Semester Two Examination 2016
Question/Answer Booklet

PHYSICS
UNITS 1 & 2

Name:________________________________

TIME ALLOWED FOR THIS PAPER
Reading time before commencing work: Ten minutes
Working time for the paper: Three hours

MATERIALS REQUIRED/RECOMMENDED FOR THIS PAPER

To be provided by the supervisor:
- This Question/Answer Booklet; Formula and Constants sheet

To be provided by the candidate:
- Standard items: pens, pencils, eraser or correction fluid, ruler, highlighter.

- Special items: Calculators satisfying the conditions set by the SCSA for this subject.

IMPORTANT NOTE TO CANDIDATES
No other items may be taken into the examination room. It is **your** responsibility to ensure that you do not have any unauthorised notes or other items of a non-personal nature in the examination room. If you have any unauthorised material with you, hand it to the supervisor **before** reading any further.

Structure of this paper

Section	Number of questions available	Number of questions to be answered	Suggested working time (minutes)	Marks available	Percentage of exam
Section One: Short answer	12	12	50	54	30
Section Two: Extended answer	7	7	90	90	50
Section Three: Comprehension and data analysis	2	2	40	36	20
			Total	180	100

Instructions to candidates

1. The rules for the conduct of Western Australian external examinations are detailed in the *Year 11 Information Handbook 2016.* Sitting this examination implies that you agree to abide by these rules.

2. Write answers in this Question/Answer Booklet.

3. When calculating numerical answers, show your working or reasoning clearly. Give final answers to **three** significant figures and include appropriate units where applicable.

   When estimating numerical answers, show your working or reasoning clearly. Give final answers to a maximum of **two** significant figures and include appropriate units where applicable.

4. You must be careful to confine your responses to the specific questions asked and follow any instructions that are specific to a particular question.

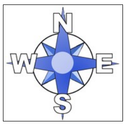
5. Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.
   - Planning: If you use the spare pages for planning, indicate this clearly.
   - Continuing an answer: If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Refer to the question(s) where you are continuing your work.

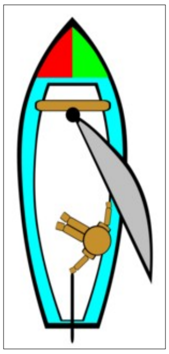
Section One: Short response 30% (54 Marks)

This section has **twelve (12)** questions. Answer **all** questions. Write your answers in the space provided. Suggested working time for this section is 50 minutes.

Question 1 (5 marks)

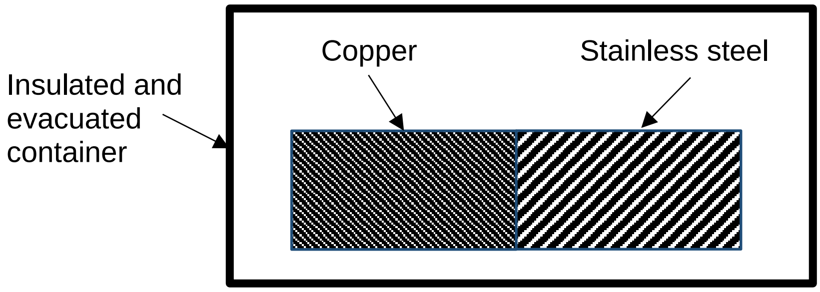
Conall is sailing a boat North at 5.50 m s^{-1} when he enters a current travelling East at 1.50 m s^{-1}. Calculate Conall's resultant velocity once he enters the current. You must state the magnitude and direction of his resultant velocity.





Question 2 **(5 marks)**

A 1.00 kg copper block at 100ºC is placed in thermal contact with a 1.00 kg stainless steel block at 50ºC in an insulated and evacuated container. After several minutes both blocks reach thermal equilibrium.



(a) Use the kinetic particle model to explain how thermal contact between the copper block and the stainless steel block leads to a net heat transfer to the stainless steel block. (3 marks)

(b) Explain why evacuating the container reduces the rate of heat loss from the blocks. (2 marks)

Question 3 **(5 marks)**

An engineer heats a 43.0 kg aluminium engine block in a furnace to a temperature of 350°C. He then plunges the block into 420 kg of water at 21.0°C. Calculate the final temperature of the aluminium and water mixture when they have reached thermal equilibrium. You can assume that the water and aluminium mixture is an isolated system.

The specific heat of aluminium is 900 J kg^{-1} $^{o}C^{-1}$.

Question 4 **(4 marks)**

As shown in the diagram Car 1 is moving to the right at an initial speed 60.0 kmh^{-1}. The car then impacts the rear end of Car 2 which is initially stationary. Both Car 1 and Car 2 have the same mass, 3000 kg. After the collision both cars are effectively joined and move to the right at 30.0 kmh^{-1}.

Determine if the collision is elastic or inelastic.

Question 5 **(5 marks)**

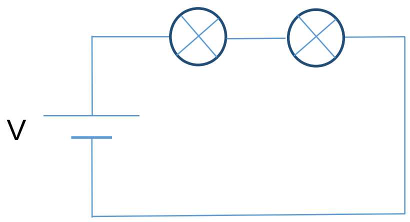
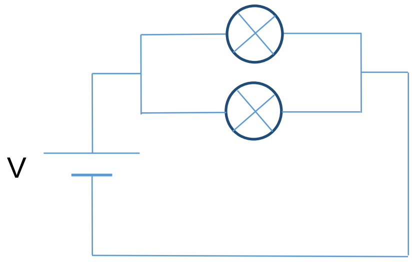
Dolphins use high frequency clicks in the range of 40.0 kHz to 150 kHz for echolocation.

(a) If the speed of sound in water is 1480 m s^{-1}, calculate the wavelength of a 150 kHz click.
(2 marks)

(b) If a stationary dolphin emits a click and it takes 150 ms for the click to return to the dolphin from the sea floor, calculate the distance from the dolphin to the sea floor.
(3 marks)

Question 6 **(6 marks)**

The diagram below shows a series circuit and a parallel circuit which consist of a voltage source and two identical lightbulbs. The effective resistance of each lightbulb is R Ω. The resistance of the wires and the ammeter can be considered negligible.

Series Circuit	Parallel Circuit
	

(a) On the **series circuit** use an arrow to indicate the direction of the conventional current. (1 mark)

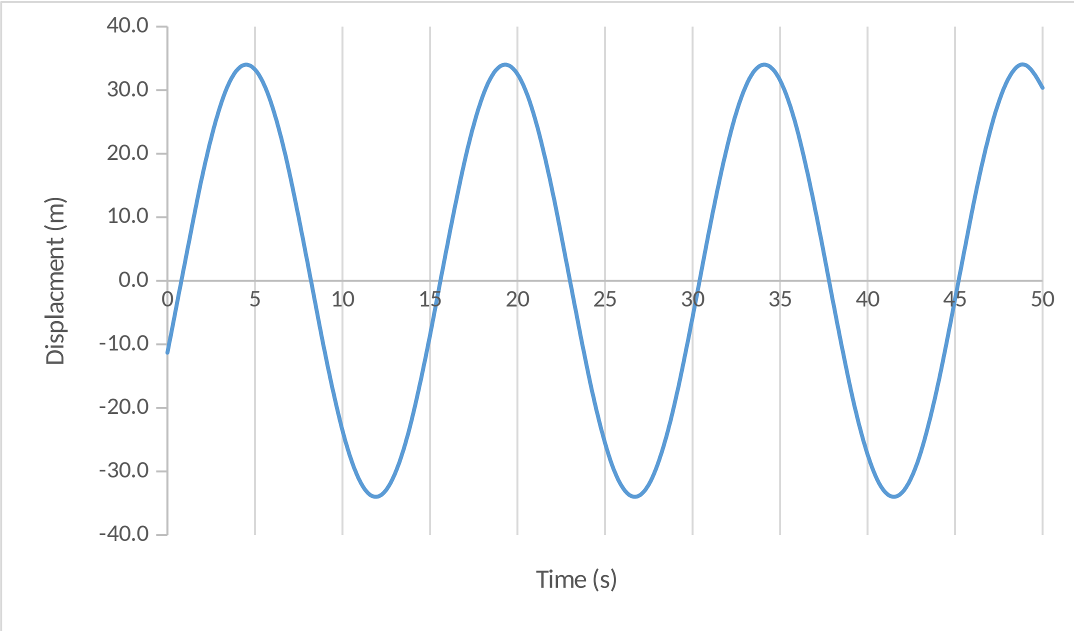
(b) Assuming that the voltage source and lightbulbs are exactly the same in each circuit, which circuit will have the brighter lightbulbs. Explain your answer. (5 marks)

Question 7 **(3 marks)**

At the end of the last Apollo 15 moon walk, Commander David Scott dropped a 1.32 kg geologic hammer and a 0.030 kg falcon feather from a height of 1.60 m above the surface of the moon. He observed that when the feather and the hammer were dropped simultaneously they both impacted the surface of the moon at the same time. Explain this observation.

Question 8 **(5 marks)**

In February, 1933, the USS Ramapo, a 146 metre navy vessel found itself in an extraordinary storm on its way from Manila to San Diego. The storm lasted 7 days and stretched from the coast of Asia to New York, producing strong winds over thousands of miles of unobstructed ocean. During the storm the crew had time to carefully observe the nearly sinusoidal ocean waves. The plot shows a displacement-time graph of waves similar to that recorded by the USS Ramapo.



(a) Use the graph to determine the amplitude of the waves. (1 mark)

(b) Use the graph to determine the period of the wave. (1 mark)

(c) If the period of a wave is 15.0 s and its speed is 23.0 m s^{-1}, calculate its wavelength. (3 marks)

Question 9 **(6 marks)**

A battery is connected in a series with a 1.20 Ω resistor. An ammeter measures a current of 6.00 A flowing through the resistor.

(a) Calculate the energy consumed by the resistor in a time of 2 minutes and 25 seconds. (4 marks)

(b) List two energy transformations that occur in the circuit and state the circuit component in which they occur. (2 marks)

Transformation 1

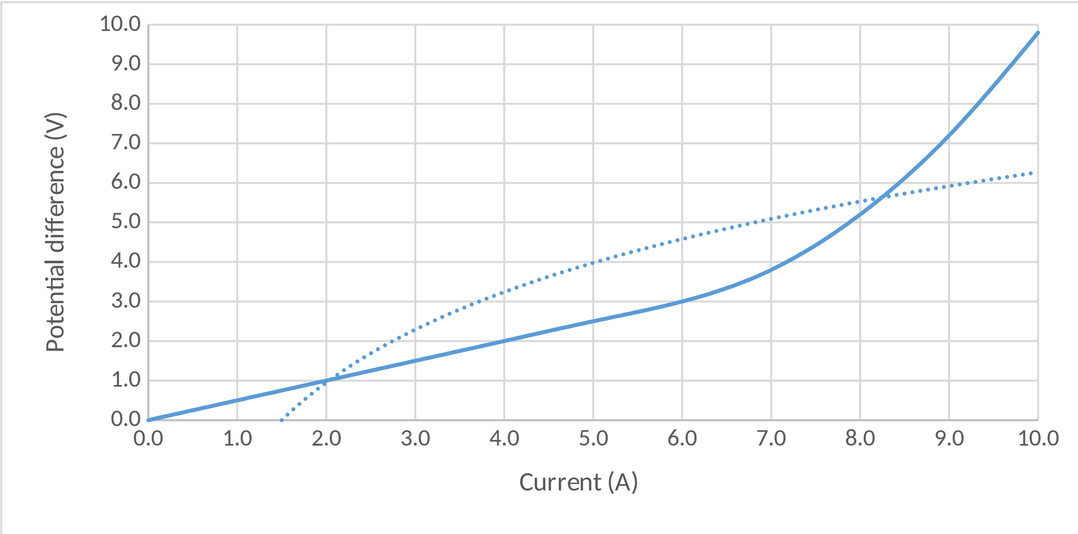
Transformation 2

Question 10 **(3 marks)**

Explain how resonance occurs when a person is pushed on the swing.

Question 11 **(4 marks)**

Jack conducted an experiment to determine the resistance of a conductor. The results of his experiment are shown in the graph below.



(a) Between which **current** values is the conductor ohmic? Give your values to two significant figures. (2 marks)

(b) Calculate the power consumed by the conductor when the current is 3.0 A. Give your answer to two significant figures. (2 marks)

Question 12 **(3 marks)**

An 87.0 kg patient is exposed to 120 TeV of alpha particle radiation during a medical procedure. Calculate the dose equivalent of radiation absorbed by the patient.

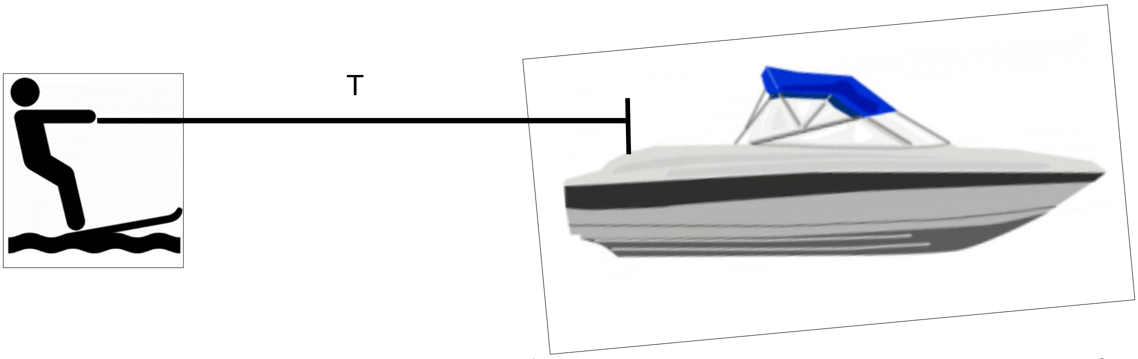
End of Section One

Section Two: Problem-solving **50% (90 Marks)**

This section has **seven (7)** questions. You must answer **all** questions. Write your answers in the space provided. Suggested working time for this section is 90 minutes.

Question 13 **(15 marks)**

The figure below shows a water skier being pulled to the right by a speed boat. The water skier and the boat are travelling in a straight line and the water skier is directly behind the boat. The mass of the person is 80.0 kg and the frictional force between the water skies and the water is 100 N. *T* is the tension in the rope.



The water skier has an initial speed of 12.8 m s^{-1} and is accelerated by the boat at 5.20 m s^{-2}.

(a) Calculate the time that it takes for the water skier to reach a final speed of 64.0 m s^{-1}. (2 marks)

(b) Calculate the distance that the skier travels while being accelerated. (3 marks)

(c) Calculate the work done by the boat while pulling the water skier a distance of 3.00 km at a constant speed of 64.0 m s^{-1}. (2 marks)

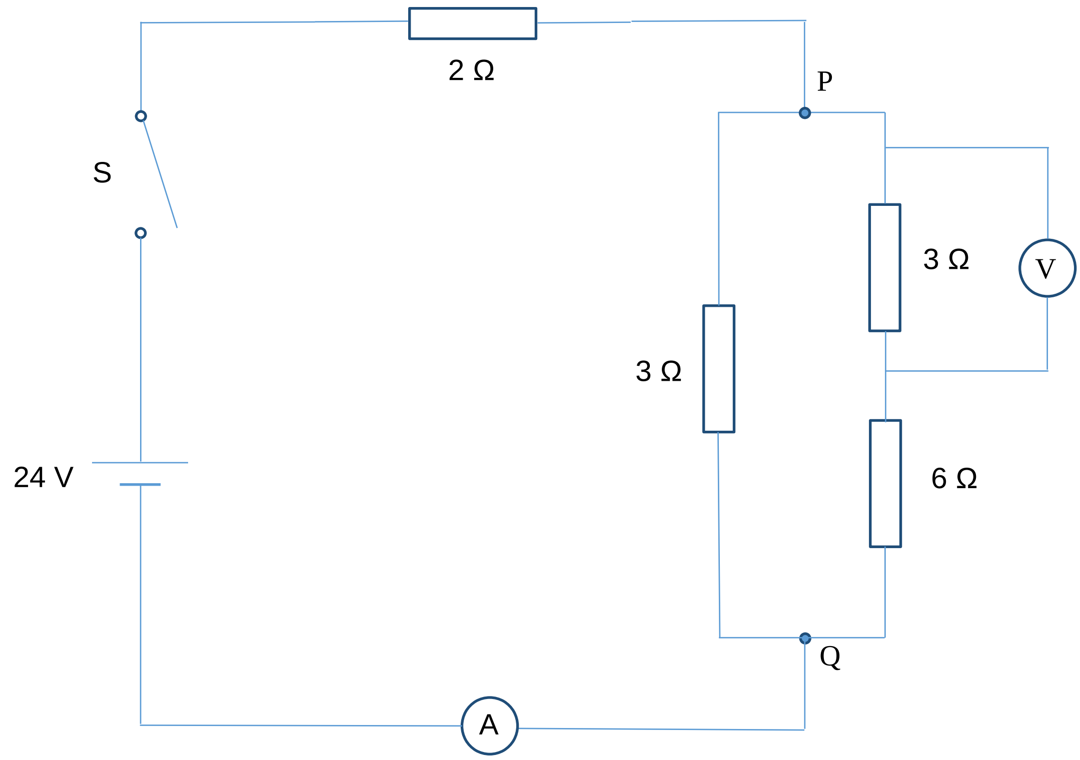
(d) Calculate the power required to overcome friction when pulling the water skier at a constant speed of 64.0 m s^{-1}. (2 marks)

(e) Calculate the tension in the rope if the rope is horizontal and the water skier is accelerated at 5.20 m s^{-2}. (3 marks)

(f) The angle of the ski rope is changed such that it now makes an angle of 15.0 ^{o} to the horizontal. Calculate the tension in the rope if the friction force is 100 N and the boat travels at a constant speed. (3 marks)

Question 14 **(13 marks)**

Alexia set up the electrical circuit shown below for his physics investigation. The circuit is powered by a 24 V DC power source and has a single switch S.



(a) Calculate the total resistance of the circuit. (4 marks)

(b) Calculate the current recorded by the ammeter when the switch is closed. (2 marks)

(c) If the current measured by the ammeter is 5.65 A, calculate the electric charge delivered by the DC power source in 2 hours and 35 minutes. (3 marks)

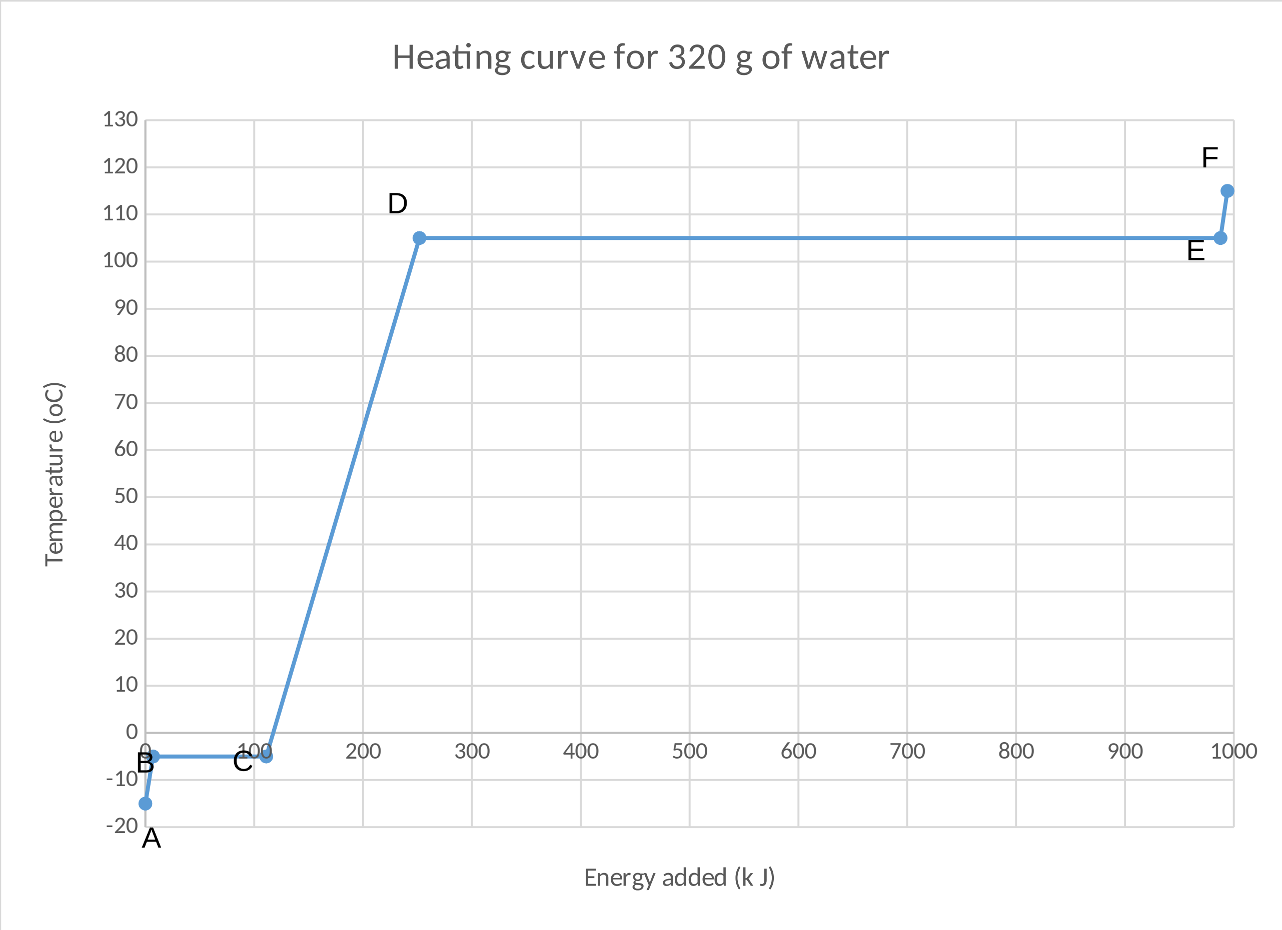
(d) If the voltage drop between P and Q is 12.7 V,

(i) calculate the voltage drop recorded by the voltmeter. (2 marks)

(ii) calculate the power consumed by the 6.00 Ω resistor. (2 marks)

Question 15 **(12 marks)**

To investigate the properties of salt water Lia heated 320 g of frozen salt water at -15ºC to a temperature of 115ºC in an insulated container. Her results are shown in the heating curve below.



(a) Explain why the temperature of the salt water is constant between points D and E. You must refer to the kinetic particle model and the internal energy of the salt water.

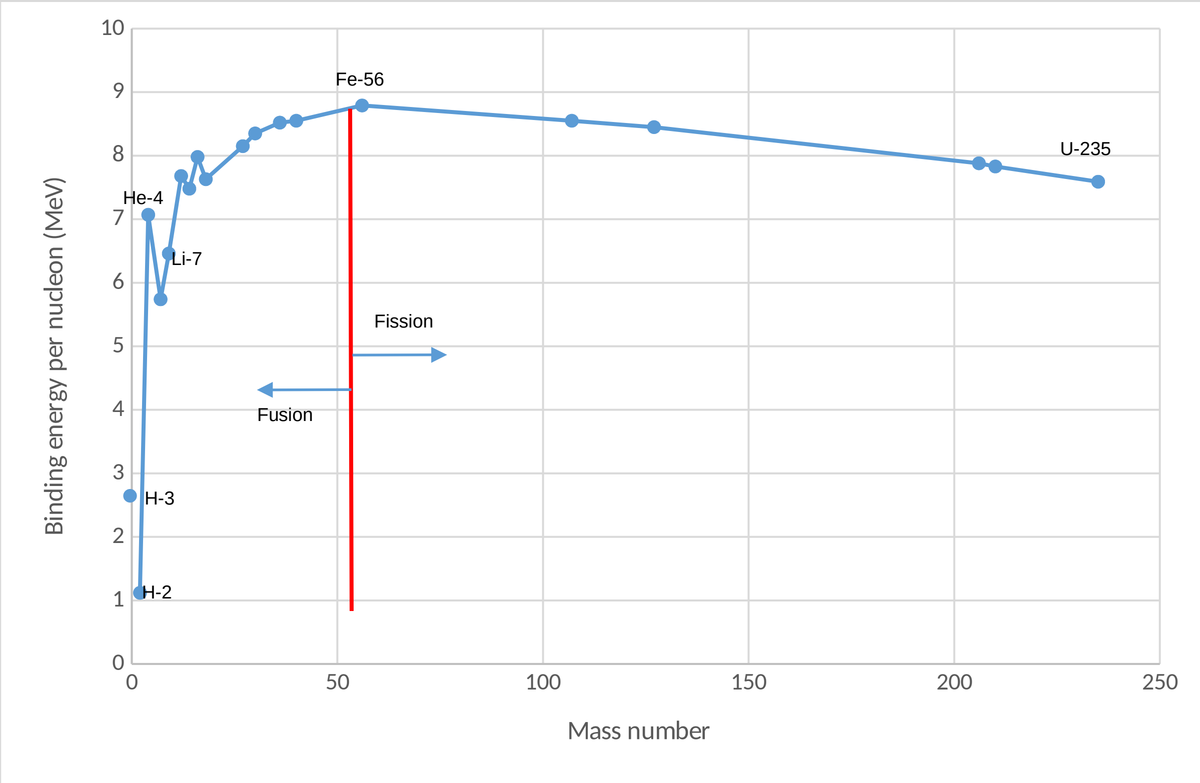
(4 marks)

(b) Calculate the latent heat of vaporisation of the salt water from the graph. (4 marks)

(c) Calculate the specific heat of salt water from the graph. (4 marks)

Question 16 **(11 marks)**

The figure below plots the binding energy per nucleon for elements of different mass numbers.



(a) Consider the Helium-4 and Lithium-7 nuclei. Which atom has the greater binding energy? Circle your answer below and provide an explanation. (3 marks)

Helium-4 Lithium-7

<u>Explanation</u>

(b) Use the graph to explain why the fusion of two H-2 atoms to form He-4 will release energy.
(3 marks)

(c) Calculate the binding energy for $^{56}_{26}Fe$ in MeV where: (5 marks)

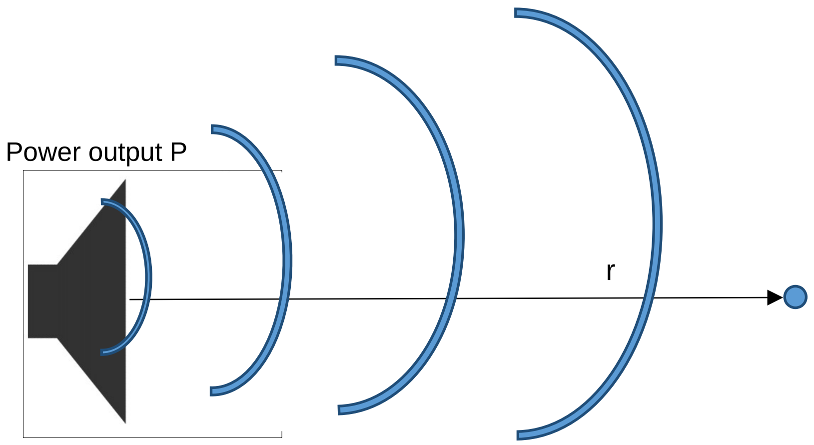
m ¿55.92069 u

m ¿

$m(n) = 1.008664\, u$

Question 17 **(17 marks)**

Jacqueline and Kieran set up an experiment to determine the power output of a loudspeaker. In this investigation they measured the sound intensity I ¿) produced by the loudspeaker at several different distances $r\,(m)$ from it. Their experimental setup is shown below.



The equation which relates the power output of the speaker, the sound intensity and the distance from the speaker is $I = \frac{P}{4\pi r^2}$

where

- $I = sound\,intensity\,(W\,m^{-2})$
- $P = power\,output\,of\,the\,speaker\,(W)$
- $r = distance$ ¿ $the\,speaker\,(m)$

A table of results for this investigation is shown below:

r (m)	I (W m^{-2})	1/r^2 (m^{-2})
0.500	39.7	
0.750	16.8	
1.50	4.20	
3.00	1.10	

(a) Complete the last column in the table above. Give your answers to three significant figures. (4 marks)

(b) On the graph paper provided plot $1/r^2$ versus sound intensity I. Plot $1/r^2$ on the *x*-axis and sound intensity on the *y*-axis. You must label your axes. (5 marks)

(c) Add a line of best fit to your graph. (1 mark)

(d) Using your line of best fit, determine the sound intensity 0.9 m from the speaker. (2 marks)

(e) Determine the gradient of your line of best fit. You must show your rise and run on the graph. (3 marks)

(f) The sound intensity equation can be written as $I = \frac{P}{4\pi} \times \frac{1}{r^2}$

The term $\frac{P}{4\pi}$ in the above equation is equal to the gradient of the line of best fit which you calculated in Part (e). Using $gradient = \frac{P}{4\pi}$ calculate the power of the source P.
If you did not calculate the gradient use a value of 9.90 W. (2 marks)

Question 18 **(13 marks)**

Jack drops a small rubber ball from a height of 1.50 m above flat ground. The mass of the ball is 0.120 kg. Air resistance can be neglected for each of the following questions.

(a) Which of the following statements correctly describes the applied forces as the ball impacts the ground? Circle the correct answer and provide an explanation below.

(i) The force that the ball applies to the ground is **greater than** the force that the ground applies to the ball.

(ii) The force that the ball applies to the ground is **less than** the force that the ground applies to the ball.

(iii) The force that the ball applies to the ground is **equal to** the force that the ground applies to the ball.

Explanation (3 marks)

(b) Calculate the velocity of the ball as it impacts the ground. (3 marks)

(c) The ball is dropped again from a different height and impacts the ground with a speed of 5.00 m s^{-1}. If the collision that the ball makes with the ground is elastic and the impact time is 0.01 s, calculate the magnitude of the average force that the ball applies to the ground.
(3 marks)

(d) A 46.0 g golf ball is dropped and impacts the ground with a velocity of 7.00 m s^{-1}. The golf ball then rounds to a height of 1.75 m above the ground. Calculate the efficiency of the impact. (4 marks)

Question 19 **(9 marks)**

Carbon-14 is a radioactive isotope of carbon which undergoes beta decay. It is used for the radiocarbon dating of archaeological objects such as boomerangs and bone.

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

(b) Write the equation for the beta decay of Carbon-14. (3 marks)

(c) Carbon-14 has a half-life of 5,730 years. Calculate the percentage of Carbon-14 which remains in boomerang which is 11,500 years old. (4 marks)

End of Section 2

Section Three: Comprehension **20% (36 Marks)**

This section contains **two (2)** questions. You must answer both questions. Write your answers in the space provided. Suggested working time for this section is 40 minutes.

Question 20 **(18 marks)**

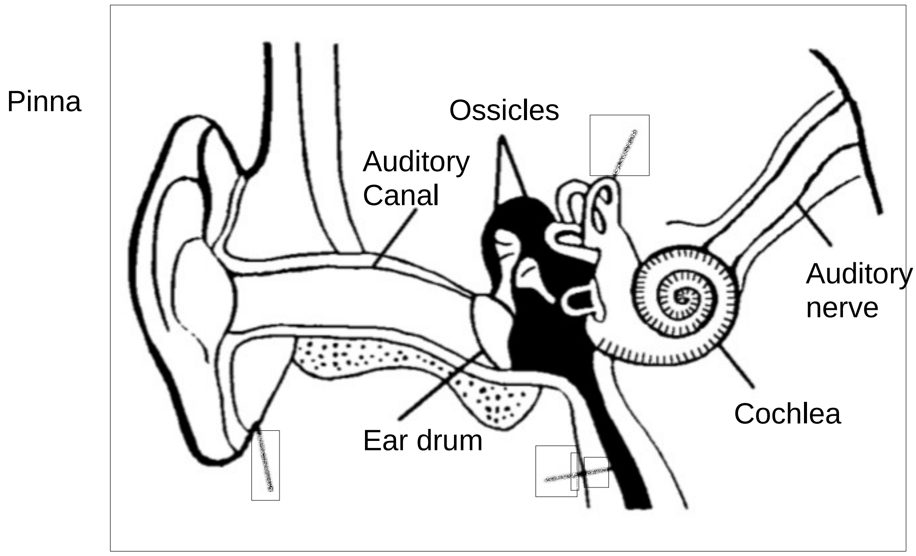
The Ear

The human ear is used for both hearing and balance and acts as transducer which converts sound energy to a nerve impulse which is sent to the brain. The ear allows us to detect pressure variations in the air which are less than one billionth of atmospheric pressure. It is able to detect these pressure variations within a range from 20 Hz to 20 kHz.

The ear comprises the outer ear, middle ear and inner ear and each part has a different function. When a sound wave is produced it travels at 340 m s^{-1} from the source and spreads out in three dimensions. The large area of the Pinna collects the sound and focuses it down the auditory canal. The auditory canal acts like a pipe closed at one end and resonance occurs within its length. The peak sensitivity of the ear to sound occurs at 3700 Hz which corresponds to the fundamental resonant frequency of the auditory canal.

The sound travels down the auditory canal to the ear drum. The sound vibrates the ear drum which vibrates the ossicles which are the three bones of the middle ear and the smallest bones in the body. The ossicles further amplify the sound.

The vibrating bones of the middle ear produce longitudinal waves in the fluid of the cochlea in the inner ear. The cochlea transforms the energy of the waves into nerve impulses which are transmitted to the brain.



(a) Vibration of the bones in the middle ear produces longitudinal waves in the cochlea. Explain how longitudinal waves are different from transverse waves. (2 marks)

(b) If sound enters the auditory canal with a frequency of 20.0 kHz how many sound waves enter the ear in 25.0 ms. (2 marks)

(c) Calculate the wavelength of sound vibrating at the fundamental resonant frequency of the auditory canal. You can assume that the speed of sound is 340 m s^{-1}. (3 marks)

(d) Calculate the effective length of the auditory canal. If you did not calculate an answer for the previous question assume that the wavelength which corresponds to the fundamental frequency is 92.0 mm. (2 marks)

(e) Calculate the frequency of the third harmonic. (1 mark)

(f) The figures below represent the auditory canal. Draw the **pressure variation** for the first and third harmonics of the auditory canal.

First harmonic (2 marks)

Third harmonic (2 marks)

(g) On the diagram above for the third harmonic label the pressure nodes. (1 mark)

(h) Explain how standing waves are formed in the auditory canal. (3 marks)

Question 21 **(18 marks)**

Plutonium Injection Experiments

On May 14, 1945 Albert Stevens was injected with 131 kBq of plutonium without his knowledge or consent. He was unknowingly one of 18 test subjects that took part in the plutonium human injection experiments. The aim of the experiments was to develop a tool to calculate the level of uptake of plutonium by the body from the urine and faeces excreted by the test subjects. The tool would then be used to determine if a worker using plutonium metal had received a dosage at or over the safe limit (Moss and Eckhardt, 1995).

Stevens checked into the University of California Hospital in San Francisco with a stomach ulcer that was so large that it was misdiagnosed as terminal cancer. As he was thought to have only a very short time to live, the doctors secretly injected him with a mixture of plutonium isotopes Pu-238 and Pu-239 to observe their effects. The half-life of Pu-238 is 87.7 years and that of Pu-239 is 24,100 years. Both elements are alpha emitters.

Approximately 10 years after the injection it was noted that the bones in his lower spine had suffered significant degeneration. Similarly to radium, plutonium was also observed to accumulate in and damage bones. Testing showed that the plutonium remained in his body for the remainder of his life however the levels of plutonium slowly decreased because of radioactive decay and biological elimination.

Stevens died of heart disease 20 years after the initial injection at the age of 79. Since his injection scientists calculated that he had accumulated an equivalent dose of 64 Sv and as a result he survived the highest known accumulated radiation dose in human history.

Reference: Moss, W., Eckhardt, R., 1995.The Human Plutonium Injection Experiments, *Los Alamos Science*. Radiation Protection and the Human Radiation Experiments (23): 177–223.

(a) Plutonium was first produced by deuterium (H-2) bombardment of U-238 which produces Np-238 and several neutrons. Np-238 then undergoes spontaneous decay to produce Pu-238.

(i) Determine the number of neutrons produced by the deuterium bombardment of U-238. (1 mark)

(ii) Using a nuclear equation determine the type of spontaneous decay which Np-238 undergoes to produce Pu-238. (2 marks)

(b) Explain why giving Stevens a dose of only Pu-239 would have caused his lifetime dose equivalent to be significantly smaller than if he was given an equivalent mass of Pu-238.
(3 marks)

(c) Explain why plutonium in the human body is difficult to detect with a Geiger counter.
(2 marks)

(d) Write the equation for the alpha decay of Plutonium-238. (2 marks)

(e) A fission reaction involving Plutonium-239 is shown below. Calculate the energy released by this reaction. Give your answer in Joules. The mass of the reactants and products involved in the reaction are given below. (4 marks)

$$^{239}_{94}Pu + ^{1}_{0}n \rightarrow ^{91}_{38}Sr + ^{146}_{56}Ba + 3\,^{1}_{0}n$$

$m\left(^{239}_{94}Pu\right) = 3.968266 \times 10^{-25} kg$
$m\left(^{1}_{0}n\right) = 1.674929 \times 10^{-27} kg$
$m\left(^{91}_{38}Sr\right) = 1.509109 \times 10^{-25} kg$
$m\left(^{146}_{56}Ba\right) = 2.422442 \times 10^{-25} kg$

(f) If each instance of a fission reaction releases $3.20 \times 10^{-11} J$ of energy, calculate the number of reactions required to produce 50.0 MW of power for a time of one hour and fifty minutes. (4 marks)

End of Questions

Additional working space

Additional working space

End of examination