2013-DSE
PHY

PAPER 2

HONG KONG EXAMINATIONS AND ASSESSMENT AUTHORITY

HONG KONG DIPLOMA OF SECONDARY EDUCATION EXAMINATION 2013

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 and 7.

(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.

A150E002

Section A : Astronomy and Space Science

Q.1: Multiple-choice questions

1.1 Arrange the following celestial bodies in ascending order of distance from the Earth:

(1) Sun
(2) Sirius, which is 8.6 ly from Earth
(3) Uranus, which is 19 AU from Earth

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

A ○ B ○ C ○ D ○

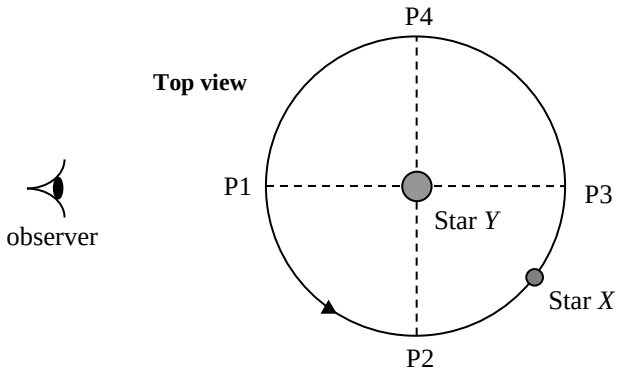
1.2 Which of the following statements about Ptolemy's geocentric model and Copernican's heliocentric model of the universe is/are correct ?

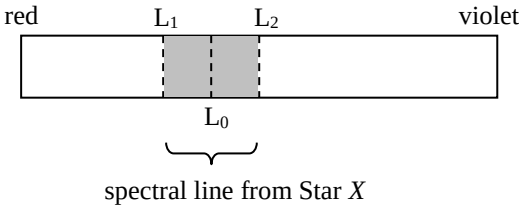
(1) Orbits are circular in both models.
(2) The Earth is at the centre of the Moon's orbit in both models.
(3) Retrograde motion can be explained in both models.

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

A ○ B ○ C ○ D ○

1.3 Star *X* orbits around Star *Y* approximately in a circular orbit. An observer on the Earth viewing a spectral line from *X* found that its wavelength varies between the limits L_1 and L_2. L_0 is the wavelength of that line observed in the laboratory.





Which wavelengths correspond to positions P1, P2, P3 and P4 of Star *X* ?

	P1	P2	P3	P4
A.	L_0	L_1	L_0	L_2
B.	L_1	L_0	L_2	L_0
C.	L_0	L_2	L_0	L_1
D.	L_2	L_0	L_1	L_0

A ○ B ○ C ○ D ○

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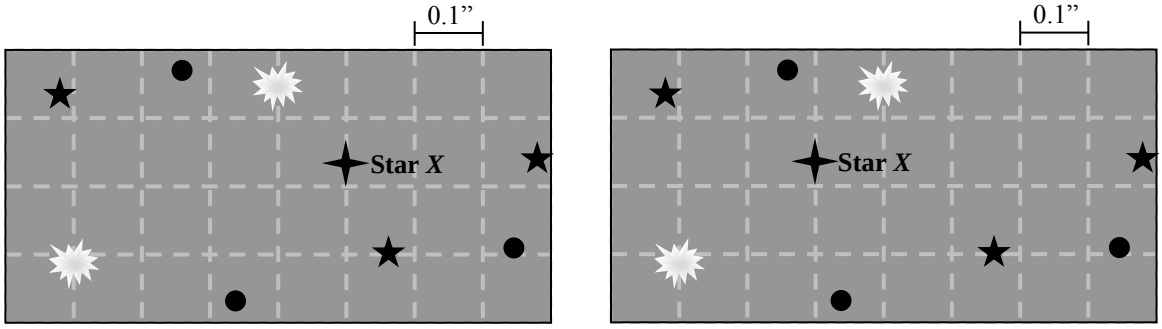
1.4 The following are two pictures of the same region of the sky taken six months apart. Gridlines are overlaid on the pictures. Each grid square corresponds to an angular scale of 0.1 arc second. What is the distance of Star *X* from the Earth in unit of parsec ?

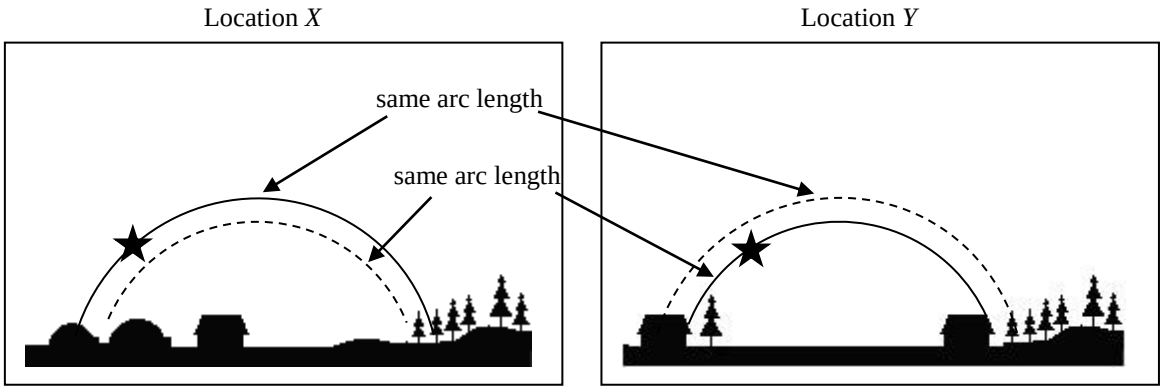


January view　　July view

A. 0.1 pc
B. 0.2 pc
C. 5 pc
D. 10 pc

A　B　C　D

1.5 The same star is observed at location *X* and location *Y* in the northern hemisphere. The scenes at the two locations on the same night are shown below.



facing south　　facing south

Which of the following descriptions is correct ?

A.	*X* is south of *Y*.	The time duration for the star to rise and set is longer at *X* than at *Y*.
B.	*X* is south of *Y*.	The time duration for the star to rise and set is shorter at *X* than at *Y*.
C.	*X* is north of *Y*.	The time duration for the star to rise and set is longer at *X* than at *Y*.
D.	*X* is north of *Y*.	The time duration for the star to rise and set is shorter at *X* than at *Y*.

A　B　C　D

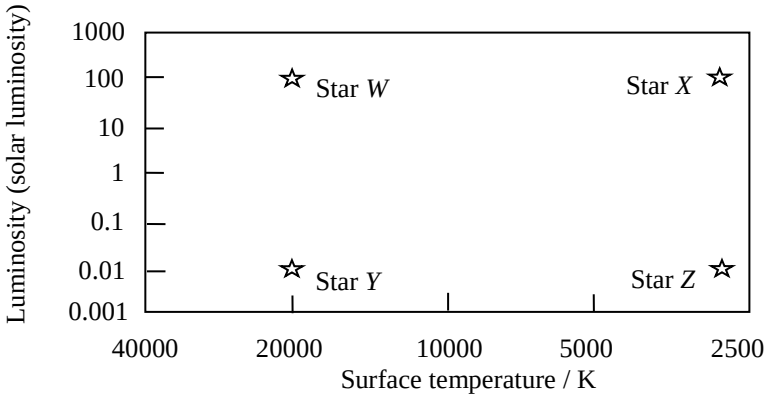
Go on to the next page

1.6 Stars *P* and *Q* have the same luminosity. Star *P* is 25 times brighter than Star *Q*. We can deduce that

A. *P*'s distance is 5 times that of *Q*.
B. *Q*'s distance is 5 times that of *P*.
C. *P*'s distance is 25 times that of *Q*.
D. *Q*'s distance is 25 times that of *P*.

A B C D

1.7 The figure below shows some information of stars *W*, *X*, *Y* and *Z*.



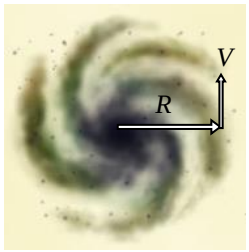
Which statement(s) about the radii of stars is/are correct ?

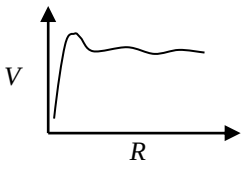
(1) radius of *X* > radius of *W*
(2) radius of *W* > radius of *Y*
(3) radius of *Y* > radius of *Z*

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

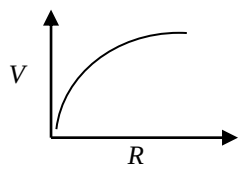
A B C D

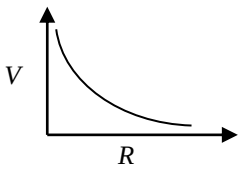
1.8

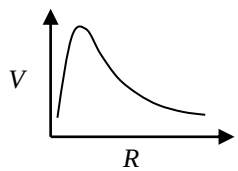


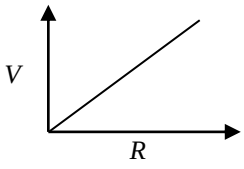


The diagram shows the top view of a galaxy and the observed variation of the rotation speed *V* with radius *R* from the galactic centre. This curve suggests the existence of dark matters. Which of the following should be the expected rotation curve without the existence of dark matters ?

A.


B.


C.


D.


A B C D

Please stick the barcode label here.

Q.1: Structured question

Given: $GM = 4.0 \times 10^{14}$ N m^2 kg^{-1}, where G is the universal gravitational constant and M is the mass of the Earth.
Mean radius of the Earth = 6400 km.
Radius of the geostationary orbit is about 42400 km, i.e. 36000 km above Earth's surface.

The following describes a way to launch a satellite into the geostationary orbit:

- The satellite is first launched by a rocket to a circular near-Earth orbit (1) at 300 km above the Earth's surface.
- At *A*, the satellite's engine is fired for a short period of time to give it a boost needed to enter the elliptical transfer orbit (2), with *AB* as the ellipse's major axis.
- At *B*, the satellite's engine is fired again briefly to boost it into the geostationary orbit (3).

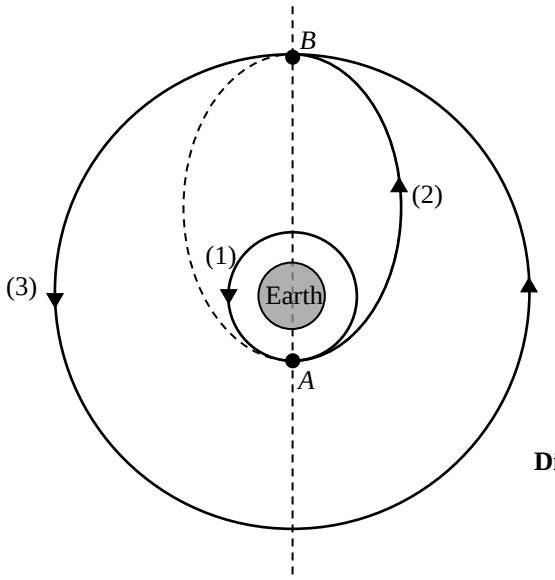


Diagram NOT drawn to scale

Assume that the three orbits are coplanar such that the elliptical orbit touches the two circular orbits at *A* and *B* respectively. During the period when the satellite travels from *A* to *B* along the transfer orbit, its engine is shut.

(a) Communications satellites are usually launched into the geostationary orbit. State and explain the advantage of such an arrangement. (2 marks)

(b) Find the speed of the satellite in the near-Earth orbit (1). (2 marks)

(c) (i) Show that for a satellite of mass m moving in a circular orbit of radius r around the Earth, its total mechanical energy is $-\frac{GMm}{2r}$, where M is the mass of the Earth. Take the gravitational potential energy of the satellite at infinity to be zero. (2 marks)

(ii) Use the result in (c)(i) to calculate the energy required to transfer a satellite of mass m = 2000 kg from the near-Earth orbit (1) through *A* to the geostationary orbit (3) through *B*. (2 marks)

(iii) How long does it take for the satellite to travel from *A* to *B* along the transfer orbit (2) ? (2 marks)

Go on to the next page

Section B : Atomic World

Q.2: Multiple-choice questions

2.1 In an α-particle scattering experiment, the electrons of the atoms have negligible effects on the path of the incident α-particles. The most probable reason is that

A. electrons are so small that α-particles do not collide with them.
B. electrons are uniformly distributed inside an atom, thus the resultant force on an α-particle is zero.
C. there is no electrical interaction between electrons and α-particles.
D. the kinetic energy change of α-particles colliding with electrons is negligible.

A B C D
○ ○ ○ ○

2.2 According to classical electromagnetic theory, what deductions about Rutherford's atomic model can be made ?

A. Atoms are stable and atomic spectra are continuous spectra.
B. Atoms are stable and atomic spectra are line spectra.
C. Atoms are unstable and atomic spectra are continuous spectra.
D. Atoms are unstable and atomic spectra are line spectra.

A B C D
○ ○ ○ ○

2.3 Which of the following spectra is/are continuous ?

(1) the spectrum from a burning candle
(2) the spectrum from an incandescent lamp
(3) the spectrum from a gas discharge tube

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

A B C D
○ ○ ○ ○

2.4 The energy level of an electron in a hydrogen atom is given by $E_n = -\frac{E_0}{n^2}$, where E_0 is a constant and n = 1, 2, 3, …. What is the maximum wavelength of a photon that can ionize a hydrogen atom in its first excited state ? (h = Planck constant, c = speed of light in a vacuum)

A. $\frac{3hc}{4E_0}$
B. $\frac{hc}{E_0}$
C. $\frac{4hc}{3E_0}$
D. $\frac{4hc}{E_0}$

A B C D
○ ○ ○ ○

Please stick the barcode label here.

2.5 When an electron in a hydrogen atom falls from an excited state to the ground state, which of the following forms of radiation will **NOT** be emitted ?

A. γ-radiation
B. ultra-violet radiation
C. infra-red radiation
D. visible light

A	B	C	D
○	○	○	○

2.6

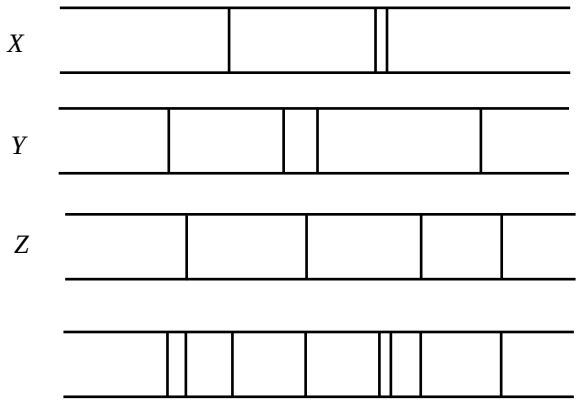


Figure (1)

Figure (2)

Figure (1) shows the line spectra of three elements *X*, *Y* and *Z* while Figure (2) shows the line spectrum of a certain mineral substance. From spectral analysis, which element must be **ABSENT** from the mineral substance ?

A. *X*
B. *Y*
C. *Z*
D. All three elements are present in the mineral substance.

A	B	C	D
○	○	○	○

2.7 The minimum resolvable length of a typical transmission electron microscope (TEM) is about 0.2 nm. If a particle has the same charge of an electron and its mass is four times that of an electron, and a beam of such particles is accelerated through the same voltage in a TEM, the minimum resolvable length becomes

A. 0.05 nm.
B. 0.1 nm.
C. 0.4 nm.
D. 0.8 nm.

A	B	C	D
○	○	○	○

2.8 A cube with 1 mm per side is divided into nano-scale cubes, each side measuring 1 nm. How many times has the total surface area of the cube been increased ?

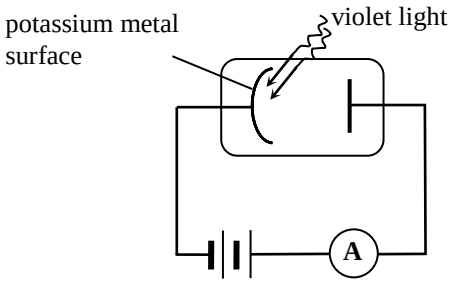
A. 10^6
B. 10^8
C. 10^{10}
D. 10^{12}

A	B	C	D
○	○	○	○

Go on to the next page

Q.2: Structured question

A potassium metal surface is illuminated by violet light of a certain wavelength and the maximum kinetic energy of the electrons emitted from the metal surface is 0.81 eV. The work function of potassium is 2.30 eV.



(a) (i) Find the energy of a violet light photon in unit of eV. (1 mark)

(ii) Not all the electrons emitted can have maximum kinetic energy. Explain. (1 mark)

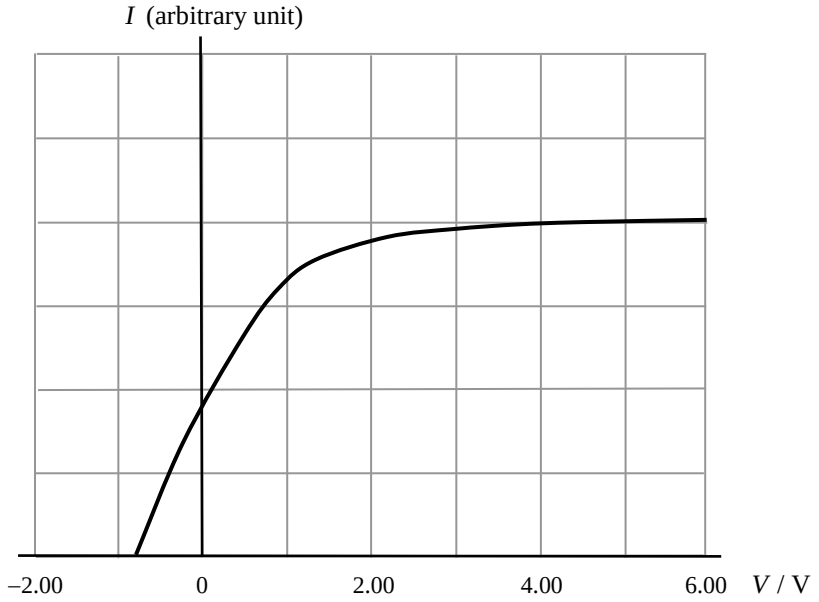
The intensity of the violet light used is 0.01 W m^{-2}.

(b) (i) According to classical wave theory, an atom has to absorb enough energy from light waves to eject an electron. Estimate the minimum time required for a potassium atom to absorb energy so as to eject an electron. Take the effective area of a potassium atom in absorbing energy as 0.01 nm^2 (1 nm = 10^{-9} m). (2 marks)

(ii) Explain why in experiments almost no time delay is observed for electrons to be ejected from the metal surface even though the intensity of light is very weak. (1 mark)

(c) If the area of the potassium metal surface receiving violet light is 4.00×10^{-4} m^2, how many photons hit the surface per second ? Find the maximum photoelectric current if one electron is emitted for every 10 photons hitting the surface. (3 marks)

(d) The curve of the photoelectric current I against the potential difference across the cathode and the anode V is shown in the graph below.



COPY THE GRAPH TO YOUR ANSWER BOOK. If the light intensity is reduced to half of its original value, use a *dotted line* to sketch the corresponding curve in the graph you have copied. (2 marks)

Section C : Energy and Use of Energy

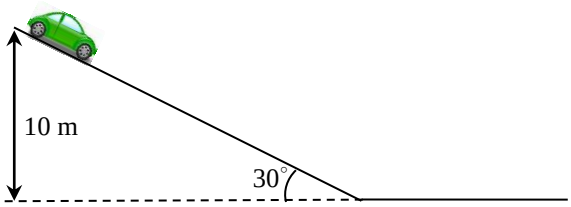
Q.3: Multiple-choice questions

3.1 LED usually produces monochromatic light because

A. the difference in energy levels of the p-layer and n-layer in an LED is fixed.
B. its surface is coated with only one type of fluorescent material.
C. the operating temperature of an LED is fixed.
D. current is only allowed to flow through an LED in one direction.

A B C D

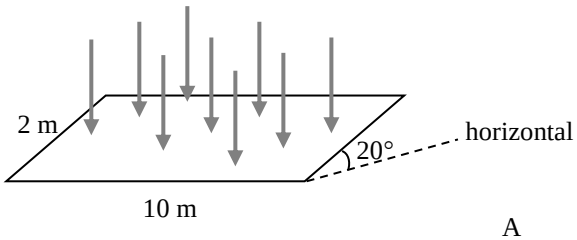
3.2 A car of mass 1000 kg has a regenerative braking system that can convert its kinetic energy into chemical energy which is stored in a battery of that system. How much energy can be stored in the battery after the car has gone downhill at a constant speed by a vertical distance of 10 m ? The overall efficiency of the regenerative braking system is 30%. (g = 9.81 m s^{-2})



A. 14.7 kJ
B. 29.4 kJ
C. 49.1 kJ
D. 98.1 kJ

A B C D

3.3 Assume that 1000 W m^{-2} of solar power reaches a certain place vertically on the Earth's surface. What is the power delivered to a solar panel of width 2 m and length 10 m inclined at 20° to the horizontal at that place ?



A. 6840 W
B. 7280 W
C. 18800 W
D. 20000 W

A B C D

3.4 A wind turbine is used to drive a pump which pumps water up to a storage reservoir. The blade-length of the wind turbine is 10 m while the average wind speed is 5 m s^{-1}. How much water can be pumped up to the reservoir in 8 hours if the overall efficiency of the system is 20% ? Assume that the average gain in gravitational potential energy by water is 981 J kg^{-1}. Given: density of air = 1.23 kg m^{-3}

A. 39.4 kg
B. 2.84×10^4 kg
C. 1.15×10^5 kg
D. 1.42×10^5 kg

A B C D

Go on to the next page

3.5 A closed foam box of dimensions 0.5 m × 0.3 m × 0.4 m and thickness 1 cm contains some melting ice. Estimate the rate of heat conducting from the surroundings into the box if the room temperature is 28 °C.
Given: thermal conductivity of the foam is 0.03 W m^{-1} $°C^{-1}$

A. 39.5 W
B. 79 W
C. 3950 W
D. 7900 W

A	B	C	D
○	○	○	○

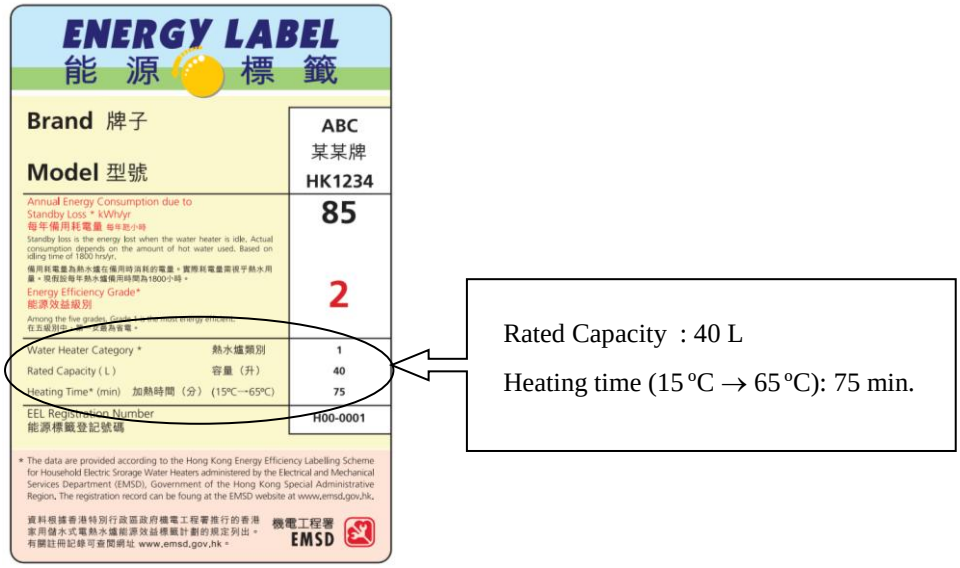
3.6 The Overall Thermal Transfer Value (OTTV) of a building can be reduced by making its glass windows smaller because

(1) glass has a much higher thermal conductivity than concrete.
(2) heat can be transferred by convection if windows are open.
(3) glass allows heat transfer by radiation.

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

A	B	C	D
○	○	○	○

3.7



Referring to the above energy label of a storage type water heater, estimate the effective output power of the heater when it is filled to maximum capacity with 40 L (1 L = 1000 cm^3) of water at 15 °C.
Given: specific heat capacity of water = 4200 J kg^{-1} $°C^{-1}$, density of water = 1000 kg m^{-3}

A. 1870 W
B. 2430 W
C. 85000 W
D. 112000 W

A	B	C	D
○	○	○	○

3.8 When four hydrogen nuclei, each of mass 1.007825 u, are fused together, one nucleus of element *Q* of mass 4.002603 u is formed. Which of the following statements is/are correct ?

(1) Hydrogen nuclei need to have extremely high kinetic energy to start the fusion process.
(2) Energy released in the process is about 26.7 MeV.
(3) Element *Q* is radioactive.

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

A	B	C	D
○	○	○	○

Q.3: Structured question

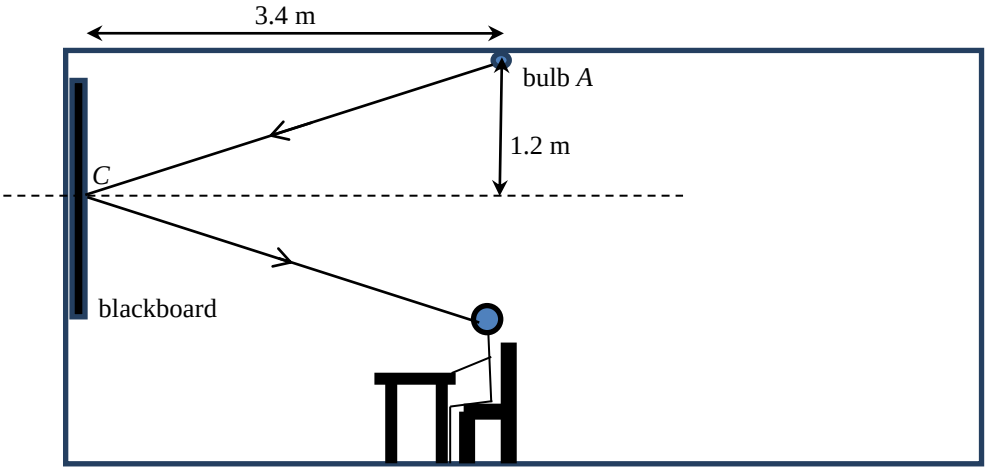


Figure 3.1

The classroom shown in Figure 3.1 has an incandescent light bulb *A* of luminous flux 2000 lm (lumens). You may treat the light bulb as a point light source.

(a) Find the illuminance, in lm m^{-2}, by bulb *A* around the blackboard's centre *C*. Neglect any reflection of light. (2 marks)

(b) Bulb *A* is mainly for illuminating the student's desk, however, the light ray reflected back into the student's eyes is undesirable (see the figure). Explain the type of surface that should be used for the blackboard so as to reduce such a problem. (2 marks)

(c) Figure 3.2 shows the appearance of the classroom. The average rate of heat gain of the classroom from outside is 14.5 kW.

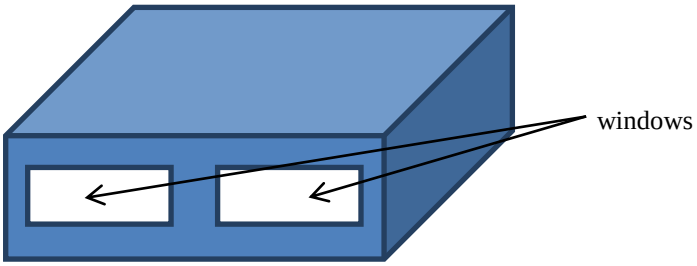


Figure 3.2

The classroom is designed to accommodate a maximum of 15 persons at the same time and each person produces on average 100 J of heat per second. There are altogether 6 identical incandescent light bulbs installed to illuminate the classroom and each bulb produces 80 J of heat per second.

(i) Estimate the cooling capacity, in kW, (due to heat produced inside the classroom and heat gain from outside) required for the classroom's air-conditioning system. Assume that there is no other equipment producing heat in the classroom. (2 marks)

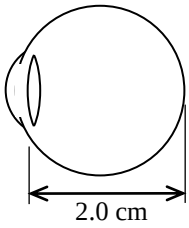
(ii) The power rating of each light bulb is 100 W. The air-conditioning system consumes 0.5 J of electrical energy for removing 1 J of heat from the classroom. Estimate the total monthly cost of electricity for lighting and air-conditioning if the classroom operates 8 hours a day and 20 days a month. Given: cost of electricity = \$1.0 / kW h (3 marks)

(iii) Suggest one way of changing either the building structure or the electrical appliance so as to reduce the electricity bill through lower consumption of energy. (1 mark)

Section D : Medical Physics

Q.4: Multiple-choice questions

4.1 The diagram shows an eyeball of a person suffering from an eye defect. The distance between the retina and optical centre of the refracting parts is 2.0 cm while the minimum power of the refracting parts is +55 D. What is the power of the spectacles required to correct the defect ?



A. −5 D
B. −10 D
C. +5 D
D. +10 D

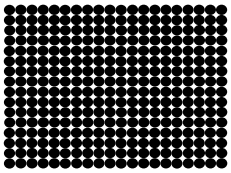
A B C D

4.2 Two point objects of separation 5 mm emitting green light of wavelength 550 nm are observed by Jacky. Assume that the diameter of the pupils of his eyes is about 3 mm in normal daylight. Estimate the maximum distance of the two objects from him such that he can still resolve them ?

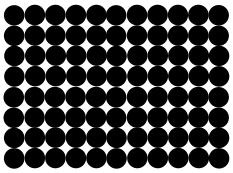
A. 42.4 m
B. 24.2 m
C. 22.4 m
D. 20.4 m

A B C D

4.3 The diagram below represents two coherent optical fibre bundles *X* and *Y* used in endoscopes. Their cross-sections have the same dimensions but *X* has more and finer fibres. Which statements are correct ?



X



Y

(1) *X* gives a much brighter image than *Y*.
(2) *X* can be bent more than *Y*.
(3) *X* gives an image of higher resolution than *Y*.

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 The sensitivity of the human ear is high because the pressure change in a sound wave is greatly amplified before reaching the inner ear. Which of the following facts contribute to this large amplification ?

(1) When the ear bones transmit the vibrations from the ear drum to the oval window of the inner ear, lever action occurs.
(2) The ear drum has a much larger area than the oval window of the inner ear.
(3) The inner ear is filled with a liquid which has a much higher density than that of air outside.

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 A speaker is connected to an amplifier to produce sound. When the power supplied to the speaker is 50 W, the resulting sound intensity level at a certain location is 100 dB. Assume that there is no other sound source and the speaker has a fixed efficiency of converting electrical energy to sound. What is the power required to produce a sound intensity level of 110 dB at the same location ?

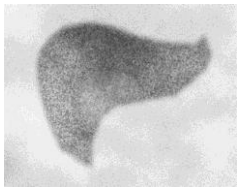
A. 52 W
B. 55 W
C. 100 W
D. 500 W

A B C D
○ ○ ○ ○

4.6 Technetium-99m is a radioisotope which undergoes γ-decay with a half-life of 6 hours. Some technetium-99m was combined with a substance which can be easily absorbed by liver. The compound was taken by a patient and a series of images were taken by a gamma camera at different times. Which of the following statements is/are correct ?


1 hour after intake


3 hours after intake


6 hours after intake

(1) The darker part of the images corresponds to the part of the liver causing a greater attenuation of γ-rays.
(2) This series of images provides functional information about the liver of the patient.
(3) The difference between the images is solely due to the decay of technetium-99m.

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

A B C D
○ ○ ○ ○

4.7 Which of the following statements about ultrasound medical imaging is/are correct ?

(1) Ultrasound is potentially hazardous as it is a form of ionizing radiation.
(2) Ultrasound is not suitable for lung scanning as it is almost totally reflected when it reaches the tissue-air boundary in the lungs.
(3) High frequency ultrasound has a greater penetrating power but provides images of lower resolution.

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

A B C D
○ ○ ○ ○

4.8 The patient of a car accident was suspected to have internal bleeding in the brain. In order to locate where the bleeding might have occurred, which medical imaging method is the most suitable to be used ?

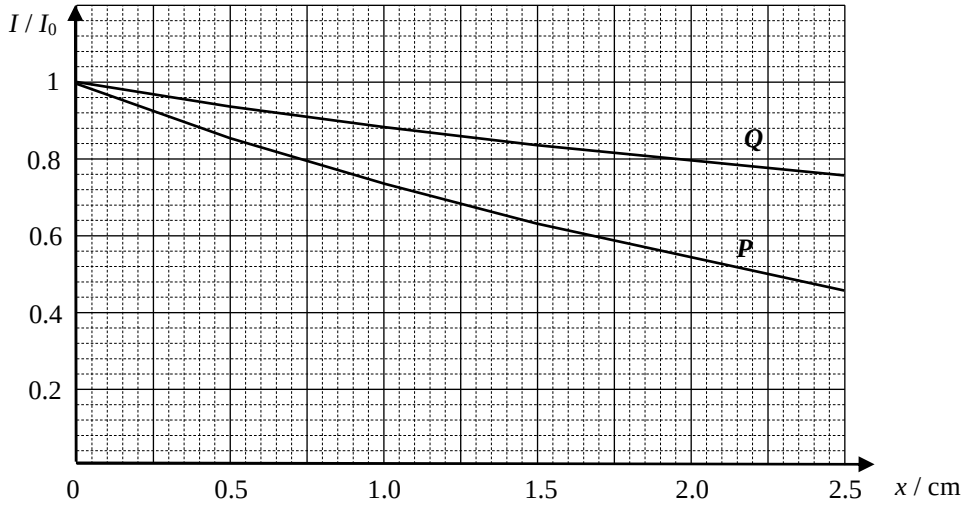
A. Ultrasound scanning
B. Endoscope
C. X-ray radiography
D. Computed tomography (CT)

A B C D
○ ○ ○ ○

Q.4: Structured question

(a) Figure 4.1 shows how the intensity of an X-ray beam changes as it travels through a distance x in two media P and Q respectively. The initial intensity of the X-ray beam is I_0.

Figure 4.1



(i) What is the half-value thickness of medium P ? (1 mark)

(ii) Find the linear attenuation coefficient of medium P. (2 marks)

(iii) Does medium Q have a density higher than, equal to or lower than that of medium P ? (1 mark)

(b) Figure 4.2 shows an X-ray radiographic image of the chest.

Figure 4.2

(i) Explain how the image is formed in terms of the effects on the passage of X-rays through different media including soft tissue and bone. (2 marks)

(ii) Briefly explain why a computed tomography (CT) image provides more detailed structural information of the body than an X-ray radiographic image. (2 marks)

(iii) Although CT images have the advantage mentioned above, give **TWO** reasons (other than CT scanners are more expensive) why conventional X-ray radiographic imaging has not been completely replaced by CT 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.