福建中學

FUKIEN SECONDARY SCHOOL

S6 Mock Examination (2020–2021)

Physics Paper 2

(1 hour)

Date: 22nd January 2021 Name:____________________

Time: 11:30 a.m. – 12:30 p.m. Class: ________ No.: _______

INSTRUCTIONS

(1) Insert the information required in the spaces provided on the question paper and answer sheet.

(2) This paper consists of **TWO** sections, Sections A and B. Each section contains eight multiple-choice questions (10 marks) and one structured question (10 marks). The total mark of the paper is 40. Attempt **ALL** questions.

(3) Write your answers in the spaces provided in the answer sheet.

(4) The diagrams in this paper are **NOT** necessarily drawn to scale.

(5) The last two pages of the answer sheet contain a list of data, formulae and relationships which you may find useful.

(6) No extra time will be given to students for inserting any information or filling in the question number boxes after the 'Time is up' announcement.

Section A: Atomic World (20 marks)

1.1 Which of the following **CANNOT** be explained by Rutherford's atomic model?

(1) Atoms are stable and do not collapse.

(2) Some α particles shot at a thin gold foil were deflected at large angles.

(3) There are discrete lines in an emission spectrum.

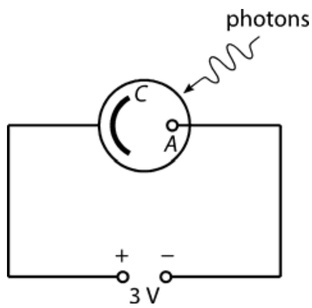
A. (2) only

B. (3) only

C. (1) and (3) only

D. (2) and (3) only

1.2 Photons of energy 6 eV are incident on the cathode C of a photocell which is connected to a 3 V d.c. source as shown in the figure below. The maximum kinetic energy of the photoelectrons that reaches the anode A is 2 eV. If photons with twice the original wavelength are now used, what will the maximum kinetic energy of the photoelectrons that reaches A be?



A. 8 eV

B. 4 eV

C. 1 eV

D. No photoelectron can reach A.

1.3 The lowest three energy levels of a certain atom are −27.2 eV, −6.8 eV and −3.0 eV. Initially, the atom is in the ground state. Which of the following statements is **INCORRECT**?

A. When a photon of energy 20.4 eV hits the atom, the atom will be excited.

B. When an electron of energy 25 eV hits the atom, the atom will be excited.

C. If two photons of energies 15 eV and 9.2 eV hit the atom one after another, the atom will be excited.

D. A photon of energy 30 eV can ionize the atom.

1.4 Which of the following about emission spectrum is/are correct?

(1) Emission spectrum contains some dark lines on a continuous spectrum.

(2) We can see an emission spectrum if we observe a gas discharge tube through a plane transmission grating.

(3) We can identify the composition of a gas by analysing the emission spectrum emitted by the gas.

A. (3) only

B. (1) and (2) only

C. (1) and (3) only

D. (2) and (3) only

1.5 When an electron is accelerated through a potential difference V, its de Broglie wavelength is λ. If the potential difference is doubled, find the new de Broglie wavelength of the electron in terms of λ.

A. $\frac{\lambda}{2}$

B. $\frac{\lambda}{\sqrt{2}}$

C. $\sqrt{2}\lambda$

D. 2λ

1.6 A transmission electron microscope (TEM) can achieve a high resolving power because

A. the magnification of the image of the TEM is very high.

B. the rate of emission of the electrons from the cathode of the electron gun of the TEM is very high.

C. the wavelength of the electrons emitted from the electron gun of the TEM is very short.

D. the fluorescent screen of the TEM is very large.

1.7 Which of the following statements about nano particles is **INCORRECT**?

A. All three dimensions of nano particles are less than 100 nm.

B. The colour of nano particles may depend on their size.

C. Nano particles of a material have a larger total surface area than the bulk form of the same material of the same mass.

D. All nano particles are man-made.

1.8 Figure (1) shows three electron transitions *X*, *Y* and *Z* in a hydrogen atom. Light *M*, *N* and *O* of different frequencies are emitted by these electron transitions.

Figure (1)

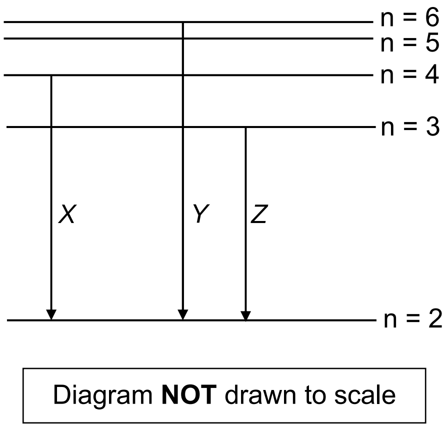
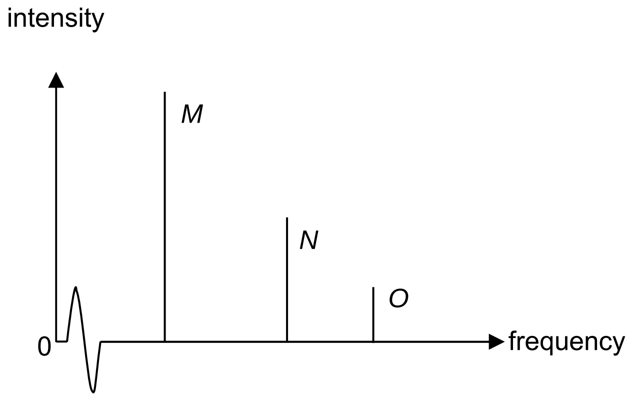


Figure (2) shows the intensities of light *M*, *N* and *O* when the light emitted by hydrogen gas is detected in an experiment.

Figure (2)



Which transitions give rise to light *M*, *N* and *O*?

	M	**N**	**O**
A.	*X*	*Y*	*Z*
B.	*Y*	*X*	*Z*
C.	*Z*	*X*	*Y*
D.	*Z*	*Y*	*Z*

1.9 A photocell is connected to a variable voltage source and an ammeter as shown in Figure (1). The photoemissive surface of the photocell is illuminated by a beam of monochromatic light. Figure (2) shows the graph of the photoelectric current I_p obtained against the voltage V of the variable voltage source. The area of the photoemissive surface is given by 4.2×10^{-4} m^2.

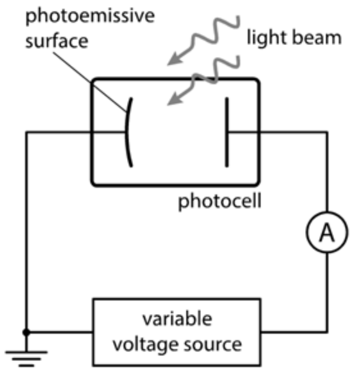


Figure (1)

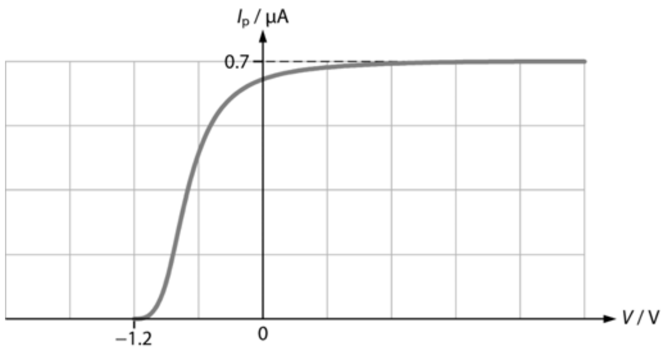


Figure (2)

(a) It is given that the work function of the photoemissive surface is 2.5 eV.

(i) Find the threshold frequency of the photoemissive surface. (2 marks)

(ii) From the information in Figure (2), find the frequency of the light. (2 marks)

(b) (i) If one photoelectron is emitted for every 5 photons hitting the photoemissive surface, find the number of photons hitting the surface per second. Hence, find the intensity of the light. (3 marks)

(ii) If the intensity of the light is reduced to one-fourth of its original value but the frequency of the light remains unchanged, sketch the corresponding graph in Figure (2) on the answer sheet. (1 mark)

(iii) It is found that the photoelectric current is produced almost without time delay even if the intensity is reduced. Explain the phenomenon in terms of the particle nature of light. (1 mark)

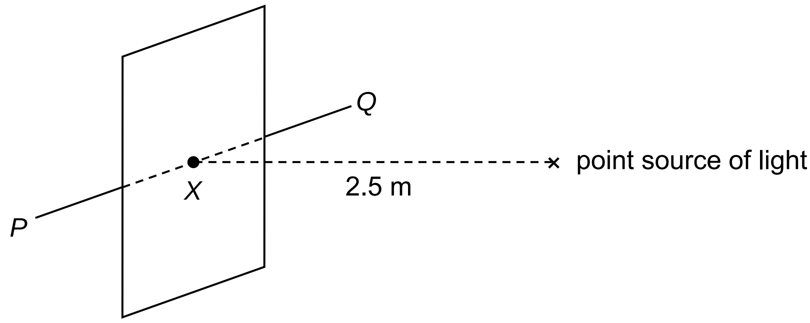
(c) A student claims that no photoelectrons are ejected from the photoemissive surface when the current passing through the circuit is zero. Comment on his statement.

(1 mark)

End of Section A

Section B: Energy and Use of energy (20 marks)

2.1 *X* is a point on a plane surface as shown in the figure below. The surface can be rotated about axle *PQ*. A point source of light is 2.5 m away from *X* and the light from the source hits *X* perpendicularly.



Which of the following can reduce the illuminance at *X* by half?

(1) Reduce the luminous flux of the light source by half.

(2) Rotate the surface about *PQ* by 30°.

(3) Increase the distance between *X* and the light source to 5 m.

A. (1) only

B. (3) only

C. (1) and (2) only

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

2.2 The following table shows the information of two electric hotplates *H* and *K*. It takes 10 minutes for *H* to raise the temperature of a pot of soup by 10 °C.

	H	*K*
Power rating	1000 W	1500 W
End-use energy efficiency	78%	65%

If *K* is used instead of *H* to heat the same pot of soup for the same rise in temperature, which of the following comparisons between the two hotplates is correct? Assume both *H* and *K* operate at their rated values.

A. The cost of electricity of using *K* is lower.

B. *K* loses more heat to the surroundings.

C. *K* has a greater useful energy output.

D. *K* takes a longer time to heat the soup.

2.3 The table below shows the input powers and the cooling capacities of air-conditioners *X* and *Y*.

	Input power / W	**Cooling capacity / W**
X	800	1600
Y	1200	2400

Which of the following statements about *X* and *Y* is/are correct?

(1) *Y* cools a room faster than *X* does.

(2) *Y* consumes more energy than *X* does in cooling a room.

(3) *Y* removes more heat from the room to the outside than *X* does within the same period of time.

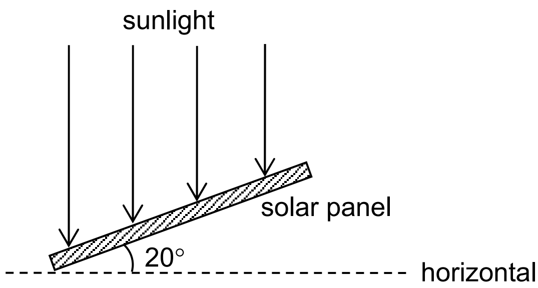
A. (1) only

B. (2) only

C. (1) and (3) only

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

2.4 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 in the figure 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

2.5 A wind turbine has blades of 10 m long. It generates a certain amount of electrical power when wind blows normally to it at a speed of 8 m s^{-1}. If the length of the blades is halved, how fast should the wind blow normally to the turbine so as to generate the same electrical power? Assume that the efficiency of the wind turbine remains the same.

A. 10.1 m s^{-1}

B. 12.7 m s^{-1}

C. 16.0 m s^{-1}

D. 17.9 m s^{-1}

2.6 The Overall Thermal Transfer Value (OTTV) of a site office is 25 W m^{-2}. There are a total of 24 identical windows in the office. The table below shows the data of the office. Find the area of each window.

	walls	**roof**	**windows**
Average rate of heat gain / W	3200	7500	4300
total area / m^2	320	250	x

A. 1.25 m^2

B. 12 m^2

C. 30 m^2

D. 287 m^2

2.7 A car of mass 2000 kg is travelling at a speed of 20 m s^{-1} on a straight road. When it brakes to stop, 30% of its energy is converted to electrical energy by its regenerative braking system. How much energy is converted to electrical energy?

A 12 kJ

B. 24 kJ

C. 60 kJ

D. 120 kJ

2.8 In which of the following cases may the fuel rods in a nuclear fission reactor melt down?

(1) The water pump for pumping seawater fails to function.

(2) The control rods inserted between the fuel rods fail to function.

(3) The moderator in the reactor fails to function.

A. (1) and (2) only

B. (1) and (3) only

C. (2) and (3) only

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

2.9 Effective ways to store energy are essential. Without storage, excess energy collected or generated will only be wasted. One way to store energy is thermal storage, especially in solar power plants. The excess energy is converted into the internal energy of a medium. 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 of water raising its temperature to 100 °C? The specific heat capacity of water is 4200 J kg^{-1} °C^{-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? Explain your answer briefly.

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

(2 marks)

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; and (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 limitation. (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 Section B

End of Question Paper

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Physics Paper 2
Answer Sheet

Date: 22nd January 2021
Time: 11:30 a.m. – 12:30 p.m.

Name:____________________
Class: ________ No.: _______

Section A: Atomic World (20 marks)

1.1	**1.2**	**1.3**	**1.4**	**1.5**	**1.6**	**1.7**	**1.8**

1.9

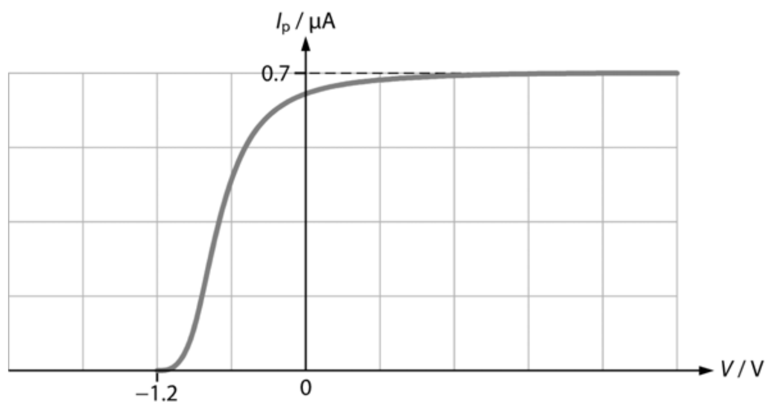

Figure 2

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Section B: Energy and Use of energy (20 marks)

2.1	**2.2**	**2.3**	**2.4**	**2.5**	**2.6**	**2.7**	**2.8**

2.9 ____

End of Answer Sheet

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	$h = 6.63 \times 10^{-34}\ \text{J s}^{-1}$

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

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

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.	$F = \frac{Q_1 Q_2}{4\pi\epsilon_0 r^2}$	Coulomb's law
A2.	$E = \ell\Delta m$	energy transfer during change of state	D2.	$E = \frac{Q}{4\pi\epsilon_0 r^2}$	electric field strength due to a point charge
A3.	$pV = nRT$	equation of state for an ideal gas	D3.	$E = \frac{V}{d}$	electric field between parallel plates (numerically)
A4.	$pV = \frac{1}{3}Nm\overline{c^2}$	kinetic theory equation	D4.	$R = \frac{\rho l}{A}$	resistance and resistivity
A5.	$E_K = \frac{3RT}{2N_A}$	molecular kinetic energy	D5.	$R = R_1 + R_2$	resistors in series
			D6.	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$	resistors in parallel
B1.	$F = m\frac{\Delta v}{\Delta t} = \frac{\Delta p}{\Delta t}$	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.	$E_K = \frac{1}{2}mv^2$	kinetic energy	D10.	$B = \frac{\mu_0 I}{2\pi r}$	magnetic field due to a long straight wire
B5.	$P = Fv = \frac{W}{t}$	mechanical power	D11.	$B = \frac{\mu_0 NI}{l}$	magnetic field inside a long solenoid
B6.	$a = \frac{v^2}{r} = \omega^2 r$	centripetal acceleration	D12.	$\varepsilon = N\frac{\Delta\Phi}{\Delta t}$	induced e.m.f.
B7.	$F = \frac{Gm_1m_2}{r^2}$	Newton's law of gravitation	D13.	$\frac{V_S}{V_P} \approx \frac{N_S}{N_P}$	ratio of secondary voltage to primary voltage in a transformer
C1.	$\Delta y = \frac{\lambda D}{a}$	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.	$t_{½} = \frac{\ln 2}{k}$	half-life and decay constant
C3.	$\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$	equation for a single lens	E3.	$A = kN$	activity and the number of undecayed nuclei
			E4.	$E = mc^2$	mass–energy relationship