JAMES RUSE AGRICULTURAL HIGH SCHOOL

2002

HIGHER SCHOOL CERTIFICATE

TRIAL EXAMINATION

Physics

Marking Guidelines

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

Part B – 60 marks
Attempt Questions 16 to 27
Allow about 1 hour and 45 minutes for this part.
Answer the questions in the spaces provided.
Show all relevant working in questions involving calculation.

Question 16 (2 marks) **Marks**

A geostationary satellite is placed at a distance of 3~~58~~00 60 km from Earth's surface. 2
Calculate the period (in days) of a satellite placed at 72000 km from the centre of the Earth.
Radius of Earth = 6.38 x 10^6 m

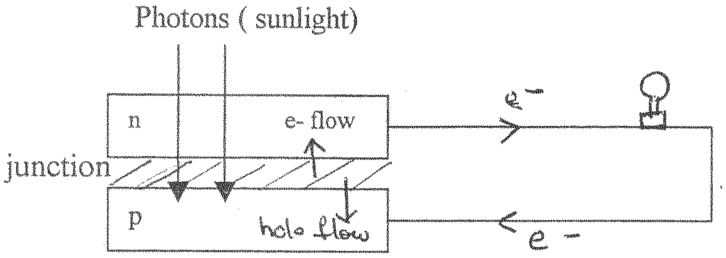
$$\frac{R^3}{T^2} = k \qquad \simeq \frac{36000 \times 10^3}{1^2} \quad T = \sqrt{2} \text{ days}$$

Question 17 (5 marks)

Solar cells make use of the photoelectric effect.
Describe the construction of a typical solar cell, and explain how it is able to produce a photocurrent. Use a labelled diagram to aid your answer.

- A solar cell converts radiant energy from the sun directly into electrical energy.
- Light energy is applied to the junction region of a semiconductor(p and n type Si)

- Electrons are released because of the photoelectric effect.
- The electro leaves a hole behind creating an e⁻ - hole pair.
- The potential barrier causes separation of these pairs, setting up an emf.
- Fine metal grid acts as electrical contacts.



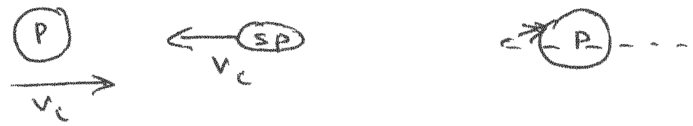
Question 18 (6 marks)

To reach the most distant planets such as Saturn and Uranus space probes require very great speeds. These space probes make use of the slingshot or gravity-assist effect.

(a) Explain how this effect works. **3**

As the space probe approaches the planet, it is accelerated by the planet's gravitational attraction, causing it to speed up relative to the planet. As the probe passes the planet, its speed is reduced relative to the planet, however, its speed has increased relative to the sun.

Include diagram showing this effect.

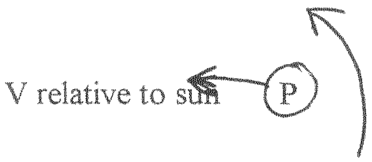


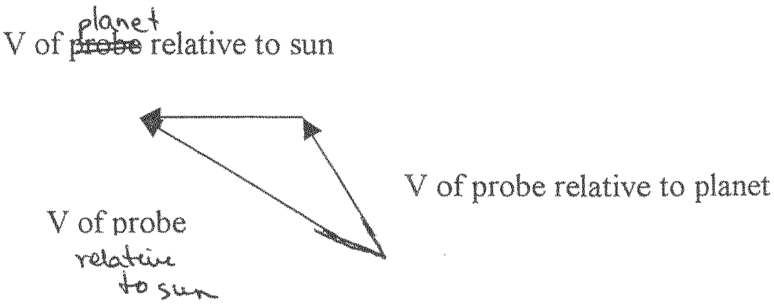
(b) Indicate where the extra energy comes from that allows the probe to leave the assisting planet faster than it arrived. **1**

Space probe picks up some of the planet's energy.

(c) Would an observer on that assisting planet agree that the probe's speed has increased? Discuss your reasons. **2**

As probe passes planet, its speed is the same relative to the observer on the planet.





Question 19 (5 marks)

The diagram shows a single – loop generator.

(a) Name the parts.

X Brush Y Slip ring

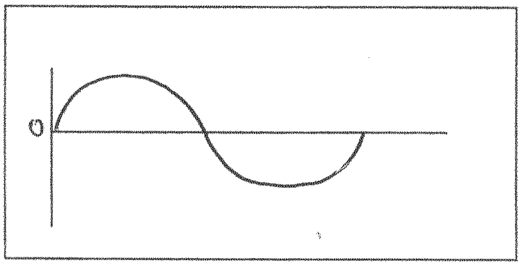
(b) What type of generator is this? Justify your answer. 2

AC generator
Slip rings are connected to the coil at its ends
Brushes make the contact with these slip rings

(c) Show on the diagram the directions of the conventional induced current flowing through the galvanometer, G. 1

From X to Y in the position shown

(d) Draw the voltage/time trace that would be obtained on a CRO from the output of this generator. 1



Question 20 (6 marks)

(a) Thomson carried out an experiment to investigate cathode rays. A simplified drawing of the equipment he used is shown. 2

What were the two main conflicting hypotheses about cathode rays that existed before this experiment?

Are cathode rays particles?
Are cathode rays waves?

(b) Referring to the diagram, in which direction will the cathode rays tend to curve as a result of the current in the coils? (Clearly indicate) 1

(c) Explain why the measurement of the radius of this curve was so important to Thompson's investigation. **2**

- Thje charge-mass ratio of the e- was determined
- The two fields were adjusted until cathode rays were moving straight.
- $F_e = F_B$
- He could calculate E and v
- He equated $qvB = \frac{mv^2}{R}$
- He could measure r directly from the tube and then calculate $\frac{q}{m}$

$$\frac{q}{m} = \frac{v}{Br} = \frac{E}{B^2r}$$

Question 21 (5 marks)

(a) Define the term 'sunspots' and explain how sunspots create problems for satellite communication. **1**

Sunspots are regions of stronger magnetic fields and cooler surface temperatures. They appear darker than the surrounding surface and seem to move across the face of the sun. Sunspots cause disruption to communication because emr is affected by magnetic fields.

(c) Explain why microwaves are preferred over radio waves for space communication. **2**

Microwaves have a frequency range 1000 – 300,000 MHz and the shorted wavelengths are more able to penetrate clouds, haze, snow . Smallere spacecraft antennae are required.

Radio waves need to be shared between FM radio stations and radio telescopes (which are very large) and interference can occur.

Question 22 (8 marks)

(a) Outline the nature of an inertial frame of reference. **1**

An inertial frame of reference is a non-accelerating frame of reference

(b) Design an investigation to help distinguish between non-inertial and inertial frames of reference. **3**

Accelerometer on trolley with masses attached or lifts accelerating up or down or rotating turntable.

Very good design must be able to distinguish clearly between the two.

(c) Explain what results will demonstrate the differences. **2**

Clear statement of result for each: inertial frame and non-inertial frame.

(d) Indicate how reliability could be improved in your investigation. **2**

Should be clearly related to the investigation designed.

Question 23 (5 marks)

(a) Distinguish between 'force' and 'torque' **2**

Force: a push or pull
Torque: the turning effect of a force applied at a distance.

(b) A circular loop of wire with radius 5.0 cm is placed in a magnetic field with strength 0.5 T. A current of 1.5 A flows in the loop. **2**

(i) Calculate the magnitude of maximum and minimum torque acting on the loop.

Max torque = nBIA = 1.03×10^{-2} Nm , Min torque: zero

(ii) How would the torque change if the loop was replaced by 50 turns of similar wire with the same radius? **1**

Increase 50 times (5.2×10^{-1} Nm)

Question 24 (6 marks)

Currents can be carried by both metallic conductors and semi-conductors.

(a) Describe the structure and properties of a metal that allow it to be a good conductor of electric current. **2**

Diagram or description showing cations in a metallic lattice with delocalised electrons.

(b) Describe the factors that influence the drift velocity of electrons through metallic resistors. **3**

Drift velocity of electrons in a conductor carrying constant current is inversely proportional to:
density of electrons, cross-sectional area and electronic charge.
(Description is necessary ~~and~~ not just listing)

(c) At low temperatures how does the resistance to the flow of electrons in good conductors compare with the resistance to the flow of electrons in semi-conductors ? **1**

In good conductors, resistance decreases with decreasing temperature.
In semi-conductors, resistance increases with decreasing temp.

Question 25 (3 marks)

A beam of monochromatic light falls onto a cold, perfect black body and imparts 0.10 mW of power to it. The wavelength of the light is 5.0×10^{-7} m.

(a) Calculate the frequency of the light. **1**

$$F = \frac{v}{\lambda} = \frac{3 \times 10^{8}}{5 \times 10^{-7}} = 6 \times 10^{14} \text{ Hz}$$

(b) Calculate the energy per photon of the light **1**

$$E = hf = 6.6 \times 10^{-34} \times 6 \times 10^{14} = 3.96 \times 10^{-19} \text{ J}$$

(c) Calculate the number of photons per second striking the black body. **1**

$$P = \frac{W}{t} \qquad \text{No. of photons} = \frac{0.11 \times 10^{-3}}{3.96 \times 10^{-19}} = 2.5 \times 10^{14}$$

Question 26 (6 marks)

The diagram shows an induction motor

(a) Discuss why it is important to have an electromagnet as opposed to a permanent magnet creating the magnetic field and how this magnetic field causes rotation. **4**

Induction motors require AC to induce the current in the rotor. A permanent magnet will not give this ac and therefore a change in magnetic flux. The lag between current and induced ac gives the phase change. This puts the rotor out of phase with the stator. This produces the turning effect.

(b) Explain why the motor produces a low power and therefore would be unsuitable for use in heavy machinery? **2**

Low current is induced in rotor and this will give a low power. Industry requires high power i.e. high current supplied by commutator.

Question 27 (3 marks)

An electric relay is a device that uses a small current in one circuit to control a large current in another circuit. For example, a large current is needed to start a car, but a small current is provided at the switch S, operated by the driver.

Use the diagram of the relay shown to explain the working of the relay R.

Switch closes and current flows through coil. This makes the soft iron core attract the iron bar. Iron bar when attracted, completes the circuit and the car motor will now be supplied with the large emf / current

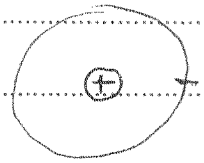
Question 28 – From Quanta To Quarks (25 marks) **Marks**

(a) Describe the similarities and differences between the Bohr and Rutherford models of the hydrogen atom. **2**

QUANTA TO QUARKS

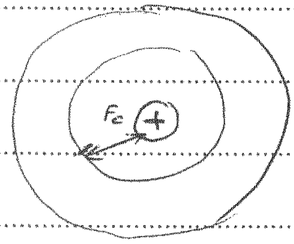
Answer Booklet   Student No...............................

a) Rutherford



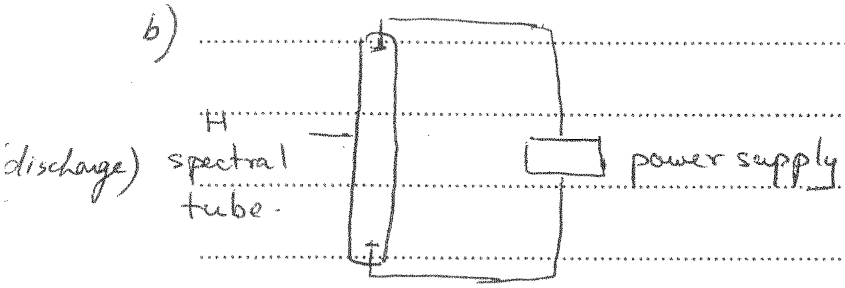
e⁻ revolving around + nucleus

Bohr



+ nucleus, with e⁻ orbitting in stable orbit.
energy of e⁻ remained constant unless it jumped into an orbit of higher or lower energy.

b)



A H discharge tube is a CRT containing $H_{2(g)}$

spectroscope.

Darken the room
Connect H spectral tube to power supply
When switched on, view the radiation produced through a spectroscope
Observe the colours of the spectral lines (and record λ)

c) In 1927, Davisson and Germer reported the diffraction of electrons.

Diffraction had been a property unique to waves until then. This was the experimental evidence that de Broglie's hypothesis needed.

Davisson and Germer were studying the reflection of e^- from a Ni target by using a narrow beam of e^- to avoid producing X-rays.

Air accidentally leaked in forming the oxide, which when baked to remove, annealed the Ni, converting it to large crystals. These crystals were larger than the width of their e^- beam.

The results were very different and they recognised that the e^- were being diffracted.

As diffraction is a property of waves, not particles, they had established that e^- had a wave nature as well as a particle nature.

d) (i) isotopes

(ii) $^{66}_{29}Cu$ then $^{66}_{29}Cu \rightarrow {}^{66}_{30}Zn + {}^{0}_{-1}e + \bar{\nu}$

(iii) β decay

Student No...............................

(e) (i) X optical/light microscope

~~(ii)~~ Y TEM transmission

~~(iii)~~ Z SEM scanning

(ii) X uses light which has a much higher λ (400 – 700 nm) and ∴ a lower resolving power. Resolving power depends on λ.

Y uses a beam of e^- with a λ of about 10 nm with a resolution of 0·2 nm, almost 1000 times better than light microscope

(f) (i) Can produce a chain reaction which can either be controlled or uncontrolled.

(ii) $^{235}_{92}U + ^{1}_{0}n \longrightarrow ^{148}_{57}La + ^{85}_{35}Br + 3\,^{1}_{0}n$.

$235{\cdot}124 + 1{\cdot}0087 \longrightarrow 147{\cdot}961 + 84{\cdot}938 + 3(1{\cdot}0087)$

$236{\cdot}1327 \qquad 235{\cdot}9251$

mass defect = $0{\cdot}2076$

B.E. $= 0{\cdot}2076 \times 931{\cdot}5 = \boxed{193{\cdot}4\ MeV}$

9) De Broglie

- e^- have wave/particle duality
- n = integral no of λ
- allowed e^- orbits were those that fitted standing waves in them.

Heisenberg

- momentum and position not simultaneously determined accurately
- idea of probability of e^- position.
- derived the same equations as de Broglie and Bohr.

Pauli

- No two e^- have all four ~~same~~ quantum no. same
- proposed that each e^- could be distinguished from others by considering their 4 quantum no.
- This explained the arrangement of e^- around atoms in the orbits ~~+~~ suborbits.
- These ideas now explain most physical and chemical properties of matter.

(Overriding statements linking all contributions)