2018-S6MK

PHY

PAPER 2

SACRED HEART CANOSSIAN COLLEGE

17–18 S6 MOCK EXAMINATION

Name: _______________

Class & No.: ______(   )

Block: _____

PHYSICS PAPER 2

Question-Answer Book

(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, 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) Graph paper and 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 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

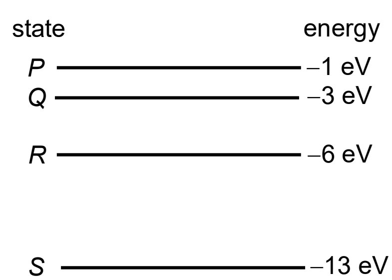
2.1 Concerning photoelectric effect, which of the following **CANNOT** be explained by the wave theory of light ?

(1) There is a threshold frequency for photoelectric effect to occur.
(2) There is no time delay in the emission of photoelectrons.
(3) Electrons on the metal surface gain the energy from the incident light and are emitted.

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 The figure shows the energy states of a certain atom. The atom is initially in state *S*.



NOT to scale

Which of the following statements is/are correct ?

(1) A photon of energy 8 eV can excite the atom to state *R*.
(2) An electron of energy 11 eV can excite the atom to state *Q*.
(3) A photon of energy 14 eV can ionize the atom.

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

A ○ **B** ○ **C** ○ **D** ○

2.3 Based on Rutherford's atomic model,

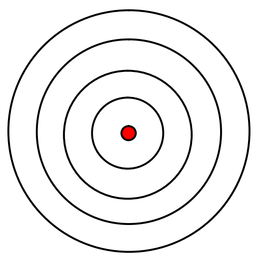
A. the atom should emit electromagnetic waves of some discrete frequencies.
B. the atom should emit electromagnetic waves of a continuous range of frequency.
C. the atom should emit electromagnetic waves of some discrete speeds.
D. the atom should not emit electromagnetic waves.

A B C D
○ ○ ○ ○

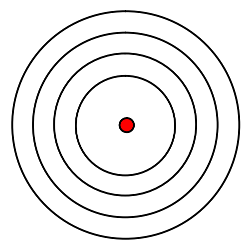
2.4 Which of the following figures best shows the relative sizes of the first four orbits of the electron in a hydrogen atom ?

A B C D
○ ○ ○ ○

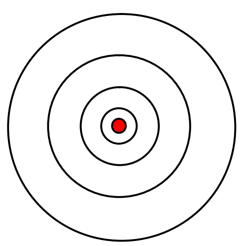
A.



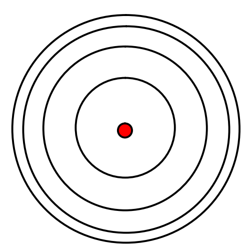
B.



C.



D.



2.5 A beam of electrons is used in a transmission electron microscope (TEM) to observe atomic structure in a nanoscale. If the de Broglie wavelength of the electrons used is 10^{-9} m, estimate the kinetic energy of the electron in the beam.

A. 0.01 eV
B. 1 eV
C. 10^2 eV
D. 10^4 eV

A B C D
○ ○ ○ ○

2.6 A man on an aeroplane 10 km from the ground observes two green cars on the ground. The diameter of the pupil of the man is 3 mm. Taking the wavelength of green light to be 500 nm, estimate the minimum distance between the two green cars he would resolve.

A. 2 m
B. 10 m
C. 25 m
D. 50 m

A ◯ **B** ◯ **C** ◯ **D** ◯

2.7 Which of the following properties of nano-sized zinc oxide (ZnO) would differ from its bulky from ?

(1) Mechanical
(2) Optical
(3) Electrical

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

A ◯ **B** ◯ **C** ◯ **D** ◯

2.8 A very thin film of titanium dioxide (TiO_2) can be used in window coating for self-cleaning. Which of the following statements is **WRONG** ?

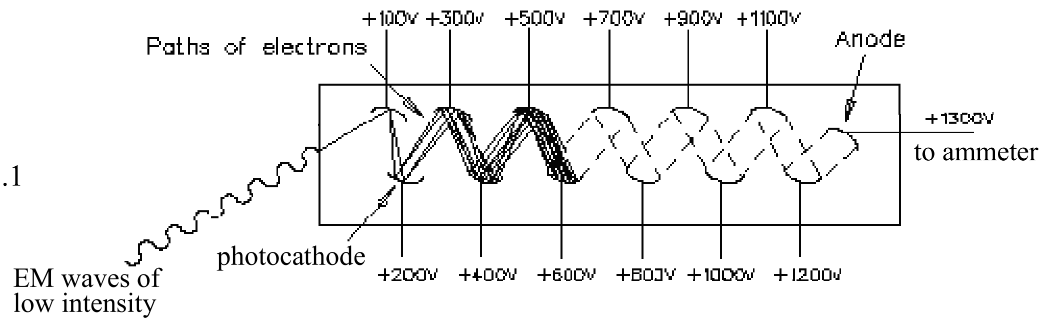
A. The coating speeds up the breaks of organic dirt.
B. The coating repels water due to the Lotus effect.
C. The coating has a very high surface-to-volume ratio.
D. The coating absorbs ultra-violet radiation.

A ◯ **B** ◯ **C** ◯ **D** ◯

Q.2: Structured question

Photomultiplier (Figure 2.1) is a device which can detect electromagnetic waves of very low intensity. When electromagnetic waves strike the first photocathodes of the photomultiplier, electrons are emitted due to photoelectric effect.

Figure 2.1



(a) A weak light beam of wavelength 500 nm is incident on the first photocathode at a power of 2×10^{-6} W. Find the frequency of such light beam. Hence, estimate the number of photons reaching the first photocathode per second. (2 marks)

(b) Why do the potentials of the photocathodes are positive and increasing towards the anode ? (2 marks)

(c) Ag-O-Cs is a common material used in the photocathodes of photomultipliers. The work function of this material is 0.8 eV.

(i) State the meaning of ‘work function’ of a material. (1 mark)

(ii) Find the threshold frequency of Ag-O-Cs. (2 marks)

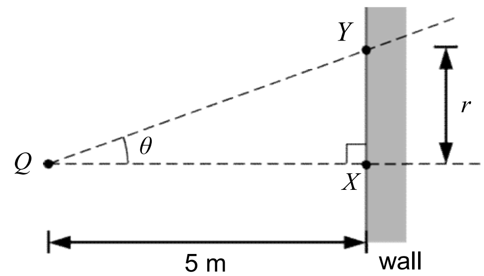
(iii) Find the maximum kinetic energy of the photoelectron emitted from Ag-O-Cs under the illumination of green light of 500 nm. (2 marks)

(iv) Is this type of photomultipliers able to detect red light ? (1 mark)

Section C: Energy and Use of Energy

Q.3: Multiple-choice questions

3.1 A point light source Q is 5 m away from a wall. Points X, Y and Q are on the same plane.



If the illuminance on the wall at X is E, what is the illuminance on the wall at Y which is at a distance r from X ?

A. $\dfrac{125E}{\left(5^2+r^2\right)^{\frac{3}{2}}}$

B. $\dfrac{25E}{\left(5^2+r^2\right)^{\frac{3}{2}}}$

C. $\dfrac{5E}{\left(5^2+r^2\right)^{\frac{3}{2}}}$

D. $\dfrac{E}{\left(5^2+r^2\right)^{\frac{3}{2}}}$

A ○ **B** ○ **C** ○ **D** ○

3.2 On average, hybrid car P consumes 0.38 L of gasoline in travelling a distance of 10 km, whereas hybrid car Q consumes 0.585 L in travelling a distance of 15 km. If the fuel tank capacity of both cars is the same, which of the following is correct ?

	higher fuel efficiency	longer range
A.	P	P
B.	P	Q
C.	Q	P
D.	Q	Q

A ○ **B** ○ **C** ○ **D** ○

3.3 Four types of lamp are available in a lamp shop:

Lamp	**Power rating**	**Efficacy**
P	20 W	85 lm W^{-1}
Q	40 W	65 lm W^{-1}
R	60 W	45 lm W^{-1}
S	80 W	25 lm W^{-1}

Which lamp is the brightest ?

A. *P*
B. *Q*
C. *R*
D. *S*

A ○ **B** ○ **C** ○ **D** ○

3.4 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** ○

3.5 A wind turbine provides an output power of 100 kW when the wind speed is 10 m s^{-1}. When the wind speed is 20 m s^{-1}, the efficiency of the turbine is halved. What is the output power of the turbine at a wind speed of 20 m s^{-1} ?

A. 200 kW
B. 400 kW
C. 600 kW
D. 800 kW

A ○ **B** ○ **C** ○ **D** ○

3.6 There is a heater in a room and it is turned off. If the temperature in the room is higher than that outside, which of the following will decrease the rate of heat loss from the room through its walls ?

(1) The outdoor temperature increases.
(2) The heater is turned on.
(3) The number of people in the room increases.

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

A ◯ B ◯ C ◯ D ◯

3.7 Find the energy released in the following nuclear reaction.

$$^{48}_{24}\mathrm{Cr} + ^{4}_{2}\mathrm{He} \rightarrow ^{52}_{26}\mathrm{Fe}$$

Given: Binding energy per nucleon of He-4 = 7.01 MeV
Binding energy per nucleon of Cr-48 = 8.57 MeV
Binding energy per nucleon of Fe-52 = 8.61 MeV

A. 5.53 MeV
B. 6.97 MeV
C. 7.14 MeV
D. 8.32 MeV

A ◯ B ◯ C ◯ D ◯

3.8 Comparing to normal glass, using low-e glass in windows can reduce the OTTV of a building. Which of the following is the major reason ?

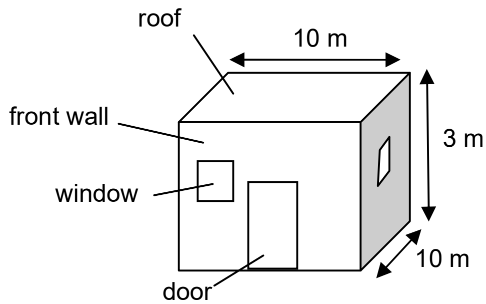
A. The U-value of low-e glass is relatively low.
B. Heat can be lost from the building through windows effectively.
C. The heat gained by the building via radiation is reduced.
D. Low-e glass reduces the natural lighting entering the building.

A ◯ B ◯ C ◯ D ◯

Q.3: Structured question

Figure 3.1 shows a concrete hut of dimensions 10 m × 10 m × 3 m. On each wall there is a window of area 1.2 m^2. A metal door of area 2 m^2 is installed on the front wall. The average U-values of the concrete roof, a side wall with a window and the front wall with a metal door are 1.5 W m^{-2} K^{-1} , 1.67 W m^{-2} K^{-1} and 2.02 W m^{-2} K^{-1} respectively.

Figure 3.1



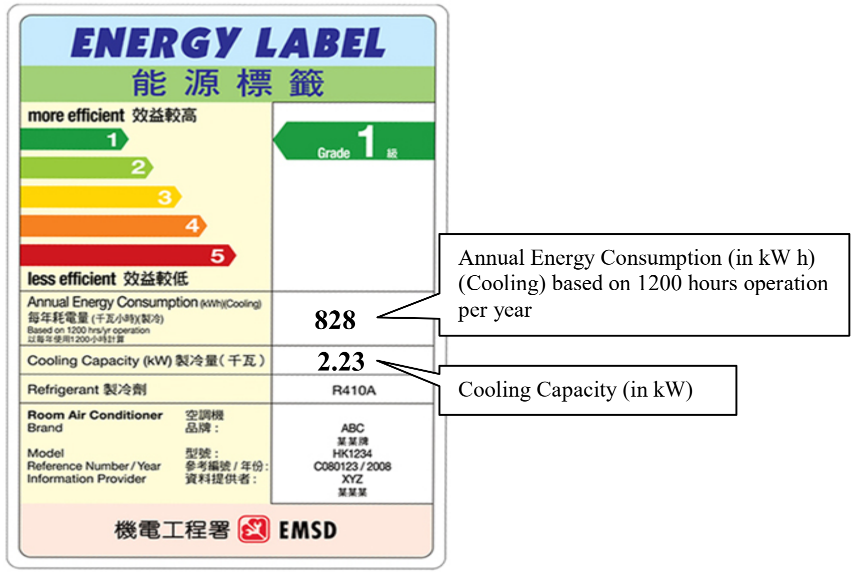
(a) The outdoor temperature is 30°C. The rate of heat transfer by radiation per unit area of the window is 160 W m^{-2}. The indoor temperature is to be maintained at 24°C with an air-conditioner.

(i) Find the rate of heat transfer by conduction through the hut envelope. (3 marks)

(ii) Find the OTTV of the hut envelope. (2 marks)

(b) Figure 3.2 shows the Energy Efficiency Label of the air-conditioner used in the hut.

Figure 3.2



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 air in the hut in Figure 3.1 from 30°C to 24°C by this air-conditioner. You may ignore the heat gained by the hut from the surroundings. (2 marks)

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

(iii) In reality, this air-conditioner would fail to lower the indoor temperature of the hut to 24°C when the outdoor temperature is 30°C. Explain briefly. (2 marks)

END OF PAPER

List of data, formulae and relationships

Data

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

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
$P = \sigma A T^4$	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
$E_n = -\frac{1}{n^2}\left\{\frac{m_e e^4}{8h^2\varepsilon_0^2}\right\} = -\frac{13.6}{n^2}\ \mathrm{eV}$	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)
$\text{power} = \frac{1}{f}$	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.	$E = \frac{V}{d}$	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