Please stick the barcode label here.

Candidate Number

PHYSICS PAPER 2

Question-Answer Book

11.45 am – 12.45 pm (1 hour)
This paper must be answered in English

INSTRUCTIONS

(1)   After the announcement of the start of the examination, you should first write your Candidate Number in the space provided on Page 1 and stick barcode labels in the spaces provided on Pages 1, 3, 5, 7 and 9.

(2)   This paper consists of **FOUR** sections, Sections A, B, C and D. Each section contains eight multiple-choice questions and one structured question which carries 10 marks. Attempt **ALL** questions in any **TWO** sections.

(3)   Write your answers in the spaces provided in this Question-Answer Book. Do not write in the margins. Answers written in the margins will not be marked. For multiple-choice questions, blacken the appropriate circle with an HB pencil. You should mark only **ONE** answer for each question. If you mark more than one answer, you will receive **NO MARKS** for that question.

(4)   Graph paper and supplementary answer sheets will be provided on request. Write your candidate number, mark the question number box and stick a barcode label on each sheet, and fasten them with string **INSIDE** this Question-Answer Book.

(5)   The diagrams in this paper are **NOT** necessarily drawn to scale.

(6)   The last two pages of this Question-Answer Book contain a list of data, formulae and relationships which you may find useful.

(7)   No extra time will be given to candidates for sticking on the barcode labels or filling in the question number boxes after the 'Time is up' announcement.

A150E002

Section A : Astronomy and Space Science

Q.1: Multiple-choice questions

1.1 Weightlessness occurs inside a spacecraft orbiting around the Earth. Which statement is correct ?

    A.   Weightlessness only occurs for objects inside a spacecraft orbiting around the Earth.

    B.   The gravitational attraction of the Earth in the spacecraft's orbit is so weak that the gravitational force is practically zero.

    C.   The gravitational attraction of the Earth is cancelled out by that of the Moon.

    D.   Both the spacecraft and the objects inside it undergo free fall towards the Earth.

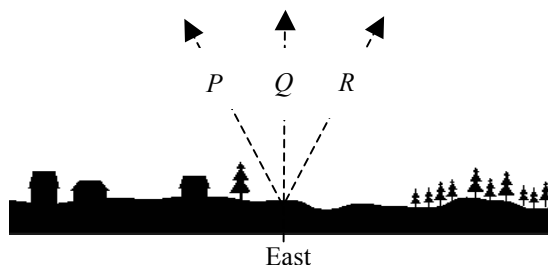| A	B	C	D
◯	◯	◯	◯

1.2 An interplanetary spacecraft is launched from the Earth. The initial speed is $\sqrt{\dfrac{3GM}{R}}$, where G is the universal gravitational constant, M is the mass of the Earth and R is the radius of the Earth. What is the speed of the spacecraft when it is very far away from the Earth ?

    A. $\sqrt{\dfrac{GM}{R}}$

    B. $\sqrt{\dfrac{GM}{2R}}$

    C. $\sqrt{\dfrac{2GM}{R}}$

    D.   zero

A	B	C	D
◯	◯	◯	◯

1.3 The Sun is about 8 kpc from the centre of the Milky Way galaxy and its rotation speed about the centre is 220 km s^{-1}. How long does it take to complete one rotation about the centre of the Milky Way ?

    A. 2.24×10^{8} years

    B. 3.55×10^{8} years

    C. 2.24×10^{11} years

    D. 3.55×10^{11} years

A	B	C	D
◯	◯	◯	◯

1.4 The figure shows a view of the horizon when you are facing east in Hong Kong. Which arrow, *P*, *Q* or *R*, represents the direction in which the stars rise from the horizon ?

    A.   Arrow *P*

    B.   Arrow *Q*

    C.   Arrow *R*

    D.   The direction varies according to the seasons.

A	B	C	D
◯	◯	◯	◯

1.5 Which statement about the motion of the Earth around the Sun is **INCORRECT** ?

    A.   The speed of the Earth in its orbit is not constant.

    B.   The Sun is at the centre of the Earth's orbit.

    C.   The distance from the Sun to the Earth changes periodically.

    D.   In general, the instantaneous velocity of the Earth is not perpendicular to the Sun's gravitational force.

A	B	C	D
◯	◯	◯	◯

1.6 Referring to the information given, which statements about stars *X* and *Y* is/are correct ?

	Absolute magnitude	Apparent magnitude
star *X*	2.8	4.7
star *Y*	5.4	3.2

(1) Star *X* is further away from the Earth than star *Y*.
(2) Star *Y* is further away from the Earth than star *X*.
(3) The distances of stars *X* and *Y* from the Earth can be determined from the information provided.

     A. (1) only
     B. (2) only
     C. (1) and (3) only
     D. (2) and (3) only

(For questions 1.7 and 1.8) The figure below shows some information of stars *W*, *X*, *Y* and *Z*.
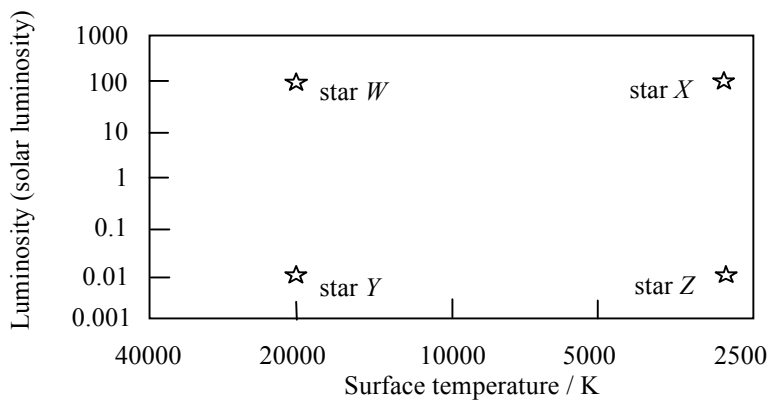
1.7 Which of the following statements is/are correct ?

(1) For star *X*, the intensity of red light is higher than any other colour light.
(2) For star *W*, the intensity of blue light is higher than any other colour light.
(3) Intensity ratio of red light to other colours of light is larger in star *Z* than that in star *Y*.

     A. (1) and (2) only
     B. (1) and (3) only
     C. (2) and (3) only
     D. (1), (2) and (3)

1.8 The absorption spectrum of star *X* contains hydrogen absorption lines. What can be concluded from this ?

(1) Star *X* is mainly composed of hydrogen.
(2) There is hydrogen gas in the outer atmosphere of star *X*.
(3) The abundance of hydrogen in star *X* is less than that in a similar star of the same temperature.

     A. (1) only
     B. (2) only
     C. (1) and (3) only
     D. (2) and (3) only

Q.1: Structured question

(a) Let R_S, T_S and L_S be the radius, surface temperature and luminosity of the Sun and R, T and L be the radius, surface temperature and luminosity of another star.

    (i) Show that $R = \left(\dfrac{T_S}{T}\right)^2 \left(\dfrac{L}{L_S}\right)^{\frac{1}{2}} R_S$.   (2 marks)

    (ii) Betelgeuse is a star with surface temperature 3650 K and luminosity 126000 times that of the Sun. Find the radius of Betelgeuse in terms of R_S. Take the surface temperature of the Sun to be 5780 K.   (2 marks)

(b) (i) An estimate of the distance to Betelgeuse is 197 pc which corresponds to the luminosity given in (a)(ii). A measurement of this distance made in 2008 was 197 ± 45 pc. Without calculating the actual value, explain how the radius of Betelgeuse found in (a)(ii) would change if the upper limit of this distance measurement were used. Betelgeuse at this distance can be treated as a point source emitting light evenly in all directions.   (2 marks)

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(ii) Suggest a reason why it is difficult to measure accurately the distance to Betelgeuse by the method of parallax. (1 mark)

(c) In 2011, some media reports suggested that when Betelgeuse undergoes a supernova explosion (i.e. the death of a star), it will appear as the "second sun" in the sky for a few weeks. Referring to the information given below, explain whether this is true or not by comparing the brightness of Betelgeuse in supernova explosion with that of the Sun. (3 marks)

A star of similar mass as that of Betelgeuse gives off a luminosity of about 10^9 times that of the Sun for a certain period of time when the star undergoes a supernova explosion. About 1% of the power of explosion appears in the form of visible light. Take the distance of Betelgeuse to be 200 pc.

Go on to the next page

Section B : Atomic World

Q.2: Multiple-choice questions

2.1 From the classical point of view what are the limitations of Rutherford's model of the atom ?

   (1) Atoms would continuously emit electromagnetic radiation.
   (2) Atoms would be unstable and they would collapse eventually.
   (3) The atomic emission spectrum would be continuous instead of discrete.

     A. (1) and (2) only
     B. (1) and (3) only
     C. (2) and (3) only
     D. (1), (2) and (3)

     A   B   C   D

2.2 Which of the following statements about spectra is/are correct ?

   (1) A tungsten-filament lamp emits a continuous spectrum.
   (2) A line absorption spectrum can be obtained when a tungsten-filament lamp is viewed through some hydrogen gas.
   (3) The emission spectrum of hydrogen consists of dark lines on a bright background.

     A. (1) and (2) only
     B. (1) and (3) only
     C. (2) and (3) only
     D. (1), (2) and (3)

     A   B   C   D

2.3 Photons with energy 7 eV are incident on the cathode of a photocell. The maximum kinetic energy of the photoelectrons emitted is 4 eV. When photons of energy 4 eV are incident on the cathode, the stopping potential will be

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

     A   B   C   D

2.4 In studying the photoelectric effect, a certain metal is illuminated by ultraviolet radiation of different frequency f and the maximum kinetic energy K of the photoelectrons emitted is measured. The graph is plotted as shown.
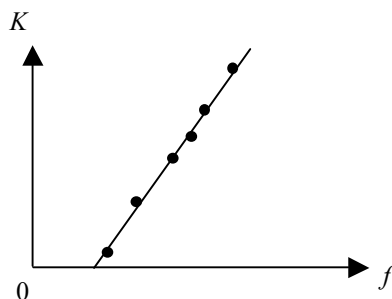
What would happen to the graph if ultraviolet radiation of higher intensity is shone on the same metal ?

	slope of the graph	intercept of the graph on the horizontal axis
A.	smaller	unchanged
B.	larger	unchanged
C.	unchanged	unchanged
D.	unchanged	smaller

     A   B   C   D

2.5 According to Bohr's model of the hydrogen atom, the ratio of the radius of the electron's orbit in the first excited state to that in the second excited state is

A. $1:2$.
B. $1:\sqrt{2}$.
C. $4:9$.
D. $2:3$.

A   B   C   D
○   ○   ○   ○

2.6 Which of the following has the shortest de Broglie wavelength ?

A. A 60 kg person walking at 0.8 m s^{-1}.
B. A bird of mass 0.3 kg flying at 20 m s^{-1}.
C. A basketball of mass 0.6 kg moving at 12 m s^{-1}.
D. A bullet of mass 0.05 kg moving at 800 m s^{-1}.

A   B   C   D
○   ○   ○   ○

2.7 Which of the following properties could explain the Lotus effect ?

A. water-attractive property
B. water-repelling property
C. wave-particle duality of matter
D. high electrical conductivity

A   B   C   D
○   ○   ○   ○

2.8 If substance is reduced in size to become particles of about 10 nm large, which of the following properties of these particles would differ from those of the substance in bulk form ?

(1) optical
(2) mechanical
(3) electrical

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

A   B   C   D
○   ○   ○   ○

Go on to the next page

Q.2: Structured question

The energy level of an electron in a hydrogen atom is given by:

$$E = -\frac{13.6}{n^2} \text{ eV}$$

(a) Explain the physical meaning of the negative sign of E. (1 mark)

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(b) State **TWO** postulates of Bohr's model of the hydrogen atom which are not "classical". (2 marks)

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(c) Hydrogen gas in ground state is illuminated by an ultraviolet light beam of wavelengths 102.8 nm and 100.0 nm. It is found that the 102.8 nm ultraviolet light is absorbed by the hydrogen gas while the 100.0 nm ultraviolet light is unaffected.

(i) Calculate the energy of an ultraviolet light photon of wavelength 102.8 nm in eV. What is the quantum number of the hydrogen atom after absorbing such a photon ? (3 marks)

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(ii)   Why does the 100.0 nm ultraviolet light pass through the hydrogen gas without absorption ?   (1 mark)

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(iii)   When the excited hydrogen atom returns to its ground state, how many transitions are possible ? State which one of these transitions gives visible light and explain your answer. Given : the energy of a visible light photon ranges from 1.7 eV to 3.2 eV.   (3 marks)

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Answers written in the margins will not be marked.

Answers written in the margins will not be marked.

Answers written in the margins will not be marked.

Section C : Energy and Use of Energy

Q.3:   **Multiple-choice questions**

3.1   Which of the following lamps has the greatest end-use energy efficiency ?

	luminous flux	**power rating**
A.	750 lm	15 W
B.	900 lm	30 W
C.	750 lm	60 W
D.	600 lm	90 W

<div align="right">
A   B   C   D
○   ○   ○   ○
</div>

3.2   Below is a diagram of a room, the illuminance at corner P is E under the illumination of a point light source S as shown. Neglect the reflections from the room surfaces.
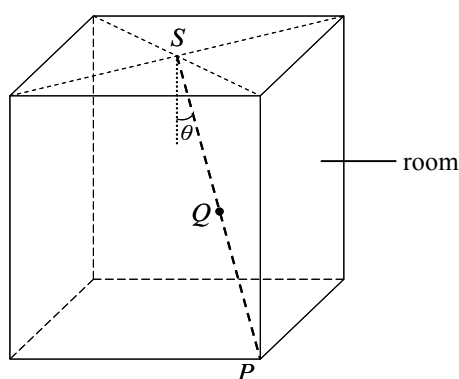
The illuminance at point Q midway between P and S is

A. $\dfrac{\sqrt{2}E}{\cos\theta}$.

B. $2E\cos\theta$.

C. $4E$.

D. $8E$.

<div align="right">
A   B   C   D
○   ○   ○   ○
</div>

3.3   Which sequence best describes the energy conversion in an electric vehicle's regenerative braking system during braking ?

A.   kinetic energy → electrical energy
B.   kinetic energy → chemical energy
C.   kinetic energy → chemical energy → electrical energy
D.   kinetic energy → electrical energy → chemical energy

<div align="right">
A   B   C   D
○   ○   ○   ○
</div>

3.4 A container is modified into an office as shown. A window of 1 m × 2 m is installed on the front side of the container. Apart from the bottom, assume that all the five surfaces of the container are under sunlight. On all the five surfaces, the equivalent temperature difference between the interior and the exterior of the container is 7ºC.

Given: U-value of metallic material of the container = 26.2 W m^{-2} K^{-1}

U-value of glass of the window = 1.8 W m^{-2} K^{-1}
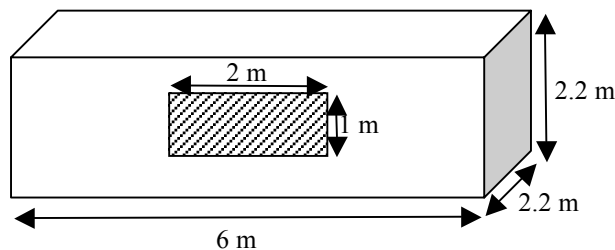
Estimate the Overall Thermal Transfer value (OTTV) in W m^{-2} of the container office.

- A. 25.2
- B. 26.2
- C. 176.5
- D. 183.4

A	B	C	D
○	○	○	○

3.5 Estimate the time required to cool an insulated room of interior volume 29.0 m^3 from 37 ºC to 24 ºC by an air conditioner of cooling capacity 2.2 kW.

Given: density of air = 1.2 kg m^{-3}

specific heat capacity of air = 1000 J kg^{-1} K^{-1}

- A. 171 s
- B. 206 s
- C. 380 s
- D. 586 s

A	B	C	D
○	○	○	○

3.6 The blades of a wind turbine are 5 m long, which are set to rotate when wind blows normally at 12 m s^{-1}. The overall efficiency of the wind turbine is 25%. Estimate the number of wind turbines required to generate an electrical power output of 1 MW. Given: density of air = 1.2 kg m^{-3}

- A. 12
- B. 49
- C. 122
- D. 196

A	B	C	D
○	○	○	○

3.7 The difference in water levels of a hydroelectric power plant is 50 m. Water passes through the turbine of the power plant at the lower water level at a rate of 3000 kg s^{-1}. Estimate the efficiency of the turbine if its output power is 1 MW. (g = 9.81 m s^{-2})

- A. 32%
- B. 60%
- C. 68%
- D. 75%

A	B	C	D
○	○	○	○

3.8 What would happen if the moderator of a nuclear fission reactor fails to function ?

- A. The chain reaction might stop eventually.
- B. Neutrons cannot be absorbed by the moderator.
- C. Heat cannot be transferred to the steam generator.
- D. The fuel rods might melt down.

A	B	C	D
○	○	○	○

Q.3:   Structured question

(a)   It is known that even on a clear day, the atmosphere absorbs an average of 26.8% of solar power. Find the maximum solar power per unit area reaching the Earth's surface. Given: solar constant = 1366 W m^{-2} (1 mark)

(b)   State the energy conversion of a solar cell and suggest a way to improve its absorption of energy.   (2 marks)

(c)   *Solar Impulse* is a Swiss project to make a solar-powered aircraft that can fly long distances. Its first prototype HB-SIA has four engines driven by batteries which are charged by the solar cells installed on the aircraft. HB-SIA made a successful international flight in May 2011. The specifications of HB-SIA are as follows:

● Power of each engine is 7.35 kW
● The surface area of each solar cell panel = 0.0172 m^2
● Conversion efficiency of solar cells = 12% during midday at normal incidence of solar radiation

(i)   Assume that all the electrical power output of the solar cells is shared equally by the four engines. Estimate the number of solar cells required if each engine is driven to its full power. Assume that all the solar cells on HB-SIA receive the same solar power per unit area found in (a).   (3 marks)

(ii) For the 2011 flight, a total of 11628 solar cells are installed on HB-SIA for a certain reason, which would not have been enough to drive the four engines to their full power. Suggest a practical reason for such a design. (1 mark)

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(d) Explain why solar power is said to be a *renewable energy source*. Besides solar power, suggest a renewable energy source that is *most feasible* to be used in Hong Kong. Justify your choice. (3 marks)

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Section D : Medical Physics

Q.4: **Multiple-choice questions**

4.1 Joan cannot see things clearly closer than 0.80 m from her eyes. What kind of lens and with what power should she wear so as to correct her near point to 0.25 m ?

A. convex lens, +2.75 D
B. convex lens, +5.25 D
C. concave lens, −2.75 D
D. concave lens, −5.25 D

A   B   C   D
○   ○   ○   ○

4.2 The diagram shows a coherent bundle of optical fibres consisting of 36 square elements. The bundle is used for viewing the object shown (Drawing is not to scale).
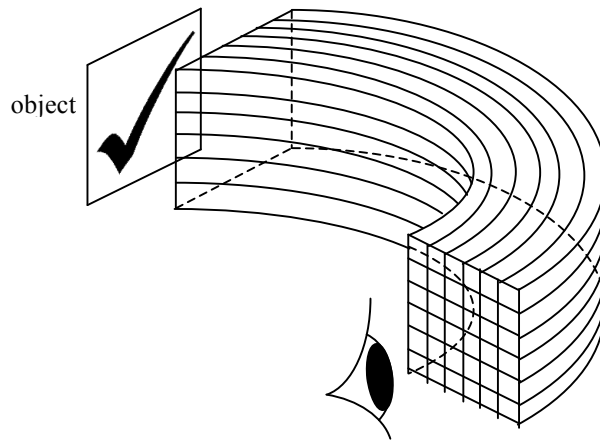
Which of the following best represents the picture as viewed by the observer ?

A.

B.

C.

D.

A   B   C   D
○   ○   ○   ○

4.3 Three musicians play three different notes *P*, *Q* and *R*. The loudness of these notes as heard by an audience is the same and the notes are shown in the equal loudness graph below. Their play is picked up by a microphone and is then reproduced by a loudspeaker at 20 dB above the original sound intensity level. Which of the following is the order of the loudness of the reproduced sound ?
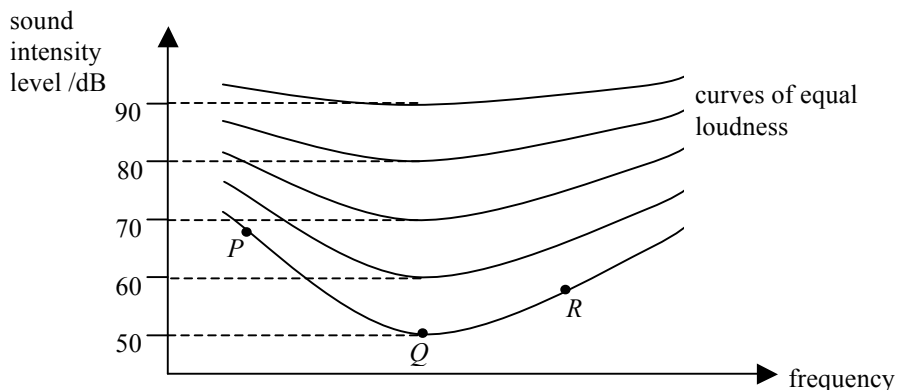
A. $P = Q = R$
B. $P > R > Q$
C. $R > Q > P$
D. $Q > R > P$

A   B   C   D
○   ○   ○   ○

4.4 The figure shows an ultrasound B-scan image. Which statements are correct ?
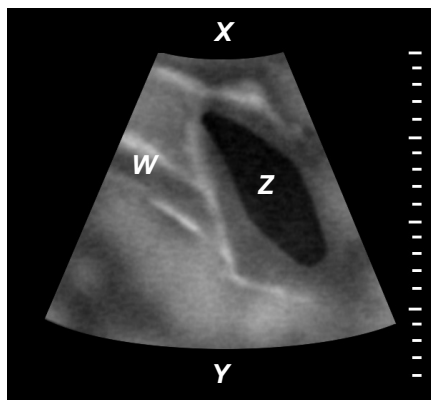
(1) *X* is closer to the scanner than *Y*.
(2) Area *Z* is low in brightness because it absorbs more ultrasound.
(3) Area *W* is high in brightness because it reflects more ultrasound.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

A   B   C   D
○   ○   ○   ○

4.5 Given that the intensity reflection coefficient between fat and muscle is 1%. Estimate the acoustic impedance of muscle if the acoustic impedance of fat is 1.38×10^6 kg m^{-2} s^{-1}.

A. 1.5×10^6 kg m^{-2} s^{-1}
B. 1.6×10^6 kg m^{-2} s^{-1}
C. 1.7×10^6 kg m^{-2} s^{-1}
D. 1.8×10^6 kg m^{-2} s^{-1}

A   B   C   D
○   ○   ○   ○

4.6 A certain body tissue of 5 cm thick reduces the intensity of a particular X-ray beam to 59% of its original value. What is the linear attenuation coefficient of this body tissue ?

A. 0.066 m^{-1}
B. 0.085 m^{-1}
C. 8.2 m^{-1}
D. 10.6 m^{-1}

A B C D
○ ○ ○ ○

4.7 The figure below shows a thyroid scan using iodine-131 tracer. The darker part represents the area with higher intensity detected by a gamma camera. Which deduction about area X is correct ?
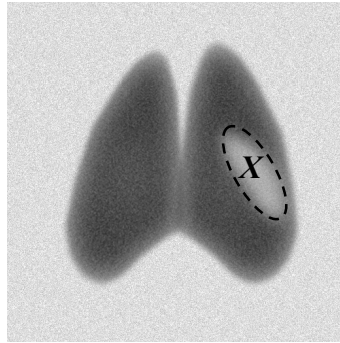
A. It is something with abnormally high attenuation of γ radiation.
B. It is something with abnormally low attenuation of γ radiation.
C. It absorbs an excessive amount of iodine.
D. It cannot absorb iodine normally.

A B C D
○ ○ ○ ○

4.8 Which statements best explain why technetium-99m is suitable for the use of medical radionuclide imaging ?

(1) It can be combined with a wide range of chemicals and proteins to form radioactive tracers.
(2) Radiation exposure to patients can be kept low as the half-life of technetium-99m is short.
(3) It emits suitable γ radiations that can be attenuated by different tissues to give a radiographic image.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

A B C D
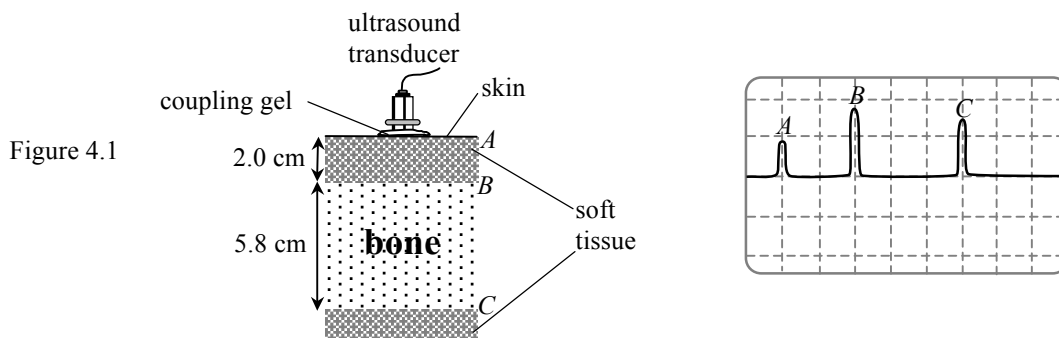○ ○ ○ ○

Q.4: **Structured question**

(a) Figure 4.1 shows a cross-section of a piece of bone with 5.8 cm thickness situated below a layer of soft tissue that is 2.0 cm thick. An ultrasound transducer with coupling gel is applied to the skin. The ultrasound pulses reflected from various boundaries *A*, *B* and *C* are displayed on a CRO.

Figure 4.1

(i) Find the ratio of the speed of ultrasound in bone to that in soft tissue. (2 marks)

The values of acoustic impedance of various body tissues to the ultrasound used are tabulated below.

tissues	acoustic impedance / kg m^{-2} s^{-1}
soft tissue (average)	1.63×10^6
bone	7.78×10^6

(ii) If the speed of ultrasound in soft tissue is 1580 m s^{-1}, estimate the density of bone. (3 marks)

Go on to the next page

(b) (i) Describe the working principles of ultrasound B-scan imaging. (3 marks)

(ii) State **ONE** advantage and **ONE** limitation of using ultrasound scans in the context of medical imaging.
(2 marks)

END OF PAPER

Sources of materials used in this paper will be acknowledged in the *Examination Report and Question Papers* published by the Hong Kong Examinations and Assessment Authority at a later stage.