CNEC Christian College

MOCK Examination (2021-2022)

Form Six

PHYSICS PAPER 2

Question-Answer Book

Time allowed: 1 hour

This paper must be answered in English

Name	
Class	
Class number	

INSTRUCTIONS

(1) Write your Name, Class and Class Number in the space provided on Page 1.

(2) Answer ALL Question.

(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. Insert the information required, mark the question number box 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 inserting any information or filling in the question number boxes after the 'Time is up' announcement.

Sec B	/20
Sec C	/20
Total	/40

Section B: Atomic World

Q.2: Multiple-choice questions

2.1 In Thomson's 'plum-pudding' model of atoms, electrons are embedded in a cloud of positive charge. Which of the following observations **CANNOT** be explained by this model?

(1) An atom is electrically neutral.

(2) In the Geiger-Marsden experiment, most α particles nearly passed straight through the gold foil.

(3) In the Geiger-Marsden experiment, a few α particles bounced back from the gold foil.

A. (2) only

B. (3) only

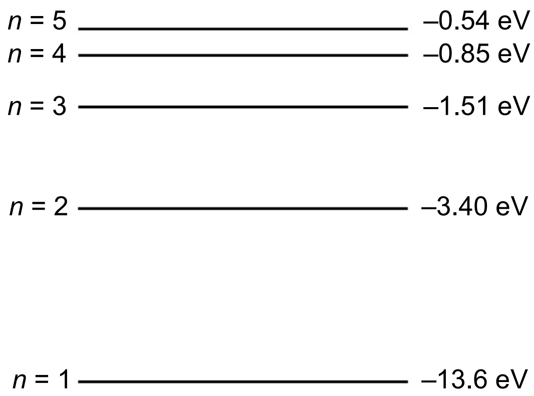
C. (2) and (3) only

D. (1), (2) and (3)

A **B** **C** **D**

○ ○ ○ ○

2.2 The diagram below shows some energy levels of a hydrogen atom. A large number of hydrogen atoms in the ground state ($n = 1$) are collided by electrons with kinetic energy of 12.8 eV and get excited. When the excited atoms drop to lower energy levels, how many spectral lines can these atoms produce?



A. 3

B. 4

C. 6

D. 7

A **B** **C** **D**

○ ○ ○ ○

2.3 The figure below shows part of the emission spectrum of hydrogen gas. All the spectral lines shown are produced by electron transitions from higher energy levels to the first excited state ($n = 2$). Which of the following statements is/are correct?

(1) Spectral line X has a higher frequency than spectral line Y.

(2) The longest wavelength of these lines is about 660 nm.

(3) The lines have the same frequencies as those of the dark lines in the absorption spectrum of hydrogen gas.

A. (1) only

B. (1) and (2) only

C. (2) and (3) only

D. (1), (2) and (3)

A **B** **C** **D**

○ ○ ○ ○

2.4 When monochromatic light of a certain wavelength is incident on the surface of a metal, photoelectrons are emitted. If other conditions are unchanged, the maximum kinetic energy of the photoelectrons will be increased by

(1) increasing the frequency of the incident light.
(2) using a metal with a lower threshold frequency.
(3) increasing the intensity of the incident light.

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

A ○ **B** ○ **C** ○ **D** ○

2.5 In right conditions, a beam of electrons directed onto a crystal surface will diffract and produce a diffraction pattern. Assume the spacing of the atoms in the crystal is 0.4 nm. What is the approximate kinetic energy of the electrons needed to obtain the pattern?

A. 1 eV
B. 10 eV
C. 100 eV
D. 1000 eV

A ○ **B** ○ **C** ○ **D** ○

2.6 A transmission electron microscope (TEM) has an angular resolution of θ (in rad) when the voltage of its electron gun is set at V. Suppose its resolving power is limited by diffraction only. If the voltage of the electron gun is increased to $2V$, what is the angular separation of the TEM?

A. $\frac{\theta}{\sqrt{2}}$
B $\frac{\theta}{2}$
C $\sqrt{2}\theta$
D θ

A ○ **B** ○ **C** ○ **D** ○

2.7 Which of the following **CANNOT** increase the resolving power of a transmission electron microscope (TEM)?

(1) increasing the accelerating voltage in the electron gun
(2) increasing the magnifying power of the magnetic projection lens
(3) using a thinner and finer specimen

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

A ○ **B** ○ **C** ○ **D** ○

2.8 Nano-sized titanium dioxide (TiO_2) is used in some self-cleaning coating of glass. Which of the following statements is/are correct?

A. Optical microscopes can be used to observe the structure of nano-sized TiO_2.

B. Nano-sized TiO_2 is very effective in reflecting all visible light.

C. Nano-sized TiO_2 makes use of the Lotus effect in the self-cleaning process.

D. Nano-sized TiO_2 can speed up the decomposition of dirt under sunlight.

A	**B**	**C**	**D**
○	○	○	○

Q.2: Structured question

The set-up shown in Figure 2.1 is used to study photoelectric effect. Light of a certain frequency is directed towards the photo-sensitive electrode *B* of a photocell. The potential difference across the electron *A* and *B* can be varied by adjusting the variable supply.

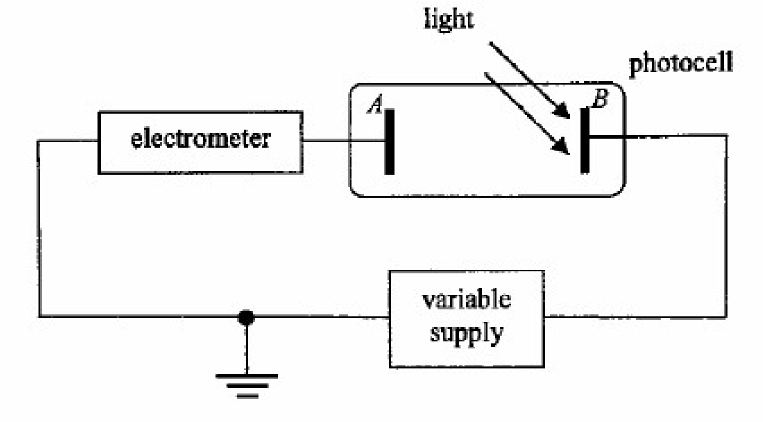


Figure 2.1

(a) When the voltage V_B of the electron *B* is zero, the electrometer still detects a current. Explain this phenomenon and state the direction of the current in the photocell. (2 marks)

(b) The work function of electrode *B* is 2.3 eV. The graph in Figure 2.2 shows the variation of the current *I* with the voltage V_B when the variable supply is adjusted.

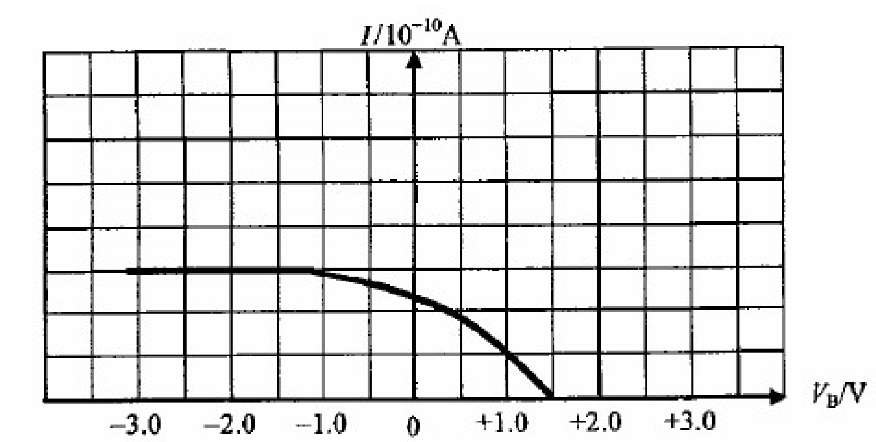


Figure 2.2

(i) Explain why the current drops when V_B is increased. (2 marks)

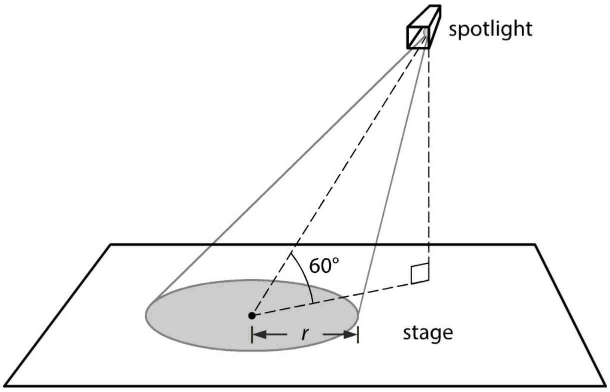
(ii) What is the maximum kinetic energy, in eV, of the photoelectrons produced? Hence find the wavelength of the light waves used and name this kind of light waves. (4 marks)

(c) In Figure 2.2, sketch the current-voltage variation when the experiment is repeated with the light intensity doubled. (2 marks)

Section C: Energy and Use of Energy

Q.3: Multiple-choice questions

3.1 A spotlight with luminous flux Φ is located at a height of h above a horizontal stage and projects a strong beam of light onto the stage. The light beam produces a bright spot, roughly circular, of radius r on the stage and the central line of the light beam makes an angle of 60° with the stage.



Take the spotlight as a point source and neglect the reflections and contributions from other light sources. Estimate the illuminance E at the centre of the bright spot.

A. $E = \frac{\Phi}{4\pi} \cdot \frac{\cos^3 30°}{r^2}$

B. $E = \frac{\Phi}{4\pi} \cdot \frac{\cos^3 60°}{r^2}$

C. $E = \frac{\Phi}{4\pi} \cdot \frac{\cos^3 60°}{h^2}$

D. $E = \frac{\Phi}{4\pi} \cdot \frac{\sin^3 60°}{h^2}$

A	B	C	D
○	○	○	○

3.2 There is a room filled with air of a heat capacity of 120 kJ °C^{-1}. It is known that if an air-conditioner with a cooling capacity of 1.2 kW is used in this room, the temperature can be kept at 25 °C. What will the temperature be after 5 minutes if another air-conditioner of a cooling capacity of 2.4 kW is used instead?

A. 19 °C

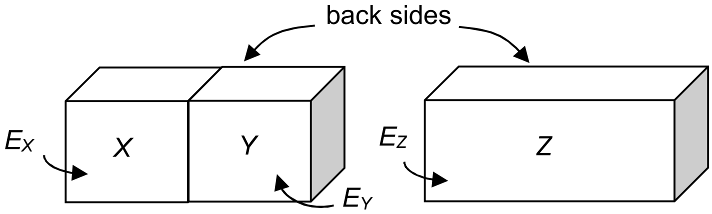
B. 22 °C

C. 28 °C

D. 31 °C

A	B	C	D
○	○	○	○

3.3 Three blocks X, Y and Z have the same thickness. The areas of their front surfaces are E_X, E_Y and E_Z respectively. When X and Y join together side by side as shown, the total rate of heat transfer by conduction from the front side to the back side through them is the same as that through Z. The temperature difference between the front and back sides of each block is the same.



If the U-values of blocks X, Y and Z are U_X, U_Y and U_Z respectively, which of the following shows how U_Z is related to U_X and U_Y?

A. $U_Z = U_X + U_Y$

B. $U_Z = \frac{U_X E_X + U_Y E_Y}{E_Z}$

C. $U_Z = \frac{(U_X + U_Y) E_Z}{E_X + E_Y}$

D. Undetermined since the blocks may not be made of the same material.

A B C D
○ ○ ○ ○

3.4 Which of the following statements about a solar cell is correct?

(1) When light is incident on a solar cell and the cell is connected to a complete circuit, the current flows from the p-side of the cell to the n-side of the cell in the circuit.

(2) The radiation power received from the Sun is directly proportional to $\cos^3 \theta$ where θ is the angle between the cell and the light incidence direction.

(3) Manufacturing solar cells do not produce any toxic wastes.

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

A B C D
○ ○ ○ ○

3.5 Arrange the following according to the energy conversion during the generation of hydroelectric power.

(1) gravitational potential energy of water
(2) electrical energy
(3) kinetic energy of water
(4) kinetic energy of turbine

A. (1), (2), (3), (4)
B. (3), (1), (4), (2)
C. (1), (3), (4), (2)
D. (3), (4), (1), (2)

A B C D
○ ○ ○ ○

3.6 The following table shows the information about four different walls.

wall	**thermal conductivity / W m^{-1} K^{-1}**	**thermal transmittance / W m^{-2} K^{-1}**
P	0.15	3
Q	0.24	2.4
R	0.50	2.5
S	1.00	25

Which wall is the thickest?

A. wall *P*

B. wall *Q*

C. wall *R*

D. wall *S*

A **B** **C** **D**

○ ○ ○ ○

3.7 Which of the following vehicles use(s) petrol as the energy source?

(1) electric vehicle

(2) fossil-fuel vehicle

(3) hybrid vehicle

A. (1) only

B. (2) only

C. (1) and (3) only

D. (2) and (3) only

A **B** **C** **D**

○ ○ ○ ○

3.8 A small factory is powered by several wind turbines, each has blades of length 5 m. The power it needs is 90 kW. If the overall efficiency of the electric system is 20% and the wind speed is kept at 10 m s^{-1}, how many wind turbines are needed? The density of air is 1.3 kg m^{-3}.

A. 9

B. 10

C. 45

D. 90

A **B** **C** **D**

○ ○ ○ ○

Q.3: Structured question

Effective ways to store energy are essential. Without storage, excess energy collected or generated will only be wasted. The excess energy can be converted into the internal energy of a medium(thermal storage). The internal energy stored can later be used to produce steam to power conventional steam turbines and generate electricity in bad weather or at night.

(a) (i) Suppose water is chosen as the medium. Assuming that the surrounding temperature is 25 °C, how much energy can be stored per kg when it is boiled? The specific heat capacity of water is 4200 J kg $^{-1}$ K^{-1}. (2 marks)

(ii) The table below lists some properties to two materials: water and molten salt *X*. Which one is more favourable as a thermal storage? Briefly explain your answer. (2 marks)

	molten salt *X*	water
melting point / °C	142	0
boiling point / °C	540	100
specific heat capacity / J kg $^{-1}$ K^{-1}	2620	4200

Besides thermal storage, pumped storage is a more common way. A pumped storage is the process of storing energy by using two vertically separated water reservoirs. It can be installed together with a power plant to act as a 'rechargeable battery'. When the electricity demand is low, excess electricity generated is outputted to the pumped storage. Water is pumped up from the lower reservoir to the upper reservoir by using a turbine. In reverse, when the electricity demand is high, the water from the upper reservoir is released to the lower reservoir and runs through the same turbine. Electricity is thus generated.

(b) Describe the energy change when the pumped storage works:

(i) during the time when the electricity demand is low. (1 mark)

(ii) during the time when the electricity demand is high. (1 mark)

(c) (i) A pumped storage can be used together with wind energy. State one advantage of this implementation. (1 mark)

(ii) However, this kind of pumped storage has some limitations. Suggest one. (1 mark)

(d) Suppose there is a pumped storage with two reservoirs 200 m vertically apart. When the power plant is generating an excess energy at a rate of 10 kW, how much water is pumped from the lower reservoir to the upper reservoir in one hour? Assume that the efficiency is 80%. (2 marks)

END OF PAPER

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 = 206 265 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
$\left\lvert\frac{\Delta f}{f_0}\right\rvert \approx \frac{v}{c} \approx \left\lvert\frac{\Delta\lambda}{\lambda_0}\right\rvert$	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
$P = \frac{1}{2}\rho Av^3$	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	D1.	$F = \dfrac{Q_1 Q_2}{4\pi\varepsilon_0 r^2}$	Coulomb's law
A2.	$E = l\Delta m$	energy transfer during change of state	D2.	$E = \dfrac{Q}{4\pi\varepsilon_0 r^2}$	electric field strength due to a point charge
A3.	$pV = nRT$	equation of state for an ideal gas	D3.	$E = \dfrac{V}{d}$	electric field between parallel plates (numerically)
A4.	$pV = \dfrac{1}{3}Nm\overline{c^2}$	kinetic theory equation	D4.	$R = \dfrac{\rho l}{A}$	resistance and resistivity
A5.	$E_K = \dfrac{3RT}{2N_A}$	molecular kinetic energy	D5.	$R = R_1 + R_2$	resistors in series
			D6.	$\dfrac{1}{R} = \dfrac{1}{R_1} + \dfrac{1}{R_2}$	resistors in parallel
B1.	$F = m\dfrac{\Delta v}{\Delta t} = \dfrac{\Delta p}{\Delta t}$	force	D7.	$P = IV = I^2R$	power in a circuit
B2.	moment = $F \times d$	moment of a force	D8.	$F = BQv \sin \theta$	force on a moving charge in a magnetic field
B3.	$E_P = mgh$	gravitational potential energy	D9.	$F = BIl \sin \theta$	force on a current-carrying conductor in a magnetic field
B4.	$E_K = \dfrac{1}{2}mv^2$	kinetic energy	D10.	$B = \dfrac{\mu_0 I}{2\pi r}$	magnetic field due to a long straight wire
B5.	$P = Fv$	mechanical power	D11.	$B = \dfrac{\mu_0 NI}{l}$	magnetic field inside a long solenoid
B6.	$a = \dfrac{v^2}{r} = \omega^2 r$	centripetal acceleration	D12.	$\varepsilon = N\dfrac{\Delta\Phi}{\Delta t}$	induced e.m.f.
B7.	$F = \dfrac{Gm_1 m_2}{r^2}$	Newton's law of gravitation	D13.	$\dfrac{V_s}{V_p} \approx \dfrac{N_s}{N_p}$	ratio of secondary voltage to primary voltage in a transformer
C1.	$\Delta y = \dfrac{\lambda D}{a}$	fringe width in double-slit interference	E1.	$N = N_0 e^{-kt}$	law of radioactive decay
C2.	$d \sin \theta = n\lambda$	diffraction grating equation	E2.	$t_{\frac{1}{2}} = \dfrac{\ln 2}{k}$	half-life and decay constant
C3.	$\dfrac{1}{u} + \dfrac{1}{v} = \dfrac{1}{f}$	equation for a single lens	E3.	$A = kN$	activity and the number of undecayed nuclei
			E4.	$\Delta E = \Delta mc^2$	mass-energy relationship