2024-DSE
PHY
PAPER 2

HONG KONG EXAMINATIONS AND ASSESSMENT AUTHORITY
HONG KONG DIPLOMA OF SECONDARY EDUCATION EXAMINATION 2024

PHYSICS PAPER 2

Question-Answer Book

11:45 am – 12:45 pm (1 hour)
This paper must be answered in English

Please stick the barcode label here.

Candidate Number

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 to the structured questions in the **ANSWER BOOK** provided. 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** the Answer Book.

(5) The Question-Answer Book and Answer Book will be collected **SEPARATELY** at the end of the examination.

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

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

(8) 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.

* A 1 5 0 E 2 M C *

Section A : Astronomy and Space Science

Q.1: Multiple-choice questions

1.1 The size of a typical galaxy is

(1) larger than that of a typical star cluster.
(2) smaller than that of a typical cluster of galaxies.
(3) smaller than that of a typical nebula.

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

A B C D

1.2 If the Earth's mass were doubled and continued to move in its present orbit around the Sun, its orbital period

A. would increase.
B. would remain unchanged.
C. would decrease.
D. cannot be determined with the information given.

A B C D

1.3 The escape velocity from Earth's surface is v. If an object is launched from the Earth's surface with initial speed $2v$ (assume the object's flight is unpowered except during launching), what will be its speed when the object is far away from the Earth ? Neglect the effects of the Earth's atmosphere and of other celestial bodies.

A. $\frac{v}{\sqrt{2}}$
B. v
C. $\sqrt{2}\,v$
D. $\sqrt{3}\,v$

A B C D

1.4 Which of the following descriptions about the Copernican model and Ptolemaic model of the solar system is/are correct ?

(1) The Copernican model is more accurate in predicting planetary motion.
(2) The Copernican model's explanation of retrograde motion of planets is simpler.
(3) The phases of Venus can be explained by both models.

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

A B C D

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1.5 Figure (1) shows a binary system consisting of two stars orbiting in uniform circular motion about their centre of mass C. O is a distant observer on the same orbital plane of the stars.

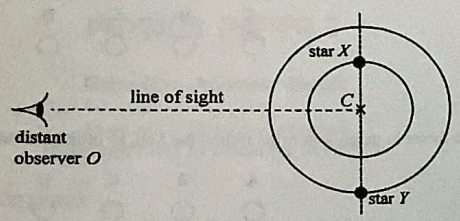


Figure (1)

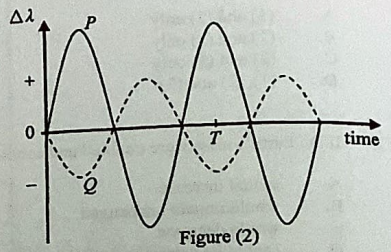


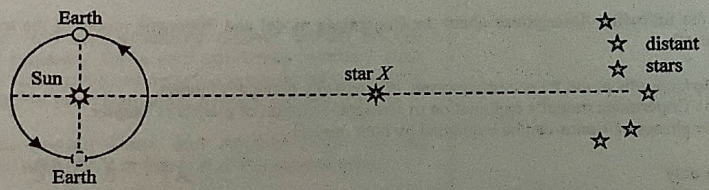
Figure (2)

The time variation of the Doppler shift $\Delta\lambda$ of a particular spectral line from the two stars measured by O is shown in Figure (2). Time T on the graph is the instant corresponding to Figure (1). In what direction is star Y moving at time T? Which curve, P or Q, is for the more massive star?

	direction of motion of star Y at time T	curve for the more massive star
A.	towards O	Q
B.	towards O	P
C.	away from O	Q
D.	away from O	P

A ○ B ○ C ○ D ○

1.6



If star X is 20 pc from the Earth, what is its maximum angular displacement against the distant stars when the star is viewed from the Earth 6 months apart?

A. 0.025 arc seconds
B. 0.05 arc seconds
C. 0.1 arc seconds
D. 0.5 arc seconds

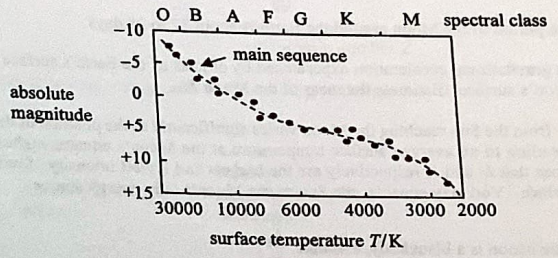
A ○ B ○ C ○ D ○

1.7 A student has determined the apparent magnitude of star X to be m. After measuring the distance D to star X, the absolute magnitude of X is deduced to be M. However, after re-examining the data, D was in fact underestimated (i.e. D should be larger). What can be said about the actual apparent and absolute magnitudes of X?

	apparent magnitude	absolute magnitude
A.	larger than m	larger than M
B.	same as m	less than M
C.	less than m	less than M
D.	same as m	larger than M

A ○ B ○ C ○ D ○

1.8



Star X is a main sequence star. It has a radius 8 times that of the Sun (a class G star). Its luminosity is 250000 times that of the Sun. Which spectral class does star X belong to?

A. class M
B. class K
C. class G
D. class O

A ○ B ○ C ○ D ○

Please stick the barcode label here.

Q.1: Structured question

The Moon is the only natural satellite of the Earth and assume that it orbits the Earth in a circular orbit of radius $r = 384400$ km.

Given: mass of the Earth $M_E = 5.97 \times 10^{24}$ kg

radius of the Moon $R_M = 0.273 \times$ radius of the Earth $= 0.273\, R_E$

(a) (i) Verify that the period of the Moon around the Earth is about 27 to 28 days. (3 marks)

(ii) Given that the gravitational acceleration experienced by objects on the Earth's surface is about 6 times that on the Moon's surface. Estimate the mass of the Moon M_M. (3 marks)

(b) The amount of energy from the Sun reaching the Moon varies significantly as the position of the Moon relative to the Sun changes, leading to an average surface temperature at the Moon's equator highest at 390 K and lowest at 95 K. Suppose that I_H and I_L respectively are the highest and lowest intensity of radiation from the Sun on the Moon's surface. You may consider the Sun as the Moon's only energy source.

(i) Assuming that the Moon is a blackbody, estimate $\frac{I_H}{I_L}$. (2 marks)

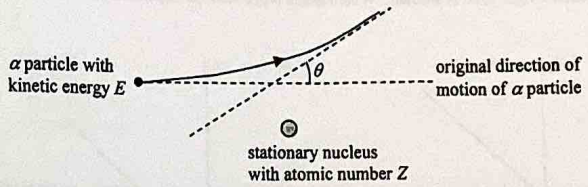
(ii) State another assumption made for the above estimation besides assuming that the Moon is a blackbody. (1 mark)

(c) Suppose a telescope is constructed on the Moon. State one advantage of such a telescope compared to that built on the Earth. (1 mark)

Section B : Atomic World

Q.2: Multiple-choice questions

2.1 Initially an α particle with kinetic energy E is far away from a stationary nucleus of atomic number Z. The α particle describes a curved trajectory making an angle of deviation θ with its original direction of motion as shown.



Which of the following change in E and Z would give the greatest θ?

	E	Z
A.	increase	increase
B.	increase	decrease
C.	decrease	increase
D.	decrease	decrease

A ○ B ○ C ○ D ○

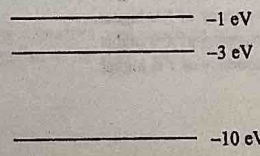
2.2 When an electron collides with a gas atom and

(1) if the collision is elastic, the electron transfers negligible kinetic energy to the atom.
(2) if the atom is excited, all kinetic energy of the electron must be transferred to the atom.
(3) if the atom is ionized, the atom must have absorbed the electron that collided with it.

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

A ○ B ○ C ○ D ○

2.3 The figure shows the energy levels of an atom. Photons are emitted due to electron transitions between energy levels.



Which of the following statements is/are correct ? Given: the energy of photons in the visible spectrum lies between 1.78 eV and 3.10 eV

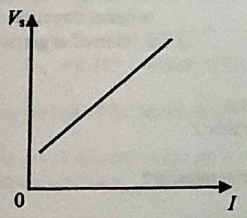
(1) Some of these photons are in the visible spectrum.
(2) At most, photons of two different frequencies can be emitted.
(3) The photons with the longest wavelength come from transitions between –1 eV and –10 eV.

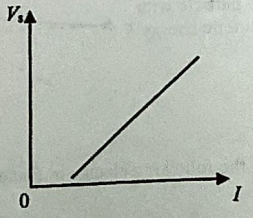
A. (1) only
B. (2) only
C. (1) and (3) only
D. (2) and (3) only

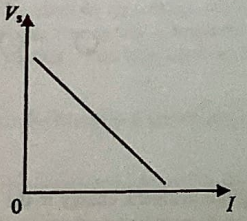
A ○ B ○ C ○ D ○

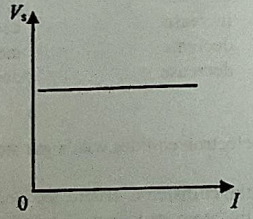
Please stick the barcode label here.

2.4 In a photoelectric emission experiment, the variation of the stopping potential V_s of a metal with the intensity I of the monochromatic light used is studied. Which graph represents the experimental result ?

A. 

B. 

C. 

D. 

A	B	C	D
○	○	○	○

2.5 Metal X and Y are illuminated in turns by monochromatic lights of wavelengths λ_1 and λ_2. Both metals show photoemission for λ_1 while only metal Y shows photoemission for λ_2. Which deduction below is correct ?

A. $\lambda_1 > \lambda_2$ and the threshold frequency of X is higher.
B. $\lambda_1 > \lambda_2$ and the threshold frequency of Y is higher.
C. $\lambda_1 < \lambda_2$ and the threshold frequency of X is higher.
D. $\lambda_1 < \lambda_2$ and the threshold frequency of Y is higher.

A	B	C	D
○	○	○	○

2.6 The de Broglie wavelength of an electron of mass m is equal to the wavelength of a photon that has energy E. Which of the following expressions is/are equal to the momentum of the electron ? (c = speed of light in vacuum)

(1) $\sqrt{2mE}$

(2) mc

(3) $\frac{E}{c}$

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

A	B	C	D
○	○	○	○

2.7 In a transmission electron microscope (TEM), emitted electrons accelerate in an electron gun and then pass through components (1) - (3) as shown in the block diagram below before being projected through a lens and forming an image on a screen.

electron gun	(1)	(2)	(3)	projection lens	screen

Which of the following combinations is correct ?

	(1)	(2)	(3)
A.	condensing lens	objective lens	specimen
B.	condensing lens	specimen	objective lens
C.	objective lens	specimen	condensing lens
D.	specimen	condensing lens	objective lens

A	B	C	D
○	○	○	○

2.8 Zinc oxide is a common ingredient in sunscreen products. Nanotechnology is often used in these products because

A. zinc oxide in bulk is not able to block ultra-violet rays.
B. zinc oxide in bulk is harmful to the skin.
C. sunscreen products using nanosized zinc oxide particles are water repelling.
D. sunscreen products using nanosized zinc oxide particles look transparent when applied on the skin.

A	B	C	D
○	○	○	○

Please stick the barcode label here.

Q.2: Structured question

Both Rutherford's atomic model and Bohr's atomic model picture the motion of an electron around the atomic nucleus.

(a) Explain why Rutherford's atomic model is not stable. (2 marks)

(b) (i) Name the kind of spectrum produced by a beam of white light passing through iodine vapour. (1 mark)

(ii) Referring to Bohr's atomic model, explain the formation of such kind of spectrum in (i). (2 marks)

(c) Answer the following parts by referring to the energy level equation for hydrogen atom.

(i) Find the momentum of the emitted photon resulting from the transition of an electron from the 6^{th} energy level (quantum number $n = 6$) of a hydrogen atom to the lowest energy level. (3 marks)

(ii) The energy E_n of the n^{th} energy level of a hydrogen atom can also be expressed as

$$E_n = -\frac{K}{r_n}$$

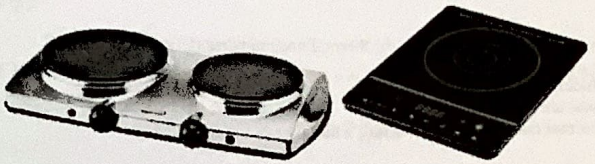
where r_n is the radius of the orbit at the n^{th} energy level, K is a positive constant and E_∞ is taken to be zero.

Express the electron's orbital radius r_6 at the 6^{th} energy level in terms of the orbital radius r_1 at the lowest energy level. (2 marks)

Section C : Energy and Use of Energy

Q.3: Multiple-choice questions

3.1 After using an electric hotplate and an induction cooker to cook the same dish, it is found that the surface temperature of the electric hotplate is much higher.

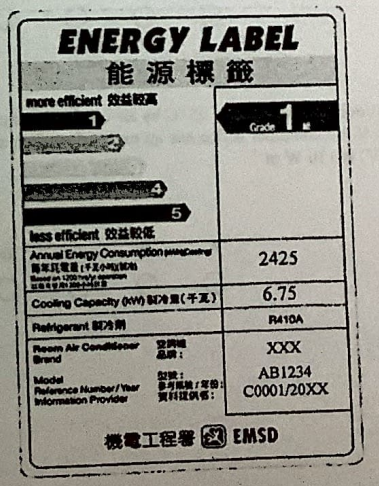


The most probable reason is that

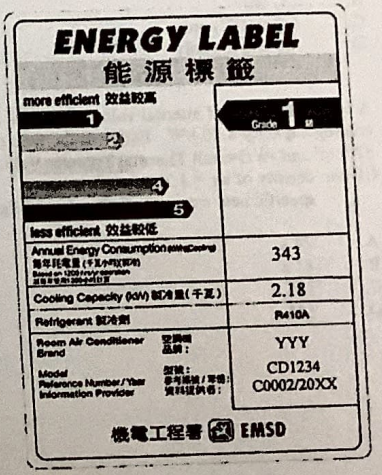
A. the power of the electric hotplate is much higher.
B. the electric hotplate heats up its plate and transfers thermal energy to the cooking utensil mainly by conduction.
C. the process of electromagnetic induction does not produce thermal energy.
D. the surface of the induction cooker is made of glass which is a poor conductor of heat.

A ○ B ○ C ○ D ○

3.2 The energy labels of air-conditioners P and Q are shown below. The annual energy consumption (kW h) of each of them is based on 1200 hours of operation.



air-conditioner P



air-conditioner Q

Which one is (a) more energy efficient, (b) more suitable for a small room ?

	more energy efficient	more suitable for a small room
A.	Q	P
B.	P	P
C.	Q	Q
D.	P	Q

A ○ B ○ C ○ D ○

3.3 Which component(s), evaporator, compressor, condenser and expansion valve, is/are located in the **indoor unit of a split-type air-conditioner ?**

A. expansion valve, evaporator and condenser
B. expansion valve and compressor
C. evaporator
D. compressor

A	B	C	D
○	○	○	○

3.4 Which of the factors below determine the thermal transmittance (U-value) of a wall ?

(1) the thickness of the wall
(2) the total area of the wall
(3) the thermal conductivity of the wall's building material

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

A	B	C	D
○	○	○	○

3.5 Compared to common glass windows, which of the following about a double-glazed window is/are correct ?

(1) Radiation penetrating the double-glazed window is significantly reduced.
(2) The gas trapped in the double-glazed window has a much lower thermal transmittance than glass.
(3) Double-glazed windows are not suitable for use in cold areas as more thermal energy would be lost through them.

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

A	B	C	D
○	○	○	○

3.6 A container office of internal volume 37.5 m^3 is to be cooled from 33 °C to 25 °C by air-conditioners of total cooling capacity 8.80 kW. Estimate the time required if the container office has an exposed surface area of 57.5 m^2 and its Overall Thermal Transfer Value (OTTV) is 110 $W\ m^{-2}$.
Given: density of air = 1.20 $kg\ m^{-3}$
specific heat capacity of air = 1000 $J\ kg^{-1}\ °C^{-1}$

A. 24 s
B. 41 s
C. 118 s
D. 145 s

A	B	C	D
○	○	○	○

3.7 On a particular day, steady wind of speed 8.0 $m\ s^{-1}$ blows normally to a wind turbine for 12 hours while for the rest of the day the wind speed is too low for operation. The maximum energy generated that day is equivalent to a day with a steady wind of speed of _____ throughout the day.

A. 6.3 $m\ s^{-1}$
B. 5.0 $m\ s^{-1}$
C. 4.0 $m\ s^{-1}$
D. 3.2 $m\ s^{-1}$

A	B	C	D
○	○	○	○

3.8 The equation below represents a typical fission reaction that occurs in a nuclear power plant.

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{90}_{36}Kr + ^{144}_{56}Ba + 2^{1}_{0}n$$

Estimate the energy released when 1.00 kg of U-235 undergoes this fission reaction. Given that binding energies per nucleon of U-235, Kr-90 and Ba-144 are 7.59 MeV, 8.59 MeV and 8.26 MeV respectively. The mass of one mole of U-235 is 235 g.

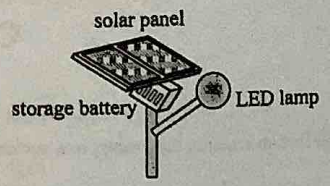
A. 2.38×10^{25} MeV
B. 1.08×10^{26} MeV
C. 4.56×10^{26} MeV
D. 4.58×10^{26} MeV

A	B	C	D
○	○	○	○

Q.3: Structured question

Figure 3.1 shows a typical solar street lamp which consists of a solar panel, a storage battery and an LED lamp.

Figure 3.1



(a) Describe the stages of conversion of solar energy involved when the storage battery is being charged. (1 mark)

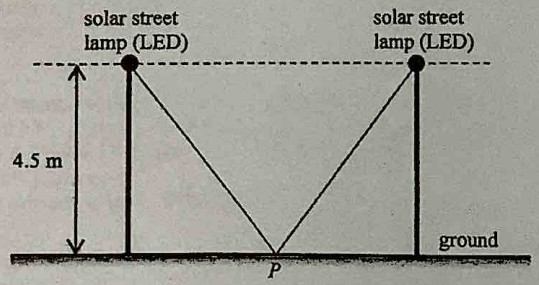
(b) The solar panel has an area of 0.111 m^2 and the battery can store a maximum of 405 W h energy. The overall efficiency of the charging system is 25%. Given: the maximum solar radiation power per unit area reaching the Earth's surface is 980 $W m^{-2}$.

(i) The battery is completely discharged initially. Estimate the minimum charging time, in hours, for the solar panel to fully charge up the battery. (2 marks)

(ii) The rated power of the LED lamp is 30 W. Suppose 80% of the energy stored in the battery can be used for lighting. Estimate the maximum duration of lighting in hours. (2 marks)

(c) Such solar street lamps (rated power 30 W each) are installed at a height of 4.5 m above the ground along a road as shown in Figure 3.2.

Figure 3.2



Each street lamp gives a luminous flux of 5160 lm.

(i) Find the efficacy of such a street lamp in lm W^{-1}. (1 mark)

(ii) The illuminance on the ground mid-way (*P*) between two adjacent street lamps should be at least 10 lx. Estimate the maximum separation between adjacent street lamps. (3 marks)

(d) Although the efficacy of compact fluorescent lamps is comparable to that of LED lamps, LED lamps are preferred for systems employing solar panels. Explain. (1 mark)

Section D : Medical Physics

Q.4: Multiple-choice questions

4.1 The near point of Mary is at 68 cm. With her spectacle lenses held at 1.5 cm away from the eyes by the spectacle frame, she is able to read clearly texts 25 cm from her eyes. What is the power of her spectacle lenses ?

A. +2.25 D
B. +2.75 D
C. +5.25 D
D. +5.75 D

A ○ B ○ C ○ D ○

4.2 Which of the following statements about hearing is **INCORRECT** ?

A. The auditory canal of the outer ear only allows sound of audible frequencies to get through.
B. The middle ear is responsible for sound amplification.
C. The inner ear is responsible for converting sound into electrical signals to the brain.
D. Hearing involves hair cells being stimulated mechanically in the inner ear.

A ○ B ○ C ○ D ○

4.3 Which statement about a fibre optic endoscope is **INCORRECT** ?

A. Each optical fibre inside the endoscope is wrapped with material having a refractive index slightly lower than that of the fibre.
B. The very small diameters of optical fibres ensure their flexibility for bending.
C. The same bundle of optical fibres is used for illumination as well as image formation.
D. The resolution of image is limited by how thin the optical fibres are.

A ○ B ○ C ○ D ○

4.4 When new windows were put into a house, the sound intensity measured inside changed from I_1 to I_2. Given that I_0 is the threshold sound intensity. The change in sound intensity level is given by

A. $10\log_{10}\left(\frac{I_1-I_2}{I_0}\right)$.
B. $10\log_{10}\left(\frac{I_2-I_1}{I_0}\right)$.
C. $10\log_{10}\left(\frac{I_2}{I_0}\right)-10\log_{10}\left(\frac{I_1}{I_0}\right)$.
D. $10\log_{10}\left(\frac{I_1}{I_0}\right)-10\log_{10}\left(\frac{I_2}{I_0}\right)$.

A ○ B ○ C ○ D ○

4.5

Tissue	Density / kg m^{-3}	Speed of sound / m s^{-1}
bone	1700	3780
fat	950	1450
muscle	1070	1590

The table lists the density of some tissues and the speed of sound in those tissues. Which statements about these tissues are correct ?

(1) Fat has the lowest acoustic impedance.
(2) Among the interfaces formed by the tissues listed, fat-muscle interface has the smallest intensity reflection coefficient.
(3) Bone-muscle interface and muscle-bone interface have the same intensity reflection coefficient.

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

A ○ B ○ C ○ D ○

4.6 Linear attenuation coefficients (unit: cm^{-1}) of X-rays for different tissues are tabulated below.

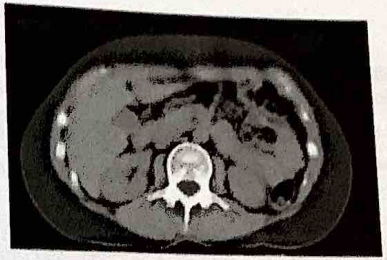
Tissue	20 keV X-rays	50 keV X-rays	100 keV X-rays
bone	5.41	0.573	0.251
fat	0.517	0.193	0.154
muscle	0.872	0.240	0.178
lung	0.874	0.238	0.178

Determine which statement is INCORRECT according to the information given.

A. Linear attenuation coefficient decreases with increasing energy of X-rays.
B. Bone has the greatest decrease in X-rays absorption from low energy to high energy X-rays.
C. 100 keV X-rays are the most suitable for X-ray radiography involving bone fractures.
D. The intensity of 20 keV X-rays is approximately reduced to 13% of its initial value after passing through 10 cm thick muscle.

A ○ B ○ C ○ D ○

4.7



Which of the following statements about the computed tomography (CT) image above is/are correct ?

(1) The image shows the absorption levels of X-rays by tissues.
(2) The white region of the image indicates the highest level of reflection of X-rays.
(3) The absorption levels of X-rays represent different functions of tissues.

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

A ○ B ○ C ○ D ○

4.8 Which of the following statements about radionuclide imaging (RNI) is/are correct ?

(1) Spatial resolution of RNI is better compared to ultrasound scan.
(2) RNI uses radioisotopes that emit X-rays.
(3) Most radioisotopes for RNI are artificially produced as they do not exist naturally.

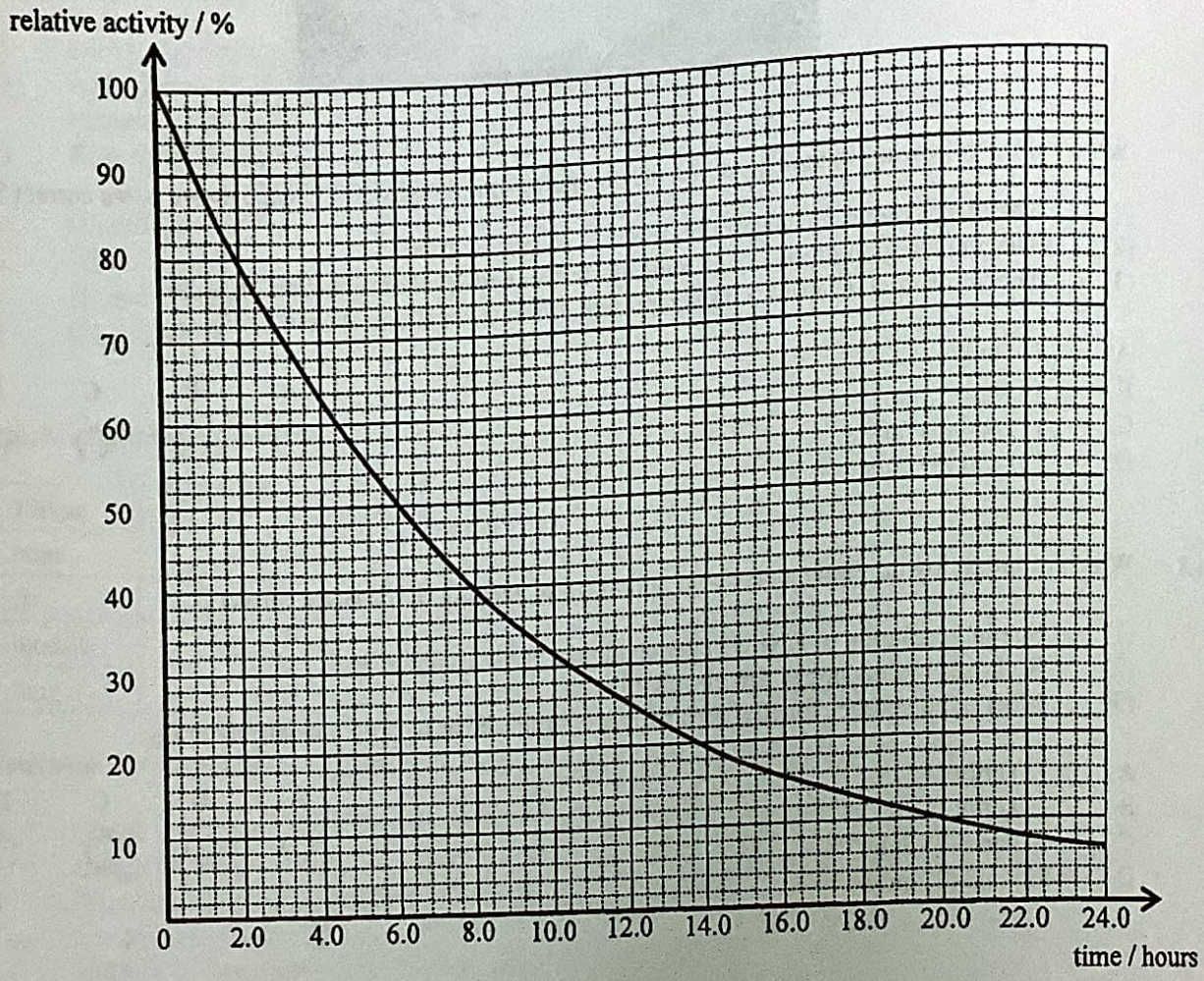
A. (1) only
B. (3) only
C. (1) and (2) only
D. (2) and (3) only

A ○ B ○ C ○ D ○

Q.4: Structured question

(a) α, β and γ rays pose radiation hazard to the human body. Referring to the penetrating power and ionizing power of radiation, explain why γ rays are chosen for radionuclide imaging (RNI). (2 marks)

(b) The decay curve below represents the time variation of the relative activity of ^{99m}Tc (with background radiation already corrected for).



(i) Find the 'physical half-life' of ^{99m}Tc (in hours). (1 mark)

(ii) In an RNI study, a solution containing a ^{99m}Tc compound is prepared for injection to the patient concerned. The solution was calibrated at 9:00 am and found that each mL of solution has 550 MBq radioactivity. If the injection to the patient is scheduled at 11:00 am (i.e. two hours later) with a prescribed dosage of 600 MBq, find the volume of solution required, in mL. (3 marks)

Given that the 'effective half-life' of ^{99m}Tc in a human body is 4.8 hours.

(iii) Find the percentage of dosage left in the body 24 hours after the injection. (2 marks)

(iv) According to the decay curve of ^{99m}Tc, the relative activity of ^{99m}Tc would decrease to about 6% in 24 hours. Account for the difference between the result found in (iii) and this value (i.e. about 6%). (2 marks)

END OF PAPER