CARMEL DIVINE GRACE FOUNDATION SECONDARY SCHOOL

SECOND TERM EXAMINATION (2021-2022)

SECONDARY VI PHYSICS PAPER 1

Name: _____( ) Date: 18/2/2022

Time: 2.5 hours

Class: S.6 ( ) No. of pages: 16

Section B: Question-Answer Book B

Start Time	
End Time	

INSTRUCTIONS FOR SECTION B

1. Write your name, class and class number in the spaces provided.
2. Refer to the general instructions on page 1 of the Question Paper for Section A.
3. Answer **ALL** questions.
4. Write your answers in the spaces provided in this Question-Answer Book.
5. Graph paper and supplementary answer sheets will be provided on request. Write your name, class and class number on each sheet.

Question	1	2	3	4	5	6	7	8	9
Marks	8	8	6	12	11	11	11	10	7

Section B: Answer **ALL** questions.

1. James wants to cook Chinese steamed egg for dinner. He first mixes 3 eggs (each of mass 60 g) and 270 g of water in a ceramic bowl, all at room temperature (25 °C). Then he covers the bowl with a lid and puts the bowl into a steamer. The total mass of the bowl and the lid is 250 g.

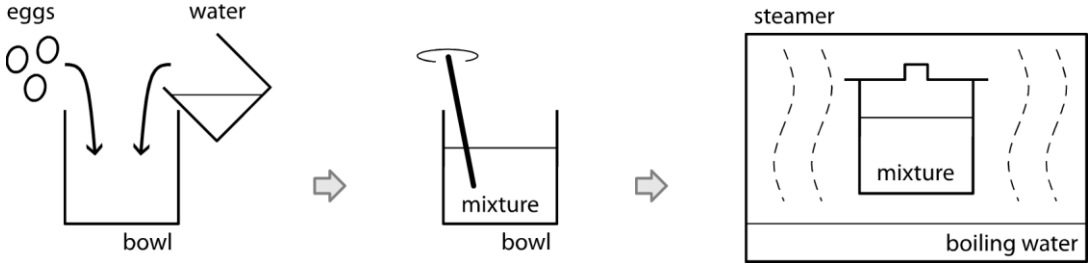


Figure 1.1

The steamer boils water and produces steam to heat up the egg mixture from room temperature to 65 °C at which the egg mixture is cooked.

(a) Find the energy required to cook the egg mixture in this process. (2 marks)

Given:

specific heat capacity of the egg mixture = 2500 J kg^{-1} $°C^{-1}$

specific heat capacity of the ceramic bowl and the lid = 840 J kg^{-1} $°C^{-1}$

(b) Briefly explain the function of steam in the cooking process. (2 marks)

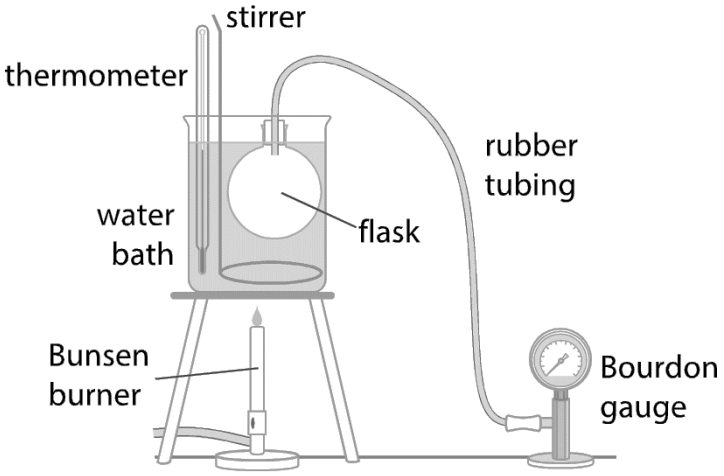
(c) There is some water boiling in the steamer before James puts the egg mixture into the steamer.

(i) If the power of the steamer is 1550 W, estimate the minimum time required to cook the dish. (2 marks)

(ii) Owing to heat loss, the actual cooking time is much longer than the value calculated in (c)(i). Briefly describe the **main** reason that heat is lost to the surrounding. (1 mark)

(d) The heat capacity of a metal bowl is approximately the same as that of the ceramic bowl. However, the cooking time can be much shortened if James uses a metal bowl instead of a ceramic bowl. Why? (1 mark)

*2. Brian is going to study the relationship between gas pressure and gas temperature under fixed volume using the set-up below. Before heating, the water bath is at room temperature 25 °C. The air inside the flask has a pressure of 1.0×10^5 Pa (atmospheric pressure).



Brian heats up the water gently. For every 5 °C, he stops heating the water and stirs the water well before taking readings.

(a) What is the expected gas pressure when the temperature of gas is 80 °C? (2 marks)

(b) Brian finds that the recorded gas pressure at 80 °C is slightly lower than that calculated in (a). The following is his suggestion:

"The volume inside the rubber tubing is not taken into account in the experiment. This makes the total gas volume larger than expected, and thus the final gas pressure is lower than that calculated in (a)."

Do you agree with him? Comment on his suggestion. Also, give an explanation for the lower gas pressure measured if you do not agree with Brian. (3 marks)

(c) The results obtained are plotted in the graph below.

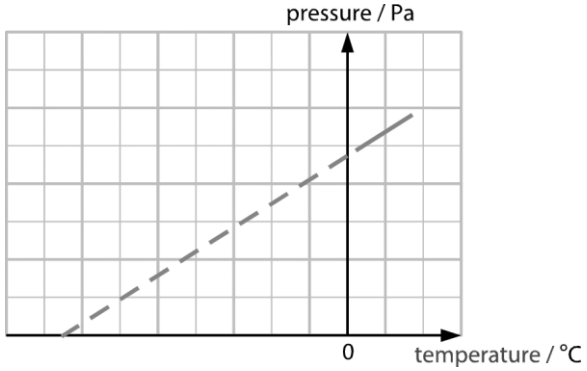


Figure 2.1

(i) Using kinetic theory, briefly explain why the gas pressure increases as the temperature increases. (2 marks)

(ii) In Figure 2.1, sketch a new graph if a larger flask containing the same number of air molecules is used. (1 mark)

3. Figure 3.1 shows the stroke cycle of a breast-stroke swimmer and how his velocity in the forward direction v varies with time t during one stroke cycle.

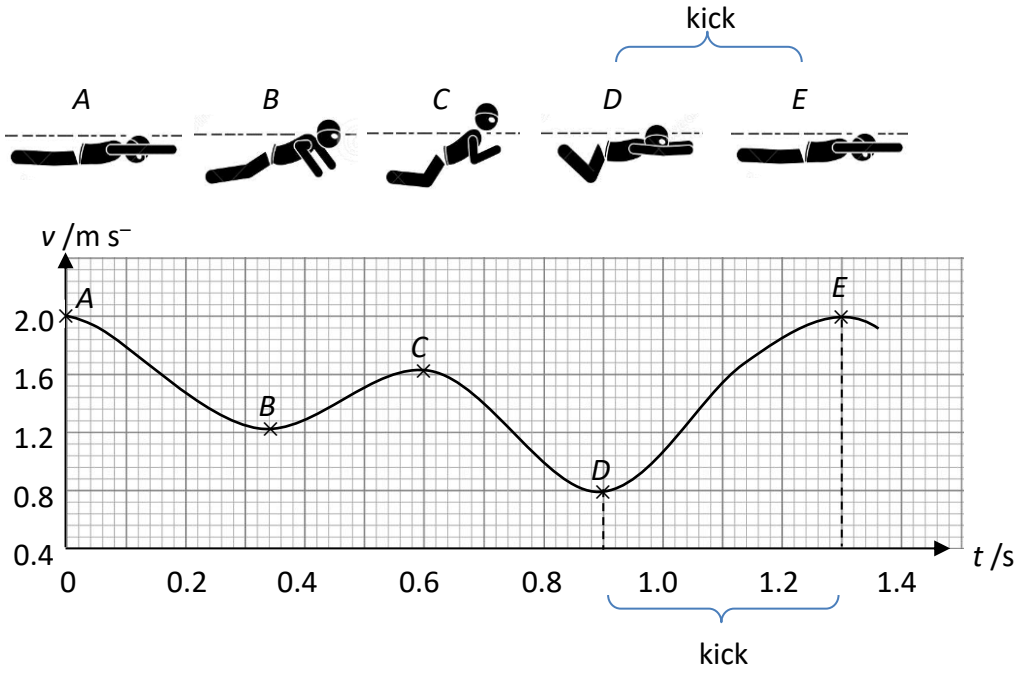


Figure 3.1

(a) Estimate from the graph the average acceleration of the swimmer during the 'kick' part of the cycle (t = 0.9 s to 1.3 s). (2 marks)

(b) If the swimmer has a mass of 55 kg and the average water resistance is 50 N during the kick, what is the magnitude and direction of the average force that his legs exert on the water during the kick? (3 marks)

(c) Give **ONE** reason why the swimmer slows down significantly from 0.6 s to 0.9 s. (1 mark)

4. Craters can be found on the surface of the Moon (Fig 4.1). They are formed by meteors hitting the Moon's surface.

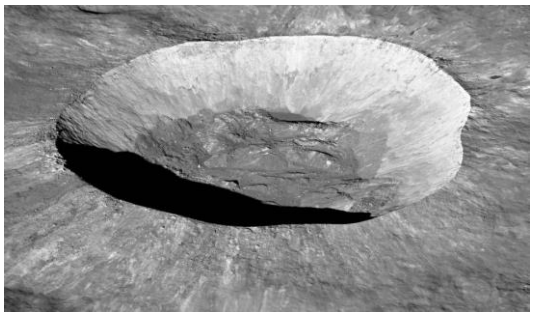


Figure 4.1

(Photo credit: NASA/Goddard/Arizona State University)

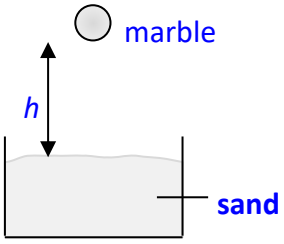


Figure 4.2

Tom simulates the formation of craters by dropping a marble into a tray of sand (Figure 4.2). He drops the marble from different heights *h* and measures the diameter *d* of each crater that is formed. Figure 4.3 shows the result of the simulation.

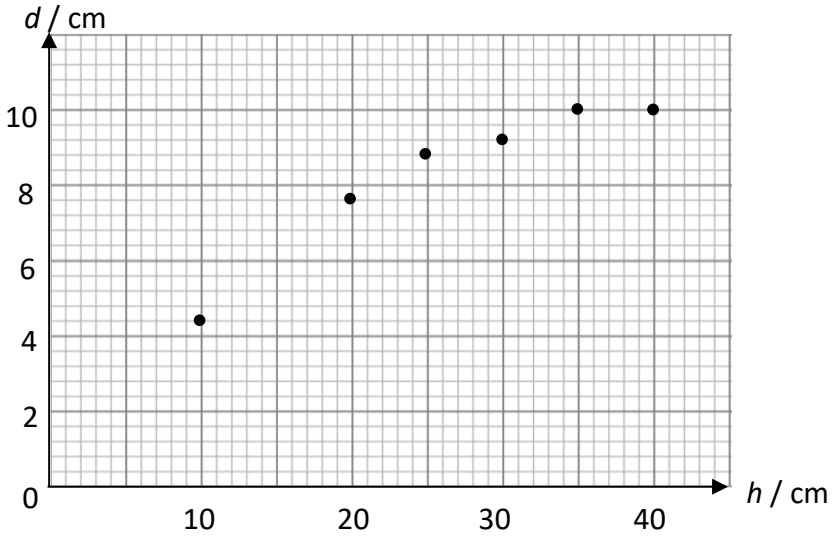


Figure 4.3

(a) In Figure 4.3, draw a suitable line according to the points and estimate the diameter of the crater formed when the marble is dropped from a height of 15 cm. (2 marks)

Diameter of crater = _____

(b) Tom then wants to simulate how the mass of meteors affects the size of craters. Describe the procedure of the investigation. State a precaution Tom should carry out in order to get a more accurate result. (5 marks)

(c) Tom drops a marble of mass 10 g from a height of 35 cm. The crater formed has a depth of 7 cm. Estimate the average resistive force acting on the marble by the sand. (2 marks)

*(d) Given: mass of the Moon = 7.35×10^{22} kg
radius of the Moon = 1.74×10^{6} m

(i) Find the acceleration due to gravity on the surface of the Moon. (2 marks)

(ii) If the simulations were done on the Moon instead of the Earth, describe any change in the kinetic energy of the marbles when they hit the sand. (1 mark)

5. Two neighbours, Tim and Sally, are both football fans living in Hong Kong. At one night, they watch an on-live England football match on television at home. The broadcasting signal is transmitted from London to Hong Kong through either a geostationary satellite or optical fibre cables as shown in Figure 5.1.

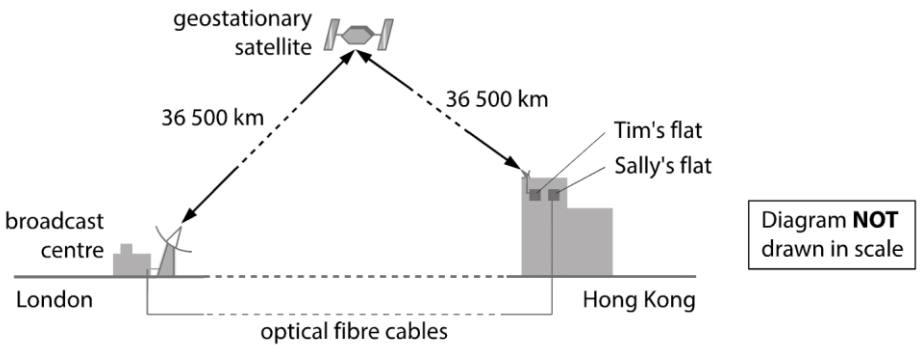


Figure 5.1

(a) Tim receives the broadcasting signal through the geostationary satellite. The broadcast centre in London emits signal in the form of electromagnetic wave with frequency 12.0 GHz. The signal is transmitted to the satellite through a distance of 36 500 km, and the satellite reflects the signal to Tim's receiver in Hong Kong through the same distance 36 500 km.

*(i) The geostationary satellite orbits around the Earth with a period of 24 hours above the Earth's equator. Estimate the height of the geostationary satellite above the Earth's surface.

Given: radius of the Earth = 6370 km (3 marks)

(ii) What kind of electromagnetic wave is the broadcasting signal? (1 mark)

(iii) How long does it take for the broadcasting signal to transmit from London to Tim's receiver in Hong Kong? (1 mark)

(iv) Tim's son thinks that high frequency ultrasound can also be used for transmitting the broadcasting signal from London to Hong Kong through the geostationary satellite. Comment on his idea. (2 marks)

(b) Sally receives the broadcasting signal through optical fibre cables. The broadcasting signal is transmitted in the form of light through underground optical fibres which connects London and Hong Kong. The total length and the refractive index of the optical fibres are 12 000 km and 1.8 respectively.

(i) What is the phenomenon involved that allows light signal to travel in the optical fibres? (1 mark)

(ii) A goal is scored in the football match. Determine who, Tim or Sally, would be more likely to watch the goal first. (3 marks)

6. Two vibrators, S_1 and S_2, are set up in a ripple tank to demonstrate interference. They vibrate in phase to produce two circular water waves of wavelength 10 cm. Figure 6.1 shows the wave pattern produced at time $t = t_0$.

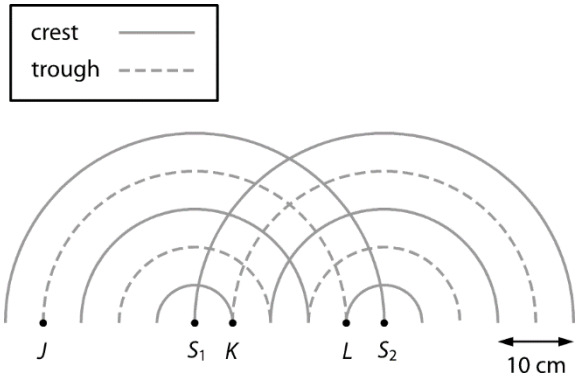


Figure 6.1

(a) (i) J is a point on the line joining S_1 and S_2 as shown. What kind of interference occurs at J? Explain your answer briefly. (2 marks)

(ii) The water level between K and L at $t = t_0$ is shown in Figure 6.2.

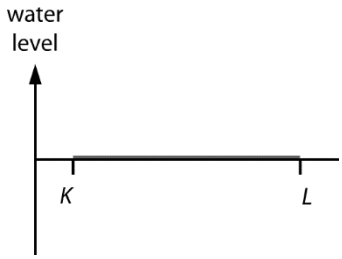


Figure 6.2

(1) A student comments that the water level between K and L remains flat all the time. Do you agree? Explain briefly. (2 marks)

(2) In Figure 6.2, sketch the water level between K and L at $t = \frac{T}{4}$ where T is the period of the water waves. (2 marks)

(b) (i) Another student suggests that, by replacing the two vibrators with two light sources and placing a screen in front of the sources, an interference pattern can be observed on the screen. Do you agree? Explain your answer briefly. (2 marks)

*(ii) An interference pattern is produced with a double slit and a point light source of frequency 6.5×10^{14} Hz. The fringe separation is 5.5 mm. When the whole set-up is put into a liquid, the fringe separation becomes 3.5 mm. Estimate the refractive index of the liquid. (3 marks)

7. Read the following article and answer the questions that follow.

DNA Fingerprinting

Almost every cell in our body contains DNA. Just like our fingerprint, DNA is something we are born with. It is unique to us. DNA fingerprinting is a technique that detects an individual's DNA characteristics to produce a pattern unique to him/her. This technique can be applied in criminal investigation.

To analyze a DNA sample, the DNA molecules are cut using enzymes. This results in a lot of DNA fragments, with various lengths and are negatively charged.

These fragments are then placed at one end of a bed of gel. A potential difference is applied across the gel to build an electric field. Owing to the electric field, the fragments move through the gel towards the positive pole. Shorter fragments move the fastest and the farthest in a given time. They are thus separated in the order of size.

Finally, the separated fragments are printed onto a nylon sheet and stained with radioactive tracers. The tracers only attach to a few particular fragments. To visualize them, a film is exposed. Dark bands will be produced at the positions of these fragments. The resulting pattern (DNA fingerprint) could then be analyzed.

*(a) Suppose an electric field is built with a pair of parallel plates. If the potential difference between the plates is 50 V and the plates are 10 cm apart, what is the size of the electric field?

(1 mark)

(b) When a fragment moves through the gel, it experiences a resistive force which increases with its speed. The fragment soon reaches a terminal speed.

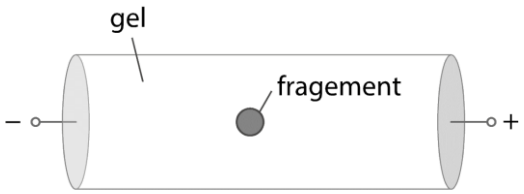


Figure 7.1

(i) In Figure 7.1, sketch a free body diagram for a fragment which has reached the terminal speed. (2 marks)

(ii) By considering the forces acting on the fragment, briefly explain how a terminal speed is reached. (3 marks)

(c) To compare two or more DNA samples, they have to be run side by side on the same gel instead of being run one by one. Why? (1 mark)

(d) (i) Suppose two kinds of radioactive tracers, *X* and *Y*, could be used for this purpose. *X* has a half-life of 5 years while *Y* has a half-life of 3 days. In terms of their half-lives, which one is more suitable? Explain briefly. (2 marks)

(ii) Will the X-ray film become radioactive after being exposed to the radiation given out by the fragments? Explain briefly. (2 marks)

8. A strain gauge resistor (Figure 8.1) is a conductor which changes its shape when it is stretched or compressed.

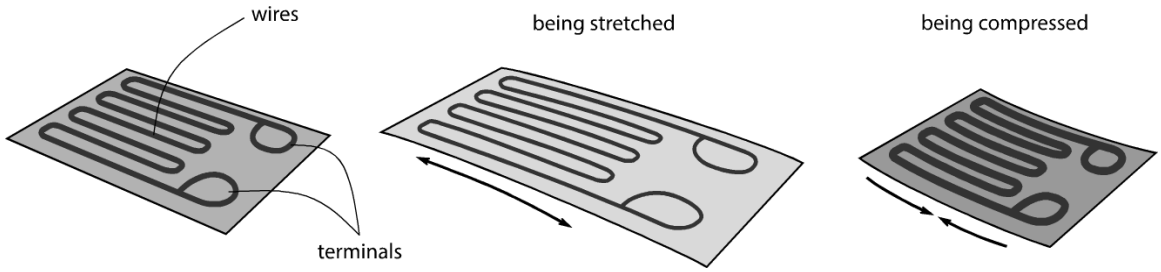


Figure 8.1

(a) How does the resistance between the terminals change when the resistor is stretched as shown in Figure 8.1? Explain briefly. (2 marks)

(b) Figure 8.2 shows a schematic diagram of an accelerometer. A mass is attached to a beam inside a frame. When the accelerometer is under acceleration, the beam curves towards one side. Identical strain gauge resistors *X* and *Y* are attached to the two sides of the beams and they are connected to a circuit as shown in Figure 8.3. Each resistor has a resistance of 120 Ω when it is not stretched or compressed.

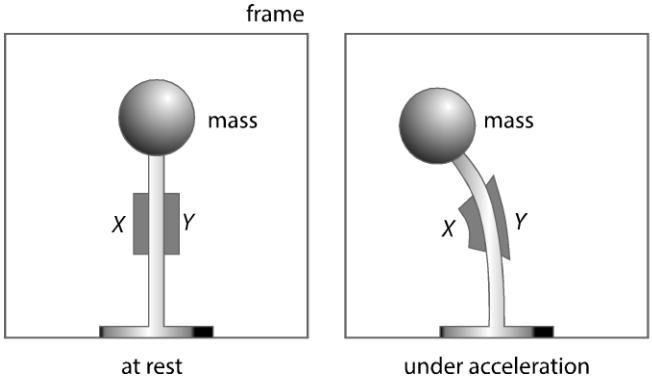


Figure 8.2

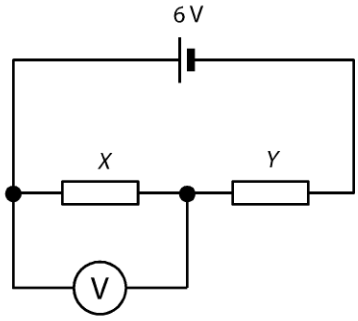


Figure 8.3

(i) Susan uses a voltmeter of 1 kΩ to measure the p.d. across *X*. What is its reading when there is no acceleration? (2 marks)

(ii) Susan now uses a voltmeter of infinite resistance. Suppose the accelerometer accelerates towards the side of *X*. How will the voltmeter reading change? Briefly explain your answer. (3 marks)

(c) To make the accelerometer in part (b) more sensitive, the strain gauges are connected to another circuit as shown in Figure 8.4.

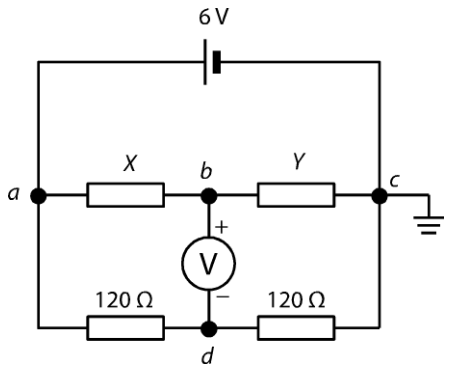


Figure 8.4

(i) What should be the voltmeter reading if the accelerometer is moving at a constant velocity towards the side of *Y*? (1 mark)

(ii) If the voltmeter reads +1.2 V, in which direction, towards the side of *X* or *Y*, is the accelerometer accelerating? Briefly explain your answer. (2 marks)

9. In 1972, a uranium deposit in Africa was found to be a natural fission reactor billion years ago.

(a) The equation below shows one of the fission of U-235 that took place in the natural fission reactor:

$$^{235}_{92}\text{U} + {}^{1}_{0}\text{n} \longrightarrow {}^{144}_{56}\text{Ba} + {}^{89}_{y}\text{Kr} + x\,{}^{1}_{0}\text{n}$$

(i) Find the values of x and y. (1 mark)

*(ii) Given: mass of $^{235}_{92}\text{U}$ nucleus = 234.9934 u
mass of $^{144}_{56}\text{Ba}$ nucleus = 143.8923 u
mass of $^{89}_{y}\text{Kr}$ nucleus = 88.8981 u
mass of neutron = 1.0087 u

Estimate the energy released (in MeV) by one U-235 nucleus in this reaction. (2 marks)

(b) The deposit contains two uranium isotopes in nature: U-235 and U-238. Both U-235 and U-238 are radioactive and their half-lives are 7.04×10^8 years and 4.49×10^9 years respectively.

(i) What is meant by half-life of a radioactive nuclide? (1 mark)

*(ii) The age of the natural fission reactor could be determined by the ratio of the number of U-235 nuclide N to that of U-238 nuclide n. When the natural fission reactor underwent fission, this ratio was 1 : 32. But since fission has stopped, both U-235 and U-238 in the reactor underwent decay. As U-235 decayed at a faster rate than U-238, this ratio drops to 1 : 138 today. How many years did the natural fission reactor stop undergo fission? Show your working. (3 marks)

END OF PAPER