SYDNEY GRAMMAR SCHOOL

2001
HIGHER SCHOOL CERTIFICATE TRIAL EXAMINATION

Physics

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Board-approved calculators may be used
- Write using blue or black pen
- Draw diagrams using pencil
- A Data Sheet, Formulae Sheets and a Periodic Table are provided at the back of this paper
- Write your Class and Student Number in the boxes provided

Collection Instructions

Hand in the following sections in 3 separate bundles

- Section I - Part A Answer sheet
- Section I - Part B Question and Answer Booklet
- Section II - Answer Booklet

Section I Pages 3 - 20

Total marks (75)

This section has two parts, Part A and Part B

Part A
Total marks **(15)**

- Attempt Questions 1 - 15
- Allow about 30 minutes for this part

Part B
Total marks **(60)**

- Attempt Questions 16 - 29
- Allow about 1 hour and 45 minutes for this part

Section II Pages 21- 23

Total marks **(25)**

- Attempt ONE Question from Questions 30 - 34
- Allow about 45 minutes for this section

Section I
Total marks (75)

Part A
Total marks (15)
Attempt Questions 1 - 15
Allow about 30 minutes for this Part

Use the multiple-choice Answer Sheet.

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

Sample 2 + 4 =

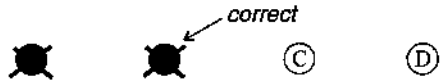
(A) 2 (B) 6 (C) 8 (D) 9

Ⓐ ● Ⓒ Ⓓ

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

● ✕ Ⓒ Ⓓ

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.



Student Number

1 A spherical asteroid has a mass of 3.1×10^{22} kg and a radius of 5.3×10^{5} m. The gravitational field strength at the surface of the asteroid is:

(A) 0.81 Nkg^{-1}.
(B) 1.6 Nkg^{-1}.
(C) 7.4 Nkg^{-1}.
(D) 9.8 Nkg^{-1}.

2 A test pilot brings a jet-powered car to rest from a speed of 118 ms^{-1} in a time of 3 s. The acceleration of the pilot is equivalent to:

(A) g.
(B) 2g.
(C) 3g.
(D) 4g.

3 The unstable sub-atomic particle called the muon has an average life-time of 2.2 μs, when measured at rest in the laboratory. However, high speed muons produced in the upper atmosphere are measured to have:

(A) a shorter average lifetime, because of length contraction.
(B) a shorter average lifetime, because of time dilation.
(C) a longer average lifetime, because of time dilation.
(D) the same average lifetime, because the effects of time dilation and length contraction cancel out.

4 An astronaut orbiting the Earth in the space-shuttle feels weightless because:

(A) the effect of the Earth's gravity is negligible.
(B) the shuttle is rotating.
(C) the gravitational attraction of the Moon cancels the gravitational attraction of the Earth.
(D) the astronaut is accelerating at the same rate as the space shuttle.

5 Rockets are launched from sites near to the Equator because:

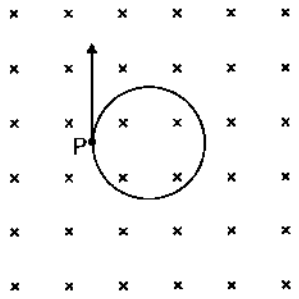
(A) the Earth's rotational velocity helps reduce the fuel required during the launch.
(B) most satellites are placed in geostationary, equatorial orbits.
(C) the distance into space is less than at the poles because the Earth is not a perfect sphere.
(D) there is less chance of the Earth's magnetic field affecting the rocket.

Student Number

6 An ideal transformer has 100 turns in its primary winding and 300 turns in its secondary. If the power input to the transformer is 60 W, the power output is:

(A) 20 W.
(B) 60 W.
(C) 180 W.
(D) 540 W.

7 An electron moves in a circular path, perpendicular to a uniform magnetic field directed into the page.



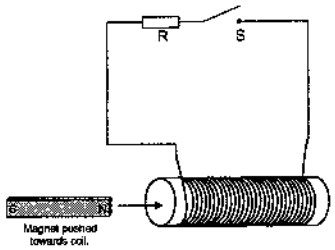
A uniform electric field is turned on at a certain instant. The electric field is such that an electron, which was at P at that instant then, moves in a straight line shown by the arrow.
What is the direction of the applied electric field?

(A) Into the page.
(B) Out of the page.
(C) To the left.
(D) To the right.

Class

Student Number

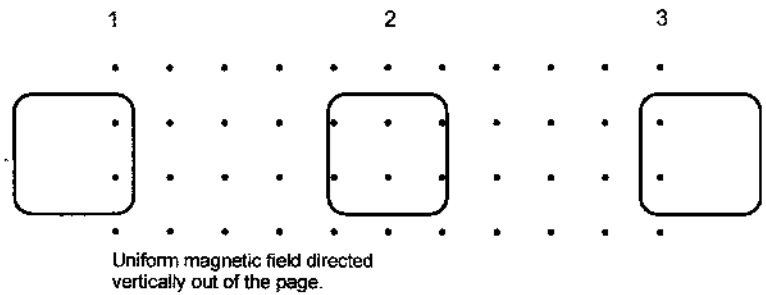
8 A bar magnet is placed so that it is initially outside a large coil. The coil is connected with a switch, S, and a resistor, R, as shown in the diagram below.



The magnet is pushed quickly into the coil in the direction shown by the arrow in the diagram.
The amount of energy required to push the North end of the magnet towards the coil is:

(A) zero, whether the switch is opened or closed.
(B) non-zero, but the same whether the switch is open or closed.
(C) more if the switch is closed than if it is open.
(D) more if the switch is open than if the switch is closed.

9 A loop of wire is moved from position 1 to position 3 at a constant speed in a magnetic field of uniform flux density.



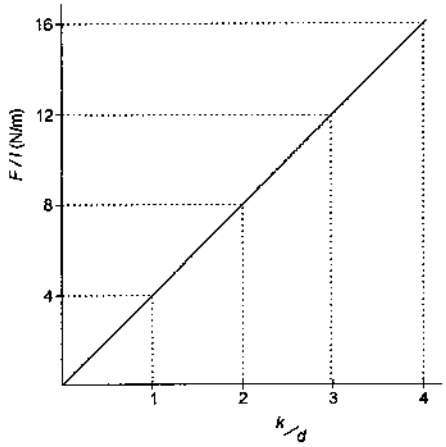
As the loop moves from positions 1 to 2 to 3 the current in the loop is:

	Position 1	Position 2	Position 3
(A)	clockwise	clockwise	clockwise
(B)	anti-clockwise	anti-clockwise	anti-clockwise
(C)	clockwise	zero	anti-clockwise
(D)	anti-clockwise	zero	clockwise

Class

Student Number

10 The graph below shows the relationship between force per unit length (F/l) and $\frac{k}{d}$ of two parallel wires carrying equal currents where d is the distance between the wires and k is the magnetic force constant (Ampere's constant).



The value of the current flowing in each wire is:

(A) 1 A.
(B) 2 A.
(C) 3 A.
(D) 4 A.

11 The scientist who introduced the idea of quantisation of energy as a means of mathematically modelling black-body radiation was:

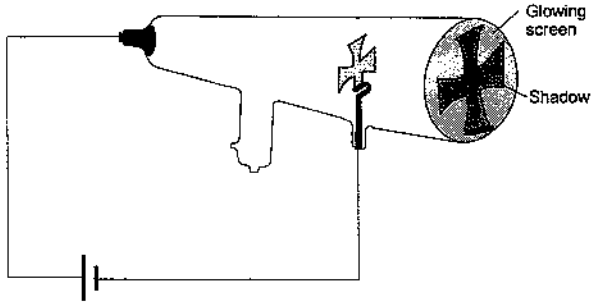
(A) Max Planck.
(B) Albert Einstein.
(C) Michael Faraday.
(D) Niels Bohr.

12 To minimise energy losses, electrical energy is transmitted along long distances at:

(A) high current, high voltage.
(B) low current, low voltage.
(C) high current, low voltage.
(D) low current, high voltage.

Student Number

13 The diagram below shows the famous Maltese Cross experiment into the nature of Cathode Rays.



The experiment demonstrates that:

(A) cathode rays are neutral.
(B) cathode rays travel in straight lines.
(C) cathode rays are undeflected by a magnetic field.
(D) cathode rays are high energy electrons.

14 Heinrich Hertz contributed to our understanding of electromagnetic radiation by:

(A) demonstrating the existence of black body radiation.
(B) theoretically linking visible light and electromagnetism.
(C) explaining the Balmer series.
(D) demonstrating the existence of radio waves which have a velocity equal to that of visible light.

15 J. J. Thompson is credited with the discovery of the electron because he was the first person to:

(A) measure the charge to mass ratio of the particles emitted as cathode rays.
(B) observe the emission of cathode rays.
(C) develop a theoretical model to explain the hydrogen spectrum.
(D) observe β emission from radioactive isotopes.

Student Number

Section I

Part B

Total marks (60)
Attempt Questions 16 - 29
Allow about 1 hour and 45 minutes for this Part

Answer the questions in the spaces provided
Show all relevant working in questions involving calculations

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Question 16 (3 marks) **Marks**

In a moving coil galvanometer, the coil, which has 24 turns each of area 8.0 cm^2, is suspended in a radial field of flux density 0.20 Tesla.

(a) What torque does the coil experience when a current of 25 mA flows through it? **2**

The spring attached to the coil provides a restoring torque of 2.0×10^{-6} Nm for every degree that the coil turns through.

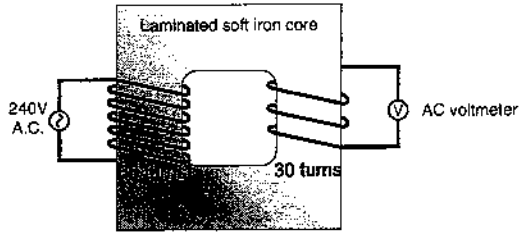
(b) How many degrees will the coil turn through before the spring brings it to rest at equilibrium? **1**

Class

Student Number

Question 17 (8 marks) **Marks**

The diagram below represents a simple ideal transformer.



(a) Explain why the soft iron core is laminated. **2**

(b) Explain why a transformer would not work if the AC power supply was replaced by a constant DC power supply. **2**

(c) Assuming the transformer has 100% efficiency, what is the reading on the voltmeter? **1**

Question 17 continued on page 10

Class

Student Number

Question 17 (continued) **Marks**

(d) Briefly discuss, with examples, why some electrical appliances in the home that are connected to the mains domestic supply use a transformer. **3**

Student Number

Question 18 (2 marks) **Marks**

The planet Mars has a mass of 6.42×10^{23} kg and a radius of 3.40×10^{6} m. Calculate the escape velocity at the surface of Mars. **2**

Question 19 (4 marks)

A satellite of mass 100 kg performs a circular orbit, 1000 km above the surface of the Earth. The radius of the Earth is 6.40×10^{6} m.

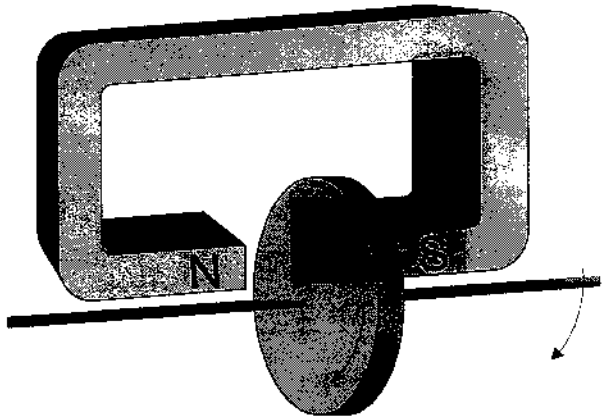
(a) Calculate the gravitational force acting on the satellite. **2**

(b) Calculate the time taken by the satellite to complete one revolution of the Earth. **2**

Student Number

Question 20 (3 marks) **Marks**

Electromagnetic braking can be achieved by applying a strong magnetic field to a spinning metal disc attached to a shaft as shown below.



(a) Identify and explain how the magnetic field slows the spinning of the disc. **2**

(b) Would the brakes work if the disc was plastic instead of metal? Explain your answer. **1**

Class

Student Number

Question 21 (2 marks) **Marks**

Light of wavelength 6×10^{-9} m is incident on a sodium surface. The work function (i.e. the minimum energy required to emit an electron) of sodium is 2.9×10^{-19} J. Calculate the maximum kinetic energy of the electrons ejected from the sodium by this light. **2**

Question 22 (4 marks)

Give an example of a modern device that uses a cathode ray tube and outline its operation. **4**

Class

Student Number

Question 23 (5 marks) **Marks**

(a) What do physicists mean by the term 'black body'? **1**

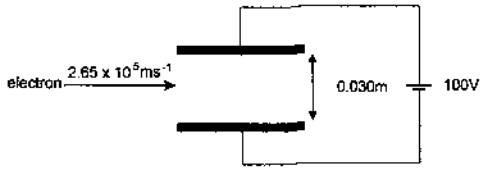
(b) (i) Sketch a graph to show how the intensity of light emitted by a black body depends upon the frequency (or wavelength) of the light. **2**

(ii) Add to your graph a second sketch for the light intensity of the same body at a higher temperature. Make sure you distinguish clearly between the two sketches. **2**

Student Number

Question 24 (5 marks) **Marks**

An electron travelling at a velocity of 2.65×10^5 ms^{-1} passes horizontally between two parallel, horizontal electric plates 0.030 m apart and connected to a potential difference of 100 V.



(a) Calculate the electric field strength between the horizontal plates. **1**

(b) What is the electrostatic force acting on the electron in the region between the plates? **2**

(c) What magnetic field must be applied to the electron to allow it to pass between the plates undeflected? **2**

Student Number

Question 25 (3 marks) **Marks**

Assess the significance of the Michaelson-Morley experiment to Einstein's theory of special relativity. **3**

Question 26 (2 marks)

A spacecraft is 80 m long, as measured by an astronaut on board. The space craft appears to be 64 m long, when measured by a scientist working on a base on the Moon. Calculate the speed of the space craft relative to the Moon. **2**

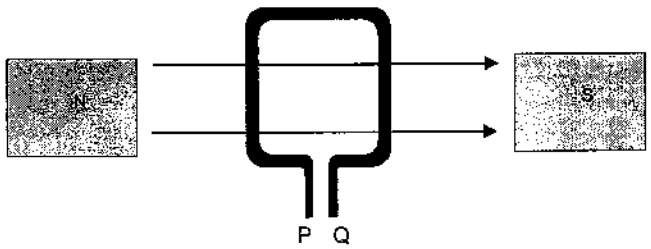
Class

Student Number

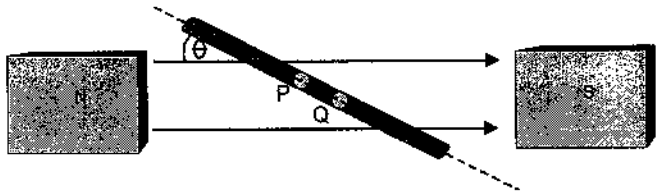
Question 27 (8 marks) **Marks**

A simple electric generator consists of a rotating rectangular loop of copper wire immersed in a magnetic field as shown in the diagram below.

TOP VIEW



SIDE VIEW



(a) For what value of θ is the magnetic flux, ϕ, through the loop a maximum? **1**

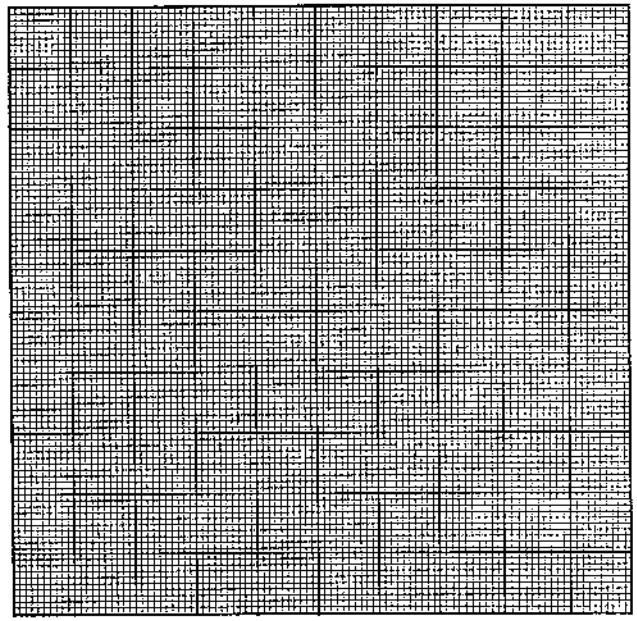
Question 27 continued on page 18

Class

Student Number

Question 27 (continued) **Marks**

(b) When the loop is rotating with a frequency of 10 Hertz, a maximum voltage of 0.5 V is produced. Sketch on the axes provided the voltage across the loop (y axis) as a function of time, taking t = 0 to be *the position of maximum flux as determined in part (a)*. Label the axes fully including numerical values and only sketch the first two complete rotations of the coil. **5**



(c) A hand-operated generator is easy to turn when it is not connected to a load such as a light bulb. However, when the light bulb is connected, the generator becomes quite difficult to turn. Briefly explain these observations. **2**

Student Number

Question 28 (5 marks) **Marks**

Describe an investigation you could carry out to demonstrate that the motion of a projectile can be analysed by separating the motion into independent horizontal and vertical components. **5**

Student Number

Question 29 (6 marks) **Marks**

Justify Einstein's use of the photon in explaining experimental observations of the photoelectric effect. **6**

Section II

Total marks (25)
Attempt ONE question from Questions 30 - 34
Allow about 45 minutes for this Part

Answer the question in a writing booklet. Extra writing booklets are available.
Show all relevant working in questions involving calculations.

Marks

Question 33 - From Quanta to Quarks (25 marks)

(a) Outline the Rutherford model of the atom. Include a diagram in your answer. **3**

(b) Briefly describe the Davisson and Germer experiment and outline what it demonstrates about the nature of electrons. **2**

(c) The Balmer series is the series of spectral lines for Hydrogen when electrons jump from higher orbitals(n=3, n=4 etc) down to the n=2 orbital.

(i) Briefly describe Bohr's model of the atom and explain why it successfully accounts for the Balmer series. **3**

(ii) Calculate the maximum wavelength of the Balmer series for Hydrogen. **2**

(iii) Determine the frequency of the light produced by your transition in (ii). **1**

(d) (i) State the de Broglie hypothesis and explain why it was considered so startling when first proposed. **2**

(ii) Calculate the de Broglie wavelength for an electron travelling with a velocity of 10^4 ms^{-1}. **1**

Question 33 continues on page 23

Question 33 - (continued)

(e) The following is an example of a nuclear reaction.

$$ {}^{1}_{0}n + {}^{235}_{92}U \rightarrow {}^{141}_{56}Ba + X + 3{}^{1}_{0}n + Energy $$

(i) Determine the nature of X. **1**

(ii) What sort of nuclear reaction is depicted above? **1**

(iii) Another example of a nuclear reaction is the following. **3**

$$ {}^{2}_{1}H + {}^{3}_{1}H \rightarrow {}^{4}_{2}He + {}^{1}_{0}n + energy $$

The rest masses of these nuclei are:

$ {}^{2}_{1}H = 3.3440 \times 10^{-27} $ kg
$ {}^{3}_{1}H = 5.0089 \times 10^{-27} $ kg
$ {}^{4}_{2}He = 6.6463 \times 10^{-27} $ kg
$ {}^{1}_{0}n = 1.6749 \times 10^{-27} $ kg

Calculate the mass defect for the above reaction.

(iv) Calculate the energy released in the reaction in part (iii). **1**

(f) Explain why Pauli found it necessary to postulate the existence of the neutrino. **3**

(g) Compare controlled and uncontrolled fission chain reactions. **2**

End of Question 35

SYDNEY GRAMMAR SCHOOL

Class

Student Number

2001
HIGHER SCHOOL CERTIFICATE TRIAL EXAMINATION

Physics
Section I Part A
ANSWER SHEET

General Instructions

- Write your class and student number in the space provided.
- Attempt all questions 1 – 15
- Use a blue or black pen
- Select the alternative A, B, C, or D that best answers the question.
- Fill in the response oval completely.

1. A ● C D
2. A B C ●
3. A B ● D
4. A B C ●
5. ● B C D
6. A ● C D
7. A B C ●
8. A B ● D
9. A B ● D
10. A ● C D
11. ● B C D
12. A B C ●
13. A ● C D
14. A B C ●
15. ● B C D

PERIODIC TABLE OF THE ELEMENTS

KEY

Atomic Number
Au 197.0
Symbol of element
Atomic Weight
Name of element

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 65.39 Zinc	31 Ga 69.72 Gallium	32 Ge 72.61 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 87.62 Strontium	39 Y 88.91 Yttrium	40 Zr 91.22 Zirconium	41 Nb 92.91 Niobium	42 Mo 95.94 Molybdenum	43 Tc [98.91] 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	72 Hf 178.5 Hafnium	73 Ta 180.9 Tantalum	74 W 183.8 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 [210.0] Polonium	85 At [210.0] Astatine	86 Rn [222.0] Radon
87 Fr [223.0] Francium	88 Ra [226.0] Radium	89–103	104 Rf [261.1] Rutherfordium	105 Db [262.1] Dubnium	106 Sg [263.1] Seaborgium	107 Bh [264.1] Bohrium	108 Hs [265.1] Hassium	109 Mt [268] Meitnerium	110 Uun — Ununnilium	111 Uuu — Unununium	112 Uub — Ununbium	113 — Ununtrium	114 Uuq — Ununquadium	115 — Ununpentium	116 Uuh — Ununhexium	117 — Ununseptium	118 Uuo — Ununoctium

Lanthanides

57 La 138.9 Lanthanum	58 Ce 140.1 Cerium	59 Pr 140.9 Praseodymium	60 Nd 144.2 Neodymium	61 Pm [146.9] 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 173.0 Ytterbium	71 Lu 175.0 Lutetium

Actinides

89 Ac [227.0] Actinium	90 Th 232.0 Thorium	91 Pa 231.0 Protactinium	92 U 238.0 Uranium	93 Np [237.0] Neptunium	94 Pu [239.1] Plutonium	95 Am [241.1] Americium	96 Cm [244.1] Curium	97 Bk [249.1] Berkelium	98 Cf [252.1] Californium	99 Es [252.1] Einsteinium	100 Fm [257.1] Fermium	101 Md [258.1] Mendelevium	102 No [259.1] Nobelium	103 Lr [262.1] Lawrencium

Where the atomic weight is not known, the relative atomic mass of the most common radioactive isotope is shown in brackets.
The atomic weights of Np and Tc are given for the isotopes ^{237}Np and ^{99}Tc.

This sheet should be REMOVED for your convenience.

Question 16. (3 marks)

(a) Marks	Marking criteria
2 marks	Uses $\tau = nBIA$ to show correctly $\tau = 24 \times 0.2 \times 25 \times 10^{-3} \times 8 \times 10^{-4}$ $= 9.6 \times 10^{-5}$ N m (ignore units)
1 mark.	uses $\tau = nBIA\cos\theta$ and fully substitutes all values into equation but does not convert I (from mA to A) and/or A (from cm^2 to m^2) OR/ if fully substitutes into above equation but leaves answer with $\cos\theta$ OR/ correctly converts both I and A but leaves B out/or transposes incorrectly OR/ correctly converts both I and A but leaves n out. OR/ if fully substituted but area is taken as $(0.08)^2$ OR/ if fully substituted with correct conversion but area wrong value
0 marks	If both n and A incorrect OR/ If I incorrectly converted and A incorrect.

Notes:
(i) units for torque Nm
(ii) some candidates calculated a value for B by using $\Phi = BA$ and substituting $0.2 = B \times 0.08$

(b) 1 mark

Marks	Marking criteria
1 mark	using $\frac{\text{Ans(a)}}{\text{restoring torque } (=2.0\times10^{-6})}$ = degrees coil turns through. $= \frac{9.6\times10^{-5}}{2\times10^{-6}} = 48^\circ$

Question 17 (8 marks)

(a) 2 marks (maximum).

Marks	Marking criteria
2 marks	Explanation in terms of reducing eddy currents and therefore improves efficiency (or reduces energy losses).
1 mark.	Mentions one of reducing eddy currents or improves efficiency only

Sample Answer:
The presence of a changing magnetic flux in the soft iron core causes eddy currents in the core (by Faraday's Law of Electromagnetic Induction). The iron core is laminated to reduce the eddy currents, thereby improving the efficiency of the transformer by reducing energy losses due to the heating effects of eddy currents.

(b) 2 marks (maximum)

Marks	Marking Criteria
2 marks	Candidate explains that the secondary coil needs to experience a change in flux to produce an induced emf. Explains that AC in the primary coil produces this changing magnetic flux whereas DC produces only a constant flux
1 mark	Explains only one of the points above.

Sample Answer:

AC voltage sets up a changing magnetic flux in the core that is necessary to induce a voltage in the secondary coil. As DC is constant, the magnetic field would not be changing so $\Delta\Phi = 0$ ∴ no emf induced in the secondary coil.

(c) 1 mark (maximum)

Marks	Marking criteria
1 mark.	Identifies $V_P/V_S = n_P/n_S$ as the relevant relationship. Substitutes to show that. $V_S = 240 \times 30/60 = 120V$

(d) 3 marks (maximum)

"Discuss..." identify issues and provide points fo

Marks	Marking criteria
3 marks	Candidate mentions (or implies) that the required voltage may be higher or lower than 240V. Describes at least two correct/accurate reasons as to why electrical appliances in the home connected to the mains supply use a transformer. Each reason is supported with a named appliance. Reasons include: voltage changes because appliance foreign made; maximised operating efficiency; appliance requires more current; impairs its function; make it safer; lower current due to delicate circuits; prevent overheating.
2 marks	Candidate mentions (or implies) that the required voltage may be higher or lower than 240V. Describes one reason as to why electrical appliances in the home connected to the mains supply use a transformer. The reason is supported with a named appliance Reasons as per the above list.
1 mark.	Candidate mentions (or implies) that the required voltage may be higher or lower than 240V. but fails to give issues or if issue(s) given not supported with specific examples

Sample Answer.

The required voltage for the appliance may be higher or lower than 240V. Portable electrical appliances contain a step-down transformer (e.g. computer circuitry) which converts the 240V domestic supply down to a lower, normal operating voltage for the correct and safe use of IC circuits. Televisions have step up transformers to produce the high voltages needed to drive the electron gun in the picture tub.

Class

Student Number

Question 18 (2 marks) **Marks**

The planet Mars has a mass of 6.42×10^{23} kg and a radius of 3.40×10^{6} m. Calculate the escape velocity at the surface of Mars. 2

$v = \sqrt{\frac{2GM}{r}}$ $\therefore v = \sqrt{\frac{6.7\times10^{-11} \times 6.42\times10^{23}}{3.4\times10^{6}}}$

(1) method.

$v = 5034 \times 10^{3}\ ms^{-1}$ (1)

5.03

Question 19 (4 marks)

A satellite of mass 100 kg performs a circular orbit, 1000 km above the surface of the Earth. The radius of the Earth is 6.40×10^{6} m.

(a) Calculate the gravitational force acting on the satellite. 2

$F = \frac{G m_1 m_2}{r^2} = \frac{6.7\times10^{-11} \times 100 \times 6.0\times10^{24}}{(6.4\times10^{6} + 1\times10^{6})^2}$ (1) method

$\therefore F = 734\ N$ (1)

98! if not adding 1×10^{6}

734 N 730.8

(b) Calculate the time taken by the satellite to complete one revolution of the Earth. 2

(1) method

$\frac{mv^2}{r} = 734.1 \quad \therefore \frac{m 4\pi^2 r^2}{T^2 r} = 734.1$

$\therefore T = \sqrt{\frac{100 \times 4\pi^2 \cdot (7.4\times10^{6})}{734.1}} \quad \therefore T = 6.3\times10^{3}$ s. (1)

(1 hr 45 min)

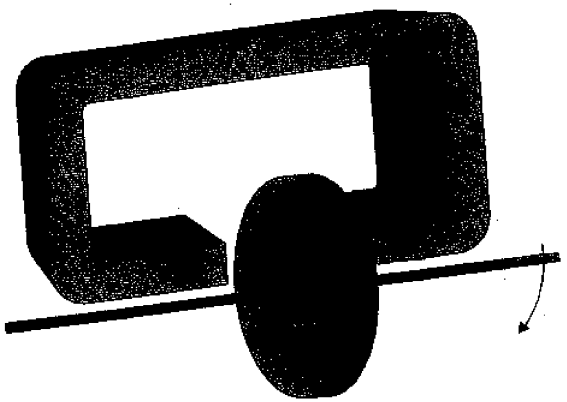
Class

Student Number

Marks

Question 20 (3 marks)

Electromagnetic braking can be achieved by applying a strong magnetic field to a spinning metal disc attached to a shaft as shown below.



(a) Identify and explain how the magnetic field slows the spinning of the disc. **2**

• motion of conductor in $\vec{B}$ induces eddy currents. (1)

• Force of $\vec{B}$ on eddy currents opposes motion (Lenz's Law) (1)

(b) Would the brakes work if the disc was plastic instead of metal? Explain your answer. **1**

No. Plastic is insulator ∴ no eddy current ∴ no force on eddy current. (Lenz's Law doesn't apply.) (1)

Class

Student Number

Question 21 (2 marks) **Marks**

Light of wavelength 6×10^{-9} m is incident on a sodium surface. The work function (i.e. the minimum energy required to emit an electron) of sodium is 2.9×10^{-19} J. Calculate the maximum kinetic energy of the electrons ejected from the sodium by this light. **2**

$\lambda = 6.0 \times 10^{-9}$ m ; $\phi = 2.9 \times 10^{-19}$

$E_k = hf - \phi = \dfrac{6.626 \times 10^{-34} \times 3 \times 10^{8}}{6 \times 10^{-9}} - 2.9 \times 10^{-19}$ (1)

$E_k = \dfrac{hc}{\lambda} - \phi$ $\quad \therefore E_k = 3.28 \times 10^{-17}$ J (1)

Question 22 (4 marks)

Give an example of a modern device that uses a cathode ray tube and outline its operation. **4**

(1) for most of the bits

(1) for all of bits

(1) for good description of how it works

(1) for how it conveys information i.e. how a signal is displayed.

This is only a guide. I graded this ∴ no marks Any

Class

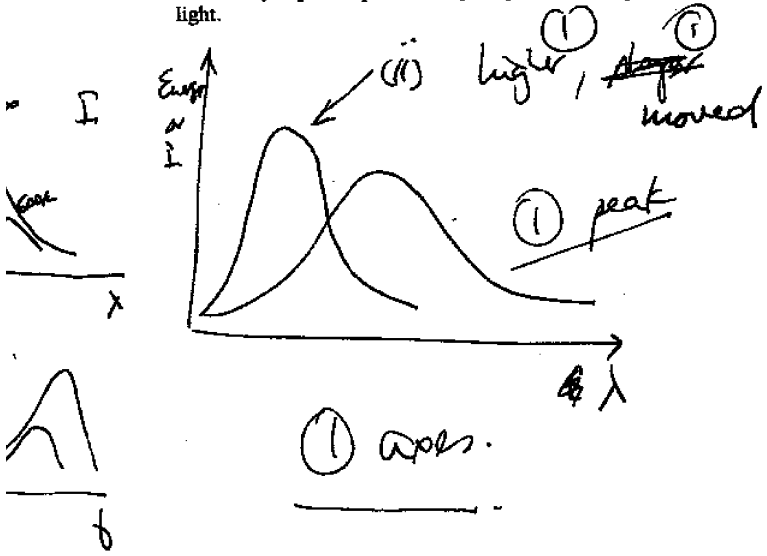
Student Number

Question 23 (5 marks) **Marks**

(a) What do physicists mean by the term 'black body'? 1

A perfect emitter or absorber of radiant energy

(b) (i) Sketch a graph to show how the intensity of light emitted by a black body depends upon the frequency (or wavelength) of the light. 2



(ii) Add to your graph a second sketch for the light intensity of the same body at a higher temperature. Make sure you distinguish clearly between the two sketches. 2

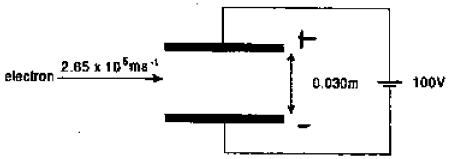
(ii) higher, (1) (1) moved

Class

Student Number

Question 24 (5 marks) **Marks**

An electron travelling at a velocity of 2.65×10^5 ms^{-1} passes horizontally between two parallel, horizontal electric plates 0.030 m apart and connected to a potential difference of 100 V.



(a) Calculate the electric field strength between the horizontal plates. 1

$\mathcal{E} = \frac{V}{d} = \frac{100}{0.03} = 3,333 \text{ Vm}^{-1}$ (1)

(b) What is the electrostatic force acting on the electron in the region between the plates? 2

$F = \mathcal{E}q = 3,333 \times 1.6 \times 10^{-19}$ N

$= 5.3 \times 10^{-16}$ N up (1)

(1)

(c) What magnetic field must be applied to the electron to allow it to pass between the plates undeflected? 2

$(b) = Bqv$ (1)

$\therefore B = \frac{(b)}{qv} = 1.26 \times 10^{-2}$ T (1) answer

$= \frac{5.3 \times 10^{-16}}{1.6 \times 10^{-19} \times 2.6 \times 10^{5}}$

Form VI Physics Trial Examination Crib –Questions 25-29

Some General Comments on the Open-Ended Questions

NB these questions were NOT marked on a 'mark per point' basis. Rather, they were marked in accordance with the Board of Studies' Performance Bands. They will *only* be accepted for remarking if they have been blatantly mismarked. If your interpretation of your answer differs from mine, my mark stands!

These questions were not well answered.

The most common failings were:

Not outlining significant concepts

e.g. discussing the photo-electric effect without saying what it is, or without defining what a photon is.

Ambiguity or Imprecision

e.g. *'the intensity is proportional to the photoemission'*

the intensity of what? what aspect of the photoemission?

Non Sequiturs

e.g. *'Michaelson-Morley experiment showed that the aether did not exist, therefore Einstein was proved correct'*

the link between the two must be elucidated.

Not using diagrams

Writing two paragraphs of barely coherent text is **never** a substitute for a decent diagram. 'Describe' does not simply mean words!

Qualitative not Quantitative Answers

e.g. *'the energy of a photon depends on its frequency'* rather than *'E=hf'*

25.

For full marks, the following were required:

1. **MM attempted to determine the velocity of the Earth through the aether, by measuring the speed of light relative to the Earth.**
2. **Despite repeating the experiment six months later – when the velocity of the Earth relative to the aether might have been expected to have changed substantially – no change in the velocity of light relative to the Earth was observed.**
3. **This provided corroborating evidence for SR as it accorded with Einstein's suggestion that the speed of light is a constant for all observers.**

Most common mistakes:

'MM proved the aether did not exist'	how can you prove something does not exist?
'the speed of light is constant'	must have 'for all observers' or similar

Some of the best answers started with the postulates of SR and showed how MM was consistent with them.

NB It is not historically true to say that MM *led to* SR. However, in the context of an otherwise correct answer, this was not penalised.

26.

Ans: **0.6c** or **1.8×10^8 m/s**

(1 mk for correct use of formula (i.e. / and /, the right way round))

27.

a) 90 degrees

b) 5 marks for:
- curve starts at zero
- two complete periods shown
- correct shape (ie sine wave, not rectified)
- axes correct and labelled
- correct numerical values on both axes

c) either:

Energy considerations suggest that electrical energyis consumed only when a load is applied. Mechanical energy must therefore only be supplied when the bulb is connected i.e. work must be done to turn the generator.

or:

A current can only flow when a load is connected. The current produces a force within the coil that – formLenz's Law – acts to oppose the change in motion, and therefore make the coil more difficult to turn.

One mark only if the answer does not explain why *the coil is harder to turn.*

28.

For full marks and answer should contain most or all of the following:

1. **A lucid description of the experimental method, including a diagram.**
2. **An outline of what data should be taken and how.**
3. **An appreciation of the practicalities of the experiment.**
4. **An appreciation that, if the two directions are independent, then $a_H=0$, $a_V=-g$.**
5. **A discussion of how the data can be quantitatively analysed to verify that the two directions are indeed independent.**

Comments:

1. Too many written descriptions of the method were ambiguous. In most cases, diagrams would have improved the answer.
2. There was little regard to the practicalities of the experiment, e.g. '*shoot a person from a cannon …*'
3. The phrase '*the data can be analysed to show that H and V are independent*' is not a substitute for actually using Newton's Equations of Motion to show it yourself.

29.

For full marks, the following are required:

1. **An outline of the photoelectric effect.**
2. **At least *two* pieces of experimental evidence that the wave model could not explain.**
3. **A description of a photon as a quanta of light energy, including the expression E=hf.**
4. **A discussion of how the photon model successfully explains the experimental observations given earlier.**

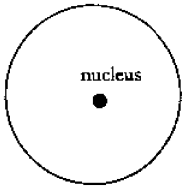
Comments:

1. An incredible number of people did not bother to outline what the photoelectric effect is. Without a context, comments like *'as the frequency is increased, the stopping potential increases'* are meaningless.
2. Most people lost marks for failing to adequately explain *why* the photon model explained the observed effects. Simply stating *'the photon model accounts for this'* or something similar is not enough.

Quanta to Quarks crib SRW

(a) Dense,tiny nucleus/electrons orbit nucleus/nucleus contains all of the positive charge and most of the mass (any two)

1 mark for diagram



Electrons in orbit

b) Fired electrons at nickel and observed a diffraction/interference pattern (1 mark)
Electrons have wave properties (1 mark)

c)i)Angular momentum of electrons is quantised and hence energy of electrons is quantised (1mark) (Must mention that angular momentum is quantised. Just stating that the energy was quantised without any justification was not accepted)
Electrons lie in stationary states where they don't radiate (1mark)
Energy in the form of e-m waves is emitted when electrons jump from a higher to lower orbit producing the Balmer spectrum (1 mark)

ii) $1/\lambda = 1.097 \times 10^7 (1/2^2 - 1/3^2)$ (1mark)
$\lambda = 6.56 \times 10^{-7}$ m (1mark)

If you had the wrong substitution you got 1 mark

iii) $c = f\lambda = 4.57 \times 10^{14}$ Hz (1mark)

d) i) Particles have wave properties given by $\lambda = h/p$ (1mark)
Many candidates talked about DeBroglie/Schrodinger's model of the atom in terms of integral numbers of wavelength. This is not the DeBroglie hypothesis but a model of the atom derived from it.

The hypothesis was startling for many reasons

1. In classical physics particles and waves are completely separate and do not have a wave-particle duality. (1 mark)

or

2. The proposal was made before there was experimental evidence (1 mark)

ii) $\lambda = h/p = 7.27 \times 10^{-8}$ m (1mark)

e) i) ${}_{36}X^{92}$ or Krypton –92 (1 mark)
ii) Nuclear Fission (1 mark). I did not accept transmutation or chain reaction. Transmutation is far too vague and chain reaction presupposes that the neutrons are going to hit other uranium atoms which is no where indicated in the equation.

iii)mass defect= (3.344 + 5.0089) x 10^{-27} kg (1mark) – (6.6463+1.6749) x 10^{-27}kg (1mark)
mass defect = 0.0317 x 10^{-27} kg (1mark)

iv) E = mass defect x c^2 = 2.853x 10^{-12} J

f) In Beta decay it was found that the following conservation laws did not appear at first to hold true. n→ p+ e^{-1} + ?

1. Momentum was not conserved (1mark)
2. Kinetic energy was not conserved (1mark)
3. The Kinetic energy of the electron was distributed across a range of values whereas mechanics predicts it should have just one energy. (1mark)
4. Angular momentum as given by the spin of the particles +- ½ was not conserved. (1 mark).

Maximum of three marks.
All of the above led Pauli to propose the existence of a third neutral particle.

(Many candidates talked about mass defect. This is not sensible as in all nuclear reactions there is a mass defect. The mass of the neutrino is so small anyway that its mass could not have even been detected at the time. What is important however is the apparent energy loss)

g) In a controlled fission reaction the numbers of neutrons which then go onto to cause fission in other Uranium atoms is limited by control rods made from Cadmium or Boron which absorb neutrons (1 mark)/

(many candidates confused moderators with control rods. Moderators will actually speed of the reaction as they slow down the neutrons so that they can more efficiently cause fission in Uranium)

In an uncontrolled fission reactions the neutrons emitted are highly likely to cause subsequent fission reactions and since 2 or 3 are emitted at a time this results in a rapid build up of neutrons and fission reactions releasing an enormous amount of energy. (1mark)