HONG KONG CHINESE WOMEN'S CLUB COLLEGE

Annual Examination (2021-2022)

Secondary 6 Physics

Paper 1 - Section B

Question-Answer Book

21/01/2022 8:30 a.m. – 11:00 a.m.

Time allowed: 2.5 hours

Full mark: 135

Examination Number				
Centre				
Group				

1. Write your Examination Number in the space provided on this cover and each page.
2. This paper consists of TWO sections, Section A and B. Section A carries 51 marks and Section B carries 84 marks.
3. Section A: Answer ALL questions in the M.C. Answer Sheet provided.

   Section B: Write your answers in the spaces provided in this Question-Answer Book.
4. Supplementary answer sheets will be supplied on request. Write your Examination Number on each sheet and fasten them with string inside this book.
5. Unless otherwise specified, numerical answers should be either exact or correct to 3 significant figures.

Section A	
Section B	
Total Mark	

Stationery:
- 1 Question Paper, 15 pages (excluding white front cover)
- 1 M.C. Answer Sheet
- 1 Question-Answer Book, 18 pages (excluding coloured front cover)
- 1 Rough work sheet

Section B: Long Questions (84 marks)

1. A student builds an air cooler by putting a water-filled sponge behind an electric fan as shown in Figure 1. A small water pump keeps adding water (at room temperature) to the sponge. The fan draws warm air through the sponge. As air passes through the sponge, some of the water in the sponge evaporates and the air is cooled.

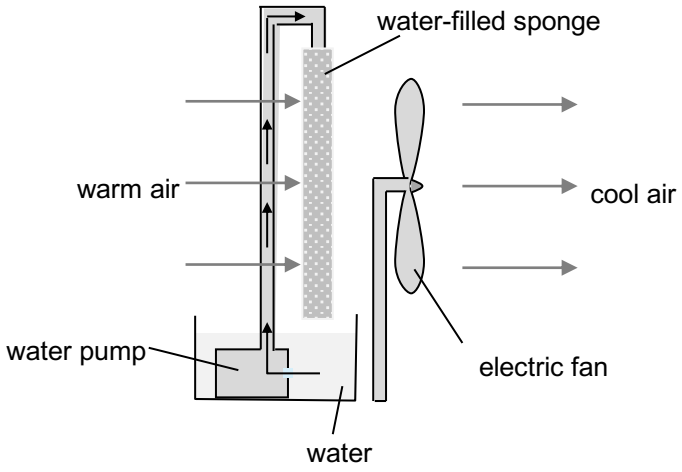

Figure 1

Given: specific latent heat of vaporization of water = 2.26×10^6 J kg^{-1}
specific heat capacity of air = 1000 J kg^{-1} K^{-1}
mass of 1 m^3 of air = 1.3 kg

(a) The student estimates that 8 m^3 of air is drawn through the cooler per minute. This causes 10 g of water in the cooler to evaporate.

(i) How much energy is needed for 10 g of water to evaporate from the sponge?

(2 marks)

(ii) Given that the cooling of air is completely due to the evaporation of water from the sponge, estimate the temperature drop. (2 marks)

(b) Explain the cooling effect of evaporation in terms of molecular motion. (2 marks)

2. A cylinder of a fire extinguisher containing a compressed carbon dioxide gas at 25 °C and 5000 kPa. The cylinder has a capacity of 0.005 m^3. Assume that the gas is ideal.
Given: mass of 1 mole of carbon dioxide gas molecules = 40 g mol^{-1}

(a) Find the number of moles of gas molecules and hence mass of the gas stored in the cylinder. (2 marks)

(b) Some gas is released from the fire extinguisher to put out the fire. Afterwards, the fire extinguisher is weighed and its mass is found to have reduced by 20 g. Find the new gas pressure inside the fire extinguisher. (2 marks)

The figure below shows a water rocket. The rocket is filled with water and compressed air.

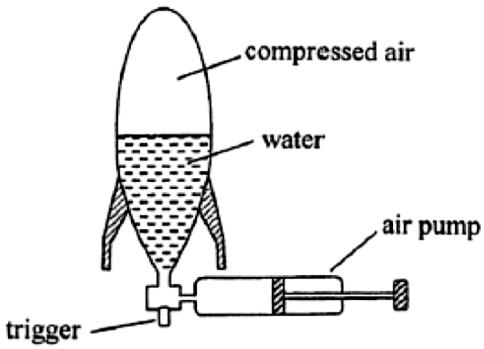

Figure 2

(c) By kinetic theory, explain why the air pressure the rocket inside will increase after air is pumped into the rocket. (2 marks)

(d) Explain why the rocket rises after launching by the physical laws involved. (4 marks)

3. The figure above shows a block *X* of mass 0.5 kg sliding down a plane inclined at an angle of 30° with the horizontal. The plane is composed of two portions made of different materials. They join at *B*.

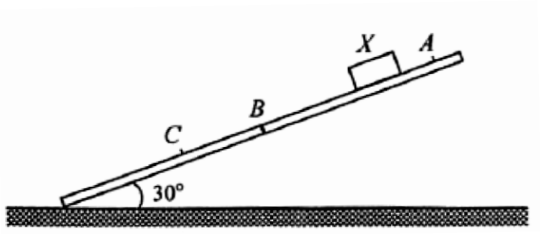

Figure 3.1

The speed-time graph of the block is shown in the figure below. *PQ* denotes the motion of the block in portion *AB* while *QR* denotes the motion in portion *BC*.

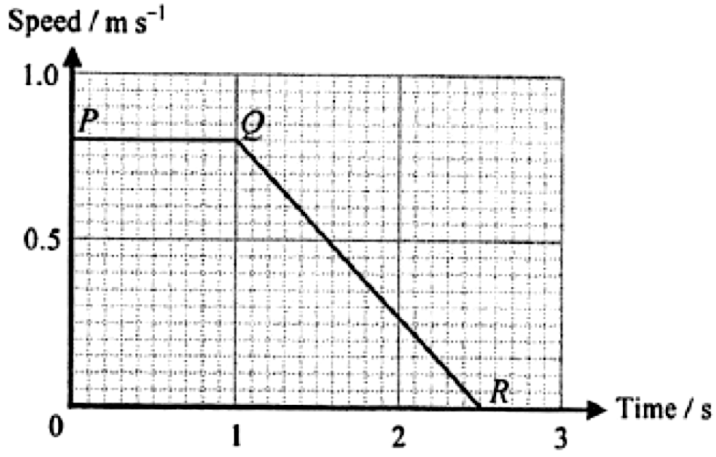

Figure 3.2

(a) (i) Draw a labelled free-body diagram for the block *X*. You may represent the block *X* by a dot. (2 marks)

(ii) Find the frictional force acting on the block *X* when the block *X* is in the portion *AB* of the inclined plane. (2 marks)

(b) From the graphs shown above, find

(i) the acceleration of the block X in the portion BC of the inclined plane. (2 marks)

(ii) the distance travelled by the block X in the portion BC of the inclined plane. (2 marks)

(c) The block X is now projected upwards from point C along the inclined plane with a certain initial speed. By considering the forces acting on the block X, explain how the total distance travelled by the block X will be affected. (2 marks)

4. (a) Two firemen direct a fire hose to shoot water to a flat on fire. The flat is located in a building which is 10 m away from the firemen. The hose shoots water at 60° to the horizontal and the water leaves the hose at a speed of 15 m s^{-1}.

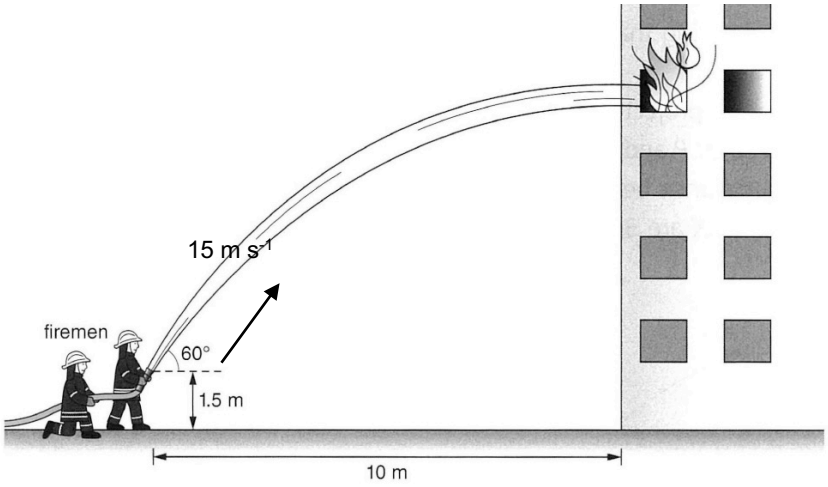

Figure 4.1

(i) Find the time required for the water to reach the fire. (2 marks)

(ii) Find the height of the flat on fire in the building. (2 marks)

(iii) What is the speed of water when reaching the flat? (2 marks)

(iv) Find the angle of velocity of water with the horizontal level at the moment that it enters the flat. (2 marks)

(b) Ken of mass 50 kg jumps out from a height of 35 m. He falls on a rescue cushion. The cushion takes 0.40 s to slow down him to rest. The cushion is 3 m high after inflation. Assume air resistance and change of size of the rescue cushion are negligible.

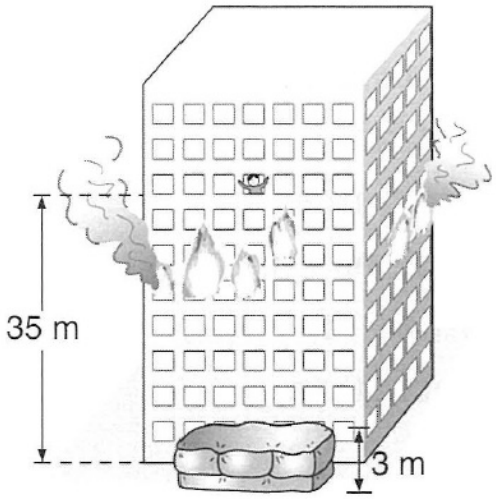

Figure 4.2

(i) Find the speed of Ken when he reaches the top of cushion. (2 marks)

(ii) Draw and label the free body diagram for Ken when the cushion is slowing down him. You may represent Ken as a dot. (1 mark)

(iii) Estimate the average force exerted by the cushion on Ken. (2 marks)

5. A spacecraft moving around the Earth in uniform circular motion. Its circular orbit has an altitude of 450 km from the Earth's surface. Given: radius of the Earth = 6370 km

(a) By considering the acceleration of gravity near the earth surface, show that $GM_E = 3.98 \times 10^{14}$ N m^2 kg^{-1}, where G is the universal gravitational constant and M is the mass of the Earth. (2 marks)

(b) (i) Find the angular speed of the spacecraft. (2 marks)

(ii) Hence, find the period of revolution of the spacecraft around the Earth. (1 mark)

(c) Explain why the gravitational pull on the spacecraft due to the Earth would not speed up motion of the spacecraft. (1 mark)

6. Jeremy looks at a print 'PHYSICS' on a book through a lens. He sees an image as shown:

Figure 6

(a) What kind of lens is used? Explain your answer. (2 marks)

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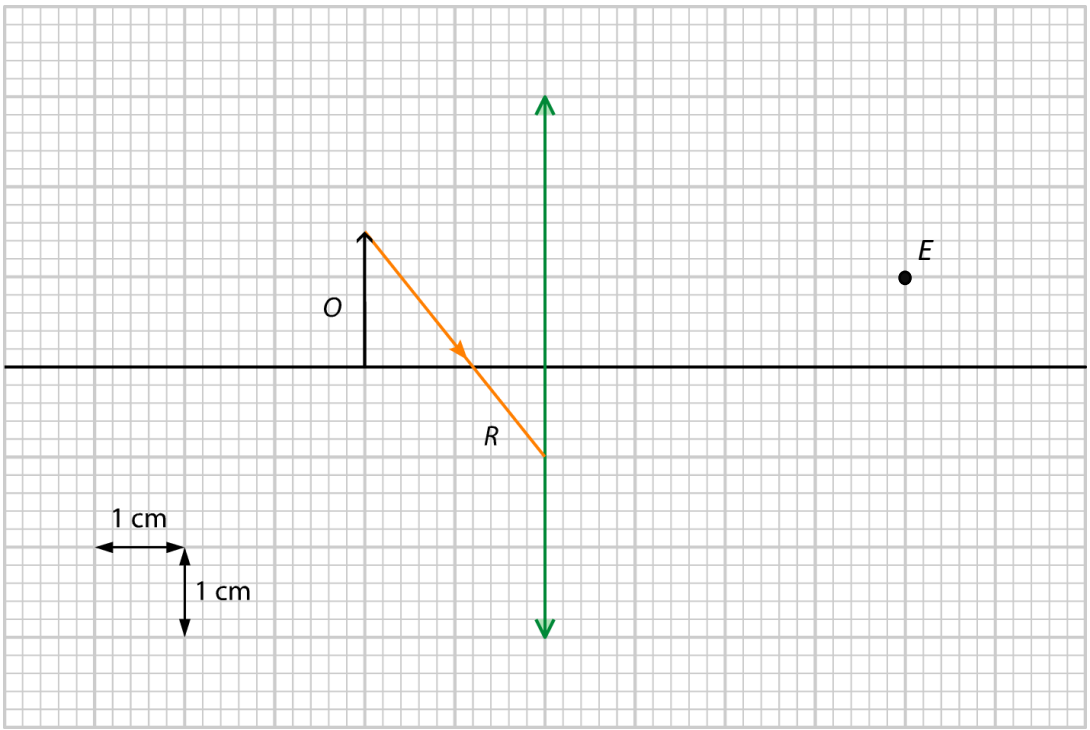
(b) Take the print 'PHYSICS' in Figure 6 as the object. It is found that the linear magnification of the image is 2. In the figure below,

(i) draw the image formed by object *O* (denote it as *I*),

(ii) draw **one** suitable light ray to find the focal length of the lens, and

(iii) complete the path of ray *R*. (4 marks)



Focal length = _____

(c) Draw a light ray to show how the eye at *E* can see the image through the lens in the figure above. (1 mark)

7. (a) The figure below shows a set-up to study the interference of microwaves. Microwaves emitted from a transmitter *T* pass through two narrow slits *A* and *B*, which are equidistant from *T*. The receiver is connected to a meter, which indicates the intensity of microwaves received.

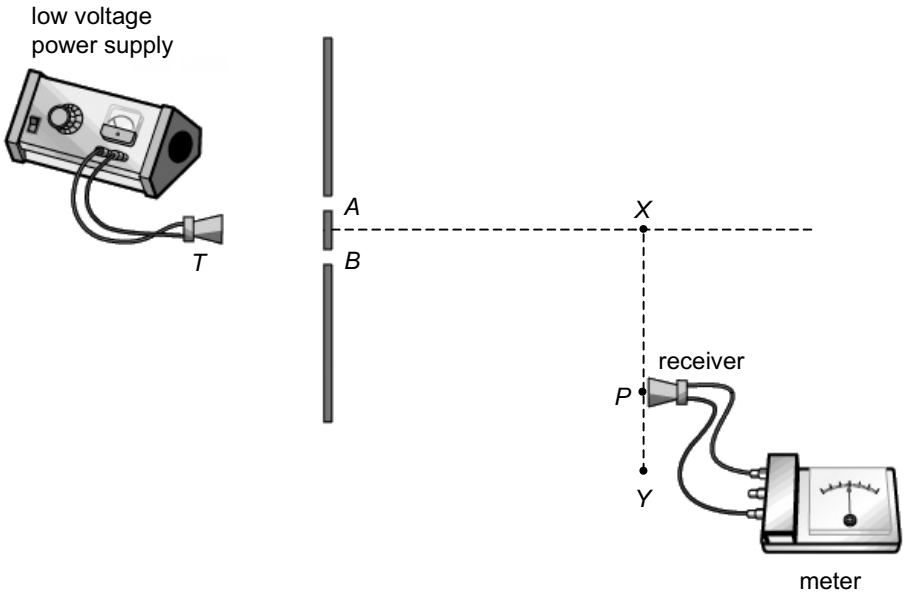


Figure 7.1

The figure below shows the variation of the meter reading as the receiver is moved along *XY*. *X* is equidistant from *A* and *B*.

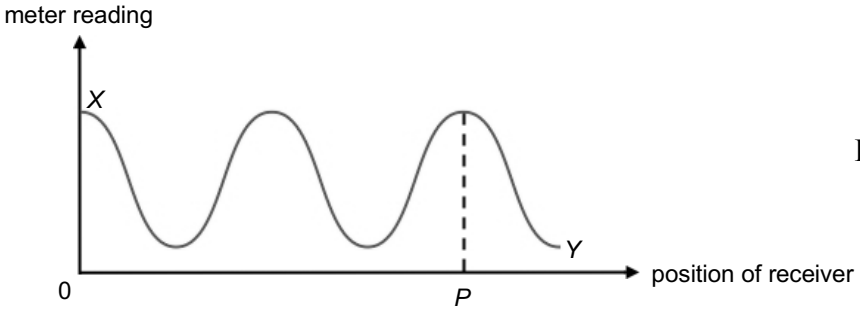


Figure 7.2

Briefly explain why the meter shows maximum and minimum readings. (2 marks)

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(b) The figure below shows a set-up with a microwave transmitter *T*, a metal plate *M* and a receiver *R* connected to a meter which measure the intensity of the microwaves received. Explain why alternate maximum and minimum meter readings are detected when *R* is moved along *XY*. (1 mark)

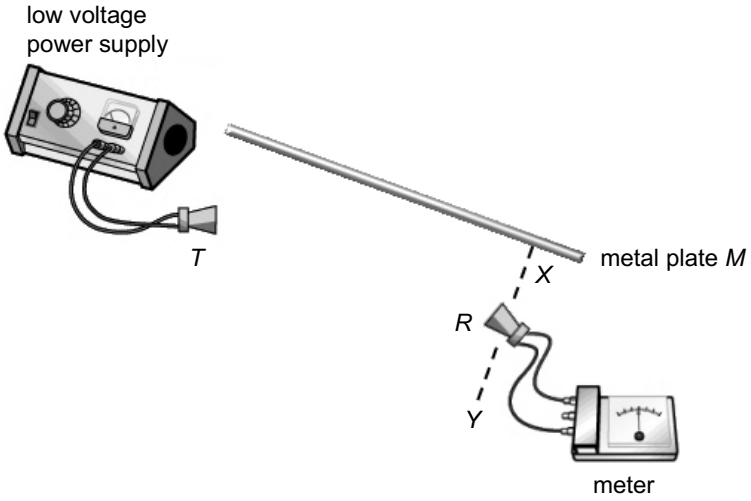

Figure 7.3

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(c) To estimate the wavelength and the speed of microwave used by a microwave oven, Cindy heats a chocolate bar in a microwave oven (without the turntable) for a while. When she removes the chocolate from the oven, she finds the chocolate melts in certain 'melted spots' as shown in Figure 7.4. This is because a stationary wave is set up inside the microwave oven. The frequency of the microwave used is 2450 MHz.

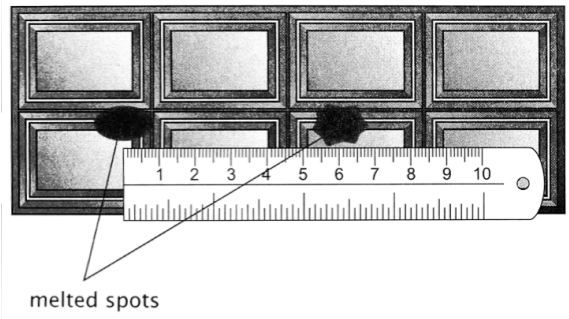

Figure 7.4

(i) On Figure 7.4, add the labels "N" and "A" above the positions of a node and an antinode of the stationary wave respectively. (1 mark)

(ii) Estimate the wavelength of the microwave used. (1 mark)

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(iii) Estimate the speed of the microwave. (2 marks)

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8. The figure below shows the structure of a hand-dryer, which produces hot air for drying wet hands. The hand-dryer consists of two parts: a fan motor and a heater.

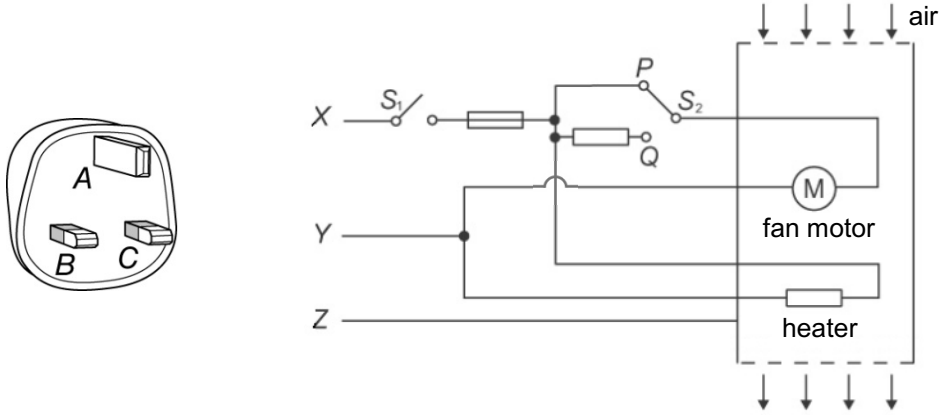

Figure 8

(a) Which pins (*A*, *B* and *C*) should wires *X*, *Y* and *Z* of the hand-dryer be connected to?

X: _____ *Y*: _____ *Z*: _____ (1 mark)

(b) Explain why switch S_1 of the hand-dryer is placed in wire *X*. (1 mark)

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(c) The hand-dryer operates at 220 V and its heater has a resistance of 50 Ω.

(i) Calculate the current passing through the heater. (2 marks)

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(ii) Find the power of the heater. (2 marks)

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(iii) The power rating of the fan motor is 220 V, 200 W. If 1 kW h of electrical energy costs $0.9, calculate the cost to switch on the hand-dryer for 5 hours. (3 marks)

(iv) Which fuse (5A, 7A or 10 A) should be used? Show your calculations. (2 marks)

9. A single-turn rectangular metal coil has mass m, length l = 0.5 m and width w = 0.2 m. It falls freely from a height h = 5 m and enters a uniform magnetic field region with magnetic field strength B = 25 mT, as shown in Figure 9. The ends of the coil are **not** joined together.

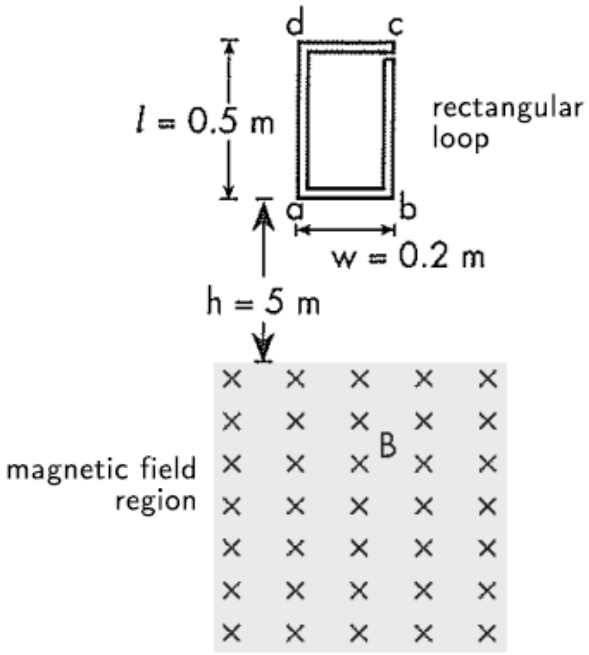

Figure 9

The dimensions of the magnetic field region are greater than that of the coil, so that the whole coil can enter the region.

(a) If the coil forms a closed loop, the time taken for the whole coil to enter the magnetic field region increases. Explain why. (3 marks)

Suppose that the coil forms a closed loop, has a resistance of 10 Ω, and enters the magnetic field region at a constant velocity.

(b) Find the induced electromotive force (e.m.f.) in the coil when it is entering the magnetic field region. (3 marks)

(c) Find the mass *m* of the coil. (3 marks)

10. The Alpha Particle X-Ray Spectrometer (APXS) is an instrument equipped by the *Opportunity*, an automated motor vehicle launched in 2003 for Martian exploration.

Figure 10(a)

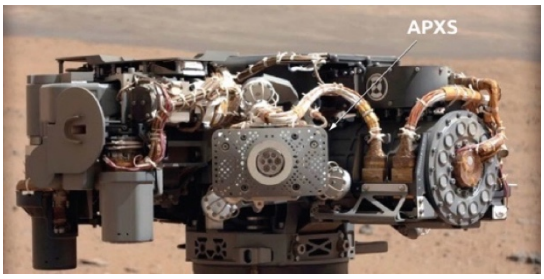

Figure 10(b)

The APXS is used for analysing the composition of the rocks on the Mars. When it operates, it emits a large number of α particles on the rock sample. The α particles collide with the nuclei in the sample and a few of them would bounce back to the APXS. By measuring the change in kinetic energy of these backscattered α particles, the composition of the sample can be determined.

(a) The APXS cannot work if the rock sample is placed far away from it. Explain. (1 mark)

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Curium-244 ($^{244}_{96}Cm$) is used as the radioactive source in the APXS. It has a half-life of 18.1 years. It undergoes an α decay to form plutonium (Pu).

(b) Write down the decay equation of curium-244. (2 marks)

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(c) At the time of launch, the activity of the curium-244 in the APXS was 1.1 GBq. 8 years after the launch, the Opportunity and the APXS equipped are still in operation. What is the activity of the curium-244 at that time? (2 marks)

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End of Paper