2018-DSE
PHY
PAPER 2

HONG KONG EXAMINATIONS AND ASSESSMENT AUTHORITY
HONG KONG DIPLOMA OF SECONDARY EDUCATION EXAMINATION 2018

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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 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 An unpowered spacecraft is travelling in an elliptical orbit around the Earth. Which of the following descriptions is/are correct ?

(1) The acceleration of the spacecraft is always pointing towards the centre of the elliptical orbit.
(2) The magnitude of the acceleration of the spacecraft is greatest when it is moving fastest.
(3) The gravitational potential energy of the spacecraft remains unchanged in the orbit.

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

A ○ B ○ C ○ D ○

1.2 The escape velocity at the Earth's surface is 11.2 km s^{-1}. A space probe launched from the Earth's surface attains a speed of 6 km s^{-1} when it is very far away from the Earth. Find the launching speed of the space probe. Assume that the flight is unpowered except during launching and neglect the effects of other celestial bodies.

A. 12.7 km s^{-1}
B. 15.6 km s^{-1}
C. 16.4 km s^{-1}
D. 17.2 km s^{-1}

A ○ B ○ C ○ D ○

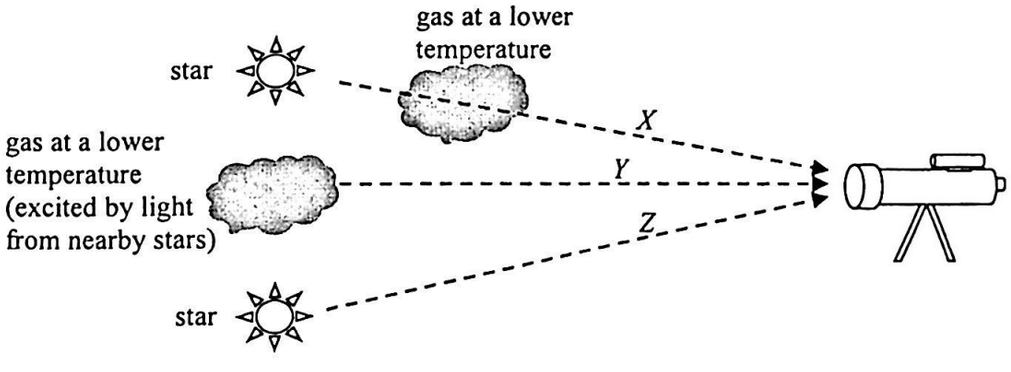
1.3 Which of the following observations can be explained by both the Ptolemy's geocentric model and the Copernicus' heliocentric model ?

(1) The brightness of planets varies throughout the year.
(2) The retrograde motion of Mars in the sky.
(3) Venus shows a complete cycle of phases in the sky.

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

A ○ B ○ C ○ D ○

1.4



A telescope obtains spectra from light coming from three directions *X*, *Y* and *Z*. Which of the following gives the spectra obtained ?

	continuous spectrum	**absorption line spectrum**	**emission line spectrum**
A.	direction *Z*	direction *X*	direction *Y*
B.	direction *Z*	direction *Y*	direction *X*
C.	direction *X*	direction *Y*	direction *Z*
D.	direction *X*	direction *Z*	direction *Y*

A ○ B ○ C ○ D ○

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1.5 A star of radius R has a parallax of θ when observed from the Earth. Which of the following gives the angular size of the star with respect to an observer on the Earth ?

A. $\frac{4R\theta}{1\,\text{AU}}$

B. $\frac{2R\theta}{1\,\text{AU}}$

C. $\frac{R\theta}{1\,\text{AU}}$

D. $\frac{R\theta}{2\,\text{AU}}$

A ○ B ○ C ○ D ○

1.6 The table below shows the apparent magnitudes and absolute magnitudes of four stars.

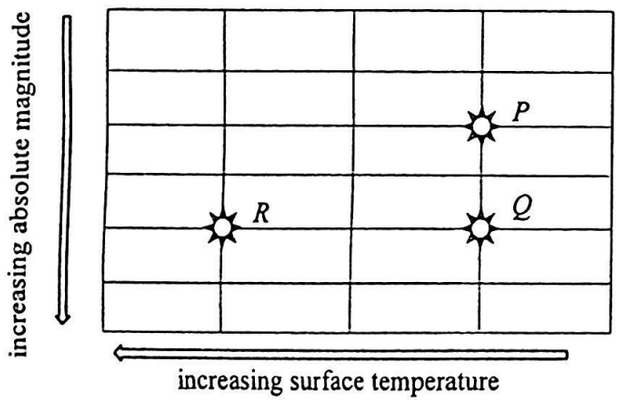
star	apparent magnitude	absolute magnitude
P	0	−0.5
Q	−0.5	2
R	2	−1.5
S	−2	−2.5

Which star is farthest from the Earth ?

A. P
B. Q
C. R
D. S

A ○ B ○ C ○ D ○

1.7 The information about the absolute magnitude and surface temperature of stars P, Q and R are shown below.

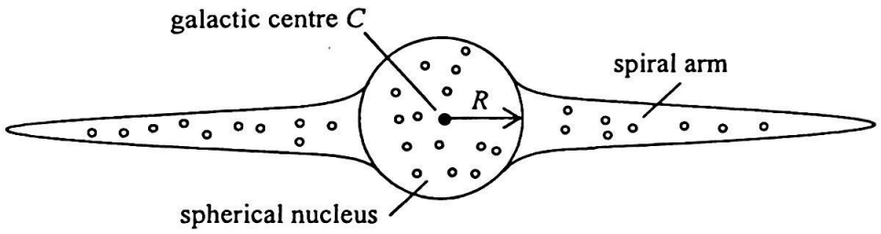


If Q belongs to the main sequence, arrange P, Q and R in ascending order of their radii.

A. $Q < R < P$
B. $R < P < Q$
C. $P < R < Q$
D. $R < Q < P$

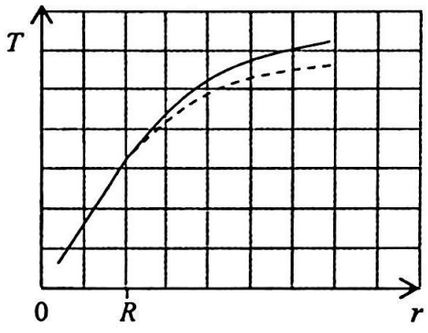
A ○ B ○ C ○ D ○

1.8 The figure shows the side view of a typical galaxy with a spherical nucleus of radius R and several spiral arms. Observations show that the stars in the nucleus are rotating about the galactic centre C as if the nucleus is a solid body. It is expected that the rotation of the stars in the spiral arms about C will obey Kepler's third law but instead the stars are observed to rotate with nearly the same constant speed.

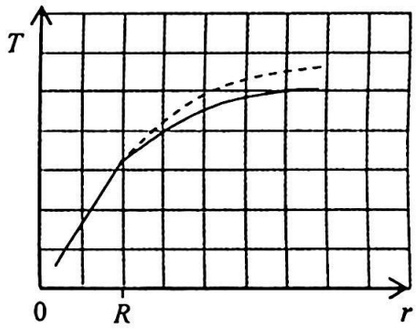


Which graph best shows the variation of the rotational period T of the stars with their distance r from C ? (The solid curve represents the observed result whereas the dotted curve represents the expected result.)

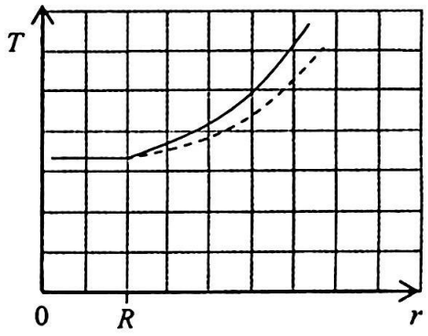
A.



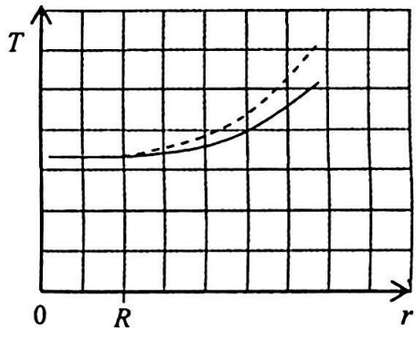
B.



C.



D.



A B C D

○ ○ ○ ○

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Q.1: Structured question

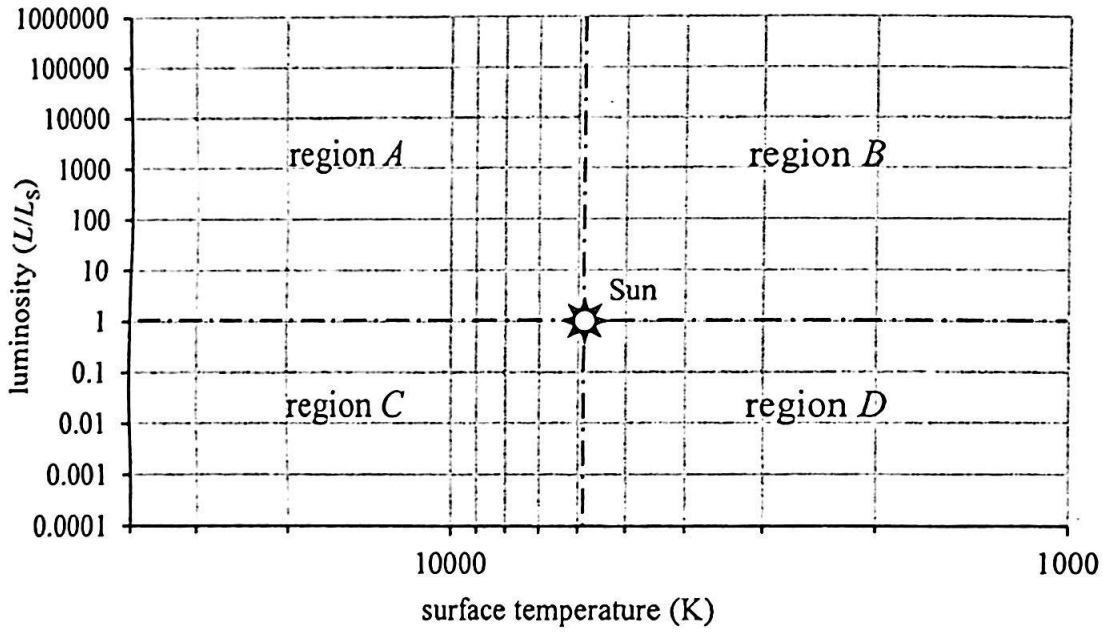
(a) X is a distant star and it has a parallax of 0.08″ when observed from the Earth.

(i) Find the distance of star X from the Earth in ly. (2 marks)

(ii) The information of star X is given below:

surface temperature = 2900 K
radius = 0.14 R_S where R_S is the radius of the Sun

Given the surface temperature of the Sun T_S = 5800 K, deduce the luminosity of star X in terms of the luminosity of the Sun, L_S. Hence, or otherwise, state in which region, A, B, C or D, on the Hertzsprung-Russell (H-R) diagram X is located. (3 marks)



(b) Star X has an Earth-sized planet Y orbiting around it.

(i) Why is it difficult to observe Y directly using optical telescopes other than it is very small and extremely far away from the Earth ? (1 mark)

(ii) Astronomers are able to deduce the orbital period T of Y around its parent star X indirectly since the interaction between them causes X to wobble (i.e. small degree of rotation about their centre of mass) with the same period. Name the kind of interaction and state what physical quantity of X should be measured in order to find T. (2 marks)

(iii) It has been postulated that a favourable condition for life to exist on a certain planet is that the power per unit area coming from the parent star onto that planet I_Y is within 0.5 to 2 times that coming from the Sun onto the Earth I_E. Deduce whether this condition is satisfied for planet Y using the result in (a)(ii). Given that the distance between X and Y is 0.04 AU. (Note: the power per unit area coming from a parent star onto its planet is given by $I = \dfrac{L}{4\pi d^2}$ where L is the luminosity of the parent star and d is the distance of the planet from its parent star.) (2 marks)

Section B : Atomic World

Q.2: Multiple-choice questions

2.1 In Rutherford's scattering experiment, the distance of closest approach of an α particle to a gold atom can be deduced. This distance is a good estimate of the upper limit of

A. the radius of an α particle.
B. the radius of a gold atom.
C. the radius of a gold nucleus.
D. the thickness of the gold foil.

A ○ B ○ C ○ D ○

2.2 Which of the following is/are the assumption(s) of the Bohr model of an atom ?

(1) The orbital radii of the electrons are quantized.
(2) The electric force between the nucleus and an electron provides the centripetal force for the circular motion.
(3) The total energy of an orbiting electron remains unchanged.

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

A ○ B ○ C ○ D ○

2.3 Which statements below about **spectra** are correct ?

(1) A steel rod heated to white hot emits a continuous spectrum.
(2) The dark lines in the absorption spectrum of an element match in frequency with the bright lines in this element's emission spectrum.
(3) The atomic spectrum of an element is a piece of evidence for the existence of energy levels in its atoms.

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

A ○ B ○ C ○ D ○

2.4 According to the Bohr model of an atom when the electron of a hydrogen atom undergoes transition from an inner orbit to an orbit of larger radius, the hydrogen atom may have

A. absorbed a photon, and the electron's kinetic energy decreases.
B. absorbed a photon, and the electron's kinetic energy increases.
C. emitted a photon, and the electron's kinetic energy decreases.
D. emitted a photon, and the electron's kinetic energy increases.

A ○ B ○ C ○ D ○

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2.5 Some hydrogen atoms in the second excited state (i.e. $n = 3$) subsequently produces a spectrum consisting of a series of discrete lines. How many spectral lines of different wavelengths are there in the spectrum ?

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

A B C D
○ ○ ○ ○

2.6. Electrons, each of mass m and charge e, are being accelerated in a transmission electron microscope (TEM). Estimate the accelerating voltage of the TEM if the de Broglie wavelength of the electrons is λ.

A. $\frac{h^2}{me\lambda^2}$
B. $\frac{h^2}{2me\lambda^2}$
C. $\frac{me\lambda^2}{h^2}$
D. $\frac{2me\lambda^2}{h^2}$

A B C D
○ ○ ○ ○

2.7 Which of the following statements about a scanning tunnelling microscope (STM) is/are correct ?

(1) It works like an optical microscope except that a high energy electron beam is used instead of visible light and a magnetic field acts as a lens.
(2) It can be used to show the arrangement of atoms at a conductive surface.
(3) The magnitude of the tunnelling current depends on the separation between the surface under investigation and the probe of the STM.

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

A B C D
○ ○ ○ ○

2.8 Which statement below is INCORRECT ?

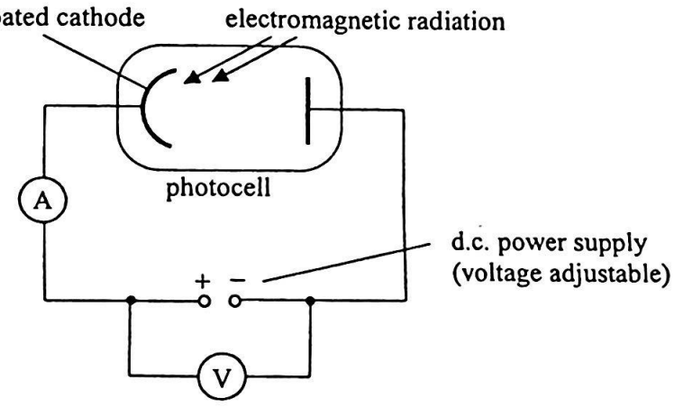
A. Nano particles of silver show a colour different from the colour of silver in bulk form.
B. Diamond is a poor thermal conductor and a poor electrical conductor as it does not have free electrons.
C. A carbon nanotube is much stronger than steel of the same size.
D. Carbon buckyballs such as C_{60} are formed by carbon atoms arranged in hollow cages.

A B C D
○ ○ ○ ○

Q.2: Structured question

The set-up shown in Figure 2.1 can be used to measure the maximum kinetic energy of photoelectrons emitted from sodium metal when electromagnetic radiations of the same intensity but having different frequencies are incident on a sodium-coated cathode.

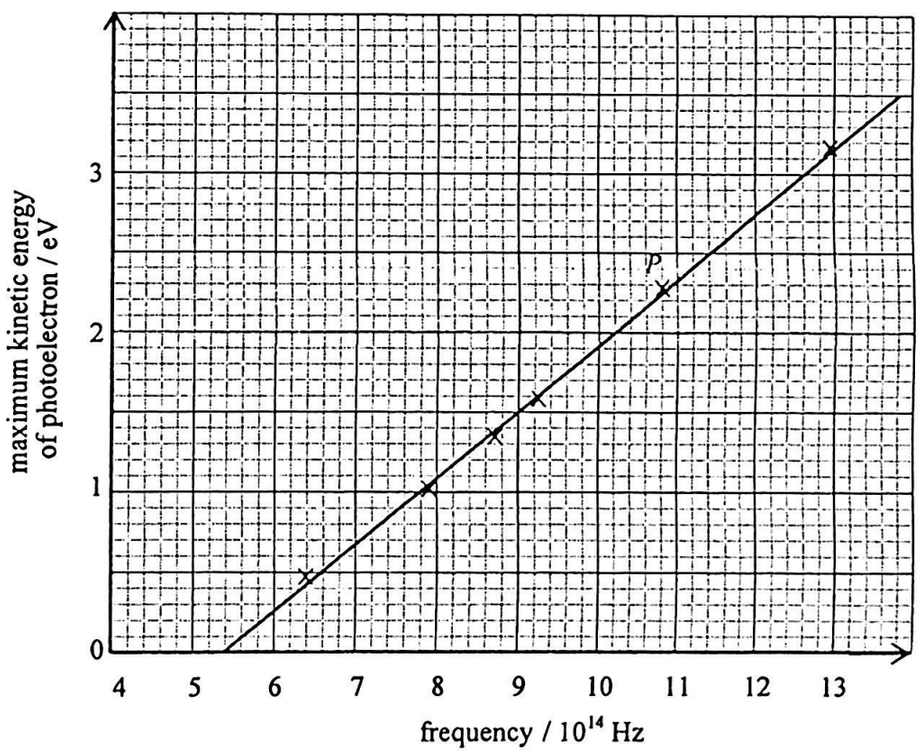
Figure 2.1



(a) Briefly describe how the maximum kinetic energy of photoelectrons can be measured using this set-up for a certain frequency (above the threshold value) of radiation. (2 marks)

(b) The graph in Figure 2.2 shows the results of the experiment.

Figure 2.2



(i) State the part of the electromagnetic spectrum from which radiation was used in obtaining data point *P*. (1 mark)

(ii) Find the slope of the graph and deduce its physical meaning. (3 marks)

(iii) Calculate the work function of sodium in eV. (2 marks)

(c) State the change, if any, in the graph obtained if the experiment is repeated with electromagnetic radiations of lower intensity. Explain. (2 marks)

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20
PH
PA

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Answers written on this page will not be marked.

Section C : Energy and Use of Energy

Q.3: Multiple-choice questions

3.1 Hybrid cars are usually equipped with combustion engines with smaller power than those in petrol cars because

(1) the combustion engine can be supplemented by the motor to provide the maximum power output of hybrid cars.
(2) combustion engines in hybrid cars are more energy efficient than those in petrol cars.
(3) the operation cost per unit power output of combustion engines with smaller power is lower.

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

A	B	C	D
○	○	○	○

3.2 Carbon dioxide emission associated with a passenger travelling in a MTR train for 1 km is about 50 g while that for a car is over 200 g. The possible reason(s) is/are

(1) The MTR train and the car need energy to move the vehicle itself.
(2) The energy efficiency in transporting a passenger for 1 km is higher in the case of the MTR train.
(3) No burning of fossil fuel is involved in the production of energy for the MTR train.

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

A	B	C	D
○	○	○	○

3.3 An air-conditioner with $\frac{\text{cooling capacity}}{\text{electrical power input}} = 2$ has a cooling capacity of 746 W. Estimate the rate at which thermal energy is being released to the environment outside.

A. 373 W
B. 746 W
C. 1119 W
D. 1492 W

A	B	C	D
○	○	○	○

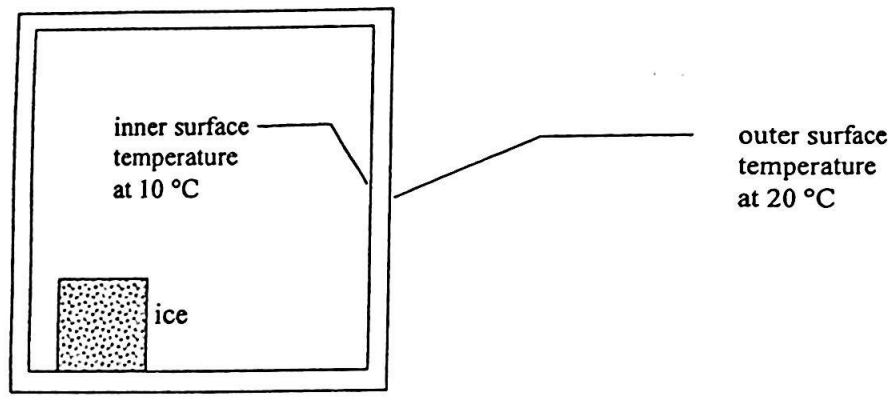
3.4 Which of the following contribute(s) to cooking with a microwave oven ?

(1) The energy of microwave is only absorbed by the food's surface and then transferred to its interior by conduction.
(2) Water molecules are polar due to non-uniform charge distribution within each molecule.
(3) The electric field of microwave is continuously changing.

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

A	B	C	D
○	○	○	○

3.5 A piece of ice is placed inside a closed plastic box. The wall of the plastic box is 2 cm thick and the thermal conductivity of plastic is 0.03 $W\,m^{-1}\,°C^{-1}$.



The temperature of the inner and the outer surfaces of the wall are 10 °C and 20 °C respectively. What is the rate of heat exchange (per unit area) between the inside and outside of the box and the direction of heat flow ?

	rate of heat exchange (per unit area)	direction of heat flow
A.	15 $W\,m^{-2}$	into the box
B.	15 $W\,m^{-2}$	out of the box
C.	36 $W\,m^{-2}$	into the box
D.	36 $W\,m^{-2}$	out of the box

A ○ B ○ C ○ D ○

3.6 Which statement below about a house and its features MUST BE correct ?

A. Thermal conduction is less efficient in materials that are darker in colour.
B. It is more desirable for the Overall Thermal Transfer Value (OTTV) of a house to be larger in cold areas.
C. Wall painted in white reduces the Overall Thermal Transfer Value (OTTV) of a house.
D. Wall painted in white increases the reflection of sunlight.

A ○ B ○ C ○ D ○

3.7 A wind turbine generator delivers a certain electric power with a wind blowing normal at speed v. If the length of the turbine blades is increased by 25% and the overall efficiency of the turbine generator remains the same, estimate the wind speed blowing normal to the turbine that gives the same electric power.

A. 0.59 v
B. 0.64 v
C. 0.86 v
D. 0.93 v

A ○ B ○ C ○ D ○

3.8 In a nuclear reactor, uranium-235 is used as the fission fuel to generate electricity. When uranium-235 undergoes nuclear fission, 0.08% of its mass is converted to energy. If 20% of this energy becomes electrical energy, estimate the amount of uranium-235 used per second for generating 500 MW of electric power.

A. 1.4×10^{-6} kg
B. 3.5×10^{-5} kg
C. 8.2×10^{-3} kg
D. 1.0×10^{-2} kg

A ○ B ○ C ○ D ○

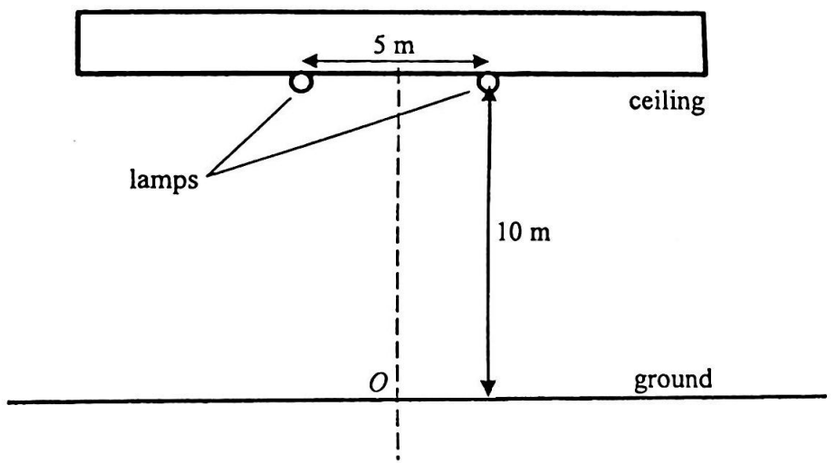
Q.3: Structured question

(a) (i) Incandescent lamps are far less energy efficient than other light sources like fluorescent lamps or light emitting diodes (LEDs). Explain why this is so in terms of how incandescent lamps produce light. (2 marks)

(ii) Two light sources of identical size and shape emit white light and green light respectively. If the light output power of them is the same, briefly explain which light source looks brighter. (2 marks)

(b) Figure 3.1 illustrates the simplified lighting arrangement within a tunnel in which two lamps each of luminous flux 10000 lumens are installed on the ceiling.

Figure 3.1



(i) Calculate the illuminance around point *O* on the ground mid-way between the two lamps. Take the lamps as point light sources and reflection is assumed negligible. (3 marks)

(ii) The specification of two kinds of lamps *A* and *B* are given below. In terms of efficacy, recommend which one the tunnel company should choose. (1 mark)

lamp	rated power	luminous flux
A	150 W	11000 lumens
B	135 W	10000 lumens

(iii) Figures 3.2(a) and 3.2(b) illustrate two arrangements of tunnel lights. In Figure 3.2(a), more lamps each with relatively lower luminous flux are used. In Figure 3.2(b), less lamps each with relatively higher luminous flux are used. The resultant average illuminance on the ground is the same in both cases.

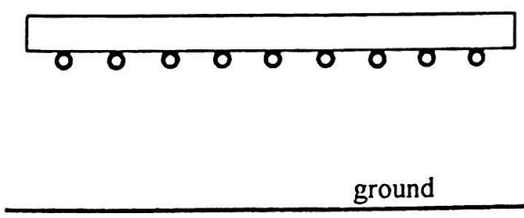


Figure 3.2(a)

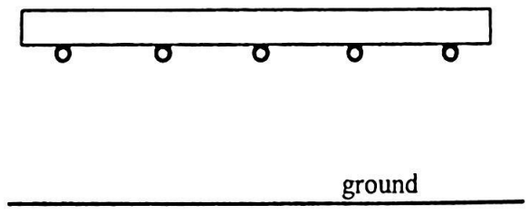


Figure 3.2(b)

State one advantage and one disadvantage of the arrangement in Figure 3.2(a) over that in Figure 3.2(b). (2 marks)

Section D : Medical Physics

Q.4: Multiple-choice questions

4.1 The refractive indices of air and the components of the eye are listed below. Which pairs of media provide the most bending of light due to refraction ?

medium	refractive index
air	1.00
cornea	1.38
aqueous humour	1.34
surface of lens	1.39
centre of lens	1.41

A. surface of lens – centre of lens
B. aqueous humour – surface of lens
C. cornea – aqueous humour
D. air – cornea

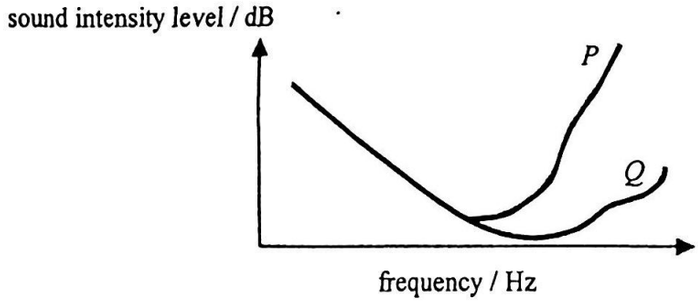
A ○ B ○ C ○ D ○

4.2 John's vision has a near-point distance of 20 cm and a far-point distance of 250 cm. If he wears spectacles that correct his far point to infinity, what should the type of spectacles be and what is his near-point distance after wearing the spectacles ?

	type of spectacles	near-point distance (with spectacles)
A.	convex lens	18.5 cm
B.	concave lens	18.5 cm
C.	convex lens	21.7 cm
D.	concave lens	21.7 cm

A ○ B ○ C ○ D ○

4.3 *The graph below shows* the threshold of hearing for two persons *P* and *Q*.



Which statements below MUST BE correct ?

(1) *P* and *Q* have the same hearing sensitivity for sound of very low frequencies.
(2) *P* does not usually hear sound of high frequencies unless the sound wave is large in amplitude.
(3) *Q* suffers from a hearing loss.

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

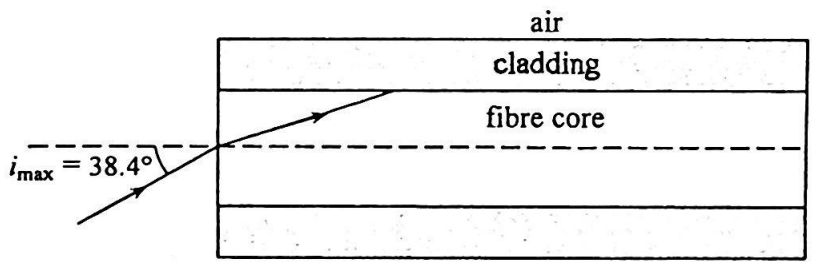
A ○ B ○ C ○ D ○

4.4 A small loudspeaker emits a sound. The sound intensity level measured at 5 m away from it is 40 dB. The power output of the loudspeaker is then reduced to half and the sound intensity level is measured again at 10 m away. By what percentage has the sound intensity level changed ?

A. 12.5%
B. 15.1%
C. 22.6%
D. 25.0%

A B C D
○ ○ ○ ○

4.5 As shown below the optical fibre used for an endoscope is cladded with material of refractive index different from that of the fibre core to avoid light leakage. The maximum angle of incidence i_{max} is 38.4° for no leakage of light. Find the refractive index of the cladding material.
Given: refractive index of the fibre core = 1.55



A. 1.69
B. 1.42
C. 1.33
D. 1.16

A B C D
○ ○ ○ ○

4.6 Which statements about radionuclide imaging (RNI) are correct ?

(1) The functions of organs in a body can be assessed using RNI.
(2) Thyroid problems can be identified using RNI.
(3) The spatial resolution of RNI is as good as that of a computed tomography (CT) scan.

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

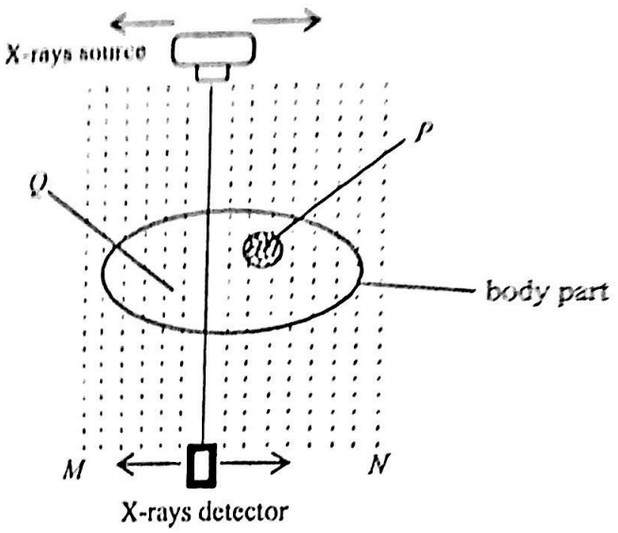
A B C D
○ ○ ○ ○

4.7 A gamma source produces a corrected count rate of 3500 s^{-1} at a point 1 m away. What minimum thickness of concrete is needed to reduce the corrected count rate to less than 200 s^{-1} at the same point ? Given: the half-value thickness of concrete is 60.5 mm.

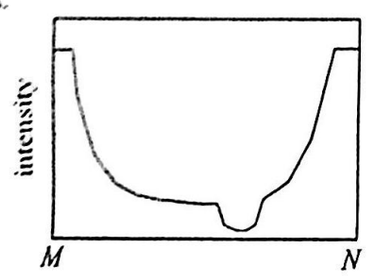
A. 40 cm
B. 25 cm
C. 15 cm
D. 10 cm

A B C D
○ ○ ○ ○

43 An X-rays source paired with a detector can move horizontally to scan a body part (consisting of tissues P and Q) as shown. Which graph below correctly shows the variation of intensity of the X-rays detected ? Given attenuation coefficient of P is greater than that of Q.



A.



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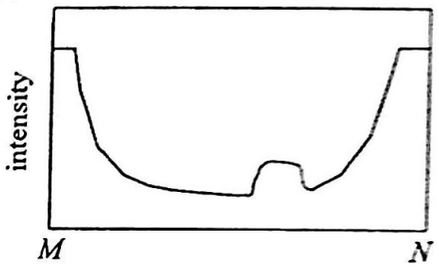
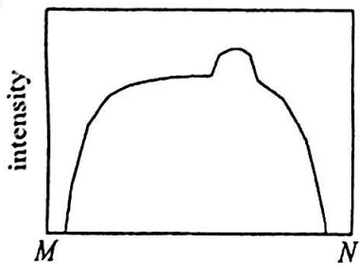
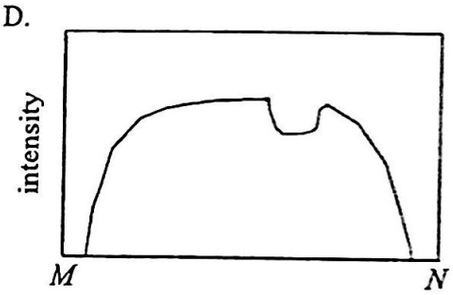


C.



D.

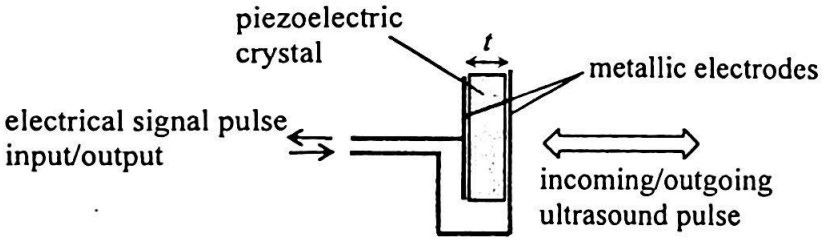


A B C D

Q.4: Structured question

(a) Piezoelectric transducers can generate as well as detect ultrasound. Figure 4.1 shows the basic construction of a piezoelectric transducer in which the thickness of the piezoelectric crystal is t.

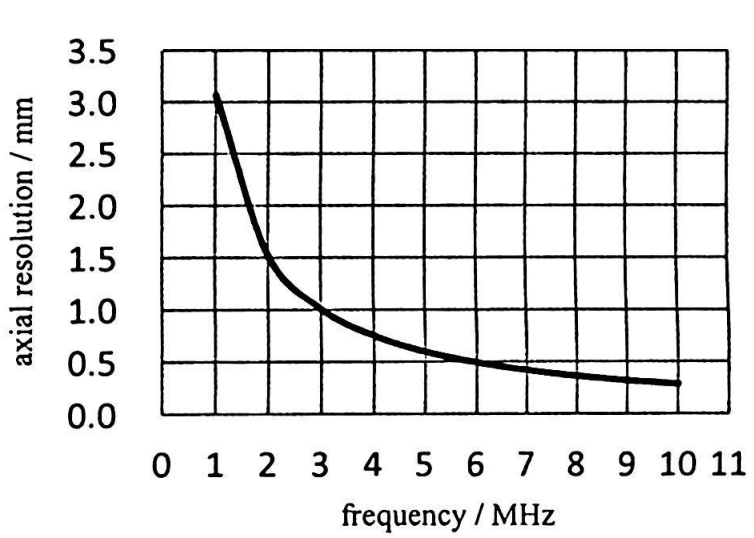
Figure 4.1



(i) The crystal has a maximum response for a certain frequency f of the electrical signal applied such that t is about half of the wavelength of the ultrasound in the crystal. The speed of ultrasound in the crystal is 4000 m s^{-1}. Estimate f if t = 0.4 mm. (1 mark)

(ii) An ultrasound pulse produced by the piezoelectric transducer is reflected back from an interface as an echo. Explain how the transducer detects this echo. (2 marks)

(b) For medical imaging using an ultrasound beam, the resolution (in mm) along the beam direction (axial direction) in soft tissue varies with the frequency (in MHz) of the ultrasound used as shown below.

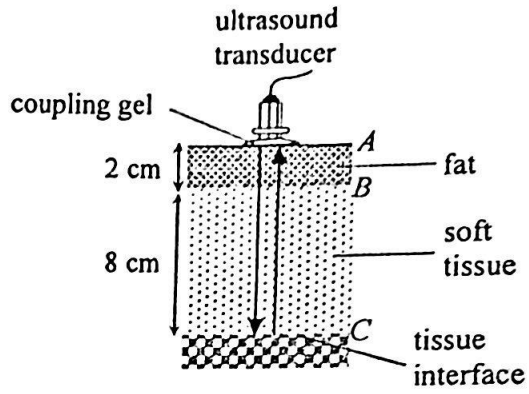


(i) Explain the importance of axial resolution in ultrasound imaging. (2 marks)

(ii) In fact the axial resolution is inversely proportional to the frequency of ultrasound used. Make use of one or two points of the graph to deduce the axial resolution of imaging when using 12 MHz ultrasound. (2 marks)

(c) Figure 4.2 shows the set-up for studying a tissue interface underneath a 2 cm thick fat layer and a 8 cm thick soft tissue layer. The speed of ultrasound in the fat layer is 1450 m s^{-1} while that in the soft tissue layer is 1540 m s^{-1}.

Figure 4.2



(i) Calculate the echo time T for the ultrasound pulse going to and from the tissue interface at C. (2 marks)

(ii) The depth of the tissue interface is computed using a device which takes the whole echo time T as being spent on propagating to and fro in soft tissue only (i.e. calibrated at a speed of 1540 m s^{-1}). Determine by how much this **computed depth** differs from the **actual depth** of the tissue interface. (1 mark)

END OF PAPER

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