Section A

1 The regions of the electromagnetic spectrum are shown in order of increasing wavelength.

Short wavelength   Long wavelength

gamma	**A**	**B**		**C**	microwave	radio

visible light
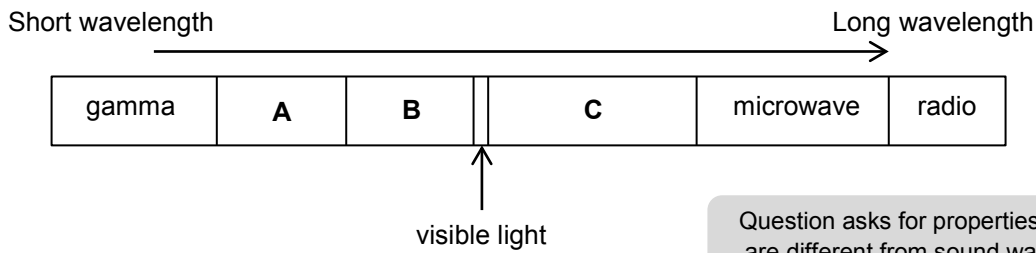
Question asks for properties that are different from sound waves!

(a) Properties of waves in regions **A** and **C** that are different from the properties of sound waves:

Choose any two of the following properties of electromagnetic waves: [2]

1. They are transverse waves.

2. They can travel through vacuum and do not require any medium to travel from one point to another.

3. They are able to travel through vacuum at a speed of 3×10^8 m/s.

(b) For waves in region **B**,

(i) They are ultraviolet rays.   [1]

(ii) **Choose any of the following uses of ultraviolet rays:**   [1]

  a. Sterilization of cutleries, surgical instruments & barber equipment

  b. Sunbeds

  c. Checking for forgery in paper currency

2 A train with a mass of 240 000 kg travels for 30 minutes at a constant speed of 60 m/s. It subsequently decelerates at a constant rate for 10 minutes until it comes to rest.

(a)   Distance travelled during the first 30 minutes = speed × time

                                                    = 60 m/s × 1800 s | 30 min = 1800 s |

                                                    = 108 000 m   [2]

(b) Acceleration of train during the final 10 minutes = $\frac{v-u}{\Delta t}$ m/s^2

| 10 min = 600 s | = $\frac{0-60}{600}$ m/s^2

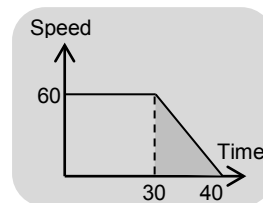   = −0.1 m/s^2 Deceleration has no minus sign.

∴ **deceleration** of the train during the final 10 minutes = 0.1 m/s^2.   [2]

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(c)   Braking force on the train during final 10 min

   = mass × acceleration

   = 240 000 kg × 0.1 m/s^2

   = 24 000 N   [2]

(d)   Distance traveled when coming to rest during final 10 min

   = 0.5 × 60 × 600 = 18 000 m

∴ Work done to bring train to rest during the final 10 minutes   = force × distance

   = 24 000 × 18 000 m

   = 4.32 × 10^8 J   [3]

3   A pure substance has a melting point of 50 °C.

(a) Graph showing how temperature of the substance changes with time as it cools from 80 °C to 30 °C.
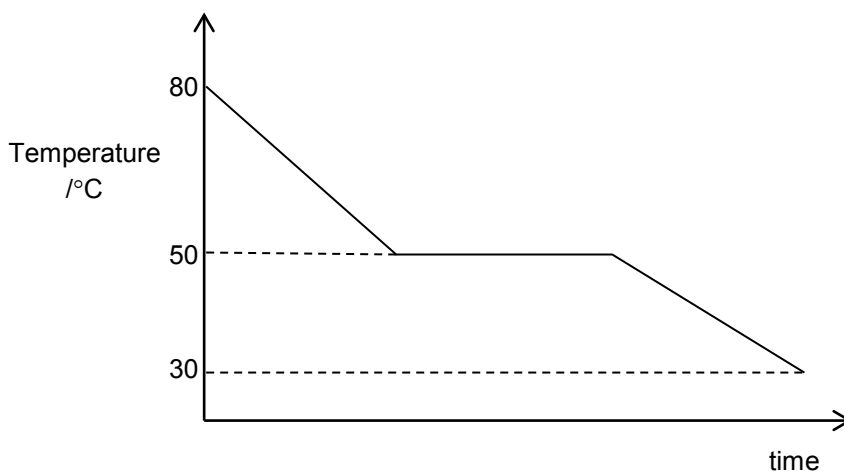
(b) (i)   As it cools from 80 °C to 51 °C, arrangement of molecules is such that the **particles get closer to one another** though still in an irregular manner, and motion of molecules **decreases with decreasing temperature** with particles sliding over each other.   [2]
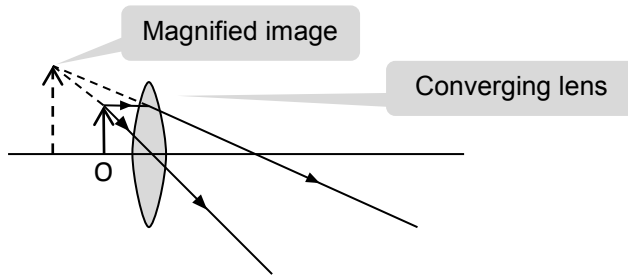
   (ii)   As it freezes at 50 °C, arrangement of molecules is such that the **particles are slowly settled in fixed positions within a regular lattice structure**, and motion of molecules **is reduced to the** extent **that they are vibrating about their fixed positions**.   [2]

Need to be careful in (b) since the question requires us to describe the <u>changes</u> (if any). As such, answer should focus on changes in molecular arrangement & motion as temperature decreases in (i) and (ii) during the process of freezing (not after).

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4 (a) A converging lens used to produce a virtual magnified image of an object O.
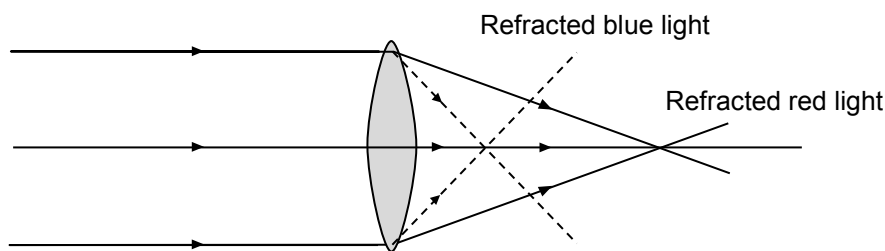

[1]

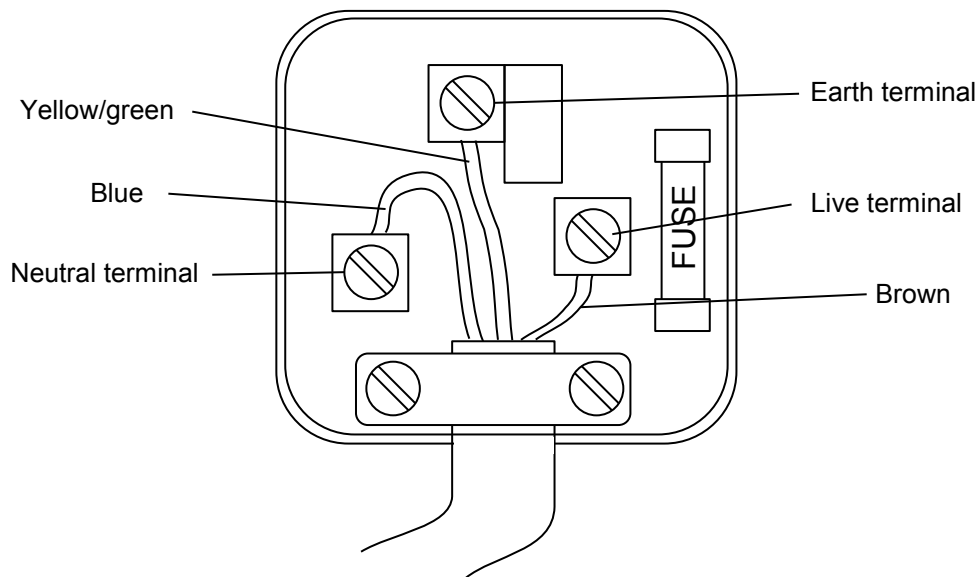(b) (i) Blue light has a shorter wavelength than red light. [1]

(ii) Rays of blue light refract more than rays of red light after passing through a lens. [1]


5 (a)

[2]

(b) As the live wire is connected to the high potential of the main supply, the switch must be connected into the live wire so that switching off disconnects the high voltage from an appliance. If the switch is fitted onto the neutral wire, the appliance will still be 'live' even when the switch is off, and this will cause an electric shock to anyone who touches the metal casing of the appliance. [1]

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6 (a) When the current is switched on, the current flows in the direction as indicated in the diagram. By the right-hand grip rule, the iron core is magnetized by the current to induce a South pole at the end nearer to the magnet. Since like poles repel, the permanent magnet moves away from the iron core. [2]

Iron core

Permanent magnet

N   S   S   N
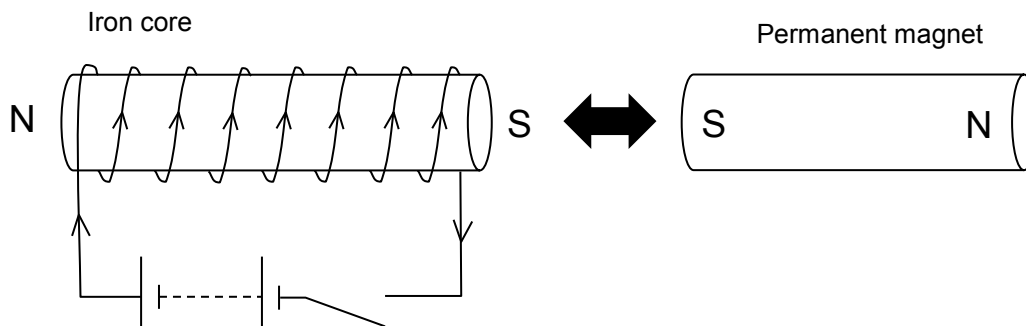
(b) When the permanent magnet is replaced by an iron rod and the current switched on again, the iron core will be magnetized in the same way in (a). The iron rod will be attracted to the magnetized iron core through magnetic induction. [2]

7 (a) Mass of liquid in the tube,

$$\text{Density, } \rho = \frac{\text{mass}}{\text{volume}}$$

$$0.8 = \frac{\text{mass}}{0.25 \times 12.4}$$
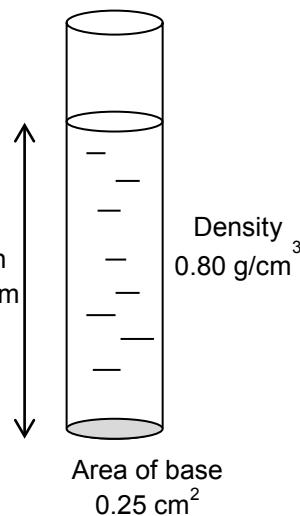
$$\therefore \text{mass} = 2.48 \text{ g} \qquad [3]$$

Length
12.4 cm

Density
0.80 g/cm^3

Area of base
0.25 cm^2

(b)   Weight of liquid in the tube = mass $\times g$

Given g = 10N/kg $\Rightarrow$
convert 2.48 g to 0.00248 kg

= 0.00248 kg $\times$ 10 N/kg

= 0.0248 N [2]

(c) Pressure on base of tube due to column of liquid,

$$\text{Pressure} = \frac{\text{Force}}{\text{Area}}$$

$$= \frac{0.0248}{0.25} = 0.0992 \text{ N/cm}^2$$

OR   Pressure = $h\rho g$

$$= 12.4 \times 0.80 \times \frac{10}{1000} = 0.0992 \text{ N/cm}^2 \qquad [2]$$

8   (a) (i)   Current in resistor **Z**,

> Sum of individual currents in each branch = main current flowing into/out of // branches

$$\text{Total current } I_1 = I_Y + I_Z$$

$$2.5\text{ A} = 1.7\text{ A} + I_Z$$

$$\therefore I_Z = 2.5 - 1.7 = 0.8\text{ A} \qquad [1]$$

(ii) Potential difference across resistor **Z**,

> Sum of p.d. across each component connected in series = p.d. across whole circuit
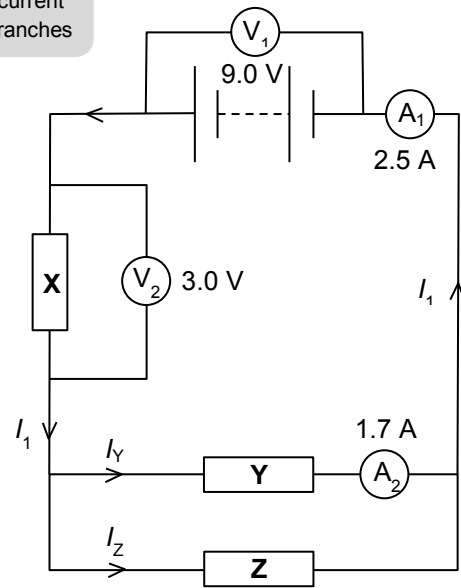
$$V_1 = V_2 + V_Z$$

$$V_Z = 9\text{ V} - 3\text{ V} = 6\text{ V} \qquad [1]$$

(iii) Resistance of resistor **Z**,

$$V_Z = I_Z R_Z$$

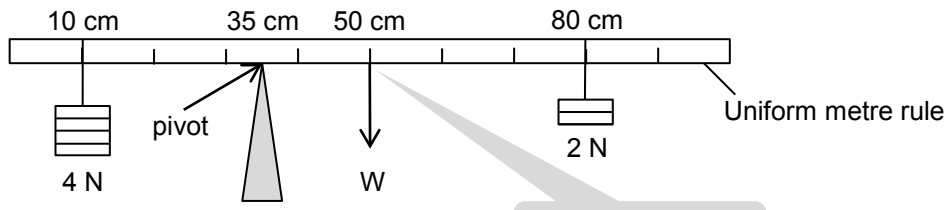$$R_Z = 6\text{ V} \div 0.8\text{ A} = 7.5\ \Omega \qquad [1]$$

(b) Charge flowing through resistor **Y** in 5 min, $Q = I_Y t$

$$= 1.7\text{ A} \times 300\text{ s} = 510\text{ C} \qquad [2]$$

(c) Total resistance of the circuit, $R_T = \dfrac{V_T}{I_T}$

$$= 9\text{ V} \div 2.5\text{ A} = 3.6\ \Omega \qquad [2]$$

9   (a) The weight of the metre rule, W, is indicated on the diagram as follows.

[1]

(b) To calculate the weight of the metre rule,

$$\sum(F_1 d_1) = \sum(F_2 d_2)$$

> Principle of Moments

$$4\text{ N} \times 25\text{ cm} = W \times 15\text{ cm} + 2\text{ N} \times 45\text{ cm}$$

$$100\text{ Ncm} = 15W + 90\text{ Ncm}$$

$$15W = 10\text{ Ncm}$$

$$W = \frac{10}{15} \approx 0.667\text{ N (3 sig. fig.)} \qquad [2]$$

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Section B

10 A pendulum is held in position **X** by a horizontal force *F* as follows:

Thin thread

F

3.0 cm

X

Metal sphere

O
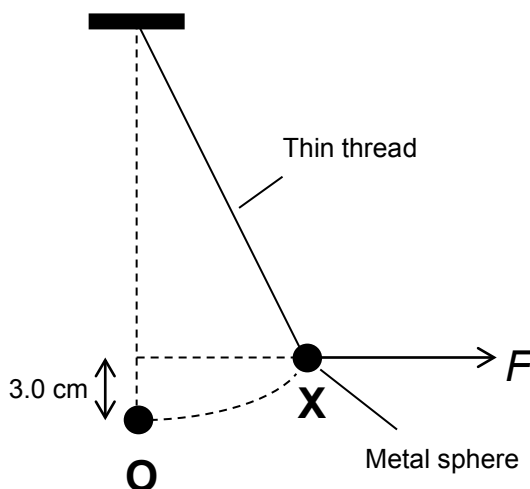
(a) Free-body diagram showing forces acting on the metal sphere when it is at **X**.

Tension

Applied force *F*
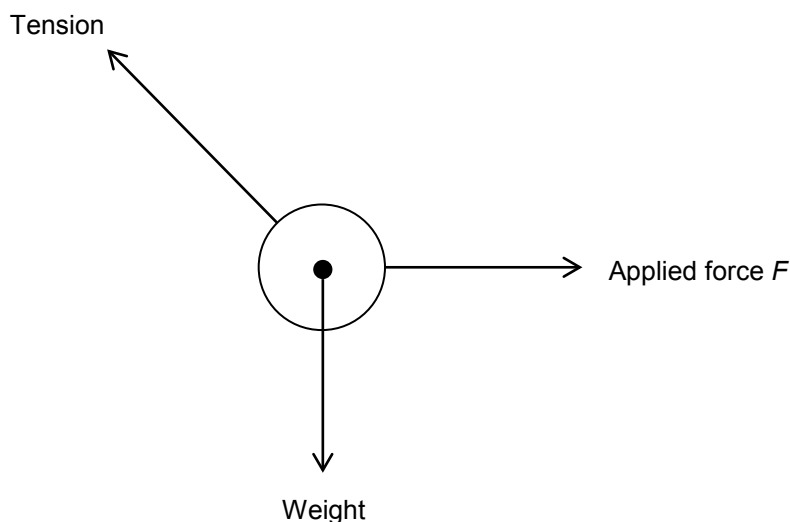
Weight

[2]

(b) When the metal sphere is released, the horizontal applied force *F* is absent so there is a net resultant force due to the tension and its weight. This resultant force acts on the metal sphere to change its state from rest to motion. Hence the metal sphere begins to move.

When the resultant force acts on the metal sphere, it will accelerate and move in the direction of the resultant force. By Newton's First Law of Motion, the metal sphere will still continue in uniform motion even though there is no resultant force acting on it when it reaches **O**. Hence it will continue to move past **O**. [2]

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(c) The mass of the metal sphere is 200 g. The gravitational field strength is 10 N/kg.

(i) Work done to raise sphere vertically by 3 cm = Force × distance

> Convert to SI units

> Work done ≈ potential energy
> = mgh

= 0.2 kg × 10 N/kg × 0.03 m

= 0.06 J

(ii) Maximum speed occurs at **O**, where all of the sphere's gravitational potential energy has been converted to kinetic energy.

$$\therefore 0.06 = \frac{1}{2}mv^2$$

$$v = \sqrt{\frac{(2\times0.06)}{0.2}} \approx 0.775 \text{ m/s (3 sig. fig.)} \hspace{2cm} [4]$$

(d) A student uses two methods to determine the time for one complete swing of the pendulum.

The first method of simply measuring the time for one complete swing is not accurate because of error due to human reaction time over one swing

The second method taking the average time over 20 swings gives a more accurate result as it minimizes the error due to human reaction time. [2]

11 (a) A refrigerator has a maximum power of 80 W when connected to a 240 V mains supply. It uses an average of 0.39 kWh of electrical energy every 24 hours.

(i) Maximum current, $I_{max} = \frac{P}{V} = \frac{80\text{W}}{240\text{V}} \approx 0.333 \text{ A}$

(ii) Average power = Average energy ÷ time

= 0.39 kWh ÷ 24 hours = 0.01625 kW = 16.25 W [4]

(b) In the refrigerator's cooling system, a liquid that is very easy to evaporate is pumped through metal pipes inside and outside the food compartment of the refrigerator.

(i) The liquid is changed into a vapour inside the freezing compartment of the refrigerator.

When the liquid vapourizes, molecules will change from an irregular arrangement into a largely random and disorderly arrangement with particles being much farther apart.

Energy is required to overcome the intermolecular forces of attraction when it changes its physical state from liquid to gas, and also to push the molecules into the atmosphere. [2]

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(ii) After passing through the freezing compartment, the vapour is pumped to the outside of the refrigerator where it is compressed back into a liquid. This warm liquid is then passed along a metal tube to which blackened metal plates are attached.

Both the <u>metal tube and metal plates</u>, being good conductors of heat, conduct the heat rapidly away from the hot liquid mainly via free diffusion of electrons.

The <u>black surfaces and large surface areas</u> of the metal plates, being a good emitter/radiator of heat, help to absorb the heat from the tube and emit it to the outside air as rapidly as possible. [4]

12 To find oil-bearing rocks, an explosion is created to send a wave to travel into the Earth. After hitting the boundary between two different types of rock, **A** and **B**, part of the wave is reflected at the boundary back towards the surface and part travels into rock **B**. The wave that is reflected towards the surface is detected by a microphone.
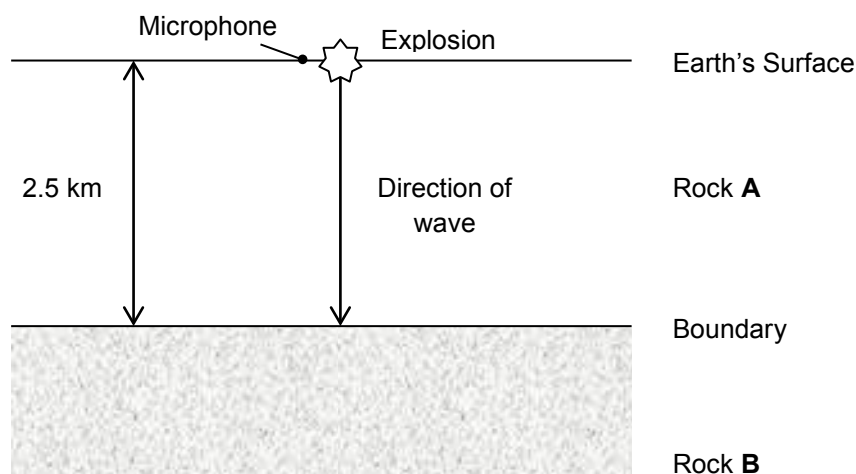
(a) A transverse wave is a wave that travels in a direction perpendicular to the direction of vibration of its particles. [3]

(b) Speed of wave in rock **A** = $\dfrac{\text{total distance traveled}}{\text{time taken to travel to boundary and back}}$

= $\dfrac{2 \times 2500\text{m}}{1.6\text{s}}$ = 3125 m/s [3]

(c) Since the number of complete vibrations per second of wave is same in rock **B** as in rock **A**, the frequency of the wave is the same in rock **A** and in rock **B**.

From $\lambda = \dfrac{v}{f}$, the wavelength λ of a wave is directly proportional to its speed v. Hence the wavelength of the wave is longer in rock **B** than in rock **A** since the speed of wave in rock **B** is greater than speed of wave in rock **A**. [4]

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