2019-S6MK

PHY

PAPER 2

SACRED HEART CANOSSIAN COLLEGE

18–19 S6 MOCK EXAMINATION

PHYSICS PAPER 2

Question-Answer Book

(1 hour)

This paper must be answered in English

Name: ________________

Class & No.: ______(   )

Block: _____

INSTRUCTIONS

(1) After the announcement of the start of the examination, you should first write your name, class, class number and block number in the spaces provided on Page 1.

(2) This paper only consists of **TWO out of the FOUR** sections of the actual paper, namely Sections B and C. Each section contains eight multiple-choice questions and one structured question which carries 10 marks. Answer **ALL** questions in **Sections B and C**.

(3) Write your answers to the structured questions on the single-lined sheets 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) Supplementary answer sheets will be provided on request. Write your name, class, class number, and mark the question number box on each sheet.

(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 candidate for writing her name or filling in the question number boxes after the 'Time is up' announcement.

SECTION B: Atomic World

Q.2: Multiple choice questions.

2.1. In the photoelectric effect experiment, a monochromatic light is directed to the metal plate. The stopping potential is 1.53 eV and the work function of the metal plate is 0.8 eV. Find the wavelength of the monochromatic light used.

A. 497 nm
B. 509 nm
C. 534 nm
D. 570 nm

A B C D

2.2. A green monochromatic light is directed to the metal plate. Only a small amount of photoelectrons are emitted. Which of the following MUST increase the amount of photoelectrons emitted?

(1) Replace the metal plate with another one of smaller work function.
(2) Replace the green monochromatic light with violet monochromatic light of the same intensity.
(3) Increase the intensity of the green monochromatic light.

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

A B C D

2.3. In Rutherford's scattering experiment, a thin gold foil is bombarded by α particles. Which of the following cannot be explained by the result of this experiment?

A. Atoms do not continuously emit electromagnetic waves.
B. The nucleus of an atom is much smaller than the atom itself.
C. The density of charge in an atom is not uniform.
D. There is a large empty space in an atom.

A B C D

2.4. What is the ratio of angular momentum of an electron in the 3rd excited state to that in the 4th excited state of a hydrogen atom?

A. 16 : 25
B. 9 : 16
C. 4 : 5
D. 3 : 4

A B C D

2.5. Which of the following are physical properties of nano materials?

(1) The colour of gold nano particles depends on its size.
(2) The electrical conductivity of copper drops drastically when it is reduced to nano size.
(3) Carbon nanotubes are harder and stronger than most metals.

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

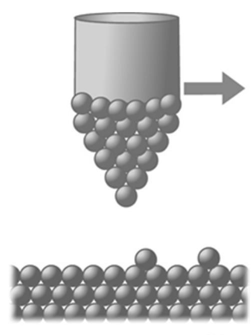
A B C D

2.6. Felix is on a plane 9100 m above the ground. Find the minimum distance between two people on the ground that he is able to resolve. Assume the people's hair reflects yellow light of wavelength 500 nm and the pupil of Felix's eye has a diameter of 3.5 mm.

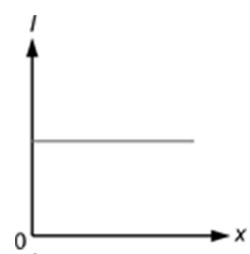
A. 1.586 m
B. 1.796 m
C. 1.902 m
D. 2.003 m

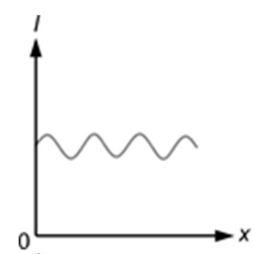
A B C D

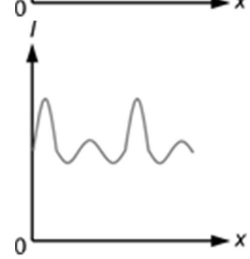
2.7. Which of the following best shows the tunnelling current *I* registered by a transmission electron microscope (TEM) against the displacement *x* of the tip?

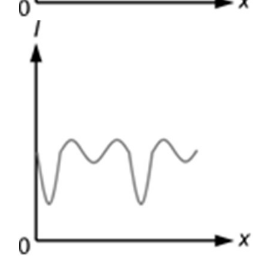


A B C D

A.


B.


C.


D.


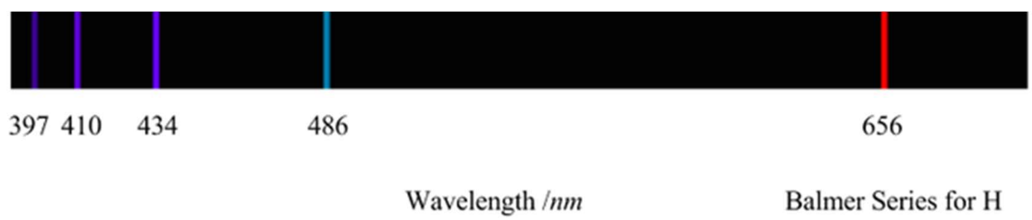
2.8. The resolution of an optical microscope is much lower than a transmission electron microscope (TEM) because

A. the aperture of TEM is too small.
B. the aperture of the pupil of human eye is too small.
C. visible wavelength is shorter than the de Broglie wavelength of high energy electron.
D. the de Broglie wavelength of high energy electron is shorter than visible wavelength.

A	B	C	D
○	○	○	○

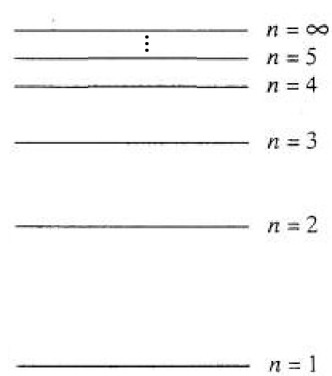
Q.2: Structured question

The light emitted from a discharged tube containing an energized, low-density hydrogen gas is observed through a transmission grating. Part of Balmer series (transition of electrons from the n^{th} excited state to the 1^{st} excited state (n = 2)) is shown in the figure below.



(a) Find the energy of photon of wavelength 486 nm and express your answer in eV. (1 mark)

(b) Copy the following energy level diagram into your answer book. Draw an arrow to show the electron transition which produces the spectral line of wavelength 486 nm. Show your calculations. (3 marks)



(c) Find the orbital radius of the electron at the 1^{st} excited state. (2 marks)
(Given: the orbital radius of the electron at the ground state = 5.29×10^{-11} m)

(d) Find the shortest wavelength of electromagnetic wave in Balmer series. What would happen to the electron at the 1^{st} excited state if it absorbs a photon of this wavelength ? (3 marks)

(e) Why are the spectral lines closer to each other at the end of shorter wavelength? Briefly explain your answer. (1 mark)

SECTION C: Energy and Use of Energy

Q.3: Multiple choice questions.

3.1. A room with an area of 5 m × 5 m has a height of 2.7 m. It is illuminated by one single lamp of luminous flux 2000 lm mounted at the centre of the ceiling. Find the ratio of the illuminance between the darkest and the brightest spots on the floor.

A. 1 : 4.5
B. 1 : 2.7
C. 1 : 2.5
D. 1 : 1.6

A B C D
○ ○ ○ ○

3.2. Which of the following features is/are essential for an induction cooker to work properly?

(1) A magnetic field alternating at a high frequency is produced.
(2) A heat-conducting surface for a cooking utensil to sit on.
(3) A utensil with a metal bottom is used.

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

A B C D
○ ○ ○ ○

3.3. A cubic refrigerator has side lengths of 0.6 m. All its surfaces are 1 cm thick and are made of an insulating material of conductivity 0.02 W m^{-1} K^{-1}. Suppose heat enters the interior of the refrigerator via all its surfaces at a rate of 40 W. Estimate the temperature difference between the inside and the outside of the surfaces of the refrigerator.

A. 5.56 °C
B. 9.26 °C
C. 18.5 °C
D. 55.6 °C

A B C D
○ ○ ○ ○

3.4. Using double-glazing glass can reduce the OTTV of a building. Which of the following is/are the major reason(s)?

(1) The U-value of double glazing glass is low.
(2) The heat gained by the building via radiation is reduced.
(3) Heat is lost from a building through a double-glazing glass window easily.

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 lighting devices in increasing order of end-use energy efficiency.

(1) A 57 W halogen lamp giving out 1370 lm.
(2) A 12 W LED giving out 456 lm.
(3) A 13 W compact fluorescent lamp giving out 780 lm.
(4) A 100 W light bulb giving out 1700 lm.

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

A B C D
○ ○ ○ ○

3.6. Identify the components that can be found in hybrid vehicles but **NOT** in electric vehicles.

(1) Internal combustion engine
(2) Fuel tank
(3) Battery

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

A B C D
○ ○ ○ ○

3.7. Which of the following statements about a nuclear reactor are correct?

(1) The nuclear fission in a nuclear reactor is under control.
(2) The coolant in a nuclear reactor is used for decreasing the rate of nuclear fission.
(3) The moderator in a nuclear reactor is used to slow down neutrons.

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

A B C D
○ ○ ○ ○

3.8. Given that: mass of proton = 1.0073 u, mass of neutron = 1.0087 u,
mass of tritium ($^{3}_{1}H$) nucleus = 3.0155 u

What is the binding energy per nucleon of a tritium nucleus?

A. 2.3×10^{-3} MeV
B. 3.1×10^{-3} MeV
C. 2.1 MeV
D. 2.9 MeV

A B C D
○ ○ ○ ○

Q.3: Structured question

Tommy installs an air-conditioner in his building. The average operating time of the air-conditioner is 10 hours in a day. The cost of electricity is $1.20 per kW h. The following data are extracted from the energy label of this air-conditioner.

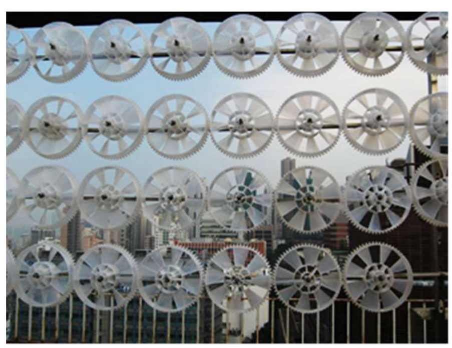
Annual energy consumption (kWh)(cooling) Based on 1200 hrs/yr operation	1087
Cooling capacity (kW)	2.53

(a) Calculate the amount of energy that can be removed by the air-conditioner in an hour. (2 marks)

(b) Estimate the coefficient of performance of the air-conditioner. (3 marks)

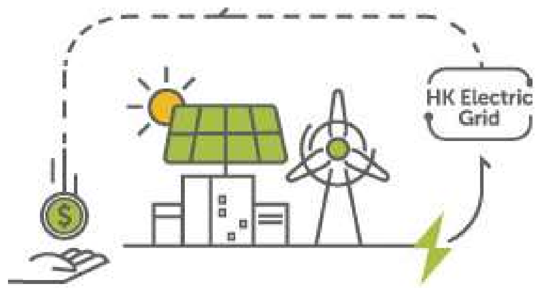
(c) Tommy has installed a micro-wind turbine with 200 plastic gearwheels in his building as shown below. Each plastic gearwheel is 26 cm in diameter. The electrical output of the turbine is about 150 W.

Take the air density as 1.225 kg m^{-3} and the average wind speed as 5 m s^{-1} throughout a day.



(i) Estimate the efficiency of the micro-wind turbine. (2 marks)

(ii) To support the development of renewable energy, HK Electric has launched the 'Feed-in Tariff Scheme", which purchases electricity generated by the renewable energy power systems of customers at a rate of $4 per kW h.



Under this scheme, can Tommy cover the daily cost of operating the air-conditioner by selling the energy generated from the wind turbine? Show your calculations. (3 marks)

END OF PAPER

Do not write on this page.

Answers written on this page will not 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	$e = 1.60 \times 10^{-19}\ \text{C}$	
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	$\text{pc} = 3.09 \times 10^{16}\ \text{m} = 3.26\ \text{ly} = 206265\ \text{AU}$	
Stefan constant	$\sigma = 5.67 \times 10^{-8}\ \text{W m}^{-2}\ \text{K}^{-4}$	
Planck constant	$h = 6.63 \times 10^{-34}\ \text{J s}$	

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		**Energy and Use of Energy**	
$U = -\frac{GMm}{r}$	gravitational potential energy	$E = \frac{\Phi}{A}$	illuminance
$P = \sigma A T^4$	Stefan's law	$\frac{Q}{t} = \kappa \frac{A(T_H - T_C)}{d}$	rate of energy transfer by conduction
$\left\lvert\frac{\Delta f}{f_0}\right\rvert \approx \frac{v}{c} \approx \left\lvert\frac{\Delta\lambda}{\lambda_0}\right\rvert$	Doppler effect	$U = \frac{\kappa}{d}$	thermal transmittance U-value
		$P = \frac{1}{2}\rho A v^3$	maximum power by wind turbine
Atomic World		**Medical Physics**	
$\frac{1}{2}m_e v_{max}{}^2 = hf - \phi$	Einstein's photoelectric equation	$\theta \approx \frac{1.22\lambda}{d}$	Rayleigh criterion (resolving power)
$E_n = -\frac{1}{n^2}\left\{\frac{m_e e^4}{8h^2\varepsilon_0^2}\right\} = -\frac{13.6}{n^2}\ \text{eV}$	energy level equation for hydrogen atom	power $= \frac{1}{f}$	power of a lens
		$L = 10\log\frac{I}{I_0}$	intensity level (dB)
$\lambda = \frac{h}{p} = \frac{h}{mv}$	de Broglie formula	$Z = \rho c$	acoustic impedance
		$\alpha = \frac{I_r}{I_0} = \frac{(Z_2 - Z_1)^2}{(Z_2 + Z_1)^2}$	intensity reflection coefficient
$\theta \approx \frac{1.22\lambda}{d}$	Rayleigh criterion (resolving power)	$I = I_0 e^{-\mu x}$	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.	$E = \frac{V}{d}$	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