2020 – 21
PHY (DSE)
MOCK

PAPER 2

F.6 MOCK EXAMINATION 2020 – 2021

PHYSICS PAPER 2

Question-Answer Book

4th February 2021
11.25am – 12.25pm (1 hour)
This paper must be answered in English

Candidate Number				

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.

(2) This paper consists of **TWO** sections, Sections B and C. Each section contains eight multiple-choice questions and one structured question which carries 10 marks. Attempt **ALL** questions in these **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 and mark the question number box on each sheet, 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 fill in the question number boxes after the 'Time is up' announcement.

Questions	Marks
2.1 – 2.8	
Q.2: SQ	
3.1 – 3.8	
Q.3: SQ	

Section B: Atomic World

Multiple-choice questions

B1. Monochromatic light is incident on a metal surface. The intensity of the light and the area of the metal surface receiving light are fixed while the wavelength λ of the light is varied. Which of the following changes **linearly** with λ?

A. The energy of each incident photon
B. The number of photoelectrons emitted from the metal surface in each second
C. The number of photons incident on the metal surface in each second
D. The maximum KE of the photoelectrons emitted from the metal surface

A B C D
○ ○ ○ ○

B2. Photoelectrons are emitted when a metal plate is illuminated by monochromatic radiation of frequency f. Which of the following statements is correct?

A. The maximum kinetic energy of the emitted photoelectrons is given by $K_{max} = hf$ where h is the Planck constant.
B. There is time delay in the emission of photoelectrons when radiation of low intensity is applied.
C. All emitted photoelectrons have the same kinetic energy.
D. More photoelectrons will be emitted if radiation intensity is increased.

A B C D
○ ○ ○ ○

B3. Which of the following are differences of Bhor's atomic model from Rutherford's atmoic model?

(1) Electrons moving in circular orbits do not radiate energy.
(2) Electrons are regarded as matter waves.
(3) Angular momenta of electrons are quantized.

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

A B C D
○ ○ ○ ○

B4. A hydrogen discharge lamp is switched on. A spectrum is observed through a diffraction grating. When a transparent jar containing hydrogen gas at low pressure is placed between the lamp and the grating,

A. the absorption spectrum of hydrogen is seen.
B. the emission spectrum of hydrogen is seen.
C. a continuous spectrum is seen.
D. no spectrum can be observed.

A B C D
○ ○ ○ ○

B5. Which of the following is related to the wave nature of particles?

(1) When energetic alpha particles are directed towards a gold foil, few of them are deflected at large angles.
(2) The use of electrons in a transmission electron microscope.
(3) Electrons are emitted when a metal surface is illuminated with high-frequency radiation.

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

A B C D
○ ○ ○ ○

B6. A car in the distance has 2 headlights. A student takes a picture of the car through a camera using visible light. On the image, there is only one light source visible. Which of the following will **NOT** make it easier to resolve the car headlights?

A. Move closer to the car to take the image.
B. Make the camera lens larger.
C. Increase the intensity of the headlights.
D. Insert a blue filter in front of the camera lens.

A ○ B ○ C ○ D ○

B7. Which of the following statements about a scanning tunnelling microscope (STM) are correct?

(1) The operational principle of the microscope cannot be explained by classical theories.
(2) The specimens must be thin enough to allow electron beams to pass through.
(3) A three-dimensional image of the surface can be obtained from the microscope.

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

A ○ B ○ C ○ D ○

B8. Nanomaterial can be used to

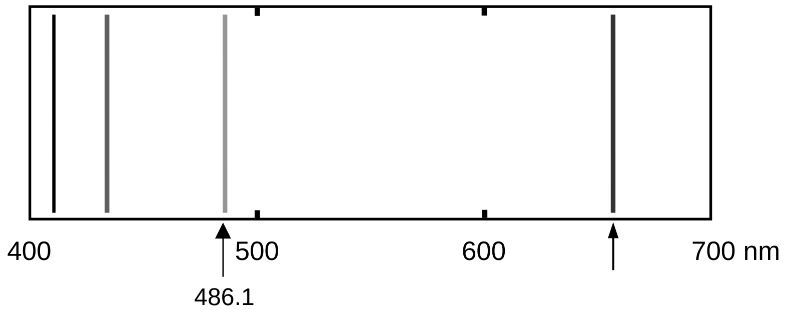
(1) produce anti-bacterial paint.
(2) increase the resolving power a transmission electron microscope.
(3) produce stain-resistant fibres.

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

A ○ B ○ C ○ D ○

Structured Question

B9. The following diagram shows the visible part of an emission spectrum of hydrogen.



(a) Explain how the spectrum provides evidence for the quantization of energy levels in hydrogen atoms. (3 marks)

(b) The spectral lines in the above spectrum correspond to the transitions from higher energy levels to the first excited state (n = 2). From which energy level does the hydrogen atom drop so that light of wavelength 486.1 nm is emitted? (3 marks)

(c) When hydrogen atoms in ground state are illuminated by an ultraviolet light beam of photon energy 24.86 eV, electrons are emitted.

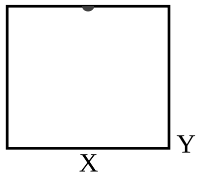
(i) Estimate the speed of the emitted electrons. (2 marks)

(ii) Calculate the de Broglie wavelength of the electrons. (2 marks)

Section C: Energy and Use of Energy

Multiple-choice questions

C1. A bulb is suspended at the centre of the ceiling of a cubical room as shown. The illuminance at the centre of the floor X is 350 lux. What is the illuminance on the wall at the corner Y of room?



A. 125 lux
B. 198 lux
C. 250 lux
D. 280 lux

A B C D
○ ○ ○ ○

C2. Two light blubs, *A* and *B*, with same rated power and luminous flux are operating at their rated voltages. Bulb *A* emits red light while bulb *B* emits green light. Which of the following statements are correct?

(1) When an observer looks at both light bulbs from the same distance, he finds that the brightnesses of the two bulbs are the same.
(2) The two bulbs have the same efficacy.
(3) The rate of light energy emitted by the two bulbs are equal.

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

A B C D
○ ○ ○ ○

C3. The following table shows the coefficients of performance and the rated powers of two air conditioners.

Air conditioner	Coefficient of Performance	Rated Power
X	1.5	1500 W
Y	1.8	1200 W

Which of the following statements is/are correct?

(1) *X* can cool down a room more quickly than *Y*.
(2) The cooling capacity of *Y* is larger than that of *X*.
(3) *Y* is more energy efficient in cooling.

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

A B C D
○ ○ ○ ○

C4. Which of the followings can reduce the OTTV of a building?

(1) Replace the windows of the building with walls of the same U value.
(2) Use low-e coating glass for the windows in the building.
(3) Install exterior sunshades above the windows in the building.

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

A B C D
○ ○ ○ ○

C5. Which of the following statements about transportation in Hong Kong is/are correct?

(1) If the number of passengers is small, the energy efficiency of a bus can be lower than that of a mini-bus.
(2) Among different public transport systems, only MTR has zero roadside emission.
(3) All taxis are powered by liquefied petroleum gas (LPG) because they will not produce any emission on road.

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

A B C D
○ ○ ○ ○

C6. Which of the following statements about nuclear fission is/are correct?

(1) In order to have a chain reaction, the mass of parent nuclei must be larger than the critical mass.
(2) The total mass of the matter before the reaction is larger than that after the reaction.
(3) The binding energy per nucleon of the parent nuclei is larger than that of daughter nuclei.

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

A B C D
○ ○ ○ ○

C7. A wind turbine has blades of length 25 m and it can capture 30% of the kinetic energy from the wind. Given the average wind speed is 10 m s^{-1} and the density of air is 1.3 kg m^{-3}, how many wind turbines are needed in order to generate at least a power output of 12 MW?

A. 10
B. 32
C. 99
D. 392

A B C D
○ ○ ○ ○

C8. Given the radius of the Earth is 6400 km and 31% of the solar radiation is reflected back to space by the Earth. Assuming that the temperature of the Earth is constant, find the rate of radiation emitted by the Earth to the space. Given that the solar constant is 1360 W m^{-2}.

A. 5.43×10^{16} W
B. 1.21×10^{17} W
C. 1.75×10^{17} W
D. 4.83×10^{17} W

A B C D
○ ○ ○ ○

Structured Question

C9. The following is some specifications for the electric car, Tesla Model 3.
Range:354 km
Mass:1611 kg
Acceleration: 5.3 s (0 – 100 km/h)
Maximum power output: 211 kW
Average electrical energy consumption: 16 kW h/100 km
Lithium-ion battery: density 0.150 kW h/ kg

(a) Estimate the mass of the battery in a Model 3. (2 marks)

(b) It takes 5.3 s to accelerate to 100 km/h from rest. Calculate the work done against resistive forces during acceleration. (2 marks)

(c) Name two resistive forces. (2 marks)

The following table shows the end-use efficiency (from energy in fuel/battery to energy for propulsion) of the motor of an electric car and the internal combustion engine of a car.

	Efficiency
Electric motor	80%
Internal combustion engine (gasoline)	25%

Efficiency of generating electricity in a power station: 38%
Transmission efficiency: 95%
Efficiency of charging the battery of the electric car: 79%

(d) Based on the following data, calculate the overall energy efficiency of the electric car. (2 marks)

(e) Based on the result in (d), can we say that the electric car is more energy efficient than the car with internal combustion engine? Explain your answer briefly. (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	$\text{pc} = 3.09 \times 10^{16} \text{ m} = 3.26 \text{ ly} = 206265 \text{ AU}$	
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

$U = -\frac{GMm}{r}$	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
$E_n = -\frac{1}{n^2}\left\{\frac{m_e e^4}{8h^2\varepsilon_0^2}\right\} = -\frac{13.6}{n^2} \text{ eV}$	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	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.	$P = IV = I^2 R$	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