**MOCK**
**PHY**
PAPER 2

# Po Leung Kuk Tang Yuk Tien College

## 2018 - 2019
## F.6 MOCK EXAMINATION

## PHYSICS PAPER 2

### Question-Answer Book

Jan 31, 2019

11:30 – 12:30 (1 hour)

This paper must be answered in English

| | |
|---|---|
| Name | |
| Class | |
| Class number | |

| | **Marker's Use Only** |
|---|---|
| Question No. | Marks |
| Section A 1.1–1.8 | |
| Section A Q.1 | |
| Section B 2.1–2.8 | |
| Section B Q.2 | |

### INSTRUCTIONS

**1.** Follow the instructions given in the announcement before the start of the examination. You should write your Name, Class and Class number in the spaces provided on this page.

**2.** This paper consists of **TWO** sections, Sections A and B. Each section contains eight multiple-choice questions and one structured question which carries 10 marks. Attempt **ALL** questions in **BOTH** 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 supplied on request. Write your Name, Class and Class number on each sheet and fasten them with string **INSIDE** this Question-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 pages of this question paper contain a list of data, formulae and relationships which you may find useful.

**8.** No extra time will be given to candidates for filling in their personal information after the 'Time is up' announcement.

## Section A: Astronomy and Space Science

Q.1: **Multiple-choice questions**

1.1 Which of the following is **not** an astronomical discovery of Galileo?

A. There are mountains, valleys and craters on the Moon.
B. The Sun is the centre of the solar system.
C. There are four moons orbiting Jupiter.
D. Venus shows a complete cycle of phases.

| A | B | C | D |
|---|---|---|---|
| ○ | ○ | ○ | ○ |

1.2 The Crab Nebula is produced by a supernova. The parallax of the Crab Nebula is 0.0005″ and its apparent diameter is about 350″. What is its actual diameter in parsec?

A. 0.00286 pc
B. 3.39 pc
C. 194 pc
D. 2000 pc

| A | B | C | D |
|---|---|---|---|
| ○ | ○ | ○ | ○ |

1.3 A planet has a diameter 2 times that of the Earth and a mass 8 times that of the Earth. Which of the following statements are correct?

(1) The escape velocity from the surface of the planet is 2 times that of the Earth.
(2) The acceleration due to gravity near the surface of the planet is 2 times that of the Earth.
(3) The linear speed of a satellite orbiting near the surface of the planet is 2 times that of the Earth.

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

| A | B | C | D |
|---|---|---|---|
| ○ | ○ | ○ | ○ |

1.4 The main asteroid belt is a donut-shaped region that contains about 500 000 asteroids. It is located roughly between the orbits of the Mars and Jupiter. It has an inner radius of 2.0 AU and an outer radius of 3.3 AU. Its thickness is about 0.3 AU. Estimate the average separation between two neighbouring asteroids in the main asteroid belt. Assume the asteroids are uniformly distributed.

A. 0.0235 AU
B. 0.0360AU
C. 0.0382 AU
D. 0.0413 AU

| A | B | C | D |
|---|---|---|---|
| ○ | ○ | ○ | ○ |

1.5 The table below shows the absolute magnitude and apparent magnitude of three stars.

| **star** | **absolute magnitude** | **apparent magnitude** |
|---|---|---|
| ***X*** | −2.4 | 1.6 |
| ***Y*** | 5.8 | −0.5 |
| ***Z*** | 3.2 | 2.8 |

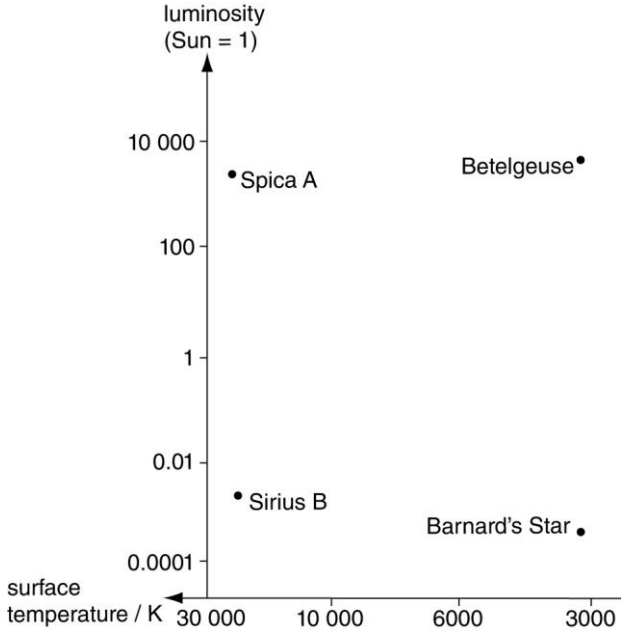
Which of the following statements is/are correct?

(1) Star *Z* is brighter than star *X* as seen from the Earth.
(2) Star *X* has a greater luminosity than star *Y*.
(3) Star *Y* is closer to us compared with the other two stars.

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

| **A** | **B** | **C** | **D** |
|---|---|---|---|
| ○ | ○ | ○ | ○ |

1.6 Refer to the H-R diagram of bright stars below.

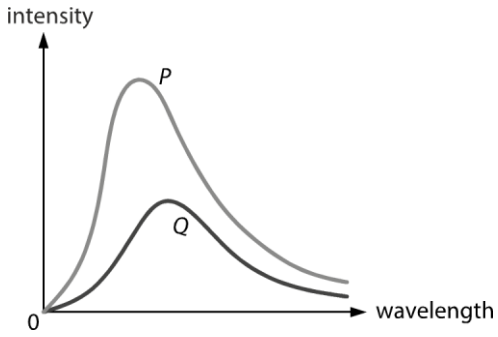



Which star labelled in the diagram has the smallest radius?

A. Barnard's Star
B. Betelgeuse
C. Sirius B
D. Spica A

| **A** | **B** | **C** | **D** |
|---|---|---|---|
| ○ | ○ | ○ | ○ |

1.7 The following graph shows the spectra of radiation received on the Earth from stars *P* and *Q*.




Which of the following can be deduced from the graph?

(1) *P* is larger in size than *Q*.
(2) *P* has a higher surface temperature than *Q*.
(3) *P* appears bluer than *Q*.

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

| **A** | **B** | **C** | **D** |
|---|---|---|---|
| ○ | ○ | ○ | ○ |

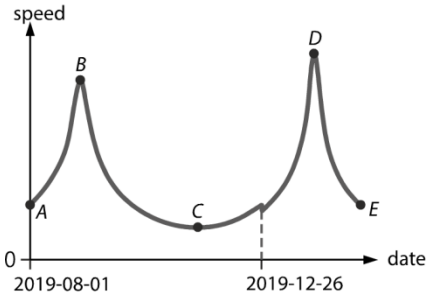
1.8 There is a galaxy in Ursa Major (the Great Bear), which is about 200 Mpc distant from the Earth. Its spectrum contains a line of laboratory wavelength 400 nm. Given that the Hubble constant *H* is about 75 km $s^{-1}$ $Mpc^{-1}$. The observed wavelength for the line from the galaxy is about _____ than the laboratory wavelength.

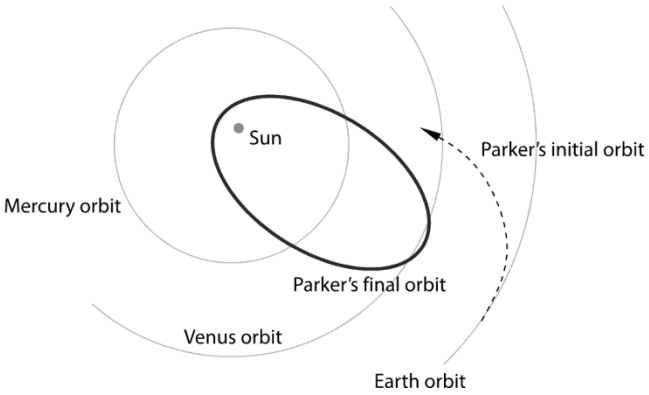
A. 20 nm longer
B. 20 nm shorter
C. 200 nm longer
D. 200 nm shorter

| **A** | **B** | **C** | **D** |
|---|---|---|---|
| ○ | ○ | ○ | ○ |

## Q.1: Structured question

Parker Solar Probe is a spacecraft launched on 12 August 2018 to study the Sun and solar wind. It will get closer to the Sun than any spacecraft before.




(a) The graph on the left shows how Parker changes its speed as it orbits around the Sun during August 2019 and February 2020.

(i) At which of the points *A* to *E* indicated on the graph is Parker the closest to the Sun? (1 mark)

(ii) On 26 December 2019, Parker will be slowed down and it will shift to a new orbit. Consider the centripetal force that Parker requires. Briefly explain why slowing down Parker will shift it to a new orbit that is closer to the Sun (in terms of the perihelion). (2 marks)

(b) The elliptical orbit (thick solid line) in the figure on the right is the final orbit of Parker. The final orbit is the orbit that is the closest to the Sun and has a semimajor axis of 0.388 AU. Estimate the orbital period of the final orbit. (2 marks)

(c) At the closest approach to the Sun, Parker is only 6.9 Gm away from the centre of the Sun (1 Gm = $10^9$ m). The radius of the Sun is about 0.7 Gm.

(i) Estimate the apparent diameter $\theta$ (in degrees) of the Sun as view from Parker at its closest approach. Assume the small-angle approximation still hold in this case. (2 marks)

(ii) Estimate the solar intensity Parker will experience at its closest approach. Given that the surface temperature of the Sun is 5770 K. (3 marks)

## Section B : Atomic World

### Q.2: Multiple-choice questions

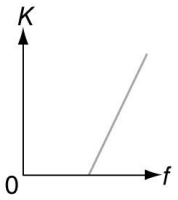
2.1. Which of the following **cannot** be explained by the Rutherford's model of the atom?

(1) Atoms of gases emit electromagnetic waves of certain characteristic frequencies only.
(2) When a thin gold foil is bombarded with α particles in a vacuum, a few α particles bounces back.
(3) When EM waves with short enough wavelength shine on a thin gold foil, electrons will be emitted from the surface.

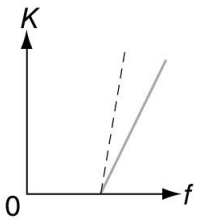
A (1) only
B (1) and (3) only
C (2) and (3) only
D (1), (2) and (3)

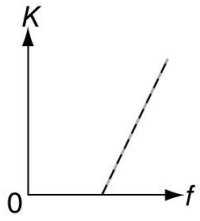
**A** **B** **C** **D**
○ ○ ○ ○

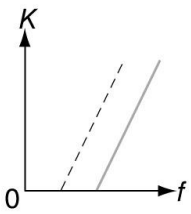
2.2

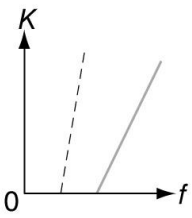



The figure above shows the relationship between the maximum kinetic energy *K* of photoelectrons and the frequency *f* of the incident radiation on a metallic surface. If the work function of the metallic surface is halved, which of the following graphs (dotted line) shows the variation of *K* with *f* ?

A.



B.



C.



D.



**A** **B** **C** **D**
○ ○ ○ ○

2.3 Which of the following statements about the photoelectric effect are **incorrect**?

(1) The maximum kinetic energy of the emitted photoelectrons is given by $K.E._{max} = hf$ where $f$ is the frequency of the incident radiation.
(2) The photoelectric effect can be explained by the wave theory of light.
(3) There is no time delay in the emission of photoelectrons when radiation of sufficiently high frequency is applied.

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

**A** **B** **C** **D**
○ ○ ○ ○

2.4 When a hydrogen atom is excited, the orbital radius of the electron is 4 times that the radius of the innermost orbit. Which of the following statements is correct?

(1) The atom is at the fourth excited state.
(2) The electron is at the energy level of –3.4 eV.
(3) The angular momentum of the electron is doubled that at the ground state.

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

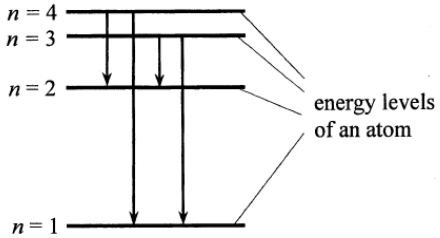
**A** **B** **C** **D**
○ ○ ○ ○

2.5 A particle of mass $m$ and kinetic energy $E$ has a de Broglie wavelength of 2 nm. What is the de Broglie wavelength of another particle of mass $2m$ and kinetic energy $2E$?

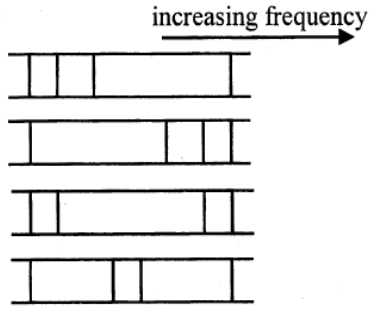
A. 8 nm
B. 4 nm
C. 2 nm
D. 1 nm

**A** **B** **C** **D**
○ ○ ○ ○

2.6 The above figure shows four energy levels of an atom drawn approximately to scale. Which emission spectrum below best corresponds to the four electron transitions indicated?




A.
B.
C.
D.




**A** **B** **C** **D**
○ ○ ○ ○

2.7 Assuming that the resolving power of a transmission electron microscope (TEM) is limited by diffraction only, which of the following can reduce the minimum resolvable length of the TEM by half?

(1) Double the acceleration voltage of the electrons.
(2) Double the diameter of the aperture.
(3) Double the distance to the specimen

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

| **A** | **B** | **C** | **D** |
|---|---|---|---|
| ○ | ○ | ○ | ○ |

2.8 Nano particles exhibit different properties when compared with large scale particles of the same substance. Which of the followings is /are the reason(s)?

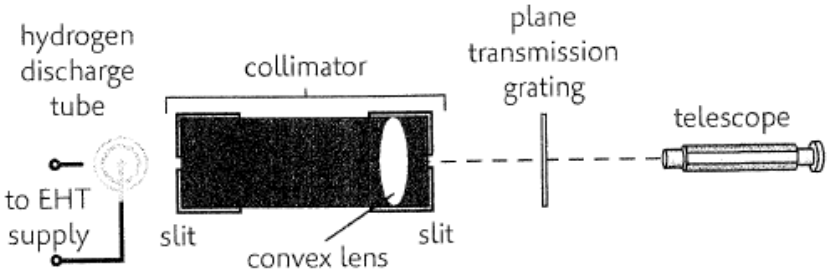
(1) Nano particles have a larger ratio of its surface area to its volume.
(2) Nano particles have more net charges.
(3) The properties of individual atoms become more obvious.

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

| **A** | **B** | **C** | **D** |
|---|---|---|---|
| ○ | ○ | ○ | ○ |

**Q.2: Structured question**

The following set-up is used to study the visible light emitted by a hydrogen discharge tube.




(a) What is the function of the collimator? (1 mark)

(b) If Rutherford's atomic model were correct, what would be the expected result of this experiment? Explain briefly. (2 marks)

(c) An emission line is observed when the telescope is rotated about the plane transmission grating at an angle of $14.1^{o}$. The grating has 500 lines per mm.

(i) Find the wavelength of the emission line. (2 marks)
(ii) Find the energy of the photon with the wavelength in (i). (2 marks)
(iii) State the transition ($m \rightarrow n$) that give rise to the emission line. Explain your answer by showing calculation. (3 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 | $h = 6.63 \times 10^{-34}\ \text{J s}^{-1}$ |

***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)

**Astronomy and Space Science**

| | |
|---|---|
| $U = -\frac{GMm}{r}$ | gravitational potential energy |
| $P = \sigma A T^4$ | Stefan's Law |
| $\left\|\frac{\Delta f}{f_0}\right\| \approx \frac{v}{c} \approx \left\|\frac{\Delta\lambda}{\lambda}\right\|$ | Doppler effect |

**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 |

**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) |

**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. | $E = \ell \Delta m$ | 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. | $E_{\mathrm{K}} = \frac{3RT}{2N_{\mathrm{A}}}$ | 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. | $E_{\mathrm{P}} = mgh$ | gravitational potential energy |
| B4. | $E_{\mathrm{K}} = \frac{1}{2}mv^2$ | kinetic energy |
| B5. | $P = Fv = \frac{W}{t}$ | 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. | $F = \frac{Q_1Q_2}{4\pi\epsilon_0 r^2}$ | Coulomb's law |
| D2. | $E = \frac{Q}{4\pi\epsilon_0 r^2}$ | 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. | $\frac{V_{\mathrm{S}}}{V_{\mathrm{P}}} \approx \frac{N_{\mathrm{S}}}{N_{\mathrm{P}}}$ | ratio of secondary voltage to primary voltage in a transformer |
| E1. | $N = N_0 \mathrm{e}^{-kt}$ | law of radioactive decay |
| E2. | $t_{½} = \frac{\ln 2}{k}$ | half-life and decay constant |
| E3. | $A = kN$ | activity and the number of undecayed nuclei |
| E4. | $E = mc^2$ | mass–energy relationship |