2014-DSE
PHY
PAPER 2

HONG KONG EXAMINATIONS AND ASSESSMENT AUTHORITY
HONG KONG DIPLOMA OF SECONDARY EDUCATION EXAMINATION 2014

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.

* A 1 5 O E 2 M C *

Section A : Astronomy and Space Science

Q.1: Multiple-choice questions

1.1 Mercury is 0.39 AU from the Sun. Which of the following is **NOT** a possible distance between Mercury and the Earth ? Assume that the orbits of Mercury and the Earth are circular and co-planar.

A. 1.20 AU
B. 1.00 AU
C. 0.78 AU
D. 0.50 AU

A	B	C	D
○	○	○	○

1.2 Given that a typical galaxy in the form of a circular disc is of diameter 10^5 ly and thickness 10^3 ly containing about 10^{11} stars, estimate the average separation between two neighbouring stars within the galaxy assuming that the stars are uniformly distributed.

A. 4.3 ly
B. 6.8 ly
C. 8.9 ly
D. 43 ly

A	B	C	D
○	○	○	○

1.3 If the Sun is on the ecliptic as shown in Figure (1), which of the following positions of the Sun in Figure (2) shows the view seen by an observer at a latitude 23.5° north of the equator at noon ?

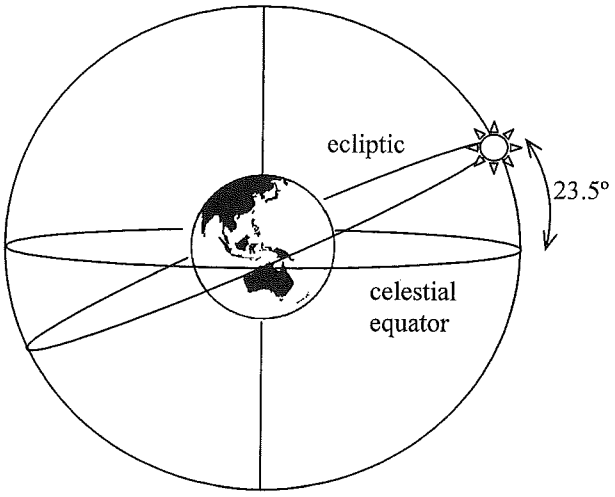


Figure (1)

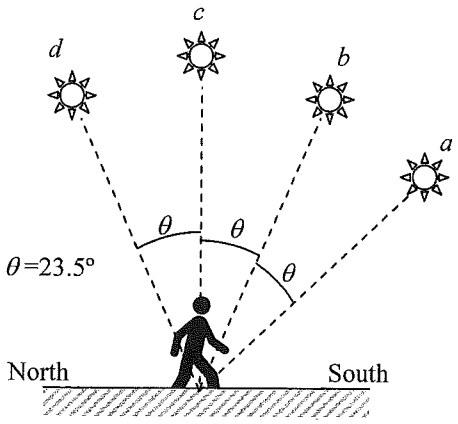


Figure (2)

A. Position *a*
B. Position *b*
C. Position *c*
D. Position *d*

A	B	C	D
○	○	○	○

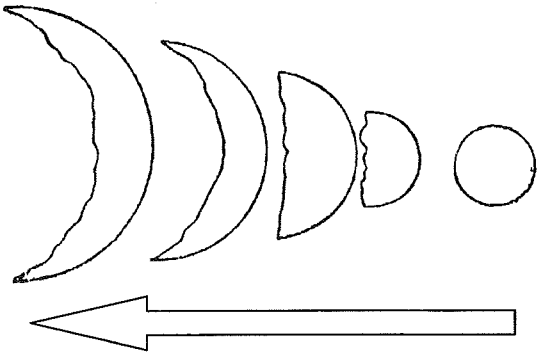
Please stick the barcode label here.

1.4 The violet line (410 nm) of the hydrogen spectrum from a distant celestial body is blue shifted and its wavelength appears 50 nm shorter when observed. What is the observed wavelength of the red line (656 nm) from the same source ?

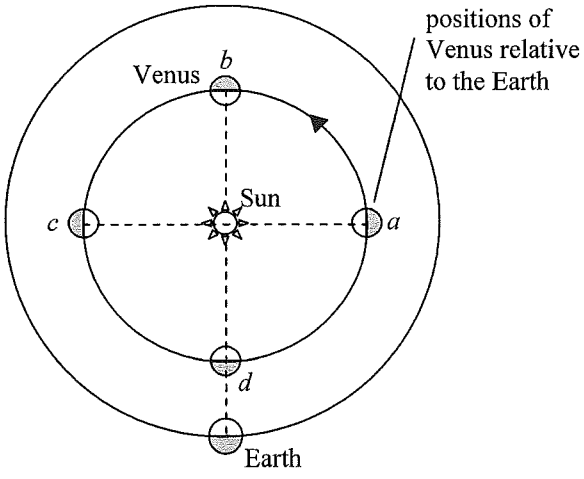
A. 576 nm
B. 606 nm
C. 706 nm
D. 736 nm

A	B	C	D
○	○	○	○

1.5 The following diagram is Galileo's drawing in 1610 showing the phases of Venus.



Which of the following parts of the orbit of Venus represent the above change of phases from right to left ?

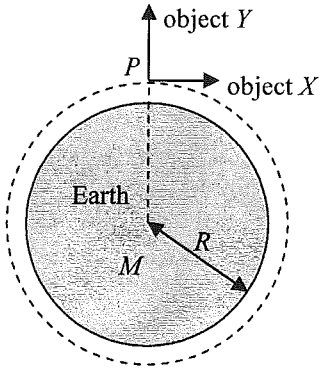


A. $a \rightarrow b \rightarrow c$
B. $b \rightarrow c \rightarrow d$
C. $c \rightarrow d \rightarrow a$
D. $d \rightarrow a \rightarrow b$

A	B	C	D
○	○	○	○

Go on to the next page

1.6 At a point P close to the Earth, two objects X, Y travel with the same speed v where $v = \sqrt{\frac{GM}{R}}$ with M and R being the mass and radius of the Earth respectively and G is the universal gravitational constant. X travels tangentially at P while Y travels radially outward from P. Which of the following statements about their subsequent motions is correct ? Neglect air resistance.

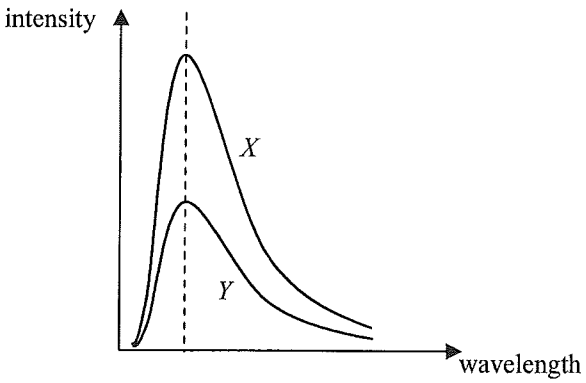


	object *X*	**object *Y***
A.	will eventually return to the Earth.	will continue to fly in its orbit.
B.	will eventually return to the Earth.	will eventually return to the Earth.
C.	will continue to fly in its orbit.	will continue to fly in its orbit.
D.	will continue to fly in its orbit.	will eventually return to the Earth.

A B C D

○ ○ ○ ○

(For questions 1.7 and 1.8) The diagram shows the spectra of radiation from stars X and Y with their peaks lying at the same wavelength.



1.7 Which statement is correct ?

A. Surface temperature of X > Surface temperature of Y
B. Surface temperature of X < Surface temperature of Y
C. Surface temperature of X = Surface temperature of Y
D. The information is not sufficient to make a comparison of the surface temperature of X and Y.

A B C D

○ ○ ○ ○

1.8 Which statement is correct ?

A. Star X is smaller than star Y.
B. Star X is bigger than star Y.
C. Star X and star Y are of the same size.
D. The information is not sufficient to make a comparison of the size of stars X and Y.

A B C D

○ ○ ○ ○

Please stick the barcode label here.

Q.1: Structured question

(a) A star of radius R and surface temperature T_s (in K) emits radiation in all directions. A planet of radius r orbits the star at a distance d, which is much larger than both R and r. Assume that both the star and the planet behave like black bodies.

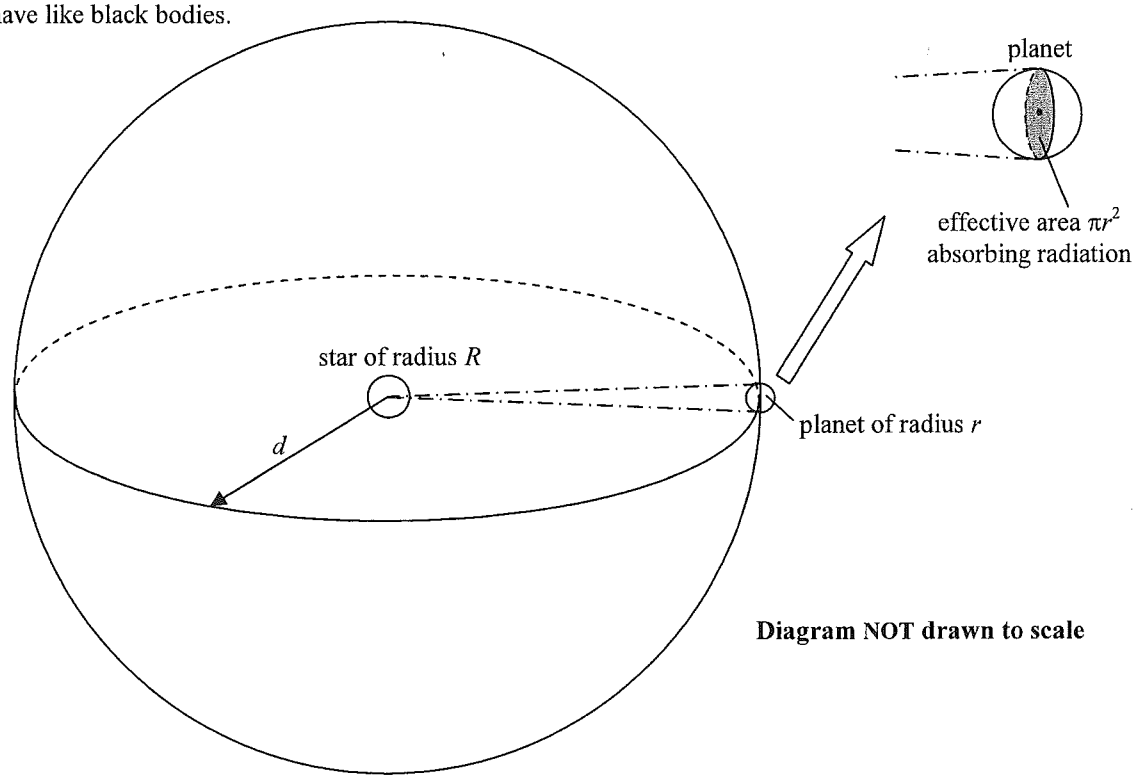


Diagram NOT drawn to scale

(i) Taking the effective area that the planet absorbs radiation emitted from the star as πr^2, show that the power absorbed by the planet is $\pi\sigma(\frac{rR}{d})^2 T_s^4$ where σ is the Stefan constant. Assume that the planet is a perfect absorber of radiation. (2 marks)

(ii) If the planet only absorbed energy, its temperature would rise indefinitely. However, this would not happen because the planet also radiates energy as it absorbs energy so that an equilibrium state is maintained. Show that the equilibrium surface temperature of the planet is given by $T_p = \sqrt{\frac{R}{2d}}\, T_s$. (2 marks)

(b) A planet called Kepler-22b was discovered orbiting a Sun-like star with orbital radius 0.84 AU (1 AU = 1.50×10^{11} m). The star has a radius of 6.82×10^8 m and its surface temperature is 5518 K.

(i) Estimate the equilibrium surface temperature of Kepler-22b using the results of (a). (2 marks)

(ii) Liquid water is believed to be essential for life to exist on a planet. Based on the information found in (b)(i), explain whether Kepler-22b would be a favourable planet for life to exist or not. (2 marks)

(iii) If Kepler-22b orbits a class K star instead of a Sun-like star (which is a class G star) with the same orbital radius, would its equilibrium surface temperature increase, decrease or remain unchanged ? State your reason. Given: the sequence of spectral classes is O B A F G K M. (2 marks)

Go on to the next page

Section B : Atomic World

Q.2: Multiple-choice questions

2.1 Which of the following statements about Rutherford's atomic model is/are correct ?

(1) All the positive charges and nearly all of the atom's mass are concentrated in its tiny central nucleus.
(2) Negatively charged electrons orbit around the nucleus.
(3) The electrons can only move in certain orbits each having a definite energy and they do not radiate while accelerating.

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

A B C D
○ ○ ○ ○

2.2 There are dark lines in the spectrum of sunlight. Which of the following statements are correct ?

(1) They are due to the absorption of certain wavelengths of light by the atoms in the Sun's atmosphere.
(2) Light absorbed by the atoms in the Sun's atmosphere is then re-emitted in all directions.
(3) The kinds of atoms present in the Sun's atmosphere can be deduced by the characteristics of the dark lines.

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

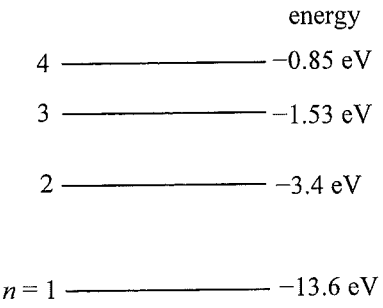
A B C D
○ ○ ○ ○

2.3 A hydrogen atom in the ground state absorbs a photon of wavelength λ so that it is excited from quantum number $n = 1$ to $n = 3$. The ionization energy, in eV, of a hydrogen atom in the ground state is given by

A. $\frac{3hc}{2\lambda}$.
B. $\frac{2hc}{3\lambda}$.
C. $\frac{9hc}{8\lambda}$.
D. $\frac{8hc}{9\lambda}$.

A B C D
○ ○ ○ ○

2.4



The lowest four energy levels of a hydrogen atom are shown above. Which statement about a hydrogen atom in the ground state is **INCORRECT** ?

A. The collision between an electron of kinetic energy 10 eV and the atom is perfectly elastic.
B. The collision between an electron of kinetic energy 12 eV and the atom can be inelastic.
C. A photon of energy 12 eV can excite the atom to the first excited state.
D. A photon of energy 14 eV can ionize the atom.

A B C D
○ ○ ○ ○

Please stick the barcode label here.

2.5 When photons each of energy 3.41 eV are incident on a metal surface, the maximum kinetic energy of the photoelectrons emitted is 0.54 eV. What is the threshold frequency of this metal ?

A. 4.33×10^{33} Hz
B. 9.53×10^{14} Hz
C. 8.23×10^{14} Hz
D. 6.93×10^{14} Hz

A	B	C	D
○	○	○	○

2.6 A beam of light of frequency f falls on the cathode of a photocell so that photoelectrons are emitted. If the light beam is replaced by another one with the same intensity but having a frequency of $2f$, how would each of the following physical quantities change ? Assume that each incident photon can emit one photoelectron.

V_s : stopping potential
I : magnitude of the saturation photoelectric current

	V_s	I
A.	increases	increases
B.	increases	decreases
C.	remains unchanged	decreases
D.	decreases	increases

A	B	C	D
○	○	○	○

2.7 The de Broglie wavelength of object X is shorter than that of object Y. Which of the following deductions must be correct ?

(1) X has a higher speed than Y.
(2) X has a greater momentum than Y.
(3) X has greater kinetic energy than Y.

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

A	B	C	D
○	○	○	○

2.8 Which statements about nanotechnology are correct ?

(1) Glass can be made self-cleaning by coating it with titanium oxide in nanoscale.
(2) Carbon nanotubes and diamonds have the same spatial arrangement of carbon atoms.
(3) When gold is reduced to nanoscale, its melting point would be different from that of its bulk form.

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

A	B	C	D
○	○	○	○

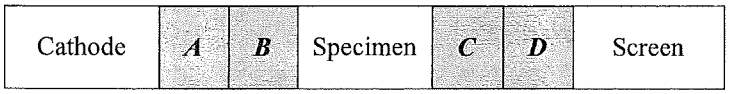
Go on to the next page

Q.2: Structured question

(a) In a Transmission Electron Microscope (TEM), electrons emitted from the cathode pass through the specimen and the four functional parts listed below before forming an image on a screen.

Functional parts: (1) objective magnetic lens
(2) projection magnetic lens
(3) condensing magnetic lens
(4) anode

Referring to the following block diagram of a TEM, match the functional parts represented by *A*, *B*, *C* and *D* in the diagram. (2 marks)



(b) (i) When an electron of mass m and charge e is accelerated from rest by a voltage V, show that its de Broglie wavelength λ is given by $\lambda = \frac{h}{\sqrt{2meV}}$ where h is the Planck constant. (2 marks)

(ii) The accelerating voltage of a TEM is 10 kV. Find λ. (2 marks)

(iii) Explain why the resolving power of a TEM is higher compared with an optical microscope. (2 marks)

(c) Both Scanning Tunnelling Microscopes (STM) and Transmission Electron Microscopes (TEM) have very high resolving powers. Now if the internal structure of a slice of metallic specimen is to be studied, which of the above microscopes would be suitable or are both suitable ? Explain. (2 marks)

Section C : Energy and Use of Energy

Q.3: Multiple-choice questions

3.1 For monochromatic light sources, which of the following pairs appear(s) to be equally bright to our eyes ?

(1) 1 lumen of red light and 1 lumen of green light
(2) red light of 1 watt and green light of 1 watt
(3) red light of 1 watt and 1 lumen of red light

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

A	B	C	D
○	○	○	○

3.2 The energy labels for air-conditioners show the annual energy consumption (based on 1200 hours of operation per year) and the cooling capacity. Which air-conditioner below is the most energy efficient ?

	annual energy consumption / kW h	cooling capacity / kW
A.	672	2.44
B.	684	2.58
C.	696	2.89
D.	750	2.63

A	B	C	D
○	○	○	○

3.3 Which of the following building materials with thicknesses listed below give the best heat insulation ?

	material	thermal conductivity / W m^{-1} K^{-1}	thickness / m
A.	concrete	0.50	0.20
B.	wood	0.15	0.05
C.	glass	1.00	0.04
D.	plaster	0.24	0.10

A	B	C	D
○	○	○	○

3.4 Glass with low-emissivity coating can reduce heat transfer into a building by reflecting mainly

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

A	B	C	D
○	○	○	○

3.5 A wind turbine generator experiences wind blowing normal to it with variable speed such that the wind speed is 1 m s^{-1} for the first two minutes and 2 m s^{-1} for the third minute. What is its average power output, in W, for this period of 3 minutes if the overall efficiency of the generator is 30% and the length of each blade is 20 m ? Given : ρ = density of air in kg m^{-3}.

A. $180\pi\rho$
B. $200\pi\rho$
C. $600\pi\rho$
D. $667\pi\rho$

A	B	C	D
○	○	○	○

Go on to the next page

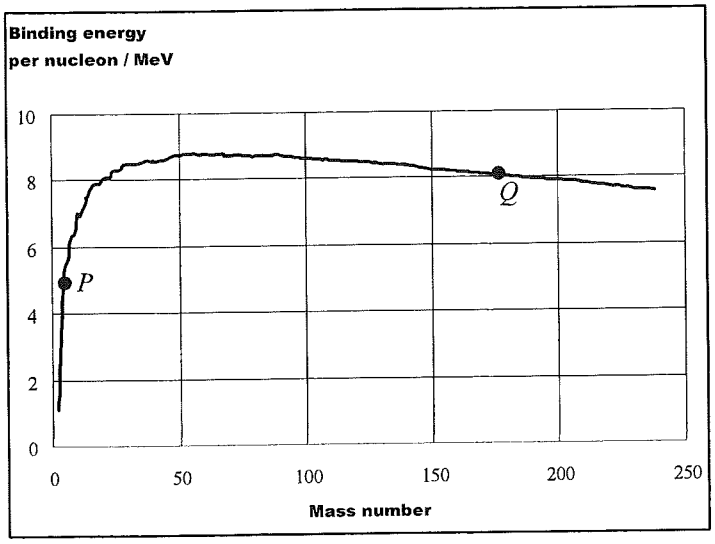
3.6 Which of the following statements about hybrid vehicles is/are correct ?

(1) The battery of a hybrid vehicle needs to be recharged by an external electric source before the vehicle can run.
(2) The power of the internal combustion engine of a hybrid vehicle is smaller than that of a conventional petrol vehicle of the same weight and performance.
(3) The primary energy source of a hybrid vehicle is 100% petrol.

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

A	B	C	D
○	○	○	○

3.7 The curve below shows the binding energy per nucleon of nuclides of different mass numbers.



Which of the following statements is/are correct ?

(1) Nuclei of P can release energy by nuclear fusion.
(2) Nuclei of Q can release energy by nuclear fission.
(3) Nuclei of P are more stable than nuclei of Q.

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

A	B	C	D
○	○	○	○

3.8 Under normal operation, which of the following statements about a pressurized water reactor (PWR) of a nuclear power plant is/are correct ?

(1) The coolant which carries energy away from the reactor is radioactive.
(2) The steam that drives the turbine is radioactive.
(3) The cooling water discharged into the sea from the nuclear power plant contains some radioactive substances of the reactor.

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

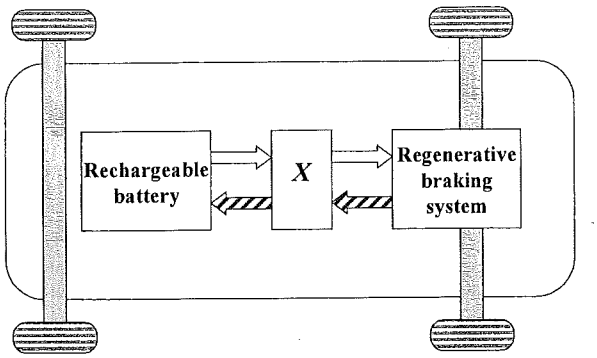
A	B	C	D
○	○	○	○

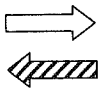
Q.3: Structured question

(a) A completely discharged battery of an electric vehicle is fully charged to store 23 kW h of energy with a terminal voltage of 220 V at an average current of 13 A. Estimate the time in hours required to fully charge the battery. Neglect the internal resistance of the battery. (2 marks)

(b) Figure 3.1 shows the schematic diagram of an electric vehicle.

Figure 3.1





denotes the transmission of energy when the vehicle is running

denotes the transmission of energy during braking

(i) What is the function of component *X* in Figure 3.1 when the vehicle is accelerating forward ? Referring to Figure 3.1, describe how the regenerative braking system saves energy during braking. (3 marks)

(ii) Assuming that a fixed percentage of energy is dissipated into heat during braking, would the regenerative braking system be more effective when the electric vehicle is moving at a low speed or a high speed ? Explain. (2 marks)

(iii) Why is it necessary for an electric vehicle also be equipped with a mechanical braking system in addition to a regenerative braking system ? (1 mark)

(c) Given that typical electric vehicles convert 60% of the electrical energy supplied into the vehicle's mechanical output, consider the following modes of operation of vehicles :

Mode 1	**Conventional petrol vehicles** : 20% of energy stored in petrol is converted to the vehicle's mechanical output.
Mode 2	**Coal-fired power plants + Electric vehicles** : coal-fired power plants are 45% efficient in converting energy stored in coal to electrical energy delivered at socket.
Mode 3	**Nuclear power plants + Electric vehicles** : nuclear power plants are 35% efficient in converting energy stored in fuel rods to electrical energy delivered at socket.

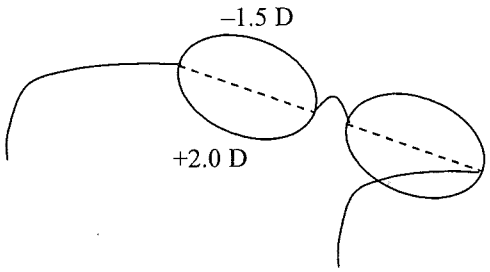
Which mode has the highest **overall energy efficiency** ? Does this mode have the minimum **overall emission of air pollutants** among the three modes ? Explain your answer. (2 marks)

Go on to the next page

Section D : Medical Physics

Q.4: Multiple-choice questions

4.1 Mr. Lee wears a pair of bifocal lenses as shown. The respective powers of the upper half and the lower half of each lens are –1.5 D and +2.0 D. Which of the following statements is/are correct ?



(1) The upper half is for viewing distant objects while the lower half is for viewing objects at a close distance.
(2) Mr. Lee only suffers from old sight (presbyopia).
(3) Without the spectacles, Mr. Lee cannot see an object clearly no matter how far it is placed from him.

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

A B C D

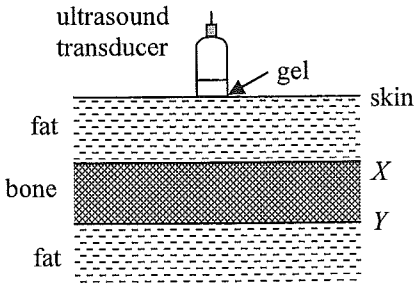
4.2 Which of the following statements about the threshold of hearing is/are correct ?

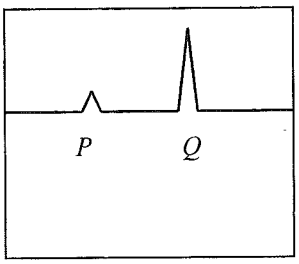
(1) The intensity of sound of the threshold of hearing is 0 W m^{-2}.
(2) The corresponding sound intensity level of the threshold of hearing is chosen as 0 dB.
(3) The threshold of hearing depends on the frequency of sound.

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

A B C D

4.3





An ultrasound transducer is placed on the skin over a certain position of the human body to perform an A-scan. The signal received contains two spikes *P* and *Q* as shown. Which of the following statements is/are correct ?

(1) There is almost no reflection from interface *Y* because the bone absorbs nearly all of the ultrasound.
(2) There is almost no reflection from interface *Y* because interface *X* reflects nearly all of the ultrasound.
(3) The spikes *P* and *Q* correspond to the reflections at interfaces *X* and *Y* respectively.

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

A B C D

4.4 Which statement about fibre optic endoscopes is correct ?

A. A coherent fibre bundle is mainly used for transporting light from a light source to the area under examination and back to the other end.

B. Non-coherent fibre bundles have a greater amount of light lost compared to coherent fibre bundles.

C. Both coherent and non-coherent fibre bundles can function normally when bent slightly.

D. Only black and white images can be displayed by fibre optic endoscopes.

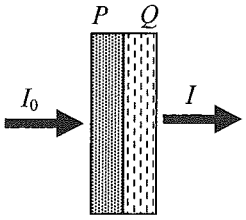
A B C D

4.5 A patient is going to take a needle aspiration biopsy in which a fine needle is inserted into his liver through the skin to take a tiny living tissue for testing. In order to minimize the risk of internal bleeding, it is important to locate the large blood vessels of the liver near the place where the needle is inserted. Also, as the liver can displace slightly inside the body, real-time imaging is therefore needed during needle insertion. The most suitable imaging method is

A. X-ray planar imaging.
B. computed tomography.
C. ultrasound imaging.
D. radionuclide imaging.

A B C D

4.6 An object is made up of two different materials P and Q of 1 cm equal thickness as shown. The linear attenuation coefficients of P and Q for X-rays are 0.05 cm^{-1} and 0.68 cm^{-1} respectively. An X-ray beam of intensity I_0 is incident on the object and emerges from the object with an intensity I. Which of the following expressions gives the ratio $\frac{I}{I_0}$?



A. $\frac{0.05}{0.68}$

B. $\frac{(0.68 - 0.05)^2}{(0.68 + 0.05)^2}$

C. $e^{-\frac{0.05}{0.68}}$

D. $e^{-(0.05 + 0.68)}$

A B C D

4.7 What is the function of artificial contrast medium (ACM) when taking radiographic images ?

A. It slows down the X-rays so that the X-rays stay longer in the organ.
B. It increases the absorption of some of the X-rays by the organ.
C. It increases the energy of X-rays before the X-rays leave the organ.
D. After injection, the ACM in aqueous form decreases the density of the organ that is undergoing radiographic imaging.

A B C D

4.8 The biological half-life and physical half-life of a radionuclide Y are two days and three days respectively. A patient takes in a quantity of Y as tracer for radionuclide imaging. How long does it take for the amount of radionuclide Y left in the patient's body to reduce to 1/8 of the original intake ?

A. 3.6 days
B. 4.8 days
C. 7.5 days
D. 15 days

A B C D

Go on to the next page

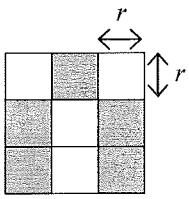
Q.4: Structured question

(a) (i) In medical imaging using ultrasound, a piezoelectric transducer is employed to scan the patient. Describe how a piezoelectric transducer generates ultrasound waves. (2 marks)

(ii) State **ONE** advantage and **ONE** disadvantage of using ultrasound of higher frequencies in medical imaging. (2 marks)

(b) (i) John has normal eyesight and the power of his eye is +59 D in viewing distant objects. Estimate the separation between the lens and the retina of his eye. Assume that the refracting power is mainly contributed by the eye lens. (2 marks)

(ii) The display panel of a smart phone *X* is made up of numerous tiny square pixels as shown.



square pixels of part of the display panel

John is looking at the graphics on the display panel of smart phone *X*. The diameter of his eye's pupil is 4.0 mm. Estimate the resolving power θ (in radians) of his eye for graphics in green colour.
Given: wavelength of green light = 5.35×10^{-7} m. (2 marks)

(iii) The pixels of smart phone *X* are so small that the human eye is unable to distinguish two adjacent pixels at a typical viewing distance $L = 0.30$ m. Using the result of (b)(ii), estimate the maximum length of a side of a square pixel, r, on the display panel of smart phone *X*. You may assume that for small angle θ in radians, $\tan\theta \approx \theta$. (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.

List of data, formulae and relationships

Data

molar gas constant	$R = 8.31$ J mol^{-1} K^{-1}
Avogadro constant	$N_A = 6.02 \times 10^{23}$ mol^{-1}
acceleration due to gravity	$g = 9.81$ m s^{-2} (close to the Earth)
universal gravitational constant	$G = 6.67 \times 10^{-11}$ N m^2 kg^{-2}
speed of light in vacuum	$c = 3.00 \times 10^8$ 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	$\varepsilon_0 = 8.85 \times 10^{-12}$ C^2 N^{-1} m^{-2}
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}$ H m^{-1}
atomic mass unit	u = 1.661×10^{-27} kg (1 u is equivalent to 931 MeV)
astronomical unit	AU = 1.50×10^{11} m
light year	ly = 9.46×10^{15} m
parsec	pc = 3.09×10^{16} m = 3.26 ly = 206265 AU
Stefan constant	$\sigma = 5.67 \times 10^{-8}$ W m^{-2} 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
$\left\|\frac{\Delta f}{f_0}\right\| \approx \frac{v}{c} \approx \left\|\frac{\Delta\lambda}{\lambda_0}\right\|$	Doppler effect

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)

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

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.	$N = N_0e^{-kt}$	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