

S2 Examination Practise 4

Q

Q1

Question 1

(2 marks)

Explain why a 'space blanket' to protect against hypothermia has a shiny silver surface.

Q2

Question 2

(2 marks)

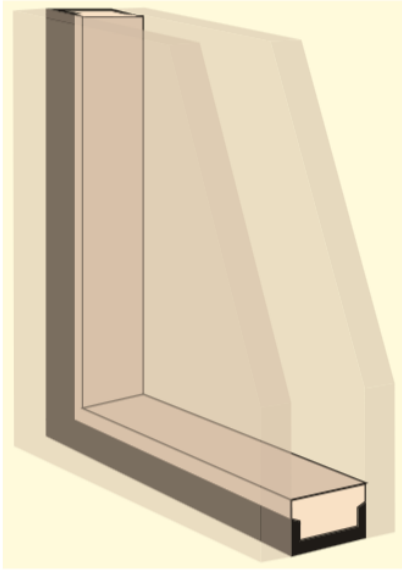
When the Space Shuttle was flying space missions it had black ceramic tiles on its nose. What was the role of these tiles when the Shuttle re-entered the Earth's atmosphere?

Q3

Question 3

(2 marks)

Double-glazed windows offer more effective insulation than single-glazed windows. Explain how double-glazed windows achieve this.

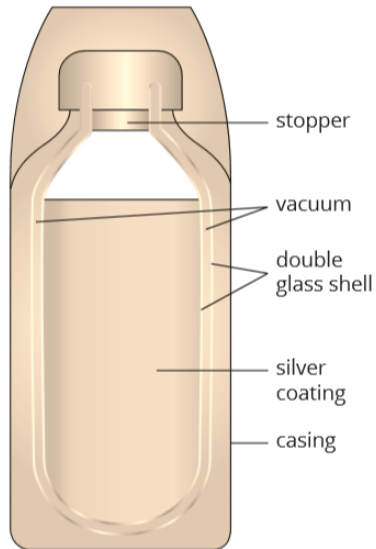


Q4

Question 4

(4 marks)

A vacuum flask (as shown below) can be used to keep hot liquids hot. In the diagram, five design features of a flask are labelled. Explain how each of the features cuts down heat loss.



Q5

Question 5

(2 marks)

${}_{28}^{58}\text{Ni}$ and ${}_{28}^{63}\text{Ni}$ are both isotopes of nickel. Explain the meaning of the term 'isotope', referring to these two atoms as examples.

Q6

Question 6

(2 marks)

${}_{28}^{63}\text{Ni}$ is a radioisotope of nickel. Explain what the term 'radioisotope' means. Explain why ${}_{28}^{63}\text{Ni}$ is radioactive and ${}_{28}^{58}\text{Ni}$ is not radioactive.

Q7

Question 7

(1 mark)

Explain what is meant by the nuclear binding energy of an atom.

Q8

Question 8

(1 mark)

A controlled chain reaction is required to sustain nuclear fission inside a nuclear reactor. For this to occur, what number of neutrons per fission needs to be released?

Q9

Question 9

(2 marks)

Cadmium is often used to control the rate of nuclear fission in a reactor. How does cadmium achieve this?

Q10

Question 10

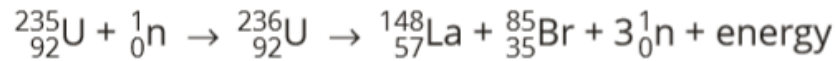
(2 marks)

In the nuclear reaction ${}_{92}^{235}\text{U} + {}_0^1\text{n} \rightarrow {}_{92}^{236}\text{U} \rightarrow {}_{36}^{91}\text{Kr} + {}_{86}^{142}\text{Ba} + X + \text{energy}$, what would X be?

Q11

Question 11

(3 marks)



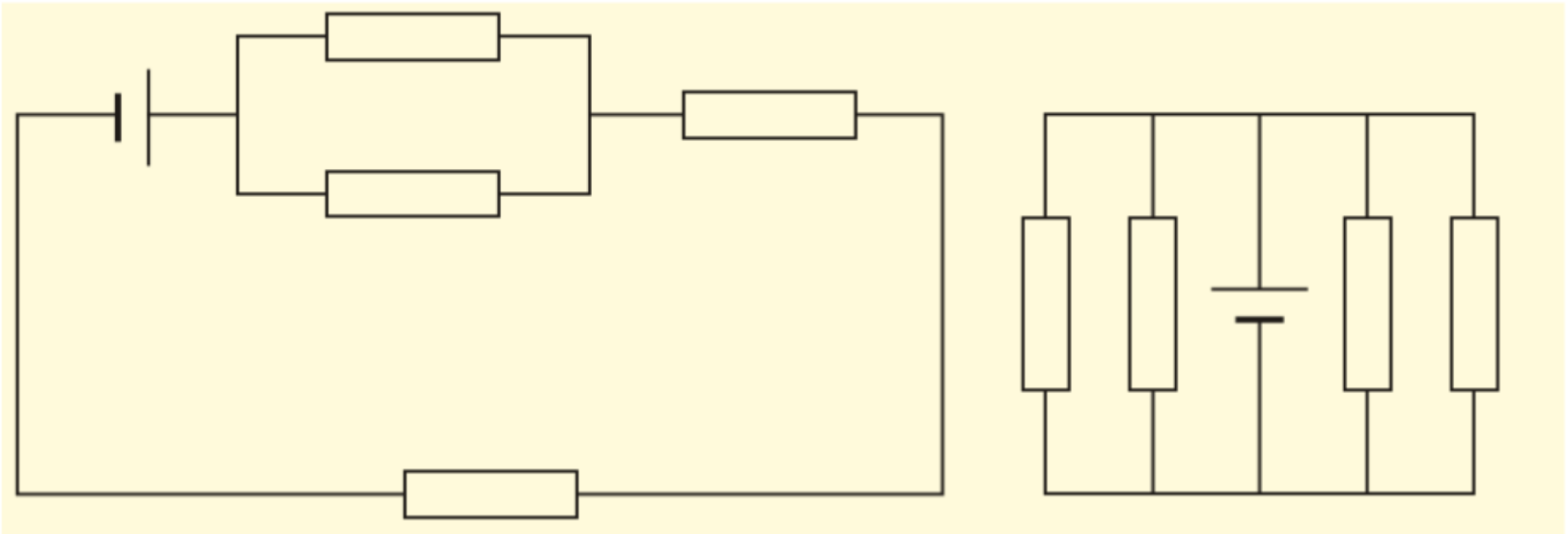
If the mass defect as a result of this nuclear reaction is 2.12×10^{-28} kg, how much energy would be released in MeV?

Q12

Question 12

(3 marks)

A student constructs two circuits, as shown below. She wants each circuit to have the same effective resistance. The resistors are all identical.



Has she achieved her aim? Use calculations to prove your answer.

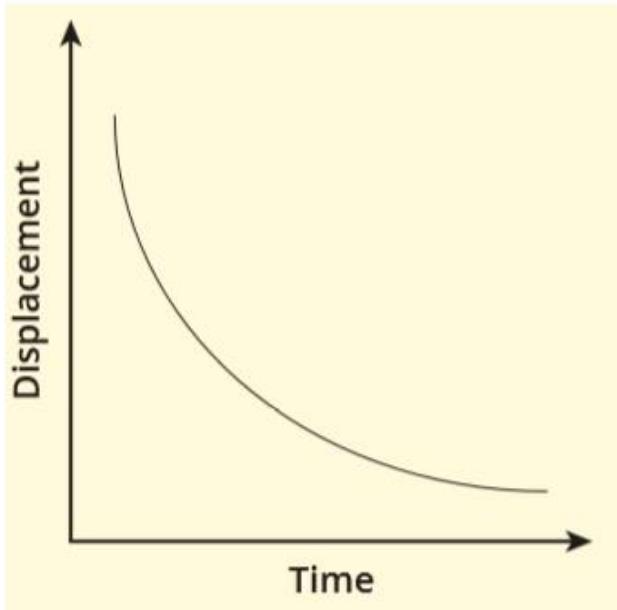
Q13

(4 marks)

Distinguish between the internal electrical resistance of ammeters and voltmeters, and give reasons for those differences.

Q14

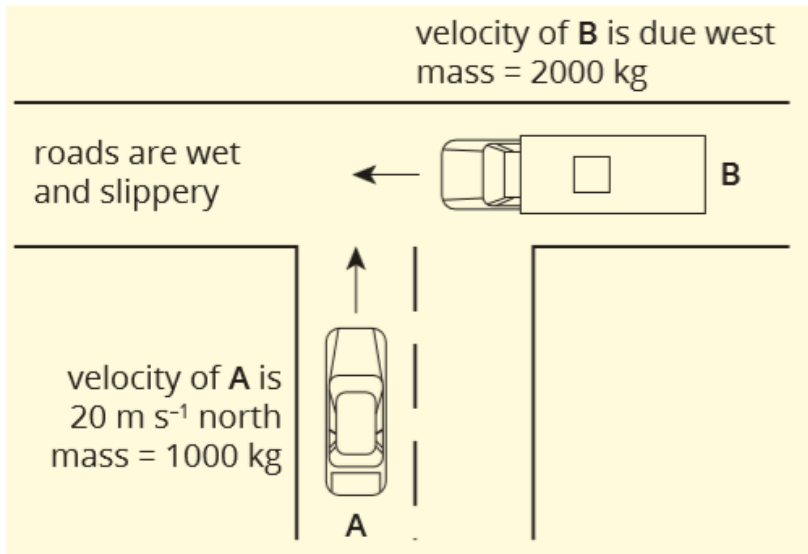
Consider the following displacement versus time graph. Sketch the shapes of its matching velocity versus time graph and acceleration versus time graph.



Q15

(4 marks)

Two vehicles are approaching each other at a T-intersection. Neither vehicle stops, and the vehicles subsequently collide.



After the impact the car becomes jammed under the truck and the two vehicles skid off as one mass with a velocity of 9.43 m s^{-1} north 45° west.

The driver of the truck claims that he was travelling at 5 m s^{-1} , just before the collision. Is he correct? If not, explain why.

Q16

(3 marks)

A 1000 kg vehicle is accelerated from rest to a speed of 17.8 m s^{-1} over 9.4 s. Determine the size of the net force acting on the vehicle during this time.

Q17

(3 marks)

A 1600 kg vehicle travelling at 14.5 m s^{-1} slows to a halt over a distance of 350 m. Determine the combined total of the frictional force and the air resistance that slows the vehicle down.

Q18

(2 marks)

Why does light refract?

Q19

(2 marks)

What type of interference will occur if two identical waves arrive at a point, 180° out of phase?
Explain your answer.

Q20

(3 marks)

A light bulb, when viewed from a distance of 5.0 m, has an intensity of 0.32 W m^{-2} . At what distance from the light bulb would the intensity be 0.50 W m^{-2} ?

Q21

James Bond, 007, likes to drink cocktails. On a warm afternoon (26°C), 007 is mixing cocktails whilst the ice is melting (0°C) in a bowl. Note: the specific heat capacity of the cocktails is $2.7 \times 10^3 \text{ J kg}^{-1} \text{ }^{\circ}\text{C}^{-1}$.

- a** A colleague of 007, 006, likes her cocktails served at 0°C . What is the minimum mass of ice cube she should select to cool her 60 g cocktail from 26°C to 0°C ? (2 marks)
- b** 007 prefers his 60 g cocktail served at 10°C and shaken not stirred! What mass of ice cube will he need to cool his drink from 26°C to this temperature? (3 marks)

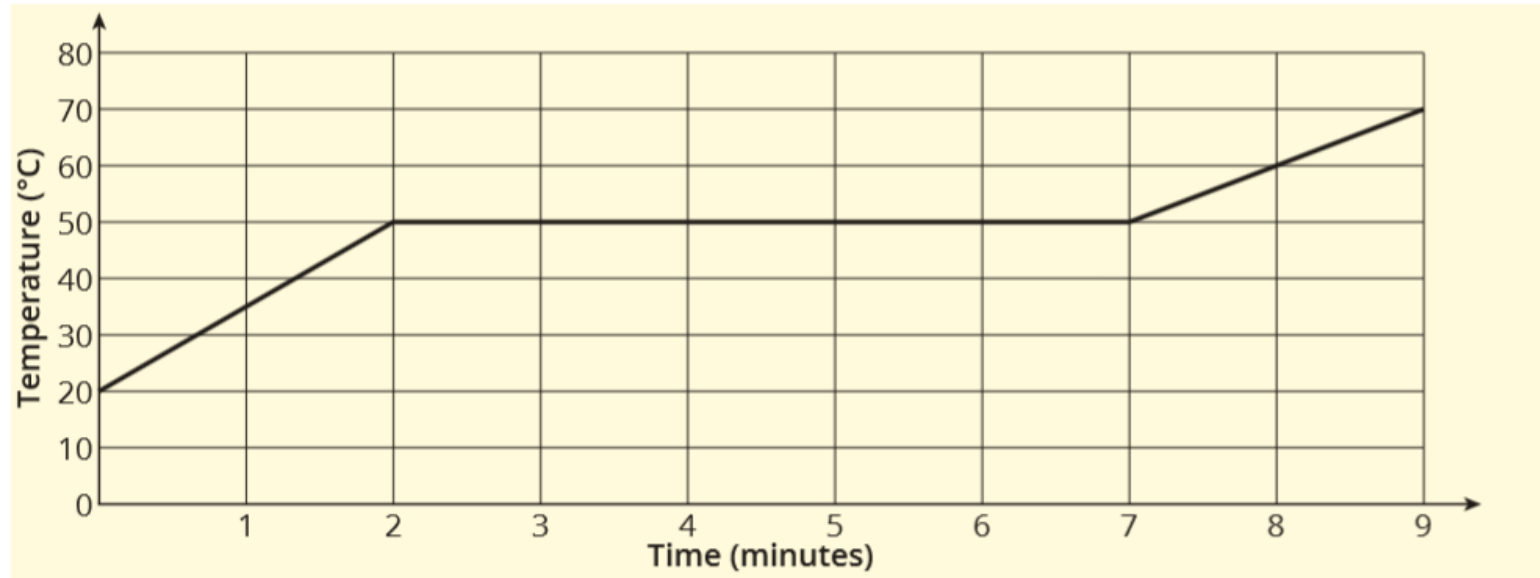
Q21 continued

- c** Another colleague, 008, decides he wants a cup of tea. He uses a 2000 W mains-operated kettle filled with 1.20 kg of water at room temperature (26°C). How long will he have to wait for the water to reach boiling point (100°C)? (2 marks)
- d** In reality, it takes a little longer than this to boil the kettle. Give one good reason why it would take longer. (1 mark)
- e** After several minutes it is noticed that there are drops of liquid water on the outside surfaces of the cold cocktail glasses. Explain why this effect occurs and describe what thermal effect this will have on the remaining contents of the glass.

Q22

(5 marks)

The graph below shows the temperature–time relationship for the heating of 0.25 kg of soft wax by an electrical heater supplying 50 J of heat energy per second.

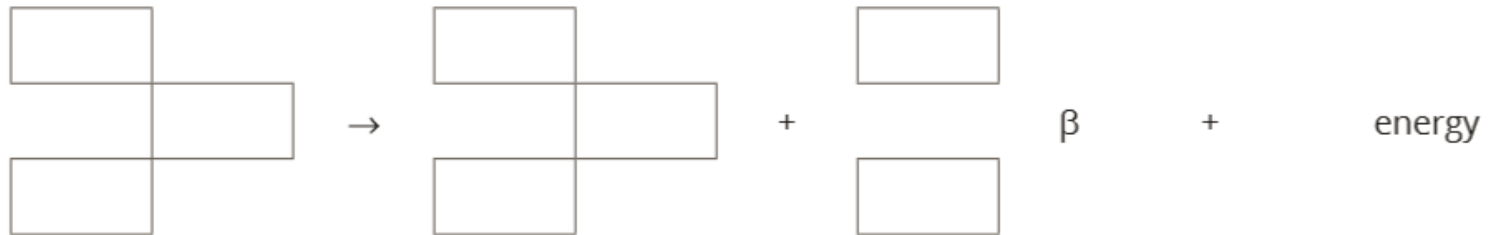


- a** Determine the wax's melting temperature. (1 mark)
-
- b** Find the latent heat of fusion (L_f) of the wax. (2 marks)

Q23

(6 marks)

- a** Complete the nuclear decay equation for Ni-63 when it emits a beta particle by placing the appropriate numbers and symbols in the boxes below: (4 marks)



- b** Explain where the emitted beta particle has come from and how it was produced. (2 marks)

Q24

(8 marks)

Polonium-215 atoms decay into atoms of lead-211 by emitting an alpha particle.

The average kinetic energy of the emitted alpha particle is 7.39 MeV.

Polonium-215 has a half-life of 1.78×10^{-3} s.

$$1.00 \text{ eV} = 1.6 \times 10^{-19} \text{ J}$$

- a** What is the average kinetic energy of an emitted alpha particle in joules? (2 marks)

As an alpha particle travels through air it will ionise about 100 000 atoms for every centimetre travelled. Each time an alpha particle ionises an atom, the alpha particle will lose about 34 eV of its kinetic energy.

- b** Approximately how much energy would an alpha particle lose as it passes through 1.0 cm of air? (2 marks)

Q24 continued

- c** Calculate the approximate distance that an alpha particle with a kinetic energy of 7.39 MeV will travel in air before it loses all of its energy. Give your answer to the nearest millimetre.
(2 marks)
- d** What percentage of the original sample of polonium-215 would be left after 4.13×10^{-3} s?
(2 marks)

Q25

(7 marks)

The diagram below illustrates the use of a type of taser that is sometimes used by police. A taser is a device designed to subdue a person by making them part of an electric circuit and then sending pulses of electrical current into their body.



When operating:

- the taser sends 10 pulses of electric current each second
- each pulse of current lasts for 1.00×10^{-4} s
- during each pulse 1.90×10^{-3} A of current flows
- during each pulse the potential difference across the circuit at the points of contact is 350 V.

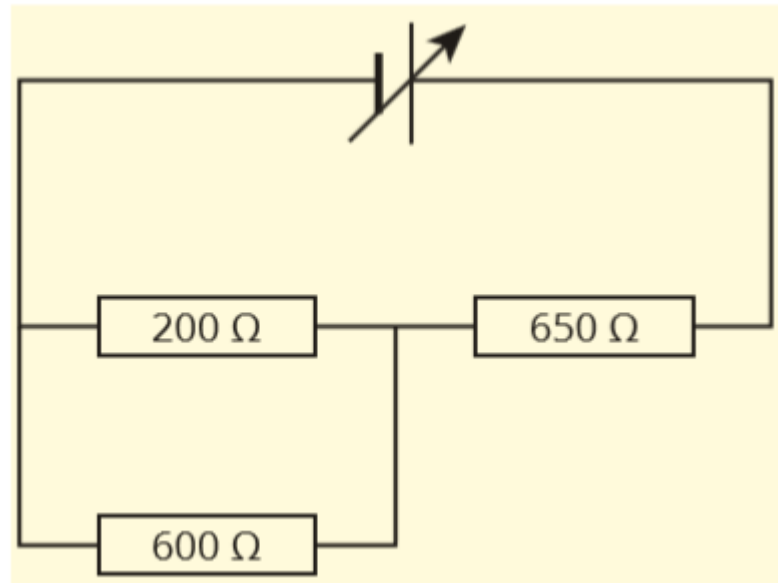
a How much charge passes through the person's body during a single pulse from the taser? (2 marks)

Q25 continued

- b** How many electrons would flow through the wires of the taser during a single pulse? (2 marks)
- c** How much electrical energy is delivered in 2.00 s? (3 marks)

Q26

- Consider the following circuit, in which three resistors are connected to a variable power supply.



Q26 continued

- a** Show, by calculation, that the total resistance of the circuit is $800\ \Omega$. (3 marks)
- b** Calculate the current that flows through the $600\ \Omega$ resistor when the output of the power supply is $6.00\ \text{V}$. (4 marks)

Q27

- Sam was driving his car at a constant speed of 54 km h^{-1} along a straight stretch of road. The total mass of the car and driver is 1600 kg .
- **a.** Use an appropriate calculation to show that Sam's car was moving at a constant speed of 15 m s^{-1} . (1 mark)

- Sam saw a traffic light in front of him change from green to red. It took him 1.2 s to see the light change and make the decision to apply his brakes in order to stop the car.

- **b** From the moment the traffic light turned red, what distance did the car travel before Sam applied the brakes? (2 marks)

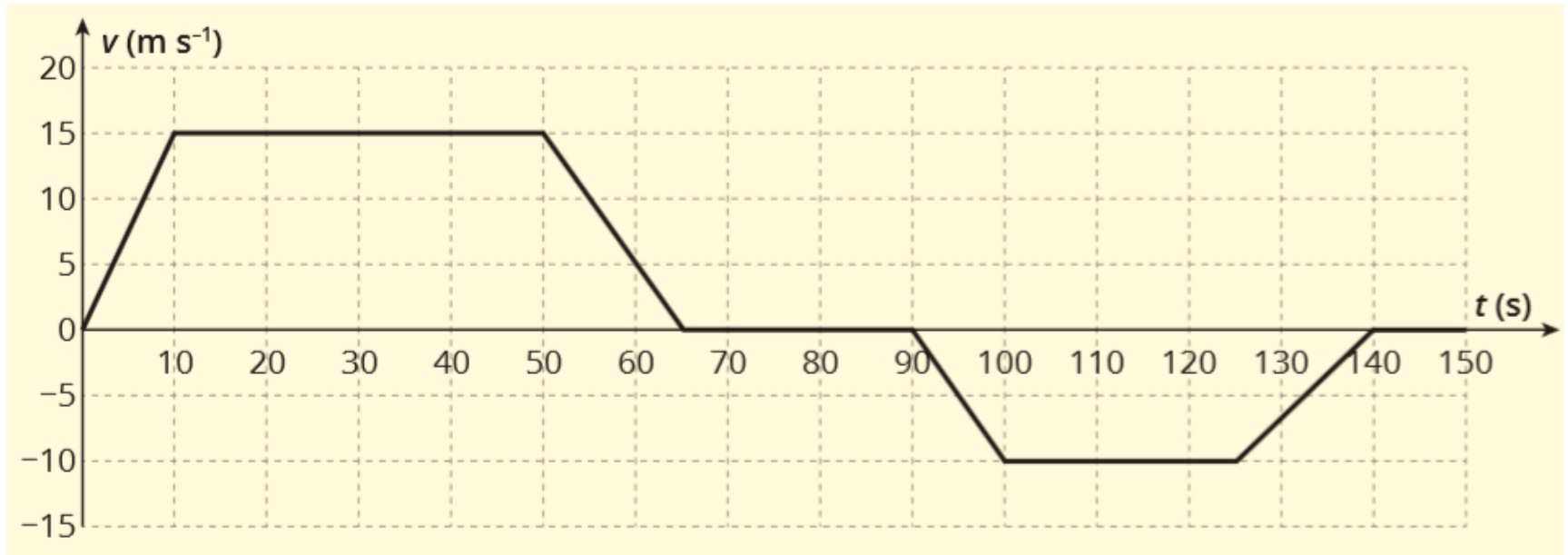
Q27 continued

- e How much work was done by the car's brakes in bringing the car to a stop? (3 marks)

Q28

(13 marks)

The graph below shows part of a journey taken by a student on a bus. The bus and its passengers have a combined mass of 32 000 kg.



- a What was the magnitude of the bus's acceleration at $t = 60$ s? (2 marks)

Q28 continued

- b** What was the net force acting on the bus at $t = 110$ s? Explain your answer. (2 marks)
- c** If the driving force provided by the bus's engine during the first 10 s of the journey was a constant 61.3 kN, what average resistive force acted against the bus during this time? (4 marks)

Q28 continued

- d** What was the bus's average speed for the 150 s journey as shown by the graph? (5 marks)

Q29

(4 marks)

Blu-ray DVD players use a laser that emits a coherent beam of blue light that has a wavelength of 405 nm (405×10^{-9} m).

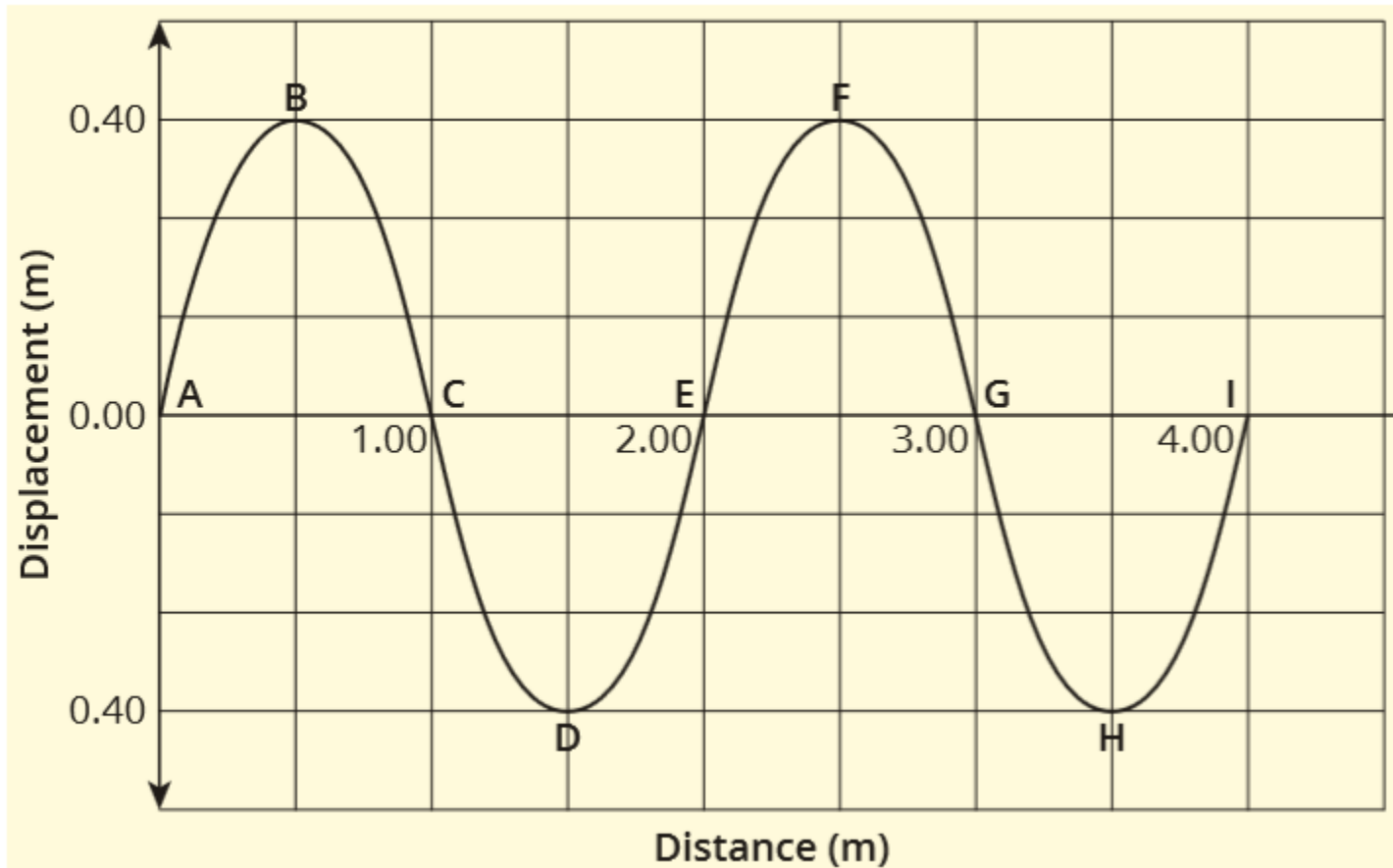
a Calculate the frequency of the blue laser light if the speed of light is 3×10^8 m s⁻¹. (2 marks)

b Calculate the period of the blue laser light

(2 marks)

Q30

- The following diagram shows a wave 1.0 s after it has been produced.



Q30 continued

- a** What is the amplitude of the wave? (1 mark)
- b** How many wavelengths are there in the diagram? (1 mark)
- c** If the driving force provided by the bus's engine during the first 10 s of the journey was a constant 61.3 kN, what average resistive force acted against the bus during this time? (4 marks)

Q 30 continued

- d What was the bus's average speed for the 150 s journey as shown by the graph? (5 marks)

Q31

(8 marks)

On 20 August 1977 the unmanned space probe *Voyager 2* (see below), was launched. Since its launch it has visited all four of the outer planets—Jupiter in 1979, Saturn in 1981, Uranus in 1986 and Neptune in 1989. As of October 2017, it was about 17.3 billion kilometres from the Sun and heading out of the solar system.



To operate its electronic instruments and be able to send radio signals back to the Earth, *Voyager 2* was equipped with a radioisotope thermoelectric generator (RTG). RTGs use the heat generated from radioactive decay to produce electricity.

The radioisotope chosen for *Voyager 2*'s RTG needed to:

- be strongly ionising in order to release enough energy to generate the power needed by the probe's electronic instruments and radio
- be easily shielded so that any emitted radiation would not damage the probe's sensitive electronic instruments
- have a working lifetime of 35 years. To achieve this, its activity cannot drop below 40% of its initial activity in that time.

The following table is a list of five possible radioisotopes that could be used for *Voyager 2*'s RTG, and the daughter radioisotopes resulting from their initial decay.

Q31 continued

Parent radioisotope	$^{108}_{47}\text{Ag}$	$^{63}_{28}\text{Ni}$	$^{137}_{55}\text{Cs}$	$^{238}_{94}\text{Pu}$	$^{250}_{98}\text{Cf}$
Type of radiation emitted	γ	β	β, γ	α	α
Energy released per decay (eV)	720×10^3	70×10^3	510×10^3	5.59×10^6	6.13×10^6
Half-life (years)	418	100	30.2	88	13.1
Daughter radioisotope	$^{108}_{47}\text{Ag}$	$^{63}_{29}\text{Cu}$	$^{137}_{56}\text{Ba}$	$^{234}_{92}\text{U}$	$^{246}_{96}\text{Cm}$
Type of radiation emitted	none	none	γ	α	α
Energy released per decay (eV)	-	-	660×10^3	4.86×10^6	5.48×10^6
Half-life	-	-	2.6 mins	2.46×10^5 years	4.70×10^3 years

Which of the five radioisotopes would be the most suitable for *Voyager 2*'s RTG? Explain your reasoning, and why the other radioisotopes are unsuitable. Where necessary you should support your answer with appropriate calculations.

Q31 continued

a Ionising ability:

(2 marks)

b Shielding:

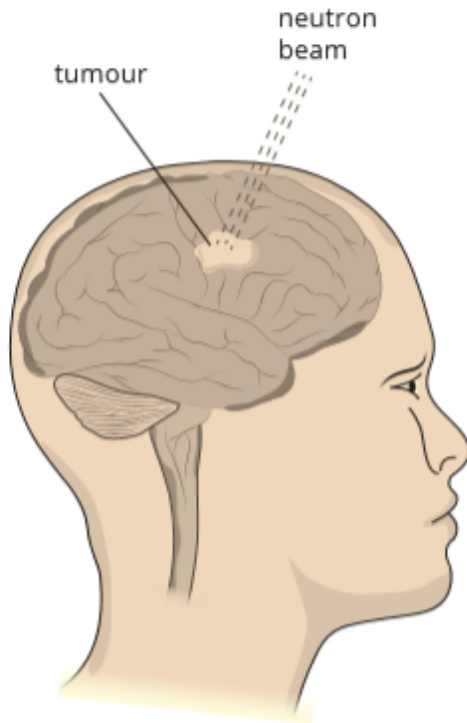
(2 marks)

c Working lifetime:

(3 marks)

Q32

(11 marks)



Boron Neutron Capture Therapy (BNCT) is a specialised form of radiotherapy that provides a way of destroying the cancer cells in a tumour without injuring adjacent normal cells. The process involves injecting the patient with the non-radioactive isotope boron-10. The cancer cells in the tumour take up the boron-10 and the patient's tumour is then irradiated with a beam of slow-moving neutrons, as shown in the diagram. The slow-moving neutrons are strongly absorbed by the boron-10 atoms, which will then decay by emitting alpha particles with an average kinetic energy of 1.47 MeV. The daughter isotope created typically has 0.84 MeV of kinetic energy.

