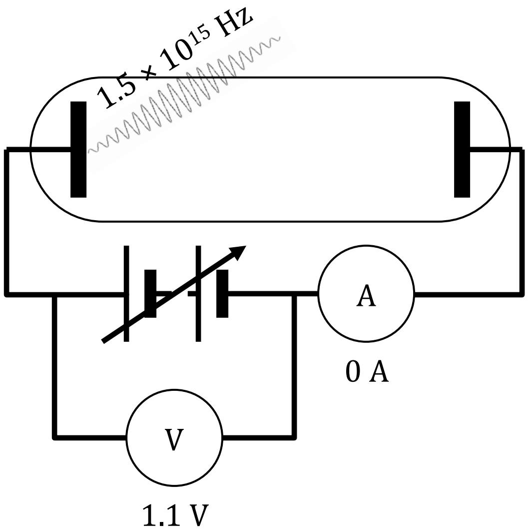
A. 1:2

B. 5:4

C. 3:2

D. 9:4

18 Ultraviolet light with a frequency of 1.5×10^{15} Hz shines on a copper target inside an evacuated glass tube, producing a photocurrent inside the tube.



The voltage across the glass tube was increased to 1.1 V, at which point the photocurrent stopped flowing.

What is the work function of copper?

A. 1.1 eV

B. 5.1 eV

C. 6.2 eV

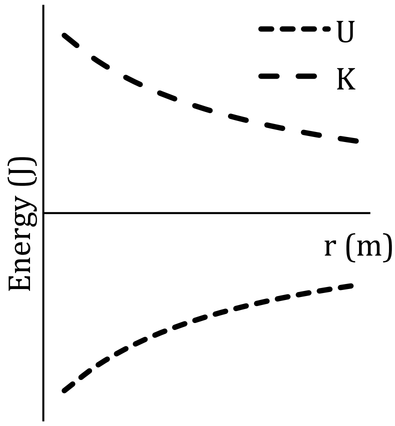
D. 7.3 eV

19 A satellite orbits the Earth.

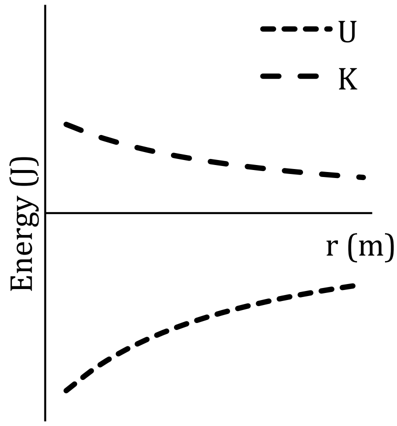
Which graph shows how the total potential energy (U) and the kinetic energy (K) of the satellite changes as the radius of its orbit is increased?

The graphs are to scale.

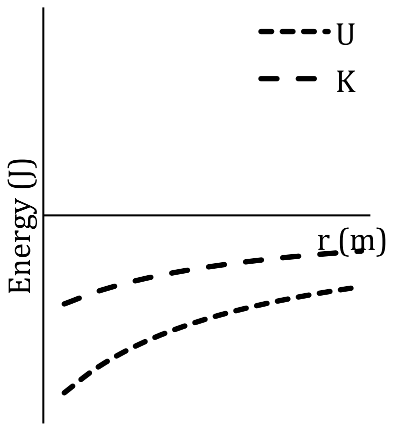
A.



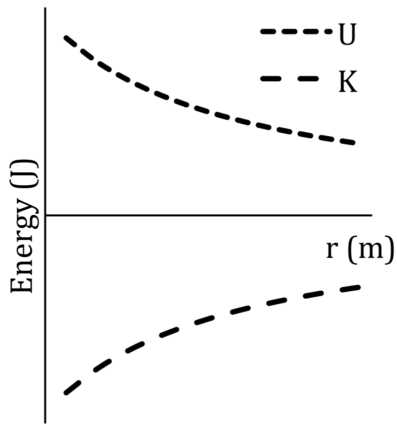
B.



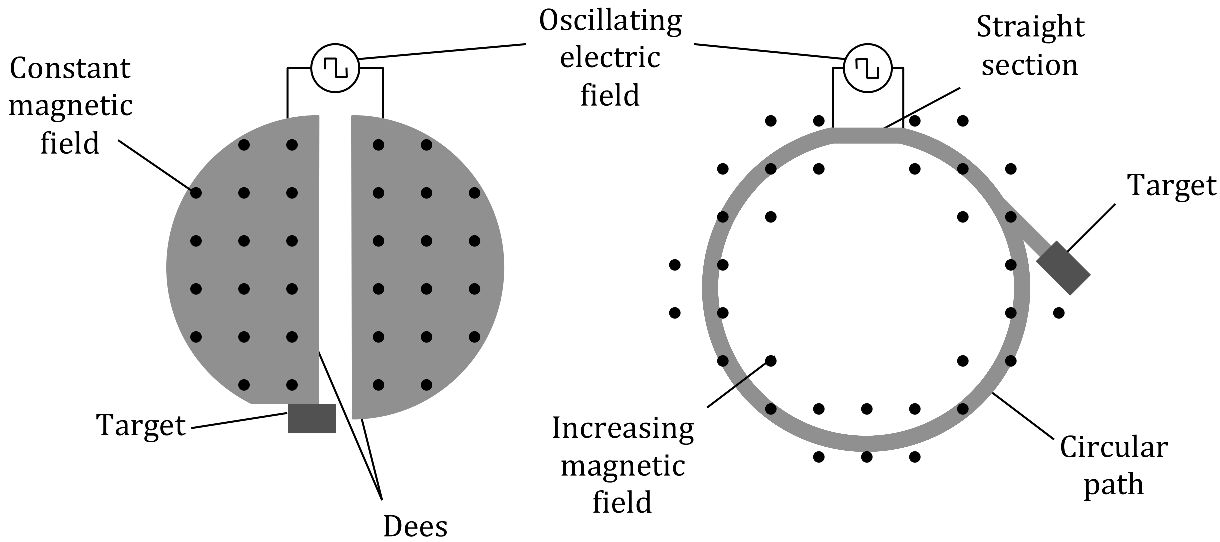
C.



D.



20 The diagrams show two particle accelerators that use magnetic fields to keep charged particles moving in a circular path.



Cyclotron	**Synchrotron**
An oscillating electric field accelerates charged particles as they move between the dees. The charged particles move in a circular path of varying radius inside the dees due to a constant magnetic field.	An oscillating electric field accelerates charged particles as they move through the straight section. The charged particles move in a circular path of fixed radius due to an increasing magnetic field.

What is an advantage of using a synchrotron instead of a cyclotron to accelerate charged particles?

A. The charged particles in a synchrotron travel in a circular path of fixed radius.

B. The charged particles in a cyclotron radiate energy as they travel in a circular path.

C. The charged particles are inside a cyclotron's dee for the same amount of time as their velocity increases.

D. The charged particles' relativistic mass increase can be compensated for by the synchrotron's increasing magnetic field.

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Physics
Section II
Answer Booklet

Name: ________________

Class: ________________

80 marks
Attempt all questions 21 – 35
Allow about 2 hours and 25 minutes for this section

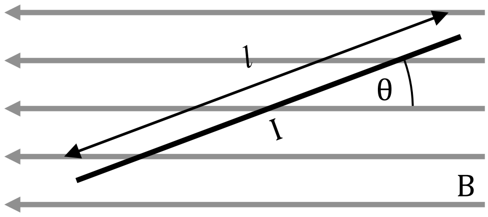
Instructions

- Write your name 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 the questions involving calculations.

Please turn over

Question 21 (2 marks)

The diagram shows a current-carrying conductor in a magnetic field.



Outline TWO ways of increasing the force on the current-carrying conductor. **2**

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Question 22 (3 marks)

Describe experimental evidence that supports the wave model of light. **3**

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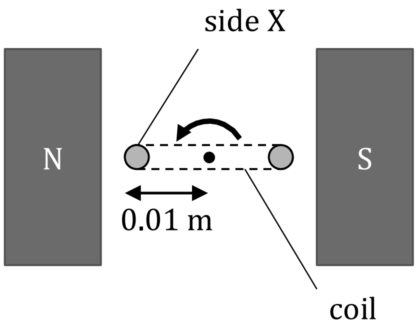
Question 23 (5 marks)

The diagram shows a cross-section of a 25 turn coil rotating in an anticlockwise direction between the magnets of a DC motor. The magnetic field between the magnets is 0.4 T



The coil has an area of 1×10^{-3} m^2. The torque on the coil in the position shown is 0.03 Nm^{-1}.

a) What is the current through side X of the coil? **3**

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b) Side X is 0.01 m from the rotational axis of the coil.

What is the force on side X due to the magnetic field? **2**

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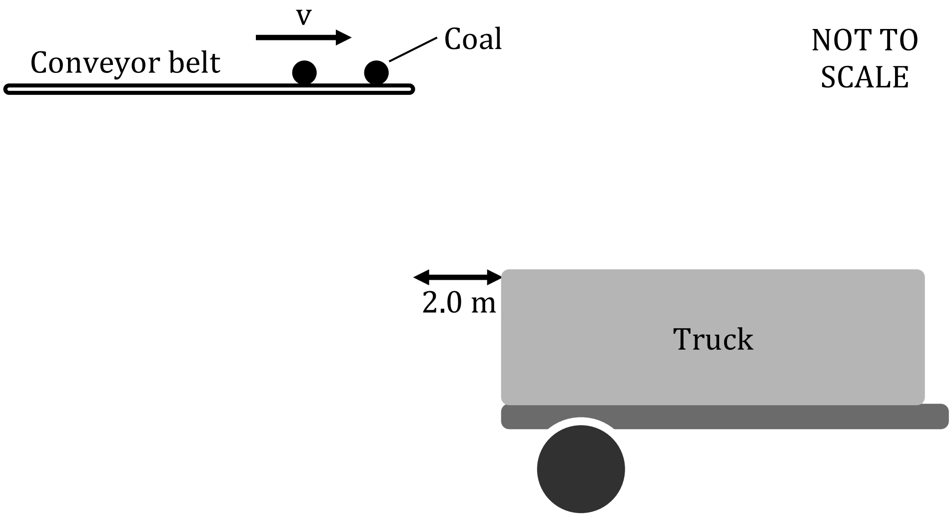
Question 24 (4 marks)

A horizontal conveyor belt is used to load coal into trucks.

It takes 0.5 s for the coal to fall from the conveyor belt into the truck.



a) How far below the conveyor belt is the truck? **2**

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b) There is a 2.0 m horizontal gap between the conveyor belt and the truck.

What is the minimum velocity of the conveyor belt if the coal falls into the truck? **2**

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Question 25 (4 marks)

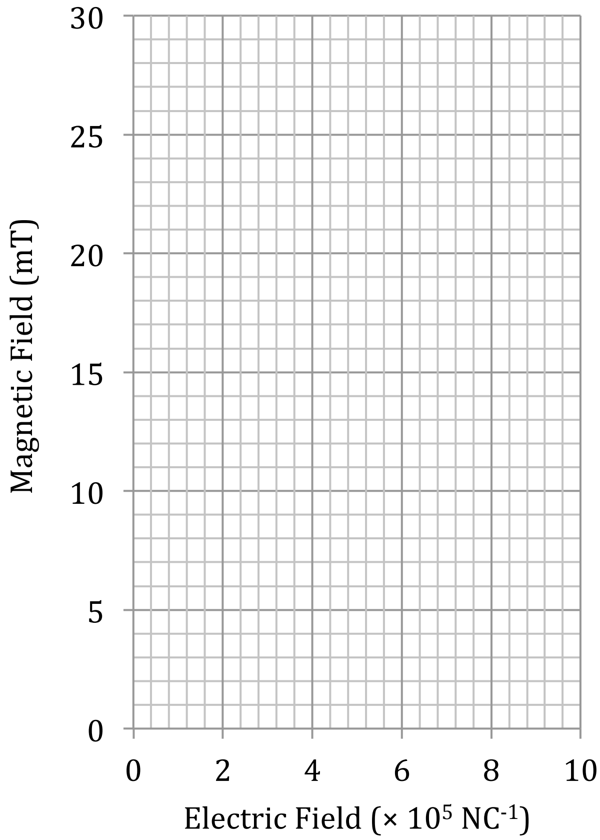
A beam of electrons was passed through an electric field and a magnetic field.

The electric field was varied and the magnetic field required for the beam to move through the field undeflected was recorded.

The following results were obtained.

Electric Field ($\times 10^5$ NC^{-1})	4.8	5.5	7.2	7.9	9.1
Magnetic Field (mT)	16	18	24	26	30

Plot the results on the axes below and hence determine the velocity of the electrons. **4**



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Question 26 (4 marks)

Explain why a metal object begins to glow red when it is heated. **4**

Question 27 (7 marks)

a) A linear accelerator is 86 m long.

A proton is travelling at 0.6 c in the linear accelerator's inertial frame of reference.

What is the length of the linear accelerator in the proton's inertial frame of reference? **3**

b) The current definition of the metre is:

the length of the path travelled by light in a vacuum during a time interval with duration of 1/299 792 458 of a second

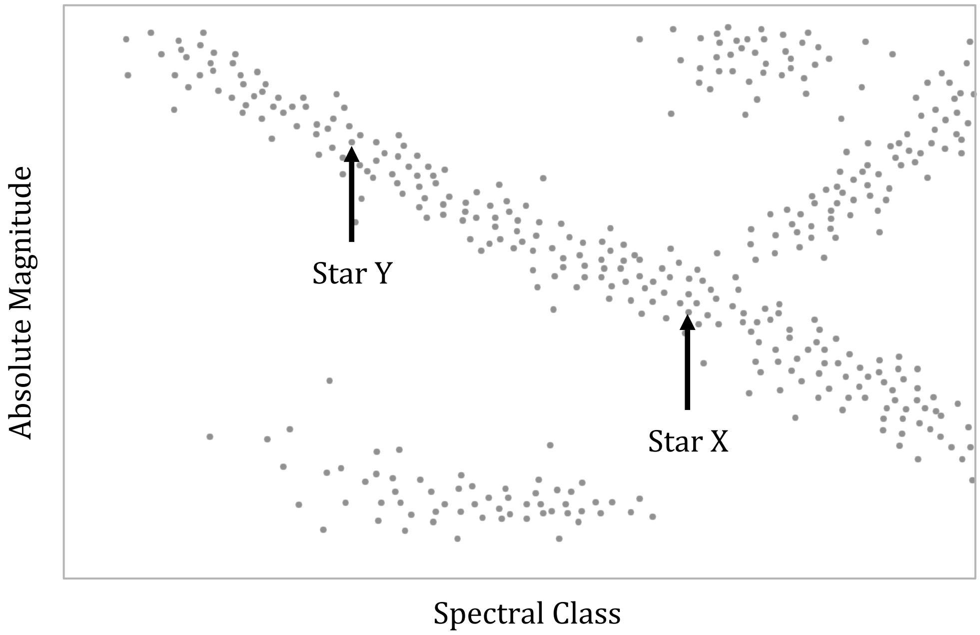
Why is the measurement of distance related to the speed of light in a vacuum? **4**

Question 28 (6 marks)

Assess the use of models in physics. In your answer refer to the ideal transformer model and ONE other model. **6**

Question 29 (5 marks)

Two Main Sequence stars are marked as Star X and Star Y on the Hertzsprung-Russell diagram.



Compare Star X and Star Y. In your answer refer to physical characteristics and nucleosynthesis reactions. **5**

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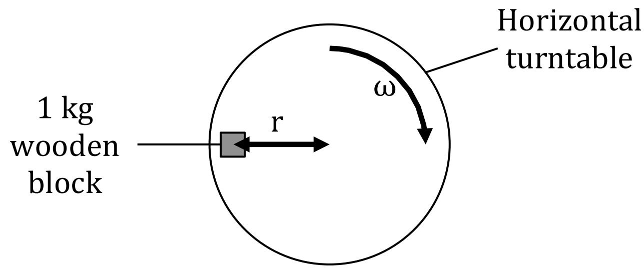
Question 30 (7 marks)

A student was given a motorised turntable, a 1 kg wooden block and ruler. The motor attached to the turntable contains a display that shows the turntable's angular velocity (ω).



a) The student wants to use this equipment to investigate how the radius of the wooden block's circular path (r) affects the angular velocity of the turntable when the block slides off.

Describe a procedure that is suitable for carrying out this investigation. In your answer, include how the student should manage an identified risk. **4**

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Question 30 continues on page 23

Question 30 (continued)

b) A force of 5 N is required for the wooden block to start sliding across the turntable.

What is the maximum distance that the block can be placed from the centre of the turntable if it is to slide off the turntable when the turntable is rotating at 2π rad s^{-1}? **3**

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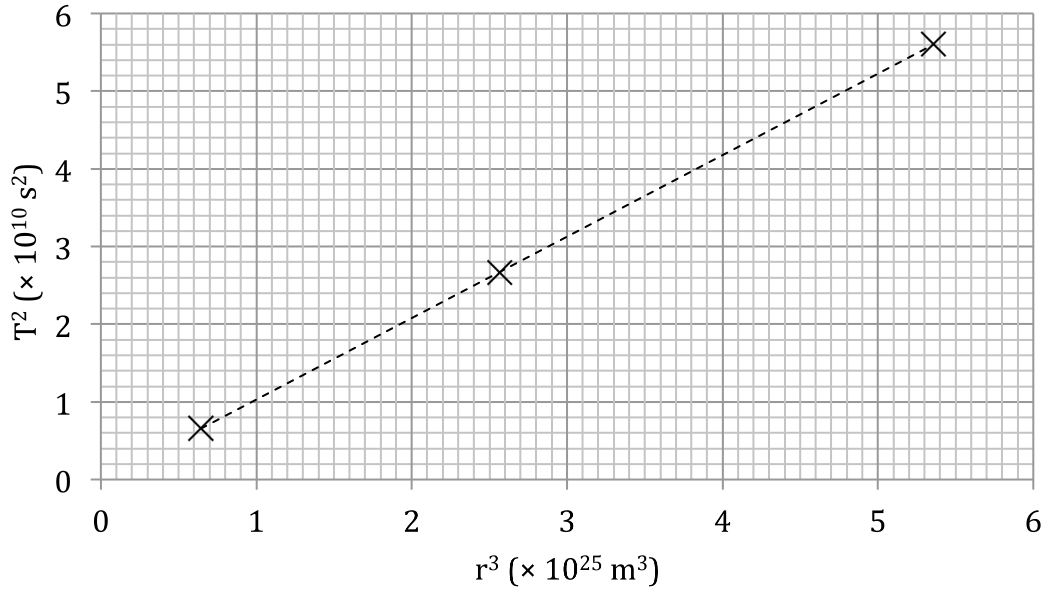
End of Question 30

Question 31 (7 marks)

The graph below shows the relationship between the square of the period (T^2) and the cube of the radius (r^3) for three moons of Saturn. The dotted line is the line of best fit for the data.



a) Enceladus is a moon of Saturn with an orbital radius of 2.38×10^8 m.

What is the period of Enceladus' orbit?

Support your answer with relevant calculations. **3**

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Question 31 continues on page 25

Question 31 (continued)

b) Titan is a moon of Saturn with an orbital radius of 1.22×10^9 m.
Therefore, $r^3 = 1.82 \times 10^{27}$ m^3.

A student used the graph to determine the period of Titan's orbit.

Discuss the validity of the student's method. **4**

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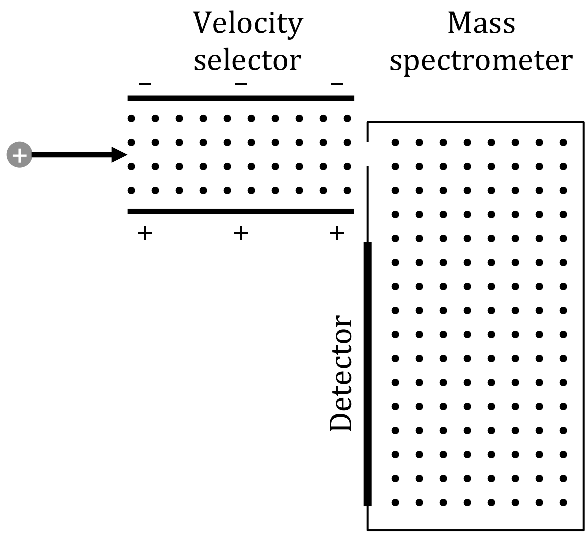
End of Question 31

Question 32 (9 marks)

Mass spectrometry is a technique used to determine the percentage of different isotopes in a sample of an element.

An electron is removed from each atom, giving the atoms a positive charge. The charged particles move through an electric field and a magnetic field in the velocity selector, then into a magnetic field in the mass spectrometer. Sensors count the number of particles that hit each point on the detector.



Explain how mass spectrometry can be used to determine the percentage of carbon-14 in a sample of carbon. **9**

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Question 32 continues on page 27

Question 32 (continued)

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End of Question 32

Question 33 (4 marks)

An equation for a nuclear reaction is shown below.

$$^{1}_{0}\text{n} + {}^{235}_{92}\text{U} \rightarrow {}^{141}_{56}\text{Ba} + {}^{92}_{36}\text{Kr} + 3{}^{1}_{0}\text{n}$$

The table below shows the mass of the nuclei involved in the reaction.

Isotope	Mass (u)
$^{235}_{92}\text{U}$	235.044
$^{141}_{56}\text{Ba}$	140.914
$^{92}_{36}\text{Kr}$	91.9263

Calculate the energy released in this reaction. **4**

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Question 34 (6 marks)

A photon contains 9.2×10^{-19} J of energy.

a) What is the wavelength of the photon? **3**

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b) The photon is absorbed by an atom and a photoelectron with kinetic energy of 2.0×10^{-19} J is ejected.

Explain why the photoelectron contains less energy than the photon that is absorbed. **3**

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Question 35 (7 marks)

"Electrons are particles; electrons are waves"

Justify this statement.

In your answer refer to the results of experiments. **7**

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END OF EXAM

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 m s^{-1}
Earth's gravitational acceleration, g	9.8 m s^{-2}
Speed of light, c	$3.00 \times 10^{8} \text{ m s}^{-1}$
Electric permittivity constant, ε_0	$8.854 \times 10^{-12} \text{ A}^2 \text{ s}^4 \text{ kg}^{-1} \text{ m}^{-3}$
Magnetic permeability constant, μ_0	$4\pi \times 10^{-7} \text{ N A}^{-2}$
Universal gravitational constant, G	$6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
Mass of Earth, M_E	6.0×10^{24} kg
Radius of Earth, r_E	6.371×10^{6} m
Planck constant, h	6.626×10^{-34} J s
Rydberg constant, R (hydrogen)	$1.097 \times 10^{7} \text{ m}^{-1}$
Atomic mass unit, u	1.661×10^{-27} kg $931.5 \text{ MeV}/c^2$
1 eV	1.602×10^{-19} J
Density of water, ρ	$1.00 \times 10^{3} \text{ kg m}^{-3}$
Specific heat capacity of water	$4.18 \times 10^{3} \text{ J kg}^{-1} \text{ K}^{-1}$
Wien's displacement constant, b	2.898×10^{-3} m K

FORMULAE SHEET

Motion, forces and gravity

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

$$v = u + at$$

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

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

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

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

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

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

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

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

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

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

$$a_{\text{c}} = \frac{v^2}{r}$$

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

$$F_{\text{c}} = \frac{mv^2}{r}$$

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

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

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

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

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

Waves and thermodynamics

$$v = f\lambda$$

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

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

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

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

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

$$n_{\text{x}} = \frac{c}{v_{\text{x}}}$$

$$\sin\theta_{\text{c}} = \frac{n_2}{n_1}$$

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

$$I_1r_1^2 = I_2r_2^2$$

$$Q = mc\Delta T$$

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

FORMULAE SHEET (Continued)

Electricity and magnetism

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

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

$$W = qV$$

$$W = qEd$$

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

$$B = \frac{\mu_0 N I}{L}$$

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

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

$$\frac{V_\mathrm{p}}{V_\mathrm{s}} = \frac{N_\mathrm{p}}{N_\mathrm{s}}$$

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

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

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

$$V = IR$$

$$P = VI$$

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

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

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

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

$$V_\mathrm{p} I_\mathrm{p} = V_\mathrm{s} I_\mathrm{s}$$

Quantum, special relativity and nuclear

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

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

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

$$E = mc^2$$

$$E = hf$$

$$\frac{1}{\lambda} = R\left(\frac{1}{n_\mathrm{f}^2} - \frac{1}{n_\mathrm{i}^2}\right)$$

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

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

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

$$N_\mathrm{t} = N_0 e^{-\lambda t}$$

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

PERIODIC TABLE OF THE ELEMENTS

KEY

Atomic Number	79
Symbol	Au
Standard Atomic Weight	197.0
Name	Gold

1 H 1.008 Hydrogen																	2 He 4.003 Helium
3 Li 6.941 Lithium	4 Be 9.012 Beryllium											5 B 10.81 Boron	6 C 12.01 Carbon	7 N 14.01 Nitrogen	8 O 16.00 Oxygen	9 F 19.00 Fluorine	10 Ne 20.18 Neon
11 Na 22.99 Sodium	12 Mg 24.31 Magnesium											13 Al 26.98 Aluminium	14 Si 28.09 Silicon	15 P 30.97 Phosphorus	16 S 32.07 Sulfur	17 Cl 35.45 Chlorine	18 Ar 39.95 Argon
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	32 Ge 72.64 Germanium	33 As 74.92 Arsenic	34 Se 78.96 Selenium	35 Br 79.90 Bromine	36 Kr 83.80 Krypton
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	50 Sn 118.7 Tin	51 Sb 121.8 Antimony	52 Te 127.6 Tellurium	53 I 126.9 Iodine	54 Xe 131.3 Xenon
55 Cs 132.9 Caesium	56 Ba 137.3 Barium	57–71 Lanthanoids	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	82 Pb 207.2 Lead	83 Bi 209.0 Bismuth	84 Po Polonium	85 At Astatine	86 Rn Radon
87 Fr Francium	88 Ra Radium	89–103 Actinoids	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 Nh Nihonium	114 Fl Flerovium	115 Mc Moscovium	116 Lv Livermorium	117 Ts Tennessine	118 Og Oganesson

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	68 Er 167.3 Erbium	69 Tm 168.9 Thulium	70 Yb 173.1 Ytterbium	71 Lu 175.0 Lutetium

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 Fermium	101 Md Mendelevium	102 No Nobelium	103 Lr Lawrencium

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 is sourced from the International Union of Pure and Applied Chemistry Periodic Table of the Elements (November 2016 version).
The International Union of Pure and Applied Chemistry Periodic Table of the Elements (February 2010 version) is the principal source of all other data. Some data may have been modified.

Name: ________________

Class: ________________

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

Sample 2 + 4 = (A) 2 (B) 6 (C) 8 (D) 9

A○ B● C○ D○

If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

A● B~~●~~ C○ D○

If you change your mind and have crossed out what you consider to be the correct answer, then indicate this by writing the word *correct* and drawing an arrow as follows:

A~~●~~ B~~●~~ C○ D○

Correct

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) ○

Acknowledgements

Quote in question 35

Gribbin, John. *In Search of Schrödinger's Cat: Quantum Physics and Reality*. Transworld Publishers Ltd, 1991.

Marking Guidelines

Section I

Multiple Choice Answer Key

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

Section II

Question 21

Criteria	Marks
• Outlines changes that can be made to TWO quantities that would increase the force on the wire	2
• Identifies a quantity that can be changed	1

Sample answer:

Increase current, increase magnetic field

Answers could include:

Increase length, increase angle

Notes:

Most students answered this question well. Some students identified an incorrect relationship between force and angle between the current and field.

Question 22

Criteria	Marks
• Provides experimental evidence for the wave nature of light	3
• Provides a feature of a relevant experiment	2
• Provides some relevant information	1

Sample answer:

Young shone light on an opaque barrier that contained two parallel slits. The light from these slits produced an interference pattern when shone on a screen.

Answers could include:

Foucault's measurement of the speed of light in water

Notes:

Some students referred to an experiment that could be explained with a particle model.

Question 23 (a)

Criteria	Marks
• Correctly calculates the magnitude and determines the direction of the current	3
• Correctly calculates the magnitude of the current OR • Determines the direction of the current	2
• Provides some relevant information	1

Sample answer:

$\tau = nIA_{\perp}B \ \therefore I = \frac{\tau}{nAB} = \frac{0.03}{25 \times 1 \times 10^{-3} \times 0.4} = 3 \text{ A}$

The current is into the page.

Notes:

Few students identified the direction of the current.

Question 23 (b)

Criteria	Marks
• Correctly calculates the force	2
• Provides some relevant information	1

Sample answer:

$$\tau = 2 \times r_{\perp}F \therefore F = \frac{\tau}{2r} = \frac{0.03}{2 \times 0.01} = 1.5 \text{ N}$$

Notes:

Many students confused the distance between the force and the fulcrum with the length of the coil perpendicular to the magnetic field. Few students distinguished between the torque on side X and the torque on the coil.

Question 24 (a)

Criteria	Marks
• Correctly calculates the height	2
• Provides some relevant information	1

Sample answer:

$$s = ut + \tfrac{1}{2}at^2 = 0 \times 0.5 + \tfrac{1}{2} \times 9.8 \times 0.5^2 = 1.2 \text{ m}$$

Notes:

Better students recognised that the vertical component of the initial velocity is zero.

Question 24 (b)

Criteria	Marks
• Correctly calculates the velocity	2
• Provides some relevant information	1

Sample answer:

$$u = \frac{s}{t} = \frac{2.0}{0.5} = 4.0 \text{ ms}^{-1}$$

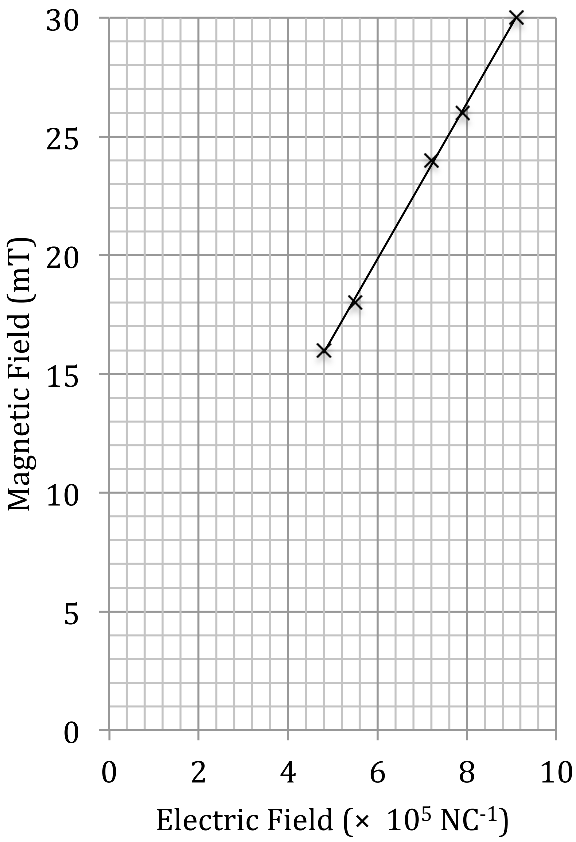
Notes:

Some students applied constant acceleration to the horizontal component of motion.

Question 25

Criteria	Marks
• Determines velocity using the line of best fit	4
• Shows the correct process to determine the velocity	3
• Plots the values on the graph • Draws a line of best fit	2
• Correctly plots some points OR • Correctly draws a line of best fit	1

Sample answer:



$qE = qvB \;\therefore\; v = \dfrac{E}{B} = \dfrac{1}{\text{gradient}} = \dfrac{1}{3.3 \times 10^{-8}} = 3.0 \times 10^{7}\ \text{ms}^{-1}$

Notes:

Some students omitted multipliers in calculation of the gradient. Some students drew a line graph instead of a line of best fit.

Question 26

Criteria	Marks
• Relates change in radiation emitted to change in temperature of the metal object	4
• Relates radiation emitted to temperature of the metal object	3
• Shows some understanding of blackbody radiation	2
• Provides some relevant information	1

Sample answer:

The metal object behaves like a blackbody, radiating energy across a spectrum of wavelengths. Before it is heated, this radiation is in the infrared range. According to Wien's Law, as the temperature of a blackbody increases, the peak wavelength becomes shorter. This means that there will be more radiation emitted at shorter wavelengths, including some in the visible light range.

Answers could include:

Graphs showing how the metal object's blackbody curve changes.

Notes:

Some students confused the blackbody spectrum with an emission spectrum.

Question 27a

Criteria	Marks
• Correctly calculates the length	3
• Provides some relevant steps	2
• Provides some relevant information	1

Sample answer:

$$l = l_0 \sqrt{1 - \frac{v^2}{c^2}} = 86 \times \sqrt{1 - \frac{(0.6c)^2}{c^2}} = 86 \times 0.8 = 69 \text{ m}$$

Notes:

Many students answered this well. Some students confused l and l_0.

Question 27b

Criteria	Marks
• Explains why the speed of light in a vacuum is used to define the metre	4
• Explains why the speed of light is used to define the metre	3
• Shows some understanding of length contraction	2
• Provides some relevant information	1

Sample answer:

Measurements of length depend on the motion in different inertial frames of motion of the observer relative to the object being measured. Two observers can disagree on the length of a physical object. For this reason, the length of a metre is defined in terms of a quantity they will both agree on – the speed of light in a vacuum.

Notes:

Better students identified the role of length contraction. Many students did not refer to inertial frames of reference.

Question 28

Criteria	Marks
• Relates the ideal transformer model and another model to the use of models in physics. • Makes an informed judgement about the use of models in physics.	5-6
• Relates the ideal transformer model and another model to the use of models in physics	4
• Describes the ideal transformer model and another model OR • Relates a named model to the use of models in physics	3
• Shows some understanding of the ideal transformer model or another model	2
• Provides some relevant information	1

Sample answer:

Physics seeks to provide an accurate understanding of how the Universe works. Models help us to do this by allowing us to predict the outcome of specific situations. For example, the ideal transformer model allows us to predict the voltage supplied to the secondary circuit given the primary voltage and the number of turns in the coils. Similarly, Newton's equations of motion allow us to predict the maximum height, time of flight, range and final velocity of a projectile.

However, models will often sacrifice accuracy for simplicity. The secondary voltage in a transformer is less than what the ideal transformer model predicts because no allowance is made for resistive heat production. Also, when Newton's equations of motion are used to predict a projectile's trajectory, it is assumed that air resistance is zero, which it is usually not.

Therefore, models are very useful in helping us to understand the real world as long as we understand the limitations of the models we are using.

Answers could include:

Wave model of light, quantum model of light, nuclear model of the atom

Notes:

Some students did not identify a model other than the ideal transformer model.

Question 29

Criteria	Marks
• Shows how the two stars are physically different • Compares the reaction processes in the two stars	5
• Shows how the two stars are similar or different with respect to TWO features	4
• Shows how the two stars are similar or different	3
• Identifies a feature of Star X or Star Y	2
• Provides some relevant information	1

Sample answer:

Star Y has a greater luminosity than star X.

Star X and Star Y both release energy by combining four hydrogen atoms to produce a helium atom. However, Star X does this by the proton-proton chain reaction whereas Star Y does it by the CNO cycle.

Answers could include:

A comparison of the surface temperature or colour of the two stars.

Notes:

Better students showed how features of the stars are similar or different. Some students did not demonstrate an understanding of the absolute magnitude scale or spectral class.

Question 30 (a)

Criteria	Marks
• Provides a suitable procedure that manages an identified risk	4
• Provides a suitable procedure OR • Outlines some relevant steps AND • Outlines how an identified risk will be managed	3
• Outlines some relevant steps OR • Outlines how an identified risk will be managed	2
• Provides some relevant information	1

Sample answer:

The students should control the motor from behind a safety screen to avoid being hit by the wooden block as it slides off.

Place the wooden block on the edge of the turntable. Use the ruler to measure the distance between the centre of the block and the centre of the turntable. Turn the motor on slowly and gradually increase the angular velocity until the wooden block slides off.

Place the same surface of the wooden block on the turntable 2 cm from the edge and repeat the above procedure. Keep repeating until the wooden block is at the centre of the turntable.

Notes:

Most students managed an identified risk. Few students controlled a variable.

Question 30 (b)

Criteria	Marks
• Correctly calculates the radius	3
• Provides some relevant steps	2
• Provides some relevant information	1

Sample answer:

$$v = \frac{2\pi r}{T} = \frac{2\pi r}{1} = 2\pi r$$

$$f_{\text{friction}} = F_{\text{c}} = \frac{mv^2}{r} = \frac{1 \times (2\pi r)^2}{r} = \frac{4\pi^2 r^2}{r} = 4\pi^2 r$$

$$r = \frac{F_{\text{C}}}{4\pi^2} = \frac{5}{4\pi^2} = 0.13 \text{ m}$$

Notes:

Better students used the orbital velocity to calculate radius.

Question 31 (a)

Criteria	Marks
• Shows correct method to determine the period of Enceladus	3
• Applies Kepler's Law of Periods • Provides a relevant calculation	2
• Applies a relevant approach to calculate r^3 or T or to determine T^2	1

Sample answer:

$r^3 = (2.38 \times 10^8)^3 = 1.35 \times 10^{25}$ m^3.

According to the graph, this corresponds with T^2 of 1.8×10^{10} s^2.

Therefore, $\text{T} = \sqrt{1.8 \times 10^{10}} = 1.3 \times 10^5$ s.

Notes:

Many students ignored multipliers in their calculation of gradient.

Question 31 (b)

Criteria	Marks
• Describes strength(s) and/or weakness(es) of the student's method	4
• Outlines a strength or weakness of the student's method	3
• Show's some understanding of validity or Kepler's Law of Periods	2
• Provides some relevant information	1

Sample answer:

According to Kepler's Third Law, T^2 is proportional to r^3 with the proportionality constant depending on the mass that the satellite is orbiting. Therefore, the gradient determined by the orbits of the three moons of Saturn should give a good indication of the orbits of the outer moons.

However, as the line of best fit is extrapolated, any uncertainty in the gradient will be magnified, meaning that any the uncertainty of the period of planets with a greater radius will be greater than for the three moons of Saturn that have been graphed.

Notes:

Some students confused validity with accuracy.

Question 32

Criteria	Marks
• Explains why a charged particle will pass through the velocity selector and hit the detector at a certain point. • Explains why carbon-14 atoms will strike the detector at a different point to another isotope of carbon. • Shows how percentage composition can be calculated from data from the detector.	9
• Explains why a charged particle will pass through the velocity selector and hit the detector at a certain point AND • Explains why carbon-14 atoms will strike the detector at a different point to another isotope of carbon. OR • Explains the path of a charged particle through the velocity selector or mass spectrometer AND • Shows how percentage composition can be calculated from data from the detector.	7-8
• Explains why a charged particle will pass through the velocity selector and hit the detector at a certain point and relates the mass of an isotope to its composition OR • Explains why carbon-14 atoms will strike the detector at a different point to another isotope of carbon.	5-6
• Describes the path of a charged particle in the voltage selector or mass spectrometer and describes the composition of a named isotope of carbon OR • Describes the force on a charged particle due to a field and relates the mass of an isotope to its composition .	4
• Describes the force on a charged particle due to a field OR • Describes the composition of a named isotope of carbon.	3
• Provides relevant information about TWO of the following areas: electric fields, magnetic fields, and isotopes	2
• Provides one piece of relevant information	1

Sample answer:

In the velocity selector, the forces that the electric field and magnetic field exert on the charged particles are in the opposite direction. This means that all of the charged particles that move through the velocity selector undeflected will have the same velocity ($v = \frac{E}{B}$).

When the charged particles move into the mass spectrometer, they will move in a circular path due to the magnetic field. As all the charged particles are travelling at the same velocity, the radius of the circular path is proportional to the mass of the charged particles, as $r = \frac{mv}{qB}$. Therefore, charged particles of different mass will arrive at different points on the detector.

Isotopes of carbon all have six protons but each has a unique number of neutrons. Therefore, each isotope has a unique mass. Because all the carbon-14 atoms have the same mass, they will all hit the detector at the same point. The percentage of carbon-14 can be determined by counting the number of particles that hit the detector at this point and the number that hit the detector at all points.

Notes:

Better students used the magnitude and direction of the forces on the charged particle to determine its path through the detector.

Question 33

Criteria	Marks
• Correctly calculates the energy released	4
• Correctly calculates mass defect OR • Shows correct process to calculate energy released	3
• Correctly calculates mass of reactants or products OR • Correct conversion of units	2
• Provides some relevant data or a relevant calculation	1

Sample answer:

$$\mathrm{m_n} = \frac{1.675 \times 10^{-27}}{1.661 \times 10^{-27}} = 1.008\ u$$
$$\Delta m = (1.008 + 235.044) - (140.914 + 91.9263 + 3 \times 1.008) = 0.1877\ u$$
$$E = 0.1877 \times 931.5 = 174.8\ \text{MeV}$$

Answers could include:

Calculation of mass defect in kg, calculation of binding energy in J

Notes:

Many students did not use consistent units.

Question 34a

Criteria	Marks
• Correctly calculates the wavelength	3
• Provides some relevant steps	2
• Provides some relevant information	1

Sample answer:

$$E = \frac{hc}{\lambda} \therefore \lambda = \frac{hc}{E} = \frac{6.626 \times 10^{-34} \times 3.00 \times 10^{8}}{9.2 \times 10^{-19}} = 2.2 \times 10^{-7}\ \text{m}$$

Notes:

Better students substituted data into relevant equations. Some students did not refer to the particle nature of light.

Question 34b

Criteria	Marks
• Relates photoelectric effect to law of conservation of energy • Accounts for all of the photon's energy after it was absorbed	3
• Shows some understanding of the photoelectric effect or the law of conservation of energy	2
• Provides some relevant information	1

Sample answer:

Because of the law of conservation of energy, all of the energy that the photon contained is transformed when the atom absorbed it. 7.2×10^{-19} J of the photon's energy is used to eject the photoelectron from the atom. The rest of the energy is given to the photoelectron as kinetic energy.

Notes:

Better students recognised that energy is required to release a photoelectron.

Question 35

Criteria	Marks
• Shows how experimental evidence supports the dual nature of electrons • Refers to the results of TWO experiments	7
• Shows how experimental evidence supports the wave or particle nature of electrons • Refers to the results of TWO experiments	5-6
• Shows how experimental evidence supports the wave or particle nature of electrons	4
• Relates an experiment to the nature of electrons	3
• Outlines a relevant experiment OR • Shows some understanding of quantum physics	2
• Provides some relevant information	1

Sample answer:

J J Thomson showed that electrons have a particle nature in his experiments on cathode rays. In determining their charge-to-mass ratio he showed that electrons have mass, which is a particle property.

De Broglie showed that electrons have a wave nature. The specific amounts of energy emitted by atomic spectra indicate that electrons are only found in certain energy levels in atoms. De Broglie explained the existence of these energy levels as circular standing waves.

As experiment results show that electrons behave like a particle in some circumstances and a wave in others, electrons therefore have a dual nature.

Answers could include:

Millikan’s oil drop experiment, diffraction of electrons

Notes:

Some students confused the dual nature of electrons with the dual nature of light.

Judging

Band	Range
1	0-18
2	19-31
3	32-48
4	49-74
5	75-90
6	91-100

Mapping Grid

Section I

Question	Marks	Content	Syllabus Outcomes
1	1	M7 Light: Wave Model	12-4, 12-14
2	1	M8 Structure of the atom	12-4, 12-15
3	1	M5 Circular Motion	12-5, 12-12
4	1	M6 Applications of the Motor Effect	12-4, 12-13
5	1	M8 Origins of the Elements	12-4, 12-15
6	1	M5 Motion in Gravitational Fields	12-6, 12-12
7	1	M6 Applications of the Motor Effect	12-6, 12-13
8	1	M7 Electromagnetic Radiation	12-5, 12-14
9	1	M5 Circular Motion	12-6, 12-12
10	1	M8 Properties of the Nucleus	12-6, 12-15
11	1	M6 Electromagnetic Induction	12-6, 12-13
12	1	M7 Light: Wave Model	12-6, 12-14
13	1	M5 Projectile Motion	12-6, 12-12
14	1	M6 Charged Particles, Conductors, Electric an Magnetic Fields	12-6, 12-13
15	1	M8 Quantum Mechanical Nature of the Atom	12-6, 12-15
16	1	M7 Light and Special Relativity	12-6, 12-14
17	1	M6 The Motor Effect	12-6, 12-13
18	1	M7 Light: Quantum Model	12-6, 12-14
19	1	M5 Motion in Gravitational Fields	12-4, 12-6, 12-12
20	1	M8 Deep Inside the Atom	12-6, 12-15

Section II

Question	Marks	Content	Syllabus Outcomes
21	2	M6 The Motor Effect	12-6, 12-13
22	3	M7 Light: Wave Model	12-6, 12-14
23a	3	M6 Applications of the Motor Effect	12-6, 12-13
23b	2	M5 Circular Motion	12-6, 12-12
24a	2	M5 Projectile Motion	12-6, 12-12
24b	2	M5 Projectile Motion	12-6, 12-12
25	4	M8 Structure of the Atom	12-4, 12-5, 12-6, 12-15
26	4	M7 Light: Quantum Model	12-6, 12-14
27a	3	M7 Light and Special Relativity	12-6, 12-14
27b	4	M7 Electromagnetic Spectrum	12-6, 12-14
28	6	M6 Electromagnetic Induction	12-6, 12-13
29	5	M8 Origins of the Elements	12-4, 12-15
30a	4	M5 Circular Motion	12-2, 12-3
30b	3	M5 Circular Motion	12-6, 12-12
31a	3	M5 Motion in Gravitational Fields	12-6, 12-12

31b	4	M5 Motion in Gravitational Fields	12-5, 12-6, 12-12
32	9	M6 Charged Particles, Conductors, Electric an Magnetic Fields	12-6, 12-13, 12-15
33	4	M8 Properties of the Nucleus	12-4, 12-6, 12-15
34a	3	M7 Light: Quantum Model	12-6, 12-14
34b	3	M7 Light: Quantum Model	12-6, 12-14
35	7	M8 Quantum Mechanical Nature of the Atom	12-5, 12-6, 12-15

Acknowledgements

Quote in question 35

Gribbin, John. *In Search of Schrödinger's Cat: Quantum Physics and Reality*. Transworld Publishers Ltd, 1991.

Marking Guidelines

Section I

Multiple Choice Answer Key

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

Section II

Question 21

Criteria	Marks
• Outlines changes that can be made to TWO quantities that would increase the force on the wire	2
• Identifies a quantity that can be changed	1

Sample answer:

Increase current, increase magnetic field

Answers could include:

Increase length, increase angle

Notes:

Most students answered this question well. Some students identified an incorrect relationship between force and angle between the current and field.

Question 22

Criteria	Marks
• Provides experimental evidence for the wave nature of light	3
• Provides a feature of a relevant experiment	2
• Provides some relevant information	1

Sample answer:

Young shone light on an opaque barrier that contained two parallel slits. The light from these slits produced an interference pattern when shone on a screen.

Answers could include:

Foucault's measurement of the speed of light in water

Notes:

Some students referred to an experiment that could be explained with a particle model.

Question 23 (a)

Criteria	Marks
• Correctly calculates the magnitude and determines the direction of the current	3
• Correctly calculates the magnitude of the current OR • Determines the direction of the current	2
• Provides some relevant information	1

Sample answer:

$\tau = nIA_{\perp}B \;\therefore\; I = \frac{\tau}{nAB} = \frac{0.03}{25 \times 1 \times 10^{-3} \times 0.4} = 3 \text{ A}$

The current is into the page.

Notes:

Few students identified the direction of the current.

Question 23 (b)

Criteria	Marks
• Correctly calculates the force	2
• Provides some relevant information	1

Sample answer:

$$\tau = 2 \times r_{\perp}F \therefore F = \frac{\tau}{2r} = \frac{0.03}{2 \times 0.01} = 1.5 \text{ N}$$

Notes:

Many students confused the distance between the force and the fulcrum with the length of the coil perpendicular to the magnetic field. Few students distinguished between the torque on side X and the torque on the coil.

Question 24 (a)

Criteria	Marks
• Correctly calculates the height	2
• Provides some relevant information	1

Sample answer:

$$s = ut + \tfrac{1}{2}at^2 = 0 \times 0.5 + \tfrac{1}{2} \times 9.8 \times 0.5^2 = 1.2 \text{ m}$$

Notes:

Better students recognised that the vertical component of the initial velocity is zero.

Question 24 (b)

Criteria	Marks
• Correctly calculates the velocity	2
• Provides some relevant information	1

Sample answer:

$$u = \frac{s}{t} = \frac{2.0}{0.5} = 4.0 \text{ ms}^{-1}$$

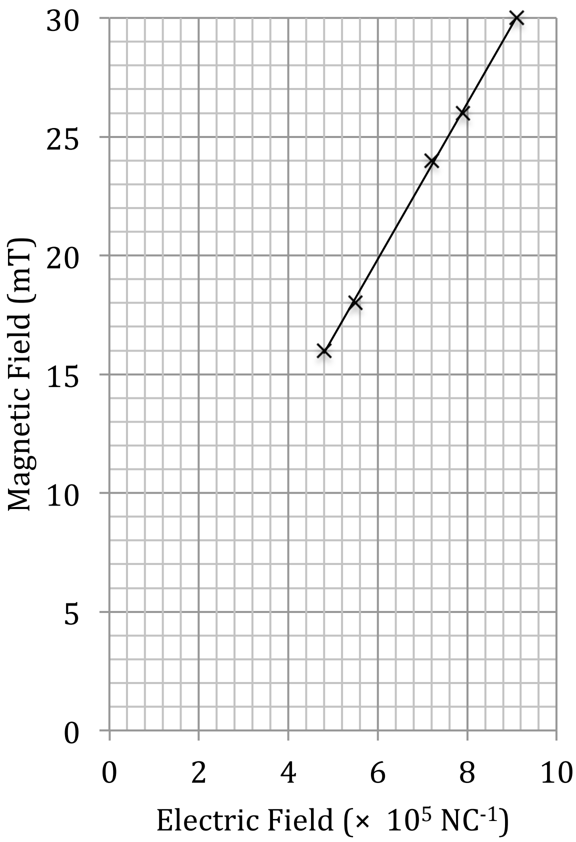
Notes:

Some students applied constant acceleration to the horizontal component of motion.

Question 25

Criteria	Marks
• Determines velocity using the line of best fit	4
• Shows the correct process to determine the velocity	3
• Plots the values on the graph • Draws a line of best fit	2
• Correctly plots some points OR • Correctly draws a line of best fit	1

Sample answer:



$$qE = qvB \ \therefore v = \frac{E}{B} = \frac{1}{\text{gradient}} = \frac{1}{3.3 \times 10^{-8}} = 3.0 \times 10^7 \text{ ms}^{-1}$$

Notes:

Some students omitted multipliers in calculation of the gradient. Some students drew a line graph instead of a line of best fit.

Question 26

Criteria	Marks
• Relates change in radiation emitted to change in temperature of the metal object	4
• Relates radiation emitted to temperature of the metal object	3
• Shows some understanding of blackbody radiation	2
• Provides some relevant information	1

Sample answer:

The metal object behaves like a blackbody, radiating energy across a spectrum of wavelengths. Before it is heated, this radiation is in the infrared range. According to Wien's Law, as the temperature of a blackbody increases, the peak wavelength becomes shorter. This means that there will be more radiation emitted at shorter wavelengths, including some in the visible light range.

Answers could include:

Graphs showing how the metal object's blackbody curve changes.

Notes:

Some students confused the blackbody spectrum with an emission spectrum.

Question 27a

Criteria	Marks
• Correctly calculates the length	3
• Provides some relevant steps	2
• Provides some relevant information	1

Sample answer:

$$l = l_0\sqrt{1-\frac{v^2}{c^2}} = 86 \times \sqrt{1-\frac{(0.6c)^2}{c^2}} = 86 \times 0.8 = 69 \text{ m}$$

Notes:

Many students answered this well. Some students confused l and l_0.

Question 27b

Criteria	Marks
• Explains why the speed of light in a vacuum is used to define the metre	4
• Explains why the speed of light is used to define the metre	3
• Shows some understanding of length contraction	2
• Provides some relevant information	1

Sample answer:

Measurements of length depend on the motion in different inertial frames of motion of the observer relative to the object being measured. Two observers can disagree on the length of a physical object. For this reason, the length of a metre is defined in terms of a quantity they will both agree on – the speed of light in a vacuum.

Notes:

Better students identified the role of length contraction. Many students did not refer to inertial frames of reference.

Question 28

Criteria	Marks
• Relates the ideal transformer model and another model to the use of models in physics. • Makes an informed judgement about the use of models in physics.	5-6
• Relates the ideal transformer model and another model to the use of models in physics	4
• Describes the ideal transformer model and another model OR • Relates a named model to the use of models in physics	3
• Shows some understanding of the ideal transformer model or another model	2
• Provides some relevant information	1

Sample answer:

Physics seeks to provide an accurate understanding of how the Universe works. Models help us to do this by allowing us to predict the outcome of specific situations. For example, the ideal transformer model allows us to predict the voltage supplied to the secondary circuit given the primary voltage and the number of turns in the coils. Similarly, Newton's equations of motion allow us to predict the maximum height, time of flight, range and final velocity of a projectile.

However, models will often sacrifice accuracy for simplicity. The secondary voltage in a transformer is less than what the ideal transformer model predicts because no allowance is made for resistive heat production. Also, when Newton's equations of motion are used to predict a projectile's trajectory, it is assumed that air resistance is zero, which it is usually not.

Therefore, models are very useful in helping us to understand the real world as long as we understand the limitations of the models we are using.

Answers could include:

Wave model of light, quantum model of light, nuclear model of the atom

Notes:

Some students did not identify a model other than the ideal transformer model.

Question 29

Criteria	Marks
• Shows how the two stars are physically different • Compares the reaction processes in the two stars	5
• Shows how the two stars are similar or different with respect to TWO features	4
• Shows how the two stars are similar or different	3
• Identifies a feature of Star X or Star Y	2
• Provides some relevant information	1

Sample answer:

Star Y has a greater luminosity than star X.

Star X and Star Y both release energy by combining four hydrogen atoms to produce a helium atom. However, Star X does this by the proton-proton chain reaction whereas Star Y does it by the CNO cycle.

Answers could include:

A comparison of the surface temperature or colour of the two stars.

Notes:

Better students showed how features of the stars are similar or different. Some students did not demonstrate an understanding of the absolute magnitude scale or spectral class.

Question 30 (a)

Criteria	Marks
• Provides a suitable procedure that manages an identified risk	4
• Provides a suitable procedure OR • Outlines some relevant steps AND • Outlines how an identified risk will be managed	3
• Outlines some relevant steps OR • Outlines how an identified risk will be managed	2
• Provides some relevant information	1

Sample answer:

The students should control the motor from behind a safety screen to avoid being hit by the wooden block as it slides off.

Place the wooden block on the edge of the turntable. Use the ruler to measure the distance between the centre of the block and the centre of the turntable. Turn the motor on slowly and gradually increase the angular velocity until the wooden block slides off.

Place the same surface of the wooden block on the turntable 2 cm from the edge and repeat the above procedure. Keep repeating until the wooden block is at the centre of the turntable.

Notes:

Most students managed an identified risk. Few students controlled a variable.

Question 30 (b)

Criteria	Marks
• Correctly calculates the radius	3
• Provides some relevant steps	2
• Provides some relevant information	1

Sample answer:

$$v = \frac{2\pi r}{T} = \frac{2\pi r}{1} = 2\pi r$$

$$f_{\text{friction}} = F_{\text{c}} = \frac{mv^2}{r} = \frac{1 \times (2\pi r)^2}{r} = \frac{4\pi^2 r^2}{r} = 4\pi^2 r$$

$$r = \frac{F_{\text{C}}}{4\pi^2} = \frac{5}{4\pi^2} = 0.13 \text{ m}$$

Notes:

Better students used the orbital velocity to calculate radius.

Question 31 (a)

Criteria	Marks
• Shows correct method to determine the period of Enceladus	3
• Applies Kepler's Law of Periods • Provides a relevant calculation	2
• Applies a relevant approach to calculate r^3 or T or to determine T^2	1

Sample answer:

$r^3 = (2.38 \times 10^8)^3 = 1.35 \times 10^{25}$ m^3.

According to the graph, this corresponds with T^2 of 1.8×10^{10} s^2.

Therefore, $T = \sqrt{1.8 \times 10^{10}} = 1.3 \times 10^5$ s.

Notes:

Many students ignored multipliers in their calculation of gradient.

Question 31 (b)

Criteria	Marks
• Describes strength(s) and/or weakness(es) of the student's method	4
• Outlines a strength or weakness of the student's method	3
• Show's some understanding of validity or Kepler's Law of Periods	2
• Provides some relevant information	1

Sample answer:

According to Kepler's Third Law, T^2 is proportional to r^3 with the proportionality constant depending on the mass that the satellite is orbiting. Therefore, the gradient determined by the orbits of the three moons of Saturn should give a good indication of the orbits of the outer moons.

However, as the line of best fit is extrapolated, any uncertainty in the gradient will be magnified, meaning that any the uncertainty of the period of planets with a greater radius will be greater than for the three moons of Saturn that have been graphed.

Notes:

Some students confused validity with accuracy.

Question 32

Criteria	Marks
• Explains why a charged particle will pass through the velocity selector and hit the detector at a certain point. • Explains why carbon-14 atoms will strike the detector at a different point to another isotope of carbon. • Shows how percentage composition can be calculated from data from the detector.	9
• Explains why a charged particle will pass through the velocity selector and hit the detector at a certain point AND • Explains why carbon-14 atoms will strike the detector at a different point to another isotope of carbon. OR • Explains the path of a charged particle through the velocity selector or mass spectrometer AND • Shows how percentage composition can be calculated from data from the detector.	7-8
• Explains why a charged particle will pass through the velocity selector and hit the detector at a certain point and relates the mass of an isotope to its composition OR • Explains why carbon-14 atoms will strike the detector at a different point to another isotope of carbon.	5-6
• Describes the path of a charged particle in the voltage selector or mass spectrometer and describes the composition of a named isotope of carbon OR • Describes the force on a charged particle due to a field and relates the mass of an isotope to its composition .	4
• Describes the force on a charged particle due to a field OR • Describes the composition of a named isotope of carbon.	3
• Provides relevant information about TWO of the following areas: electric fields, magnetic fields, and isotopes	2
• Provides one piece of relevant information	1

Sample answer:

In the velocity selector, the forces that the electric field and magnetic field exert on the charged particles are in the opposite direction. This means that all of the charged particles that move through the velocity selector undeflected will have the same velocity ($v = \frac{E}{B}$).

When the charged particles move into the mass spectrometer, they will move in a circular path due to the magnetic field. As all the charged particles are travelling at the same velocity, the radius of the circular path is proportional to the mass of the charged particles, as $r = \frac{mv}{qB}$. Therefore, charged particles of different mass will arrive at different points on the detector.

Isotopes of carbon all have six protons but each has a unique number of neutrons. Therefore, each isotope has a unique mass. Because all the carbon-14 atoms have the same mass, they will all hit the detector at the same point. The percentage of carbon-14 can be determined by counting the number of particles that hit the detector at this point and the number that hit the detector at all points.

Notes:

Better students used the magnitude and direction of the forces on the charged particle to determine its path through the detector.

Question 33

Criteria	Marks
• Correctly calculates the energy released	4
• Correctly calculates mass defect OR • Shows correct process to calculate energy released	3
• Correctly calculates mass of reactants or products OR • Correct conversion of units	2
• Provides some relevant data or a relevant calculation	1

Sample answer:

$$\mathrm{m_n} = \frac{1.675 \times 10^{-27}}{1.661 \times 10^{-27}} = 1.008\ u$$
$$\Delta m = (1.008 + 235.044) - (140.914 + 91.9263 + 3 \times 1.008) = 0.1877\ u$$
$$E = 0.1877 \times 931.5 = 174.8\ \text{MeV}$$

Answers could include:

Calculation of mass defect in kg, calculation of binding energy in J

Notes:

Many students did not use consistent units.

Question 34a

Criteria	Marks
• Correctly calculates the wavelength	3
• Provides some relevant steps	2
• Provides some relevant information	1

Sample answer:

$$E = \frac{hc}{\lambda} \therefore \lambda = \frac{hc}{E} = \frac{6.626 \times 10^{-34} \times 3.00 \times 10^{8}}{9.2 \times 10^{-19}} = 2.2 \times 10^{-7}\ \text{m}$$

Notes:

Better students substituted data into relevant equations. Some students did not refer to the particle nature of light.

Question 34b

Criteria	Marks
• Relates photoelectric effect to law of conservation of energy • Accounts for all of the photon's energy after it was absorbed	3
• Shows some understanding of the photoelectric effect or the law of conservation of energy	2
• Provides some relevant information	1

Sample answer:

Because of the law of conservation of energy, all of the energy that the photon contained is transformed when the atom absorbed it. 7.2×10^{-19} J of the photon's energy is used to eject the photoelectron from the atom. The rest of the energy is given to the photoelectron as kinetic energy.

Notes:

Better students recognised that energy is required to release a photoelectron.

Question 35

Criteria	Marks
• Shows how experimental evidence supports the dual nature of electrons • Refers to the results of TWO experiments	7
• Shows how experimental evidence supports the wave or particle nature of electrons • Refers to the results of TWO experiments	5-6
• Shows how experimental evidence supports the wave or particle nature of electrons	4
• Relates an experiment to the nature of electrons	3
• Outlines a relevant experiment OR • Shows some understanding of quantum physics	2
• Provides some relevant information	1

Sample answer:

J J Thomson showed that electrons have a particle nature in his experiments on cathode rays. In determining their charge-to-mass ratio he showed that electrons have mass, which is a particle property.

De Broglie showed that electrons have a wave nature. The specific amounts of energy emitted by atomic spectra indicate that electrons are only found in certain energy levels in atoms. De Broglie explained the existence of these energy levels as circular standing waves.

As experiment results show that electrons behave like a particle in some circumstances and a wave in others, electrons therefore have a dual nature.

Answers could include:

Millikan's oil drop experiment, diffraction of electrons

Notes:

Some students confused the dual nature of electrons with the dual nature of light.

Judging

Band	Range
1	0-18
2	19-31
3	32-48
4	49-74
5	75-90
6	91-100

Mapping Grid

Section I

Question	Marks	Content	Syllabus Outcomes
1	1	M7 Light: Wave Model	12-4, 12-14
2	1	M8 Structure of the atom	12-4, 12-15
3	1	M5 Circular Motion	12-5, 12-12
4	1	M6 Applications of the Motor Effect	12-4, 12-13
5	1	M8 Origins of the Elements	12-4, 12-15
6	1	M5 Motion in Gravitational Fields	12-6, 12-12
7	1	M6 Applications of the Motor Effect	12-6, 12-13
8	1	M7 Electromagnetic Radiation	12-5, 12-14
9	1	M5 Circular Motion	12-6, 12-12
10	1	M8 Properties of the Nucleus	12-6, 12-15
11	1	M6 Electromagnetic Induction	12-6, 12-13
12	1	M7 Light: Wave Model	12-6, 12-14
13	1	M5 Projectile Motion	12-6, 12-12
14	1	M6 Charged Particles, Conductors, Electric an Magnetic Fields	12-6, 12-13
15	1	M8 Quantum Mechanical Nature of the Atom	12-6, 12-15
16	1	M7 Light and Special Relativity	12-6, 12-14
17	1	M6 The Motor Effect	12-6, 12-13
18	1	M7 Light: Quantum Model	12-6, 12-14
19	1	M5 Motion in Gravitational Fields	12-4, 12-6, 12-12
20	1	M8 Deep Inside the Atom	12-6, 12-15

Section II

Question	Marks	Content	Syllabus Outcomes
21	2	M6 The Motor Effect	12-6, 12-13
22	3	M7 Light: Wave Model	12-6, 12-14
23a	3	M6 Applications of the Motor Effect	12-6, 12-13
23b	2	M5 Circular Motion	12-6, 12-12
24a	2	M5 Projectile Motion	12-6, 12-12
24b	2	M5 Projectile Motion	12-6, 12-12
25	4	M8 Structure of the Atom	12-4, 12-5, 12-6, 12-15
26	4	M7 Light: Quantum Model	12-6, 12-14
27a	3	M7 Light and Special Relativity	12-6, 12-14
27b	4	M7 Electromagnetic Spectrum	12-6, 12-14
28	6	M6 Electromagnetic Induction	12-6, 12-13
29	5	M8 Origins of the Elements	12-4, 12-15
30a	4	M5 Circular Motion	12-2, 12-3
30b	3	M5 Circular Motion	12-6, 12-12
31a	3	M5 Motion in Gravitational Fields	12-6, 12-12

31b	4	M5 Motion in Gravitational Fields	12-5, 12-6, 12-12
32	9	M6 Charged Particles, Conductors, Electric an Magnetic Fields	12-6, 12-13, 12-15
33	4	M8 Properties of the Nucleus	12-4, 12-6, 12-15
34a	3	M7 Light: Quantum Model	12-6, 12-14
34b	3	M7 Light: Quantum Model	12-6, 12-14
35	7	M8 Quantum Mechanical Nature of the Atom	12-5, 12-6, 12-15