Hwa Chong Institution Examinations
Secondary 3 Integrated Programme

CANDIDATE NAME					
CLASS				REGISTER NUMBER	

PHYSICS **October 2020**

Paper 2 Theory **1 hr 45 mins**

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, class and register number on all the work you hand in.
Write in dark blue or black pen.

You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES

Section A
Answer **all** questions.

Section B
Answer **all** questions. Question 10 has a choice of parts to answer.

Candidates are reminded that **all** quantitative answers should include appropriate units.
The use of an approved scientific calculator is expected, where appropriate.
Candidates are advised to show all their working in a clear and orderly manner, as more marks are awarded for sound use of Physics rather than correct answers.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

SECTION A (40 MARKS)

Answer **all** *the questions in this section.*

1 Fig. 1.1 and 1.2 show the readings on a vernier caliper with the jaws closed and with a test tube clamped between its jaws respectively.

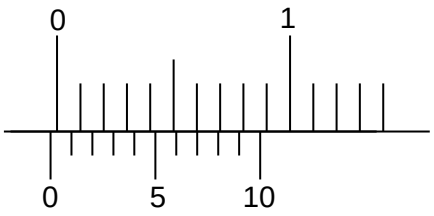

Fig. 1.1

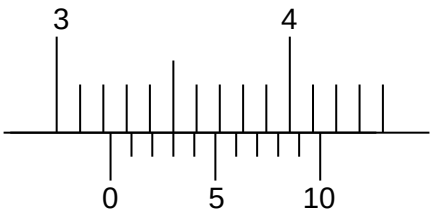

Fig. 1.2

(a) Write down the zero error of the vernier caliper.

[1]

(b) Determine the actual diameter of the test tube.

[2]

(c) Besides zero error, name a systematic error that could occur when conducting this measurement.

[1]

2 Diamond is useful for industrial applications and jewellery. The cut of a diamond affects how light gets transmitted into the eye of the observer when light passes through diamond. The depth of its pavilion from its crown governs the path light will travel when it enters the diamond from the outside.

A diamond that has a good cut is one that allows most light rays to exit from the top of the crown when light is shone from any angle around it. An incident ray of light is allowed to enter the surface of the diamond as shown in Fig. 2. The refractive index of diamond is 2.4 and its critical angle is approximately 25 °.

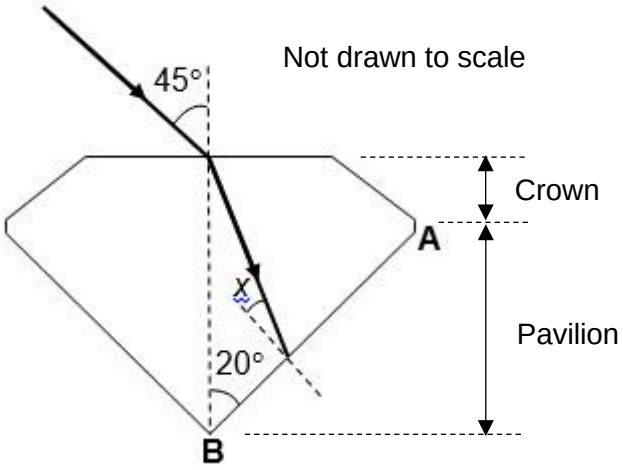

Fig. 2

(a) Calculate the speed of light in diamond given the speed of light in air is 3.0×10^8 m s^{-1}.

[1]

(b) Given the angle of incidence that light enters the diamond is 45 °, find the angle of incidence, *x*, that the light ray hits surface **AB**.

[2]

(c) Complete the path of the light ray in Fig. 2 to show how it exits the top of the diamond. (Note: the diagram is not drawn to scale) [2]

(d) The depth of the pavilion plays a pivotal role in how light gets reflected internally and thus how bright a diamond sparkles. With reference to Fig. 2, explain why a diamond with a shallower pavilion will not shine as brightly as one with a deeper pavilion.

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…….. [2]

3 Fig. 3 shows a sharp image being formed on a screen placed in front of a thin converging lens.

(a) Complete Fig. 3 to show how the ray diagram can be used to determine the position of the object.

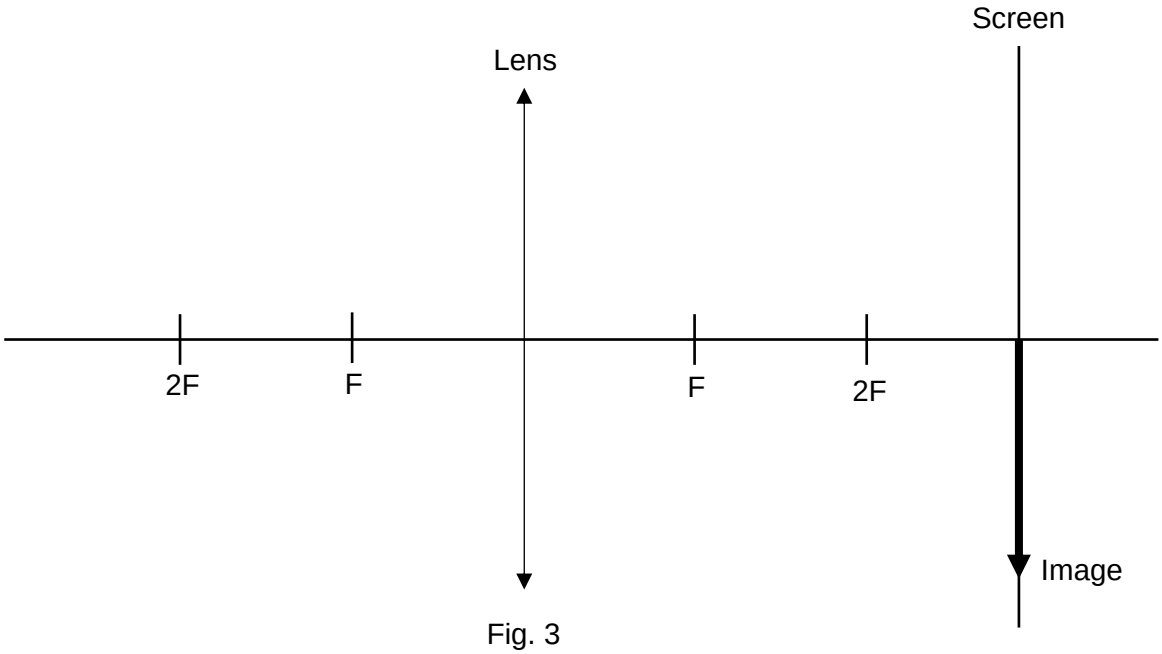

Fig. 3

[3]

(b) When a permanent marker is used to shade the upper half of the lens, the image on the screen looks different. Identify the difference and suggest a reason for the difference.

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..... [2]

4 Fig. 4 shows a 400 N weight supported by two strings, inclined at angles 30 ° and 50 ° to the vertical respectively. By drawing a scaled diagram, determine the tensions in both strings. State the scale used.

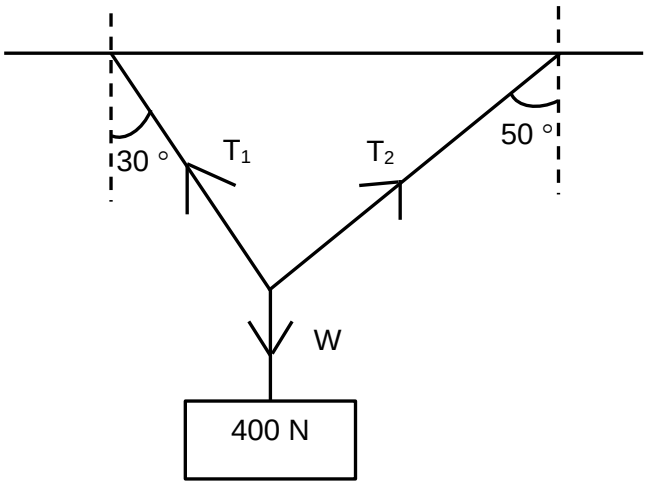

Fig. 4

[5]

5 Fig. 5.1 shows a ball placed at the top of a slope. A block is fixed rigidly to the lower end of the slope.

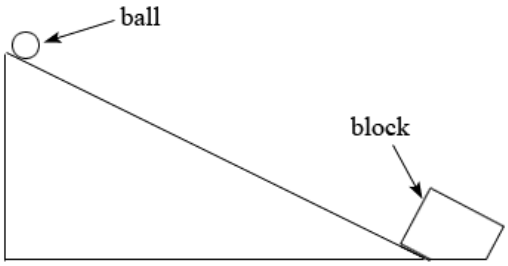

Fig. 5.1

The ball of mass 0.70 kg, initially at rest, is released from the top of the incline and the velocity of the ball rolling down the slope is found to vary with time as shown in the velocity-time graph as shown in Fig. 5.2.

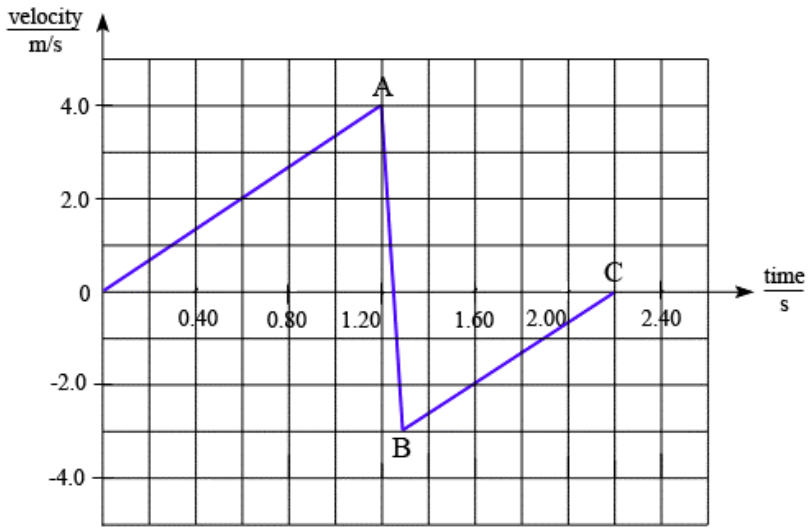

Fig. 5.2

(a) Describe the motion of the ball during the following periods:

(i) 0A

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…. ……... [1]

(ii) AB

……..

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……..

…… [2]

(b) Explain why the speed at B is less than the speed at A.

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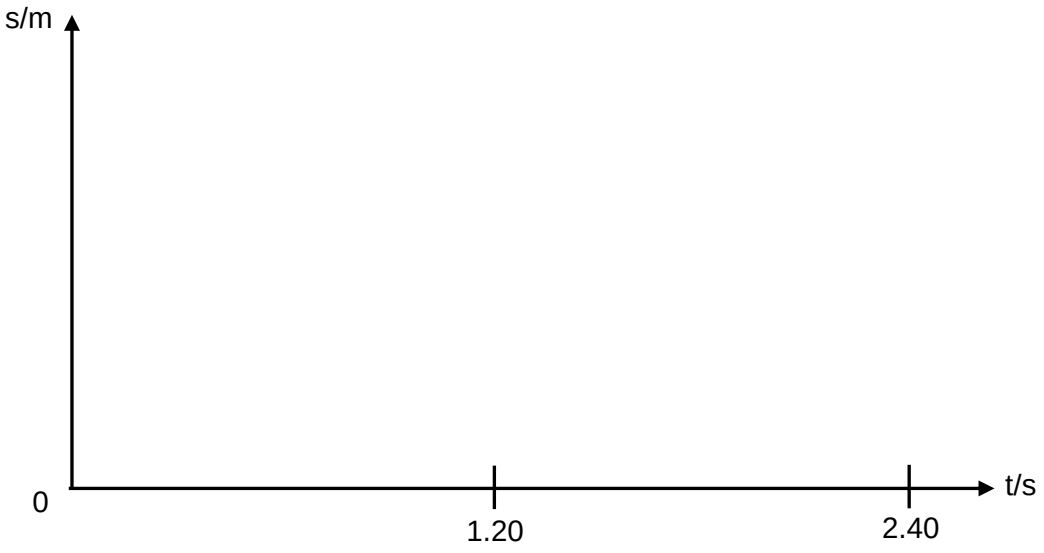
…… [1]

(c) Calculate the acceleration of the ball down the inclined slope.

[2]

(d) Sketch a displacement-time graph of the motion of the ball for t = 0 s to t = 2.20 s. The axes are drawn for you below.



[2]

6 Table 6 shows a table of data of planetary radius and masses.

Planet	Radius / 10^6 m	Mass / 10^{25} kg
Earth	6.38	0.597
Jupiter	71.5	190
Mars	3.40	0.0640
Mercury	2.44	0.0330
Neptune	24.8	10.2

Table 6

The gravitational field strength, g, depends on the mass of the planet (in kg) and the radius of the planet (in m), given by the relationship:

$$g = \frac{6.67 \times 10^{-11} \times \text{mass of planet}}{(\text{radius of planet})^2}$$

(a) Using the above relationship and the information in Table 6, calculate the weight of a 65.0 kg astronaut on earth.

[2]

(b) The mass and weight of the astronaut is now measured on Neptune.

(i) Suggest how the measurements on Neptune would be different from those measured on Earth.

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…… [1]

(ii) Explain, with numerical evidence, your answers in 6(b)(i).

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…… [1]

(c) A spacecraft travelled past Neptune and took several pictures. It is programmed to send signals of these pictures back to Earth and is detected by big-dish antenna on Earth as shown in Fig. 6.

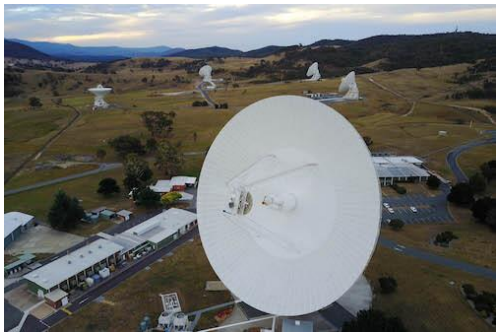

Fig. 6

(i) Identify the component in the electromagnetic spectrum that is used to send these signals.

……..……. [1]

(ii) Suggest a reason why this component is used.

……..……..

…… [1]

7 An experiment, as shown in Fig. 7, involves heating a thin-wall aluminium container that is half-filled with water. A small opening is made at the top of the container.

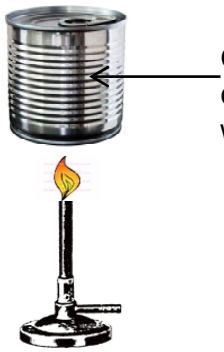

Fig. 7

(a) Using kinetic theory of matter, explain how air pressure is exerted on the walls in the container.

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…….. [2]

(b) After some time, the Bunsen burner is turned off and the container is sealed. Ice water is poured over it.

Describe and explain what will happen to the sealed container when ice water is poured over it.

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…….. [3]

SECTION B (30 Marks)

Answer question 8, 9 and either 10A or 10B in this section

8 The stopping distance travelled by a car depends on many factors. Two of the physical factors – road condition and the condition of the tyres – which determine whether the car stops or skids on braking is considered in this situation here. During wet road condition, a patterned tyre with (full tread) will allow water between the tyre and the road to be channelled out while a bald tyre does not.

Fig. 8.1 shows how the maximum possible friction between a car tyre and the road varies with the speed of the car under wet road conditions.

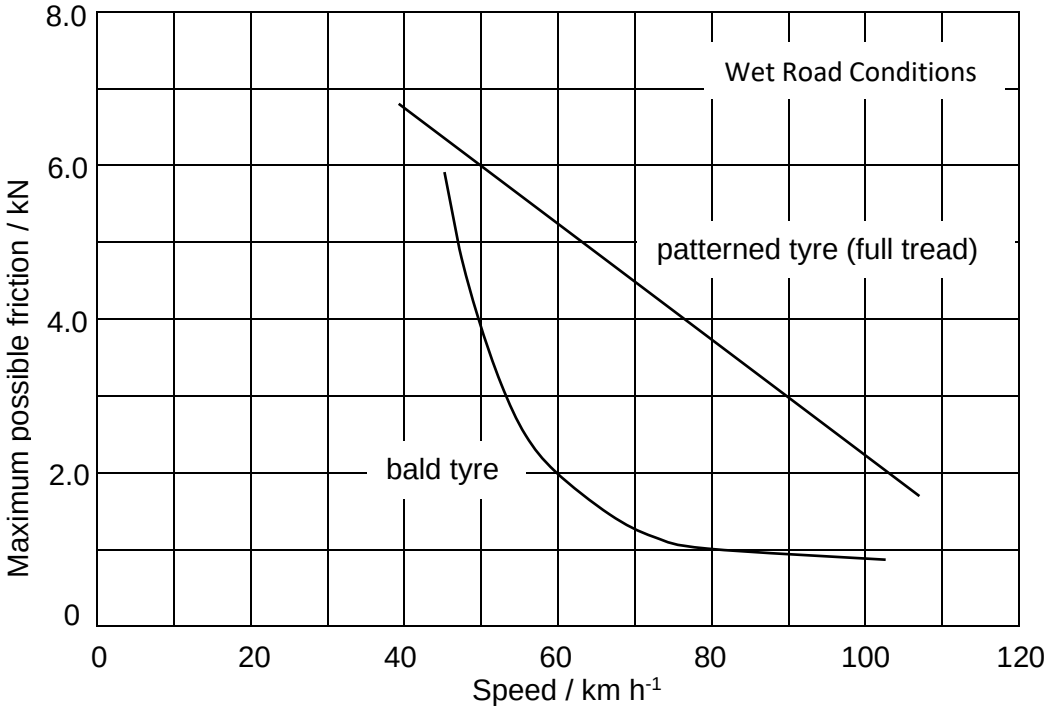

Fig. 8.1

Patterned tyre
(full tread)
Fig. 8.2

Bald tyre

Fig. 8.3

(a) Explain why the maximum friction on a patterned tyre (full tread) shown in Fig. 8.2, is greater than that of a bald tyre (Fig. 8.3).

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……..……. [2]

(b) In addition to the frictional forces between the tyres and the road, the car also experiences air resistance. The air resistance $\mathbf{F_{air}}$ experienced by a car at any speed **v** (in km h^{-1}) is given by the equation:

$$\mathbf{F_{air} = kv^2}$$, where **k** is a constant.

A car with patterned tyres (full thread) is moving on a **wet** road at a constant speed of 50 km h^{-1}. The total mass of the car and its passengers is 900 kg. If the air resistance experienced by the car at that speed is 5.0 kN, determine (from Fig. 8.1)

(i) the driving force of the car.

[2]

(ii) Find the value of the constant **k** when the car is moving at 50 km h^{-1}.

[2]

(iii) If the car's speed is now increased to a new constant speed of 90 km h^{-1}, determine the new driving force of the car at this constant speed.

[2]

(c) A special thermometer is used to measure the temperature of the air, T / °C, by relating it to the air pressure, P / kPa within a certain range of pressure. The relationship is given by:

$$P = k\,T + c$$

where k and c are constants

Some the pressure and temperature values of the air in the tyre are shown in Table 8.

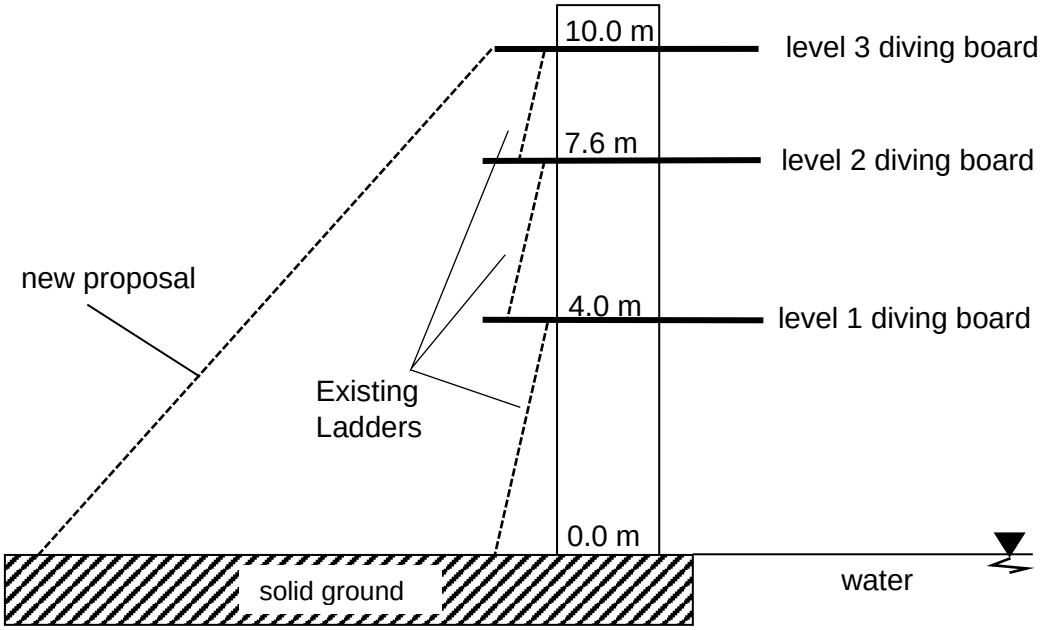
P / kPa	T / °C
170	20.0
240	70.0

Table 8

Calculate the temperature of the air in the tyre when the pressure is 200 kPa.

[2]

9 There are three diving boards at different heights in a diving pool. Each level is accessible by means of near vertical ladders. Level 1 is 4.0 m, level 2 is 7.6 m and level 3 is 10.0 m from the surface of the water.



(a) Find the gravitational potential energy gained by a diver that has a mass of 47 kg when he climbs from the ground to level 3.

[2]

(b) Determine the average effective power if it takes him 35 s to climb up to level 3.

[2]

(c) A diver dives from level 3 into the water. Calculate his speed just before he hits the surface of the water.

[2]

(d) Explain if there is any work done by gravity as a man walks along level 1.

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……..…… [2]

(e) A new proposal involves building an incline stairs that runs directly from the ground to level 3. It allows divers to go walk up a gentler incline instead of the existing near vertical climb.

Explain if the new proposal will reduce the work done by the diver against gravity.

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..…… [2]

EITHER

10A When a spacecraft returns to Earth from space, it must first re-enter the atmosphere. A high speed spacecraft has a very large amount of kinetic energy. As it is slowed down, the kinetic energy is converted into thermal energy. The temperature rise during re-entry is a major problem for spacecraft designers—the astronauts inside must not be cooked! During the re-entry of the American Mercury capsules, the air outside the capsule reach a temperature of 5260°C and turned an orange colour. The outside of the capsule itself reached a temperature of 1648°C.

(a) A special resin (a solid or highly viscous substance), on a fiberglass screen, was applied to the surface. The resin boiled and vapourised during this re-entry journey.

Explain the purpose of this special resin coating on the surface of the American Mercury capsules.

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…… [2]

(b) The space shuttle uses special silica tiles to protect it. The bottom and the leading edge are covered with glossy black tiles and a black reinforced carbon material covers the nose and wing leading edges.

Fig. 10.1

Comment on the following properties of the silica tiles used to cover the outer surface of a spacecraft as shown in Fig. 10.1:

(i) Colour (black or white);

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…… [2]

(ii) Large specific heat capacity;

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…… [2]

(iii) Poor thermal conductivity.

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…… [1]

(c) During the launch of the NASA space shuttle, the used rocket thruster will be ejected just before the space shuttle exit the atmospheric layer. An aluminium section (boiling point of 2467 °C) of a used rocket thruster has a mass of 1.0 kg. It returns to Earth at a speed of 5000 m s^{-1}.

(i) By assuming that all its kinetic energy is converted into thermal energy as it enters the atmosphere, find the temperature rise of the section. (The specific heat capacity of aluminium is 900 J $kg^{-1}°C^{-1}$)

[2]

(ii) Explain why such small sections of the rocket thruster would not be likely to be found on the surface of the Earth.

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…… [1]

OR

10B Read the following passage about a steam wax extractor and answer the questions that follow.

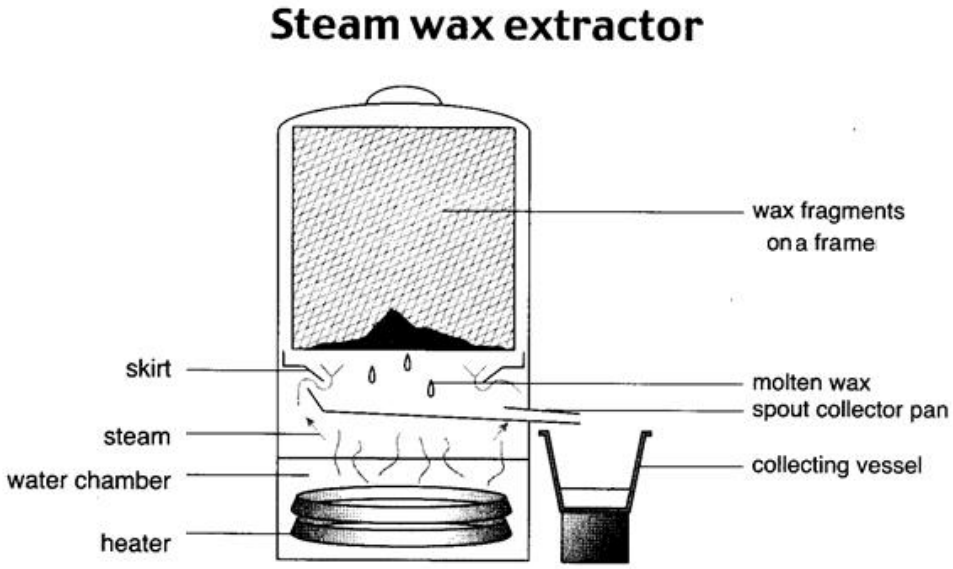

Fig. 10.2

Beeswax is the main component of the honeycomb build by honey bees. Uses of Beeswax includes making candles, furniture polish and even cosmetics. In modern bee farms, honey bees will build honey combs in wooden frames that can be removed from a bee hive. After the honey is extracted from the combs, the beeswax can be collected using a wax extractor.

A steam wax extractor consists of a water chamber where water is boiled by a gas or electric heater. The spout collector pan allows the molten wax and condensed steam to run out into a collecting vessel. The skirt above the spout collector pan that deflects any molten wax into the pan rather than falling into the boiling water below. A steam wax extractor, shown in Fig. 10.2, is a simple and an effective tool to extract wax from honeycombs, as beeswax absorbs vapour and becomes molten wax.

Beeswax melts at 63 °C and its *specific latent heat of fusion* is 1.7×10^5 J kg^{-1} which is only about 8.0 % *specific latent heat of vaporization* of water.

(a) Explain why steam is a better medium to melt beeswax than boiling water.

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…… [2]

(b) Define the term *specific latent heat of fusion.*

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…… [1]

(c) Using the information above and given that the specific latent heat of vaporization and specific heat capacity of water are 2.26×10^6 J kg^{-1} and 4200 J kg^{-1} $°C^{-1}$ respectively, estimate the maximum mass of beeswax melted by 0.100 kg of steam at 100 °C.

[4]

(d) Using ideas from molecular theory, describe what happens to the wax molecules during melting.

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…… [2]

(e) Suggest one way to increase the efficiency of extracting wax using this steam wax extractor, without increasing the power of the heater.

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…… [1]

END OF PAPER