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2023 Trial Examination

STUDENT NUMBER									Letter

PHYSICS

Unit 1 – Written examination

Reading time: 15 minutes
Writing time: 1 hour and 30 minutes

QUESTION & ANSWER BOOK

Structure of book

Section	*Number of questions to be answered*	*Number of marks*
Areas of Study		
1. How are light and heat explained?	6	30
2. How is energy from the nucleus utilised?	6	30
3. How can electricity be used to transfer energy?	9	30
		Total 90

- Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners and rulers
- Students are NOT permitted to bring into the examination room: blank sheets of paper and/or white out liquid/tape.
- A scientific calculator is permitted in this examination.
- A double-sided A3 cheat sheet is allowed

Materials supplied

- Question and answer book of 28 pages.

Instructions

- Print your name in the space provided on the top of this page.

Students are NOT permitted to bring mobile phones and/or any other unauthorised electronic communication devices into the examination room.

Instructions
Where an answer box has a unit printed in it, give your answer in that unit.
Where answer boxes are provided, write your answers in the box.
In questions worth more than 1 mark, appropriate working should be shown
Unless otherwise indicated, diagrams are not to scale

Area of Study 1 – How are light and heat explained?

Question 1 (1 mark)

Which of the following statements best describes the electromagnetic (EM) waves.

A. They are transverse waves travelling at the speed of light, c in all mediums.
B. They are longitudinal waves travelling in a straight line
C. They are transverse waves travelling at the speed of light, c in a vacuum.
D. They are transverse waves that require a medium to propagate.

Question 2 (1 mark)

Heating the air in a hot air balloon lowers its density and causes it to rise and then float. According to the kinetic energy model, the best explanation for this effect is

A. An increase in the thermal energy of the systems the air molecules gain energy and gain speed which results in a lower density compared to its surrounding.
B. The temperature of the air inside the balloon increases causing it to become hot and rise which pushes the balloon up.
C. As the temperature increases, the volume of the balloon decreases making it lighter and less dense which causes it to float.
D. As the air molecules gain energy they rise and escape from the balloon causing its overall mass to decrease and rise.

Area of Study 1- continued

Question 3 (1 mark)

The average temperature of Earth is 16 ^{0}C and it emits most of its energy in the infrared range of the electromagnetic spectrum as re-radiation. Calculate the maximum wavelength of this re-radiated energy. [$\lambda_{max} T = 2.898 \times 10^{-3}$]

A. 10 μ m
B. 1.0 μ m
C. 1.06 x 10^{-5} m
D. 1.8 x 10^{-4} m

Question 4 (9 marks)

a. A 25 m long Aboriginal dugout canoe is anchored at Yarra River. When the crest of one of the waves is at the front of the canoe, the trough of the same waves reaches the back. It was noticed that exactly 14 waves completely pass the front of the canoe in 7 minutes and the peak-to-peak height of each wave was 2 m.

i. Calculate the amplitude of the waves

m

(1 mark)

ii. Determine the wavelength of each wave.

m

(2 marks)

iii. Determine the frequency of the waves

(2 marks)

Hz

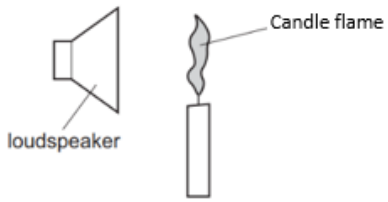
iv. Find the speed of the waves in 2 decimal places.

(1 mark)

ms^{-1}

b. To investigate sound waves, a physics student placed a candle in front of a loudspeaker. The speaker produces sound waves causing air particles to vibrate. The student notices that the vibrating air particles make the candle flame vibrate in the same direction as the air particles.

Draw the direction of vibration on the candle flame using arrows and identify the nature of sound waves.



(2 marks)

Area of study 1 – continued

c. Nearly all of the energy available on Earth comes from sun in the form of solar radiation. List the three main types of electromagnetic spectrum radiation emitted from the sun.

(1 mark)

Question 5 (10 marks)

a. A group of physics students' setup an experiment to investigate refraction of light. They aim a laser pointer to a glass prism as shown in Figure 1 below.

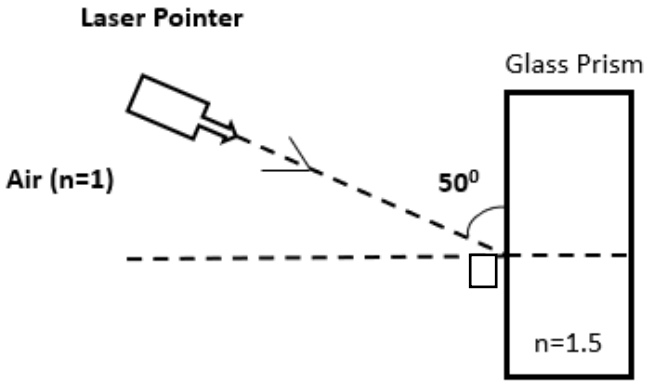


Figure 1

i. Draw an arrow at the air-glass boundary to show how the light ray refracts as it enters the glass.

(1 mark)

ii. Determine the angle of refraction.

(2 marks)

b. One of the students suggests that when light enters glass, its speed changes causing refraction due to a change in both its wavelength and frequency.

Identify the misconception in the student's statement

(2 marks)

c. The students then observe how light re-enters air from the glass prism. Calculate the angle of incidence when the angle of refraction is 90^0

^{0}

(1 mark)

d. Optical fibres are replacing copper cables for communication because they are cheap, light and can carry more data. They are made up of a glass core material and coated with glass cladding. When light enters the core, it reflects totally internally. State the two conditions for total internal reflection to occur.

(2 marks)

Area of study 1 – continued

e. Identify one use of UV radiation and one use of gamma rays in our society.

(2 marks)

Question 6 (8 marks)

Earth ovens were a common traditional method of cooking food in a several countries. Shown is an example of an earth oven used by the Māori communities.

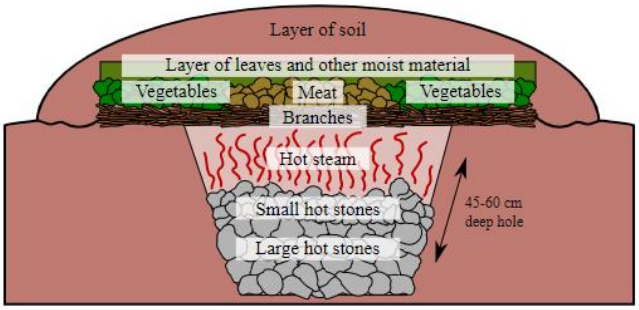


Figure 1: Ref: https://upload.wikimedia.org/wikipedia/commons/6/62/Maori_earth_oven.svg

a. The pit contains red hot stones, and the food is placed at the top, covered by a layer of soil as shown in Figure 1. Convection is the main method of heat transfer from the hot stones. Explain how heat is transferred in an earth oven via the process of convection.

(1 mark)

Area of study 1 – continued

TURN OVER

b. The heating element of a hot water jug is positioned at the bottom of the unit.
How does this setup ensure that all water can reach the boiling point if the heat element only heats up the water at the bottom area?

(2 marks)

c. The water jug can hold 2 kg of water. Fardeen heated the water from a room temperature of 21^0 C to its boiling point. the jug maintains its temperature until all water is evaporated completely.

i. Determine the amount of energy that must be transferred to the water to raise its temperature from 21^0 C to boiling point. ($c = 4200\ Jkg^{-1}K^{-1}$)

(2 marks)

kJ

ii. Calculate the amount of energy required to change liquid water to steam (gas).

kJ

(1 mark)

d. Vaporisation of water molecules from the earth's atmosphere is a process where heat is absorbed from the environment. This phenomenon should cool planet earth down, however water vapour is said to be responsible for more than 50% of the Earth's greenhouse effect.

Explain how vaporisation causes the Earth's temperature to increase.

(2 marks)

END OF AREA OF STUDY 1
TURN OVER

Area of Study 2 - How is energy from the nucleus utilised?

Question 7 (1 mark)

Which of the following is a source of the Sun's energy?

A. Fusion of protons
B. Fusion of carbon nuclei
C. Exothermic chemical reactions
D. Fission of uranium-235

Question 8 (1 mark)

When Uranium -236 undergoes fission reaction, one of the products has an atomic mass number of 137. What is the most likely element produced?

A. Silver
B. Gold
C. Barium
D. Rubidium

Question 9 (1 mark)

If all the energy released in a reaction were converted into alpha particles containing 3.9 MeV, the mass defect of this reaction is closest to

A. 3.85×10^{-25} kg
B. 6.93×10^{-30} kg
C. 6.65×10^{-27} kg
D. 6.35×10^{-13} kg

Question 10 (11 marks)

a. The helium - 4 is a stable isotope of helium. Its nucleus consists of two protons and two neutrons. There are two electrons in orbit around the nucleus.
Identify and describe the forces responsible to maintain the nuclear stability of Helium -4.

(3 marks)

b. Technetium-99m has a half-life of 6 hours and is commonly used for selective imaging of organs.

i. Define the term half life

(1 mark)

Area of study 2 - continued
TURN OVER

ii. If a patient is injected with Technetium- 99m, what fraction of the original amount will have decayed after 36 hours.

(2 marks)

c. The table below shows the properties of α, β^-, β^+ and γ radiation.

Property	Radiation Type
No mass	
Charge of +2	
Emits positron	
Neutrons decay into a proton	

Complete the above table by filling in the correct radiation type corresponding to its property. (2 marks)

d. Complete the following decay equations by calculating both atomic and mass numbers and then finding the missing particle. (3 marks)

$$^{238}_{92}\text{U} \rightarrow {}^{234}_{90}\text{Th} + \square + \text{Energy}$$

$$^{11}_{6}\text{C} \rightarrow {}^{11}_{5}\text{B} + \square + \text{Energy}$$

$$^{99m}_{643}\text{Tc} \rightarrow {}^{99}_{43}\text{Tc} + \square$$

Area of study 2 - continued

Question 11 (10 marks)

a. Shown in Figure 3 below is the Uranium decay series where $^{238}_{92}\mathbf{U}$ decays to gradually transform into stable $^{206}_{82}\mathbf{Pb}$

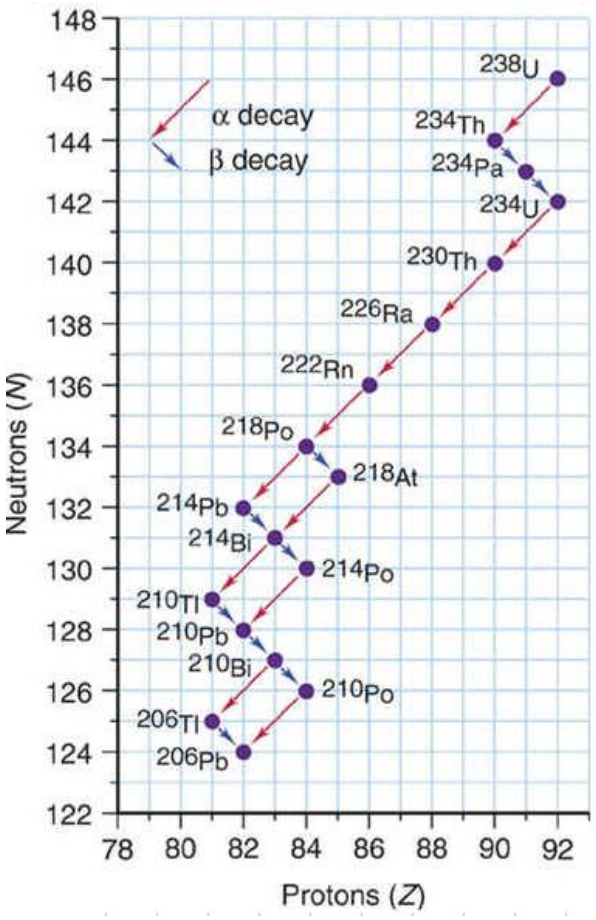


Figure 3

Ref: http://www.kentchemistry.com/links/Nuclear/naturalTrans.htm

i. Define the term decay series.

_____

_____

_____

(1 mark)

Area of study 2 - continued

TURN OVER

ii. How many alpha decays did Uranium 238 undergo to become Po -208?

(1 mark)

b. A 80 kg person absorbs 0.072 J of energy due to ionisation radiation.

i. Determine the absorbed dose.

(1 mark)

Gy

ii. Calculate the equivalent dose of the energy was delivered by alpha particles of quality factor 15

(1 mark)

Sv

Area of study 2 - continued

c. If the energy delivered is replaced by x-rays of quality factor 1, explain whether this will increase or decrease biological damage to the person. Support your answer with calculations.

(3 marks)

d. Yttrium -90 is a radioisotope used to treat non-Hodgkin's lymphoma and liver cancer. Outline a general process of how medical radioisotopes are used for therapy and identify two common side effects.

(3 marks)

Area of study 2 – continued

TURN OVER

Question 12 (8 marks)

a. To produce nuclear energy the nucleus of a radioisotope undergoes fission reaction. This isotope is said to lose a small amount of mass.

Explain how nuclear energy is generated from this process and what happens to this lost mass.

(2 marks)

b. Uranium -236 emits two or three neutrons with nuclear reactions.

i. State the name of this reaction (1 mark)

ii. In some fission reactions a moderator is used to slow down the neutrons. One such moderator is water. Identify another commonly used moderator. (1 mark)

iii. Some isotopes absorb free neutrons which prevents a sustainable chain reaction to occur. Identify a process to overcome this difficulty.

(1 mark)

c. Figure 5 shows a binding energy -per-nucleon graph.

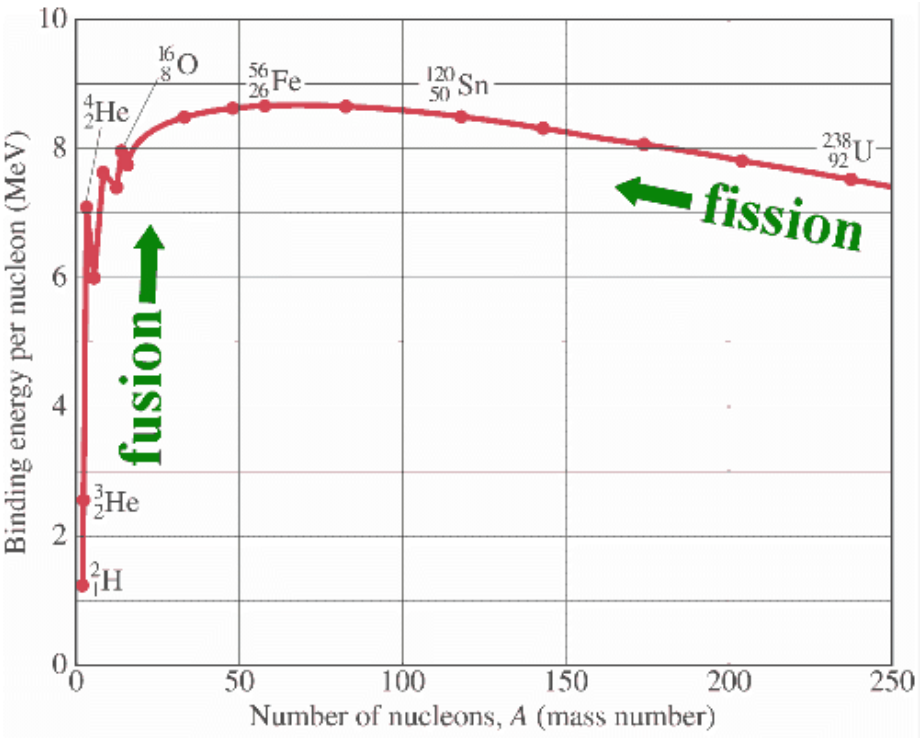


Figure 5

i. Identity the most stable nucleus from the above graph.

(1 mark)

ii. Circle the correct option in the table shown below to identify the nuclear reaction and stability of Helium and Sn.

Nucleus	Nuclear Reaction	Stability
$^{3}_{2}$ **He**	Fusion / Fission	stable / unstable
$^{120}_{50}$ **Sn**	Fusion / Fission	stable / unstable

(2 marks)

END OF AREA OF STUDY 2
TURN OVER

Area of Study 3 - How can electricity be used to transfer energy?

Question 13 (1 mark)

A 4000 W heater operates for 2 hours. If the price for household electricity is 25 cents per kWh, what is the cost of running the heater for 2 hours?

A. $200.00
B. $2.00
C. $4.00
D. $8.00

Question 14 (1 mark)

Which of the following is true about the residual current device (RCD)

A. The current in the active wire flows in the same direction as in the neutral wire.
B. It is useful only when the current flows to the earth and not through an individual between the active and neutral wires.
C. It operates by automatically resting the circuit current to the required value.
D. The RCD has a metal strip which melts when excessive current flows through it.

Area of study 3 – continued

Question 15 (1 mark)

A kitchen circuit has the following operating appliances; a 300 W toaster, 1500 W kettle, 1 kW microwave, a 315 W refrigerator, and a 60 W food processor. The circuit is protected by a fuse.

Which one of the following is an appropriate rating of the fuse to ensure the safety of the circuit if a voltage of 230 V, 50Hz is supplied to the kitchen?

A. 13.5 A
B. 12.0 A
C. 14.0 A
D. 13.7 A

Question 16 (9 marks)

a. A 12 V battery delivers a current of 5.0 A which passes through a load and flows for 2 minutes and 20 seconds.

i. Determine the number of electrons that passes through in 2 minutes and 20 seconds.

Electrons (2 marks)

ii. How much energy does the 12 V battery provide?

J (2 marks)

Area of study 3 – continued

TURN OVER

b. A light bulb is connected to a 6 V variable power supply as shown below in Figure 6.

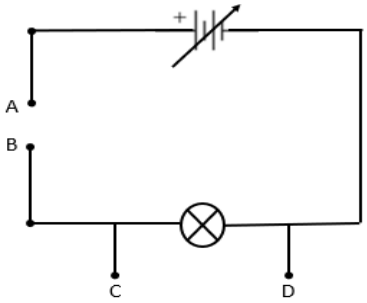


Figure 6

To complete the circuit two electrical meters needs to be connected from point A to B and C to D.

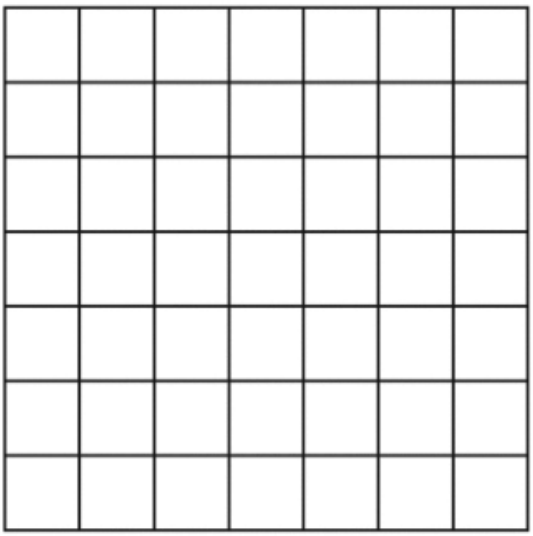
i. Draw and label two electrical meters that needs to be connected in these two positions.

(2 marks)

c. The table below shows the voltage and current readings for the light bulb.

I (Amps)	V (Volts)
0	0
1	2
2	4
3	6

i. Sketch a graph of voltage (y-axis) against current on the grid provided.



(1 mark)

Area of study 3 – continued

ii. Calculate the gradient of the graph.

(1 mark)

iii. What does the gradient represent.

(1 mark)

Question 17 (9 marks)

a. Three resistors are arranged in a circuit diagram as shown in Figure 7 below.

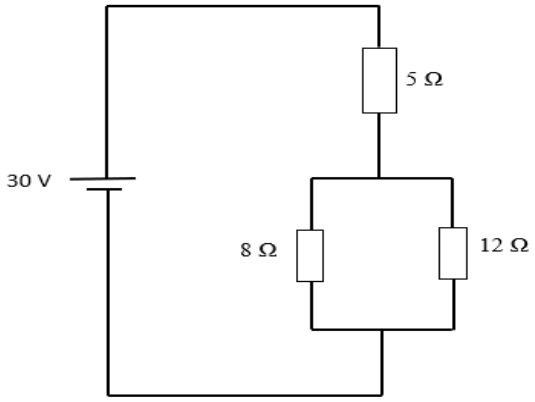


Figure 7

i. Determine the effective resistance of the circuit.

Ω

(2 marks)

ii. Calculate the voltage across the 5 Ω resistor.

V

(2 marks)

iii. Determine the current through the 12 Ω resistor.

(2 marks)

b. A circuit setup consists of an electrical component A which acts as a dimmer switch as shown in Figure 8 below.

A

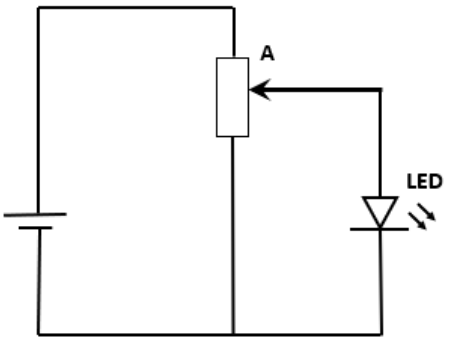


Figure 8

i. Name the electrical component A.

(1 mark)

Area of study 3 – continued

ii Explain how this electrical component controls the brightness of the LED.

(2 marks)

Question 18 (9 marks)

a. A voltage divider circuit consists of a 20V supply voltage, 10 kΩ fixed resistor, and a NTC thermistor as shown in Figure 9 (a) below.

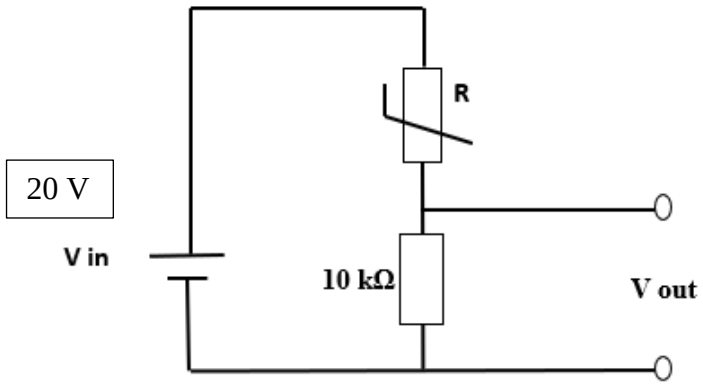


Figure 9 (a)

Area of study 3 – continued

TURN OVER

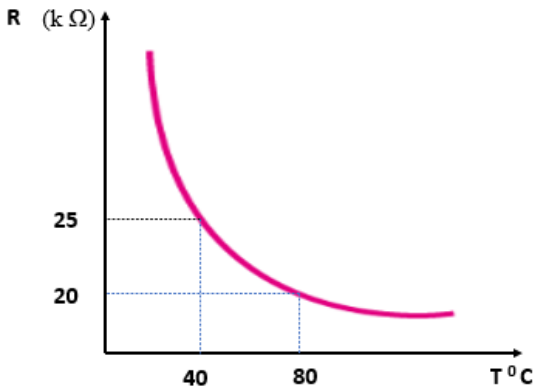


Figure 9 (b)

Figure 9 (b) shows how the resistance of the thermistor varies with time.

The thermistor is labelled as NTC (negative temperature coefficient).

i. Explain why the thermistor is stated as NTC.

(1 mark)

ii. Determine the amount of current flowing in the circuit when the temperature of the thermistor is 80 ^{0}C.

mA

(2 marks)

Area of study 3 – continued

b. A second electrical circuit is constructed using an LED and component B as shown in Figure 10 below.

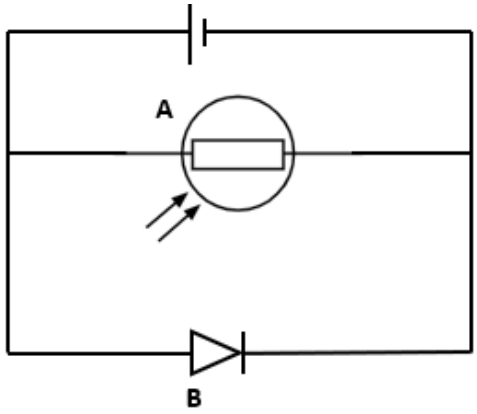


Figure 10

i. State the name of the electrical component B.

(1 mark)

ii. LEDs are quite cheap to compared to incandescent light. Outline another advantage of LEDs over incandescent light bulbs.

(1 mark)

c. The household (AC) electrical systems in Melbourne can be modelled as simple direct current (DC) circuits. Houses are connected to the 230 V_{RMS} at 50 Hz to the main electrical grid.

i. What does the 230 V_{RMS} mean in terms of the direct current (DC)

(1 mark)

ii. Provide one reason why homes are mostly built with parallel circuits.

(1 mark)

d. A common household appliance is the electrical toaster. Inside the toaster an earth wire is permanently connected to its metal casing.

i. State the common colour of the earth wire

Colour:

(1 mark)

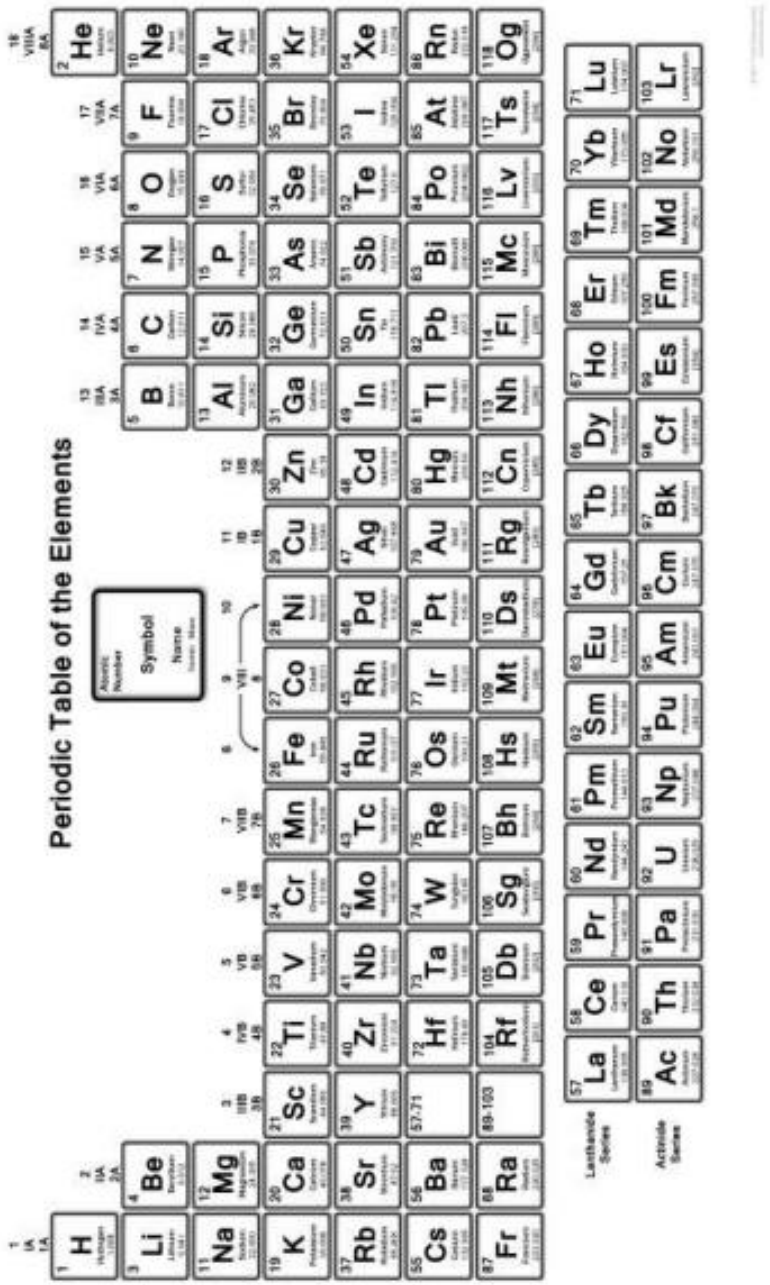
ii. Outline the function of this earth wire

(1 mark)

END OF AREA OF QUESTION AND ANSWER BOOK

Formula and Data Sheet:

Wave equation	$v = f\lambda$
Snell's law	$n_1 \sin\theta_1 = n_2 \sin\theta_2$
Refractive index and wave speed	$n_1 v_1 = n_2 v_2$
Wien's Law:	$\lambda_{max} T = 2.898\ x\ 10^{-3}$ m K
Heat Capacity	Q = mcΔT
Latent Heat	Q = mL
Specific heat of solid water	2.108 x 10^3 J Kg^{-1} K^{-1}
Specific heat of liquid water	4.187 x 10^3 J Kg^{-1} K^{-1}
Specific heat of gaseous water	3.34 x 10^5 J Kg^{-1} K^{-1}
Latent heat of fusion of water	3.34 x 10^5 J Kg^{-1}
Latent heat of vaporisation of water	2.27 x 106 J Kg^{-1}
Binding Energy	$E = mc^2$
Speed of light, c	3 x 10^8 ms^{-1}
Electric charge	Q = It
Electric Work	W = QV
Power	$P = \frac{E}{t} = VI$
Voltage	V = IR
Resistors in series	$R_{TOTAL} = R_1 + R_2 + \ldots\ldots + R_N$
Resistors in parallel	$\frac{1}{R_{TOTAL}} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots + \frac{1}{R_N}$
Electronic Charge	1.6 x 10^{-19} C


Periodic Table of the Elements
Atomic Number
Symbol
Name
Lanthanide Series
Actinide Series