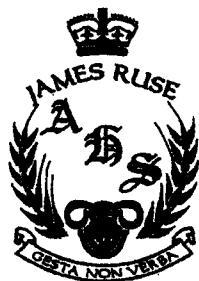# JAMES RUSE AGRICULTURAL HIGH SCHOOL

2002

HIGHER SCHOOL CERTIFICATE

TRIAL EXAMINATION

Physics

General Instructions:

- Reading time – 5 minutes

- Working time – 3 hours

- Write using black or blue pen

- Draw diagrams using pencil

- Board-approved calculators may be used

- A data sheet, formulae sheets and Periodic Table are provided at the back of this paper

- Write your Student Number at the top of pages as indicated.

Total marks - 100

Section I   Pages 2 - 18

75 marks

This section has two parts, Part A and Part B

Part A – 15 marks

* Attempt Questions 1 – 15

* Allow about 30 minutes for this part

Part B – 60 marks

* Attempt Questions 16 – 27

* Allow about 1 hour and 45 minutes for for this part

Section II   Pages 21 – 23

25 marks

* Attempt Question 28

* Allow about 45 minutes for this section

1. During a visit to the Moon an astronaut throws a rock vertically and it reaches a height of 20.0 m. Acceleration due to gravity on moon is 1.6 ms^{-2}.
   What is the speed at which it was thrown on the moon?

   (a)   25.3 ms^{-1}
   (b)   62.6 ms^{-1}
   (c)   640 ms^{-1}
   (d)   3920 ms^{-1}

2. What is the de Broglie wavelength of an electron whose speed is half of the speed of light?

   (a)   3.6 x 10^{-12} m
   (b)   4.4 x 10^{-11} m
   (c)   4.9 x 10^{-12} m
   (d)   1.2 x 10^{-11} m

3. When the speed of a DC motor drops because of an increased load, there is also a drop in one other quantity. Which quantity also decreases?

   (a)   battery voltage
   (b)   current
   (c)   back emf
   (d)   armature resistance

4. A rocket is to be launched to arrive at its destination, X. The relative positions of the Earth, Sun and X are shown in the diagram (not drawn to scale).
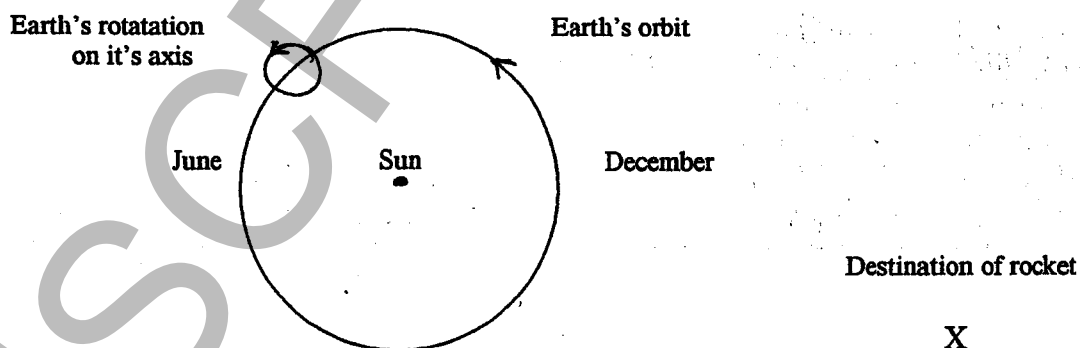
   What is the best time for launching the rocket to take advantage of the Earth's motion in space?

   (a)   September at midnight
   (b)   September at midday
   (c)   November at midnight
   (d)   November at midday

5. An atom emits a photon when one of its electrons is in a particular situation. Which situation will this be?

    (a) Electron collides with another electron
    (b) Electron exchanges quantum states with another of its electrons
    (c) Electron undergoes a transition to a quantum state of lower energy
    (d) Electron undergoes a transition to a quantum state of higher energy.

6. A 100% efficient transformer has 100 turns in its primary winding and 300 turns in its secondary. If the power input to the transformer is 60 W, the power output is

    (a) 20 W
    (b) 60 W
    (c) 180 W
    (d) 540 W

7. A battery voltage is applied across two parallel conducting plates, d_0 and d_1. The battery voltage is removed without discharging the plates.

d_1 ——————

d_0 ——————

x　　　　　　　y　　　　　　　z
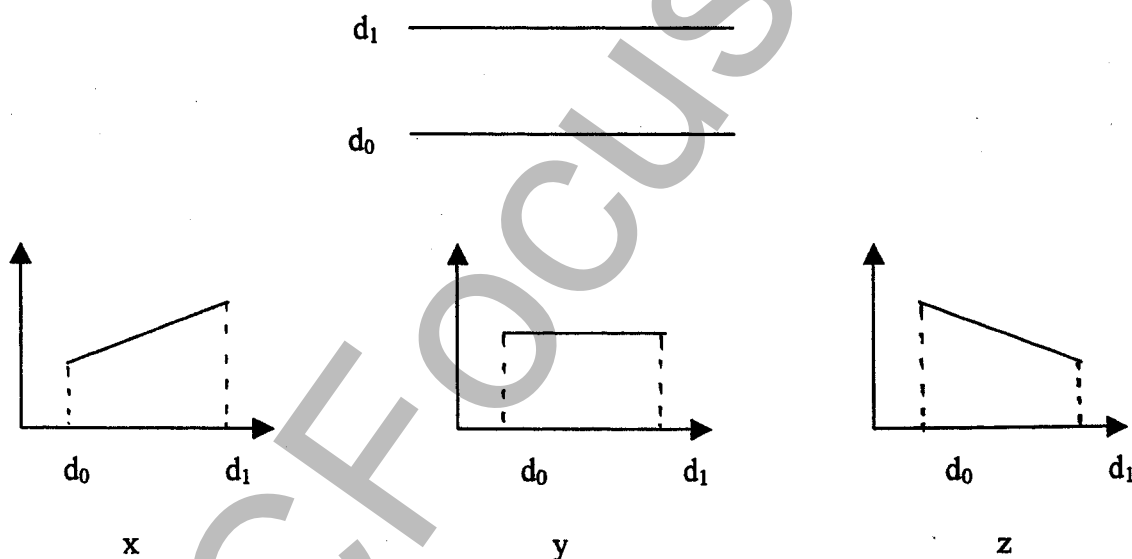
Which graphs best describe the variation in voltage difference between the plates and electric field between the plates?

	voltage difference	electric field
(a)	x	y
(b)	y	x
(c)	z	y
(d)	x	z

8. "It is not possible to detect uniform velocity motion while within a frame of reference without referring to another frame". Which principle correctly describes this statement?

   (a) The principle of constancy of velocity
   (b) The principle of uncertainty
   (c) The principle of relativity
   (d) The exclusion principle

9. A metal ring is passed with a constant velocity v through a rectangular region enclosing a magnetic field as shown in the following diagram, beginning at W and ending at Z.
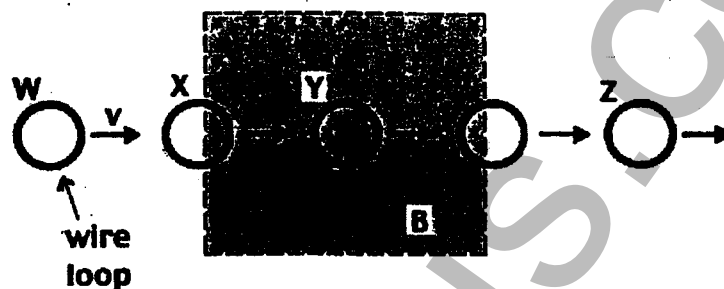
   A current flows around the coil when it is in the labelled positions

   (a) W, X, Y and Z
   (b) X and Y only
   (c) Y only
   (d) X only

10. In the construction of high power transmission lines which of the following is not a necessary precaution?

   (a) Insulating the wires from supporting structures
   (b) Protecting the main wires from lightning strikes
   (c) Separating the wires by a minimum safe distance
   (d) Keeping the current in adjacent wires out of phase

11. Which of the following orbits is most likely to suffer from orbital decay?

   (a) high-altitude circular orbit
   (b) low-altitude elliptical orbit
   (c) mid-altitude polar orbit
   (d) geostationary orbit

12. A wire 20 m long passes through the ceiling of a building carrying a direct current of 20 A from east to west. Considering the horizontal component of the earth's magnetic field at this point is 2×10^{-5} T, what is the magnitude of the magnetic force acting on the wire?

$$\longleftarrow I$$

    (a) 8×10^{-3} N
    (b) 2×10^{-5} N
    (c) 4×10^{-3} N
    (d) 1×10^{-5} N

13. An electron follows a circular path in a uniform magnetic field of strength 2.7×10^{-2} T. The speed of the electron is 5.3×10^{7} ms^{-1}.
After 2 complete orbits how much energy does the electron gain?

    (a)   0 J
    (b) 1.28×10^{-15} J
    (c) 1.79×10^{-21} J
    (d) 1.43×10^{6} J

14. Which statement is correct about Planck's hypothesis regarding the photoelectric effect?

    (a)   Radio waves are created at a right angle to the gap in an induction coil.
    (b)   The charge to mass ratio of an electron is quantised.
    (c)   Radiation absorbed and emitted by the walls of a black body cavity is quantised.
    (d)   Electrons without enough kinetic energy to cross a gap in an induction coil can do so when light is incident upon the electrons.

15. The gravitational potential energy (GPE) of a mass m at a point R from a mass M is -J joules.
What is the ratio of the GPE of m when it is R from M compared with when it is at $4R$ from M?

    (a)   -12 : 1
    (b)   12 : 1
    (c)   3 : 1
    (d)   4

Section I (continued)

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 about 36000 km from the centre of the Earth.
Calculate the period (in days) of a satellite placed at 72000 km from the centre of the Earth.

_____

_____

_____

_____

_____

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.

_____

_____

_____

_____

_____

_____

_____

_____

Question 18 (6 marks)   **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 slingshot effect works.   **3**

_____

_____

_____

_____

_____

_____

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

_____

_____

_____

_____

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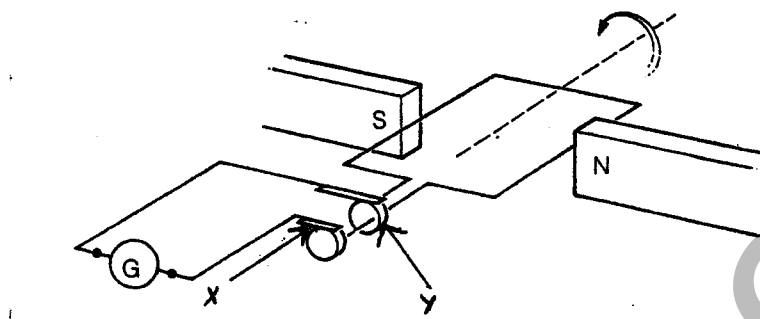
_____

_____

_____

_____

Question 19 (5 marks)

The diagram shows a single – loop generator.   **Marks**

(a)   Name the parts.

X ——————————————   Y ——————————————   **1**

(b)   What type of generator is this? Justify your answer.   **3**

_____

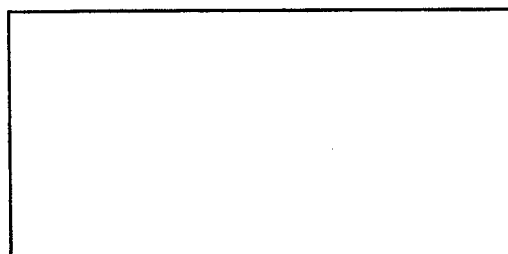_____

_____

_____

_____

_____

_____

(c)   Show on the diagram the directions of the conventional induced current   **1**
        flowing through the galvanometer, G.
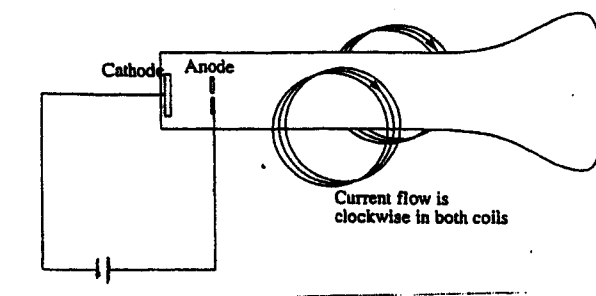
(d)   Draw the voltage/time trace that would be obtained on a CRO from the output   **1**
        of this generator.

Question 20 (6 marks)   **Marks**

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

Cathode   Anode

Current flow is
clockwise in both coils

(a) What were the two main conflicting hypotheses about cathode rays that   2
    existed before this experiment?

_____

_____

_____

_____

_____

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

_____

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

_____

_____

_____

_____

Question 20 continued on next page

(d)   What important discovery was made from the result of this experiment?   1

_____

_____

_____

Question 21 (5 marks)

(a)   Describe the nature of sunspot activity and explain how sunspots create
problems for satellite communication.   3

_____

_____

_____

_____

_____

_____

_____

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

_____

_____

_____

_____

_____

Question 22 (8 marks)

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

1

_____

_____

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

3

_____

_____

_____

_____

_____

_____

_____

_____

(c)   Explain what results will demonstrate the differences.

2

_____

_____

_____

_____

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

2

_____

_____

Question 23 (5 marks)   **Marks**

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

_____

_____

_____

_____

_____

(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.

       (i)   Calculate the magnitude of maximum and minimum torque acting on the loop.   2

_____

_____

_____

_____

_____

_____

_____

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

_____

_____

_____

Question 24 (6 marks)

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

_____

_____

_____

_____

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

3

_____

_____

_____

_____

_____

_____

_____

(c) As temperatures decrease, 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

_____

_____

_____

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.

_____

_____

(b) Calculate the energy per photon of the light

_____

_____

_____

_____

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

_____

_____

_____

_____

Marks

1

1

1

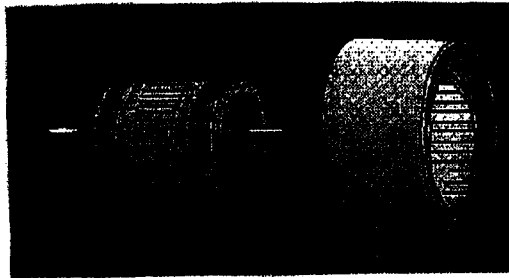**Question 26** (6 marks)   **Marks**

The diagram shows an induction motor

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

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

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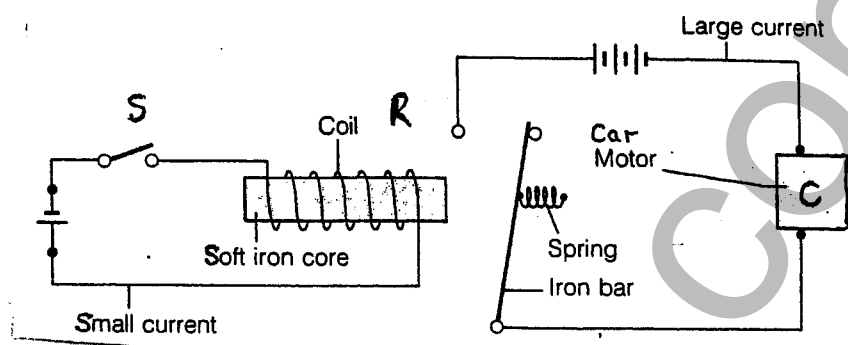   unsuitable for use in heavy machinery.

_____

_____

_____

_____

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.

_____

_____

_____

_____

_____

_____

_____

_____

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

(b) A student performed an investigation to observe the hydrogen spectrum.   **2**
Describe using a diagram how the student would have set up and used the
equipment to make the observations.

(c) Explain how the Davisson and Germer experiment confirmed de Broglie's   **3**
proposal about the nature of electrons.

(d) Between 1934 and 1938 Enrico Fermi and his co-workers bombarded many of the
elements with neutrons.

    (i) What were formed as a result of this bombardment?   **1**

    (ii) Complete the equations for one of the reactions that Fermi investigated   **2**

$$^{65}_{29}Cu + ^{1}_{0}n \longrightarrow ^{?}_{?}Cu \quad \text{then} \quad ^{?}_{?}Cu \longrightarrow ^{?}_{30}Zn + ^{0}_{-1}e$$

    (iii) What type of decay does the resulting copper nucleus undergo?   **1**

(e) The photographs show rabbit sperm cells observed using three different microscopes.
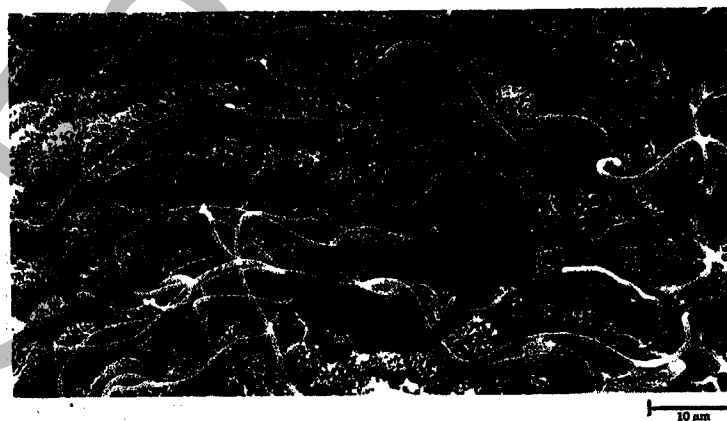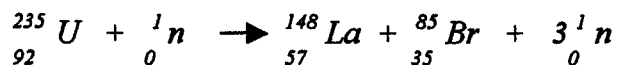
X
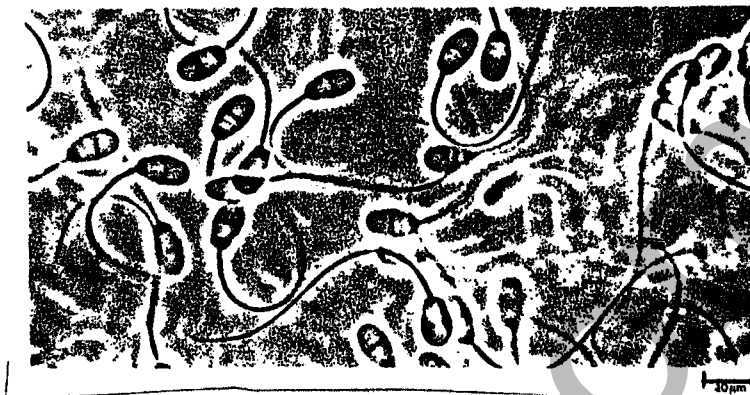
Y

Z

(i) Identify the type of microscope that would have been used to obtain each of the photographs X, Y and Z.

2

(ii) Explain why the resolving powers for microscopes X and Y are different.

2

Question 28 continued on next page

(e) A $^{235}_{92}U$ nucleus can undergo fission by this reaction:

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{148}_{57}La + ^{85}_{35}Br + 3\,^{1}_{0}n$$

(i) What is the significance of the fact that one neutron fired in, can cause three neutrons to be released?   **1**

(ii) The rest masses of some quantities are listed: **2**

$$^{235}_{92}U = 235.124\,u$$

$$^{148}_{57}La = 147.961\,u$$

$$^{85}_{35}Br = 84.938\,u$$

$$^{1}_{0}n = 1.0087\,u$$

Calculate the energy released, in MeV, from the fission of a ^{235}U nucleus undergoing the reaction above.

(f) Discuss the contributions of de Broglie, Heisenberg and Pauli to the development of atomic theory.   **7**

End of paper