FUKIEN SECONDARY SCHOOL

S6 First Term Uniform Test (2021–2022)

Physics

(1 hour)

Date: 10th November 2021 Name: ______________________

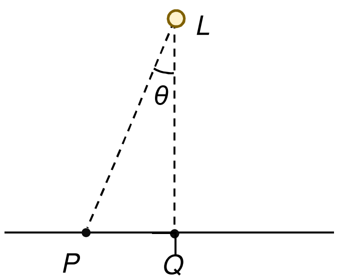
Time: 11:00a.m. – 12:00nn Class: __________ No.:________

Instructions to students:

1. Write your name, class and class number on both the question paper and the answer sheets.
2. Answer ALL questions.
3. Write down all the answers on the answer sheets.
4. Hand in the question paper and the answer sheets at the end of the examination.
5. The total mark of the paper is 40.
6. The paper consists of two sections: Section A Multiple Choice Questions (20 marks) and Section B Structured Questions (20 marks).
7. The numerical answers should be either exact or correct to 3 significant figures.
8. The last two pages of this paper contain a list of data, formulae and relationships which you may find useful.

Section A: Multiple Choice Questions (20 marks)

1. Two points P and Q on the floor are illuminated by a point light source L which is directly above Q. The illuminances at P and Q are 320 lx and 400 lx respectively.



Find the angle θ between LP and LQ.

A. 21.8°

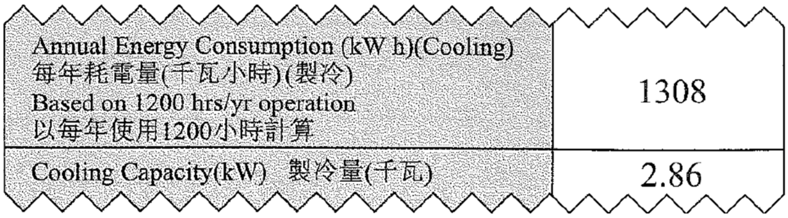
B. 26.6°

C. 28.1°

D. 36.9°

2. Which of the following descriptions about LEDs is/are correct?
   (1) LEDs can work with a.c. and d.c. voltages.
   (2) An LED can emit light of various wavelengths.
   (3) LEDs have longer lifetime comparing with incandescent lamps.
   A. (2) only
   B. (3) only
   C. (1) and (2) only
   D. (1) and (3) only

3. The figure below shows parts of the energy label affixed on an air-conditioner. The annual operation time is assumed to be 1200 hours.



Annual Energy Consumption (kW h)(Cooling) 每年耗電量(千瓦小時)(製冷) Based on 1200 hrs/yr operation 以每年使用1200小時計算	1308
Cooling Capacity(kW) 製冷量(千瓦)	2.86

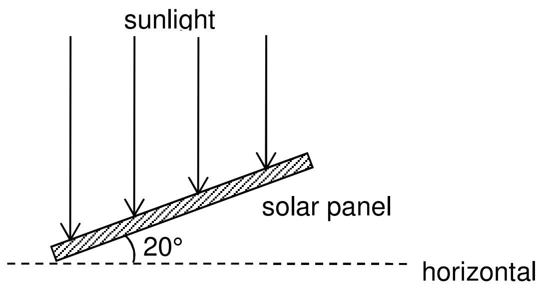
How much heat can be removed from the room installed with this air-conditioner in a year?
   A. 3.43×10^{6} J
   B. 3.74×10^{10} J
   C. 12.36×10^{6} J
   D. 1.24×10^{10} J

4. A factory roof has an area of 600 m^2. It is made from corrugated iron sheets which have a thick coating of insulating material to reduce energy loss. The U-value of the sheet is 0.5 W m^{-2} $°C^{-1}$. The exterior temperature is 15 °C and the temperature in the factory is 25 °C. Determine the rate of energy transfer through the roof.
   A. 3000 W
   B. 4500 W
   C. 7500 W
   D. 12000 W

5. Which of the following statements about hybrid vehicles is/are correct?
   (1) The batteries of hybrid vehicles require external charging.
   (2) Hybrid vehicles have lower emissions than cars running on petrol or diesel.
   (3) The electric motor of hybrid vehicles is used to provide extra power for acceleration.
   A. (2) only
   B. (3) only
   C. (1) and (2) only
   D. (2) and (3) only

6. In a hydroelectric power plant, water flows from the upper level to the lower level at a rate of 2400 kg s^{-1} and drives the turbine. The difference between the water levels is 60 m. If the efficiency of the turbine is 70%, estimate the output power of the turbine.
   A. 101 kW
   B. 989 kW
   C. 1410 kW
   D. 2020 kW

7. At a certain place, 1000 W m^{-2} of solar radiation reaches the Earth's surface vertically. A solar panel of area 2 m^2 is installed at 20° to the horizontal as shown below.



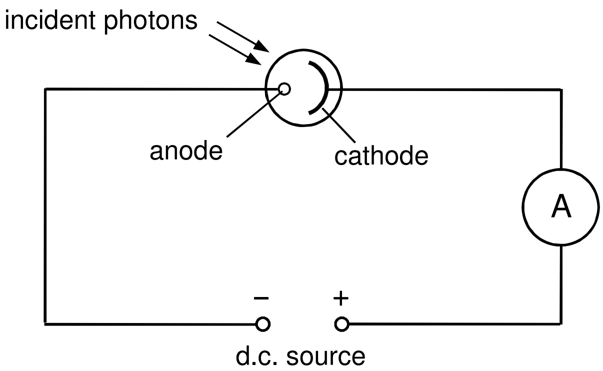
   If the efficiency of the solar panel in converting solar energy into electrical energy is 15%, at most how many 40 W light bulb can operate at the rated value when connected to the panel?
   A. 4
   B. 5
   C. 6
   D. 7

8. What is the meaning of nuclear binding energy?
   A. the energy required to ionize all the electrons in an atom
   B. the energy released when a nucleus undergoes fission
   C. the energy released in the radioactive decay of a nucleus
   D. the energy required to disintegrate a nucleus into individual nucleons

9. J. J. Thomson proposed that electrons were embedded in a cloud of positive charge to form an uncharged atom. Which of the following results obtained from the α particles scattering experiment CANNOT be explained by Thomson's atomic model?
   (1) Most of the α particles passed through the gold foil with very little or no deflection.
   (2) Some α particles were deflected by large angles.
   (3) Some α particles bounced back.
   A. (1) and (2) only
   B. (1) and (3) only
   C. (2) and (3) only
   D. (1), (2) and (3)

10. Which of the following statements about Bohr's atomic model is/are correct?
    (1) The model has both classical and quantum aspects.
    (2) In this model, the electron does not have acceleration during its motion in its orbit.
    (3) The model explains the quantized angular momentum of the electron.
    A. (1) only
    B. (2) only
    C. (1) and (3) only
    D. (1), (2) and (3)

11. A photocell is connected to a d.c. source with constant e.m.f. The polarities are connected as shown below.



When photons each of energy 4 eV are incident on the cathode of the photocell, the maximum kinetic energy of the photoelectrons reaching the anode is 2 eV. Which of the following **MUST BE** correct?
    A. If photons each of energy 2 eV are incident on the cathode, no photoelectron is emitted.
    B. If photons each of energy 2 eV are incident on the cathode, photoelectrons are emitted but none of them reach the anode.
    C. If photons each of energy 2 eV are incident on the cathode, photoelectrons are emitted and the maximum kinetic energy of the photoelectrons reaching the anode is 1 eV.
    D. The work function of the cathode is 2 eV.

12. In a photoelectric effect experiment, ultraviolet radiation of frequency 2×10^{15} Hz falls onto the metal plate in a photocell and a current is formed. The photoelectric current is lowered to zero when the potential difference across the electrodes of the photocell is increased to 1.87 V. Find the work function of the metal plate in the photocell.
    A. 1.87 eV
    B. 6.42 eV
    C. 8.29 eV
    D. 10.3 eV

13. A hydrogen atom absorbs a photon of energy E so that it is excited from quantum number n=2 to n=3. How much energy would it absorb if it is excited from quantum number n=3 to n=4?

A. $\frac{7}{144}E$

B. $\frac{3}{16}E$

C. $\frac{7}{20}E$

D. $\frac{1}{2}E$

14. A hydrogen atom is raised to the 4th excited state. Which of the following wavelengths of visible light must **NOT** be emitted when the atom returns to the ground state?

A. 435 nm

B. 488 nm

C. 605 nm

D. 658 nm

15. Which of the following statements about a scanning tunnelling microscope are correct?

(1) It only works on a conducting surface.

(2) It makes use of quantum tunnelling to produce images of a sample surface.

(3) It has a high resolving power because the electrons in the current produced in it have very short wavelengths.

A. (1) and (2) only

B. (1) and (3) only

C. (2) and (3) only

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

16. Which of the following are the functions of adding titanium dioxide (TiO_2) nano particles to fabrics?

(1) Blocking UV light

(2) Preventing the static charges to accumulate

(3) Inhibiting the growth of bacteria

A. (1) and (2) only

B. (1) and (3) only

C. (2) and (3) only

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

End of Section A

Section B: Structured Questions (20 marks)

1. (a) As shown in Figure 1.1, a house has dimensions of 3 m × 3 m × 2 m. A window of 2 m × 1 m is installed on one of the walls. The walls and roof of thickness 20 mm are made by glass wool. Assume that the equivalent temperature difference between the interior and the exterior of the house is 10 °C. The thermal conductivity of glass wool is 0.043 W m^{-1} K^{-1}.

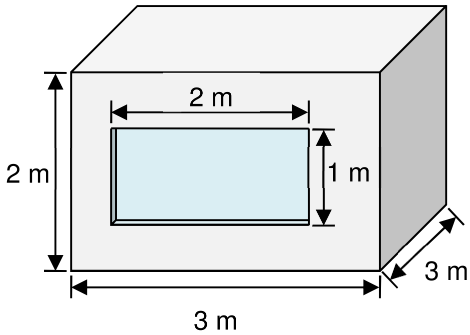


Figure 1.1

(i) Find the U-value of the walls and roof of the house. (1 mark)

(ii) Find the rate of conduction through the walls (excluding the window) and roof of the house. (2 marks)

(iii) If the average rate of heat gained by the window is 600 W, what is the OTTV of the whole house? (2 marks)

(b) As shown in Figure 1.2, some solar panels are installed on the roof of an office building to supply electricity for lighting and air conditioning during daytime.

Figure 1.2

(i) It is known that the solar constant is 1366 W m^{-2}. Give TWO reasons why this value should not be taken as the average solar power received by the solar panels of the building during the daytime of a sunny day. (2 marks)

(ii) On a sunny day, the average solar power received by the solar panels during daytime

is 840 W m^{-2}, and the efficiency of the solar panels is 15%. To provide a total output power of

(iii) Suggest **ONE** limitation of this solar-powered system. (1 mark)

2. (a) When monochromatic light is shone on a metal plate, there is a threshold frequency for photoelectric effect to occur. How does the particle nature of light explain the existence of threshold frequency? (2 marks)

(b) The threshold frequency for a metal surface is 6×10^{14} Hz. Light of frequency 7.2×10^{14} Hz and power 2×10^{-6} W is incident on the surface.

(i) Find the maximum kinetic energy (in joules) of the photoelectrons emitted. (2 marks)

(ii) Explain why the number of photoelectrons emitted in each second cannot be determined from the given information. (1 mark)

(c) In a transmission electron microscope (TEM), an electron beam is transmitted through a sample and falls onto the screen after some focusing processes as shown in Figure 2.1.

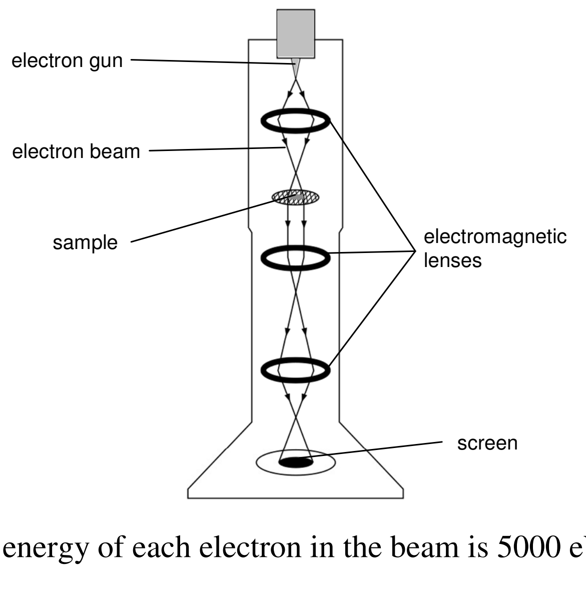


Figure 2.1

The kinetic energy of each electron in the beam is 5000 eV.

(i) Find the de Broglie wavelength of the electron. (3 marks)

(ii) If the diameter of apertures in the TEM is 0.05 mm, estimate the angular resolution of the microscope. (2 marks)

End of Section B

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)

Atomic World

$$\frac{1}{2}m_c {v_{\max}}^2 = hf - \phi$$

Einstein's photoelectric equation

$$E_n = -\frac{1}{n^2}\left\{\frac{m_e e^4}{8h^2\epsilon_0^2}\right\} = -\frac{13.6}{n^2}\text{eV}$$

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)

Energy and Use of Energy

$E = \frac{\Phi}{A}$ illuminance

$\frac{Q}{t} = k\frac{A(T_H - T_C)}{d}$ rate of energy transfer by conduction

$U = \frac{k}{d}$ thermal transmittance U-value

$P = \frac{1}{2}\rho A v^3$ maximum power by wind turbine

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