Sydney Grammar School

2001
HIGHER SCHOOL CERTIFICATE
TRIAL EXAMINATION

Class: ______

Student Number: ______

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) (B) ● (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 79; Symbol of element Au; Atomic Weight 197.0; Name of element 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 65.39 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 Lanthanides	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 Actinides	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	114 Uuq — Ununquadium	115	116 Uuh — Ununhexium	117	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)

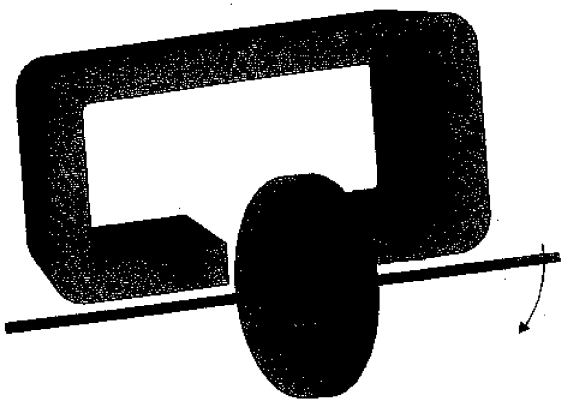
Class

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

Marks

Question 21 (2 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

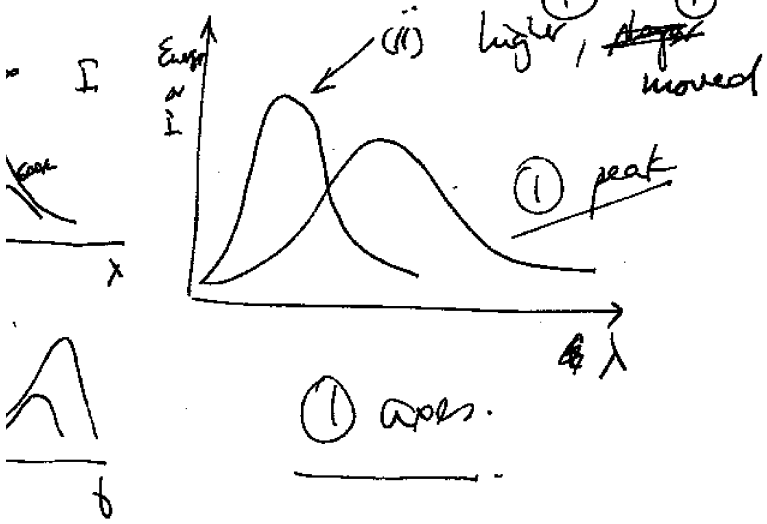
Student Number

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



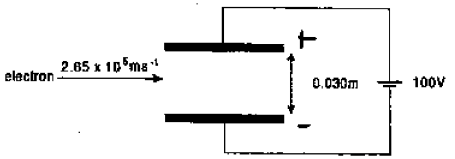
(ii) Add to your graph a second sketch for the light intensity of the same body at a higher temperature. Make sure you distinguish clearly between the two sketches. 2

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.**

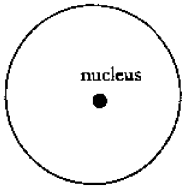
Comments:

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. $n \rightarrow p + e^{-1} + ?$

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)