Neap

Trial Examination 2023

VCE Physics Unit 1

Written Examination

Question and Answer Booklet

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

Student's Name: _____

Teacher's Name: _____

Structure of booklet

Section	*Number of questions*	*Number of questions to be answered*	*Number of marks*
A	10	10	10
B	9	9	80
			Total 90

Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, rulers, pre-written notes (one folded A3 sheet or two A4 sheets bound together by tape) and one scientific calculator.

Students are NOT permitted to bring into the examination room: blank sheets of paper and/or correction fluid/tape.

Materials supplied

Question and answer booklet of 23 pages

Formula sheet

Answer sheet for multiple-choice questions

Instructions

Write your **name** and your **teacher's name** in the space provided above on this page, and on the answer sheet for multiple-choice questions.

Unless otherwise indicated, the diagrams in this booklet are **not** drawn to scale.

All written responses must be in English.

At the end of the examination

Place the answer sheet for multiple-choice questions inside the front cover of this booklet.

You may keep the formula sheet.

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

SECTION A – MULTIPLE-CHOICE QUESTIONS

Instructions for Section A

Answer **all** questions in pencil on the answer sheet provided for multiple-choice questions.

Choose the response that is **correct** or that **best answers** the question.

A correct answer scores 1; an incorrect answer scores 0.

Marks will **not** be deducted for incorrect answers.

No marks will be given if more than one answer is completed for any question.

Unless otherwise indicated, the diagrams in this booklet are **not** drawn to scale.

Take the value of g to be 9.8 m s^{-2}.

Use the following information to answer Questions 1–3.

The Sun emits a continuous spectrum of visible light that ranges between approximately 250 nm and 2500 nm in length. The wavelength emitted with the greatest intensity has a length of 502 nm.

Question 1

What is the surface temperature of the Sun?

A. 5.78×10^{3} K

B. 1.16×10^{4} K

C. 1.73×10^{5} K

D. 2.06×10^{17} K

Question 2

What is the highest frequency of light emitted by the Sun?

A. 1.20×10^{14} Hz

B. 4.00×10^{14} Hz

C. 5.98×10^{14} Hz

D. 1.20×10^{15} Hz

Question 3

Stars with a lower temperature than the Sun have been observed to emit their peak wavelengths at lower energy.

Which part of the electromagnetic spectrum are these wavelengths likely to be emitted in?

A. gamma ray

B. X-ray

C. ultraviolet

D. infrared

Use the following information to answer Questions 4 and 5.

During fission reactions inside nuclear reactors, uranium-235 absorbs a neutron before splitting. One of the possible fission reactions occurs according to the following equation.

$$ {}^{1}_{0}n + {}^{235}_{92}\mathrm{U} \rightarrow {}^{100}_{44}\mathrm{Ru} + {}^{130}_{48}\mathrm{Cd} + 6\,{}^{1}_{0}n $$

Each fission reaction releases approximately 365 MeV of energy.

Question 4

Which one of the following statements best explains why a neutron is needed to cause the fission of uranium-235?

A. The neutron increases the atomic number of the nucleus, decreasing its stability.

B. The neutron increases the electrostatic repulsion present in the nucleus, decreasing its stability.

C. The neutron increases the binding energy of the nucleus, making the nucleus fissile.

D. The neutron increases the separation between nucleons, reducing the amount of repulsion in the nucleus.

Question 5

Which one of the following statements best explains the role of the six neutrons released during the fission reaction in a nuclear reactor?

A. The neutrons carry excess kinetic energy away from the fission products to ensure they are stable.

B. The neutrons increase the number of particles present in the sample to ensure it remains above critical mass.

C. The neutrons are unbound and therefore act to absorb heat generated by the reactor.

D. The neutrons sustain the chain reaction by initiating other fission reactions.

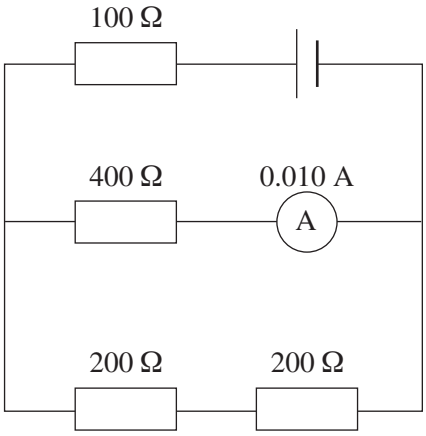
Question 6

Which of the following best summarises the viability of nuclear energy in Australia if the fission products are radioisotopes?

	Viability	Explanation
A.	low	The necessary safe storage and disposal sites for radioisotope waste are not yet readily available.
B.	high	Radioisotopes are a byproduct of nuclear energy; this waste can be repurposed for many uses.
C.	high	The amount of energy released per nucleus far exceeds the amount of energy needed to process and store any potential waste products.
D.	high	As the radioisotopes are likely to have short half-lives, only short-term storage would be needed before the radioisotopes can be safely deposited into landfill.

Use the following information to answer Questions 7–10.

The diagram below shows a circuit containing resistors that are connected to a battery.



Question 7

What is the equivalent resistance of the circuit?

A. 100 Ω

B. 300 Ω

C. 400 Ω

D. 900 Ω

Question 8

What magnitude of voltage does the 400 Ω resistor use?

A. 2.5 V

B. 4.0 V

C. 6.0 V

D. 9.0 V

Question 9

What magnitude of current flows through the 200 Ω resistors?

A. 0.0050 A

B. 0.010 A

C. 0.020 A

D. 0.040 A

Question 10

Which one of the following statements best explains why the battery supplies more voltage than is used by the 400 Ω resistor?

A. The 200 Ω resistor branch is supplied with equal voltage; therefore, the battery supplies double the voltage used by the 400 Ω resistor.

B. The 200 Ω resistor branch provides two additional circuit elements to the closed loop; therefore, more voltage needs to be supplied for current to move through them.

C. The 100 Ω resistor in series with the parallel branches uses some of the voltage supplied by the battery before the current reaches the parallel branches.

D. There are multiple junctions in the circuit, each requiring additional voltage to allow the current to split and follow each path.

END OF SECTION A

SECTION B

Instructions for Section B

Answer **all** questions in the spaces provided.

Where an answer box is provided, write your final answer in the box.

If an answer box has a unit printed in it, give your answer in that unit.

In questions where more than one mark is available, appropriate working **must** be shown.

Unless otherwise indicated, the diagrams in this booklet are **not** drawn to scale.

Take the value of g to be 9.8 m s^{-2}.

Question 1 (11 marks)

Diamonds have a refractive index of 2.42 and are often used in jewellery due to their capacity to strongly refract and internally reflect light. Fake diamonds have similar refractive properties but are made of less expensive material. A jeweler is investigating the composition of a piece of jewellery containing a refractive stone. The jeweller directs a ray of light at the stone that is incident on one of the surfaces at 60°, refracting across the interface at 25.6°.

a. Determine the refractive index of the refractive stone. Show your working. 2 marks

b. Calculate the angle of refraction that would be expected if the refractive stone was made of diamond. Show your working. 2 marks

°

c. The ray travelling through the refractive stone is incident on the next interface at 32°, as shown in Figure 1.

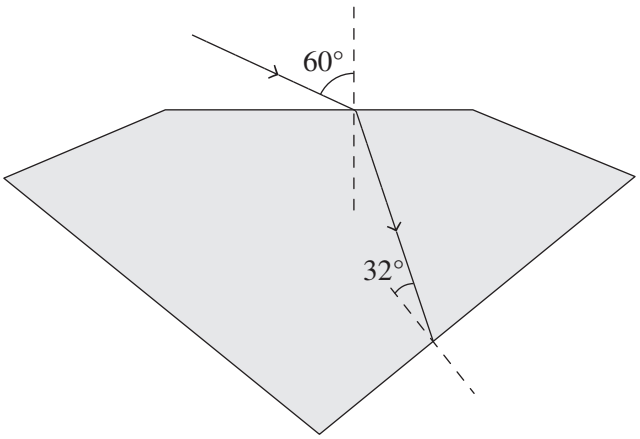


Figure 1

On Figure 1, sketch the path of the ray after it interacts with the interface. Use appropriate calculations for the critical angle to justify your sketch. 4 mark

d. When light moves through a diamond, sparkles that form a rainbow of colours can be observed.

Explain how these rainbows are formed with reference to an applicable light phenomenon. 3 marks

Question 2 (9 marks)

On a hot summer day, Minh leaves a 125 g bowl of ice cream out in the sun. Over time, Minh observes that the ice cream melts at 0°C and then begins to heat up once it becomes a liquid. In its liquid state, the ice cream has a specific heat capacity of 2100 J kg^{-1} K^{-1}.

a. Identify the method of heat transfer that occurs when heat is transferred from the Sun to the ice cream. Justify your response. 2 marks

b. To melt the sample of ice cream, 34.4 kJ of heat energy is absorbed.
Determine the latent heat of fusion of the ice cream. Show your working. 2 marks

J kg^{-1}

c. Explain why a phase change allows the temperature of the ice cream to increase above 0°C. Refer to the kinetic energy of particles in your response. 2 marks

d. When the sample is at 10°C, Minh begins to measure the energy absorbed by the ice cream. They stop measuring once the ice cream absorbs 3150 J of energy.

Calculate the final temperature of the liquid ice cream, expressing your answer in kelvin. Show your working. 3 marks

K

Question 3 (7 marks)

The leaves of forest plants can reflect light more readily than concrete or brick buildings. When urbanisation occurs in coastal areas, forests are cleared and replaced with buildings. The buildings have a lower specific heat capacity than forest vegetation. Buildings and the roads that connect them are often dark in colour.

a. Evaluate how the urbanisation of coastal areas affects the temperature in the area. Refer to the absorption of energy in your response. 3 marks

b. Local convection currents often form when the land and sea are at different temperatures due to the uneven heating of air.

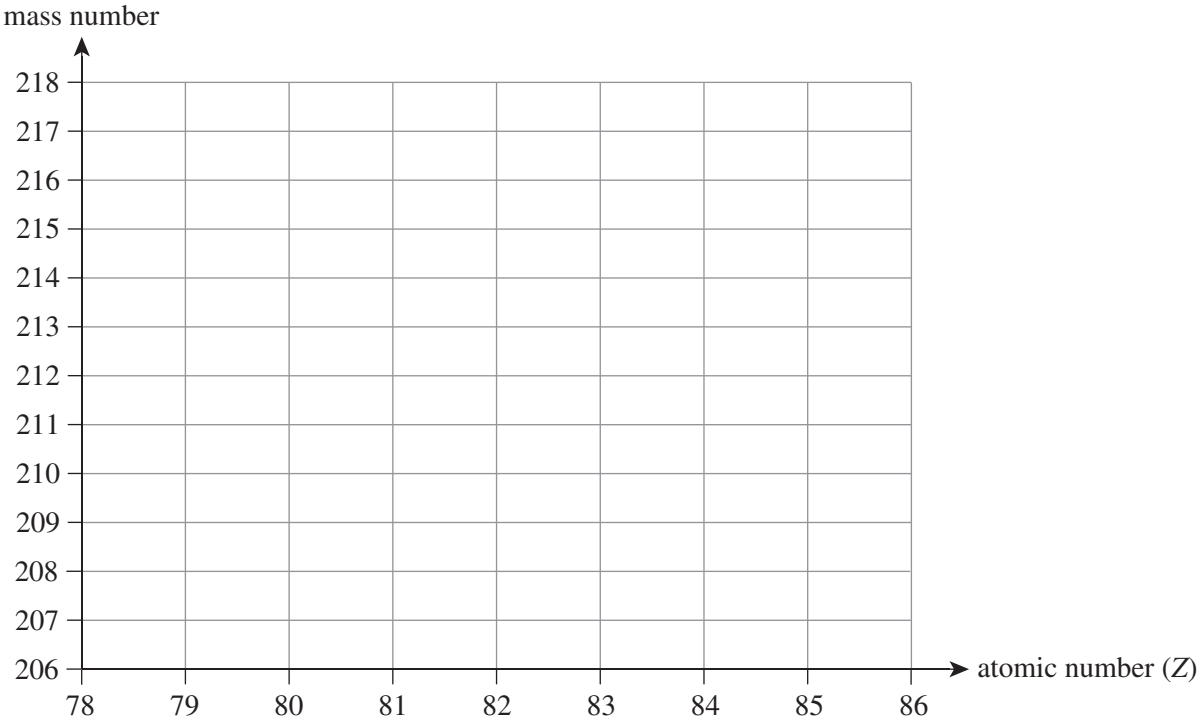
Evaluate how the urbanisation of coastal areas affects convection currents. In your response, explain the processes that facilitate the formation of convection currents. 4 marks

Question 4 (9 marks)

A sample of polonium-216 is able to undergo a series of subsequent radioactive decays, emitting two α particles and two β^- particles before forming a stable daughter nucleus. Radon is not observed as a product of any of the decays.

a. Identify the final stable daughter nucleus. 1 mark

b. On the axes below, sketch **two** possible decay series that would produce the daughter nucleus determined in **part a.** 2 marks



c. Write a decay equation to represent **one** of the final decays shown in **part b.** 2 marks

d. Explain why the mass numbers of the parent and daughter nuclei are equal during β^- decays. 2 marks

e. Explain why the final daughter nucleus is more stable than the initial polonium-216 nucleus. Refer to the strong nuclear force in your response. 2 marks

Question 5 (13 marks)

Positron emission tomography (PET) is a type of medical diagnostic scan. PET utilises the radioisotope fluorine-18 to image organs such as the brain. Fluorine-18 emits β^+ particles and has a half-life of approximately 2 hours. It is injected into patients so that the radioisotope can travel to the organ being imaged. When the β^+ particles collide with electrons inside the organ, annihilation occurs and produces a pair of gamma rays that each have an energy of 511 keV. The gamma rays travel out of the patient's body and are captured by a detector.

a. Write a decay equation to represent the β^+ decay of fluorine-18. 2 marks

b. Explain why gamma rays are able to leave the patient's body and evaluate the risk this poses to the patient. 3 marks

A patient has a brain scan and is injected with a dose of fluorine-18 with an initial activity of 0.20 GBq. The patient's brain mass is 1.3 kg. Once the scan is complete, the radioisotope leaves the patient's body via the kidneys and bladder. The table below shows the weighting factors of these organs.

Organ	Weighting factor
brain	0.01
kidney	0.009
bladder	0.04

The β^+ radiation has a quality factor of 1.

c. The patient's brain receives a dose equivalent of 16 mSv.

Determine the energy absorbed by the brain due to β^+ particles. Show your working. 3 marks

J

d. The kidney and bladder each absorb 12 mSv of radiation.

Determine the total effective dose absorbed by the patient in their brain, kidney and bladder. Show your working. 2 marks

mSv

e. The patient is advised not to interact with other people until their activity drops below 12.5 MBq.

Determine the amount of time the patient needs to wait. Show your working. 3 marks

hours

Question 6 (5 marks)

Figure 2 shows the binding energy per nucleon stored in nuclei of different masses.

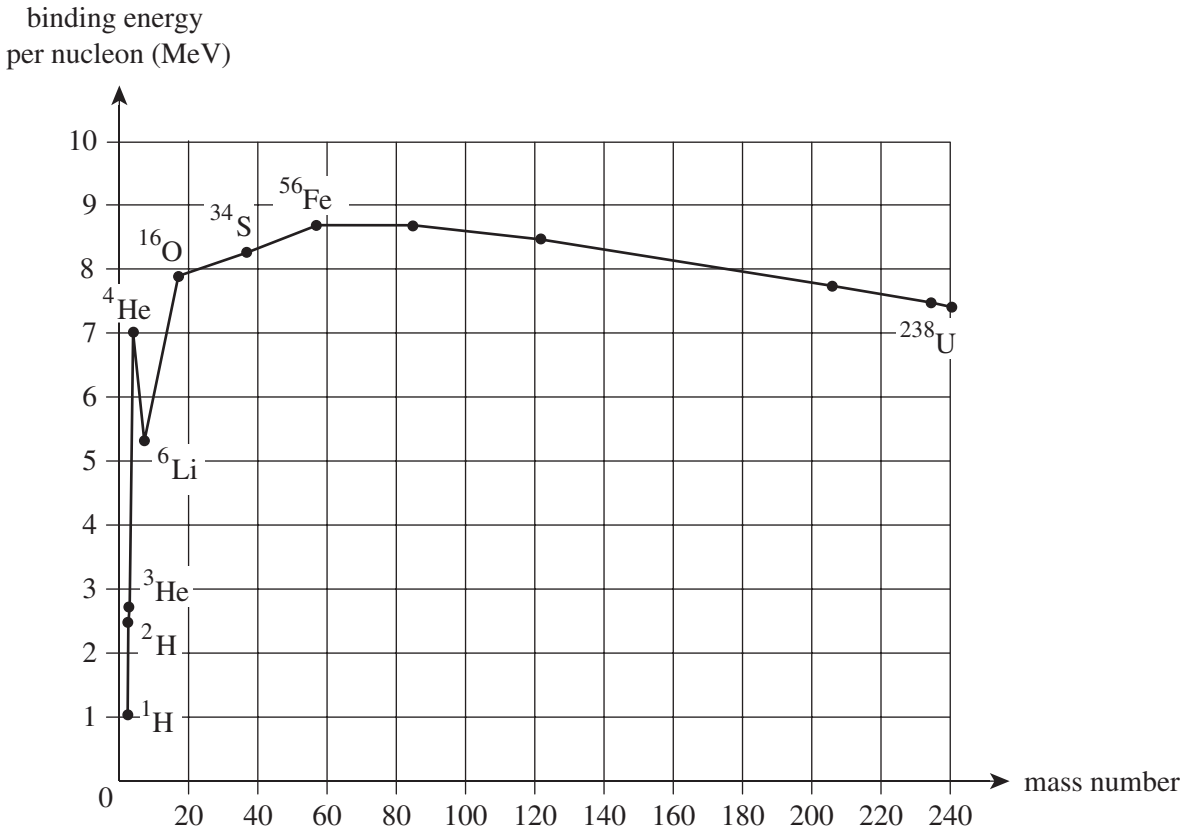


Figure 2

a. With reference to the trends shown in the graph in Figure 2, explain why the processes of fission and fusion are both able to release energy. 3 marks

b. How does the release of energy during fission and fusion affect the mass of each nucleon? Refer to an appropriate equation in your response. 2 marks

Question 7 (11 marks)

Antonio uses his blender for 12 minutes each day while he is preparing dinner. The blender has a power rating of 1200 W and is connected to a power supply of 240 V.

a. Calculate the resistance of the blender. Show your working. 2 marks

Ω

b. Determine the magnitude of charge that flows through the blender in 12 minutes. Show your working. 3 marks

C

c. Determine the magnitude of energy used by the blender in 12 minutes. Express your answer in kW h. Show your working. 3 marks

kW h

d. A circuit breaker protects the circuit the blender is plugged into.

Explain the role that the circuit breaker plays in the circuit and why the circuit breaker is placed on the active wire. 3 marks

Question 8 (8 marks)

Figure 3 shows a characteristic graph of the current that flows through an LED when the voltage across it is varied.

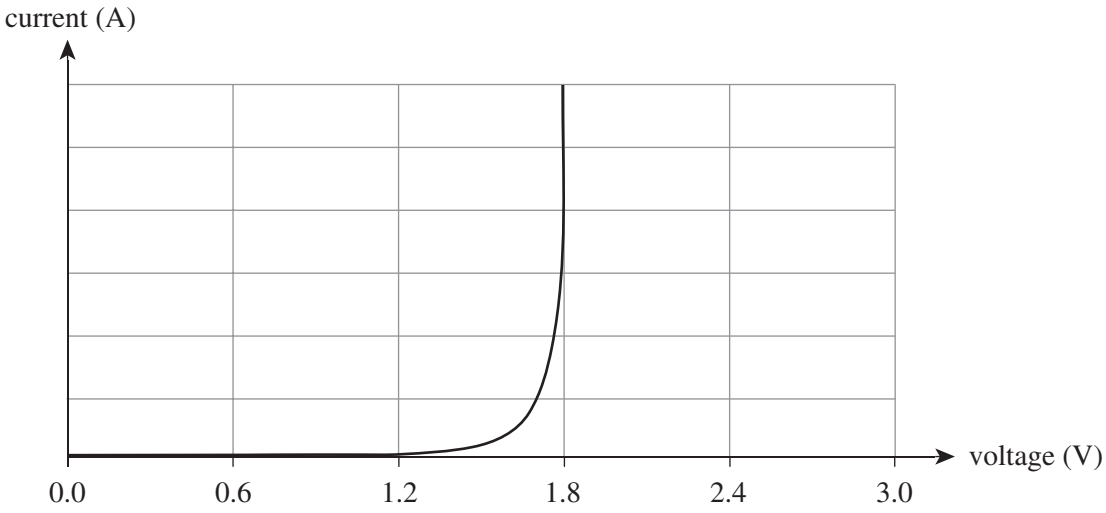


Figure 3

The LED is placed into the circuit shown in Figure 4.

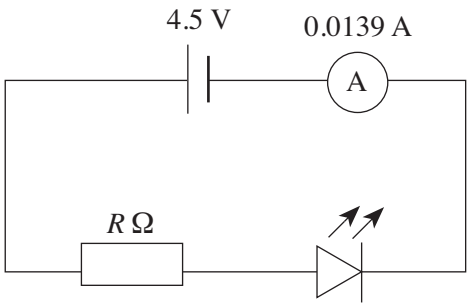


Figure 4

a. With reference to the graph in Figure 3, explain why the LED is a non-ohmic device. 2 marks

b. Determine the resistance of the limiting resistor, *R*. Show your working. 2 marks

Ω

c. Calculate the power output of the LED. Show your working. 2 marks

W

d. Describe the effect that reducing the resistance of the limiting resistor, *R*, would have on the operation of the circuit. 2 marks

Question 9 (7 marks)

A thermistor is able to respond to external temperature conditions. Figure 5 shows the temperature characteristic graph of the thermistor.

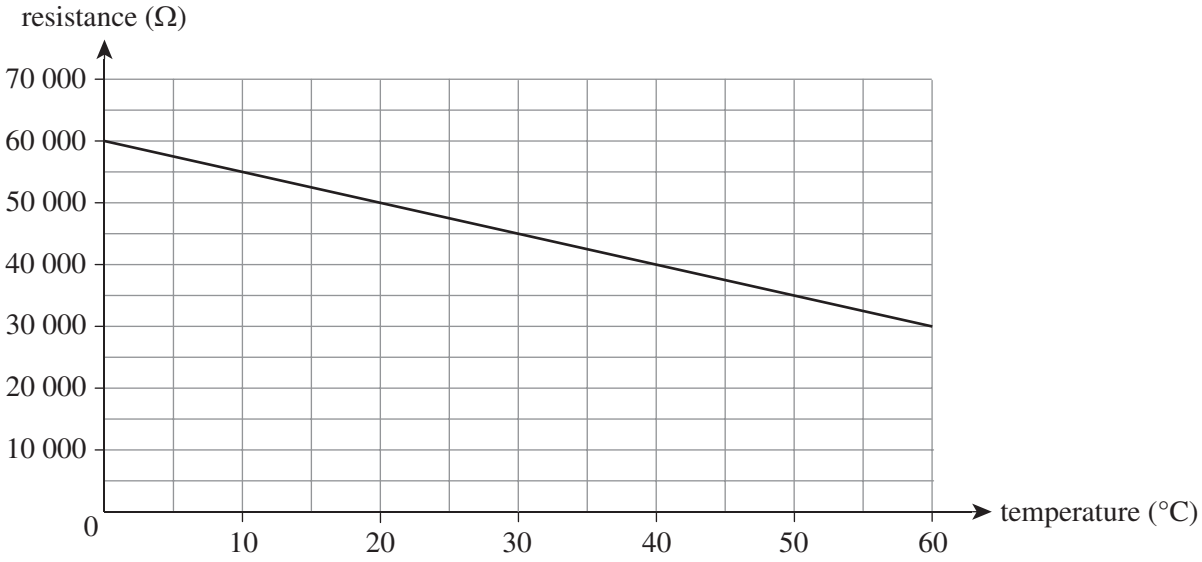


Figure 5

The thermistor is used in a device that activates when the external temperature reaches 30°C. In the device, the thermistor is placed in series with a variable resistor, as shown in Figure 6.

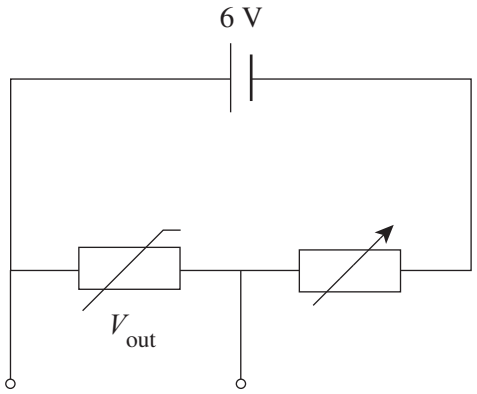


Figure 6

a. Determine the resistance of the thermistor at 30°C. 1 mark

Ω

b. When the voltage output, V_{out}, has a value of less than 1.5 V, the device connected across the terminals switches on.

Determine the resistance of the variable resistor at which the device switches on at 30°C.
Show your working. 3 marks

Ω

c. The resistance of the variable resistor is now changed to 157.5 kΩ.

Determine the temperature at which the device connected to the output will switch on.
Show your working. 3 marks

°C

END OF QUESTION AND ANSWER BOOKLET