Section One: Short answer **40% (64 Marks)**

This section has **17** questions. Answer **all** questions. Write your answers in the space provided.
Suggested working time for this section is 60 minutes.

Question 1

Write balanced nuclear equations for the following decays.

a. Potassium-42 by beta negative decay.

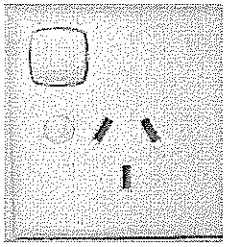
(2)

b. Polonium-210 by alpha decay.

(2)

Question 2

If a switch is placed on the neutral wire rather than the active wire in a household electrical circuit the switch is still able to turn devices on and off. However, a switch is placed on the neutral wire is potentially hazardous. Explain why.

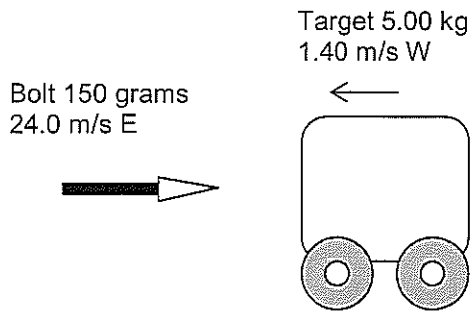


(3)

SEE NEXT PAGE

Question 3

A steel bolt of mass 150 g is fired from a crossbow at a rolling wooden target that is moving toward the crossbow. The crossbow bolt is moving at 24.0 m s^{-1} East. The rolling target has a mass of 5.00 kg and is moving at 1.40 m s^{-1} West. On impact the crossbow bolt becomes embedded into the target. Calculate the velocity of the target and embedded bolt after the collision.



(3)

Question 4

Explain the concept of electrical current and also explain how an electrical current is established.

(3)

Question 5

A rocket of mass 10 tonnes (including fuel) is in deep space where the effects of gravity from any other objects can be ignored. When it starts to burn fuel there is a constant thrust force from its engines. *Refer to Newton's laws of motion in your answers to this question.*

a) Explain how the burning of fuel to make exhaust gas exit from the back of the jet cones can accelerate the rocket forwards.

(2)

b) Explain what happens to the magnitude of acceleration as the rocket is burning fuel.

(2)

c) The rocket burns 2 tonnes of fuel to accelerate to 1500 m s^{-1} over a distance of 100 km. How much fuel would be needed to continue forwards at a constant velocity of 1500 m s^{-1} for a distance of 2,000 km? Explain briefly.(no calculation required)

(2)

Question 6

Explain the process of heat transfer by convection with reference to kinetic molecular theory.

(3)

SEE NEXT PAGE

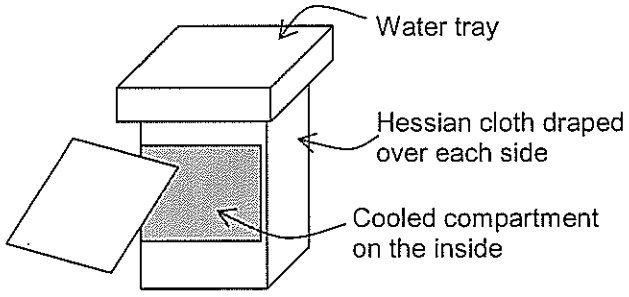
Question 7

Polonium-210 is a radioactive isotope that decays by alpha emission. It is present in tobacco smoke. Explain why this presents risks to someone inhaling smoke from a cigarette and compare it with the risks to somebody handling packets of cigarettes in a supermarket.

(3)

Question 8

The Coolgardie Safe was a simple refrigerator used in Australia up until the 1950s. The Coolgardie Safe was made of wire mesh on a wooden frame with an iron tray on top filled with water. Hessian cloth was hung over every side with the top end of the cloth placed in the water tray. The Hessian cloth would soak up water and become wet all over. It was placed on a verandah so that the breeze would blow across the cloth and evaporate the water. This had the effect of cooling food stored inside the safe.



a) Briefly explain how the Coolgardie Safe can keep food cool?

(2)

b) Explain how the effectiveness of the Coolgardie Safe would change in humid conditions.

(1)

c) State one factor that could be changed to increase the rate of cooling in the safe.

(1)

SEE NEXT PAGE

Question 9

Four 1.50 V, AA batteries connected in series are used to power an mp3 player. The mp3 player has a resistance of 200 Ω. Calculate how much electrical potential energy is transformed whilst listening to a 3½ minute song on the mp3 player.

(3)

Question 10

A 428 g block of stainless steel is heated in a flame and placed into 1.20 L of water at 18°C. The final temperature of the steel and water mixture was 37°C when they reached thermal equilibrium in a fully insulated container. (density of water 1 g cm^{-3})

a. Calculate how much energy was transferred from the stainless steel block to the water.

(2)

b. Calculate the initial temperature of the stainless steel block. The specific heat capacity of stainless steel is 4.45×10^2 J Kg^{-1} K^{-1}.

(2)

Question 11

Give an example of how a house in Western Australia can be insulated from heat transfer into the house by radiation. As part of your answer you must explain the physics principles involved.

(3)

Question 12

Workers at the Fukushima Daiichi nuclear power plant have recovered a case of radioactive waste. They measured its activity from a set distance to be 242 Bq. The average half-life of the waste is 5.40×10^4 years. Calculate how much time it will take for the waste to have an activity of 8.00 Bq.

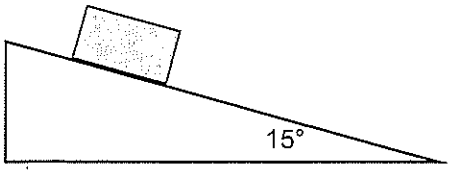
(4)

SEE NEXT PAGE

Question 13

A brick of mass 3 kg is at rest on an inclined plane which has a rough surface. The incline makes an angle of 15° with the horizontal.

Vector diagram:



a. Identify the 3 forces acting on the brick by placing arrows on the diagram and labelling them to make a free body diagram.

(1)

b. Transfer the forces to the space on the right to construct a vector diagram for this situation. You must show relevant angles and label your forces.

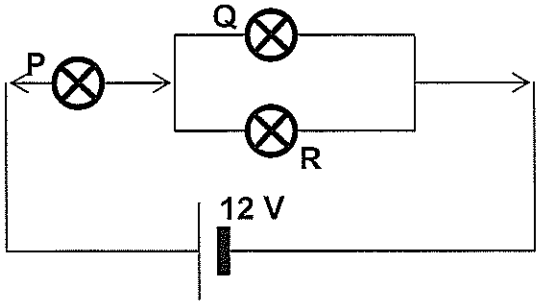
(1)

c. Calculate the force of friction acting to keep the brick in equilibrium on the plane.

(2)

Question 14

The diagram shows 3 electric light globes P, Q and R connected in a circuit.



a. Show, by sketching on the diagram, where you would connect a voltmeter to measure the potential difference for globe P.

(1)

b. Show, by sketching on the diagram, where you would connect an ammeter to measure the current in globe R.

(1)

c. Indicate on the diagram which part of the dry cell is positive and which part is negative.

(1)

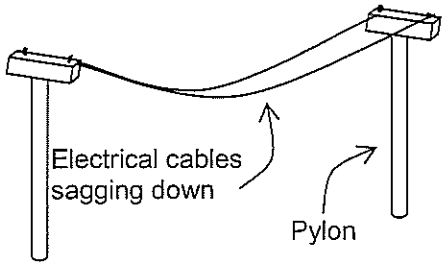
d. Indicate the direction of conventional current in this circuit with an arrow and label it 'conventional current'.

(1)

SEE NEXT PAGE

Question 15

When electrical power lines are constructed, the metal cables between each pylon have sufficient length to allow the cables to sag down somewhat. Explain why the power lines are designed in this way.



(3)

Question 16

When a uranium-235 nucleus absorbs a thermal neutron it can undergo fission. One reaction results in the formation of Antimony-133 (Sb), Niobium-98 (Nb) and neutrons.

a) Write the equation for this reaction and clearly identify the number of neutrons produced.

(2)

b) The total number of protons and neutrons is balanced on either side of the equation. Explain then why there is a mass difference between each side.

(2)

SEE NEXT PAGE

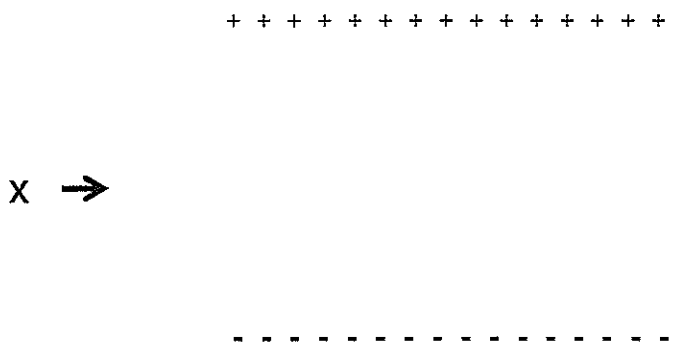
Question 17

A uniform electric field exists between the two charged parallel plates shown below. Three particles (alpha, beta and gamma) are moving right through location X and then enter the uniform field.

a. Sketch the approximate paths of the α, β and γ particles as they enter the electric field showing the relative degree of curvature for each particle and clearly label each path.

(2)

Particle	Relative Speed
α	0.1 c
β	0.9 c
γ	c



b. Explain the curvature of your paths relative to each other, with reference to the momentum and charge of each particle.

(3)

c. Circle the best response. The direction of the electric field between the two parallel plates is:

Up Down Left Right Into Page Out of Page

(1)

End of Section One

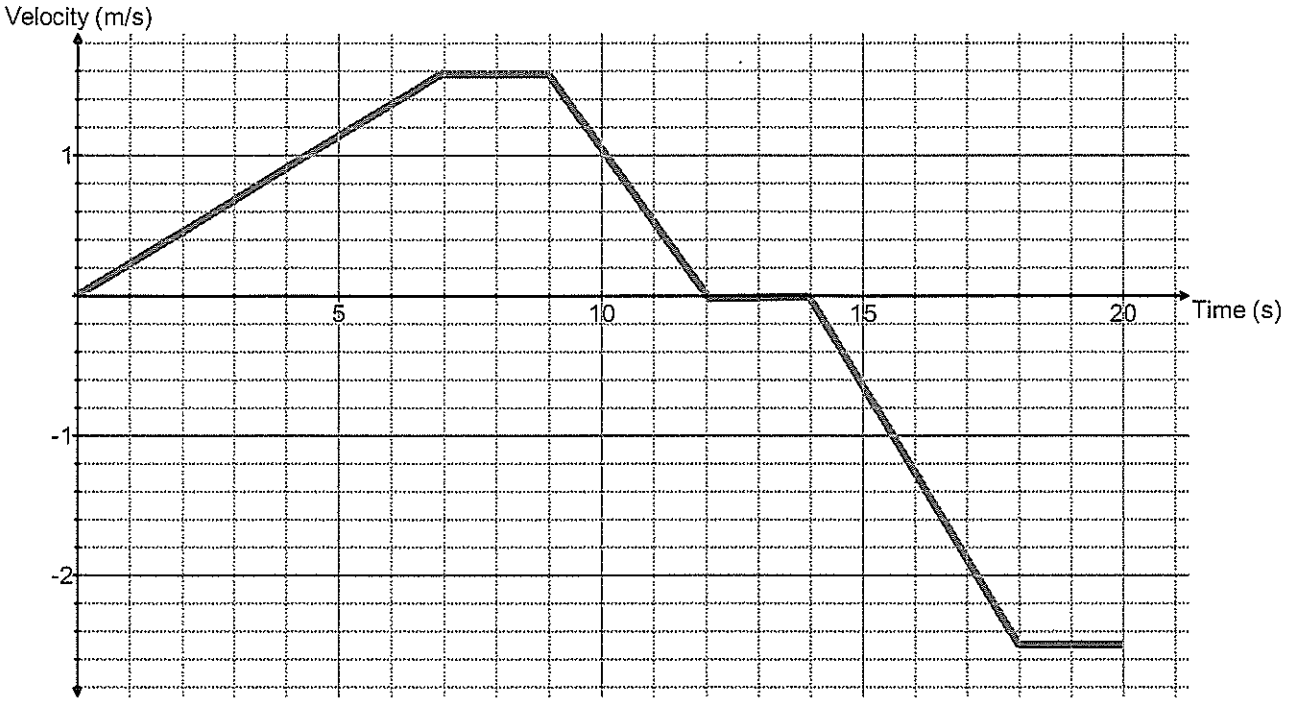
SEE NEXT PAGE

Section Two: Problem-solving 50% (80 Marks)

This section has **seven (7)** questions. Answer **all** questions. Write your answers in the space provided. **Suggested working time for this section is 75 minutes.**

Question 18 [11 marks]

The graph shows the velocity of a toy car over a 20 second period. The car can only move back and forth along a straight line. East of the start point is considered positive.



a) From the graph, determine the velocity of the car after 3 seconds of travel.

(1)

b) For how many seconds was the car stationary?

(1)

c) At a time of 10 seconds, explain whether the car was moving towards or away from the initial position.

(2)

SEE NEXT PAGE

d) Between which two times was the magnitude of acceleration the greatest?

(1)

e) From your graph, determine the acceleration at 16 seconds.

(2)

Answer_____

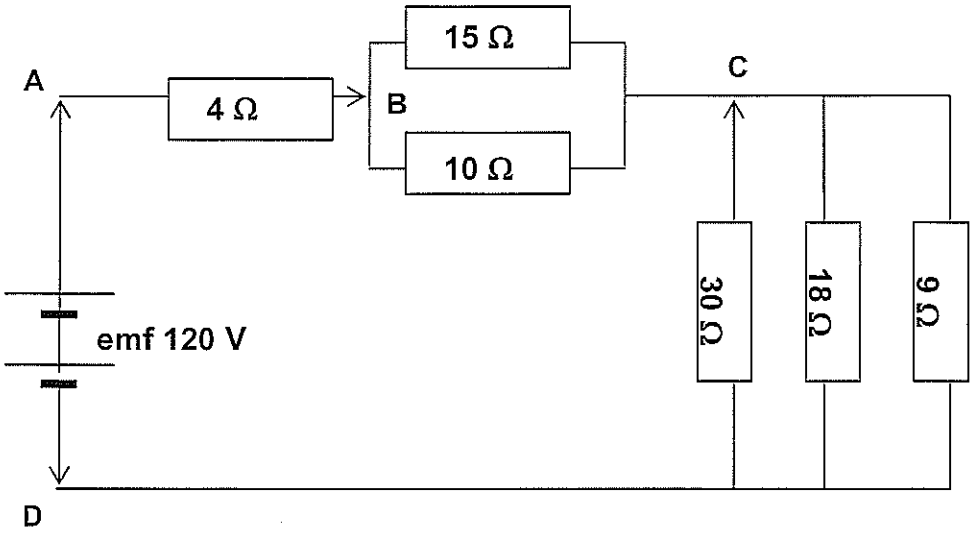
f) Determine the displacement of the car after 20 seconds.

(4)

Answer_____

Question 19 [12 marks]

A complex circuit diagram is shown below.



a) Calculate the effective resistance of the circuit between points A and D. (3)

b) Calculate the current through the 4.00 Ω resistor. (2)

SEE NEXT PAGE

c) Calculate the potential difference across the 30.0 Ω resistor.

(3)

d) Calculate the current flowing through the 18.0 Ω resistor.

(2)

e) Calculate the power of the 9.00 Ω resistor.

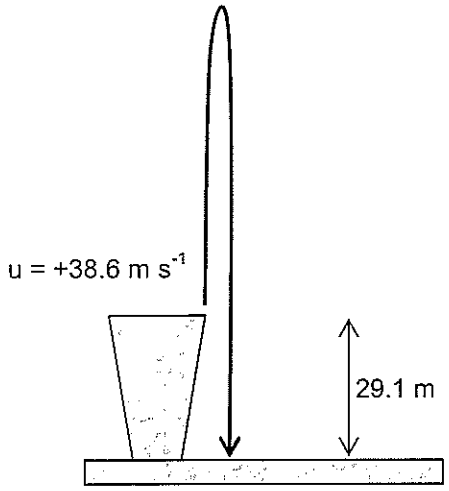
(2)

SEE NEXT PAGE

Question 20 [12 marks]

A hunter leans over the edge of a cliff and fires a crossbow bolt vertically upwards with an initial velocity of 38.6 m s^{-1}.

The bottom of the cliff is 29.1 m below the point where the bolt left the crossbow.



a) Calculate the maximum height reached by the bolt above the launch height of the hunter. (3)

b) Determine the acceleration of the bolt at its maximum height. (1)

c) Calculate the velocity of the bolt 5.00 seconds after leaving the crossbow.

(2)

d) Calculate the total time the bolt was in flight from leaving the crossbow to arriving at the bottom of the cliff.

(4)

e) Calculate the average velocity of the bolt from leaving the crossbow to arriving at the bottom of the cliff.

(2)

SEE NEXT PAGE

Question 21 [10 marks]

The Carbon-Nitrogen-Oxygen cycle is a complex set of fusion reactions by which stars convert hydrogen to helium. One of these reactions is shown below

$$^{14}_{7}N + ^{1}_{1}p \rightarrow ^{15}_{8}O + \gamma$$

a. Use the data in the table below to calculate the energy (in MeV) released in this reaction

Particle	Nitrogen-14	Proton	Oxygen-15
Mass (u)	13.999234	1.00728	14.998677

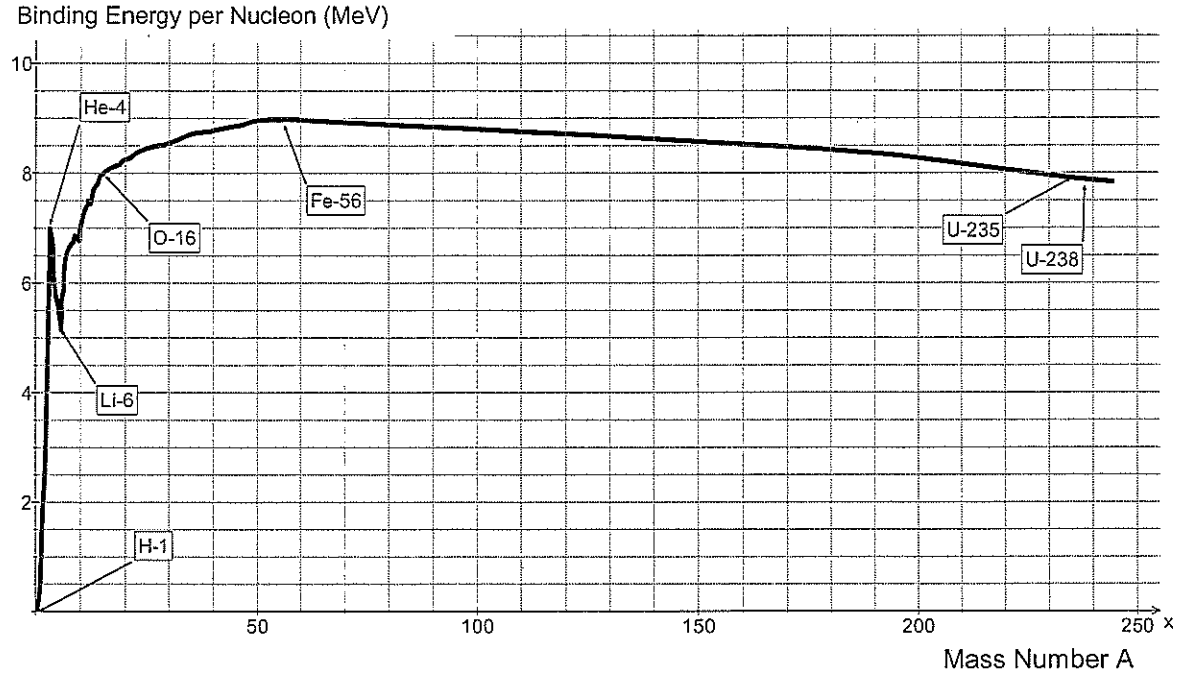
(3)

b. Mass is converted to energy in nuclear reactions. In what form could this energy be. Describe two examples.

(2)

SEE NEXT PAGE

The graph below shows the binding energy per nucleon versus mass number for the nuclei of some common isotopes.



c. What is binding energy essentially a measure of in the context of nuclear physics?

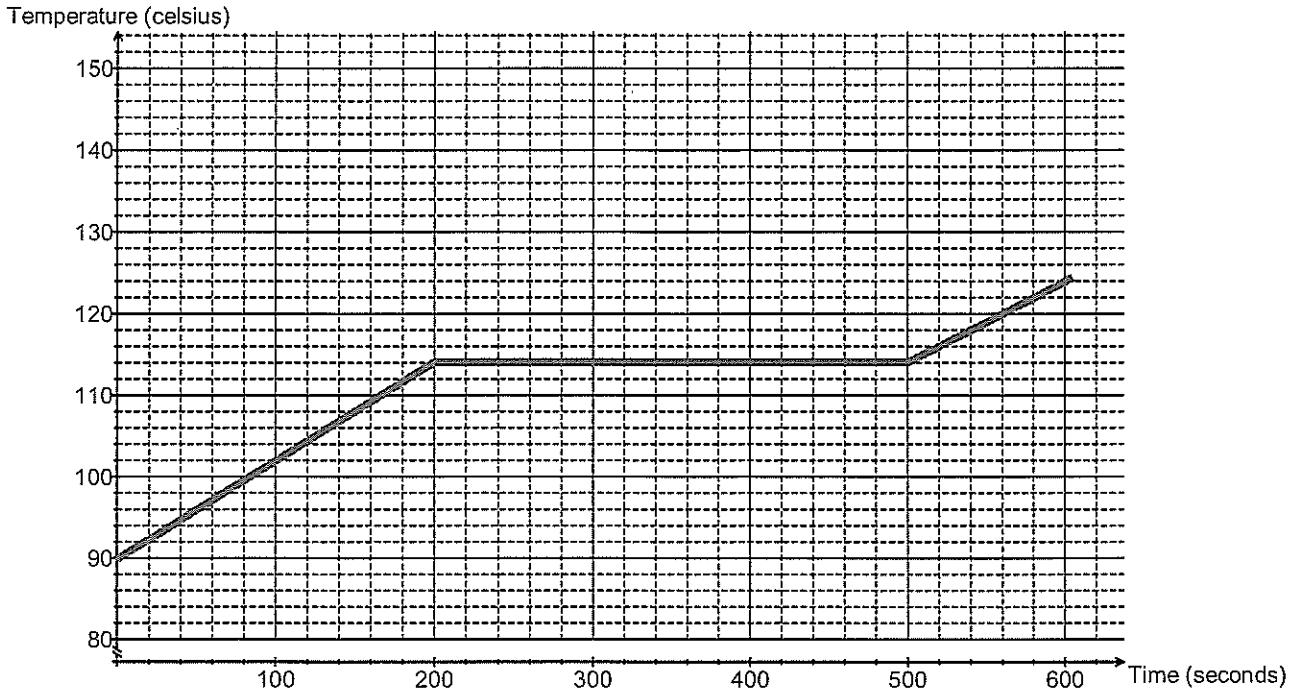
(2)

d. The oxygen-16 nucleus has a mass of 15.990526 u, a proton has a mass of 1.00728 u and a neutron has a mass of 1.00867 u. Calculate the average binding energy per nucleon for the oxygen-16 nucleus in MeV. (The above graph allows you to verify your answer).

(3)

Question 22 [9 marks]

Some students are investigating the latent heat of fusion for sulphur. They place a 50.0 g sample of solid sulphur into a crucible in a fume cupboard and record the temperature of the sample for a period of 600 seconds whilst the energy input to the sulphur is fixed at 6.50 J per second. A graph of the results is shown below.



a. Referring to Kinetic Molecular Theory, explain why the temperature of the sulphur stayed constant in the middle section of the graph even though its internal energy was increasing.

(3)

b. In terms of Kinetic Molecular Theory explain the difference between heat and temperature.

(2)

c. Determine the melting point of sulphur from the graph.

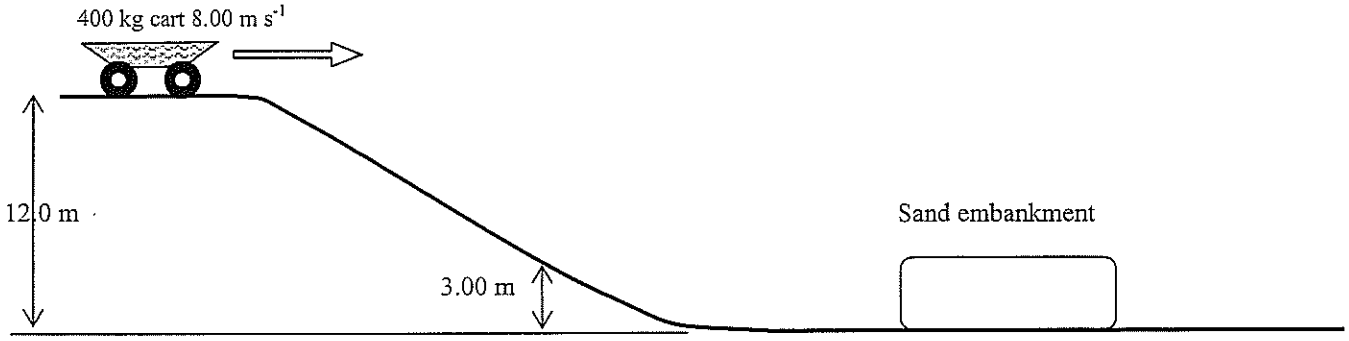
(1)

d. Determine the latent heat of fusion of sulphur.

(3)

Question 23 [11 marks]

A cart of mass 400 kg is travelling at 8.00 m s^{-1} at the top of an inclined plane 12.0 m above ground level. It rolls down the inclined plane and is stopped by colliding with a sand embankment.



a. With reference to the principal of conservation of mechanical energy, calculate the speed of the cart when it is at a height of 3.00 m above ground level on the inclined plane.

(3)

b. When the cart arrives at the sand embankment it has a velocity of 17.3 m s^{-1} right. It collides with the sand embankment and is brought to rest by an average force of 27 680 N left. Calculate the time taken to bring the cart to rest.

(2)

c. Determine the distance travelled by the cart during the collision with sand embankment.

(2)

d. If the cart was required to be stopped in a shorter distance explain any changes in the force acting on the cart.

(2)

e. Explain any two possible energy transformations that occur during the collision.

(2)

Question 24 [15 marks]

Determining the Specific Heat Capacity of Mercury.

A group of physics students are conducting an experiment to determine the **specific heat capacity** of the mercury (Hg).

- 275 g of mercury is placed in an insulated heating vessel at an initial temperature of 22.0 °C.
- Heat energy is delivered to the vessel by an electrical heating element in its base
- The students control the energy delivered to the vessel and record the temperature of the mercury as the energy input increases:

Energy (J)	200	400	600	800	1000	1200	1400	1600
Temperature (°C)	27	30	37	41	45	52	56	58
ΔT (°C)	+5							

Answer the following questions:

a) Complete the table by filling in the row for ΔT. (The first value has been done for you).

(1)

b) From the starting point of an equation on your data sheet, show algebraic steps to derive the following expression which shows the relationship between the variables in a

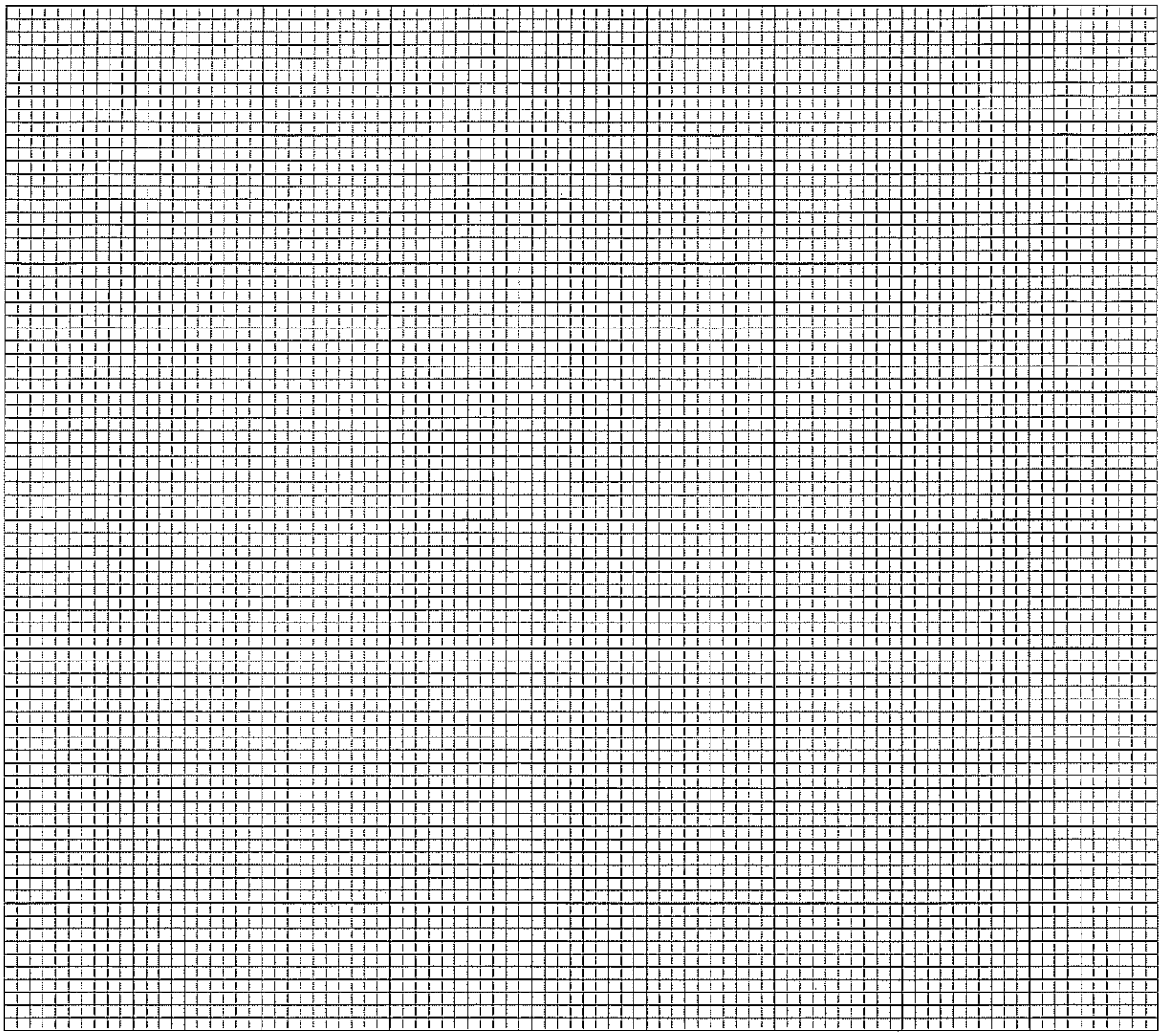
y = m.x format where the gradient of the line of best fit is an average value of $\frac{1}{m.c}$

$$\Delta T = \frac{1}{m.c}.Q$$

ΔT = change in temperature (K or °C)
m = mass of mercury (kg)
c = specific heat capacity of mercury
Q = energy (J)

(2)

SEE NEXT PAGE



c) Plot a graph of Change in Temperature (ΔT) on the y-axis versus Energy (J) on the x-axis on the graph paper above and put a line of best fit onto your graph. Ensure that the graph is correctly labelled.

(4)

SEE NEXT PAGE

d) Calculate the gradient of your line of best fit. Show your working clearly on the graph.

(3)

e) By using the value of the gradient you calculated from your graph and other data in the question, calculate the specific heat capacity (**c**) of the mercury.

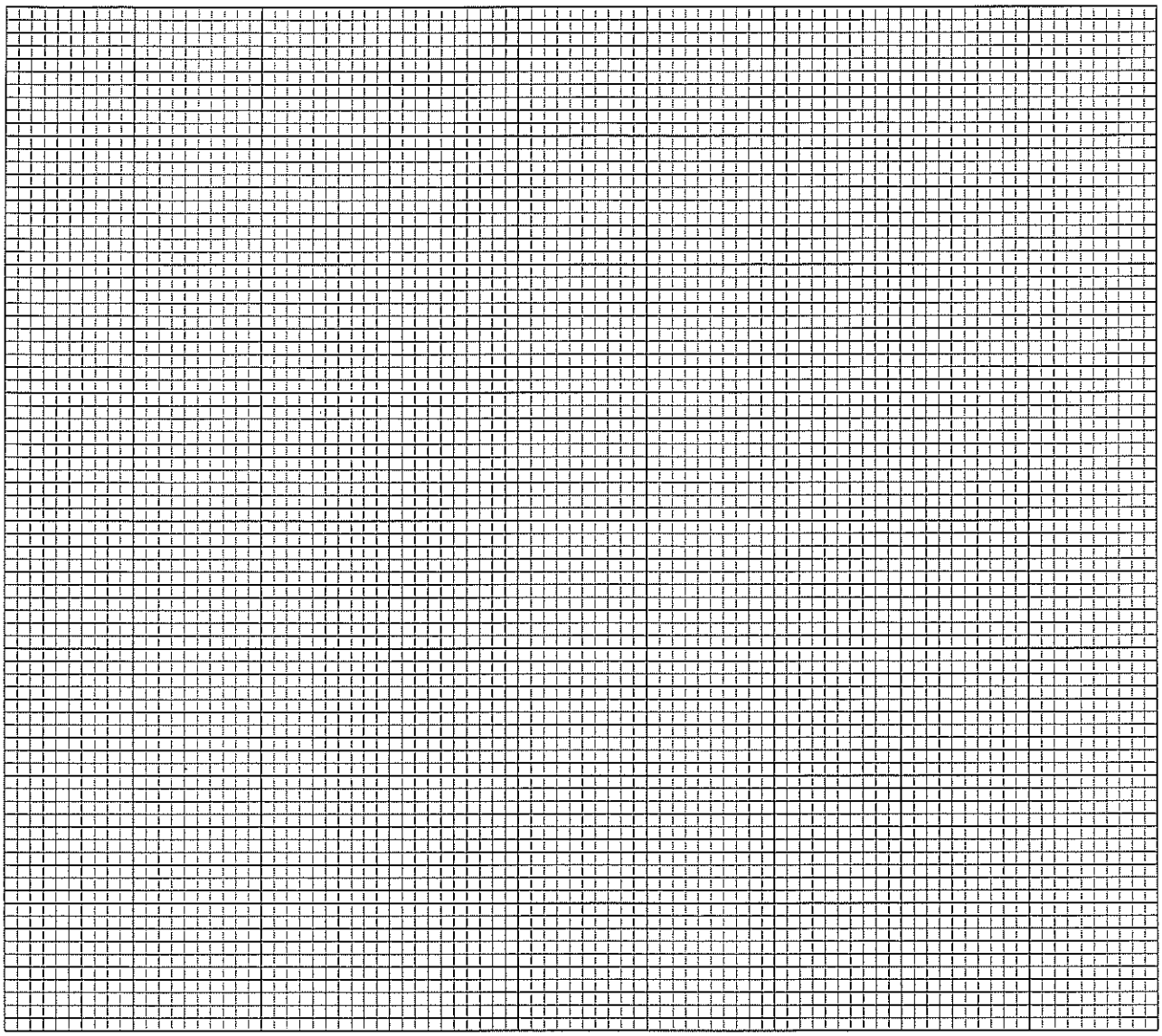
(3)

f) Compare your calculated value with the accepted value of 140 J kg^{-1} K^{-1} and calculate the percentage error of your result. If you were unable to obtain an answer use an experimental result of 156 J kg^{-1} K^{-1}.

(2)

End of section B

Spare Graph Paper



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Section Three: Comprehension 10% (16 Marks)

This section contains **one (1)** question. You must answer this question. Write your answer in the space provided. Suggested working time for this section is 15 minutes.

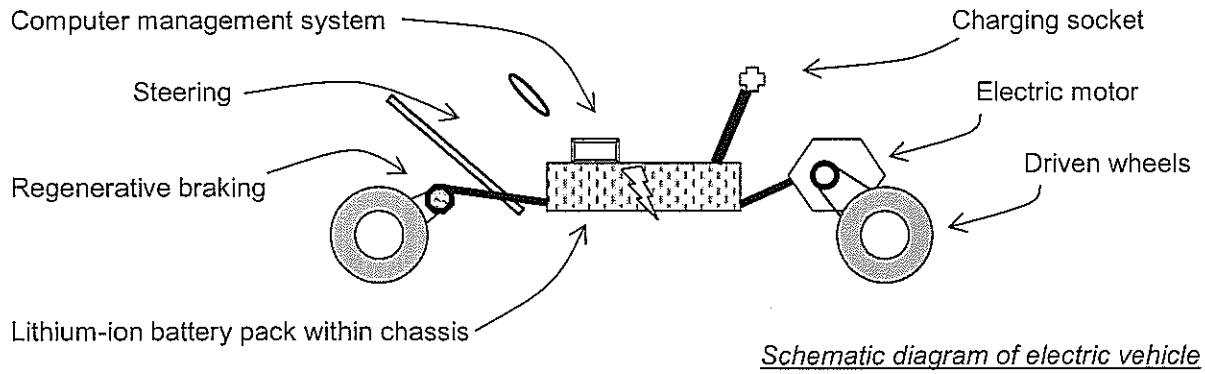
Question 25 **Full Battery Electric Vehicles**

Vehicles powered by the internal combustion engine (ICE) have been in use for over a century. The operating principles of the engine are practically unchanged and they are still very inefficient. Alternative forms of propulsion are now receiving serious consideration.

Earth's finite energy resources are being used unsustainably and urban transport plays a major role in energy wastage and pollution that contributes to climate change. The unremitting increase in oil costs and the dramatic improvement in the performance, price and lifecycle of batteries are making a compelling case for Electric Vehicles.

Hybrid vehicles recently entered the Australian market. They have both a fuel burning engine and an electric motor with a small battery that is recharged by the engine. A full battery Electric Vehicle (EV) has an electric drive system only and is powered by batteries.

The comparatively affordable technology required for Electric Vehicles is ready now. It is a solution that produces zero emissions, has the highest motor-to-wheel efficiency and requires minimal support infrastructure.



Schematic diagram of electric vehicle

The main components of an Electric Vehicle are as follows

Battery - lithium-ion technology as used in mobile telephones and laptop computers which can provide a typical range of up to 300 km.

Electric Motor – drives the wheels with high torque, giving sports car like performance, but with a very low noise level and smooth delivery.

Regenerative Braking System - energy recovered recharges the battery.

Computerised Management System - controls all electrical systems to ensure optimal performance and durability of the battery. Also allows charging to be synchronised with off-peak electricity.

SEE NEXT PAGE

Charging socket – can be connected to a normal 240 V AC household outlet to recharge the battery in typically six to eight hours. Many councils are considering providing charging stations within cities.

Until the production volume of EVs rises significantly they will be more expensive to manufacture compared to similar sized petrol cars. Electric vehicles allow savings of up to 90% on fuel expenses and 50% on maintenance costs which makes them viable when all costs are considered.

A perceived financial risk is the lifetime and expense of the battery so some manufacturers will opt for leasing of the vehicle rather than outright purchase or leasing of the battery pack alone.

The main drawback of an EV over conventional ICE vehicles is the limited range and the time taken to recharge the battery. However, studies have shown that 99% of urban users do less than 150 km per day.

So when used as an urban vehicle that can be charged overnight, drivers should be able to adapt quickly and enjoy the benefits of this mode of transport. The EV may be the car of the future for many Australian families.

Answer the following questions

a. State 4 advantages of an EV over an ICE vehicle.

(2)

b. Why is an EV more suited to urban driving rather than cross-country trips?

(2)

SEE NEXT PAGE

c. Explain why braking is more efficient on an EV compared to a conventional ICE car by describing the energy transformations in each case.

(3)

d. A certain EV has an electric motor with a maximum electrical power rating of 40 kW. Over a 5 minute driving cycle at full power engineers measured 1.02×10^7 J of mechanical energy available at the driven wheels. Calculate the efficiency of the electric motor.

(3)

e. The computer management system controls a component in the vehicle called an inverter. This enables household electricity to be used to charge the battery and is needed because of fundamental difference between the electricity from a household socket and the electricity in a battery. What is this fundamental difference?

(2)

SEE NEXT PAGE

f. A certain lithium-ion battery pack has an energy capacity of 56.1 kW hours. It takes 8 hours to recharge the battery from empty. Calculate the current in the charging socket from a 240 V household supply assuming 100% efficiency and a steady rate of charge.

(1 kW hour = 3.60 MJ)

(3)

g. The cost of electricity from Synergy is 20.8 cents per kilowatt hour. Calculate how much it will cost to recharge the battery with a capacity of 56.1 kW hours.

(1)

End of questions

Additional working space

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