NAME:	NO:	CLASS:

ADMIRALTY SECONDARY SCHOOL

END-OF-YEAR EXAMINATION 2022

SUBJECT	:	Physics
CODE/PAPER	:	6091
LEVEL/STREAM	:	Secondary 3 Express
DATE	:	12 October 2022
TIME	:	0800h – 1000h
DURATION	:	2 hours

Instructions to candidates:
Write your name, index number and class on the cover page.
Write in dark blue or black pen.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A: Multiple Choice Questions [25 marks]
Answer all questions in the OTAS provided.

Section B: Short Answer Questions [45 marks]
Answer all questions. Write your answers in the spaces provided in the question paper.

Section C: Structured Questions [30 marks]
Answer all questions, the last question is in the form either/or. Write your answers in the spaces provided in the question paper.

Submit the question paper and OTAS separately.

Candidates are reminded that all quantitative answers should include appropriate units.
The use of an approved scientific calculator is expected, where appropriate.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
Section A	/ 25
Section B	/ 45
Section C	/ 30
Total	/ 100

DO NOT TURN OVER THIS PAPER UNTIL YOU ARE TOLD TO DO SO.

This question paper consists of **26** printed pages including this cover page.

Section A
Answer all questions.

1 Which of the following correctly identifies one scalar quantity and one vector quantity?

	scalar	vector
A	time	mass
B	length	moment
C	temperature	work done
D	weight	acceleration

2 Vernier calipers are used to measure the length of an iron block. Diagram 1 shows the reading when the jaws are closed. Diagram 2 shows the reading when the block is between the jaws.

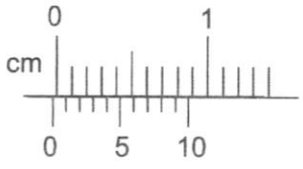


diagram 1

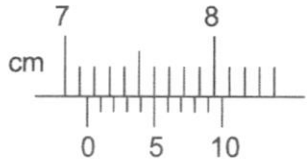
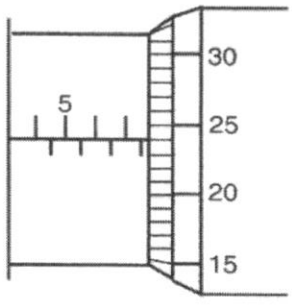


diagram 2

What is the length of the iron block?

A 7.08 cm **B** 7.12 cm **C** 7.18 cm **D** 7.22 cm

3 A wire is placed between the jaws of a micrometer screw gauge. The diagram shows the reading after the jaws are tightened.

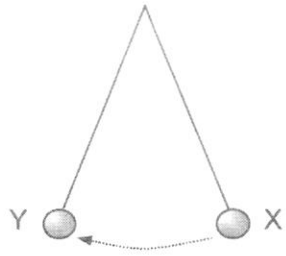


What is the radius of the wire?

A 3.87 mm **B** 5.12 mm **C** 7.74 mm **D** 10.24 mm

3

4 The diagram shows a pendulum swinging between points X and Y.



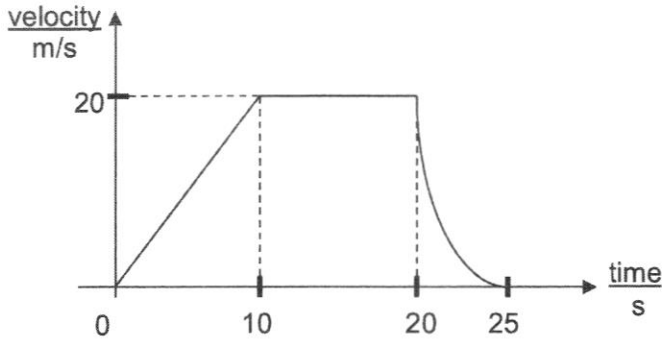
The time taken for a pendulum to swing from X to Y is 0.3 s.
What is the time taken for the pendulum to make 10 complete oscillations?

A 1.2 s **B** 3.0 s **C** 6.0 s **D** 12 s

5 A ball is dropped in vacuum.
Which of the following describes the motion of the ball?

A Speed decreases at a non-constant rate.
B Speed decreases at a constant rate.
C Speed increases at a non-constant rate.
D Speed increases at a constant rate.

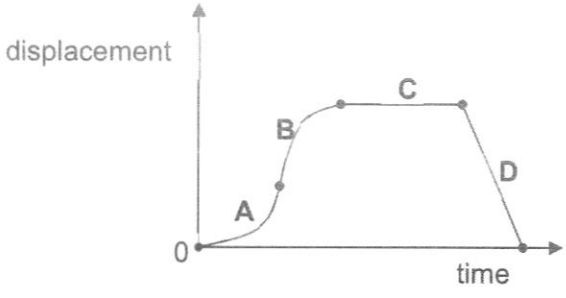
6 While driving on the road, a driver notices an obstruction and applies the brakes. The graph shows how the velocity of the car changes with time for its whole journey.



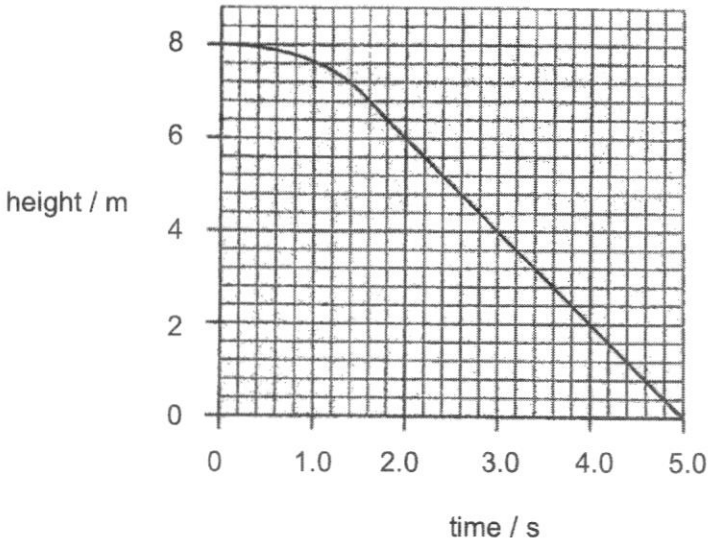
How far does the car travel before the brakes are applied?

A 100 m **B** 200 m **C** 300 m **D** 350 m

7 The graph shows a displacement time graph of a cyclist.
Which region of the graph represents decreasing velocity?



8 The graph shows how the height of a falling object changes with time.



What is the terminal velocity of the object?

A 1.0 m/s **B** 1.3 m/s **C** 1.6 m/s **D** 2.0 m/s

9 A measuring cylinder consists of 70 cm^3 of water. When a metal bolt is completely submerged in the water, the reading of the measuring cylinder goes up to 78 cm^3.

The mass of the bolt is 56 g.

What is the density of the bolt?

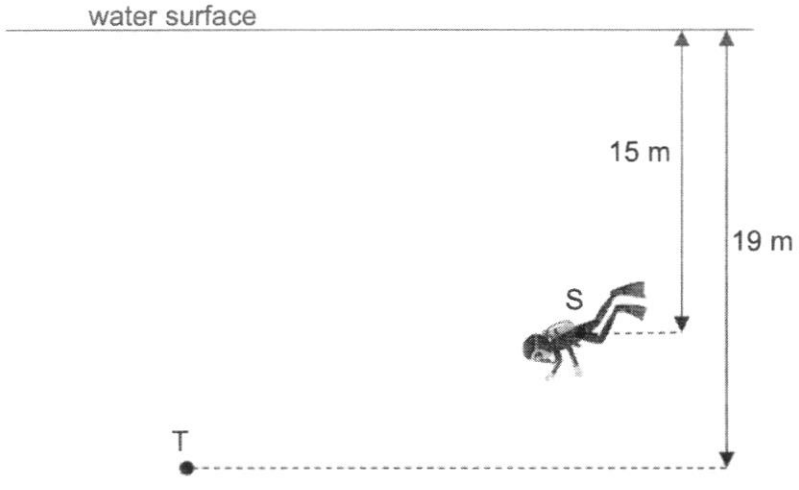
A 0.71 g/cm^3 **B** 1.4 g/cm^3 **C** 7.0 g/cm^3 **D** 14 g/cm^3

5

10 Which property of an object resists a change in its state of rest or motion?

A acceleration
B mass
C speed
D volume

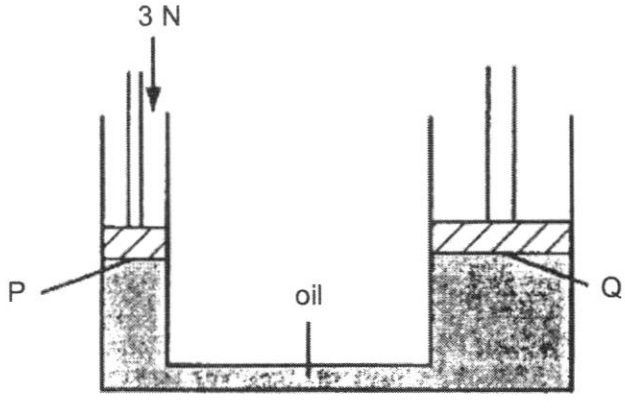
11 A man is in water of density 1000 kg/m^3. He dives from point S to point T.



The gravitational field strength is 10 N/kg. The atmospheric pressure is 1 x 10^5 Pa.
What is the change in pressure on the man?

A 4000 Pa **B** 40000 Pa **C** 140 000 Pa **D** 190 000 Pa

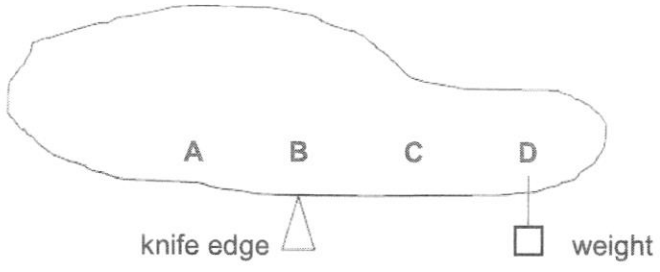
12 The diagram shows a hydraulic press.



Piston P has a cross-sectional area of 2 cm^2 and piston Q has a cross-sectional area of 6 cm^2. A 3 N force is exerted on piston P.
What is the upward force on piston Q?

A 1 N **B** 1.5 N **C** 9 N **D** 12 N

13 A student places an irregularly shaped object on a knife edge. To balance the object, she suspends a weight on the right side of the object as shown in the diagram.



Where is the centre of gravity of the object most likely to be at?

14 An electric motor is supplied with 600 J of energy to produce 450 J of mechanical energy. What is the efficiency of the motor?

A 25% **B** 30% **C** 75% **D** 130%

15 A crane lifts 1500 kg of building material from the ground to an elevated platform in 5 minutes. The height from the ground to the platform is 15 m. The gravitational field strength is 10 N/kg. What is the average power of the crane?

A 75 W **B** 750 W **C** 45000 W **D** 225000 W

16 The table shows the resistance measured by a resistance thermometer at two reference temperatures.

temperature / °C	resistance / Ω
0	2.0
60	6.0

What is the resistance measured by the thermometer at 90 °C?

A 1.0 Ω **B** 2.0 Ω **C** 8.0 Ω **D** 9.0 Ω

17 Pollen grains in water are illuminated by a beam of light and observed under a microscope. The pollen grains are observed to be in continuous and random motion. Why is this so?

A The convection currents in water move the pollen grains.
B The pollen grains collide frequently with one another.
C The beam of light transfers energy to the set-up.
D The water molecules are moving.

18 Which of the following increases when a liquid becomes a gas at its boiling point?

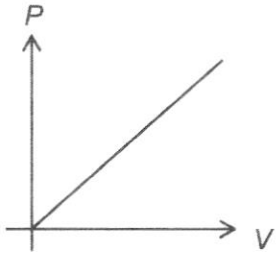
A average speed of the molecules
B distance between molecules
C number of molecules
D size of molecules

19 How is heat from a flame transferred through the base of a metal frying pan?

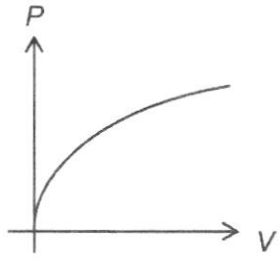
A by conduction only
B by radiation only
C by conduction and convection
D by convection and radiation

20 Which of the following graphs shows the correct relationship between pressure and volume of an ideal gas at constant temperature?

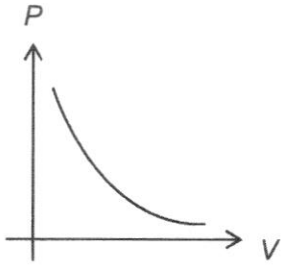
A



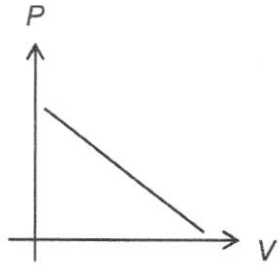
B



C



D



21 The heat capacity of a block of lead is 39 J $°C^{-1}$.
Which of the following statements is true?

A 39 J of energy is needed to raise the temperature of the lead by 1°C.
B 39 J of energy is needed to raise the temperature of the lead by 1°C in one second.
C 39 J of energy is needed to raise the temperature of a unit mass of lead by 1°C.
D A bigger block of lead will still have the same heat capacity value of 39 J $°C^{-1}$.

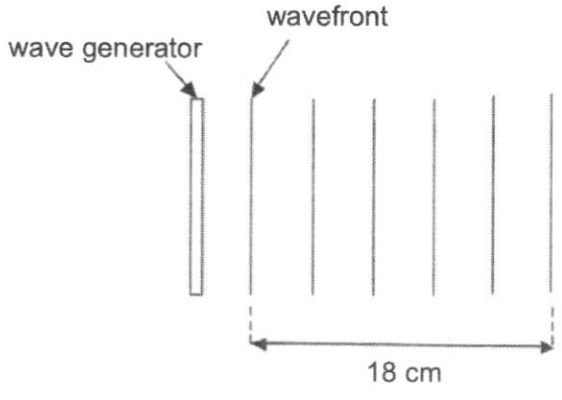
22 Which statement describes the evaporation of liquid?

A It occurs at any temperature and only on the surface of the liquid.
B It occurs at any temperature and throughout the liquid.
C It occurs at a fixed temperature and only on the surface of the liquid.
D It occurs at a fixed temperature and throughout the liquid.

23 Which of the following is equal to the amplitude of a wave?

A horizontal distance between two successive crests
B half the horizontal distance between two successive crests
C vertical distance from the crest to the trough
D half the vertical distance from the crest to the trough

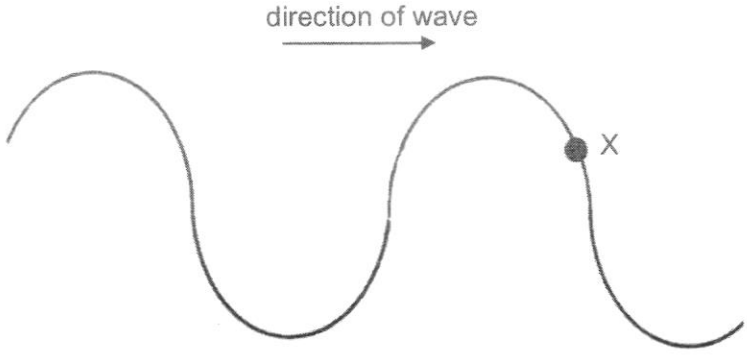
24 The diagram shows waves produced by a source.



The source makes 4 oscillations per second.
Which of the following gives an accurate description of the waves produced?

	frequency / Hz	wavelength / cm	speed / cm/s
A	0.25	3.6	0.90
B	0.25	18	4.5
C	4.0	3.6	14
D	4.0	18	72

25 A point X is marked on a rope before the rope is set to oscillate. The direction of the wave travel in the rope is shown. At the particular instant, what is the direction in which point X moves?



A down **B** left **C** right **D** up

Section B
Answer all questions.

1 **(a)** Circle the prefix with the smallest value.

μ n G m [1]

(b) Mass and length are examples of base quantities.
State one other base quantity and its corresponding SI unit.

..... [1]

(c) Fig. 1.1 shows a Spinning Teacups ride at an amusement park. When in operation, each teacup moves in a circular path of diameter 14 m as shown in Fig. 1.2.

Fig. 1.1

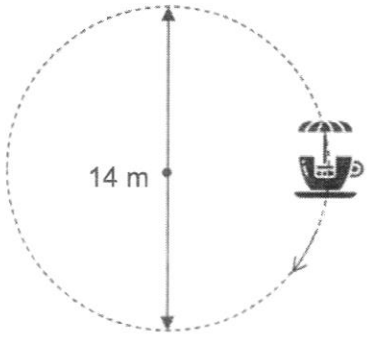


Fig. 1.2

(i) The teacup takes 20 s to complete one rotation.
Calculate the average speed of the teacup.

speed = ... [2]

(ii) Describe what happens to the average velocity of the teacup for one complete rotation.

.....

..... [2]

2 Fig. 2.1 shows an art piece being supported by two strings suspended from a beam.

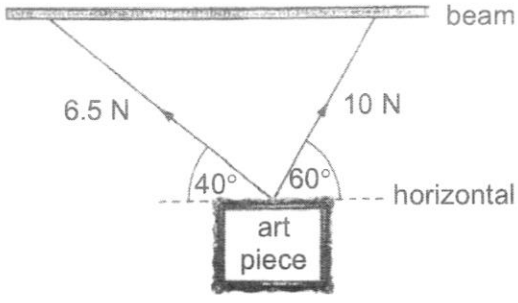


Fig. 2.1

The tensions in the two strings are 6.5 N and 10 N.

(a) In the space below, draw a scale diagram to determine the size of the resultant force.

resultant force = ... [3]

(b) Hence or otherwise, state the weight of the art piece.

weight = ... [1]

3 Fig. 3.1 shows a boat in motion. The boat is travelling in a straight line.

Fig. 3.1

The boat has a mass of 1360 kg and experiences a constant force of 3500 N acting forwards on its propellers.

(a) At one instant, the drag force acting backwards on the boat due to the water is 2000 N. Calculate the acceleration of the boat.

acceleration = ... [3]

(b) Explain, in terms of the forces acting, why the acceleration of the boat changes during the motion.

.....

.....

.....

..... [2]

(c) The 3500 N force and the drag force are not a Newton's Third Law action-reaction pair.
Describe the other force that is part of the action-reaction pair with the 3500 N force and state the body on which it acts.

.....

..... [2]

4 An archer shoots an arrow using a bow. She pulls back the string on the bow to stretch it, as shown in Fig. 4.1, before letting go to launch the arrow.

Fig. 4.1

(a) The archer exerts a constant force of 65 N and pulls the string over a distance of 50 cm. Assuming that there are no energy losses, calculate the energy transferred to the string.

energy = ... [2]

(b) The arrow has a mass of 0.016 kg. Calculate the speed of the arrow when it first leaves the bow.

speed = ... [2]

(c) Fig. 4.2 shows the pathway taken by an arrow after it leaves the bow.

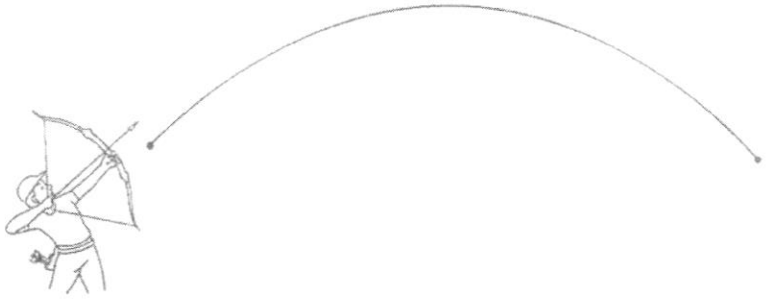


Fig. 4.2

Describe the energy changes from the time the string is pulled to the time when the arrow reaches the highest point.

.....

.....

..... [2]

5 **(a)** Fig. 5.1 shows the dimensions of a block.

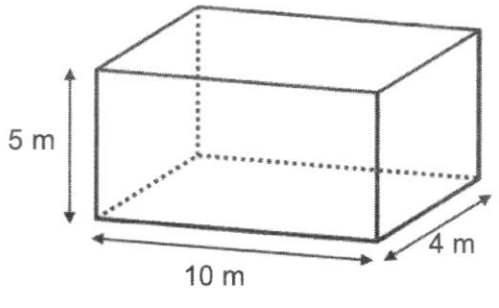


Fig. 5.1

The block has a mass of 40 kg and is rested on one of its flat surfaces on the ground. The gravitational field strength is 10 N/kg.
Calculate the maximum pressure that the block can exert on the ground.

pressure = ... [2]

15

(b) Fig. 5.2 shows a manometer used to measure the pressure difference between air inside a container and atmospheric pressure.

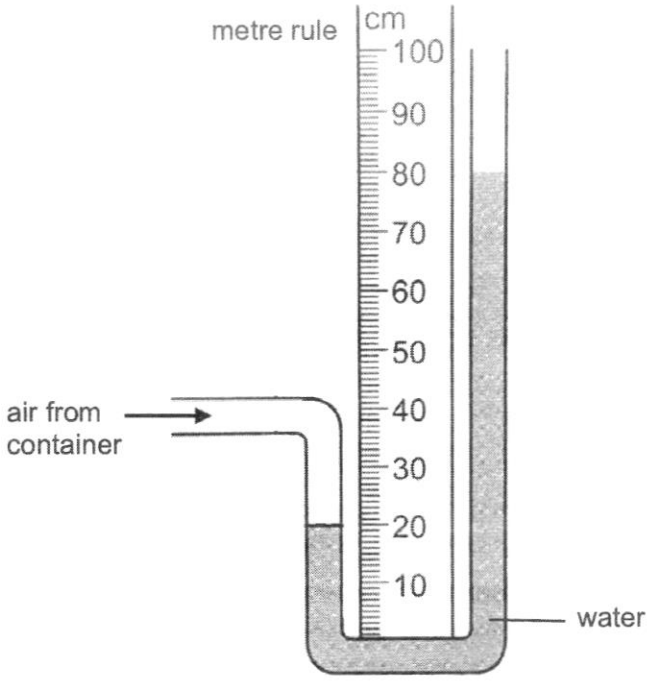


Fig. 5.2

(i) Calculate the pressure difference as shown by the manometer in Fig. 5.2. The gravitational field strength is 10 N/kg. The density of water is 1000 kg/m^3.

pressure difference = ... [2]

(ii) State whether the height difference between the liquid columns will increase, decrease or remain the same if liquid mercury is used instead of water. The density of mercury is 14000 kg/m^3.

.....

.....

..... [2]

(iii) State one precaution which must be taken in the laboratory to ensure that the height readings obtained are accurate.

.....

..... [1]

6 Fig. 6.1 shows an uncalibrated liquid-in-glass thermometer.

Fig. 6.1

Describe how the thermometer can be calibrated with the Celsius scale of temperature.

.....

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.....

.....

..... [3]

7 In an experiment, heat is supplied at a constant rate to a fixed mass of substance. The variation with time of the temperature of the substance is shown in Fig. 7.1.

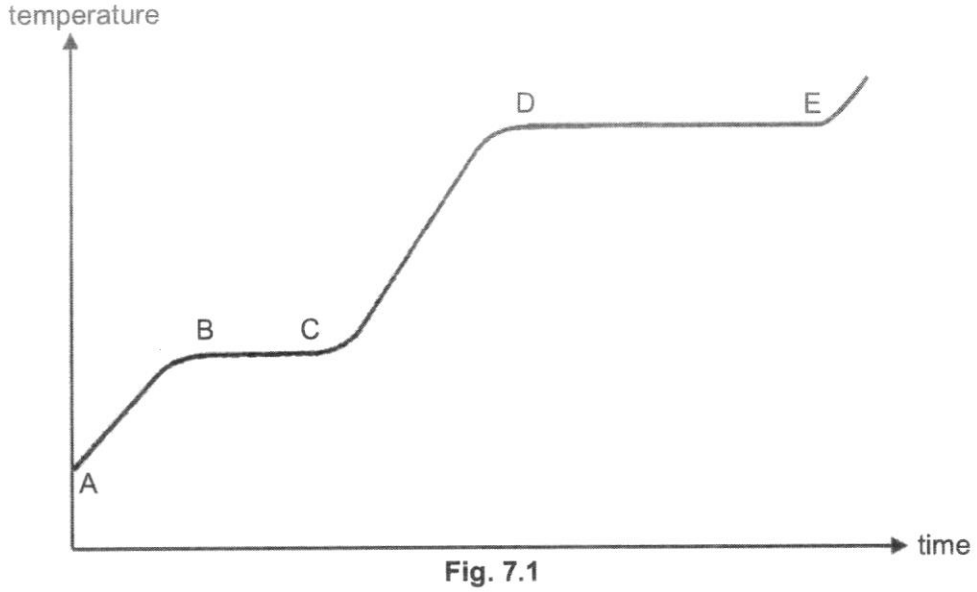


Fig. 7.1

(a) State the changes that happen, if any, to the kinetic energy and to the potential energy of the molecules of the substance at region CD.

kinetic energy .....

potential energy ..... [1]

(b) Explain, in terms of molecules, why the temperature of the substance remains constant at region BC even though heat is supplied to it.

.....

.....

.....

..... [2]

(c) By making reference to Fig. 7.1, state and explain how the specific latent heat of fusion of the substance compares with its specific latent heat of vaporization.

.....

.....

.....

..... [2]

8 **(a)** Describe the difference between conduction and convection.

.....

.....

..... [2]

(b) Fig. 8.1 shows parts of a filament lamp.

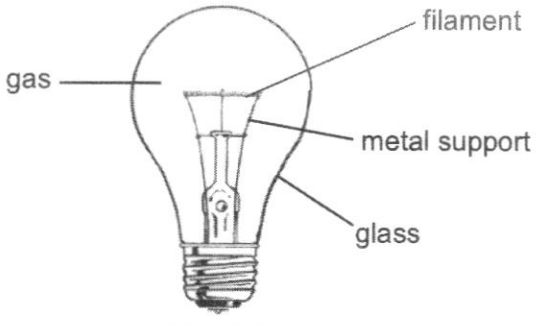


Fig. 8.1

When the lamp is connected in a circuit, electric current passes through the filament and heats the filament up until it glows.

(i) Describe how thermal energy is transferred by convection inside the lamp.

.....

.....

.....

.....

.....

..... [3]

(ii) Describe one way through which thermal energy is transferred by conduction in the lamp.

.....

..... [1]

(iii) The filament lamp has a low energy efficiency. Explain why this is so.

.....

..... [1]

Section C

Answer all the questions in this section.
Question 11 is in the form Either / Or.

9 The space shuttle was a manned, recoverable and reusable spacecraft designed to carry people and cargo into outer space. Fig. 9.1 shows the main components involved in the launching of the space shuttle from Earth.

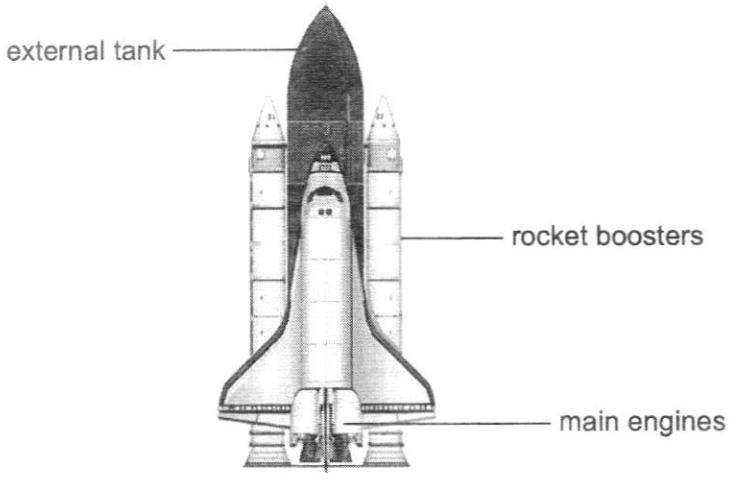


Fig. 9.1

Data relevant to the space shuttle is given in the box.

Space Shuttle Mass of space shuttle with main engines: 1.05×10^5 kg Rocket Booster Number of rocket boosters: 3 Mass of each booster at launch: 5.87×10^5 kg Mass of each empty booster: 8.72×10^4 kg External Tank Number of external tanks: 1 Mass of external tank at launch: 7.52×10^5 kg Mass of empty external tank: 2.95×10^4 kg

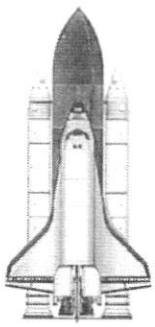
During launch, the space shuttle's main engines and rocket boosters provide the initial thrust force, which is 150% of the total weight.

Two minutes after launch, the rocket boosters run out of fuel and are discarded. The main engines continue to provide thrust force.

8.5 minutes after launch, the external tank runs out of fuel and is discarded.

20

(a) On the diagram below, draw and label the two vertical forces acting on the space shuttle at launch.



[1]

(b) Explain why the thrust force required for launch must be greater than the total weight.

.....

.....

..... [2]

(c) **(i)** The gravitational field strength is 10 N/kg.
Calculate the initial thrust force needed at launch.

thrust force = ... [3]

(ii) State and explain whether the initial thrust force needed would be greater or less than the value calculated in **(c)(i)** if the space shuttle were launched from the moon instead.

.....

..... [1]

(d) Calculate the rate of fuel consumption, in kg/min, in the external tank.

rate = ... [2]

(e) State one assumption made in your calculation for **(d)**.

.....

..... [1]

10 Fig. 10.1 shows a man of mass 80 kg snowboarding down a slope.

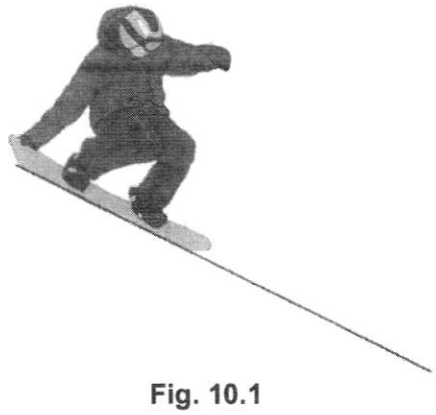


Fig. 10.1

Table 10.2 shows the height of the man above the ground and his velocity for the first 10 seconds of his motion.

time / s	height / m	velocity / m/s
0.0	50.0	0
2.0	49.0	2
4.0	47.5	4
6.0	44.0	6
8.0	40.0	7
10.0	33.0	7

Table 10.2

(a) Using Fig. 10.1, identify and explain two ways that the man is keeping stable.

.....

.....

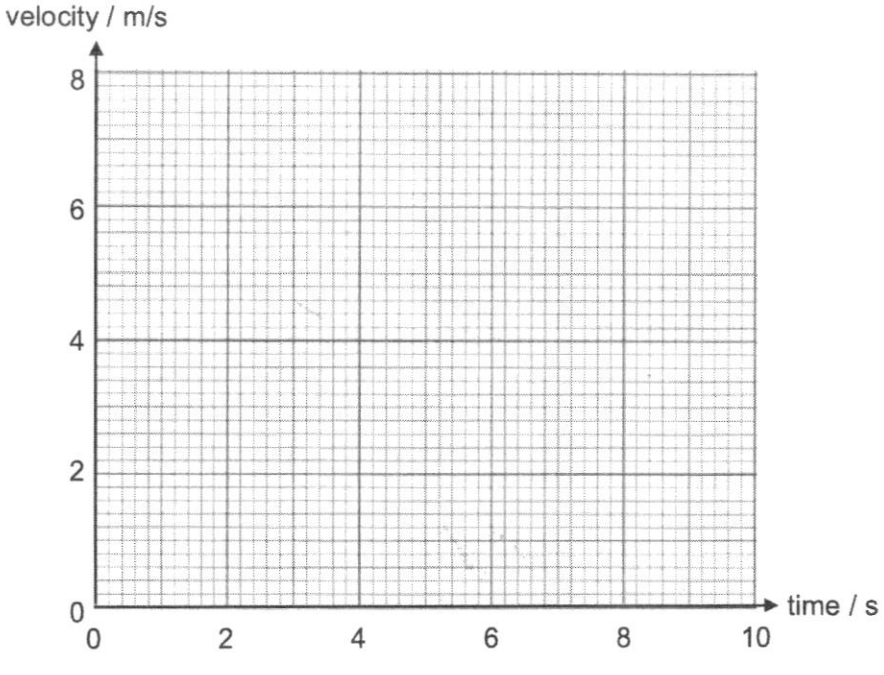
.....

..... [2]

(b) Show that the man loses 1360 J of energy over the first 4 seconds.

[3]

(c) (i) Using the relevant information from Table 10.2, plot the velocity-time graph for the first 10 seconds of the man's motion.



[2]

(ii) Describe the motion of the man from time = 0.0 s to time = 10.0 s.

.....

.....

.....

.....

.....

..... [3]

11 EITHER

Fig. 11.1 shows a set up consisting of a rod, piston and cylinder. A 550 N load is suspended at one end of the rod to keep the air in the cylinder under pressure. The mass of the rod and piston are negligible.

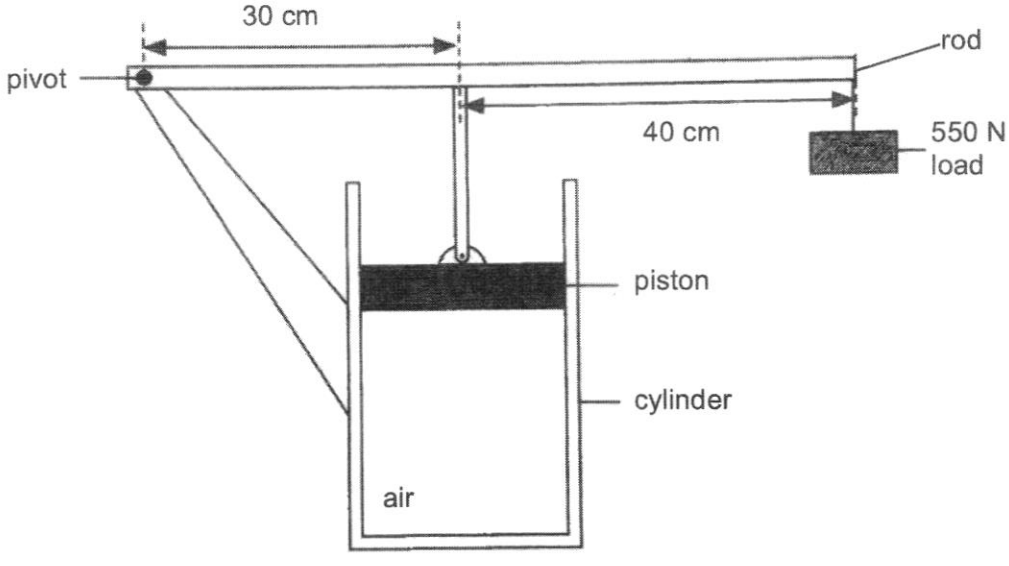


Fig. 11.1

(a) Explain, using ideas about molecules, how the air inside the cylinder creates a pressure.

.....

.....

.....

..... [2]

(b) State the principle of moments.

.....

.....

.....

..... [2]

(c) By taking moments about the pivot, determine the force acting on the piston.

force = ... [2]

(d) The air in the cylinder is heated up and the piston is observed to move.

(i) Determine the direction of piston movement.

..... [1]

(ii) Explain, using ideas about molecules, your answer in **(d)(i)**.

.....

.....

.....

..... [3]

11 OR

In an experiment, a student heats up water in a microwave oven. The walls of the beaker are painted black.

(a) The microwave oven cooks food by exposing it to waves of frequency 2.4×10^9 Hz.

(i) Explain what it means for a wave to have a frequency of 2.4×10^9 Hz.

.....

..... [1]

(ii) If the speed of the wave is 3.0×10^8 m/s, calculate its wavelength.

wavelength = ... [1]

(b) The mass of the water in the beaker is 50 g and the specific heat capacity of the water is 4.2 J/(g°C).
The input power of the microwave oven is 700 W.
Only 40% of the input energy is absorbed by the water.
Calculate the time taken to warm the water from 20 °C to 90 °C.

time taken = ... [3]

(c) The beaker of water is taken out from the oven and placed in the laboratory. The temperature of the water is then measured over an extended period of time. Fig. 11.2 shows the variation of the temperature with time.

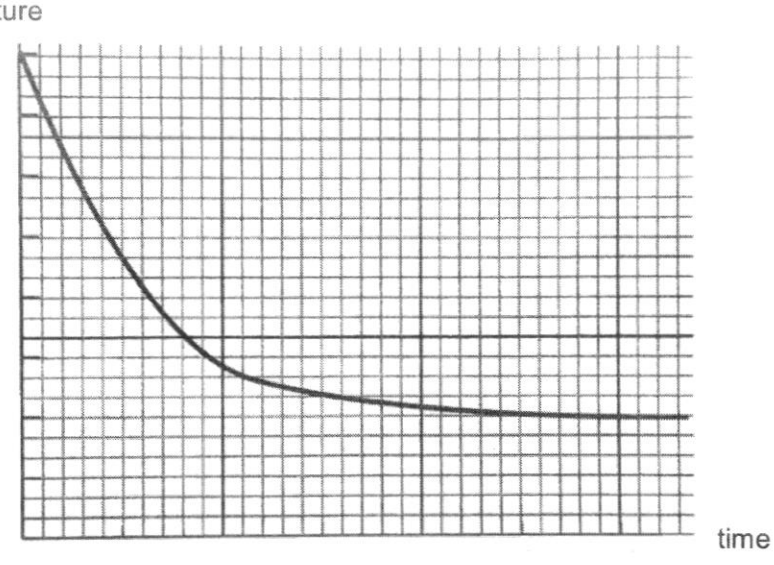


Fig. 11.2

(i) Explain why the temperature of the water becomes constant after some time.

.....

..... [1]

(ii) On Fig. 11.2, sketch a graph to show how temperature of water would vary with time if the walls of the beaker are painted white instead. [2]

(iii) Explain your answer in **(c)(ii)**.

.....

.....

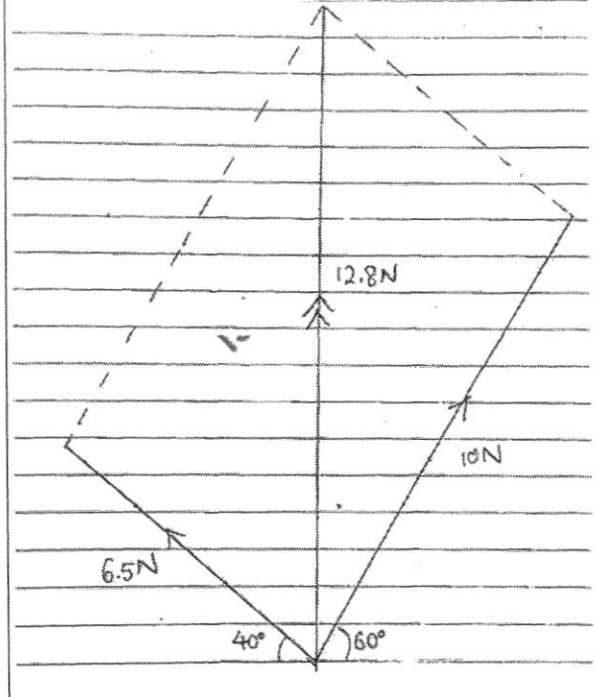
.....

..... [2]

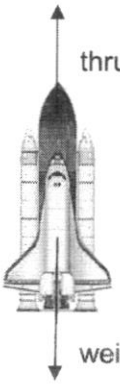
END OF PAPER

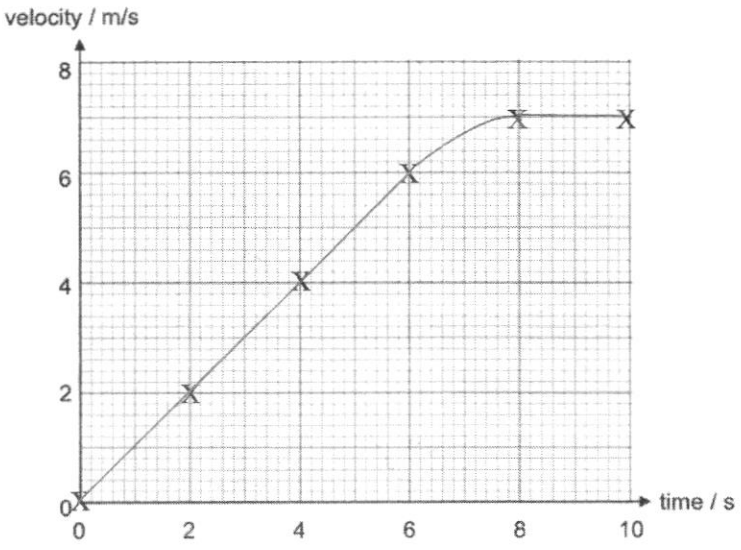
Admiralty Secondary School
3E PHYSICS (6091) EOY 2022 Marking Scheme

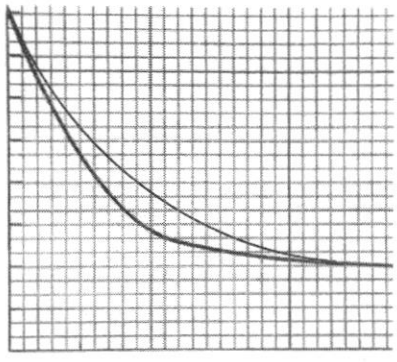
SECTION A (25 marks)									
1	B	6	C	11	B	16	C	21	A
2	C	7	B	12	C	17	D	22	A
3	A	8	D	13	A	18	B	23	D
4	C	9	C	14	C	19	A	24	C
5	D	10	B	15	B	20	C	25	D

	SECTION B (45 m)		
Qn.	**Description**		**Remarks**
1a	n	1	
b	ANY ONE: Time – seconds Temperature – kelvin Current – ampere Luminous intensity – candela Amount of substance – mole	1	
ci	Average speed = total distance / total time = (π x 14) / 20 = 2.20 m/s (3 sf)	 1 1	 Correct distance
cii	The start and end points of the teacup are the same, so total displacement is zero. Since average velocity = total displacement/total time, the average velocity is zero.	1 1	
2a	Scale 1.0 cm: 1 N  Resultant force = 12.8 N	1 1 1	A: any reasonable scale Vector diagram (must have > and >>) A: 12.6 N – 13.0 N
2b	12.8 N	1	Ecf allowed

3a	Resultant force = 3500 – 2000 = 1500 N F = ma 1500 = 1360a a = 1.10 m/s^2	1 1 1	 Full ecf allowed
b	As the boat speeds up in water, the drag force increases. Since net force will decrease, acceleration of the boat will decrease.	1 1	
c	Force of propeller on the water	1 1	Mention of propeller Mention of water
4a	W = Fs = 65 x 0.5 = 32.5 J	1	Correct formula used
b	Work done = Initial kinetic energy of arrow 32.5 = ½ mv^2 32.5 = ½ (0.016) v^2 v = 63.7 m/s	1 1	 Full ecf allowed
c	As the archer releases the string, elastic potential energy of the string is converted to kinetic energy of the arrow As the arrow travels upwards, kinetic energy is converted to gravitational potential energy	1	if full conversion is given without description of scenario, only 1m will be awarded
5a	Maximum pressure = Weight / Smallest surface area = (40 x 10) / (5 x 4) = 20 Pa	 1 1	 Correct surface area
bi	Pressure difference = pgh = 1000 x 10 x (0.80 - 0.20) = 6000 pa	1 1	Correct height (cm or m)
bii	The height difference will decrease For the same pressure difference, an increase in density will lead to a decrease in height difference	1 1	
biii	Align line of sight with the reading. Ensure that metre rule is perpendicular to table	1	A: any logical answers
6	Immerse bulb of thermometer into pure melting ice. The liquid level corresponds to 0° C Make a marking on the stem. Position the bulg of the thermometer above boiling water. The liquid lebel corresponds to 100°C. Make a marking on the stem. Divide the space between the two markings into 100 equal divisions.	1 1 1	
7a	Kinetic energy increases Potential energy remains the same	1	Both correct
b	Thermal energy is used to weaken the bonds between the molecules. Since average kinetic energy remains constant, the average speed of the molecules will remain the same and hence temperature will not change.	1 1	
c	The specific latent heat of fusion is lower than the specific latent heat of vaporization. For the same mass of substance, less time is needed to melt the substance than to boil it.	1 1	
8a	During conduction, thermal energy is transferred without any transfer of the medium but during convection, thermal energy is transferred through bulk movement of the medium.	1 1	

bi	Gas directly above the filament heats up, expands, becomes less dense and rises. Gas higher up in the lamp being cooler and denser, sinks. The cycle repeats to set up a convection current.	1 1 1	
bii	Thermal energy is conducted away from the filament by the metal support/gas. OR Thermal energy is transferred from the gas to the surroundings by conduction through the glass.	1	
biii	Much of the input energy is converted to thermal energy.	1	
	SECTION C (30 m)		
Qn.	**Description**		**Remarks**
9a	 	1	Both forces
b	When thrust is greater than weight, there is a net upward force. Since F = ma, the space shuttle will accelerate from rest upwards.	1 1	
ci	Total mass = $(1.05 \times 10^5) + (3 \times 5.87 \times 10^5) + (7.52 \times 10^5)$ = 2 618 000 kg (or 2.618×10^6 kg) Initial thrust = 150% of total weight = $\frac{150}{100} \times mg$ = $\frac{150}{100} \times 2\,618\,000 \times 10$ = 39300000 N (or 3.93×10^7 N)	1 1 1	 Allow ecf Allow ecf
cii	Since gravitational field strength on the moon is lower, the initial thrust force needed will be lower.	1	
d	Mass of fuel in external tank = $(7.52 \times 10^5) - (2.95 \times 10^4)$ = 722 500 kg Rate of fuel consumption = 722 500 / 8.5 = 85 000 kg/min	1 1	 Allow ecf
e	Rate of fuel consumption is constant.	1	
10a	The man is keeping low so that his centre of gravity is lowered. The man is keeping his arm and legs wide apart to increase base area.	1 1	

b	Total energy at 0 s = 80 x 10 x 50 = 40 000 J Total energy at 4s = (80 x 10 x 47.5) + (1/2 x 80 x 4^2) = 38 640 J Energy loss = 40 000 – 38 640 = 1360 J	1 1 1	
ci		1 1	Points line
cii	From 0 to 6 s, the man is moving with constant acceleration. From 6 to 8 s, acceleration is decreasing. From 8 to 10 s, velocity is constant.	1 1 1	
11	EITHER		
a	Air molecules collide with the walls of the cylinder, exerting an force. The force per unit area gives rise to the pressure exerted by the molecules.	1 1	
b	For a system to be in equilibrium, the sum of clockwise moments about a pivot must be equal to the sum of anticlockwise moments about the same pivot.	1 1	Moments Conditions: equilibrium and same pivot
c	Sum of clockwise moments = sum of anticlockwise moments 550 x 0.70 = Force x 0.30 Force = 1280 N (3 sf)	1 1	
di	upwards	1	
dii	When temperature increases, the average speed of the air molecules increase. The air molecules will collide more vigorously and frequently with the inner surface of the cylinder. Air pressure increases, and exerts a net upward force on the piston to push it upwards.	1 1 1	

11	OR		
ai	In one second, 2.4×10^9 oscillations/waves are produced.	1	R: unit time
aii	Wavelength = speed / frequency $= (3.0 \times 10^8) / (2.4 \times 10^9)$ $= 0.125$ m	1	
b	Energy absorbed by water = 0.40 x P x t = 0.40 x 700 x t = 280t $Q = mc\Delta\theta$ $280t = 50 \times 4.2 \times (90 - 20)$ $t = 52.5$ s	1 1 1	40% factored in $mc\Delta\theta$ ecf allowed
ci	The water is in thermal equilibrium with the surroundings. / The water reaches room temperature.	1	
cii	temperature 	1 1	Slower rate of decrease Reaches same final temperature
ciii	White surface is a poorer emitter of radiation than black. Hence the rate of heat loss via radiation will be slower.	1 1	