福建中學

# FUKIEN SECONDARY SCHOOL

S6 Mock Examination (2020-2021)

Physics Paper 1

(2 hours 30 minutes)

Section B: Question-Answer Book

Date: 22nd January 2021 Name: _____

Time: 8:30a.m. – 11:00a.m. Class: _____ No.: _____

**Instructions to students:**

1. Write your name, class and class number in this Question-Answer Book.
2. Refer to the general instructions on the cover of the Question Paper for Section A.
3. Hand in this Question-Answer Book at the end of the examination.
4. This section carries 84 marks. **Answer ALL questions**.
5. Write your answers in the spaces provided in this Question-Answer Book.
6. The diagrams in this section are **NOT** necessarily drawn to scale.

**Section B:** Answer **ALL** questions. Parts marked with * involve knowledge of the extension component. Write your answers in the spaces provided.

1. An electric food steamer is used to heat food with steam. Water is added to the steamer and is heated to steam.

Figure 1

Given: specific heat capacity of water = 4200 J $kg^{-1}$ $°C^{-1}$
specific latent heat of vaporization of water = $2.26 \times 10^6$ J $kg^{-1}$

(a) Suggest a reason why steam can heat food quickly. (1 mark)

(b) The power of the steamer is 980 W. After adding 500 g of water at 25 °C to the steamer, the steamer is switched on. Assume there is no energy loss to the surroundings and the evaporation of water during heating can be neglected. Estimate the time used to produce 10 g of steam. (3 marks)

(c) Compare heating food using electric food steamers with gas stoves. Which method is more energy efficient? Explain your answer. (2 marks)

*2. The setup in Figure 2 below is used to study the relation between the gas temperature and volume at constant gas pressure.

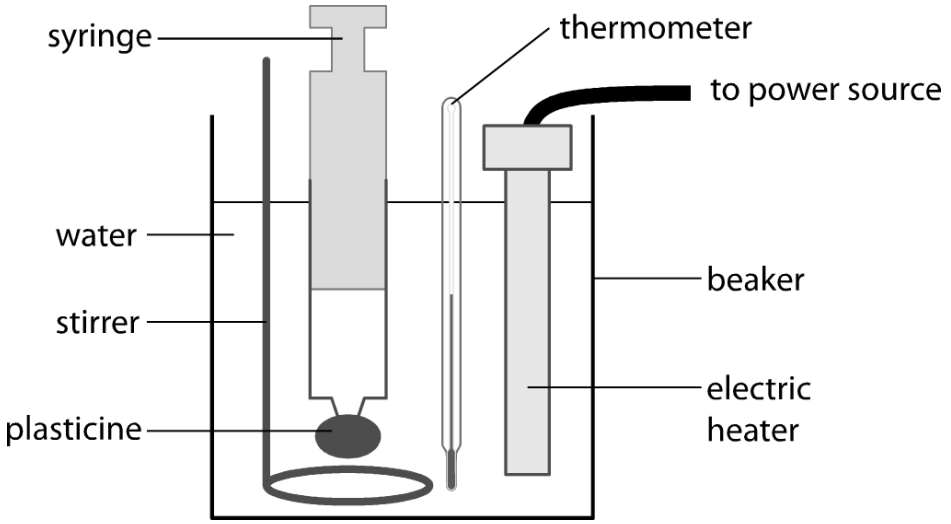



Figure 2

(a) Describe the procedures of the experiment. State the physical quantities to be measured and the result expected. (3 marks)

(b) (i) Suggest **TWO** procedures to be taken before taking a reading in order to ensure that the air inside the syringe and the water have the same temperature. (2 marks)

(ii) Explain how the experimental result is affected if the interior of the syringe is wet. (1 mark)

(c) Use kinetic theory of an ideal gas to explain why the volume of the air inside the syringe increases when the temperature increases. (2 marks)

3. Figure 3.1 below shows a conveyor belt in a factory. A parcel of mass 10 kg is placed at position *P* when the belt remains at rest. The worker controls the belt to move the parcel.

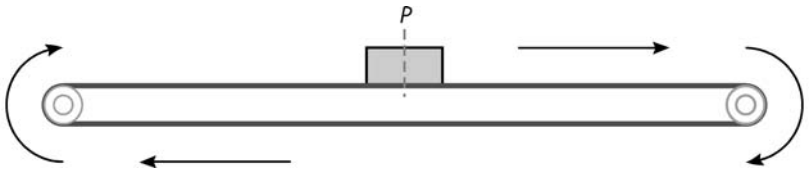



Figure 3.1

The variation of the velocity of the parcel over time is shown in Figure 3.2. The direction to the right is taken as positive.

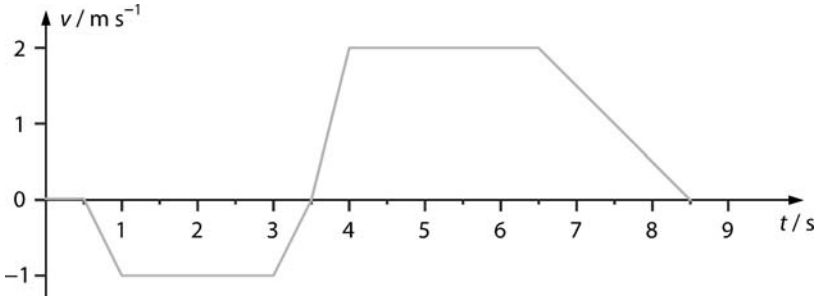



Figure 3.2

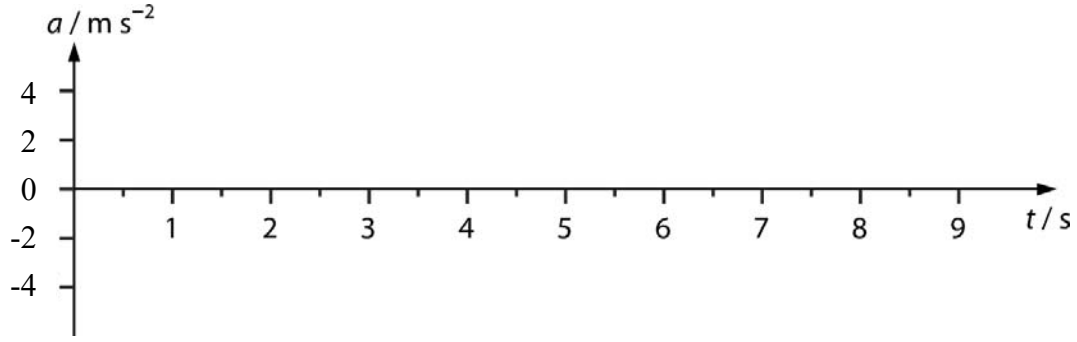
(a) Describe the motion of the parcel from $t = 0$ s to $t = 3$ s. (2 marks)

(b) When does the parcel pass through position *P* again? Explain your answer. (2 marks)

(c) The parcel and the conveyor belt move together without slipping during the entire motion.

(i) In which period does the parcel experience the greatest frictional force by the conveyor belt throughout the entire motion? Find this force. (2 marks)

(ii) Sketch the variation of the acceleration of the parcel over time. (2 marks)



4. As shown in Figure 4, two blocks *X* and *Y* of masses 4 kg and 3 kg respectively are connected by an inextensible light string. A constant force of 25 N is applied on *Y* to pull the blocks up an inclined plane at a constant speed of 3.5 $ms^{-1}$ as shown below. The plane makes an angle $\theta$ with the horizontal. The frictional force between **each block** and the inclined plane is 2 N.

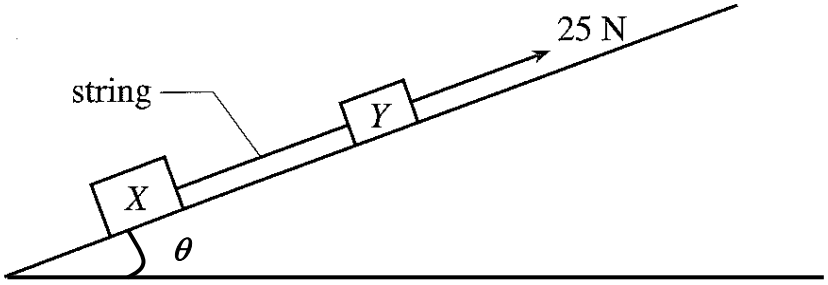



Figure 4

(a) Find the angle $\theta$. (3 marks)

(b) Suddenly the string breaks at $t = 4$ s. Describe the subsequent motion of block *X* after $t = 4$ s. Calculate the corresponding accelerations. (3 marks)

5. As shown in Figure 5, a spacecraft with an astronaut on board is launched on a rocket booster. The rocket with the spacecraft has a total initial mass of $4.80\times10^5$ kg at take-off. The rocket engine propels hot exhaust gas at a constant speed of 2600 m $s^{-1}$ relative to the rocket in a backward direction. Assume that $2.30\times10^3$ kg of gas is expelled in the first second. (Neglect air resistance.)

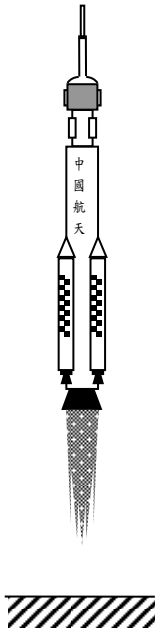



Figure 5

(a) Calculate the average thrust (the upward force) acting on the rocket due to the exhaust gas during the first second. (2 marks)

*(b) The spacecraft of mass $7.80\times10^3$ kg now enters a circular orbit around the earth at a height of $3.45\times10^5$ m above the earth's surface. The radius of the earth is 6.37 x $10^6$ m. Calculate the speed of the spacecraft in the orbit. (4 marks)

6. In order to study the interference of sound waves, two identical loudspeakers *P* and *Q* are connected to a signal generator in a laboratory as shown in Figure 6.1. The speakers emit sound of the same frequency and amplitude. The frequency of the sound emitted is 440 Hz. Line $L_1$ is equidistant from *P* and *Q*. Line $L_2$ is perpendicular to $L_1$. *X*, *Y* and *Z* are points on $L_2$.

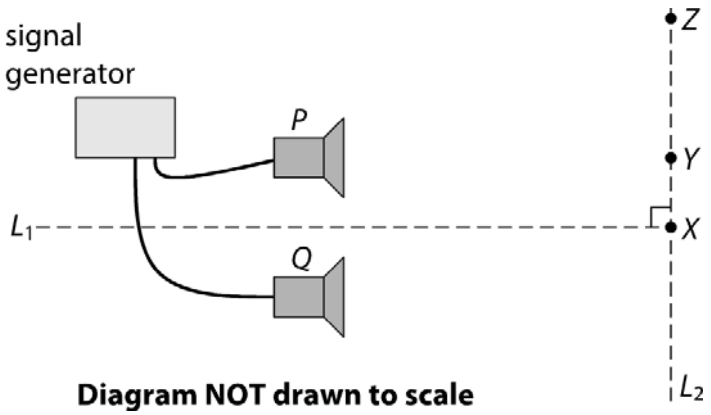



Figure 6.1

(a) Explain why the speakers are connected to the same signal generator instead of two signal generators with the same setting. (1 mark)

(b) When a microphone is moved from *X* to *Y*, the sound level detected gradually decreases to a minimum.

(i) Explain why this happens. (1 mark)

(ii) If $PY = 3.21$ m and $QY = 3.60$ m, estimate the speed of sound in air. (2 marks)

6. (b) (iii) The microphone continues to move to *Z* after passing *Y*. Figure 6.2 shows how the sound level detected by the microphone changes with the positions from *X* to *Z*.

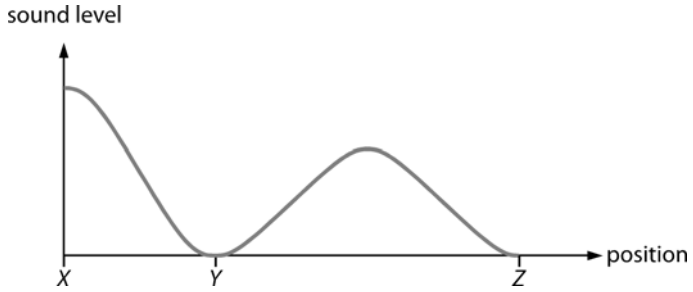



Figure 6.2

Sketch on Figure 6.2 to show how the sound level changes from *X* to *Z* if the frequency of the sound emitted is doubled. (2 marks)

(c) The set-up is placed such that *X*, *Y* and *Z* are far from the wall of the laboratory to achieve a more accurate result. Why? (1 mark)

_____

_____

(d) A student suggests that as sound wave is a longitudinal wave, if a glowing candle is put in front of one of the two loudspeakers, we shall observe that the flame of the candle vibrates back and forth. Comment on the student's suggestion. (1 mark)

_____

_____

7. As shown in Figure 7, an object *O* is placed in front of a lens *L*. An image *I* is formed behind the object.

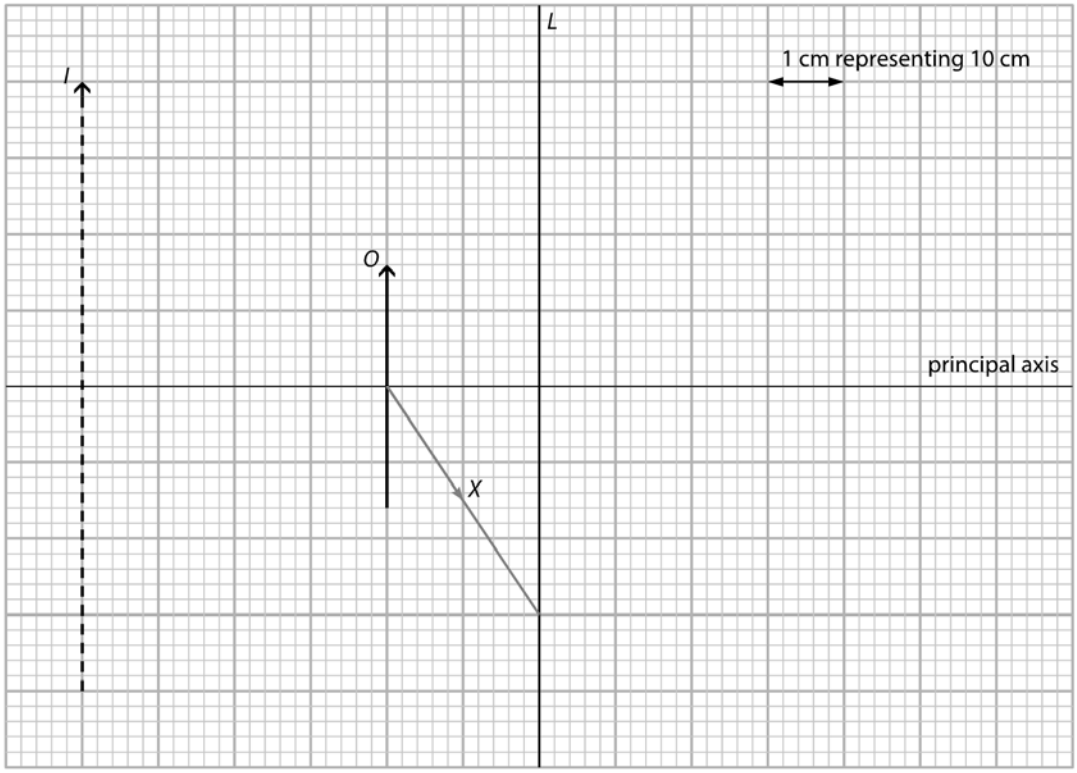



Figure 7

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

_____

_____

(b) Draw a light ray to locate the principal focus *F* of the lens *L*. Find its focal length. (2 marks)

Focal length = _____

(c) Complete the path of the ray *X* from the object. (1 mark)

8. A student wants to determine the slit separation of a diffraction grating using the setup shown in Figure 8. Light from a laser is directed normally at a diffraction grating which is set at the centre of a circular scale.

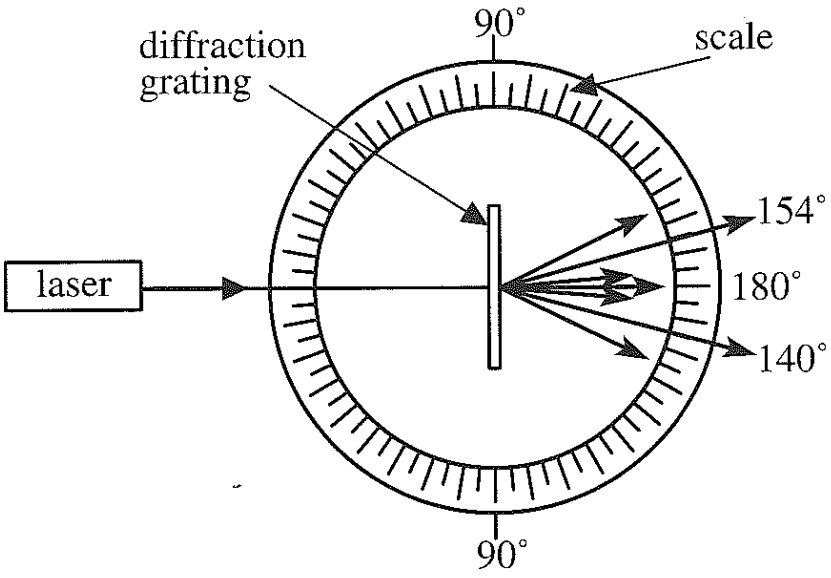



Figure 8

(a) The wavelength of the laser light is 560 nm. The readings on the scale for the two second order diffracted beams are 154° and 140° respectively.

(i) State ONE advantage of using the reading for the second order diffracted beams over using those for the first order diffracted beams. (1 mark)

_____

_____

*(ii) Calculate the number of lines per 1mm of the diffraction grating. (3 marks)

_____

_____

_____

_____

(b) Suggest ONE reason why the interference pattern produced by a diffraction grating is brighter than that produced by a double slit with the same slit separation when the same light source is used. (1 mark)

_____

_____

8. *(c) When the laser light is replaced by a white light source, a number of spectra are observed at different diffraction angles.

(i) Describe how the widths of the spectra formed vary with the order. (1 mark)

_____

_____

(ii) Determine whether the second order spectrum overlaps with the third order spectrum. (2 marks)

_____

_____

_____

_____

*9. (a) Positively charged particles *A* and *B* are projected horizontally into a gap between two parallel charged plates. The electric field in the gap is 2500 V $m^{-1}$. A uniform magnetic field of magnitude 0.022 T is also applied to the gap so that the two fields are perpendicular to each other. The set-up only allows charged particles with a particular speed to pass through. As show in Figure 9.1, particle *A* can pass through the set-up without deflection while particle *B* cannot.

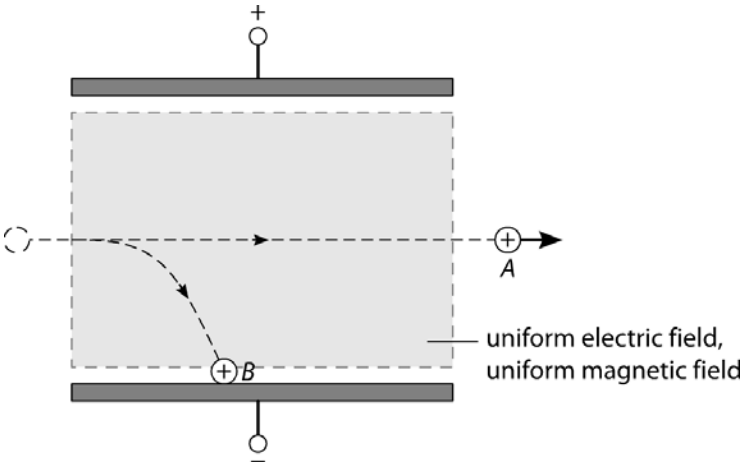



Figure 9.1

(i) Explain how the set-up works and find the allowed speed. (3 marks)

(ii) Particle *A* passes through the gap without deflection but particle *B* is deflected towards the negative plate. Determine whether the speed of particle *B* is higher or lower than the speed of particle *A*. Explain your answer. (2 marks)

(iii) If particle *A* is negatively charged with the same speed, can it still pass through the gap? Why? (1 mark)

9. (b) A square coil of side length 2 cm is moved between a pair of slab-shaped magnets with unlike poles facing each other. Figure 9.2 shows the position of the coil at time $t = 0$.

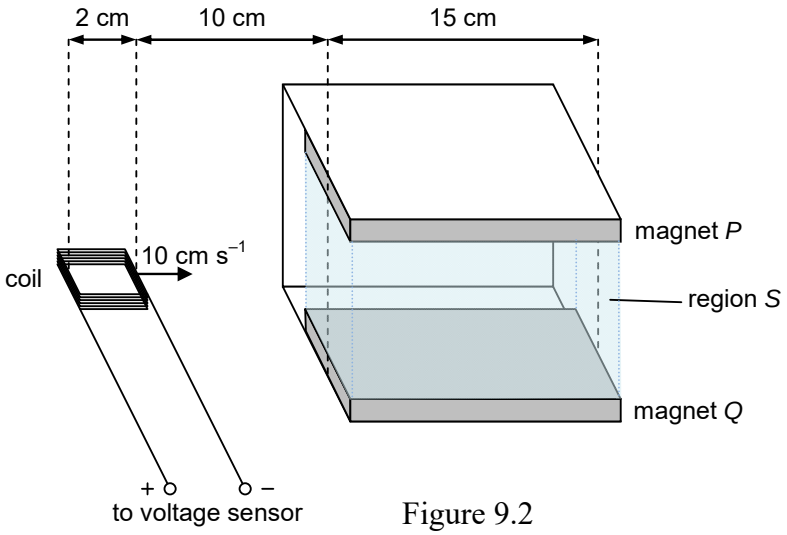



Figure 9.2

*S* is the region between the two magnets and is shaded in Figure 9.2. The coil moves horizontally through region *S* at a constant speed of 10 cm $s^{-1}$. Assume that a uniform magnetic field points from magnet *Q* to magnet *P* in region *S*, and there is no magnetic field outside region *S*.

(i) Describe and explain how the voltage sensor reading varies with time from $t = 0$ to $t = 3$ s. (3 marks)

(ii) The coil has 50 turns. The magnetic flux density in region *S* is $5 \times 10^{-4}$ T. Calculate the maximum magnitude of the e.m.f. induced in the coil when it travels through the magnetic field. (2 marks)

(iii) Suggest TWO methods that can increase the induced e.m.f. in the coil. (2 marks)

10. Figure 10 below shows the structure of a hair dryer. The resistance of the two identical heating coils at 30 °C are 40 Ω.

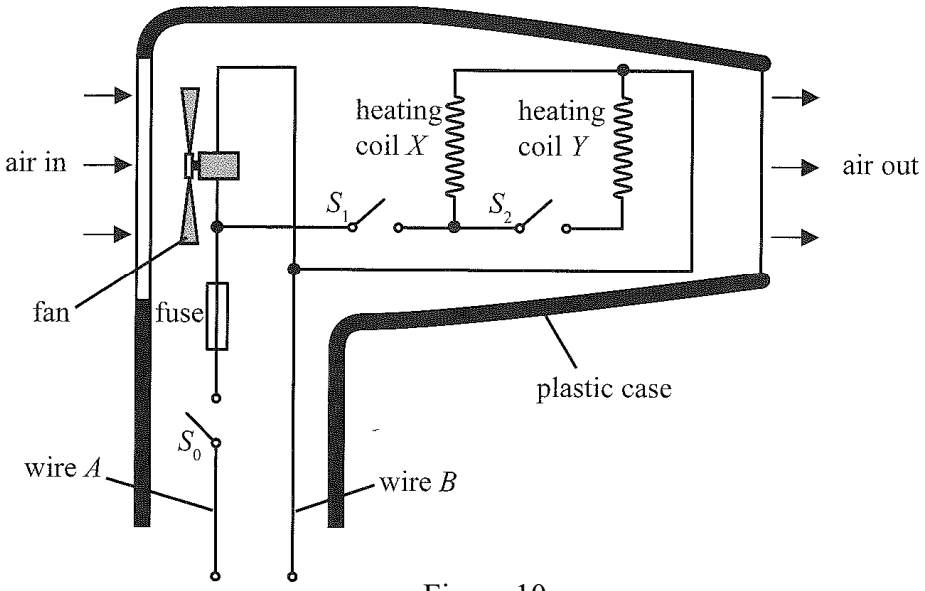



Figure 10

(a) Identify which of the wires *A* or *B* is the live wire. (1 mark)

_____

_____

(b) Which switch(es), $S_0$, $S_1$ and $S_2$, should be closed so that the air blown out from the hair dryer is

(i) the hottest;

(ii) at room temperature? (2 marks)

_____

_____

(c) (i) Determine the equivalent resistance of the heating coils at 30 °C when they are operated to heat the air to the highest temperature. (2 marks)

_____

_____

_____

(ii) Explain why the actual equivalent resistance of the heating coils is higher than the value found in (c) (i) when they are operating. (1 mark)

_____

_____

10. (d) State the function of the earth wire in an electric appliance. Explain why the above hair dryer does not need an earth wire. (2 marks)

_____

_____

_____

11. (a) A deuterium ($^{2}_{1}H$) and a tritium ($^{3}_{1}H$) undergo a nuclear reaction to form a helium ($^{4}_{2}He$) and a neutron.

(i) Write a nuclear equation for this nuclear reaction. (1 mark)

*(ii) Calculate the energy released in this reaction. Express your answer in MeV. (2 marks)

Given that

mass of $^{4}_{2}He$ = 4.002 602 u mass of $^{2}_{1}H$ = 2.014 102 u

mass of $^{3}_{1}H$ = 3.016 049 u mass of neutron = 1.008 665 u

(iii) This reaction has to be triggered by a very high temperature. Why? (1 mark)

(b) A radioactive potassium-40 (K-40) atom decays to a stable argon-40 (Ar-40) atom with a half-life of $1.25 \times 10^{9}$ years. Potassium–argon dating is a dating method based on this decay. By finding the ratio of the number of stable Ar-40 atoms to that of K-40 atoms in a sample, the age of it can be determined.

*(i) In a rock sample, the ratio of stable Ar-40 atoms to the number of K-40 atoms equals 10.3 : 1. Assume that all Ar-40 atoms come from the decay of K-40 originally present in the sample, show that the age of the rock is about $4.4 \times 10^{9}$ years. (3 marks)

(ii) State another assumption when you derive the formula in (b) (i). (1 mark)

**END OF PAPER**