2022-DSE
PHY

PAPER 2

DIOCESAN BOYS' SCHOOL

HONG KONG DIPLOMA OF SECONDARY EDUCATION EXAMINATION 2022

G 12 FINAL EXAMINATION

PHYSICS PAPER 2

Question-Answer Book

Time allowed: 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 Name, Class and Class number in the spaces provided on Page 1.

(2) This paper consists of **TWO** sections, Sections E2 and E3. Each section contains eight multiple-choice questions and one structured question which carries 10 marks. Attempt **ALL** questions.

(3) Write your answers in the spaces provided in this Question-Answer Book. 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 Name, Class, Class number, and fill in the question number box on each sheet. Fasten them with string **INSIDE** this Question-Answer Book.

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

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

(7) No extra time will be given to candidates for filling in the question number boxes after the 'Time is up' announcement.

(8) Unless otherwise specified, numerical answers should be either exact or correct to 3 significant figures.

Name	
Class	
Class Number	

	Teacher Use Only
	Marks
E2	**Atomic world**
MCQ	
SQ	
E3	**Energy and use of energy**
MCQ	
SQ	
Total	

Section E2: Atomic World

Multiple-choice questions

2.1 Which of the following statements about Rutherford's atomic model are **incorrect**?

(1) It explains the line spectra of atoms.
(2) It fails to explain why electrons orbit around the nucleus.
(3) It predicts that all atoms are unstable.

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 sunlight spectrum. Which of the following explanations about the formation of the dark lines is correct?

A. The atoms in the Sun's atmosphere emit photons of all wavelengths except some characteristic wavelengths.
B. The atoms in the Sun's atmosphere absorb photons of some characteristic wavelengths and then emit them in all directions.
C. The atoms in the Sun's atmosphere absorb photons of all wavelengths except some characteristic wavelengths.
D. The atoms in the Sun's atmosphere absorb photons of all wavelengths and then emit photons of some characteristic wavelengths in all directions.

A B C D
○ ○ ○ ○

2.3 According to Bohr's model of the hydrogen atom, what is the orbital radius of an electron at the k^{th} excited state? (r_1 denotes the orbital radius of an electron at the ground state.)

A. $k\,r_1$
B. $k^2\,r_1$
C. $(k + 1)\,r_1$
D. $(k + 1)^2\,r_1$

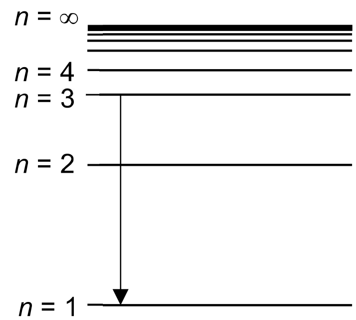
A B C D
○ ○ ○ ○

2.4 An electron in a hydrogen atom is excited from the ground state to the second excited state. What is the ratio of its total energy before the excitation to that after the excitation?

A. 1 : 4
B. 1 : 9
C. 9 : 1
D. 4 : 1

A B C D
○ ○ ○ ○

2.5 The energy level diagram of an atom is shown in the figure. The transition from $n = 3$ to $n = 1$ corresponds to the emission of visible light. Which of the following is a possible transition corresponding to the emission of ultraviolet radiation?



A. $n = 2$ to $n = 1$
B. $n = 4$ to $n = 1$
C. $n = 3$ to $n = 2$
D. $n = 4$ to $n = 2$

A **B** **C** **D**
○ ○ ○ ○

2.6 The de Broglie wavelength of neutrons used to study crystal structure is 1.2 nm .
(Given: mass of a neutron = 1.67×10^{-27} kg)

The speed of these neutrons would be

A. 3.0×10^{6} m s^{-1}
B. 3.3×10^{2} m s^{-1}
C. 3.0×10^{-3} m s^{-1}
D. 3.3×10^{-7} m s^{-1}

A **B** **C** **D**
○ ○ ○ ○

2.7 Two point sources of violet light, 4 m apart, with wavelength $\lambda = 400$ nm, are placed at a distance, *d*, from an observer such that they can just be resolved by the naked eye. If two other point sources of red light, with wavelength $\lambda = 700$ nm, are placed at the same distance, *d*, from the observer, at what distance should the two sources of red light be separated?

A. 11 m apart from each other
B. 7 m apart from each other
C. 2 m apart from each other
D. 1 m apart from each other

A **B** **C** **D**
○ ○ ○ ○

2.8 Which of the following statements about transmission electron microscopes (TEM) are **incorrect**?

(1) A TEM typically has a higher resolution than an optical microscope.
(2) The resolving power of a TEM can be made higher by using electrons with lower kinetic energy.
(3) A TEM can **only** image non-conducting samples.

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

A **B** **C** **D**
○ ○ ○ ○

Section E2: Atomic World

Structured question

(a) A set-up to investigate photoelectric effect is shown in **Fig. 2A** .

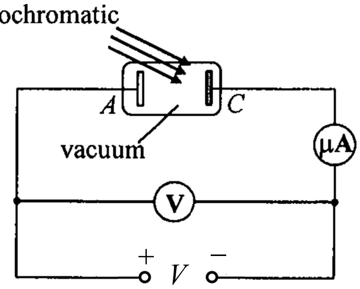


Fig. 2A

A monochromatic light (L_1) of frequency f_1 and intensity 1.0 W m^{-2} is shone on the cathode C and a varying potential difference V is applied across C and the anode A of the photocell. A sensitive microammeter is used to detect any current that flows. The cathode is made of a metal with work function 2.3 eV .

The light is then replaced by another monochromatic light (L_2) of the same intensity, but a different frequency f_2 . In both cases, V is varied, and the maximum ammeter reading is recorded. The results are shown in the table below.

light	**frequency / Hz**	**photon energy /eV**	**intensity of light / W m^{-2}**	**work function / eV**	**max. ammeter reading / μA**
L_1	4.34×10^{14}		1.0	2.3	0.00
L_2	9.17×10^{14}		1.0	2.3	0.20

(i) Fill in the above table by writing down the corresponding photon energy in eV . (1 mark)

(ii) (1) Explain why the ammeter reading for L_1 is zero. (1 mark)

(2) It is known that only 1 in 1200 of incident photons causes emission of an electron. Considering the case when the ammeter reading is 0.20 μA , calculate the number of photons emitted per second for L_2 . (2 marks)

(iii) Write down the maximum ammeter reading when the intensity of light is increased to 4.0 W m^{-2} for both L_1 and L_2 . (The frequencies of L_1 and L_2 remain the same.) (2 marks)

L_1: ____________ μA ; L_2: ____________ μA

(iv) Another ultraviolet radiation with wavelength 110 nm and intensity 4.0 W m^{-2} is shone on the same cathode. Find the maximum speed of the photoelectrons that are emitted. (2 marks)

(b) In the past, films used in the cinema to play movies had an optical soundtrack next to the picture frames. A photo of the film is shown in **Fig. 2B**, and a schematic is shown in **Fig. 2C**.

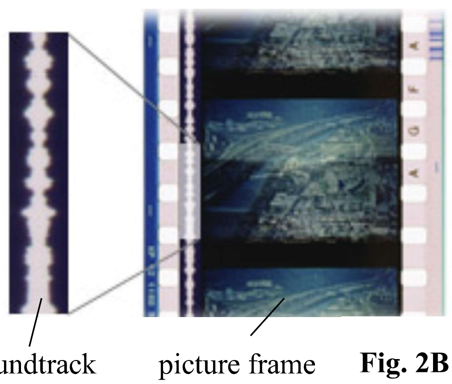


Fig. 2B

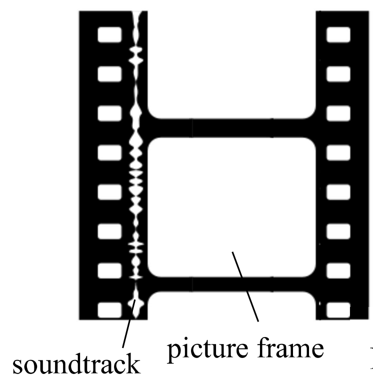


Fig. 2C

Film restoration (i.e. digitalising old films) can be done by moving the film in a projector through a source of light. Light is then detected by a photocell on the other side of the soundtrack (see **Fig. 2D**). The sound signal is then produced in the photocell circuit and be recorded digitally.

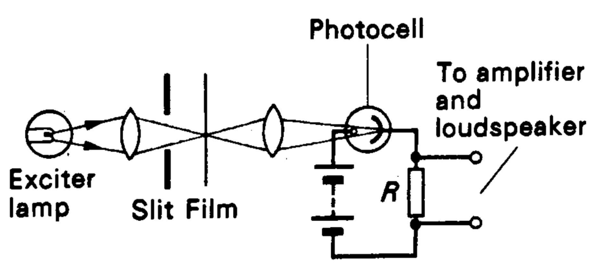


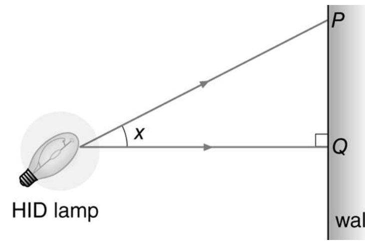
Fig. 2D

Explain how the changing pattern of the soundtrack produces a sound signal. (2 marks)

Section E3: Energy and Use of Energy

Multiple-choice questions

3.1 An HID lamp is placed in front of a wall as shown in the figure. Assume that the lamp is small enough to be regarded as a point source. What is the ratio of the illuminance at Q to the illuminance at P?



A. $\dfrac{1}{\cos x}$

B. $\dfrac{1}{\cos^3 x}$

C. $\cos^3 x$

D. It cannot be determined as the distance between the HID lamp and the wall is not known.

A B C D

3.2 Which of the following cookers make(s) use of the heating effect of current and emit(s) electromagnetic waves during cooking?

(1) Electric hotplate
(2) Induction cooker
(3) Microwave oven

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

A B C D

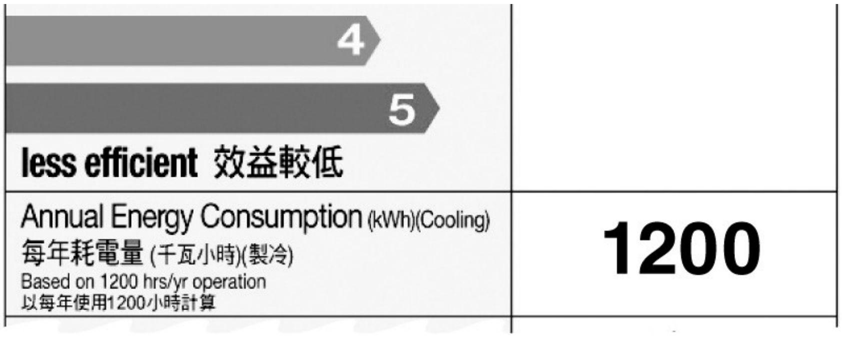
3.3 An architect decides to increase the thickness of an exterior wall to meet the requirements of a construction plan. Which of the following statements are **incorrect**?

(1) The U-value of the wall will increase.
(2) The thermal conductivity of the wall will increase.
(3) The OTTV of the building will decrease.

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

A B C D

3.4 The following shows an energy label of an air-conditioner. The annual energy consumption is based on 1200 hrs / yr operation.



If the air-conditioner is operated for 1400 hours per year, what is the approximate amount of energy the air-conditioner consumes in 12 years?

A. 8.64×10^6 kW h
B. 16800 kW h
C. 7200 kW h
D. 3600 kW h

A B C D

3.5 The Three Gorges Dam is the world's largest hydroelectric power station. The difference in water level on the two sides of the dam is about 175 m. 26 turbine generator units were installed before 2008. This provides a total of 18200 MW of electricity generating capacity. When the power station operates at its full capacity, what is the flow rate of water running through each turbine? (Given: $g = 9.81$ m s^{-2})

A. 1.20×10^{12} kg s^{-1}
B. 3.92×10^{7} kg s^{-1}
C. 1.06×10^{7} kg s^{-1}
D. 4.08×10^{5} kg s^{-1}

A B C D

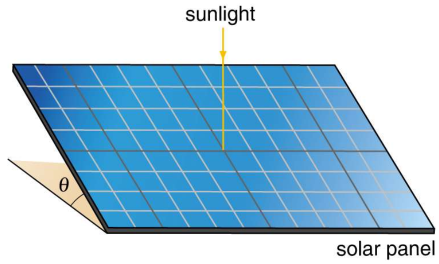
3.6 Which of the following vehicles contain(s) a regenerative braking system?

(1) Petrol vehicle
(2) Electric vehicle
(3) Hybrid vehicle

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

A B C D

3.7 The figure shows a solar panel inclined at an angle θ to the roof top of a house. Sunlight shines from above vertically.



Which of the following can increase the output voltage of the panel?

(1) Increase the angle θ.
(2) Add an anti-reflection film to the top of the solar panel.
(3) Connect the output of the panel with a step-up transformer.

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

A B C D
○ ○ ○ ○

3.8 The following table shows the masses of a H-3 nucleus, a proton and a neutron.

Particle	**Mass in kg**
${}^{3}_{1}\mathrm{H}$ nucleus	m_H
Proton	m_p
Neutron	m_n

What is the binding energy per nucleon of a ${}^{3}_{1}\mathrm{H}$ nucleus?

A. $\dfrac{(m_H - m_p - 2m_n)(931)}{3}$ (in MeV)

B. $\dfrac{(m_p + 2m_n - m_H)(931)}{3}$ (in MeV)

C. $\dfrac{(m_H - m_p - 2m_n)(3\times10^8)^2}{3}$ (in J)

D. $\dfrac{(m_p + 2m_n - m_H)(3\times10^8)^2}{3}$ (in J)

A B C D
○ ○ ○ ○

Section E3: Energy and Use of Energy

Structured question

(a) Read the following article about the development of nuclear reactors in China and answer the questions that follow.

> The "Hualong One" (China Dragon No.1) is a Chinese generation III pressurized water nuclear reactor. Generation III is a class of nuclear reactor that incorporates evolutionary improvements in design including improved fuel technology, higher thermal efficiency, enhanced safety systems and a longer design life.
>
> Hualong One reactors are now constructed in different units of nuclear power plants in China. Unit 5 of the Fuqing Nuclear Power Plant was the first Hualong One to begin commercial operation in January 2021. A nuclear power technology company has also been set up to promote Hualong One in overseas markets.

(i) Is nuclear power a renewable energy source? Explain briefly. (2 marks)

(ii) In a nuclear power station, nuclear fission of uranium-235 takes place in a reactor. Briefly describe how (1) energy is released and (2) the chain reaction takes place. (2 marks)

(iii) Why is the water pressurized in "Hualong One"? (1 mark)

(iv) In relation to the nuclear accidents in recent decades, suggest one aspect of nuclear safety that should be addressed by the "enhanced safety systems" in "Hualong One". (1 mark)

(v) Suppose that the energy released by a fission reaction is about 178 MeV. The efficiency of the reactor is 30% and 145 g of uranium-235 is used to produce energy each hour in the reactor. Find the power output of the reactor (in MW). (2 marks)

(b) Although there is no large-scale power station using renewable energy sources in Hong Kong, different projects have been carried out by electrical companies. In one project, an electrical company proposes to build 5 wind turbines at a place to supply 4 MW electrical power. Each wind turbine has blades of 30 m long. The efficiency of wind turbines is 75%. Other data have also been obtained as follows:

Average wind speed = 12 m s^{-1}
Air density = 1.25 kg m^{-3}
Percentage of wind energy captured = 40%

Determine whether the proposal can fulfil the required power supply. (2 marks)

END OF PAPER

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	$e = 1.60 \times 10^{-19}\ \text{C}$
electron rest mass	$m_e = 9.11 \times 10^{-31}\ \text{kg}$
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	$\text{u} = 1.661 \times 10^{-27}\ \text{kg}$ (1 u is equivalent to 931 MeV)
astronomical unit	$\text{AU} = 1.50 \times 10^{11}\ \text{m}$
light year	$\text{ly} = 9.46 \times 10^{15}\ \text{m}$
parsec	$\text{pc} = 3.09 \times 10^{16}\ \text{m} = 3.26\ \text{ly} = 206\ 265\ \text{AU}$
Stefan constant	$\sigma = 5.67 \times 10^{-8}\ \text{W m}^{-2}\ \text{K}^{-4}$
Planck constant	$h = 6.63 \times 10^{-34}\ \text{J s}$

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

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

Energy and Use of Energy

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

Atomic World

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

Medical Physics

$\theta \approx \dfrac{1.22\lambda}{d}$	Rayleigh criterion (resolving power)
$\text{power} = \dfrac{1}{f}$	power of a lens
$L = 10\log\dfrac{I}{I_0}$	intensity level (dB)
$Z = \rho c$	acoustic impedance
$\alpha = \dfrac{I_r}{I_0} = \dfrac{(Z_2 - Z_1)^2}{(Z_2 + Z_1)^2}$	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 separation 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.	$E = \frac{V}{d}$	electric field between parallel plates (numerically)
D4.	$R = \frac{\rho l}{A}$	resistance and resistivity
D5.	$R = R_1 + R_2$	resistors in series
D6.	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$	resistors in parallel
D7.	$P = IV = I^2R$	power in a circuit
D8.	$F = BQv\sin\theta$	force on a moving charge in a magnetic field
D9.	$F = BIl\sin\theta$	force on a current-carrying conductor in a magnetic field
D10.	$B = \frac{\mu_0 I}{2\pi r}$	magnetic field due to a long straight wire
D11.	$B = \frac{\mu_0 NI}{l}$	magnetic field inside a long solenoid
D12.	$\varepsilon = N\frac{\Delta\Phi}{\Delta t}$	induced e.m.f.
D13.	$\frac{V_s}{V_p} \approx \frac{N_s}{N_p}$	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