2015-DSE
PHY

PAPER 2

HONG KONG EXAMINATIONS AND ASSESSMENT AUTHORITY

HONG KONG DIPLOMA OF SECONDARY EDUCATION EXAMINATION 2015

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.

A150E2MC

Section A : Astronomy and Space Science

Q.1: Multiple-choice questions

1.1 A satellite is orbiting the Earth at a distance h from the Earth's surface. What is the gain in gravitational potential energy of the satellite in the orbit with respect to the Earth's surface ?

m = mass of the satellite
R = radius of the Earth
g = acceleration due to gravity on the Earth's surface

A. $mgh\left(\frac{R}{R+h}\right)$

B. $mgh\left(\frac{R}{R+h}\right)^2$

C. $mgh\left(\frac{R+h}{R}\right)$

D. $mgh\left(\frac{R+h}{R}\right)^2$

A B C D

1.2 Where is the best location on Earth to build an observatory so as to observe most of the celestial sphere ?

A. latitude 90° N
B. latitude 90° S
C. latitude 0°
D. It is the same for any latitude.

A B C D

1.3 The Earth receives solar radiation of power P_0 per unit area. Estimate the power of solar radiation received per unit area on Pluto which is 40 AU from the Sun.

A. $\frac{1}{39}P_0$

B. $\frac{1}{40}P_0$

C. $\left(\frac{1}{39}\right)^2 P_0$

D. $\left(\frac{1}{40}\right)^2 P_0$

A B C D

1.4 Which of the following observations by Galileo contradict with the geocentric model of the universe ?

(1) the discovery of satellites of Jupiter
(2) the retrograde motion of Mars
(3) the changing phase of Venus

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

A B C D

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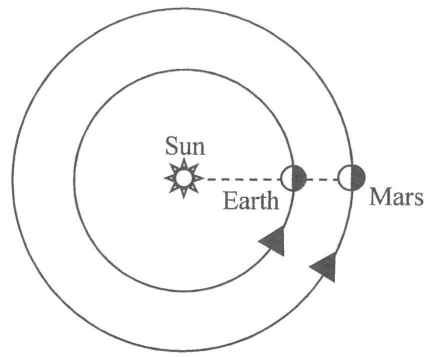
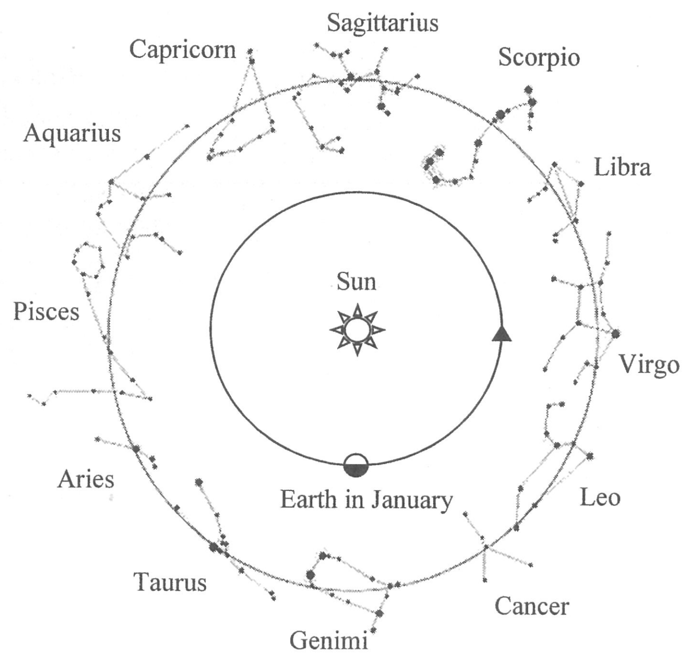
1.5 When the Earth lines up with the Sun and Mars as shown, how does Mars appear to move across the night sky as viewed from Earth ?



A. Mars moves from west to east against the background stars.
B. Mars moves from east to west against the background stars.
C. Mars does not move against the background stars.
D. The movement of Mars cannot be determined because the east and west directions are not known.

A B C D

1.6 Which constellations and in what sequence can be seen to pass the Earth's meridian at night in January ?



A. Capricorn, Sagittarius, Scorpio
B. Scorpio, Sagittarius, Capricorn
C. Taurus, Gemini, Cancer
D. Cancer, Gemini, Taurus

A B C D

Go on to the next page

1.7

	absolute magnitude	apparent magnitude
star *X*	2.8	4.7
star *Y*	5.4	3.2

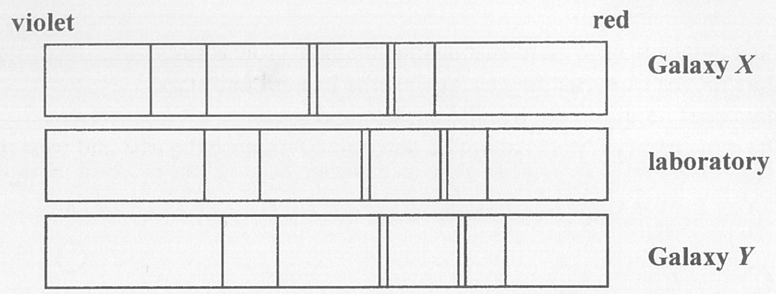
According to the information given above, which of the following about stars *X* and *Y* is/are correct ?

(1) Luminosity of star *X* is greater than that of star *Y*.
(2) A telescope collects more energy per unit area per unit time from star *X* than from star *Y*.

A. Only (1) is correct.
B. Only (2) is correct.
C. Both (1) and (2) are correct.
D. Both (1) and (2) are incorrect.

A B C D
○ ○ ○ ○

1.8 The respective absorption spectra of hydrogen from Galaxy *X*, in the laboratory, and Galaxy *Y* are shown below :



Which of the following descriptions about the motions of Galaxy *X* and Galaxy *Y* and their velocities v_X and v_Y relative to the Earth is correct ?

	Galaxy *X*	velocities	Galaxy *Y*
A.	moving away from Earth	$\lvert v_X \rvert < \lvert v_Y \rvert$	moving towards Earth
B.	moving away from Earth	$\lvert v_X \rvert > \lvert v_Y \rvert$	moving towards Earth
C.	moving towards Earth	$\lvert v_X \rvert < \lvert v_Y \rvert$	moving away from Earth
D.	moving towards Earth	$\lvert v_X \rvert > \lvert v_Y \rvert$	moving away from Earth

A B C D
○ ○ ○ ○

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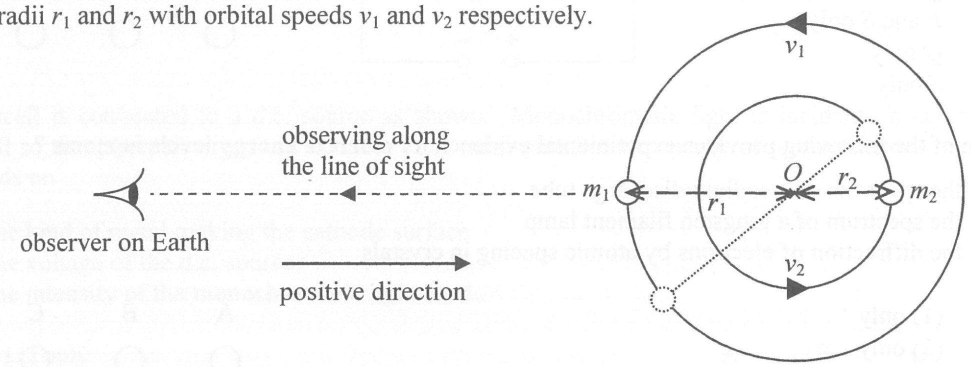
Q.1: Structured question

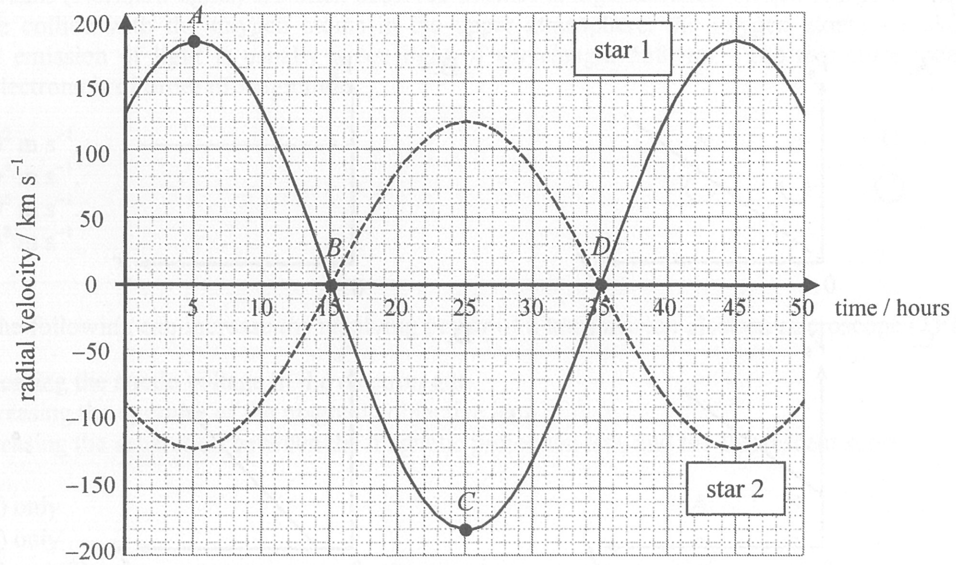
Figure 1.1 shows a distant binary star system viewed by an observer on Earth who is also on the orbital plane of the two stars. The system consists of stars 1 and 2 with masses m_1 and m_2 respectively orbiting in uniform circular motion about their centre of mass *O* under their mutual gravitational force. They move with **the same period** in two orbits of radii r_1 and r_2 with orbital speeds v_1 and v_2 respectively.

Figure 1.1



By finding the radial velocity v_r of the two stars inferred from the Doppler shift ($\Delta\lambda$) of the hydrogen-alpha line (H_α) observed on Earth, astronomers are able to deduce the masses of the stars. Assume that the centre of mass *O* of the binary system is stationary with respect to the observer. Figure 1.2 shows the radial velocity curves for the two stars. The direction moving away from the observer is taken to be positive velocity.

Figure 1.2



(a) (i) What does it mean by **radial velocity** v_r of a star observed on Earth ? (1 mark)

(ii) Identify which point, *A*, *B*, *C* or *D*, marked on the radial velocity curve corresponds to the orbital position of star 1 (in solid line) **at the instant** shown in Figure 1.1. (1 mark)

(b) Find, from Figure 1.2, the orbital speed v_1 of star 1 and calculate its orbital radius r_1. Using a similar method, or otherwise, find the orbital radius r_2 of star 2. (4 marks)

(c) By considering the circular motion of star 1, calculate the mass m_2 of star 2. (2 marks)

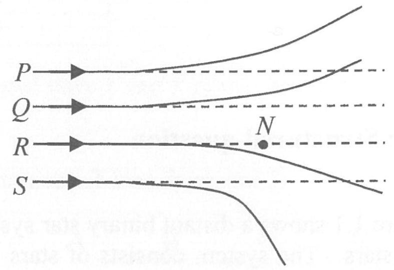
(d) A spectrometer can only measure change of wavelength larger than 0.5 nm. Explain whether this instrument is suitable to measure the Doppler shift $\Delta\lambda$ of the hydrogen-alpha line (λ_0 = 656.28 nm) of the two stars. (2 marks)

Go on to the next page

Section B : Atomic World

Q.2: Multiple-choice questions

2.1 A beam of α-particles with the same initial kinetic energy are scattered by a heavy nucleus N. In the figure, if P is a possible path for one of the α-particles, which of the paths, Q, R and S, is/are possible for these α-particles ?



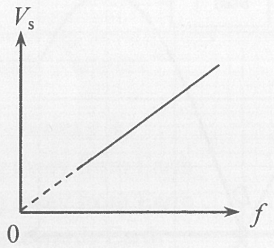
A. Q and R only
B. R and S only
C. Q only
D. S only

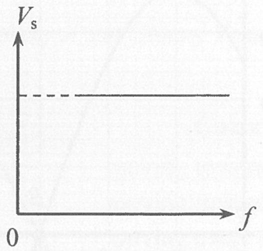
2.2 Which of the following provides experimental evidence for **discrete energy levels** in atoms ?

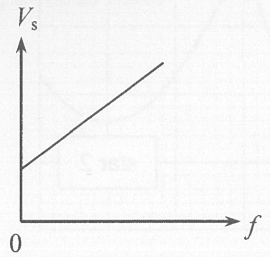
(1) the spectrum of a sodium discharge tube
(2) the spectrum of a tungsten filament lamp
(3) the diffraction of electrons by atomic spacing in crystals

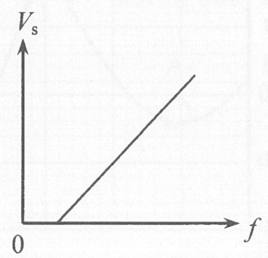
A. (1) only
B. (3) only
C. (1) and (2) only
D. (2) and (3) only

2.3 In a photoelectric experiment, monochromatic light of frequency f is incident upon a metal surface and the stopping potential for the photoelectrons emitted is V_s. If the frequency f is changed, how would V_s vary with f ?

A.


B.


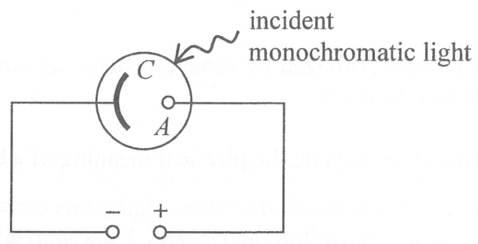
C.


D.


2.4 A spy aircraft is cruising at a height of 10 km above the Earth's surface. It is equipped with a camera having an objective lens of aperture 10 cm. Estimate the minimum separation of two small objects on the Earth's surface to be distinguished by this camera. Assume that both objects emit light of wavelength 500 nm.

A. 0.05 m
B. 0.061 m
C. 0.10 m
D. 0.122 m

2.5



A photocell is connected to a d.c. source as shown. Monochromatic light is incident on cathode C of the photocell so that photoelectrons are emitted. The maximum kinetic energy of photoelectrons reaching anode A depends on

(1) the kind of metal making the cathode surface.
(2) the voltage of the d.c. source.
(3) the intensity of the monochromatic light used.

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

2.6 Aurora Borealis (Northern lights) are often observed in skies at high latitudes. When energetic electrons from outer space collide with the oxygen atoms in the upper atmosphere, the oxygen atoms are excited. The subsequent emission of light is usually green light of wavelength 558 nm. The minimum speed of these energetic electrons is of order of magnitude

A. 10^2 m s^{-1}.
B. 10^4 m s^{-1}.
C. 10^6 m s^{-1}.
D. 10^8 m s^{-1}.

2.7 Which of the following can increase the resolving power of a transmission electron microscope (TEM) ?

(1) increasing the anode voltage in the electron gun
(2) decreasing the aperture of the magnetic objective lens
(3) increasing the separation between the magnetic projection lens and the fluorescent screen

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

2.8 Zinc oxide (ZnO) is used in some suntan lotion. Which of the following statements is/are correct ?

(1) Nano-sized ZnO can block ultra-violet radiation while bulk-sized ZnO cannot.
(2) Nano-sized ZnO is more effective in reflecting visible light than bulk-sized ZnO.
(3) Suntan lotion with nano-sized ZnO appears transparent when applied to the skin.

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

Q.2: Structured question

The energy levels E_n of an electron in a hydrogen atom from the Bohr model can take the form below:

$$E_n = \frac{-13.6}{n^2}\text{ eV} \quad \text{where } n = 1, 2, 3, \ldots$$

(a) Bohr's idea was sometimes criticized by some physicists as semi-classical and semi-quantum. Point out **ONE classical aspect** in the Bohr model. (1 mark)

(b) From the energy point of view, state the physical meaning of a hydrogen atom being in its **ground state**. (1 mark)

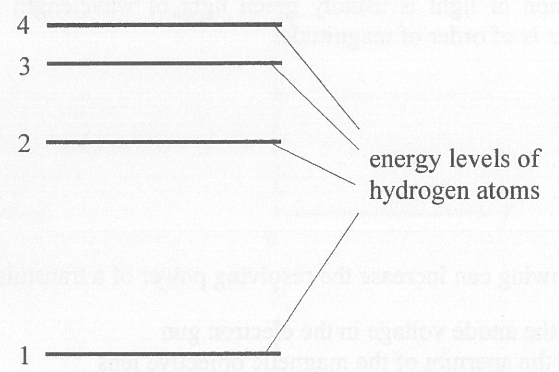
(c) If the minimum energy required to ionize a hydrogen atom in the ground state is E, express the minimum momentum p of a photon for ionizing such a hydrogen atom in terms of E and another physical constant. (2 marks)

(d) Hydrogen atoms in the ground state are bombarded by electrons each with kinetic energy 12.9 eV.

(i) Show that these hydrogen atoms can be excited at most to the third excited state (i.e. $n = 4$). (2 marks)

(ii) For a hydrogen atom excited to the third excited state ($n = 4$), what is the de Broglie wavelength of the orbiting electron in the atom ? Given: the orbital radius r_n of the electron in a hydrogen atom from the Bohr model is equal to $0.053\ n^2$ (unit: nm), where $n = 1, 2, 3, \ldots$ (2 marks)

(iii) **Copy the energy level diagram below to your answer book** and draw arrow(s) to illustrate all possible transitions leading to emission of photons by these excited hydrogen atoms. (2 marks)



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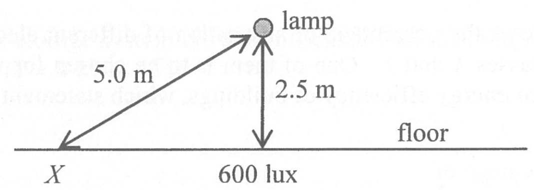
Section C : Energy and Use of Energy

Q.3: Multiple-choice questions

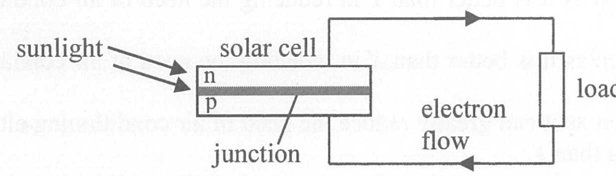
3.1 A lamp is fixed on the ceiling of a room as the only light source. The illuminance on the floor directly under the lamp is 600 lux. Assuming that the lamp emits light uniformly in all directions, what is the illuminance on the floor around point X as indicated in the diagram ? Neglect any reflections of the walls and the ceiling.



A. 75 lux
B. 130 lux
C. 150 lux
D. 300 lux

A B C D

3.2 The schematic diagram below shows a solar cell under sunlight. Incident light photons reach the cell's junction of p-type and n-type semiconductor layers. Which of the following sequences correctly explains how electrical energy can be supplied to the load ?



(1) The electric field developed within the junction draws free electrons and holes to the n-type and p-type layers respectively.
(2) Free electrons flow to the p-type layer through the load and rejoin the holes there.
(3) Incident light photons knock out electrons from atoms in the junction such that free electrons result, leaving the holes behind.

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

A B C D

3.3 A satellite is powered by a solar panel of an area of 100 m^2 and having a conversion efficiency of 15%. Sunlight falls from a direction 30° to the normal of the panel. The solar constant is 1370 W m^{-2}. Estimate the electrical power output of this solar panel.

A. 10.3 kW
B. 17.8 kW
C. 20.6 kW
D. 58.2 kW

A B C D

Go on to the next page

3.4 A coal-fired power plant generates and transmits electrical energy to consumers a long distance away. When a consumer connects an incandescent lamp to the mains supply, the following data illustrates what happens per 1000 J of energy in coal converted to electrical energy which is then supplied to the lamp.

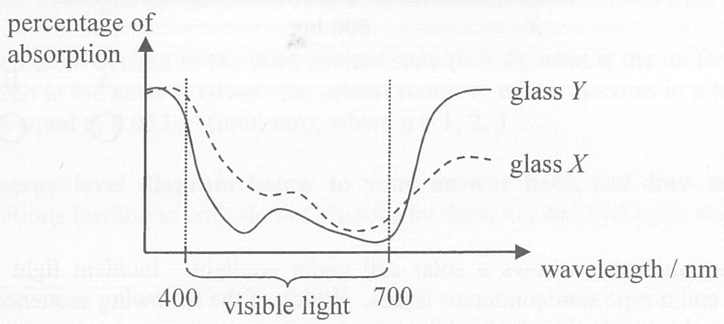
Loss during generation process in the power plant	600 J
Loss during transmission before reaching the lamp	100 J
Heat generated by the lamp	250 J
Visible light generated by the lamp	50 J

What is the **end-use energy efficiency** of this incandescent lamp ?

A. 5 %
B. 12.5 %
C. 16.7 %
D. 30 %

A B C D

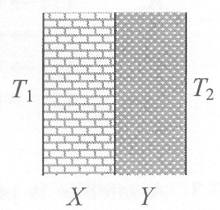
3.5 The following graph shows the percentage of absorption of different electromagnetic radiations when passing through two types of glasses X and Y. One of them is to be chosen for windows of buildings in Hong Kong. With the consideration of energy efficiency of buildings, which statement is correct ?



A. X should be chosen as it is better than Y in reducing the need of air conditioning and the amount of lighting.
B. Y should be chosen as it is better than X in reducing the need of air conditioning and the amount of lighting.
C. X should be chosen as it can greatly reduce the need of air conditioning although it needs a bit more amount of lighting than Y.
D. Y should be chosen as it can greatly reduce the need of air conditioning although it needs a bit more amount of lighting than X.

A B C D

3.6 The diagram shows a wall composed of two layers X and Y of equal thicknesses. The thermal conductivity of the material of X is higher than that of Y. The two sides of the wall are maintained at different temperatures T_1 and T_2. Which of the following statements is/are correct ?

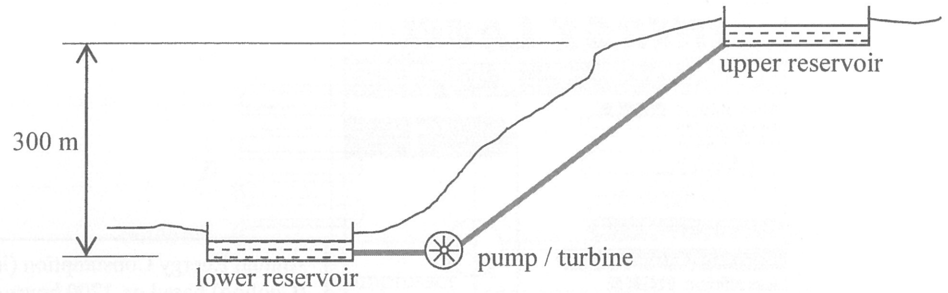


(1) The thermal transmittance of layer X is higher than that of layer Y.
(2) The energy flowing through layer X per second is greater than that through layer Y.
(3) The temperature drop across layer X is smaller than that across layer Y.

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

A B C D

3.7 A power plant is always running at its maximum output power of 1800 MW. However, as the demand of electricity fluctuates greatly within a day, a hydroelectric storage system is therefore designed to increase the output in the high demand period. During the 14 hours of low demand period in a day, the average demand is only 600 MW and the excess output is used to pump water from the lower reservoir to the upper one. When the demand is higher than 1800 MW, the water returns to the lower reservoir through a turbine to generate electricity.



Assume that the hydroelectric storage system is 100% efficient, find the minimum capacity (in kg of water) of the upper reservoir required. ($g = 9.81$ m s^{-2})

A. 1.03×10^{10} kg
B. 1.47×10^{10} kg
C. 2.06×10^{10} kg
D. 3.08×10^{10} kg

A B C D

3.8 What is the function of the **moderator** in a nuclear fission reactor ?

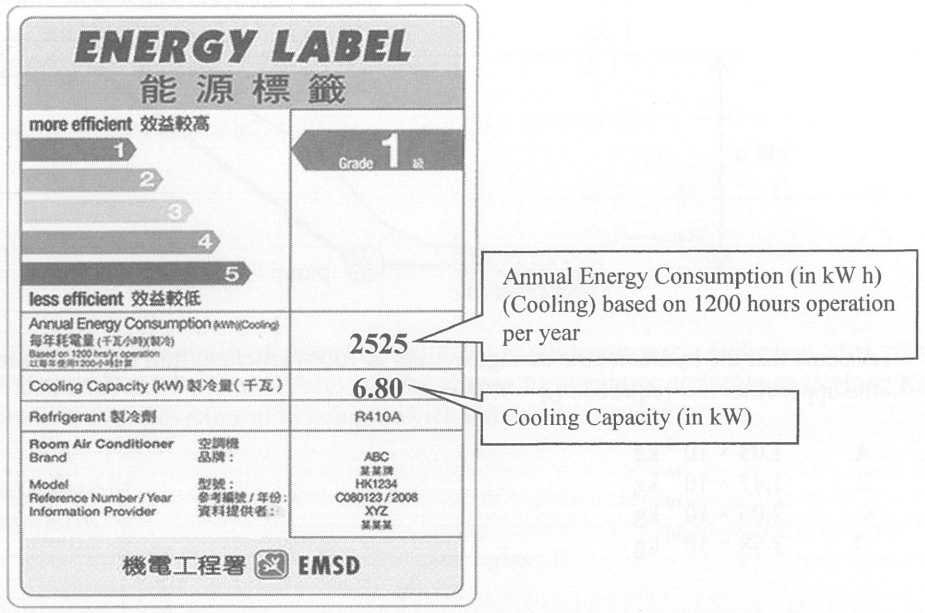
A. It slows down neutrons and this helps increase the rate of nuclear fission.
B. It slows down neutrons and this helps reduce the rate of nuclear fission.
C. It absorbs neutrons and this helps reduce the rate of nuclear fission.
D. It generates neutrons for nuclear fission.

A B C D

Q.3: Structured question

Figure 3.1 shows the Energy Efficiency Label of an air-conditioner X.

Figure 3.1



(a) This air-conditioner is installed in a room of floor area of 20.0 m^2 and height of 3.0 m.
Given: density of air = 1.2 kg m^{-3}, specific heat capacity of air = 1000 J kg^{-1} °C^{-1}

(i) Estimate the time required to cool the room from 33°C to 25°C. Assume that the density and specific heat capacity of air remain constant throughout. (2 marks)

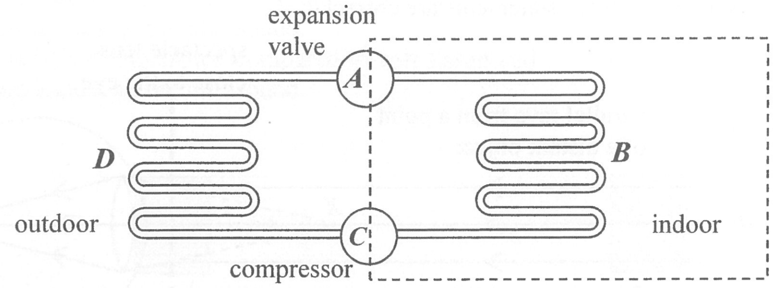
(ii) Suggest a reason why the actual time for cooling from 33°C to 25°C is longer than the result found in (a)(i). (1 mark)

(b) (i) Find the average electrical power input (in kW) of air-conditioner X during operation. (1 mark)

(ii) Find the value of $\dfrac{\text{cooling capacity}}{\text{electrical power input}}$ for this air-conditioner. A student comments that this ratio having a value greater than 1 violates the principle of conservation of energy because the amount of heat removed by the air-conditioner is greater than the electrical power input. Discuss the student's comment. (3 marks)

(c) X is a cool-only air-conditioner as it can only cool air. Nowadays, 'reverse-cycle air-conditioners' (RCAC) that can either cool or warm air are available in the market and they have the same major components of X. Figure 3.2 shows a simplified schematic diagram of an RCAC with four components A, B, C and D, in which A is the expansion valve and C is the compressor.

Figure 3.2



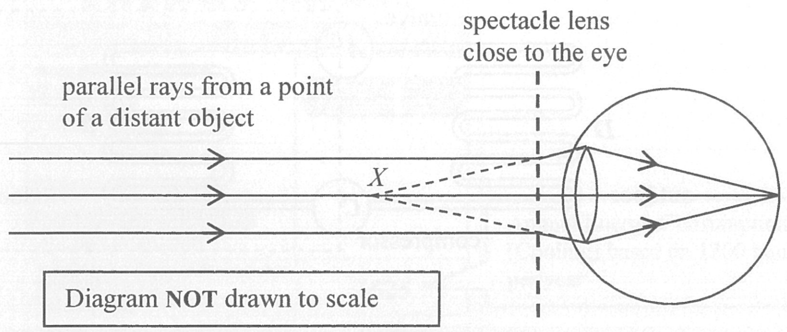
(i) If the RCAC operates in a mode **to warm air** during winter time, give the direction of the flow of refrigerant starting from compressor C using the letters A, B, C and D. State in which component, A, B or D, the refrigerant has the highest temperature. (2 marks)

(ii) Suggest **ONE** modification that can convert a cool-only air-conditioner into an RCAC. (1 mark)

Section D : Medical Physics

Q.4: Multiple-choice questions

4.1 Peter suffers from a certain eye defect and needs to wear spectacles. The diagram shows the spectacle lens for correcting this defect. Which statements are correct ?



(1) Peter is suffering from short sightedness.
(2) Point X is the near point of his unaided eye.
(3) If X is 0.8 m from the spectacle lens, the power of the lens should be −1.25 D.

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

A B C D

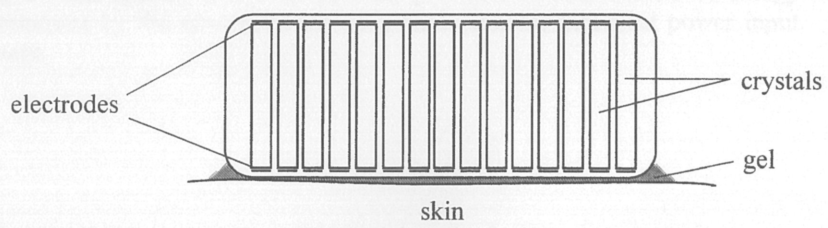
4.2 Which of the following are disadvantages of a fibre optic endoscope ?

(1) Anesthesia is sometimes required.
(2) It can only be used for viewing the inner surface of an organ with cavity.
(3) It may cause internal bleeding.

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

A B C D

4.3 The following diagram shows an ultrasound scanner with an array of crystals. A pair of electrodes is connected across each crystal. Which of the following statements is/are correct ?



(1) The gel is used to reduce the attenuation of ultrasound when passing the gap between the scanner and the skin.
(2) When a crystal receives ultrasound, an electrical signal is generated between the electrodes by piezoelectric effect.
(3) This scanner is designed for taking B-scan images.

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

A B C D

4.4 Ultrasound scanning is **NOT** suitable for the lungs because air in the lungs

A. has a high attenuation coefficient and can absorb almost all the ultrasound.
B. has a low attenuation coefficient and can absorb almost all the ultrasound.
C. has high acoustic impedance compared to soft tissue and can reflect almost all the ultrasound.
D. has low acoustic impedance compared to soft tissue and can reflect almost all the ultrasound.

A B C D

4.5

The diagram shows an X-ray beam passing through a metal block of linear attenuation coefficient μ. Its intensity is reduced from I to $\frac{I}{2}$. If the metal block is replaced by another one of the same thickness but having a linear attenuation coefficient of 3μ, what would the intensity of the emergent X-ray beam be ?

A. $\frac{I}{6}$
B. $\frac{I}{8}$
C. $\frac{I}{9}$
D. $\frac{I}{16}$

A B C D

4.6 The image of a computed tomography (CT) scan is of size 32 cm × 32 cm and the size of each pixel of the image is 0.391 mm^2. Which matrix size below corresponds to the resolution of this CT scan image ?

A. 128 × 128
B. 256 × 256
C. 512 × 512
D. 1024 × 1024

A B C D

4.7 A doctor decides to conduct radionuclide imaging of a patient's kidneys. Which of the following is the main reason for choosing radionuclide imaging rather than other imaging methods ?

A. Diagnosis of the kidneys' function can be made.
B. Fine details of the kidneys' structure can be seen.
C. The image produced has the highest resolution compared to the other methods.
D. Diagnosis will give highly specific information of the kind of kidney disease.

A B C D

4.8 The following radioactive sources are all non-toxic and readily absorbed by a certain organ. Which one is the most suitable to be used as a tracer for radionuclide imaging of that organ ?

A. a γ-source of half-life 16 hours
B. a γ-source of half-life 8 months
C. a β-source of half-life 20 seconds
D. a β-source of half-life 12 hours

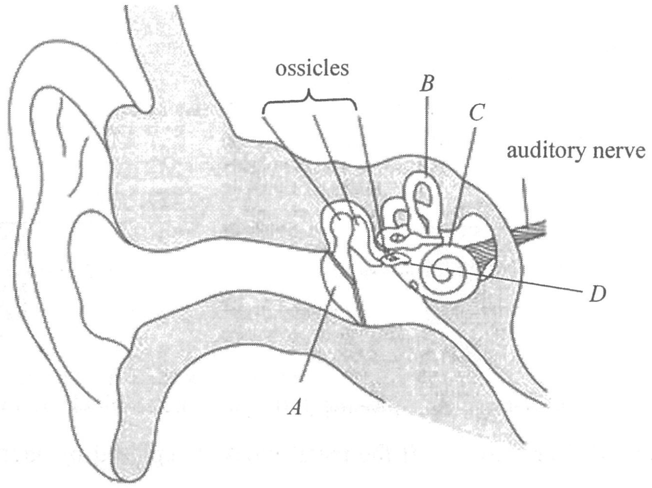
A B C D

Go on to the next page

Q.4: Structured question

Figure 4.1 shows the structure of human ear.

Figure 4.1

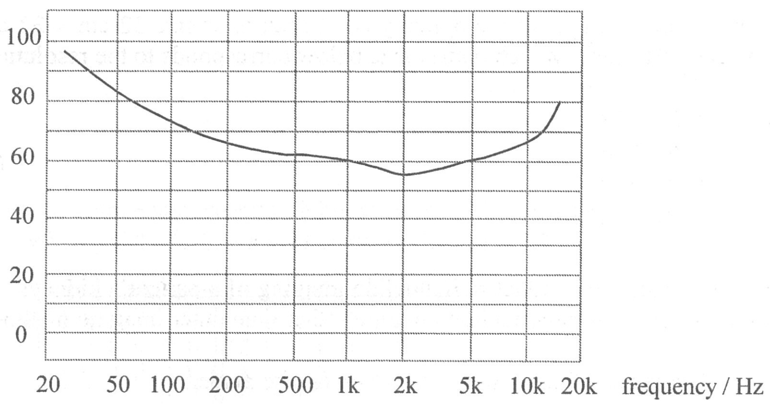


(a) (i) Match the letters *A*, *B*, *C* and *D* in Figure 4.1 with the parts of the ear, namely, **eardrum**, **oval window**, **semi-circular canals** and **cochlea**. State the function of *C*. (2 marks)

(ii) The ratio of area of *A* to that of *D* is 20. If the ear amplifies the pressure of a sound signal by 25 times totally after passing *D*, find the gain of pressure contributed by the lever action of the ossicles. (1 mark)

(b) Figure 4.2 shows an equal loudness curve of people with normal hearing.

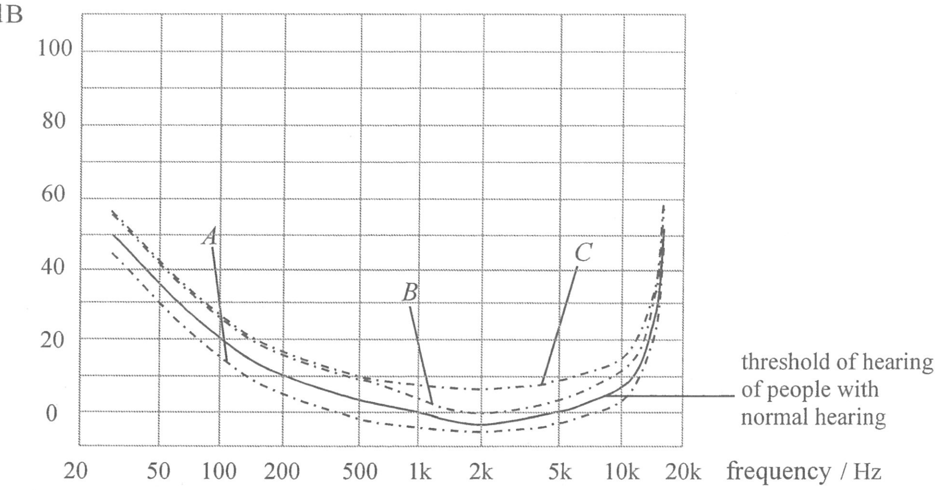
Figure 4.2



(i) State the loudness, in phons, represented by this curve. State the physical significance of the curve being higher up at both ends. (2 marks)

(ii) A worker has suffered from hearing loss due to prolonged exposure to a noisy environment and the loss is most severe for sounds around kHz frequencies. If the worker is tested for the threshold of hearing, which of the equal loudness curves, *A*, *B* and *C*, in Figure 4.3 best represents his response ? Explain your choice. (2 marks)

Figure 4.3



(c) An engineer working near an operating engine is exposed to noise of sound intensity 80 W m^{-2}. After putting on earmuffs, the sound intensity of the noise heard is reduced to 2.5×10^{-5} W m^{-2}. Estimate the decrease in sound intensity level of the noise, in dB, heard after wearing the earmuffs. (3 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.

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Answers written on this page will not be marked.

List of data, formulae and relationships

Data

molar gas constant	$R = 8.31 \text{ J mol}^{-1} \text{ K}^{-1}$	
Avogadro constant	$N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$	
acceleration due to gravity	$g = 9.81 \text{ m s}^{-2}$ (close to the Earth)	
universal gravitational constant	$G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$	
speed of light in vacuum	$c = 3.00 \times 10^8 \text{ m s}^{-1}$	
charge of electron	$e = 1.60 \times 10^{-19}$ C	
electron rest mass	$m_e = 9.11 \times 10^{-31}$ kg	
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2}$	
permeability of free space	$\mu_0 = 4\pi \times 10^{-7} \text{ H m}^{-1}$	
atomic mass unit	$u = 1.661 \times 10^{-27}$ kg	(1 u is equivalent to 931 MeV)
astronomical unit	$AU = 1.50 \times 10^{11}$ m	
light year	$ly = 9.46 \times 10^{15}$ m	
parsec	$pc = 3.09 \times 10^{16} \text{ m} = 3.26 \text{ ly} = 206265 \text{ AU}$	
Stefan constant	$\sigma = 5.67 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$	
Planck constant	$h = 6.63 \times 10^{-34}$ J s	

Rectilinear motion

For uniformly accelerated motion :

$$v = u + at$$
$$s = ut + \frac{1}{2}at^2$$
$$v^2 = u^2 + 2as$$

Mathematics

Equation of a straight line	$y = mx + c$
Arc length	$= r\theta$
Surface area of cylinder	$= 2\pi rh + 2\pi r^2$
Volume of cylinder	$= \pi r^2 h$
Surface area of sphere	$= 4\pi r^2$
Volume of sphere	$= \frac{4}{3}\pi r^3$

For small angles, $\sin\theta \approx \tan\theta \approx \theta$ (in radians)

Astronomy and Space Science

$U = -\frac{GMm}{r}$	gravitational potential energy
$P = \sigma AT^4$	Stefan's law
$\left\lvert\frac{\Delta f}{f_0}\right\rvert \approx \frac{v}{c} \approx \left\lvert\frac{\Delta\lambda}{\lambda_0}\right\rvert$	Doppler effect

Energy and Use of Energy

$E = \frac{\Phi}{A}$	illuminance
$\frac{Q}{t} = \kappa\frac{A(T_H - T_C)}{d}$	rate of energy transfer by conduction
$U = \frac{\kappa}{d}$	thermal transmittance U-value
$P = \frac{1}{2}\rho A v^3$	maximum power by wind turbine

Atomic World

$\frac{1}{2}m_e {v_{max}}^2 = hf - \phi$	Einstein's photoelectric equation
$E_n = -\frac{1}{n^2}\left\{\frac{m_e e^4}{8h^2\varepsilon_0^2}\right\} = -\frac{13.6}{n^2}$ eV	energy level equation for hydrogen atom
$\lambda = \frac{h}{p} = \frac{h}{mv}$	de Broglie formula
$\theta \approx \frac{1.22\lambda}{d}$	Rayleigh criterion (resolving power)

Medical Physics

$\theta \approx \frac{1.22\lambda}{d}$	Rayleigh criterion (resolving power)
power $= \frac{1}{f}$	power of a lens
$L = 10 \log\frac{I}{I_0}$	intensity level (dB)
$Z = \rho c$	acoustic impedance
$\alpha = \frac{I_r}{I_0} = \frac{(Z_2 - Z_1)^2}{(Z_2 + Z_1)^2}$	intensity reflection coefficient
$I = I_0 e^{-\mu x}$	transmitted intensity through a medium

A1.	$E = mc\,\Delta T$	energy transfer during heating and cooling
A2.	$E = l\,\Delta m$	energy transfer during change of state
A3.	$pV = nRT$	equation of state for an ideal gas
A4.	$pV = \frac{1}{3}Nm\overline{c^2}$	kinetic theory equation
A5.	$E_K = \frac{3RT}{2N_A}$	molecular kinetic energy
B1.	$F = m\frac{\Delta v}{\Delta t} = \frac{\Delta p}{\Delta t}$	force
B2.	moment = $F \times d$	moment of a force
B3.	$E_P = mgh$	gravitational potential energy
B4.	$E_K = \frac{1}{2}mv^2$	kinetic energy
B5.	$P = Fv$	mechanical power
B6.	$a = \frac{v^2}{r} = \omega^2 r$	centripetal acceleration
B7.	$F = \frac{Gm_1m_2}{r^2}$	Newton's law of gravitation
C1.	$\Delta y = \frac{\lambda D}{a}$	fringe width in double-slit interference
C2.	$d\sin\theta = n\lambda$	diffraction grating equation
C3.	$\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$	equation for a single lens
D1.	$F = \frac{Q_1Q_2}{4\pi\varepsilon_0 r^2}$	Coulomb's law
D2.	$E = \frac{Q}{4\pi\varepsilon_0 r^2}$	electric field strength due to a point charge
D3.	$V = \frac{Q}{4\pi\varepsilon_0 r}$	electric potential due to a point charge
D4.	$E = \frac{V}{d}$	electric field between parallel plates (numerically)
D5.	$I = nAvQ$	general current flow equation
D6.	$R = \frac{\rho l}{A}$	resistance and resistivity
D7.	$R = R_1 + R_2$	resistors in series
D8.	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$	resistors in parallel
D9.	$P = IV = I^2R$	power in a circuit
D10.	$F = BQv\sin\theta$	force on a moving charge in a magnetic field
D11.	$F = BIl\sin\theta$	force on a current-carrying conductor in a magnetic field
D12.	$V = \frac{BI}{nQt}$	Hall voltage
D13.	$B = \frac{\mu_0 I}{2\pi r}$	magnetic field due to a long straight wire
D14.	$B = \frac{\mu_0 NI}{l}$	magnetic field inside a long solenoid
D15.	$\varepsilon = N\frac{\Delta\Phi}{\Delta t}$	induced e.m.f.
D16.	$\frac{V_s}{V_p} \approx \frac{N_s}{N_p}$	ratio of secondary voltage to primary voltage in a transformer
E1.	$N = N_0 e^{-kt}$	law of radioactive decay
E2.	$t_{\frac{1}{2}} = \frac{\ln 2}{k}$	half-life and decay constant
E3.	$A = kN$	activity and the number of undecayed nuclei
E4.	$\Delta E = \Delta mc^2$	mass-energy relationship