

Class \_\_\_\_\_  
Student Number \_\_\_\_\_

# Physics

## Section I Part A

### ANSWER SHEET

2001  
HIGHER SCHOOL CERTIFICATE  
TRIAL EXAMINATION

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)

#### 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.

PERIODIC TABLE OF THE ELEMENTS

I 1.008 Hydrogen																		2 4.003 Helium	
3 6.941 Lithium	4 9.012 Beryllium																	10 20.18 Neon	
11 22.99 Sodium	12 24.31 Magnesium																	18 39.95 Argon	
19 39.10 Potassium	20 40.08 Calcium	21 44.96 Scandium	22 47.87 Titanium	23 50.94 Vanadium	24 52.00 Chromium	25 54.94 Manganese	26 55.85 Iron	27 58.93 Cobalt	28 58.69 Nickel	29 63.55 Copper	30 65.39 Zinc	31 69.72 Gallium	32 72.61 Germanium	33 74.92 Arsenic	34 78.96 Selenium	35 79.90 Bromine	36 83.80 Krypton		
37 85.47 Rubidium	38 87.62 Strontium	39 88.51 Yttrium	40 91.22 Zirconium	41 92.91 Niobium	42 95.94 Molybdenum	43 98.91 Technetium	44 101.1 Ruthenium	45 102.9 Rhodium	46 106.4 Palladium	47 107.9 Silver	48 112.4 Cadmium	49 114.8 Indium	50 118.7 Tin	51 121.8 Antimony	52 127.6 Tellurium	53 126.9 Iodine	54 131.3 Xenon		
55 132.9 Cesium	56 137.3 Barium	57-71 Lanthanides		72 178.5 Hafnium	73 180.9 Tantalum	74 183.8 Tungsten	75 186.2 Rhenium	76 190.2 Osmium	77 192.2 Iridium	78 197.0 Platinum	79 197.0 Gold	80 200.6 Mercury	81 204.4 Thallium	82 209.0 Lead	83 209.0 Bismuth	84 [210.0] Polonium	85 [210.0] Astatine	86 [222.0] Radon	
87 [223.0] Francium	88 [226.0] Radium	89-103 Actinides		104 [261.1] Rutherfordium	105 [262.1] Dubnium	106 [263.1] Seaborgium	107 [264.1] Bohrium	108 [265.1] Hassium	109 [268] Meitnerium	110 Uuo	111 Uuh	112 Uub	113 Uuq	114 Uuq	115 Uup	116 Uub	117 Uuq	118 Uuo	
Lanthanides																			
57 138.9 Lanthanum	58 140.1 Cerium	59 140.9 Praseodymium	60 144.2 Neodymium	61 [146.9] Promethium	62 150.4 Samarium	63 152.0 Europium	64 Eu	65 157.3 Gadolinium	66 158.9 Terbium	67 162.5 Dysprosium	68 164.9 Holmium	69 167.3 Erbium	70 168.9 Thulium	71 173.0 Ytterbium	72 175.0 Lutetium				
Actinides																			
89 [227.0] Actinium	90 232.0 Thorium	91 231.0 Protactinium	92 238.0 Uranium	93 [237.0] Neptunium	94 [239.1] Plutonium	95 [241.1] Americium	96 [244.1] Curium	97 [249.1] Berkelium	98 [252.1] Californium	99 [257.1] Einsteinium	100 [257.1] Fermium	101 [258.1] Mendelevium	102 [259.1] Nobelium	103 [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 <sup>237</sup>Np and <sup>99</sup>Tc.

This sheet should be REMOVED for your convenience.

Question 16: (3 marks)

Marks	Marking criteria
2 marks	Uses $T = n B I A$ to show correctly $T = 2A \times 0.2 \times 25 \times 10^{-3} \times 8 \times 10^{-4}$ $= 9.6 \times 10^{-5} \text{ Nm (units)}$
1 mark	uses $T = n B I A \cos \theta$ and fully substitutes all values into equation but does not convert I (from mA to A) and/or A (from $\text{cm}^2$ to $\text{m}^2$ ) 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  
OR/  
If both  $n$  and A incorrect  
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 $\text{Ans (a)}$ restoring torque $(= 2.0 \times 10^{-6})$ $= \frac{9.6 \times 10^{-5}}{2 \times 10^{-6}} = 48^\circ$

Question 17 (8 marks)

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

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  $\Delta\Phi = 0$   
 $\therefore$  no emf induced in the secondary coil.

(c) 1 mark (maximum).

Marks	Marking criteria
1 mark.	<p>Identifies <math>V_p/V_s = N_p/N_s</math> as the relevant relationship. Substitutes to show that. <math>V_s = 240 \times 30/60 = 120V</math></p>

(d) 3 marks (maximum)

"Discuss..." identifies issues and provide points for

Marks	Marking criteria
3 marks	<p>Candidate mentions (or implies) that the required voltage may be higher or lower than 240V. Describes at least <u>two</u> 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.</p>
2 marks	<p>Candidate mentions (or implies) that the required voltage may be higher or lower than 240V. Describes <u>one</u> 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.</p>
1 mark.	<p>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</p>

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 tube.

**Question 18 (2 marks)**

Marks

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

$$v = \sqrt{\frac{2GM}{r}} \quad \therefore v = \sqrt{\frac{6.7 \times 10^{-11} \times 6.42 \times 10^{23}}{3.4 \times 10^6}}$$
  
1 method.
   

$$v = 6.3 \times 10^3 \text{ ms}^{-1}$$
  
6.03

**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  $6.40 \times 10^6$  m.

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

$$F = \frac{GM_1M_2}{r^2} = \frac{6.7 \times 10^{-11} \times 100 \times 6.0 \times 10^{24}}{(6.4 \times 10^6 + 1 \times 10^6)^2}$$
  

$$F = 734.1 \text{ N}$$
  
1 method

981 is not adding 1x10

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

$$\frac{Mv^2}{r} = \frac{M4\pi^2 r}{T^2}$$
  

$$\therefore T = \sqrt{\frac{100 \times 4\pi^2 (1 \times 10^6)^2}{734.1}} = 6.3 \times 10^3 \text{ s} \quad \text{A. 1}$$
  
1 method

Marks

Question 21 (2 marks)

2

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

$\lambda = 6.0 \times 10^{-9}$  m  
 $E_k = hf - \phi$

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

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

$$E_k = \frac{h c}{\lambda} - \phi ; E_k = 3.28 \times 10^{-17} \text{ J} \quad (1)$$

Question 22 (4 marks)

4

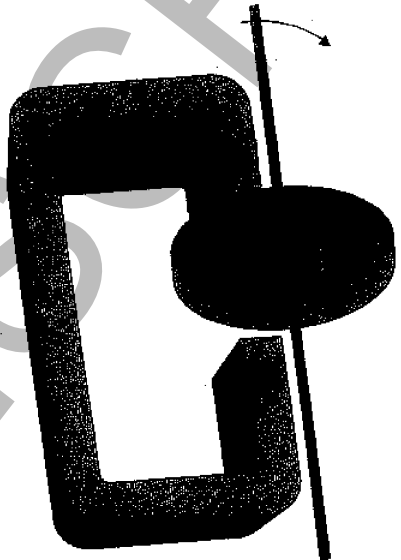
Give an example of a modern device that uses a cathode ray tube and outline its operation.

- (1) for most of the bits
  - (1) for all of bits
  - (1) for good description of how it works
  - (1) for how it convey information & how a signal is displayed.
- This is only a guide. I grade the top  $\therefore$  no marks  $\text{Any}$

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.



2

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

- motion of conductor in  $\vec{B}$  induces eddy currents. (1)
- force of  $\vec{B}$  on eddy currents opposes motion (Lenz's Law) (1)

1

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

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

Class \_\_\_\_\_  
Student Number \_\_\_\_\_

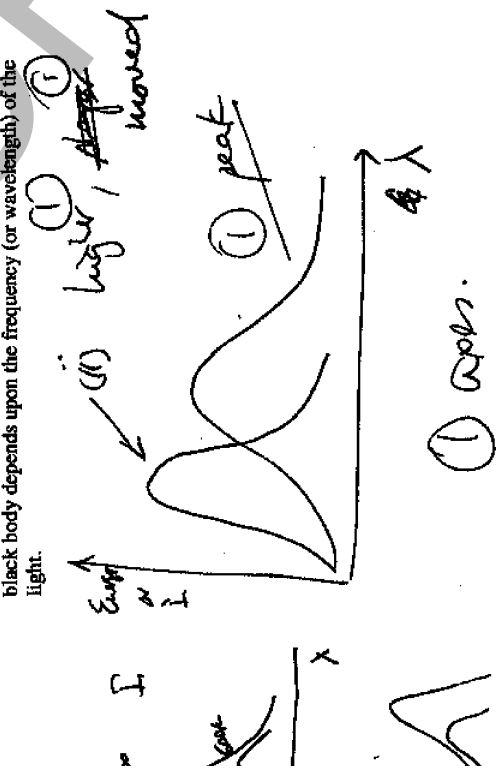
Question 23 (5 marks)

Marks

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

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.



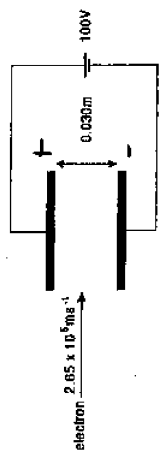
(ii) Add to your graph a second sketch for the light intensity of the same body at a higher temperature. Make sure you distinguish clearly between the two sketches.

Class \_\_\_\_\_  
Student Number \_\_\_\_\_

Question 24 (5 marks)

Marks

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



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

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

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

$$F = Eq = 3,333 \times 1.6 \times 10^{-19} = 5.3 \times 10^{-16} \text{ N}$$

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

$$(b) = Bqv$$

$$\therefore B = \frac{F}{qv} = \frac{5.3 \times 10^{-16}}{1.6 \times 10^{-19} \times 2.6 \times 10^5} = 1.26 \times 10^{-2} \text{ T}$$

## 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. '*Michelson-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  $1.8 \times 10^8$  m/s

(1 mk for correct use of formula (i.e.  $v$  and  $l$  the right way round))

27.

a) 90 degrees

b) 5 marks for:

- curve starts at zero
- two complete periods shown
- correct shape (is sine wave, not rectified)
- axes correct and labelled
- correct numerical values on both axes

c) either:

Energy considerations suggest that electrical energy 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 – from Lenz'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  $u_x = 0$ ,  $a_y = -g$ .
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:

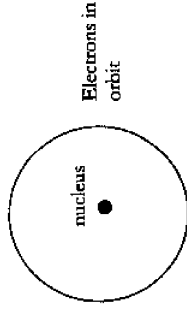
1. An outline of the photoelectric effect.
2. At least *two* pieces of experimental evidence that the wave model could not explain.
3. A description of a photon as a quantum of light energy, including the expression  $E=hf$ .
4. A discussion of how the photon model successfully explains the experimental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



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

c) Angular momentum of electrons is quantised and hence energy of electrons is quantised (1 mark) (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 (1 mark)  
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)  $1/\lambda = 1.097 \times 10^7 (1/2^2 - 1/3^2)$  (1 mark)  
 $\lambda = 6.56 \times 10^{-7} \text{ m}$  (1 mark)

If you had the wrong substitution you got 1 mark

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

d) i) Particles have wave properties given by  $\lambda = h/p$  (1 mark)  
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 starting 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)  $\lambda = h/p = 7.27 \times 10^{-8} \text{ m}$  (1 mark)

- e)  ${}_{36}^{82}\text{Kr}$  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 =  $(3.344 + 5.0089) \times 10^{-27} \text{ kg}$  (1 mark) -  $(6.6463 + 1.6749) \times 10^{-27} \text{ kg}$  (1 mark)  
mass defect =  $0.0317 \times 10^{-27} \text{ kg}$  (1 mark)

iv)  $E = \text{mass defect} \times c^2 = 2.853 \times 10^{12} \text{ J}$

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