Pymble Ladies' College

Physics

2001
Trial Examination

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Board-approved calculators may be used
- Write using black or blue pen
- Draw diagrams using pencil

Section I Total marks **(75)**
This section has two parts. Part A and Part B

Part A Multiple choice Total marks **(15)**
- Attempt Questions 1–15
- Allow about **30 minutes** for this part

Part B Extended Answers Total marks **(60)**
- Attempt Questions 16–30
- Allow about **1 hour and 45 minutes** for this part

Section II Total marks **(25)**
- Attempt ONE question - Question 31
- Allow about **45 minutes** for this section

Physics

2001
Trial Examination

Multiple Choice Answer Sheet

Select the alternative A, B, C or D that best answers the question.

Fill in the response space completely. 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.

Question	A	B	C	D
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

Section I Total marks **(75)**
This section has two parts, Part A and Part B

Part A Multiple choice Total marks **(15)**
- Attempt **Questions 1–15**
- Allow about **30 minutes** for this part

Question 1

Jill has a weight of 550 N on the earth. What is her weight on a planet with half the mass of earth and half the radius of earth?

A 69 N

B 275 N

C 550 N

D 1100 N

Question 2

Which of the following factors does not affect the escape velocity of an object from earth?

A the mass of the object

B the mass of the earth

C the radius of the earth

D the gravitational constant G

Question 3

A satellite in orbit at a distance R from the centre of the earth has a period of 12 hours. What is the period of a satellite orbiting at a distance 3R?

A 4 hours

B 21 hours

C 36 hours

D 62 hours

Question 4

Which of the following is an inertial frame of reference?

A a rocket just after takeoff

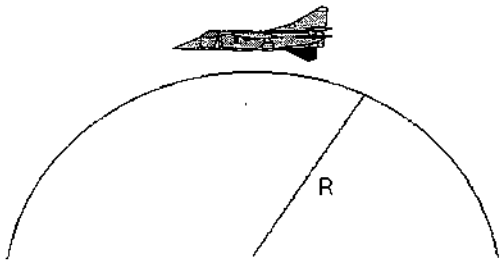
B a deep space probe without fuel

C a satellite in geostationary orbit around the earth

D a sub-orbital rocket at the point of maximum height in its trajectory

Question 5

Trainee astronauts could have the experience of 'weightlessness' by flying in a plane that is travelling in vertical, circular path, as shown in the diagram below.



What is the radius R of the vertical circle if the plane is flying at a constant speed of 20 $m.s^{-1}$ and the astronauts feel 'weightless' at the top of the circle?

A 20 m

B 40 m

C 80 m

D 160 m

Question 6

Who was the scientist who discovered that an electric current could be induced by moving a magnet near a coil of wire?

A Ampere

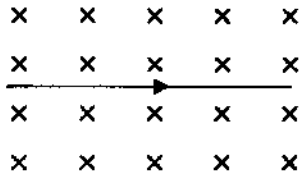
B Lenz

C Faraday

D Tesla

Question 7

The diagram below shows a current carrying wire in a magnetic field.



In which direction will the wire tend to move?

A up

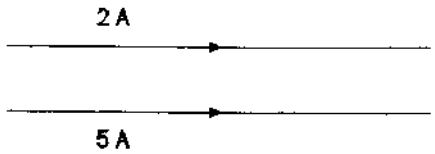
B down

C into the page

D out of the page

Question 8

Two straight current-carrying conductors are placed parallel to each other, 4 cm apart. One has a current of 2 A travelling through it and the other has a current of 5 A travelling through it. Both currents travel in the same direction.



What is the force on 1 m of the 5 A wire due to the 2 A wire?

A 5×10^{-5} N towards the 2 A wire.

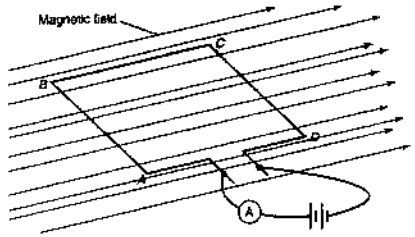
B 5×10^{-5} N away from the 2 A wire.

C 5×10^{-7} N towards the 2 A wire.

D 5×10^{-7} N away from the 2 A wire.

Question 9

The square loop shown in the diagram below has sides 50 mm x 50 mm and is supported on a central axle, parallel to the sides AB and CD. It carries a current of 5 A and is in a uniform magnetic field of 2.0×10^{-2} T.



What is the torque experienced by the loop when the plane of the loop is lying parallel to the magnetic field as shown?

A 0 Nm

B 2.5×10^{-4} Nm

C 5.0×10^{-3} Nm

D 2.5 Nm

Question 10

Which of the following methods is used to reduce energy losses in electrical transmission wires?

A using good insulation

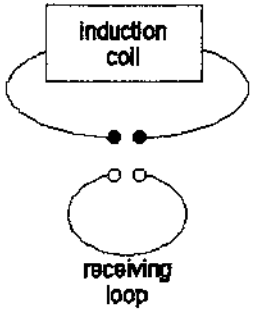
B keeping voltage as low as possible

C keeping current as low as possible

D keeping resistance as high as possible

Question 11

What was the equipment below used for?



A To demonstrate the photoelectric effect

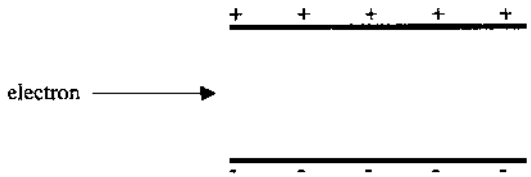
B Hertz' experiment with electromagnetic waves

C The first radio

D To demonstrate thermionic conduction

Question 12

The diagram below shows two charged, parallel plates.



An electron is fired into the space between the two plates in the direction shown. The electron will travel through without being deflected if a magnetic field is also present between the plates. What would the direction of the magnetic field have to be?

A into the page

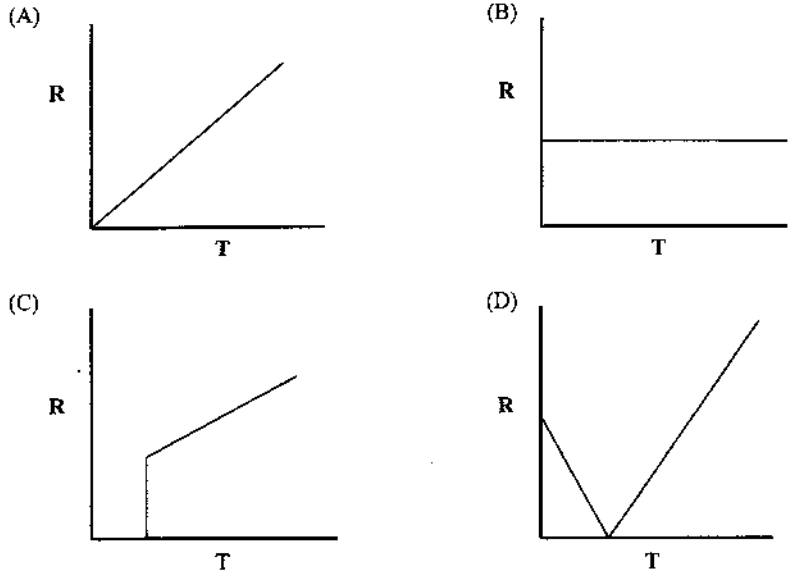
B out of the page

C towards the positive plate

D towards the negative plate

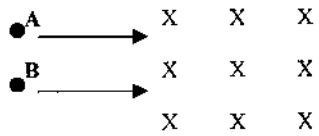
Question 13

The resistance (R) of a superconductor is plotted as a function of temperature (T).
Which graph would most closely represent the results obtained?



Question 14

Two charged particles, **A** and **B**, are fired into a uniform magnetic field as shown below.



The initial velocity of particle **A** is twice that of particle **B**.
Particle **A** has a charge of -0.5Q coulombs.
Particle **B** has a charge of +Q coulombs.
F_A is the force acting on particle **A** due to the magnetic field.
F_B is the force acting on particle **B** due to the magnetic field.

Which of the following statements is true?

A F_A is the same size as F_B.

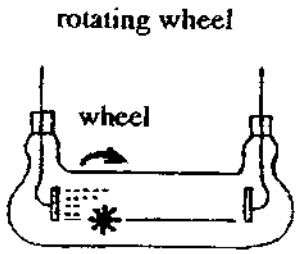
B F_A is twice the size of F_B.

C F_A is half the size of F_B.

D F_A is a quarter the size of F_B.

Question 15

The diagram below shows one of the cathode ray tubes that can be used to demonstrate the properties of cathode rays. Which of the following can be deduced from the effect observed from this particular cathode ray tube?



A Cathode rays are negatively charged.

B Cathode rays are fast moving electrons.

C Cathode rays have energy and momentum.

D Cathode rays are electromagnetic.

Part B Extended Answers Total marks **(60)**

- Attempt **Questions 16–30**
- Allow about **1 hour and 45 minutes** for this part

Question 16: (3 marks) **Marks**

Describe difficulties associated with effective and reliable communications between satellites and earth. **3**

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Question 17: (4 marks) **Marks**

A rocket is fired from its launch pad with an initial speed of 80 $m.s^{-1}$ at an angle of 35° to the horizontal.

Calculate:

(a) its total time of flight. **3**

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(b) its range. 1

Question 18: (4 marks) **Marks**

A rocket is travelling to the star closest to earth, Proxima Centauri, which is a distance of 4.3 light years away. The rocket travels at a speed of 0.7c and the time taken to accelerate and decelerate is negligible.

(a) Calculate the number of years that will pass, as measured by the crew of the rocket, as they travel to Proxima Centauri. 2

(b) Calculate the distance to Proxima Centauri, as measured by the crew, in light years. 2

Question 19: (5 marks) **Marks**

Describe a first-hand investigation to determine a value for the acceleration due to gravity using pendulum motion. 5

The relevant equation is $g = 4\pi^2 \ell / T^2$

where g is the acceleration due to gravity

ℓ is the length of the pendulum

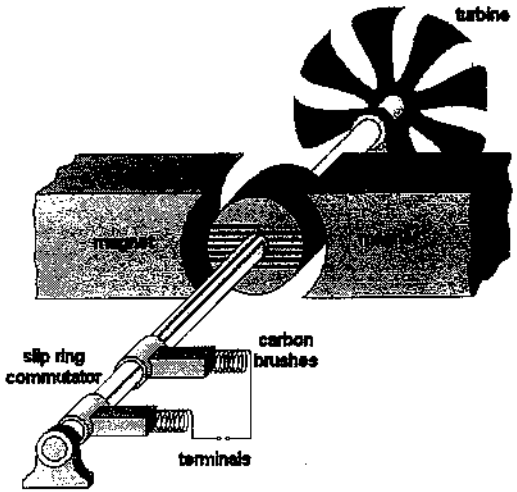
T is the period of oscillation of the pendulum

Question 20: (4 marks) **Marks**

Explain how space probes may use planets to provide a slingshot effect. 4

Question 21: (5 marks) **Marks**

The diagram below shows a generator.

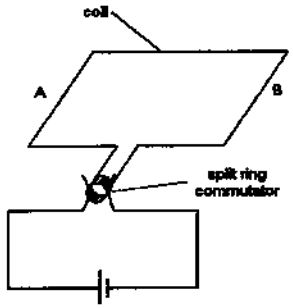


(a) Explain how the generator works. 4

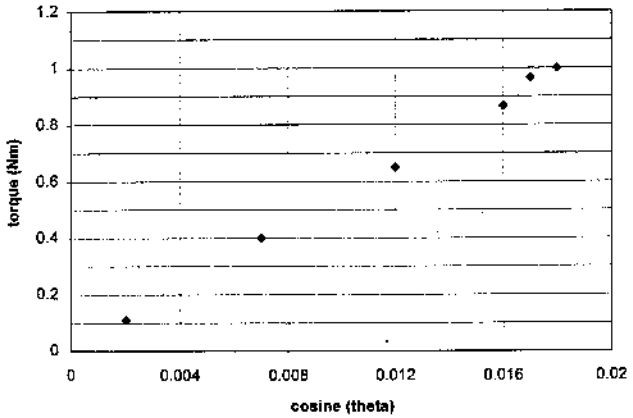
(b) Describe how this generator could be transformed into a DC generator. 1

Question 22: (3 marks) **Marks**

Below is a diagram of a square coil of wire attached to a split-ring commutator and a power source that provided a current of 2 A. The coil had 250 turn and sides of 4 cm x 4 cm.



A student placed some permanent magnets at A and B and the motor started spinning. Attaching a torque meter to the axle, the student was able to determine the torque at various angles θ (theta). The student then plotted a graph of torque (Nm) against cosine θ, as shown below.



Use the graph and the information given to calculate the strength of the magnetic field provided by the magnets. Show all working. 3

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Question 23: (3 marks) **Marks**

Explain the advantages of induction motors compared with conventional A.C. motors. 3

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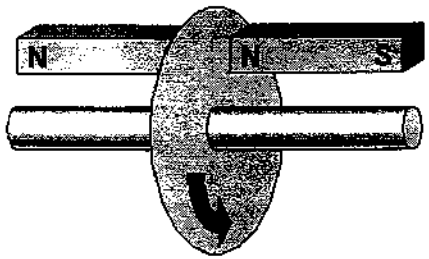
Question 24: (4 marks) **Marks**

Two magnets are brought near to a spinning aluminium disc, as shown in the diagram below.



(a) Explain what happens when the magnets are brought near. **2**

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(b) Explain how this effect could be reduced. **2**

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Question 25: (5 marks) **Marks**

A transformer has 300 turns in the primary coil and 10 turns in the secondary coil. The primary voltage is 240 V AC and the primary current is 2 A.

(a) Calculate the secondary voltage in the transformer. **1**

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(b) Explain why an experimentally observed value might be different to your answer to part (a)? **1**

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(c) Explain why some electrical appliances in the home that are connected to the mains domestic power supply use a transformer. **3**

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Question 26: (4 marks)

Outline Thomson's experiment to measure the charge/mass ratio of the electron. **4**

Question 27: (7 marks)

a) Discuss the ability of the wave model of light to explain the photoelectric effect. **4**

b) Explain the photoelectric effect using Einstein's model for light. **3**

Question 28: (3 marks)

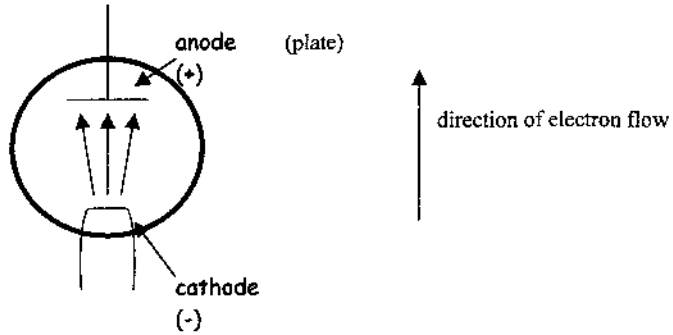
With reference to the two types of doped semiconductors, explain what the term doping means. **3**

Question 29: (2 marks)

Evaluate one current or possible future application of superconductors. **2**

Question 30: (4 marks)

The diagram below shows a thermionic device called a diode valve.



a) State what the term "thermionic" means when used for this type of diode. **1**

b) Compare and contrast the equivalent semiconductor device to the thermionic diode. **3**

Section II Total marks **(25)**
Allow about **45 minutes** for this section.
Answer **Question 31** on the writing paper provided.
Extra writing paper is available.

Question 31 – From Quanta to Quarks (25 marks) **Marks**

a) Carbon-13 is one isotope of the element carbon. With reference to Carbon explain the term "isotope". **1**

b) i) By considering the various forces within the nucleus explain why there must be a strong nuclear force. **2**

ii) State one property of the strong nuclear force. **1**

c) i) Compare and contrast a controlled and uncontrolled nuclear chain reaction **3**

ii) Explain how a controlled nuclear chain reaction is maintained in a nuclear reactor. **3**

d) Write an equation for the nuclear reaction that occurs when Plutonium-241 undergoes α decay. **2**

e) A typical fission reaction is **3**

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

Calculate the amount of energy released in this reaction.

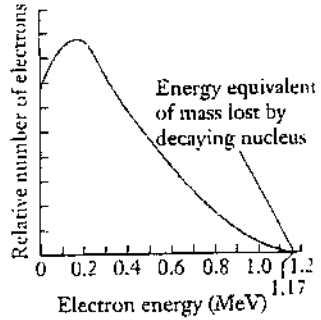
Data: ${}^{1}_{0}n$ 1.008665 u ${}^{141}_{56}Ba$ 140.9141 u

${}^{235}_{92}U$ 235.043925 u ${}^{92}_{36}Kr$ 91.9250 u

Question 31 continued on next page

Question 31 continued.

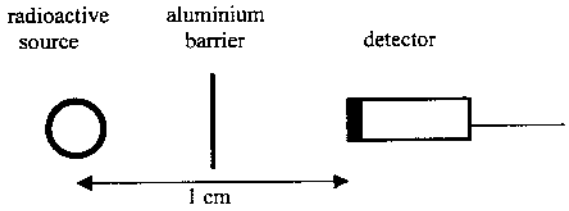
f) The graph below shows the relative number of beta particles emitted by a radioactive source as a function of the beta particle's kinetic energy.



i)Explain the difficulty in understanding this pattern of energy distribution when it was first observed. **3**

ii) Describe how this difficulty was overcome. **1**

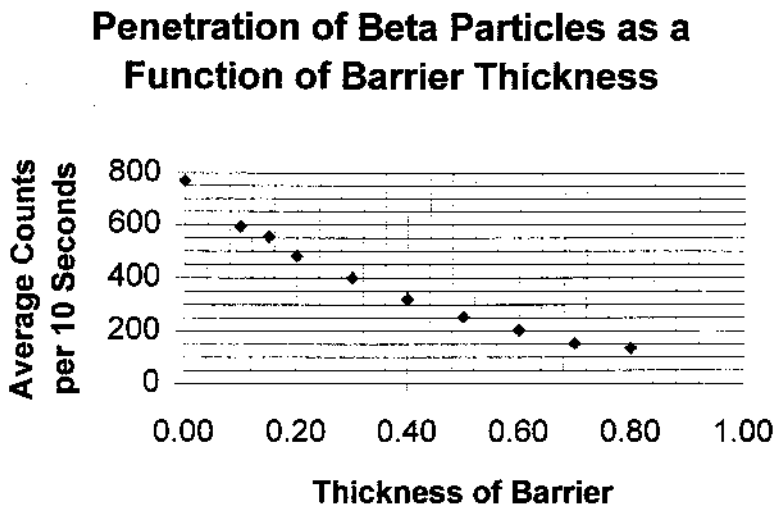
g) An experiment was done in which an aluminium barrier was placed between a radioactive source and a detector. The radioactive source emitted α particles and the number of counts during a 10 second time interval was recorded. The diagram below shows the experimental arrangement. When the radioactive source was removed, the detector registered 4 counts in the 10 second interval.



In the experiment a number of different thicknesses of aluminium were used.

The graph of the experimental results is shown below.

Question 31 continued.



Analyse the experimental results. 6

PHYSICS DATA SHEET

Numerical values of several constants

Charge on the 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 (in vacuo), c	3.00×10^8 m s^{-1}
Magnetic force constant, $\left(k \equiv \frac{\mu_0}{2\pi}\right)$	2.0×10^{-7} N A^{-2}
Universal gravitational constant, G	6.67×10^{-11} N m^2 kg^{-2}
Mass of Earth	6.0×10^{24} kg
Planck's constant, h	6.626×10^{-34} J s
Rydberg's constant, R_H	1.097×10^7 m^{-1}
Atomic mass unit, u	1.661×10^{-27} kg 931.5 MeV/c^2
1 eV	1.602×10^{-19} J
Density of water, r	1.00×10^3 kg m^{-3}
Specific heat capacity of water	4.18×10^3 J kg^{-1} K^{-1}

$c = f\lambda$

Intensity $\propto \frac{1}{d^2}$

$\frac{v_1}{v_2} = \frac{\sin i}{\sin r}$

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

$R = \frac{V}{I}$

$P = VI$

Energy $= VIt$

$v_{av} = \frac{\Delta r}{\Delta t}$

$a_{av} = \frac{\Delta v}{\Delta t} = \frac{v-u}{t}$

$\sum F = ma$

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

$p = mv$

$\Delta p = Ft$

$F = \frac{Gm_1m_2}{r^2}$

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

$m_1 + m_2 = \frac{4\pi^2 r^3}{GT^2}$

$M = m - 5\log\left(\frac{d}{10}\right)$

$\frac{I_A}{I_B} = 100^{(m_B - m_A)/5}$

$d = \frac{1}{p}$

$F = BIl\sin\theta$

$\frac{F}{l} = k\frac{I_1 I_2}{d}$

$\tau = Fd$

$\tau = nBIA\cos\theta$

$\frac{V_p}{V_s} = \frac{n_p}{n_s}$

$E_p = \frac{Gm_1m_2}{r}$

$v = u + at$

$v_x^2 = u_x^2$

$v_y^2 = u_y^2 + 2a_y\Delta y$

$\Delta x = u_x t$

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

$\frac{s}{t} = \frac{u+v}{2}$

$l_v = l_o\sqrt{1 - \frac{v^2}{c^2}}$

$t_v = \frac{t_o}{\sqrt{1 - \frac{v^2}{c^2}}}$

$F = qvB\sin\theta$

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

$E = hf$

$Z = \rho v$

$\frac{I_r}{I_o} = \frac{[Z_2 - Z_1]^2}{[Z_2 + Z_1]^2}$

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

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

Amplifier gain $= \frac{V_{out}}{V_{in}}$

$A_o = \frac{V_o}{V_+ - V_-}$

PERIODIC TABLE OF THE ELEMENTS

KEY

Atomic Number — 79 — Symbol of element
Atomic Weight — 197.0 — Name of element
Au — 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 — Ununnilium	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.

Year 12 Physics 2001
Assessment Task 5
Trial Examinations

Marking guidelines

Section I
Part A: Multiple Choice (1 mark each)

		Outcomes			Outcomes			Outcomes
1.	D	H9	6.	C	H1	11.	B	H2
2.	A	H9	7.	B	H9	12.	A	H9
3.	D	H6	8.	A	H9	13.	C	H10
4.	B	H13	9.	B	H9	14.	A	H9
5.	B	H6	10.	C	H9	15.	C	H2

Part B: Extended answers

Q.16. (3 marks)
Outcomes: H7, H13

- distance e.g. inverse square law for intensity of the signal in either direction (called 'space loss'). Special receiving devices are required to detect the weak signals. Also time delay of signals.
- Some frequencies are attenuated by the Earth's atmosphere, so microwave frequencies (which are not as attenuated as much as many other frequencies) are used.
- sunspot activity – sunspots are associated with the solar wind (a stream of charged particles, mostly protons & electrons streaming out from the sun). The solar wind affects the Earth's magnetic fields which in turn affects communication using electromagnetic radiation. When solar activity occurs, the radiation flux in the ionosphere is quite variable. Ionisation of gases will vary which refract the signals and will also cause scintillation which results in the signal varying in intensity and phase.
- van Allen radiation belts – two belts of charged particles (mostly protons & electrons) forming a donut-shape around the Earth). Solar activity can disrupt the van Allen belts. Changes in the magnetic field associated with the charged particles in the 'ring current' of the outer van Allen belt can cause interference of short wave radio communication and errors in communication satellites.

Marks: 1 mark each for any three points above (maximum of 3 marks).

Q.17.
Outcomes: H9

(a) Time of flight = 2 x time for rocket to reach maximum height (i.e. only the vertical component of the velocity is important for this).
Vertical motion:
To find time to maximum height (t):
If 'up' is +, then
$u_v = 80 \sin 35\ ms^{-1}$
$a_v = -9{,}8\ ms^{-2}$
$v_v = 0\ ms^{-1}$ (at maximum height)
$t = t$

$v_v = u_v + (a_v)t$
$0 = (80)(\sin 35) + (-9.8)t$
$t = 4.68$ s

Therefore, time of flight = 2 x t = **9.36s**

Marks:
- 1 mark for using correct vertical component of v
- 1 mark for correct formula and substitution
- ½ mark for 4.68 s

½ mark for 9.36 s

(b)
The range depends on the horizontal component of the velocity.
Horizontal motion:
If motion to the 'right' is +, then
$u_h = 80 \cos 35\ ms^{-1}$
$a_h = 0\ ms^{-2}$
$t = 9.36$ s
$s_h = s_h$ = Range
$\therefore$
$s_h = u_h.t$
$s_h = (80)(\cos 35)(9.36)$
$s_h =$ **613.38 m**

Marks:
- ½ mark for correct horizontal component of v
- ½ mark for 613.38 m

Q18.
Outcomes: H6

(a)
$t_v = s/v$
$t_v = 4.3/0.7 = 6.14$ yrs

$t_0 = t_v(1-v^2/c^2)^{0.5}$
$t_0 = 6.14(1 - 0.7^2c^2/c^2)^{0.5}$
$t_0 =$ **4.38 years**

Marks:
- 1 mark for 6.14 yrs
- ½ mark for correct equation
- ½ mark for 4.38 years

(b)
$L_v = L_0(1-v^2/c^2)^{0.5}$
$L_v = 4.3\ (1 - 0.7^2c^2/c^2)0.5$ (1 mark)
$L_v =$ **3.07 light years** (1 mark)

Marks:
- ½ mark for correct equation
- ½ mark for correct substitution
- 1 mark for 3.07 ly.

Q.19.

Outcomes: H2, H9, H11, H15

Marks:

- Appropriate labelled diagram (1 mark)
- Stating variables to be measured (1/2 mark)
- Stating quantities to be kept constant (& e.g. angle < 10°) (1/2 mark)
- Repeated measurements at same length (1 mark)

If length is varied:

- Graph to plot to obtain straight line (i.e. T^2 vs ℓ) (1 mark)
- How to use graph to obtain slope to calculate g. (slope = $g/4\pi^2$) (1 mark)

If length not varied:

- using formula to calculate g (1/2 mark)

Q.20.

Outcomes: H2, H7, H9, H13

The 'slingshot effect' (or 'gravity assist'):

- suitable diagram (before and after interaction with planet)

Explanation:

- *As the probe approaches the planet used for the 'slingshot effect', it speeds up due to the gravitational attraction, *relative to the planet*.
- *By Newton's 3rd Law, Venus will slow down in response, but because of its much greater mass, this is imperceptible.
- As the probe goes past the planet, it will slow down due to the gravitational attraction, *relative to the planet*.
- *However, the planet is rotating around the Sun, and its gravity drags the probe with it, causing it to increase its velocity *relative to the Sun* (as well as changing the probe's direction as required). The probe gains some of the angular momentum of the planet.

Marks:

- 1 mark for diagram.
- 1 mark for each point with a * and/or ½ mark for other point (maximum of 4 marks)

Q.21.

Outcomes: H7, H9, H13

(a) How the generator works:

- Steam or some other moving fluid would turn the turbine.
- This would induce a current in the coil of wire due to the magnetic field.
- The current would change direction every half cycle of rotation of the coil of wire producing an AC current, the frequency of which would be equal to the revolutions per second.
- The AC current flows through wires to slip rings which are attached to the carbon brushes. This allows the current to be accessed through the terminals.

Marks: 1 mark for each point or other appropriate points (maximum 4 marks)

(b)

The generator could be transformed into a DC generator by replacing the slip rings with a split ring commutator. This consists of two half cylinders connected to the wires from either end of the coil. These split rings are also connected to carbon brushes. They work by switching contact with each brush as the shaft rotates every half cycle. This ensures that the current flows in one direction only.

Marks: 1 mark for mentioning the split ring commutator.

Q.22.

Outcomes: H9, H13

$\tau = nIAB\cos\theta$

$\therefore$ in the graph of τ vs $\cos\theta$, the slope = nIAB

$\therefore B = \text{slope}/nIA$

Slope of graph = 1.1/0.02 = 55 Nm.

$B = \text{slope}/nIA = 55/(250)(2)(4 \times 10^{-2})(4 \times 10^{-2})$ = **69 T**

Marks:

If gradient of line of best fit used:

- ½ mark for line of best fit
- 1 mark for slope with units.
- 1 mark for slope = nIAB
- ½ mark for 69 T.
- subtract ½ mark if wrong order of magnitude
- subtract ½ mark if wrong or no units

If data points from graph used:

- 1½ mark if one point used.
- 2 marks if several points used and an average taken.
- subtract ½ mark if wrong order of magnitude
- subtract ½ mark if wrong or no units

Q.23.

Outcomes: H3, H4, H9, H13

- simple design
- low maintenance because there are no brushes to wear out as in other motors.
- induction motors have no sparking (sparking can be a problem in some circumstances e.g. if there

are flammable fumes around). • relatively low cost • the location of the coil relative to the magnets may affect starting (& starting direction) for conventional AC motors, but this is not a problem for induction motors. • suitable for domestic appliances
Marks: - 1 mark for any of above (to a maximum of 3 marks).

Q.24.
Outcomes: H7, H9, H13
(a) • Because the disk is spinning electrons in the metal are flowing. These are moving charged particles in a magnetic field so they will experience a force. Therefore they will move and other electrons will take their spot resulting in a current cycle. These cycles are called eddy currents and multiple eddy currents will be set up throughout the disk. • Because there is now a current flowing in the disk this will induce a force on the disk slowing it down (Lenz's law).
Marks: - 1 mark for production of eddy currents (½ if the term 'eddy currents' is not used in either (a) or (b)) - 1 mark for force opposing the motion and therefore slowing it down.
(b) The eddy currents may be overcome by cutting slits in the disk so that the electrons have nowhere to flow.
Marks: - 1 mark for slits in disc - 1 mark for explaining that this would reduce the ability of eddy currents to form.

Q.25.
Outcomes: H3, H4, H7, H9, H13
(a) $n_s/n_p = V_s/V_p$ $V_s = 240 \times 10 / 300$ $V_s = \underline{8\ V}$
Marks: - 1 mark for 8 V
(b) The transformer would not have worked at 100 % efficiency (in transferring energy from primary to secondary coils via the soft iron core connecting the coils) and therefore the potential difference across the secondary terminals would be lower than expected.
Marks: - 1 mark for loss of energy.
(c) • Some household appliances use a much smaller voltage than the mains 240 V (step-down transformer) e.g. a shaver has a small transformer in it; a laptop computer has an external transformer (external to reduce heating effects in the computer itself). • Some appliances require a much larger voltage (step-up transformer), e.g. the cathode ray tube of a TV set.
Marks: - 1 mark for statement that some appliances use voltages different from 240 V AC as supplied by the 'mains'. - 1/2 mark for step-down transformer - 1/2 mark for example using step-down - 1/2 mark for step-up transformer - 1/2 mark for example of step-up - ½ mark for safety explanation (Maximum of 3 marks)

Question 26

Outcomes: H1, H9, H13	
Criteria	**Marks**
Answers would provide a clear explanation of • the path of the cathode rays, • the use of the charged plates and the electromagnet, • the balancing of the forces on the cathode rays due to these • the measurement of relevant variables to determine the charge to mass ratio.	4
All 4 present but 1 or 2 errors minor errors or slight confusion	3.5
Only 3 of the 4 criteria above met (clear explanation)	3
Some information covering 3 criteria but with a number of errors and/or confusion	2.5
Only 2 of the criteria met (clear explanation)	2
Two criteria met but with a number of errors and/or confusion	1.5
Only one criterion met (clear explanation)	1

Question 27 Outcomes: H2, H8, H10, H13

(a)

Criteria	**Marks**
Answer indicates • waves to transfer energy - can explain electrons gaining energy • problem with threshold frequency • problem with effect of increased intensity answer needs to clearly indicate how wave model can or cannot explain photoelectric effect	4
Uses only two (must be one pro one con) and shows clearly how the wave model explains them or not.	3.5
Mentions all three but does not clearly indicate how the wave model does or does not explain them.	3
Uses only two (must be one pro one con) and does not clearly indicate how the wave model does or does not explain them	2.5
Uses two but both show inadequacy. Explanation clear and complete	2

Shows inadequacy of the model (one or two problems) but explanation unclear or contains errors.	1

(b)

Criteria	Marks
States that 1. light consists of photons (or particles) E = hf which is transferred to e's Explains clearly 2. threshold frequency using photon model 3. increase in KE of electrons when frequency increased.	3
All 3 stated/explained but a few errors or unclear in places	2.5
Only 2 and 3 of the above explained but done clearly	2
Two stated/explained but a few errors or unclear in places	1.5
Only one of 2 or 3 explained but done clearly	1
1 stated but no explanation	0.5

Question 28 Outcomes: H10, H13

Criteria	Marks
a) Describes starting material in terms of number of bonds (4) in solid b) Identifies doping involves adding small amounts of an element in group 3 (p type) or group 5 (n type) c) Describes effect in terms of bonding Covers all of these clearly	3
Covers all 3 but some confusion and/or a few errors	2.5
Covers a) and b) of the above but does so clearly	2
Covers a) and b) of the above but with some confusion or a few errors OR Covers all 3 but very confused and major errors OR Covers b) and c) clearly	1.5
Covers b) and c) with some confusion and/or a few errors OR Covers any 1 of the above but does so clearly	1
Covers any 1 of the above but with some confusion or errors	0.5

Question 29 Outcomes: H5, H3, H9, H13

a)

Criteria	Marks
Clear description of an application and an evaluation of its value compared to old technology	2
Description of an application that is not clear and an evaluation of its value compared to old technology	1.5
Clear description of an application but no evaluation of its value	1

Question 30 Outcomes: H3, H9, H13

a)

Criteria	Marks
States clearly meaning of term thermionic -heating of cathode giving energy to the electrons in the metal allowing them to move under the influence of the electric field.	1

b)

Criteria	Marks
At least 3 and from both sections Describes clearly similarities • allows current to flow in only one direction • electrons move under influence of electric field Describes clearly way in which devices differ • Size difference • No need for heating in semiconductor device • Difference in robustness • Time delay for thermionic device	3
Two comparisons only but one from each section	2.5
Three or more but from the one section	2
Two comparisons but from one section	1.5
One comparison	1

Section II (Option: From Quanta to Quarks) Marking Guidelines

Question 31

a)

Criteria	Marks
Refers to number neutrons in C-13. Compares the number of neutrons in C-13 to the number in a different isotope of carbon. OR Defines isotope in standard way (same number of protons, different number of neutrons) then uses C-13 as an example. Identifies number of neutrons and states a different isotope would have a different number of neutrons (no need to use C-12 or C-14 specifically)	1
Gives standard definition without reference to carbon	0.5

b) i)

Criteria	Marks
States • qualitatively relative size of gravitational and electrostatic forces, • larger force of repulsion and therefore a force needed to hold the nucleus together.	1
Misses one of the points above	0.5

ii)

Criteria	Marks
Any two of • force of attraction • short range • between all nucleons	2
One property only	1

c) i)

Criteria	Marks
At least 3 and from both sections Describes similarities clearly • Both consist of fission reactions • Neutron produced in one reaction goes on to cause another reaction Describe differences clearly • Average number of neutrons that cause further reactions • Rate of energy production	3
Two comparisons only but one from each section	2.5
Two comparisons but from one section	1.5
One comparison only	1

ii)

Criteria	Marks
Explains role of • moderator • control rods in maintaining average number of neutrons causing further fission at 1	3
Describes function of each but does not clearly explain effect on average number of neutrons causing further fission	2.5
Explains function of control rods only but explains clearly how they maintain chain reaction	2
Describes both in terms of slowing down or absorbing neutrons but does not attempt to link to effect on average number of neutrons causing further fission	1.5
Explains only one in terms of its effect on neutrons but not on chain reaction	1
Lists one or both parts with no further explanation	0.5

d)

Criteria	Marks
$^{241}_{94}Pu \longrightarrow {}^{237}_{92}Pa + {}^{4}_{2}He$	2
Minus 1 per mistake	

e)

Criteria	Marks
Mass of reactants = 236.052590 u Mass of products = 235.865095 u } 1 mark - 1 off per mistake Difference in mass = 0.187495 u 1 mark - 1 off per mistake 0.187495 u = 0.187495 x 931.5 Mev = 174.65 MeV (or 2.798×10^{-17} J) 1 mark 1 off per mistake 1 off for wrong units but only once in question	3

f) i)

Criteria	Marks
Clear and logical explanation • Initial theory that only daughter nucleus and beta particle produced • Fixed amount of energy released by radioactive decay which is carried away by the decay products • Little energy is taken by the large nucleus most of the energy should be taken by the electron • All the electrons should have the same amount of energy and close to the maximum released • There should not be a distribution of energies over the range from 0 to 1.7 • Energy distribution would break Law of Conservation of Energy if only 2 particles produced (2nd last point not essential)	3
All the points above but minor error or confusion OR 4 points only	2.5
4 points only but minor error or confusion OR 3 points only	2
3 points only but minor error or confusion OR 2 points only	1.5
States only that Law of Conservation of Energy broken	1

ii)

Criteria	Marks
Third decay product/neutrino proposed which took varying amounts of the energy produced	1
Existence of the neutrino proposed	0.5

g)

Criteria	Marks
• Extracted numerical data with correct units from the graph * • Identifies the dependent and independent variables • Identifies that increasing barrier thickness decreases the average count * • Identifies that the rate at which the count decreases is decreasing * • Recognises that the count does not appear to be approaching zero • Identifies that zero thickness is equivalent to count in air or with no barrier • Recognises background count and its likely effect on the counts * • Explains that increasing the thickness increases the chance of interaction with atoms in barrier	6
Points marked with * worth 1 mark Other points worth 1 mark	