S2 Examination Practise 5

Q

Q2

(4 marks)

Consider a bucket of water and a swimming pool both at the same temperature. Complete the following table using only the words same, less or more.

	Average kinetic energy	Internal energy
bucket		
pool		

Q3

(10 marks)

500 g of water at 25.0°C in a plastic beaker is placed in a freezer, which coverts it to ice in 8.00 minutes. (Assume the heat capacity of the plastic beaker is negligible.)

a Calculate the heat transfer, Q_1, from the water as its temperature falls from 25°C to 0°C.

(1 mark)

b Calculate the heat transfer, Q_2, from the water as it changes from 0° water to 0° ice.

(2 marks)

c Calculate the rate of heat transfer from the water. (3 marks)

Q3 continued

d An immersion heater rated at 1200 W is placed into 0.75 kg of water at 10°C for 2.00 minutes. What is the final temperature of the water? (4 marks)

Q4

(4 marks)

State whether the following statements are true or false.

	Statement	True or False
a	Thermal energy is a measure of the average kinetic energy of the particles in a substance.	
b	Heat is the energy that transfers from a substance whose particles have a higher kinetic energy to a substance whose particles have a lower kinetic energy.	
c	In experiments, Scientists have been able to remove all the kinetic energy of atoms, and the motion of these atoms have ceased.	
d	During one stage of a heating process of turning ice into water, the temperature remained constant for a while. This was because during this period the internal energy of the material was not increasing.	

Q5

- A bath contains 75 L of water. Initially the water is at 50°C. Calculate the amount of energy that must be transferred from the water to cool the bath to 30°C.

Q6

(4 marks)

The estimated dose equivalent an individual might receive from one X-ray for a joint or limb is 6.0 mSv. Using the quality factor of 1.5, calculate the amount of energy absorbed by a patient of 50 kg receiving such an X-ray.

Q7

(4 marks)

Not all of the elements of the periodic table are naturally occurring. Some have been synthesised, often by neutron bombardment. This is known as artificial transmutation.

Enrico Fermi was the first to perform this. He bombarded uranium-238 with high-energy neutrons.

a Write a nuclear equation to show the neutron absorption of a uranium-238 atom. (2 marks)

This new nuclide is unstable and was found to undergo beta decay to form a new element.

b Write a nuclear reaction for the beta decay of this new nuclide. (2 marks)

Q8

(4 marks)

Plutonium-239 is a fissile material. A plutonium-239 nucleus is struck by a fast moving neutron in a fast breeder reaction. It splits into barium-145 and strontium-93 and releases some neutrons. The nuclear equation for this is:

$${}^{1}_{0}n + {}^{239}_{94}Pu \rightarrow {}^{145}_{56}Ba + {}^{93}_{38}Sr + X\ {}^{1}_{0}n + \text{energy}$$

a Determine the number of neutrons released. (1 mark)

_____

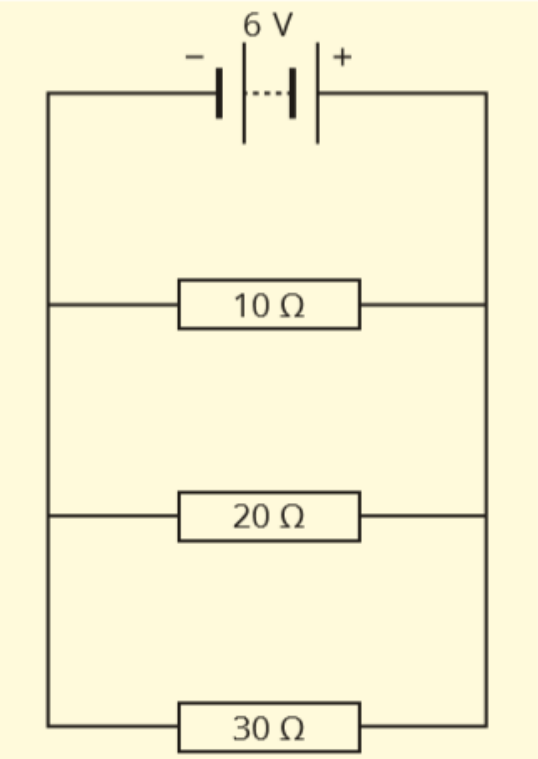
The energy released during the fission of this plutonium nucleus is 2.76×10^{-11} J.

b Calculate the loss in mass (the mass defect) during this fission reaction. (3 marks)

Q9

(7 marks)

Three resistors are connected in parallel as shown in the diagram below:



Q9 continued

a What is the value of the ratio $\frac{\text{potential difference across the 20 Ω resistor}}{\text{potential difference across the 10 Ω resistor}}$? (1 mark)

b State Ohm's law. (1 mark)

c What is the current, in amps, through the 30 Ω resistor? (2 marks)

d What is the effective resistance of the circuit? (3 marks)

Q10

(3 marks)

A typical train on a rural railway line travels at 110 km h^{-1}. When the brakes are applied it will travel 1500 m before it stops. What is the average deceleration of such a train?

Q11

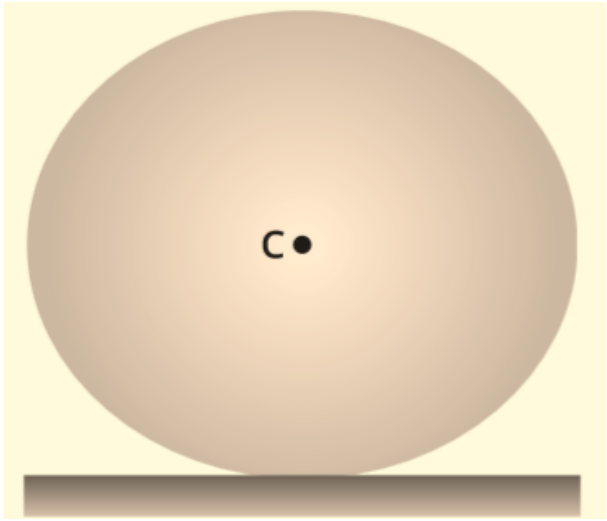
(2 marks)

The two largest male lions at Perth's zoo, Nelson and Mandela, have an approximate weight of 1764 N each. Calculate their individual approximate mass. Include the correct units in your answer.

Q12

(3 marks)

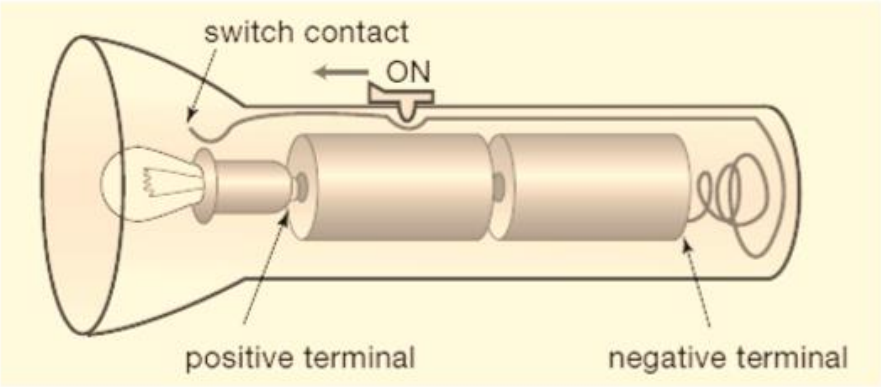
Below is a ball that is in the process of bouncing. Its centre is marked with the letter C. It has been dropped from a certain height, made contact with the floor and is slowing down. The velocity is still downwards. However, the ball has deformed sufficiently such that the acceleration, *a*, is now upwards. Draw labelled vector arrows of the appropriate length on the diagram to show clearly the forces acting on the ball.



Q13

(2 marks)

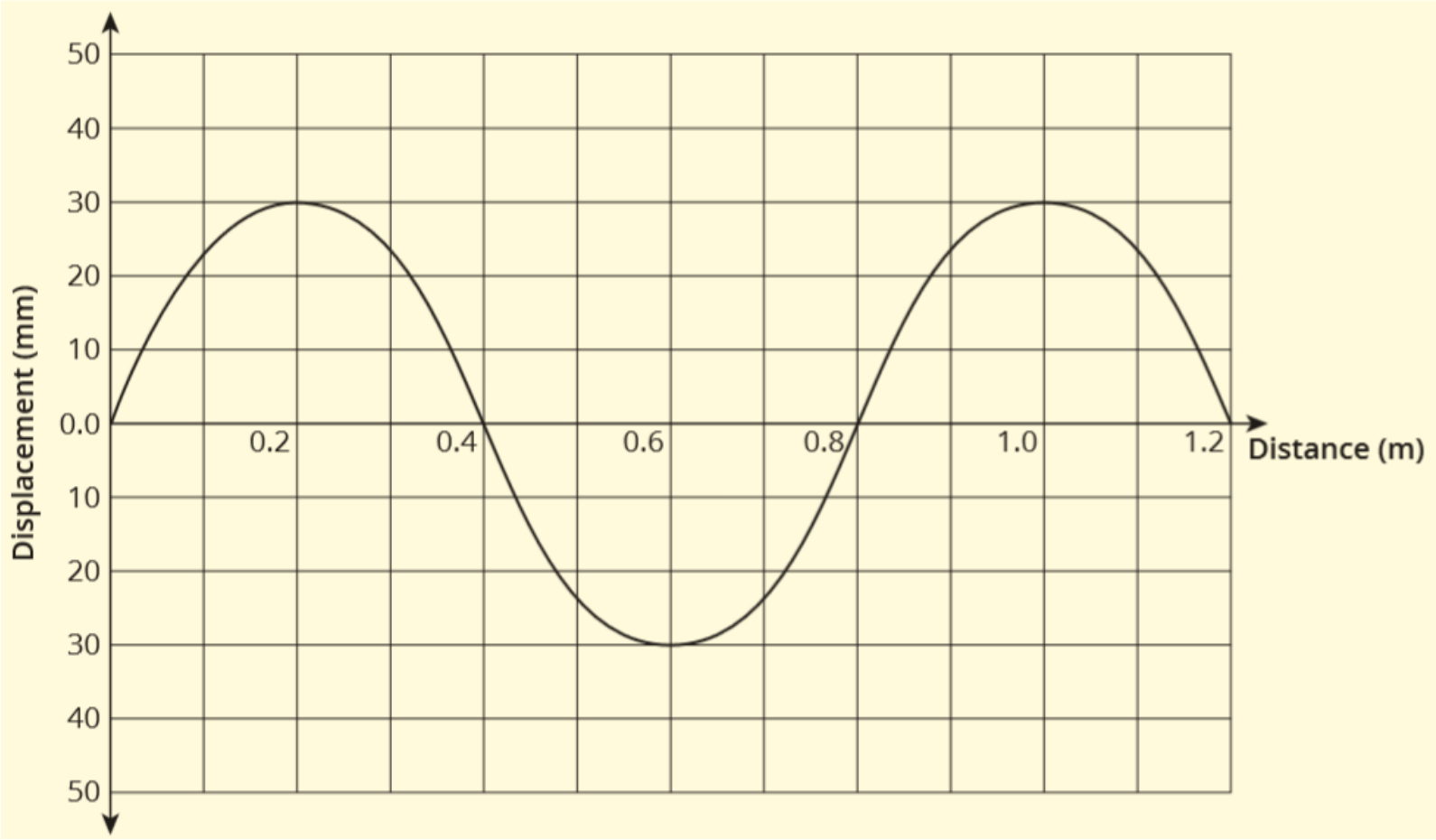
A typical torch, shown in the diagram, uses two 1.50 V batteries in series and is rated 0.900 W. Calculate its resistance.



Q14

(8 marks)

A student sets up a ripple tank and uses data-logging equipment to produce the graph shown below.



Q14 continued

a What is the amplitude of the wave? (1 mark)

b What is its wavelength? (1 mark)

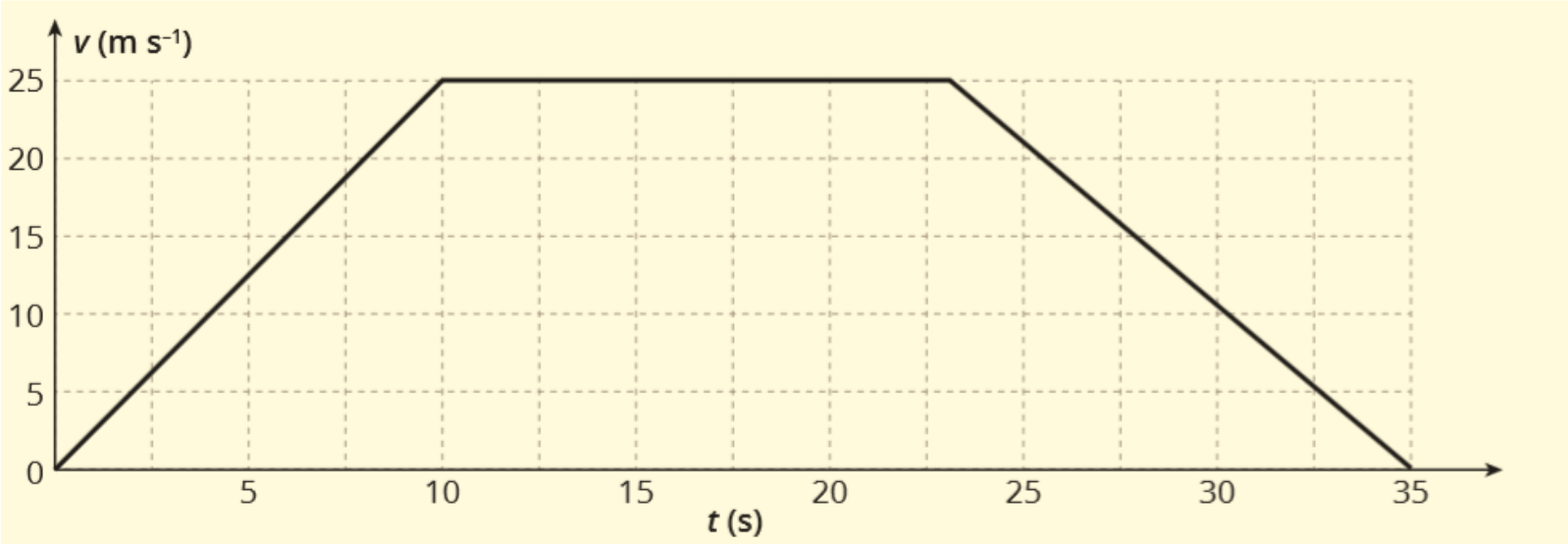
c The speed of the wave is 1.5 m s^{-1}. What is the period of this wave? (2 marks)

d Explain the difference between a transverse and longitudinal wave, and give an example of each. (4 marks)

Q15

Question 15 **(12 marks)**

A driver accelerates uniformly away from a set of traffic lights in her 1200 kg car. The velocity versus time graph for this motion is shown below:



a What is the initial acceleration of the car? Give appropriate units with your answer. (3 marks)

b What is the total distance travelled, in metres, in the 35 s? (3 marks)

Q15 continued

c What is the net force acting on the car at time t = 30 s? (3 marks)

d What is the net force acting on the car at time t = 20 s? Explain your answer. (3 marks)

Q16

- A lion with a mass of 155kg begins to accelerate as a zebra runs by at its top speed of 20 m s−1. The lion reaches its top speed of 30 m s−1 after accelerating constantly for 5 s. The lion maintains this speed until it catches the zebra. Draw a graph and calculate the following:

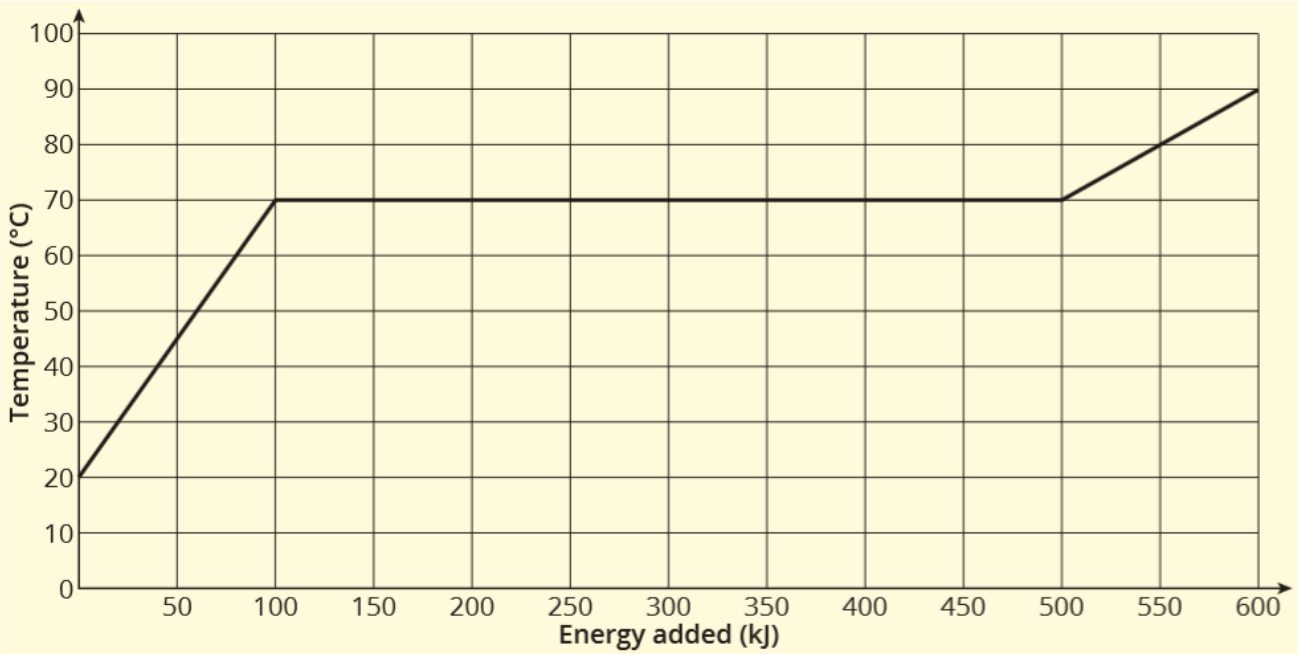
a How long does it take the lion to catch the zebra? (3 marks)

b What distance has the zebra travelled before the lion catches up? (2 marks)

Q17

(9 marks)

The graph below shows the curve for a 2.0 kg sample of material that begins as a solid at room temperature and finishes as a hot liquid. Energy is added at a constant rate.



a What is the temperature at which the substance melts? (1 mark)

b What is the specific heat capacity of the material in its solid form? (3 marks)

Q17 continued

c What is the specific latent heat of fusion of the material? (2 marks)

d Explain why the temperature remained constant for a while during one stage of the heating process. (3 marks)

Q18

Question 18 **(9 marks)**

There are four naturally occurring stable isotopes of strontium. Many unstable isotopes of strontium are known to exist, the longest-lived of which is strontium-90 which decays through beta emission and has a half-life of 29 years.

a Explain what is meant by the term 'isotope'. (2 marks)

b Write a beta decay equation for strontium-90. (2 marks)

Q18 continued

The 1986 Chernobyl nuclear accident contaminated a vast area with strontium-93, $^{93}_{38}Sr$. Beta radiation is dangerous to the human body, as it is ionising radiation.

c Explain what is meant by the term 'ionising radiation'. Why would the main concern regarding strontium-90 (beta decay) be the inhalation or ingestion of this isotope, rather than external exposure. (2 marks)

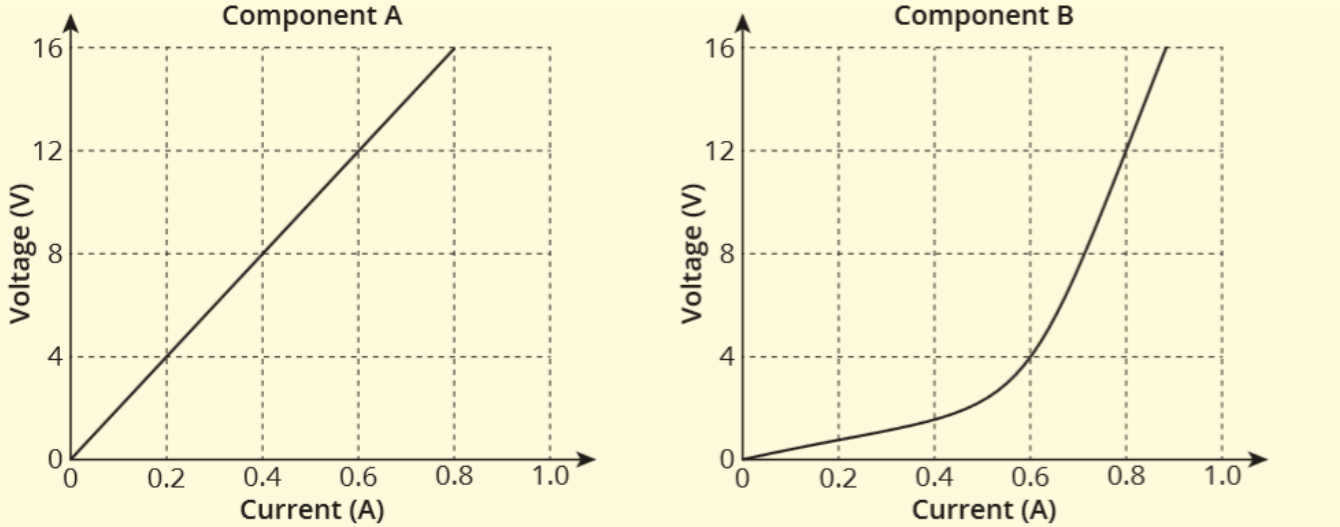
d Another radioisotope of strontium, strontium-89, is an artificial radioisotope that is used in the treatment of bone cancers. Typically, cancer treatments will be treated with a dose of 150 MBq. Pellets of this isotope are embedded near the tumour. Strontium-89 has an approximate half-life of 50.5 days. A particular patient feels relief from such a dose for 202 days. Calculate the activity of this dose after 202 days. (2 marks)

e Why is radioactive decay often referred to as a random process? (1 mark)

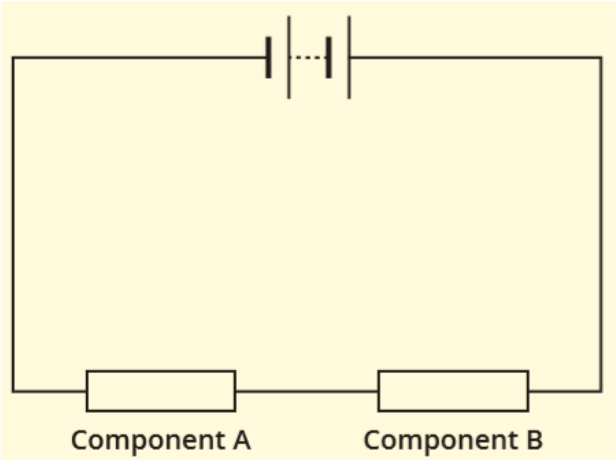
Q19

Question 19 **(7 marks)**

The two graphs below show current–voltage characteristics for two circuit components, A and B.



a Which of the components (A, B or neither) is ohmic? (1 mark)



Q19 continued

The potential difference across component A is measured to be 12 V.

b Determine the current through component A. Include units in your answer. (3 marks)

c Find the voltage supplied by the battery. (3 marks)

Q20

- 3 L of water is heated from a fridge temperature of 4°C to its boiling point at 100°C. It is boiled at this temperature until it is completely evaporated. How much energy in total is required to raise the temperature and boil the water?
-

Q21

(7 marks)

A 150 g ice puck collides head on with a 100 g ice puck, initially stationary, on a smooth, frictionless surface. The initial speed of the 150 g puck is 2 m s^{-1}. After the collision, the 150 g ice puck moves off at 0.5 m s^{-1} in the same direction as its initial direction of motion.

a What is the velocity of the 100 g puck after the collision? (2 marks)

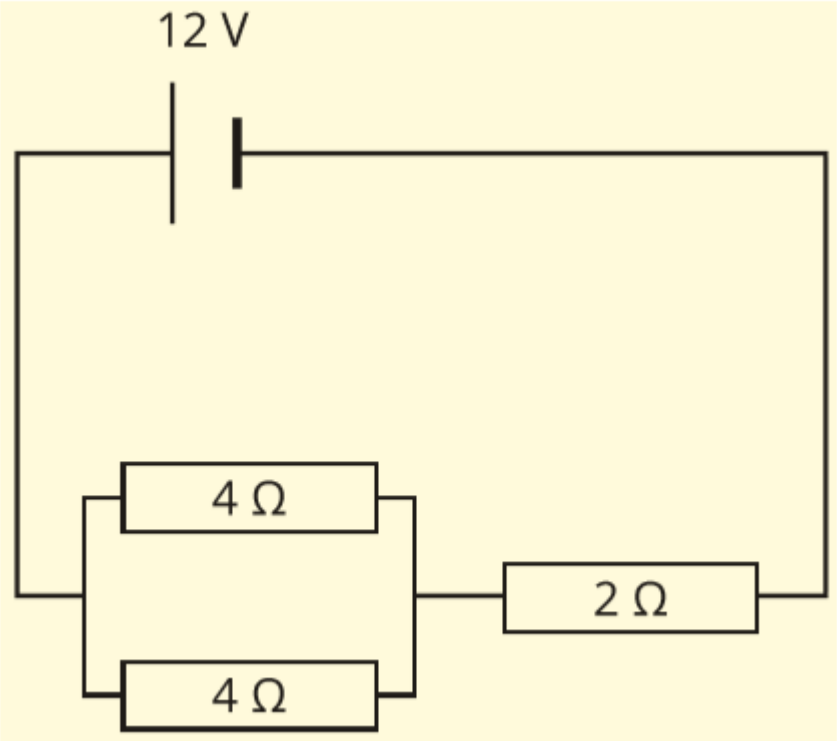
b Is this collision elastic or inelastic? Use calculations to justify your answer. (5 marks)

Q22

(10 marks)

Two resistors of 4 Ω are connected in parallel, and are then connected in series with a 2 Ω resistor. The voltage supplied to this circuit is 12 V.

a Draw the circuit. (3 marks)



Q22 continued

b Calculate the total resistance of the circuit. (3 marks)

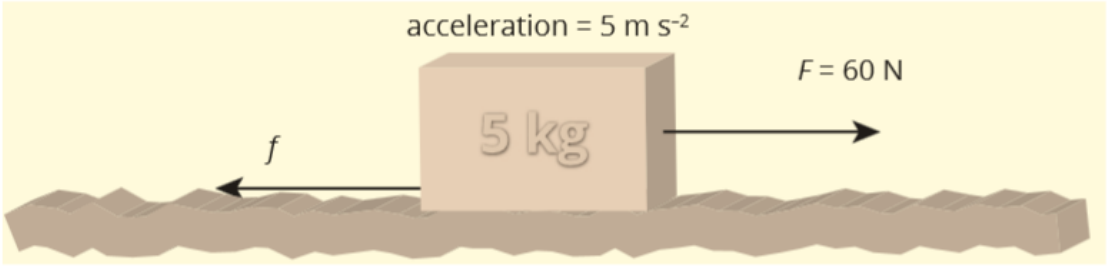
c Calculate the current flowing through the 2 Ω resistor. (2 marks)

d Calculate the power dissipated by the 2 Ω resistor. (2 marks)

Q23

Question 23 **(14 marks)**

The diagram below shows a 5.0 kg object accelerating at 5 m s^{-2} on a rough horizontal surface.



a What is the net force acting on the 5 kg mass? (2 marks)

b What is the magnitude of the force of friction, f? Include units in your answer. (3 marks)

c The 5 kg mass accelerates from rest for 2 s. How far did the 5 kg mass travel? (3 marks)

Q23 continued

d What is the work done by the applied force on the mass? Include units in your answer. (3 marks)

e How much energy has been dissipated as heat during this time? Include units in your answer. (3 marks)

Q24

- The Smoke Energy pop band were studying resonance in an air column using a narrow tube of length 40 cm that was closed at one end and open at the other, as shown in the diagram. They used an audio signal generator and loudspeaker to generate a range of sound frequencies.

- The group begin at 0 Hz and increase the frequency until the first resonant frequency (fundamental frequency) is identified. Take the speed of sound to be 340 m s−1.

a What is the first resonant frequency (fundamental frequency)? (4 marks)

Q24 continued

b What is the next resonant frequency? (2 marks)

c How will the students know they have identified a resonant frequency? (2 marks)

Q25

(13 marks)

Technetium-99m is the most widely used radioisotope in nuclear medicines. It is used for diagnosing cancer. However, this radioisotope decays relatively quickly and so usually needs to be produced close to where it is to be used. Technetium-99m is produced in small nuclear generators near hospitals around the country. In this process, the radioisotope molybdenum-99, obtained from Lucas Heights in NSW, is used as the parent nuclide, and is transported quickly and efficiently to the smaller generators near the hospital. Molydenum-99 decays by beta emission to form a relatively stable (or metastable) isotope of technetium, technetium-99m. The half-life of technetium-99m is approximately 6 hours; molydenum-99 has a half-life of approximately 67 hours.

The technetium-99m is flushed from the generator using a saline solution. The radioisotope is then diluted and attached to an appropriate chemical before being administered to the patient as a tracer. Technetium-99m is purely a gamma emitter. This makes it a very useful tool for locating and treating cancers.

a Write the decay equation for molybedum-99 decaying to technetium-99m. (2 marks)

b Write the decay for technetium-99m decaying to technetium-99. (2 marks)

Q25 continued

c State an advantage of choosing radioactive isotopes with a short half-life for medical purposes. (2 marks)

d Why must a much higher amount of molydenum-99 leave the manufacturing point at Lucas Heights in NSW than is needed by the hospitals? (2 marks)

e When using technetium-99m for diagnostic purposes information is monitored and collected by special radiation cameras outside the patient. Explain why technetium-99m is suitable for this purpose. (2 marks)

f A patient is administered 500 MBq of technetium-99m. Determine the activity of this isotope in the patient after 24 hours. (3 marks)

Q26

(10 marks)

A popular misconception among motorists is that cars would be much safer if they were sturdier and more rigid. Drivers often complain that cars seem to collapse too easily during collisions, and it would be better if cars were structurally stronger—more like an army tank. In fact, cars are specifically designed to crumple to some extent. This makes them safer and actually reduces the seriousness of injuries suffered in car accidents.

Army tanks are designed to be extremely sturdy and rigid vehicles. They are able to withstand the effects of collisions without suffering serious structural damage. If a tank travelling at 50 km h^{-1} crashed into a solid obstacle, the tank would be relatively undamaged. However, its occupants would most likely be killed. This is because the tank has no 'give' in its structure and so the tank and its occupants would stop in an extremely short time interval. The occupants would lose all of their momentum in an instant, which means all the forces acting on them would be extremely large. The occupants would sustain serious injuries even if they were wearing seat belts.

Cars today have strong rigid passenger compartments; however, they are also designed with non-rigid sections such as bonnets and boots that crumple if the cars are struck from the front or the rear. The chassis contains members that have grooves or beads cast into them. In a collision, these beads act as weak points in the members, causing them to crumple in a concertina shape.

This concertina effect allows the front or rear of the car to crumple, extending the time interval over which the car and its occupants come to a stop. Because the occupants' momentum is lost more gradually, the maximum forces that act on the occupants are smaller and so the chances of injury are reduced.

a With respect to the relationship $\Delta p = F\Delta t$ explain how crumple zones reduce the force on an occupant of a car in a collision. (2 marks)

Q26 continued

If an 80 kg crash test dummy was travelling at 50 km h^{-1} in an army tank that crashed, it would come to rest in 0.01 s, while the same crash test dummy would come to rest in 0.1 s if it was travelling in a car with a crumple zone that crashed.

b Covert 50 km h^{-1} into m s^{-1}. (1 mark)

c In which situation did the crash test dummy experience the greater change in momentum? Use calculations to support your answer. (3 marks)

d In which situation did the crash test dummy experience a greater stopping force? Use calculations to support your answer. (4 marks)

Q27

Question 27 **(13 marks)**

The flute is a typical example of a pipe open at both ends where an air column can be made to vibrate. Blowing over the hole of a flute produces vibrations that correspond to a range of frequencies that create sound waves in the tube. The natural vibrations of the air in the flute are due to resonance. When a note is played on a flute, vibrations, or waves, travel back and forth and standing waves are produced. Several harmonically related standing waves are possible. The first pattern has the longest wavelength and is called the first harmonic or the fundamental frequency. Other harmonics are possible, including the second, third, fourth and so on. Different harmonics can be emphasised depending on how the flute is blown. Placing fingers over the holes in the flute, in differing combinations, changes the effective length of the tube.

A particular flute has an effective length of 30 cm. Take the speed of sound to be 340 m s^{-1}.

a Calculate the fundamental frequency of the flute. (2 marks)

b Calculate the frequency of the next three possible harmonics for this flute. (3 marks)

Q27 continued

c Explain how standing waves are produced. (3 marks)

d At the open ends of the flute, will there be pressure antinodes or pressure nodes? Explain how these are formed at the open end of the pipe. (3 marks)

e The length of the flute cannot be changed. Name two different ways in which different sounds can be produced by the flautist. (2 marks)