Index Number: _______________ SEC24/1.21s

L-Università ta' Malta

MATRICULATION AND SECONDARY EDUCATION CERTIFICATE EXAMINATIONS BOARD

SECONDARY EDUCATION CERTIFICATE LEVEL
2021 SUPPLEMENTARY SESSION

SUBJECT:	**Physics**
PAPER NUMBER:	I
DATE:	11th October 2021
TIME:	4:00 p.m. to 6:05 p.m.

Answer ALL questions.
You are requested to show your working and to write the units where necessary.
When necessary, take g, acceleration due to gravity, as 10 m/s².

Density	$m = \rho V$		
Pressure	$F = p A$	$p = \rho g h$	
Moments	Moment = F × perpendicular distance		
Energy and Work	$PE = m g h$	$KE = \frac{1}{2} m v^2$	$W = F s$
	Work Done=energy converted		$E = P t$
Force and Motion	$m a$ = unbalanced force	$W = m g$	$v = u + a t$
	average speed $= \frac{\text{total distance}}{\text{total time}}$		$s = (u + v)\frac{t}{2}$
	$v^2 = u^2 + 2 a s$	$s = u t + \frac{1}{2} a t^2$	momentum = $m v$
Waves	$\eta = \frac{\text{speed of light in air}}{\text{speed of light in medium}}$		$v = f\lambda$
	$\eta = \frac{\text{real depth}}{\text{apparent depth}}$	Magnification $= \frac{\text{image distance}}{\text{object distance}}$	
	Magnification $= \frac{\text{image height}}{\text{object height}}$		$T = \frac{1}{f}$
Electricity	$Q = I t$	$V = I R$	$E = Q V$
	$P = I V$	$R \propto \frac{L}{A}$	$E = I V t$
	$R_{total} = R_1 + R_2 + R_3$	$\frac{1}{R_{total}} = \frac{1}{R_1} + \frac{1}{R_2}$	
Electromagnetism	$\frac{V_p}{V_s} = \frac{N_p}{N_s}$	$V_p I_p = V_s I_s$	
Heat	$Q = m c \Delta\theta$		
Radioactivity	$A = Z + N$		
Other equations	Area of a triangle $= \frac{1}{2} b h$	Area of a trapezium $= \frac{1}{2} (a + b) h$	
	Area of a circle $= \pi r^2$		

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1. Figure 1 shows the displacement-time graph for a student's journey over a time interval of 150 s.

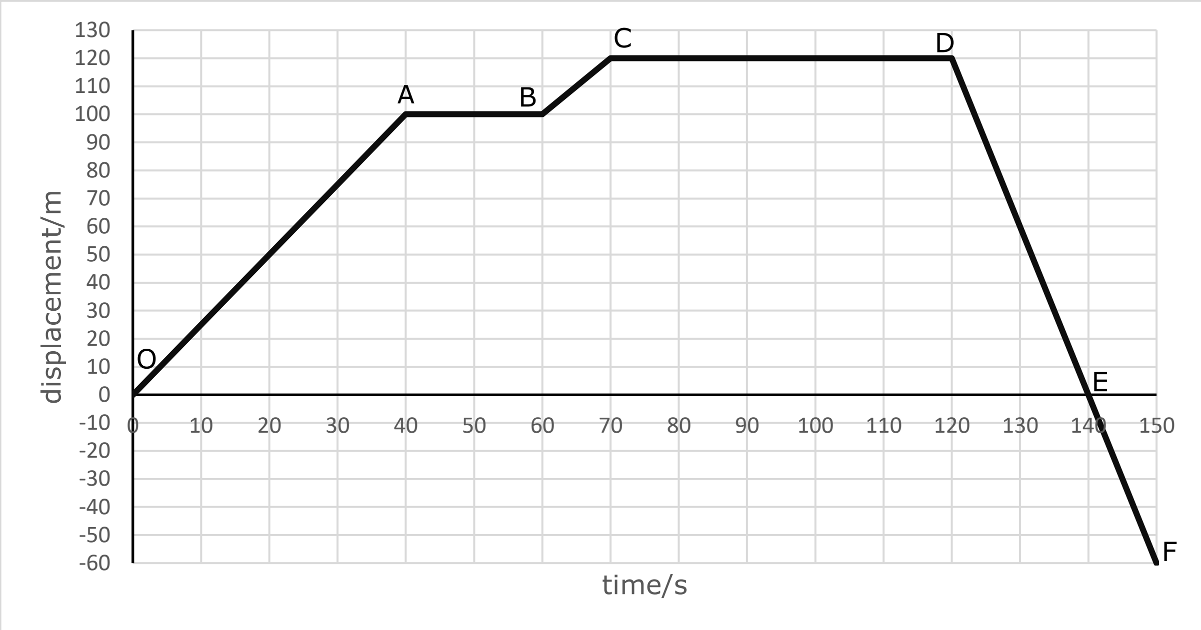

Figure 1

a. Describe the student's motion in the following paths:

- OA: ______________________________ (1)
- CD: ______________________________ (1)
- DE: ______________________________ (1)
- EF: ______________________________ (1)

b. Which path shows the student moving at the highest velocity?

______________________________ (1)

c. Calculate the velocity along the path BC.

____

______________________________ (2)

d. Calculate the total distance covered by the student in these 150 s.

____

______________________________ (1)

e. Calculate the average speed for the whole journey.

____

______________________________ (2)

(Total: 10 marks)

10

2. A car is travelling with a velocity of 22 m/s. The driver sees a large rock positioned in the middle of the road 50 m ahead of him.

   a. It took 0.8 s from the moment the rock was seen until the brakes of the car were applied.

      i. Calculate the distance travelled by the car during this thinking time.

      ____

      ____ (2)

      ii. When the brakes are applied, the car decelerates at 6.4 m/s^2. Calculate the distance travelled during braking until the car comes to rest.

      ____

      ____

      ____ (2)

      iii. Calculate the time taken for the car to stop during braking.

      ____

      ____ (2)

      iv. Calculate the total stopping distance of the car and hence state whether the car will stop before hitting the rock.

      ____

      ____ (2)

   b. Under normal circumstances, when travelling at 22 m/s, the thinking distance is 15 m and the braking distance is 38 m.

      i. State **ONE** factor that could have caused the thinking distance to be longer.

      ____ (1)

      ii. State **ONE** factor that would cause a longer braking distance.

      ____ (1)

(Total: 10 marks)

Please turn the page

10

3. a. State Newton's second law of motion.

____

____ (2)

b. A group of parachutists are practicing skydiving from an aircraft. Figure 2a shows the forces acting on a skydiver sometime after jumping, but before the parachute is opened. Figure 2b shows the velocity-time graph of the skydiver from the moment he jumps, opens the parachute and lands on the ground.

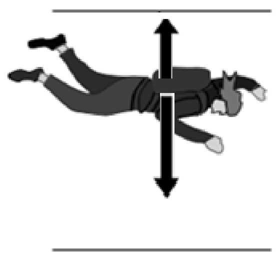

Figure 2a

Source: https://www.pikpng.com/

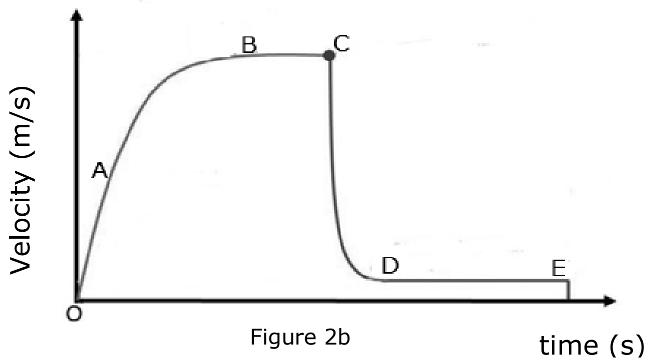

Figure 2b

i. Label the **TWO** forces acting on the skydiver in Figure 2a. (2)

ii. By referring to Figure 2b state the initial velocity of the skydiver at t = 0 s.

____ (1)

iii. By referring to Figure 2b state what is happening to the velocity between O and B.

____ (1)

iv. State the initial acceleration of the skydiver at the instant he jumps from the aircraft.

____ (1)

v. Underline the correct answer from the options in brackets, to complete the statements referring to the motion described in Figure 2b.

During OB, the downward force acting on the skydiver is (larger than, smaller than, equal to) the force acting upward. (1)

During BC, the downward force acting on the skydiver is (larger than, smaller than, equal to) the force acting upward. (1)

vi. At point C the parachute is opened, and the velocity decreases drastically. Is the resultant force acting on the skydiver upwards or downwards between C and D?

____ (1)

(Total: 10 marks)

10

4. Sean fills a bucket with 25 kg of water. The water column in the bucket has a height of 35 cm.
   a. Calculate the density of the water in the bucket if it contains 0.025 m^3 of water.

____

____ (2)

   b. Work out the pressure of the water at the bottom of the bucket, due to water column only.

____

____ (2)

   c. Sean fills his water pistol with water from the bucket. He exerts a force F on the plunger and water shoots out of it as shown in Figure 3.
   The water pipe inside the pistol consists of part A and part B. Part A of the pipe has a cross-sectional area of 2.25×10^{-4} m^2, whereas part B has a cross-sectional area of 1.5×10^{-5} m^2.

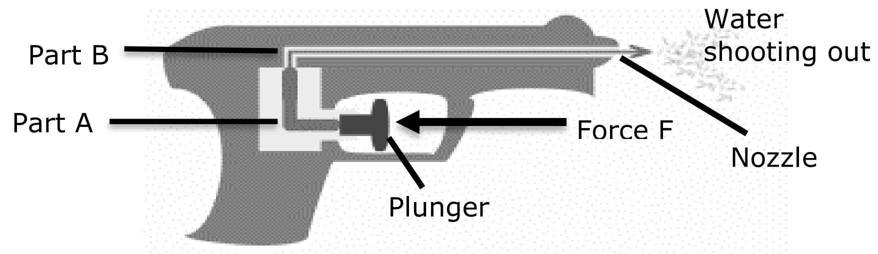

Figure 3

   i. Calculate the pressure exerted on the water in part A of the pipe when a force F of 81 N is exerted on the plunger.

____

____(2)

   ii. State the pressure of the water in part B of the pipe. ______________________ (1)

   iii. Identify the important property of water that allows it to be used in the water pistol.

____(1)

   iv. Sean placed his finger on the nozzle to prevent the water from shooting out. Calculate the force acting by the water on his finger. Assume that the force F applied, on the plunger is still 81 N.

____

____(2)

(Total: 10 marks)

Please turn the page

10

5. A student wants to determine the rate of temperature increase inside a black car. The car's temperature increases due to the process of heat transfer by radiation.

   a. Explain how the process of radiation occurs.

   ____

   ____ (1)

   b. The temperature inside the car was measured every 10 minutes and the readings obtained are shown in Table 1.

Table 1

Time / minutes	0	10	20	30	40	50	60
Temperature / °C	33	37	41	45	49	52	54
Temperature increase / °C	0	4			16		

   i. Fill in the missing values in Table 1. (1)

   ii. Plot a graph of Temperature increase / °C on the y-axis against Time / minutes on the x-axis. (4)

   iii. The gradient of the graph gives the rate of temperature increase. Calculate its value in the first 40 minutes, including the appropriate units.

   ____

   ____ (2)

   iv. What changes, if any, would be observed in the gradient of the graph had the experiment been conducted inside a metallic silver car? Explain.

   ____

   ____ (2)

(Total: 10 marks)

10

6. Figure 4 shows the oscillation created when a rope is made to vibrate from one end.

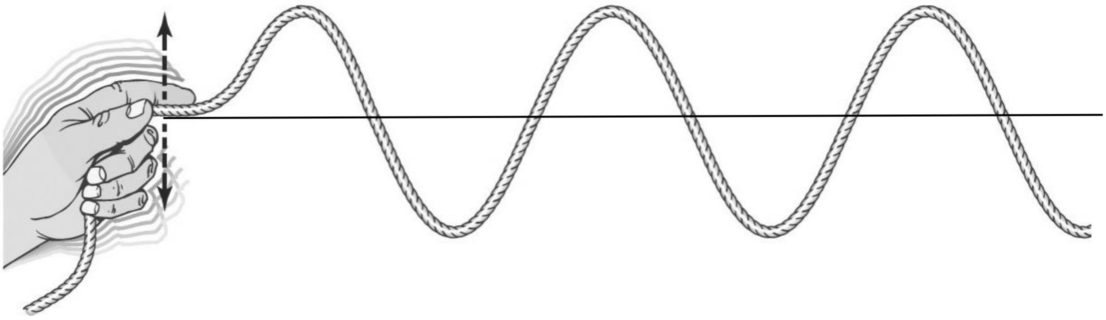

Figure 4

Source: https://alevelphysics.co.uk

a. Name this type of wave. ____ (1)

b. On Figure 4 mark: i. the wavelength with the symbol "λ"; (1)

ii. amplitude of the wave with the symbol "a". (1)

c. Measure the wavelength of the wave in Figure 4 using your ruler. Give your answer in metres.

____ (1)

d. The velocity of the above wave is 0.25 m/s. Calculate the frequency of this wave.

____

____

____ (2)

e. Explain the meaning of the term frequency calculated in part (d).

____ (1)

f. Calculate the periodic time of the wave in Figure 4.

____ (1)

g. What changes, if any, occur in the values of the frequency and periodic time, if the rope is made to vibrate at a faster rate?

____

____ (2)

(Total: 10 marks)

10

7. In 2019, Malta issued a national energy and climate plan and committed to increase considerably energy production by renewable sources of energy, such as with solar panels, by 2030 (*https://ec.europa.eu/).*

   a. Define renewable sources.

   ____

   ____ (1)

   b. Mention **ONE** other renewable resource and give a disadvantage of using this resource.

   ____

   ____ (2)

   c. A solar panel of area 1.8 m^2 can generate around 250 W of electrical energy.

      i. Explain the quantity 250 W.

      ____ (1)

      ii. Calculate the electrical energy generated in 1 hour by this solar panel.

      ____

      ____ (2)

      iii. Some of the most efficient solar panels have efficiency ratings of about 20 %. Calculate the energy input required in 1 hour.

      ____

      ____ (2)

   d. Presently a large percentage of energy is still produced from fossil fuels.

      i. Name **ONE** example of a fossil fuel.

      ____ (1)

      ii. State **ONE** disadvantage of using fossil fuels.

      ____ (1)

(Total: 10 marks)

Please turn the page

10

8. a. Figure 5 shows a satellite orbiting the Earth.

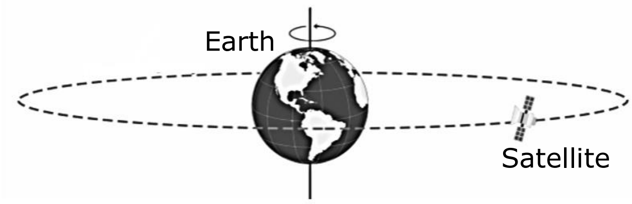

Figure 5

Source: quora.com

i. Name the force that keeps the satellite in its orbit.

____ (1)

ii. State **TWO** uses of satellites.

____ (2)

b. Assuming a circular orbit of radius 4.2×10^7 m, calculate the distance covered by the satellite as it completes one revolution around the Earth.

____

____ (2)

c. Assuming the satellite orbits the earth with an average speed of 3056 m/s, calculate the time it takes to complete one revolution. Give your answer in hours.

____

____ (2)

d. Satellites can be launched in space by putting them on rockets such as the one shown in Figure 6. Rockets obtain their forward movement by ejecting exhaust gases backwards.

Figure 6

Source: https://slidetodoc.com/

i. Fill in the blanks to complete the law of conservation of momentum during an explosion.

The total momentum before an explosion is _____________ to the total momentum after the explosion, provided that no external _____________ act on the system. (1)

ii. Briefly explain how the conservation of momentum helps the rocket move forward.

____

____(2)

(Total: 10 marks)

10

9. Figure 7 shows an electric kettle with a heating element rated at 1500 W, 230 V.

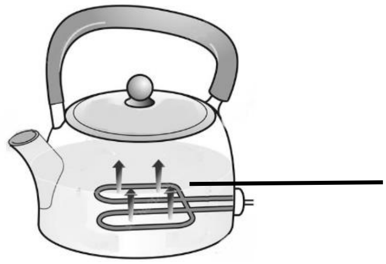

Figure 7
Source: https://www.sciencephoto.com/

a. Calculate the current flowing through the element when the kettle is switched on.

____

____ (2)

b. Which of the following fuses 2 A, 5 A, 10 A or 13 A should be used with the kettle?

____ (1)

c. Explain why fitting a fuse with a much higher rating is not recommended.

____ (1)

d. Calculate the resistance of the heating element when the kettle is switched on.

____

____ (2)

e. Does the resistance of the heating element of the kettle change when it cools down after it is switched off? Explain.

____

____ (2)

f. Calculate the charge that flows through the element when it is switched on for 3 minutes.

____

____ (2)

(Total: 10 marks)

Please turn the page

10

10. In one type of smoke detector, an alpha emitting isotope, ${}^{241}_{95}\mathrm{Am}$, is placed between two oppositely charged metal plates as shown in Figure 8a. The alpha particles ionize the air between the plates, and this causes a current to pass between them. When smoke enters the detector as shown Figure 8b, it blocks and absorbs the alpha particles. This causes the current to stop and triggers an alarm.

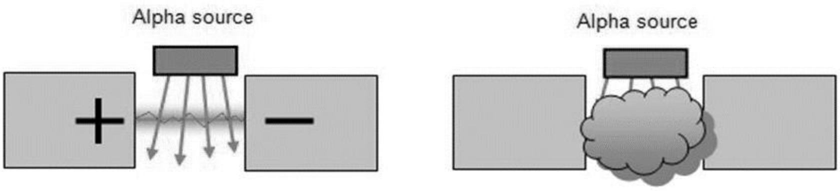

Figure 8a Figure 8b

Source: www.schoolphysics.co.uk

a. State what an alpha particle consists of and state its charge.

____ (2)

b. Explain what ionization is and why this causes a current to pass between the plates.

____

____

____ (2)

c. Beta or gamma emitting isotopes would not be suitable in this case. Explain.

____ (1)

d. ${}^{241}_{95}\mathrm{Am}$ emits only alpha particles and its half-life is 430 years.

i. Define half-life.

____ (1)

ii. These smoke detectors are normally fixed to ceilings. Give **TWO** reasons why the room is still considered safe to be in.

____

____ (2)

iii. Give **ONE** disadvantage of using a different isotope with a half-life of 1 year.

____ (1)

iv. These devices cannot be disposed of with regular waste in a landfill. Explain.

____ (1)

(Total: 10 marks)

10

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L-Università ta' Malta

MATRICULATION AND SECONDARY EDUCATION CERTIFICATE EXAMINATIONS BOARD

SECONDARY EDUCATION CERTIFICATE LEVEL
2021 SUPPLEMENTARY SESSION

SUBJECT:	**Physics**
PAPER NUMBER:	IIB
DATE:	12th October 2021
TIME:	4:00 p.m. to 6:05 p.m.

Answer ALL questions.
You are requested to show your working and to write the units where necessary.
When necessary, take g, acceleration due to gravity, as 10m/s².

Density	$m = \rho V$		
Pressure	$F = p A$	$p = \rho g h$	
Moments	Moment = F × perpendicular distance		
Energy and Work	$PE = m g h$	$KE = \frac{1}{2} m v^2$	$W = F s$
	Work Done=energy converted		$E = P t$
Force and Motion	$m a$ = unbalanced force	$W = m g$	$v = u + a t$
	average speed $= \frac{\text{total distance}}{\text{total time}}$		$s = (u + v)\frac{t}{2}$
	$v^2 = u^2 + 2 a s$	$s = u t + \frac{1}{2} a t^2$	momentum = m v
Waves	$\eta = \frac{\text{speed of light in air}}{\text{speed of light in medium}}$		$v = f\lambda$
	$\eta = \frac{\text{real depth}}{\text{apparent depth}}$	Magnification $= \frac{\text{image distance}}{\text{object distance}}$	
	Magnification $= \frac{\text{image height}}{\text{object height}}$		$T = \frac{1}{f}$
Electricity	$Q = I t$	$V = I R$	$E = Q V$
	$P = I V$	$R \propto \frac{L}{A}$	$E = I V t$
	$R_{total} = R_1 + R_2 + R_3$	$\frac{1}{R_{total}} = \frac{1}{R_1} + \frac{1}{R_2}$	
Electromagnetism	$\frac{V_p}{V_s} = \frac{N_p}{N_s}$	$V_p I_p = V_s I_s$	
Heat	$Q = m c \Delta\theta$		
Radioactivity	$A = Z + N$		
Other equations	Area of a triangle $= \frac{1}{2} b h$	Area of a trapezium $= \frac{1}{2}(a + b) h$	
	Area of a circle $= \pi r^2$		

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1. Figure 1 shows a drying stand used to dry clothes in a garden. The metal pole is pushed into the soil and the drying stand balances horizontally when no clothes are hung to it.

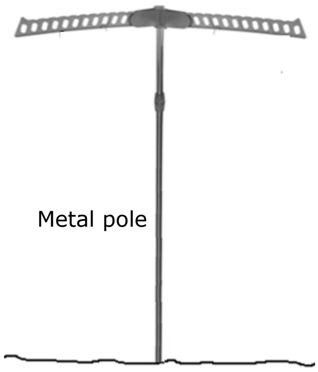

Figure 1
Source: www.acehardware.com/

a. Mark the pivot with a **P** on Figure 1. (1)

b. A shirt of mass 200 g is hung on the left hand side of the pivot, 10 cm away from the pivot.

i. Calculate the force exerted by the shirt on the drying stand.

____ (1)

ii. Calculate the moment created by the shirt about the pivot.

____

____ (2)

iii. Where can a scarf of mass 120 g be hung, so that the drying stand remains in equilibrium? Give your answer in meters.

____

____

____ (2)

iv. If the scarf used in part (iii) had a smaller mass, would it have to be placed closer or further away from the pivot so that the drying stand remains in equilibrium? Explain.

____

____ (2)

v. State the law used to determine your answers above.

____

____ (2)

vi. From the following list, underline the correct name of the process by which clothes dry when hung outside.

Condensation Conduction Evaporation Precipitation (1)

c. A student suggests that a heavy, wide base as the one shown in Figure 2, can be used to increase the drying stand's stability and avoid it from toppling.

i. Explain why a heavy base makes the drying stand more stable.

____

____(1)

ii. Explain why a wider base makes the stand even more stable.

____

____(1)

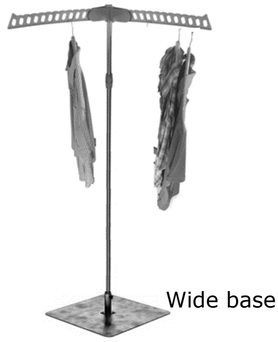

Figure 2
Source: acehardware.com/

iii. Suggest **ONE** other change in the design of the drying stand that would increase its stability.

____ (1)

d. The student decides to investigate the extension of springs by hanging the clothes from the same drying stand using a spring balance as shown in Figure 3.

i. What difference would he notice in the spring, when the scarf and shirt described in part (b) are hung separately from the spring balance?

____

____ (1)

ii. State Hooke's law.

____

____ (2)

Figure 3
Source: www.tarifekilic.com/

iii. The spring extends by 0.02 m when the scarf is hung from it. Calculate the extension of the spring when only the shirt is hung from it, given the elastic limit is **not** exceeded.

____

____(2)

iv. What will happen to the spring if the elastic limit is exceeded?

____ (1)

(Total: 20 marks)

Please turn the page.

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2. Figure 4 shows different layers that make up planet Earth and the approximate range of densities of each layer in g/cm^3. The figure is not to scale.

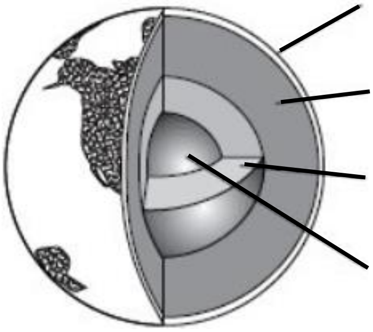

Figure 4
Source: https://www.proprofs.com/

a. The mantle has substances ranging in densities between 3.4 g/cm^3 and 5.6 g/cm^3. On Figure 4, mark:
   i. the position where substances of density 3.4 g/cm^3 are more likely to be found with an **X**, (1)
   ii. the position where substances of density 5.6 g/cm^3 would be found with a **Y**. (1)

b. Explain, in terms of pressure, why the inner core is the densest layer.

____

____ (2)

c. A geologist attempts to calculate the density of a small irregular rock found inside a deep mine.
   i. Briefly describe how the geologist can find the volume of the irregular rock. You can include diagrams to help you in your explanation.

____

____

____ (3)

   ii. The mass of the rock is 38 g. Name the instrument used to find the mass of the rock.

____ (1)

   iii. Calculate the density of the sample rock in g/cm^3, if it has a volume of 16.5 cm^3.

____

____ (2)

iv. The geologist collects another piece of irregular rock of the same density as that calculated in part (iii). The size of this rock is much larger than the previously collected one. State how the following quantities of the newly found rock, compare to the previously found sample:

Volume: ____

Mass: ____ (2)

d. Table 1 shows the average temperature and the state of the inner and outer core layers of Earth.

Table 1

Layer	**Temperature/°C**	**State**
Inner core	5200	Solid
Outer core	4500	Liquid

i. Explain the difference in the particle movement of the inner core and the outer core.

____

____ (2)

ii. The inner core supplies heat to the outer core. Name and explain the process by which heat travels in the outer core.

____

____ (2)

iii. The inner core is made of iron, and it is cooling down at the rate of 100 °C per billion years. Underline the correct answer to explain how it is cooling down.

Answer 1: Heat energy is leaving the inner core.

Answer 2: Heat energy is entering the inner core. (1)

iv. The inner core is estimated to have a mass of 1×10^{23} kg. If iron has a specific heat capacity of 450 J/kg°C, calculate how much heat is being transferred from the inner core of the Earth every billion years.

____

____

____ (3)

(Total: 20 marks)

Please turn the page

20

3. Two students want to measure the speed of sound in water. They are provided with a very accurate millisecond timer connected to two waterproof sound probes, a tank of water and a sound emitter.

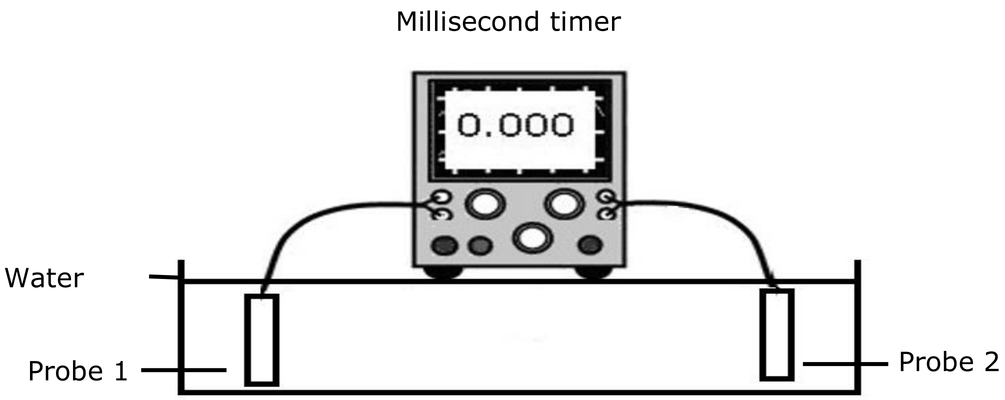

Figure 5

a. They need another piece of apparatus to be able to carry out their investigation. Draw and label the missing apparatus in the exact position it must be placed in Figure 5. (2)

b. Put the following statements in order by using the numbers 1, 2, 3 and 4 to describe the method used by the students to find the speed of sound water. (4)

Record the time taken by the wave to reach probe 2 from the timer.	
A sharp sound is produced next to probe 1.	
Measure the distance between the two probes.	
Repeat the procedure to obtain an average time.	

c. The average time taken by the sound wave to travel from probe 1 to probe 2 was 0.6 milliseconds. Convert the reading to seconds.

____

____ (1)

d. Calculate the speed of sound in water if the exact distance between the two probes is 0.84 m.

____

____ (2)

e. State whether sound waves are of a transverse or a longitudinal nature.

____ (1)

f. The speed of sound in air is 330 m/s. Give **ONE** reason why sound waves travel faster in water than in air.

____

____ (1)

g. Ships use the speed of sound in water to detect what's underneath them. To do so they use sound pulses and echoes.

i. How is an echo formed?

____

____ (2)

ii. A ship sends a sound pulse towards the seabed at a speed of 1498 m/s and it receives it back after 1.5 s. Calculate the depth of water underneath the ship.

____

____

____ (3)

iii. Give **ONE** other practical example where echoes are used.

____ (1)

h. Sonars used to detect shoals of fish underneath the sea surface have frequencies ranging from 50 kHz up to 455 kHz.

i. What is the name of sound waves that have such a high frequency?

____ (1)

ii. Calculate the wavelength of the sound wave produced by the sonar of the above ship if it uses a frequency of 50 kHz.

____

____ (2)

(Total: 20 marks)

Please turn the page

20

4. a. Complete the following sentences by using the words listed in brackets. Each word may be used more than once or not used at all. (10)

(metals, **voltage**, **plastic**, **low**, **high**, **current**, **rheostat**, **electrons**, **opposition**, **protons**, **fixed)**

i. _________________ in a circuit is due to a flow of charges such as _________________.

ii. Resistance in a circuit is a measure of the _________________ to the flow of charges.

iii. Bad conductors such as _________________ have a _________________ resistance.

iv. Values of resistors used in circuits may be _________________ or variable.

v. A variable resistor, also known as a _________________, can be used to change the value of _________________ in a circuit.

vi. A _________________ applied across a resistance in a circuit causes a _________________ to flow in the resistance.

b. Figure 6 shows a combination of three resistors.

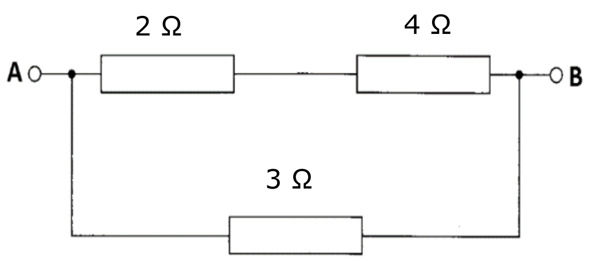

Figure 6

i. Calculate the total resistance in the section containing the 2 Ω and 4 Ω resistors.

____ (1)

ii. Calculate the total resistance between A and B.

____

____ (2)

c. Figure 7 shows a light emitting diode (LED) rated at 2.0 V, 5 mA. It is connected to a 5.0 V battery and a resistor in series. The resistor limits the voltage applied to the LED to 2.0 V. A current of 5 mA flows through the circuit.

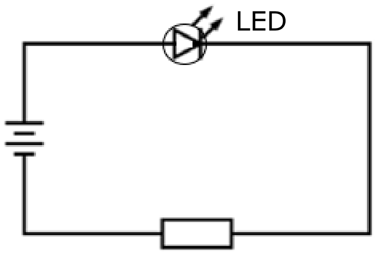

Figure 7

i. Calculate the p.d. across the resistor.

____ (1)

ii. Convert 5 mA to A. ______________________________ (1)

iii. Calculate the value of the resistance of the resistor.

____

____ (2)

d. An unknown component is connected in series with an ammeter and a cell as shown in Figure 8. The ammeter reading changes when different light intensities fall on the unknown component.

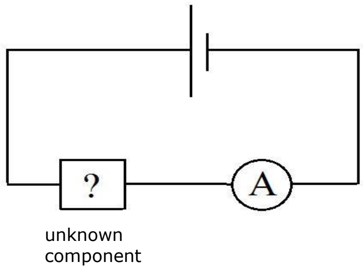

Figure 8

i. Identify the unknown component and explain the change in the ammeter reading.

____

____ (2)

ii. Draw the correct symbol used for this unknown component in the space provided below. (1)

(Total: 20 marks)

Please turn the page

20

5. a. Figure 9 shows a long straight wire placed in a magnetic field. The wire carries a current flowing into the paper when seen from above.

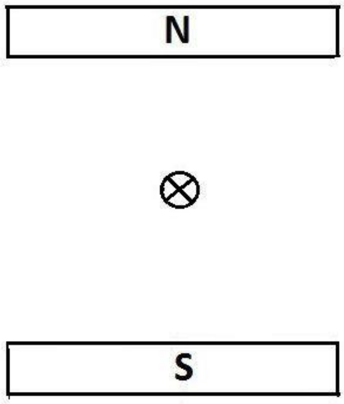

Figure 9

i. Draw **ONE** magnetic field line on Figure 9 to show the shape and direction of the magnetic field due to the current in the wire. (2)

ii. Draw **ONE** magnetic field line on Figure 9 showing the shape and direction of the magnetic field due to the permanent magnet. (2)

iii. The current-carrying wire experiences a force. Draw an arrow, labeled F, showing the direction of this force. (1)

iv. Which rule was used to determine the direction of force F?

____ (1)

v. State **TWO** ways how the size of force F can be increased.

____

____ (2)

vi. The battery is replaced by a 5 Hz a.c. supply and the wire is seen to vibrate. Explain why the wire vibrates.

____

____ (2)

vii. Explain why the wire is not seen to vibrate when the a.c. supply is now set at 10 kHz.

____ (1)

viii. The above phenomenon is an example of a change from electrical to kinetic energy. Give **ONE** practical application of this in everyday life.

____ (1)

b. Figure 10 shows the principle of operation of the transformer. Two similar coils of wire A and B are placed near each other as shown. Coil A is connected to a cell via a switch, while coil B is connected to a galvanometer.

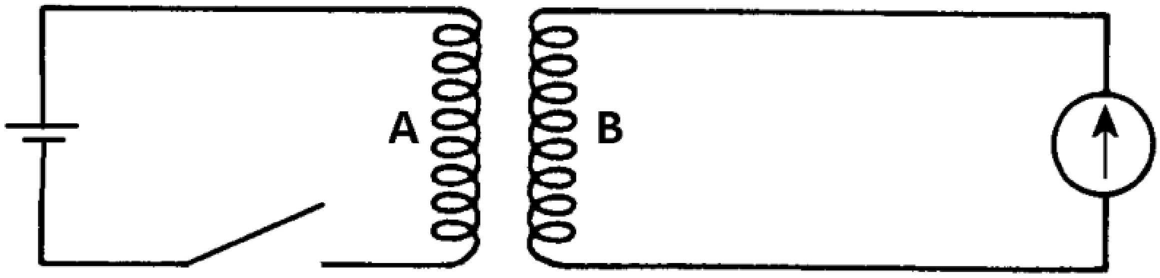

Figure 10

i. The cell acts as a d.c. supply. What do the initials d.c. stand for?

____ (1)

ii. What does this term indicate about the direction of current produced from this cell?

____ (1)

iii. What is observed on the galvanometer as soon as the switch is closed and then allowed to remain closed?

____

____ (2)

iv. What is observed on the galvanometer as soon as the switch is opened again and allowed to remain open?

____

____ (2)

v. State **TWO** ways, other than changing the number of turns in the two coils, how the same galvanometer can be made to record a larger reading.

____

____ (2)

(Total: 20 marks)

20

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