Neap:

Trial Examination 2012

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 Core – Area of study			
1. Nuclear physics and radioactivity	18	18	38
2. Electricity	13	13	28
B Detailed studies			
1. Astronomy **OR**	12	12	24
2. Astrophysics **OR**	12	12	24
3. Energy from the nucleus **OR**	12	12	24
4. Investigations: Flight **OR**	12	12	24
5. Investigations: Sustainable energy sources **OR**	12	12	24
6. Medical physics	12	12	24
			Total 90

Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, rulers, up to two pages (one A4 sheet) of pre-written notes (typed or handwritten) and one scientific calculator.
Students are NOT permitted to bring into the examination room: blank pieces of paper and/or white out liquid/tape.

Materials supplied

Question and answer booklet of 38 pages including formulae, data and a periodic table at the front.

Answer sheet for multiple-choice questions.

Instructions

Please ensure that you write your **name** and your **teacher's name** in the space provided on this booklet and on the answer sheet for multiple-choice questions.

Always show your working where space is provided.

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

All written responses must be in English.

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

ABN 49 910 906 643 96–106 Pelham St Carlton VIC 3053 Tel: (03) 8341 8341 Fax: (03) 8341 8300

FORMULAE

absorbed dose	absorbed dose = $\frac{E}{m}$
mass–energy equation	$E = mc^2$
torque	$\tau = Fr$
power	$P = \frac{E}{t}$ or $P = Fv$
Bernoulli's equation	$\frac{1}{2}\rho v^2 + \rho gh + P = \text{constant}$
electrical charge	$Q = It$
electrical work	$W = QV$
charge on the electron	$e = -1.6 \times 10^{-19}$ C
voltage	$V = IR$
power	$P = VI$
resistors in series	$R_T = R_1 + R_2 \ldots$
resistors in parallel	$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} \ldots$
efficiency	efficiency (%) = $\frac{\text{useful energy output}}{\text{energy input}} \times 100$
speed	speed = $\frac{\text{distance}}{\text{time}}$
Glide ratio (lift-to-drag ratio)	$\frac{\text{glide distance}}{\text{loss of altitude}}$

DATA

speed of light in vacuum = 3.0×10^8 m s^{-1}

1 eV = 1.6×10^{-19} J

PREFIXES

Prefix	Abbreviation	Value
giga	G	10^9
mega	M	10^6
kilo	k	10^3
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}

THE PERIODIC TABLE OF THE ELEMENTS

atomic number	**79**	symbol of element
	Au	
relative atomic mass	197.0	
	gold	name of element

1 **H** 1.0 hydrogen																	**2** **He** 4.0 helium
3 **Li** 6.9 lithium	**4** **Be** 9.0 beryllium											**5** **B** 10.8 boron	**6** **C** 12.0 carbon	**7** **N** 14.0 nitrogen	**8** **O** 16.0 oxygen	**9** **F** 19.0 fluorine	**10** **Ne** 20.2 neon
11 **Na** 23.0 sodium	**12** **Mg** 24.3 magnesium											**13** **Al** 27.0 aluminium	**14** **Si** 28.1 silicon	**15** **P** 31.0 phosphorus	**16** **S** 32.1 sulfur	**17** **Cl** 35.5 chlorine	**18** **Ar** 39.9 argon
19 **K** 39.1 potassium	**20** **Ca** 40.1 calcium	**21** **Sc** 44.9 scandium	**22** **Ti** 47.9 titanium	**23** **V** 50.9 vanadium	**24** **Cr** 52.0 chromium	**25** **Mn** 54.9 manganese	**26** **Fe** 55.8 iron	**27** **Co** 58.9 cobalt	**28** **Ni** 58.7 nickel	**29** **Cu** 63.5 copper	**30** **Zn** 65.4 zinc	**31** **Ga** 69.7 gallium	**32** **Ge** 72.6 germanium	**33** **As** 74.9 arsenic	**34** **Se** 79.0 selenium	**35** **Br** 79.9 bromine	**36** **Kr** 83.8 krypton
37 **Rb** 85.5 rubidium	**38** **Sr** 87.6 strontium	**39** **Y** 88.9 yttrium	**40** **Zr** 91.2 zirconium	**41** **Nb** 92.9 niobium	**42** **Mo** 95.9 molybdenum	**43** **Tc** 98.1 technetium	**44** **Ru** 101.1 ruthenium	**45** **Rh** 102.9 rhodium	**46** **Pd** 106.4 palladium	**47** **Ag** 107.9 silver	**48** **Cd** 112.4 cadmium	**49** **In** 114.8 indium	**50** **Sn** 118.7 tin	**51** **Sb** 121.8 antimony	**52** **Te** 127.6 tellurium	**53** **I** 126.9 iodine	**54** **Xe** 131.3 xenon
55 **Cs** 132.9 casesium	**56** **Ba** 137.3 barium	**57** **La** 138.9 lanthanum	**72** **Hf** 178.5 hafnium	**73** **Ta** 180.9 tantalum	**74** **W** 183.8 tungsten	**75** **Re** 186.2 rhenium	**76** **Os** 190.2 osmium	**77** **Ir** 192.2 iridium	**78** **Pt** 195.1 platinum	**79** **Au** 197.0 gold	**80** **Hg** 200.6 mercury	**81** **Tl** 204.4 thallium	**82** **Pb** 207.2 lead	**83** **Bi** 209.0 bismuth	**84** **Po** (209) polonium	**85** **At** (210) astatine	**86** **Rn** (222) radon
87 **Fr** (223) francium	**88** **Ra** (226) radium	**89** **Ac** (227) actinium	**104** **Rf** (261) rutherfordium	**105** **Db** (262) dubnium	**106** **Sg** (263) seaborgium	**107** **Bh** (264) bohrium	**108** **Hs** (265) hassium	**109** **Mt** (268) meitnerium	**110** **Ds** (271) darmstadtium	**111** **Rg** (272) roentgenium	**112** **Uub**		**114** **Uuq**		**116** **Uuh**		**118** **Uuo**

58 **Ce** 140.1 cerium	**59** **Pr** 140.9 praseodymium	**60** **Nd** 144.2 neodymium	**61** **Pm** (145) promethium	**62** **Sm** 150.3 samarium	**63** **Eu** 152.0 europium	**64** **Gd** 157.2 gadolinium	**65** **Tb** 158.9 terbium	**66** **Dy** 162.5 dysprosium	**67** **Ho** 164.9 holmium	**68** **Er** 167.3 erbium	**69** **Tm** 168.9 thulium	**70** **Yb** 173.0 ytterbium	**71** **Lu** 175.0 lutetium
90 **Th** 232.0 thorium	**91** **Pa** 231.0 protactinium	**92** **U** 238.0 uranium	**93** **Np** 237.1 neptunium	**94** **Pu** (244) plutonium	**95** **Am** (243) americium	**96** **Cm** (251) curium	**97** **Bk** (247) berkelium	**98** **Cf** (251) californium	**99** **Es** (252) einsteinium	**100** **Fm** (257) fermium	**101** **Md** (258) mendelevium	**102** **No** (259) nobelium	**103** **Lr** (260) lawrencium

SECTION A – CORE

Instructions for Section A

Answer **all** questions **for both** Areas of study in this section of the paper.
Where 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 should be shown.

Area of study 1 – Nuclear physics and radioactivity

The following information relates to Questions 1 to 4.

Consider the following isotopes of oxygen atoms.

- Oxygen-18
- Oxygen-16
- Oxygen-15

Question 1

How do the three isotopes differ in their composition?

1 mark

Question 2

Which isotope has the lowest number of neutrons? Explain.

2 marks

Question 3

Both oxygen-16 and 18 are naturally occurring while oxygen-15 is an artificial isotope.

What is meant by the term ‘artificial isotope’ as opposed to ‘natural isotope’?

2 marks

Question 4

Oxygen-15 is able to transmutate into nitrogen-14 as shown in the following equation:

$$^{15}\mathrm{O} \rightarrow {}^{0}_{+1}e + {}^{14}\mathrm{N}$$

Is oxygen-15 an example of a radioactive substance? Explain your reasoning. (You do not have to write any equations in your explanation.)

2 marks

The following information relates to Questions 5 to 8.

Consider the radioactive decay of a parent radioactive element to a daughter radioactive element. The curves of the radioactive decay of the two elements are shown (not in any particular order) as graph *A* and graph *B* in Figure 1.

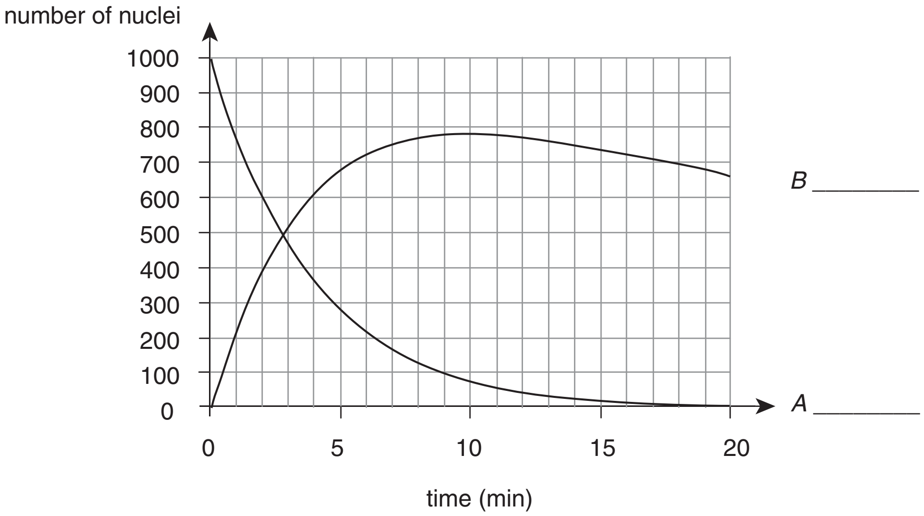


Figure 1

Question 5

On Figure 1, write next to the letters (*A* and *B*) which is the parent nucleus and which is the daughter nucleus. Explain how you arrived at your conclusion.

3 marks

Question 6

What is the half-life of the radioactive element shown in graph *A*?

☐ minutes

1 mark

Question 7

For graph *A*, how many half-lives have passed until $\frac{1}{16}$ of the number of atoms remain? Give your answer to the nearest half-life. Explain how you arrived at your conclusion.

2 marks

Question 8

Which of the two elements has the longer half-life? Justify your answer.

2 marks

The following information relates to Questions 9 to 10.

Due to the recent earthquake and tsunami in Japan, the nuclear power plant at Fukushima released large quantities of radioactive material into the surrounding environment. One radioactive element was caesium-137. Part of the decay sequence involving caesium-137 is shown.

$$^{137}\mathrm{Xe} \rightarrow {}^{137}\mathrm{Cs} + A \rightarrow {}^{137}\mathrm{Ba} + B$$

Question 9

What are *A* and *B* in this case?

2 marks

Question 10

Explain what has happened to the caesium-137 nucleus as it decayed into barium-137. (Equations are not necessary.)

2 marks

A large area around the Fukushima nuclear plant was blanketed with radioactive materials, some areas receiving the equivalent of 5.00 milliSieverts (mSv) in one year. The International Atomic Energy Agency recommends no more than 1.00 mSv per year.

Question 11

What would be the energy absorbed (in Joules) for an average (65.0 kg) person if exposed to the 5.00 mSv? (Take the quality factor to be 1.)

J

2 marks

The following information relates to Questions 12 and 13.

Caesium-137 is also used in cancer treatment since the energy given off when it forms Barium-137 is mainly as a γ-ray with an average energy of 662 keV (electron volt).

Question 12

What is the energy of the γ-ray in joules?

J

2 marks

Question 13

A typical tumour treated with radiotherapy may receive 400 Gy per 250 grams.

How many disintegrations of caesium-137 atoms are required to provide that absorbed dose? You must show your calculations.

3 marks

The following information relates to Questions 14 and 15.

Table 1 lists the three main types of radiation.

Property	α-particle	β-particle	γ-ray
typical energy	~5 MeV	~1 MeV	~0.1 MeV
penetration through matter	a few centimetres	1 or 2 metres	many metres
ionising ability	high	medium	low

Table 1

Question 14

Explain why β-radiation is labelled 'particles' while γ-radiation is labelled 'ray'.

2 marks

Question 15

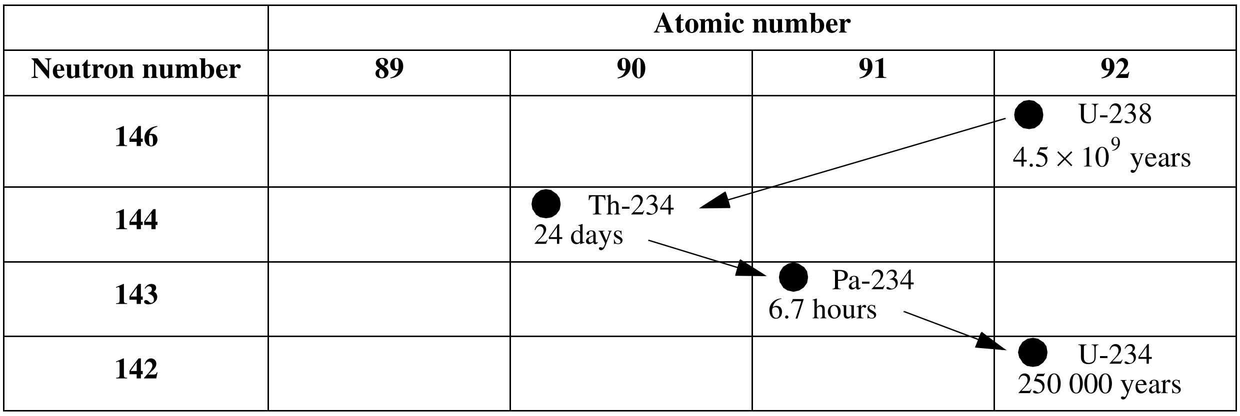
Tracers used in radiotherapy enable a non-surgical means of looking inside the body. For example, technetium-99 is a gamma emitter used to monitor the function of the liver.

Explain why in radiotherapy a 'tracer' injected inside the body needs to be a γ-ray rather than an α-particle.

3 marks

The following information relates to Questions 16 to 18.

One of the naturally occurring decay series involves U-238. The first four decays are shown in Table 2 along with their respective half-lives.



	Atomic number			
Neutron number	**89**	**90**	**91**	**92**
146				● U-238 4.5×10^9 years
144		● Th-234 24 days		
143			● Pa-234 6.7 hours	
142				● U-234 250 000 years

Table 2

Question 16

In the space provided below write the nuclear reaction for the decay of U-238.

2 marks

Question 17

Next to the three arrows in Table 2, state the appropriate type of radiation emitted (α, β, or γ).

3 marks

Question 18

A radioactive sample is analysed and found to contain approximately 50% U-238, with the remainder a mixture of Thorium-234, Protactinium-234, Uranium-234 and other elements.

How old is the sample? Explain your reasoning.

2 marks

END OF AREA OF STUDY 1

Area of study 2 – Electricity

The following information relates to Questions 1 to 5.

In Tom's house all the kitchen appliances are on a single fuse rated for 15 A. One morning he is using the microwave oven (rated 1500 W) and the kettle (rated 1800 W). When Tom tries to put on the toaster, all appliances turn off at once and he is unable turn them on again.

Question 1

What might have happened to turn off all appliances? Explain why this would happen.

3 marks

Question 2

Using calculations, determine the lowest possible rating of the electric toaster that Tom is using. All appliances use standard 240 V power.

W

3 marks

Question 3

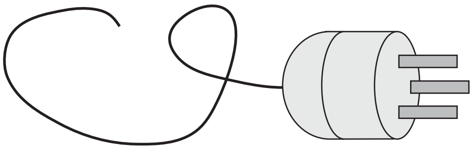
Calculate the combined resistance of the microwave oven and the kettle.

Ω

2 marks

Question 4

While dealing with his breakfast problems Tom notices that his toaster has three pins connecting it to the main power supply as shown in the diagram below.



Explain the function of each of the three pins on the power plug.

3 marks

On another day, Tom uses the microwave oven at full power to cook his roast chicken. The instructions on the frozen chicken state that he should cook the bird for 1.5 hrs.

Question 5

How much electrical energy will Tom use? Give your answer in both kiloWatt hours and Joules.

kWh	J

2 marks

The following information relates to Questions 6 to 8.

A 12 V car battery is rated as having a capacity of 40 Ah (Ampere hours).

The owner of the car has left his lights on. There are four light bulbs that power the front and rear lights; each light bulb is rated as 12 V, 24 W.

Question 6

Calculate the current flowing through each bulb when used at full power.

A

2 marks

Question 7

How much electrical energy is stored in the fully charged battery?

J

2 marks

Question 8

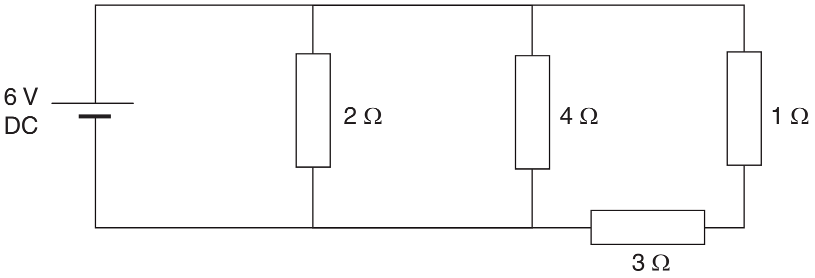
Assuming that the battery is fully charged to begin with, how long can the lights stay on until the battery is completely drained?

h

2 marks

The following information relates to Questions 9 to 13.

Consider the circuit shown in the following circuit diagram. The power supply is 6 V and all of the resistors have a different resistance as shown.



Question 9

Calculate the effective resistance in the circuit.

Ω

2 marks

Question 10

What is the value of the current passing though the battery?

A

1 mark

Question 11

What is the value of the current passing through the 3 Ω resistor?

A

2 marks

Question 12

Calculate the power dissipated in the 1 Ω resistor.

W

2 marks

Question 13

Using one additional 3 Ω resistor and without removing any of the other resistors, draw on the diagram on page 13 how you would use the 3 Ω resistor to lower the total resistance of the circuit.

2 marks

END OF AREA OF STUDY 2

SECTION B – DETAILED STUDIES

Instructions for Section B

Select **one** Detailed study.

Answer **all** the questions on the Detailed study you have chosen, 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 2, 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.

You should take the value of g to be 10 m s^{-2}

Detailed study 1 – Astronomy

The following information relates to this Detailed study.

Melbourne’s geographical position:

- Latitude –38°
- Longitude 145°

Question 1

When the sun sets exactly due west, the best estimates for the sun’s altitude–azimuth would be

A. altitude 90°; azimuth 90°.
B. altitude 0°; azimuth 270°.
C. altitude 180°; azimuth 0°.
D. altitude 0°; azimuth 90°.

Question 2

On 23 September, a star spotted directly overhead in the Melbourne sky at midnight would have a declination of

A. 0°.
B. 90°.
C. –38°.
D. 52°.

Question 3

A star is observed to have the following co-ordinates:

• Right ascension	4 h, 23 min
• Declination	15°

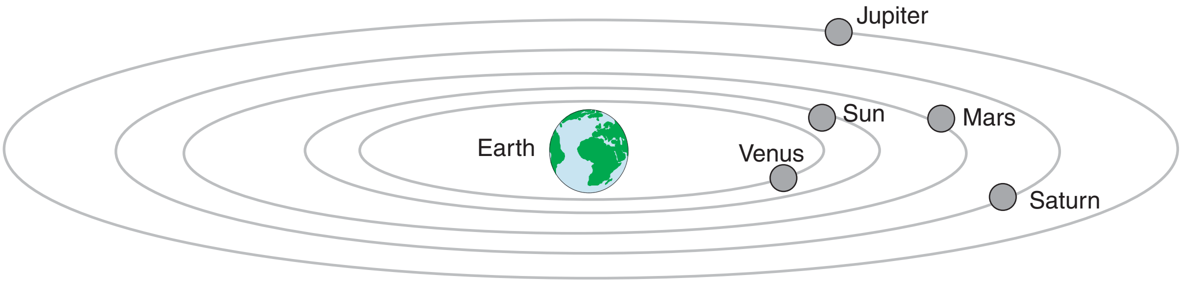
The same star is now observed four hours later.

Its coordinates will now be

A. 8 h, 23 min, 15°.
B. 4 h, 23 min, 15°.
C. 0 h, 23 min, 15°.
D. 4 h, 23min, 19°.

Question 4

The diagram shown below represents which one of the following cosmological systems? (Not all planets are shown.)



A. Aristotle's
B. Ptolomeic
C. Copernican
D. Keppler's

Question 5

Mars sometimes shows retrograde motion.

Which of the following is the best explanation of this observation?

A. Mars turns on its own small epicycle in addition to its own solar orbit.
B. Mars sometimes moves backwards while it goes around the Sun.
C. As seen from Earth, Mars only moves in one direction.
D. The Earth orbits faster, so Mars seems to go backward as Earth overtakes it.

Question 6

Venus shows phases, just like our Moon does. Two of the following four statements can be combined to explain why the phases of Venus occur.

1. The Sun illuminating only one half of Venus' surface at any one time.
2. The Sun illuminating a different portion of Venus' surface at different times.
3. Venus' rotation around the Sun causes the amount of shade on Venus to change.
4. Venus' rotation around the Sun causes us to see Venus from differing directions.

Which **two** statements can be used to explain the phases of Venus?

A. statements 1 and 2
B. statements 2 and 3
C. statements 1 and 4
D. statements 3 and 4

Question 7

The image below has been going around the internet for quite a few years. It supposedly shows the setting Sun, and the Moon just above it, as seen from somewhere in the arctic.

It is possible to tell that it is not a real photo because

A. the Moon should be full.

B. the Sun should be above the Moon.

C. the Sun and Moon should appear as nearly the same size from Earth.

D. the Sun should be bigger than the Moon as seen from Earth.

Question 8

Which two planets in our solar system were discovered after the invention of the optical telescope?

A. Mercury and Uranus

B. Neptune and Jupiter

C. Saturn and Mars

D. Neptune and Uranus

Question 9

The largest telescopes in use today are radio telescopes.

Which of the following best explains why these telescopes need to be very large?

A. The radio signals they detect have extremely low energy.

B. The radio signals they detect have extremely high energy.

C. The radio signals they detect have extremely short wavelengths.

D. The radio signals they detect have extremely high frequencies.

Question 10

Galileo’s telescopic observations of the Moon and the planets were important because they showed that

A. planets and moons of the solar system are very different to Earth.

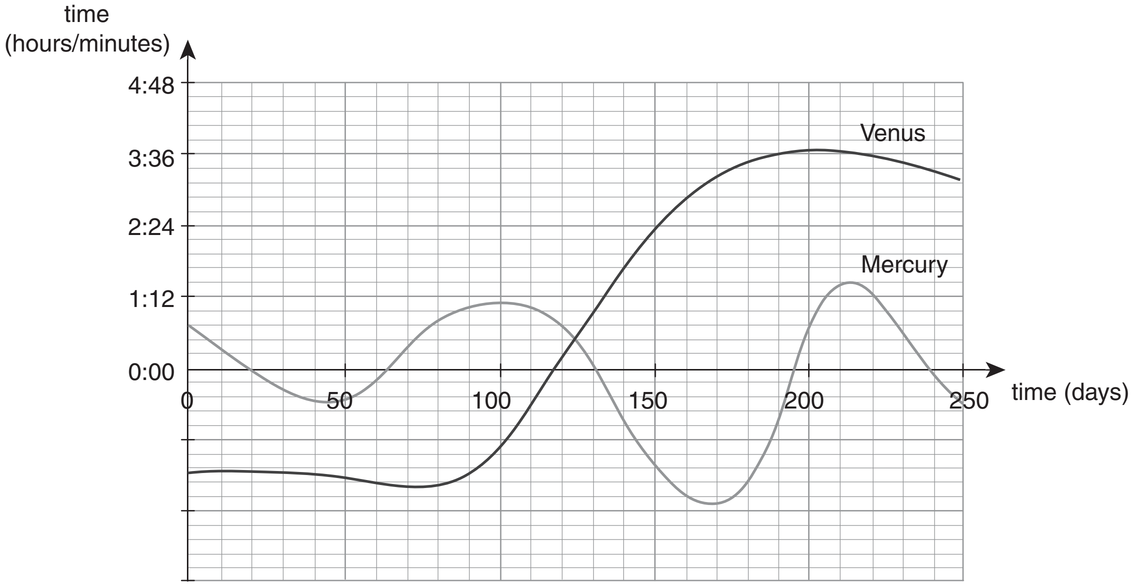
B. planets and moons of the solar system are perfect spheres.

C. planets and moons of the solar system are in many ways quite similar to Earth.

D. planets and moons of the solar system all revolve around the Sun.

Question 11

The graph below shows the difference in hours between sunset and the setting of both Venus and Mercury.



The two conclusions you can draw from the data are that

A. Mercury is smaller than Venus; Mercury has a smaller orbital period than Venus.
B. Mercury has a greater orbital radius than Venus; Mercury has a smaller orbital period than Venus.
C. Mercury is smaller than Venus; Mercury has a smaller orbital radius than Venus.
D. Mercury has a smaller orbital radius than Venus; Mercury has a smaller orbital period than Venus.

Question 12

Astronomers spend billions of dollars to put telescopes into space.

Which one of the following best explains why is it important to be able to make observations from space?

A. Certain kinds of EM radiation cannot pass through our atmosphere.
B. Our atmosphere causes distortions to the starlight.
C. The atmosphere partially absorbs some of the energy from the signals astronomers want to observe.
D. All of the above are good reasons for using space-based telescopes.

END OF DETAILED STUDY 1 – ASTRONOMY

Detailed study 2 – Astrophysics

Question 1

In terms of astronomical distances, the one that covers the longest distance is the

A. Giga-metre (Gm).
B. Astronomical Unit (AU).
C. light-year (ly).
D. parsec (pc).

The following information relates to Questions 2 and 3.

The Sun is the closest star to our planet. It is made of various layers, some of which are shown in Figure 1.
Note: Figure 1 is not drawn to scale and is only to provide a representation.

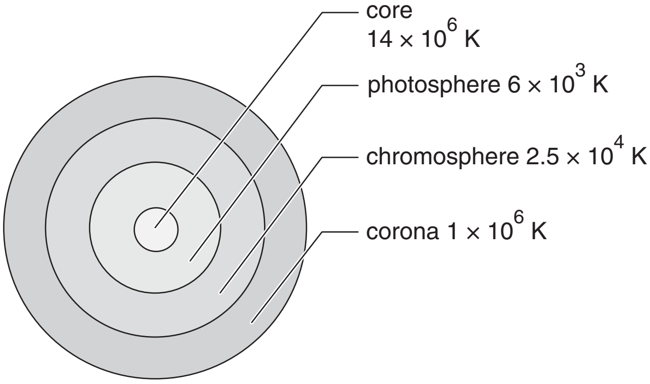


Figure 1

Question 2

The layer which produces the majority of the visible light that reaches the Earth is the

A. core.
B. photosphere.
C. chromosphere.
D. corona.

Question 3

Which of the following is one of the principal reactions that take place in the core of the Sun?

A. hydrogen + hydrogen → helium
B. hydrogen + carbon → nitrogen
C. helium + helium → beryllium
D. neutron + plutonium → barium + strontium + neutrons

Question 4

One way of measuring the temperature of the star is by analysing its visible spectrum.

A hotter star, when compared to a cooler one, will have more radiation in which part of the visible spectrum?

A. yellow-green
B. Both will have the same visible spectrum.
C. red part of spectrum
D. blue part of spectrum

Question 5

The energy received on Earth from the Sun is an average 1370 W m^{-2} (Watts per square metre).

Given the Earth is 150 million kilometres from the Sun, the total energy given off by the Sun is

A. 1370 W.
B. 2.6×10^{15} W.
C. 3.9×10^{26} W.
D. 2.9×10^{24} W.

The following information relates to Questions 6 to 8.

Astronomers often compare the hydrogen emission spectra of a distant star (similar in size and temperature) to that of the Sun. Only some of the spectra is shown and it is not to scale. The results are shown below.

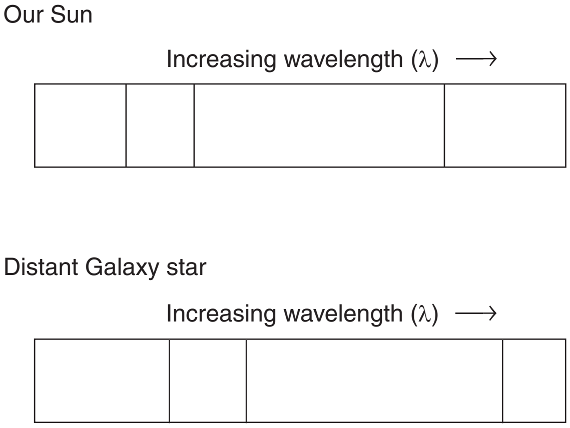


Figure 2

Question 6

The shift in wavelength of the distant galaxy when compared to the Sun is known as

A. hydrogen shift.
B. resonance shift.
C. blueshift.
D. redshift.

Question 7

From this shift in wavelength it is possible to conclude that

A. the distant galaxy was moving away from us.
B. the distant galaxy was moving towards us.
C. the distant galaxy was remaining stationary.
D. we can not deduce anything from the wavelength shift.

Question 8

Data from distant galaxies also provides evidence that the universe's size in the past

A. was static and unchanging.
B. was smaller.
C. was larger.
D. oscillated from small to large.

Question 9

Which one of the following statements is incorrect?

A. The Milky-Way is an example of an elliptical galaxy.
B. Galaxies can contain hundreds of millions of stars.
C. A star emits electromagnetic radiation in the visible spectrum whereas a planet does not.
D. Galaxies can merge to form 'super' galaxies.

The following information relates to Questions 10 to 12.

The Hertzsprung–Russell (H–R) diagram is a very useful way of showing stellar information. One simplified H–R diagram is shown below.

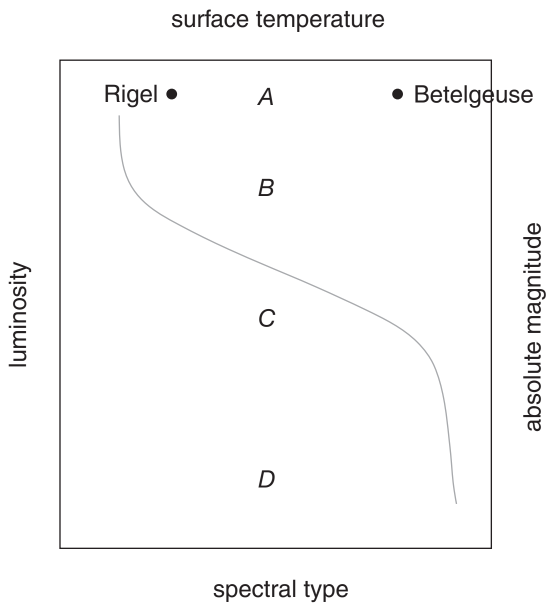


Figure 3

Question 10

The Sun is most likely to be found in position

A. *A*
B. *B*
C. *C*
D. *D*

Question 11

Rigel and Betelgeuse are two stars (each has a • next to their name).

When comparing these two stars on an H–R diagram, which one of the following is correct?

A. Betelgeuse has a cooler temperature than Rigel.
B. Betelgeuse has the same temperature as Rigel.
C. The H–R diagram provides no information to compare.
D. Betelgeuse has a hotter temperature than Rigel.

Question 12

Both Betelgeuse and Rigel could be classified as

A. White Dwarfs.
B. Red Giants.
C. Main Sequence.
D. Super Giants.

END OF DETAILED STUDY 2 – ASTROPHYSICS

Detailed study 3 – Energy from the nucleus

Question 1

A hydrogen atom is made up of a proton and an electron.

Which one of the following statements is incorrect?

A. The electron orbits the nucleus.
B. The radius of the electron orbit is thousands of times greater than the radius of the nucleus.
C. The electron and proton are oppositely charged.
D. The electron has the majority of the mass of the atom.

Question 2

The strong nuclear force works at the sub-atomic level and is needed to keep

A. nucleons together.
B. protons and electrons apart.
C. protons and electrons together.
D. nucleons apart.

Question 3

Consider the graph in Figure 1 which shows the potential energy changes as two light nuclei approach each other.

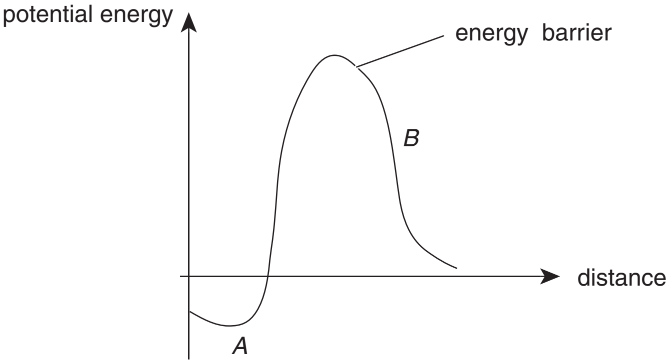


Figure 1

The correct forces acting at *A* and *B* are

A. *A* = strong nuclear; *B* = electrostatic
B. *A* = electrostatic; *B* = strong nuclear
C. *A* = strong nuclear; *B* = strong nuclear
D. *A* = electrostatic; *B* = electrostatic

Question 4

The Sun is a giant fusion machine, forcing light nuclei such as hydrogen together to form helium. Since both protons are positively charged they naturally repel each other.

The Sun overcomes this repulsion by having

A. high pressure.
B. high density.
C. high temperature.
D. all of the above.

The following information relates to Questions 5 to 7.

One typical fission reaction that plutonium-239 can undergo is

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

Question 5

The number of neutrons (X) required to complete the reaction is

A. 0.
B. 1.
C. 2.
D. 3.

Question 6

This single reaction results in energy being released which has the mass equivalent of 3.07×10^{-28} kg.

How many of these reactions must occur to power a typical 80.0 Watt (J s^{-1}) light globe for just one minute?

A. 2.9×10^{12}
B. 1.7×10^{14}
C. 2.8×10^{-11}
D. 3.0×10^{8}

Question 7

The fission fragments, Ba and Sr, have mainly gained which type of energy?

A. electrical
B. kinetic
C. potential
D. electromagnetic

Consider the graph in Figure 2 which shows the relationship between the number of neutrons and the number of protons in stable atomic nuclei.

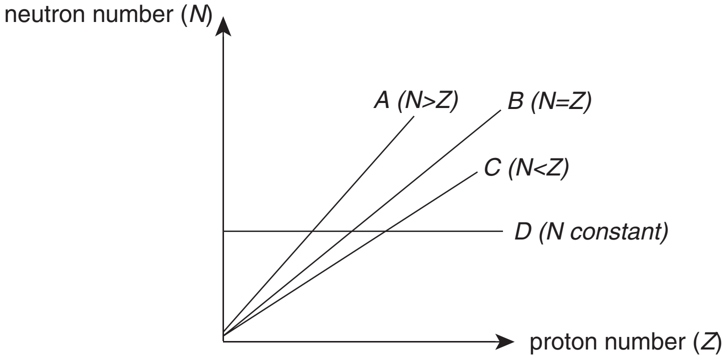


Figure 2

Question 8

The graph that is **most** correct is

A. *A*
B. *B*
C. *C*
D. *D*

Question 9

When scientists worked on the first nuclear bomb they found that a flattened sheet of U-235 was subcritical and did not explode. The same mass, when made into a spherical shape, did explode.

The main reason the flat shape did not work was

A. there was not enough mass present.
B. the increased surface area allowed too many neutrons to escape.
C. the flattened surface slowed down the speed of the nuclear reaction.
D. the flattened surface allowed oxygen to penetrate the mass which interfered with the nuclear reaction.

Question 10

One key design difference between a thermal reactor and a fastbreed reactor is

A. thermal reactors do not require a moderator while fastbreed reactors do.
B. thermal reactors do not require control rods while fastbreed reactors do.
C. thermal reactors do require control rods while fastbreed reactors do not.
D. thermal reactors do require a moderator while fastbreed reactors do not.

Question 11

A slow-moving neutron is captured by a large atomic mass nucleus.

If the absorption of this neutron is sufficient to cause fission, then the nucleus was most likely

A. U-235.
B. Pu-239.
C. U-238.
D. Pu-244.

Question 12

Nuclear reactors produce different levels of radioactive waste.

Which waste most likely requires storage in water ponds due to the heat generated?

A. low-level
B. intermediate-level
C. high-level
D. None once they are put into storage containers.

END OF DETAILED STUDY 3 – ENERGY FROM THE NUCLEUS

Detailed study 4 – Investigations: Flight

The following information relates to Questions 1 to 3.

Figure 1 shows a commercial aircraft taking off from the ground.

It gains 300 m of altitude in 5.0 s. During this time the aircraft is flying at a constant velocity. The weight force on the aircraft is 2×10^6 N.

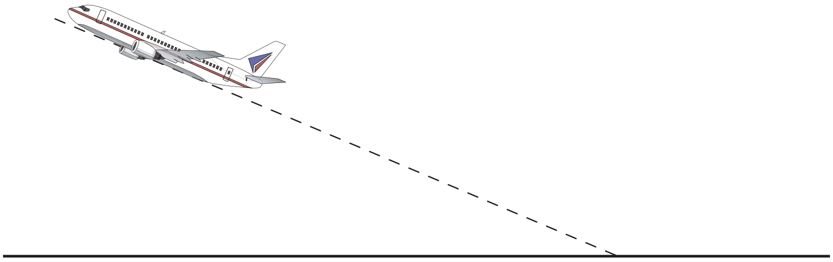


Figure 1

Question 1

Which of the following statements about this aircraft is correct?

I Thrust is equal to drag.

II Weight is smaller than lift.

A. Only I is correct.
B. Only II is correct.
C. Both I and II are correct.
D. Neither I nor II are correct.

Question 2

During take-off, the engines need to develop at least _______________ of power.

A. 6×10^8 W

B. 2×10^6 W

C. 1.2×10^8 W

D. 3×10^8 W

Question 3

After a short while the aircraft reaches cruising altitude. It now flies at a constant speed and altitude. The engines now provide 5×10^7 W of power and generates 2.0×10^5 N of thrust.

Under these circumstances the cruising speed must be

A. 250 m s^{-1}

B. 25 m s^{-1}

C. 500 m s^{-1}

D. 100 m s^{-1}

Question 4

While cruising, the lift-to-drag ratio of the aircraft is

A. 0.1.
B. 1.
C. 10.
D. 100.

Question 5

There are several different sources of friction or drag that affect aircraft.

Which of the following can not be reduced by aircraft designers without partially sacrificing the aircraft's ability to generate lift?

A. skin drag
B. form drag
C. parasite drag
D. induced drag

The following information relates to Questions 6 to 9.

Some Physics students perform an experiment to investigate Bernoulli's Principle. The experimental set-up is shown in Figure 2.

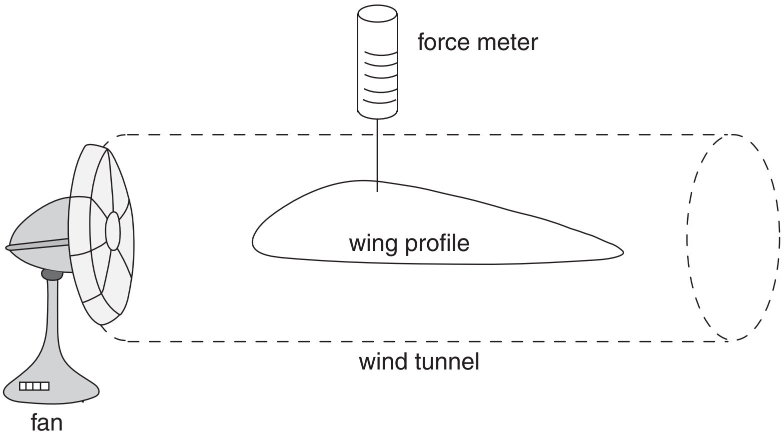


Figure 2

Question 6

As the speed of the fan is increased, the reading on the force meter will

A. increase.
B. decrease.
C. remain unchanged.
D. decrease first, then increase.

Question 7

In this experiment the reading on the Newton (force) meter is

A. the controlled variable.
B. the dependent variable.
C. the independent variable.
D. none of the above

Question 8

The students now keep the fan speed constant but increase the angle of attack of the wing profile. Initially they see the lift force generated by the wing profile increasing.

Which of the students' hypotheses are correct?

I The pressure above the wing profile becomes less compared to the pressure below.

II The moving air exerts a greater upward impulse on the wing profile.

A. Only I is correct.
B. Only II is correct.
C. Both I and II are correct.
D. Neither I nor II are correct.

Question 9

As the angle of attack continues to be increased the lift force will

A. continue to increase.
B. reach a constant maximum value.
C. will slowly decrease.
D. will quickly decrease beyond a critical angle.

Question 10

Each of the following changes will cause a plane to turn left or right.

For a plane to turn right the pilot should

A. decrease the drag on the left wing.
B. increase the thrust from the right engine.
C. decrease the thrust from the left engine.
D. decrease the drag on the right wing.

The following information relates to Questions 11 and 12.

The plane in Figure 3 is cruising at a constant altitude. Both the wings and the tail provide lift. Lift force 1 (L1) = 800 000 N, the mass of the plane is 1 × 10^5 kg. The plane is 60 m long

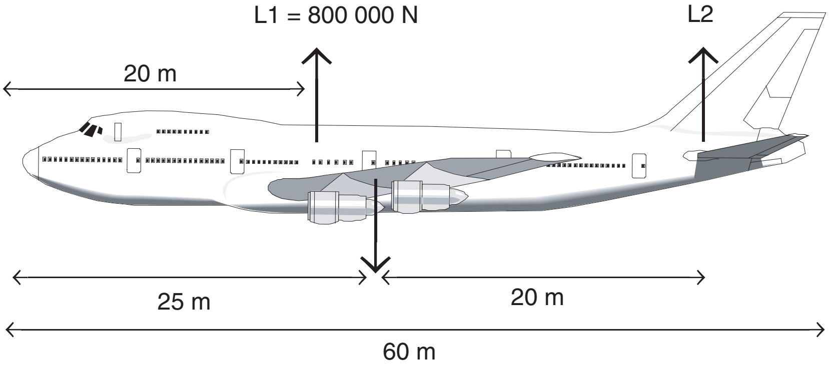


Figure 3

Question 11

Lift force L2 must be equal to

A. 2.0×10^5 N.

B. 1.2×10^6 N.

C. 8.0×10^5 N.

D. 1.0×10^6 N.

Question 12

The plane is not rotating.

Which of the following is correct regarding the torques provided by L1 and L2 calculated about the plane's centre of mass?

A. Torque from L1 is greater than the torque from L2.
B. Torque from L1 is smaller than the torque from L2.
C. Torque from L1 is equal to the torque from L2.
D. Torque from L1 could be greater or smaller than the torque from L2.

END OF DETAILED STUDY 4 – INVESTIGATIONS: FLIGHT

Detailed study 5 – Investigations: Sustainable energy sources

Question 1

A sustainable energy resource is one that we can continue to use for many years without ill effects for future generations. A renewable energy source is one that keeps topping itself up, and can therefore be used indefinitely.

Under these definitions, consider the following two forms of energy (hot rock geothermal and wind) and decide on the correct classifications.

	Hot Rock Geothermal	Wind
A.	sustainable only	renewable only
B.	sustainable and renewable	sustainable renewable
C.	renewable only	sustainable
D.	sustainable only	sustainable and renewable

The following information relates to Questions 2 to 5.

It has been shown that the energy available from waves on the south coast of Australia averages 120 kW m^{-1}.

Question 2

Given that our southern coastline is about 4000 km long, how much energy could we extract from waves assuming we could do this with 20% efficiency?

- **A.** 96 MW
- **B.** 96 GW
- **C.** 480 KW
- **D.** 480 GW

Question 3

The amount of energy potentially available from wave energy on the south coast of Australia is roughly equivalent to the amount generated by

- **A.** much less than one coal fired power station.
- **B.** one coal fired power station.
- **C.** two or three coal fired power stations.
- **D.** many coal fired power stations.

Question 4

The amount of wave power available at any one location varies a lot because

- **A.** wave power is only available at night.
- **B.** wave power depends on the height of the waves.
- **C.** wave power depends on the tides.
- **D.** wave power depends on the geography of the coastline.

Question 5

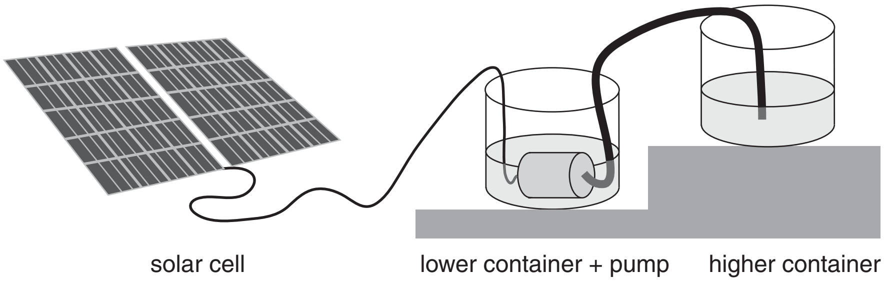
Given the current advice from scientists about the causes of global warming, wave power would be considered to be a more environmentally friendly alternative to fossil fuel use because

A. it generates power for free.
B. it is not going to run out soon.
C. it is renewable.
D. it does not generate carbon dioxide.

The following information relates to Questions 6 to 10.

Julia and Tony have been asked by their Physics teacher to design a small power generation system using a solar cell, an electric water pump and two containers of water.

The diagram below shows how Tony and Julia have set up their system.



Question 6

Which of the following sequences correctly describes the energy transformations taking place as the system is working?

A. heat → electrical energy → kinetic energy → gravitational energy
B. light → electrical energy → hydro energy → gravitational energy
C. heat → kinetic energy → electric energy → gravitational energy
D. light → electrical energy → kinetic energy → gravitational energy

Question 7

The solar cells are 12% efficient and have an area of 0.2 m^2. The solar constant in Melbourne on the day of the experiment was 1000 W m^{-2}.

How much electrical power was delivered to the water pump?

A. 24 W m^{-2}
B. 24 W
C. 120 W m^{-2}
D. 120 W

Question 8

On a different day, 15 W of energy is coming from the solar cells. The water is pumped into the higher container at a rate of 30 g s^{-1}. The water surface in the higher container is 1.5 m above the lower container.

The efficiency of the pump is therefore

A. 25%
B. 30%
C. 3.0%
D. 2.5%

Question 9

Julia and Tony suggest that this system could be used to store energy, so that the system can provide electrical energy even when the sun is not shining.

To do this, which three more elements would they need to add to the system?

A. a generator, a rechargeable battery and a motor

B. a water turbine, a rechargeable battery and a motor

C. a generator, a water turbine, and a rechargeable battery

D. a water turbine, a pump and a generator

Question 10

If both water containers have the same dimensions and the capacity of the containers is 50 kg, what would be the maximum amount of energy that can be stored this way?

A. 750 J

B. 750 W

C. 500 J

D. 500 W

Question 11

A windmill can convert kinetic energy from the wind to electrical energy. The maximum power available from a wind turbine is thought to be proportional to v^3, where v is the wind speed.

If the wind speed on Monday is twice that on Tuesday, the ratio

$$\frac{\text{electrical energy output on Monday}}{\text{electrical energy output on Tuesday}}$$

is likely to be

A. 2

B. 4

C. 8

D. 16

Question 12

Solar energy currently makes up only a small percentage of our total power use in Australia.

Which one of the following is **not** a reason why we use so little solar power?

A. Solar power is currently quite expensive.

B. Solar power does not deliver power at a constant rate.

C. There is not enough solar energy available in Australia.

D. Government support is needed to increase solar power use.

END OF DETAILED STUDY 5 – INVESTIGATIONS: SUSTAINABLE ENERGY SOURCES

Detailed study 6 – Medical Physics

The following information relates to Questions 1 and 2

The 'acoustic impedance' of a medium is a measure of the material's ability to allow the passage of a sound wave through it. It is usually calculated by the formula: $Z = \rho v$ where Z is the acoustic impedance (kg m^{-2} s^{-1}), ρ is the density of the medium (kg m^{-3}) and v is the velocity of sound in the medium.

Table 1 below indicates typical Z values.

Medium	***Z***
air	430
fat	1.38×10^6
soft tissue	1.63×10^6
muscle	1.70×10^6
bone	$5.6 - 7.8 \times 10^6$

Table 1

Question 1

Fat has a density of approximately 900 kg m^{-3}.
What is the speed at which an ultrasound travels through fat?

A. 1.4×10^6 m s^{-1}

B. 1.2×10^9 m s^{-1}

C. 1.5×10^3 m s^{-1}

D. 6.5×10^{-4} m s^{-1}

Question 2

The speed of an ultrasound is determined by the multiplication of its wavelength and frequency $(v = \lambda f)$.

If the frequency is kept constant but the wavelength is shortened, then Z will

A. decrease.
B. increase.
C. remain constant.
D. increase then decrease.

The following information relates to Questions 3 and 4.

Scan *A*

Scan *B*

Scan *C*

Question 3

Scan *A* is most likely to be

A. thermal (temperature).
B. an ultrasound.
C. an MRI.
D. an X-ray.

Question 4

Scan *C* is most likely to be

A. thermal (temperature).
B. an ultrasound.
C. an MRI.
D. an X-ray.

Question 5

Safety precautions have to be taken with X-rays.

The use of X-rays is generally not recommended for

A. elderly people.
B. very young children.
C. middle-aged males.
D. pregnant females.

Question 6

Generally, X-rays are classified as one of two types, either ‘soft’ or ‘hard’.

The difference between the two is

A. penetrating power through the body.
B. speed of X-ray.
C. one is a form of electromagnetic radiation, the other is not.
D. how they are produced.

The following information relates to Questions 7 and 8.

In nuclear medicine there is a difference in the radio-isotopes used for medical diagnostic (scanning) purposes and those used as an external source to treat tumours. Three radio-isotopes are listed below.

1. Iodine-131 undergoes β-decay (with low energy γ-emissions) and it has a radioactive half-life of 8 days.
2. Strontium-90 undergoes β-decay (with very little γ-emissions) and it has a half-life of 28.8 years.
3. Cobalt-60 is essentially a pure high-energy γ-emitter with a half-life of 5 years.

Question 7

From a medical diagnostic point of view, the best radioisotope to use would be

A. Iodine-131.
B. Strontium-90.
C. Cobalt-60.
D. all are adequate

Question 8

To treat a tumour with an external source, the best radioisotope to use would be

A. Iodine-131.
B. Strontium-90.
C. Cobalt-60.
D. all are adequate

The following information relates to Question 9.

All radioisotopes involve the use of unstable isotopes. Some of these unstable isotopes are made artificially. An example is Nitrogen-14 which is bombarded with deuterium (hydrogen-2) to produce oxygen-15. This unstable isotope of oxygen decays according to the following nuclear reaction:

$$^{15}\text{O} \rightarrow {}^{0}_{+1}\text{e} + {}^{15}\text{N}$$

Question 9

In which of the following diagnostic (scanning) devices would this reaction most likely appear?

A. MRI
B. ultrasound
C. PET
D. X-ray

Question 10

Most diagnostic equipment needs to be 'shielded'. In one case, a room is shielded because the diagnostic equipment can cause interference with electrical equipment.

The type of scanning is most likely to be

A. MRI
B. ultrasound
C. PET
D. X-ray

Question 11

An endoscope uses optical fibres to view the inside of a patient.

The light is able to travel through the endoscope by

A. dispersion.
B. total internal reflection.
C. refraction.
D. diffraction.

Question 12

When a surgeon looks through the eyepiece, they are receiving information from optical fibres. One 'bundle' of fibres provides illumination while another bundle is used to provide an image of inside the body.

Which of the following choices with regards to coherence is most correct?

	Illumination bundle	**Image bundle**
A.	non-coherent	non-coherent
B.	coherent	non-coherent
C.	coherent	coherent
D.	non-coherent	coherent

END OF QUESTION AND ANSWER BOOKLET