

系所組別： 材料科學及工程學系

考試科目： A科目

考試日期： 0225，節次： 1

※ 考生請注意：本試題可使用計算機，並限「考選部核定之國家考試電子計算器」機型

A 卷：普通物理(20 題選擇題[1-20],每題 1.5 分)、量子物理導論(10 題選擇題[21-30],每題 3 分)、物理冶金(6 題非選擇題[31-36],每題 5 分)。滿分 90 分。倒扣至零分為止。

### 一、選擇題 (請以 2B 鉛筆劃卡作答)

科目名稱： 普通物理

每題為 4 選 1，每一題答對得 1.5 分，答錯倒扣 0.375 分。

- In a conductor carrying a current, we expect the electron drift speed to be:  
Ⓐ about the same as the average electron speed  
Ⓑ less than the average electron speed at low temperature and greater than the average electron speed at high temperature  
Ⓒ much greater than the average electron speed  
Ⓓ much less than the average electron speed
- A certain x-ray tube requires a current of 7mA at a voltage of 80 kV. The rate of energy dissipation (in watts) is:  
Ⓐ 5600                      Ⓑ 560                      Ⓒ 26                      Ⓓ 11A
- An airplane is in level flight at a speed of 600Km/h with respect to the surrounding air. A wind is blowing toward the northeast direction at a speed of 100km/h. In what direction must the pilot aim the plane so that the velocity direction of the plane with respect to the ground is due north?  
Ⓐ the pilot should aim about  $6.8^\circ$  west of north  
Ⓑ the pilot should aim about  $6.8^\circ$  east of north  
Ⓒ the pilot should aim about  $6.8^\circ$  west of south  
Ⓓ the pilot should aim about  $6.8^\circ$  east of south
- You are located at the merry-go-round of diameter 20.0m and are orbiting at 6.00rev/mim. What is your tangential speed?  
Ⓐ 0.628 rad/s  
Ⓑ 0.628 m/s  
Ⓒ 6.28m/s  
Ⓓ  $6.28\text{m/s}^2$
- When you skydive what is the main cause of your acceleration?  
Ⓐ Your weight  
Ⓑ Your body position  
Ⓒ Wind  
Ⓓ All of the above

(背面仍有題目,請繼續作答)

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6. When you stand on the ground. The normal force is
- Ⓐ Parallel to the earth surface
  - Ⓑ Perpendicular to the earth surface
  - Ⓒ Depends on its orientation
  - Ⓓ Always have an angle  $<45$  degree with the surface
7. Two masses  $m_1$  and  $m_2$  are connected by an ideal string passing over an ideal pulley. Mass  $m_2$  is on an inclined (by an angle  $\theta$ ) frictionless surface. With  $m_1$  falling directly down. Which of the following statements are true
- Ⓐ the force of the cord on  $m_2$  was the same as the force of the cord on  $m_1$
  - Ⓑ the acceleration of  $m_2$  perpendicular to the plane is  $m_2 g \cos \theta$
  - Ⓒ the tension in the rope is a function of  $\sin \theta$
  - Ⓓ the magnitude of the tension in the cord is equal to  $m_1 g$
8. Today, the standard unit of mass is defined in terms of
- Ⓐ a specific volume of water at  $4^\circ\text{C}$ .
  - Ⓑ a standard platinum-iridium cylinder.
  - Ⓒ a specified number of cesium atoms.
  - Ⓓ a standard platinum bar.
9. Today, the standard unit of time is defined in terms of
- Ⓐ the electromagnetic waves emitted by cesium atoms.
  - Ⓑ the motion of the moon around the earth.
  - Ⓒ the average solar day.
  - Ⓓ the speed of light.
10. A particle has a mass of one milligram. Which on the following statements indicates the correct mass of the particle in grams?
- Ⓐ The particle has a mass of  $1 \times 10^6$  grams.
  - Ⓑ The particle has a mass of  $1 \times 10^3$  grams
  - Ⓒ The particle has a mass of  $1 \times 10^{-3}$  grams.
  - Ⓓ The particle has a mass of  $1 \times 10^{-1}$  grams.
11. Which of the following is the longest length?
- Ⓐ  $10^5$  micrometers
  - Ⓑ  $10^4$  millimeters
  - Ⓒ  $10^7$  nanometers
  - Ⓓ  $10^2$  centimeters

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12. The surface of a lake has an area of  $15.5 \text{ km}^2$ . What is the area of the lake in  $\text{m}^2$ ?
- (A)  $1.55 \times 10^4 \text{ m}^2$   
(B)  $1.55 \times 10^6 \text{ m}^2$   
(C)  $1.55 \times 10^7 \text{ m}^2$   
(D)  $1.55 \times 10^8 \text{ m}^2$
13. The human eye is most sensitive to light having a frequency of about  $5.5 \times 10^{14} \text{ Hz}$ , which is in the yellow-green region of the electromagnetic spectrum. How many wavelengths of this light can fit across the width of your thumb, a distance of about 2.0 cm?
- (A) 370000                      (B) 37000                      (C) 730000                      (D) 73000
14. A person whose eyes are 1.50 m above the floor stands in front of a plane mirror. The top of his head is 0.10 m above his eyes. How far above the floor should the bottom edge of the mirror be placed?
- (A) 0.85                      (B) 0.80                      (C) 0.75                      (D) 0.70 m
15. A 2.0-cm-high object is situated 15.0 cm in front of a convex mirror with a radius of curvature of  $1.00 \times 10^2 \text{ cm}$ , an object distance of 25.0 cm, and a 10.0-cm-high object. Measure the location and the height of the image.
- (A) Image distance is 16.7 cm behind the mirror; image height is 6.67 cm, and the image is upright  
(B) Image distance is 16.7 cm in front of the mirror; image height is 6.67 cm, and the image is inverted  
(C) Image distance is 16.7 cm in front the mirror; image height is 6.67 cm, and the image is upright  
(D) Image distance is 16.7 cm behind the mirror; image height is 6.67 cm, and the image is inverted.
16. A gemstone is placed 20.0 cm in front of a concave mirror and is within the focal point. When the concave mirror is replaced with a plane mirror, the image moves 15.0 cm toward the mirror. Find the focal length of the concave mirror.
- (A) -16.7 cm                      (B) +16.7 cm                      (C) -46.7 cm                      (D) +46.7 cm.
17. In a certain time, light travels 3.50 km in a vacuum. During the same time, light travels only 2.50 km in a liquid. What is the refractive index of the liquid?
- (A) 1                      (B) 1.2                      (C) 1.4                      (D) 1.6
18. A quarter (diameter = 2.4 cm) is held at arms length (70.0 cm). The sun has a diameter of  $1.39 \times 10^9 \text{ m}$  and is  $1.50 \times 10^{11} \text{ m}$  from the earth. What is the ratio of the angular size of the quarter to that of the sun?
- (A) 3.7                      (B) 3.8                      (C) 3.9                      (D) 4.0

(背面仍有題目,請繼續作答)

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19. A person looks at a scene through a diverging lens with a focal length of  $-12.5$  cm. The lens forms a virtual image  $5.00$  cm from the lens. Find the magnification.

- (A) + 0.8                      (B) -0.8                      (C) +0.6                      (D) -0.6

20. An electric power line carries a current of  $1400$  A in a location where the earth's magnetic field is  $5.0 \times 10^{-5}$  T. The line makes an angle of  $75^\circ$  with respect to the field. Determine the magnitude of the magnetic forces on a  $120$ -m length of line.

- (A) 8.1                      (B) 8.0                      (C) 7.9                      (D) 7.8 N

科目名稱： 量子物理導論

每題為 4 選 1，每一題答對得 3 分，答錯倒扣 2 分。

Planck's constant  $h=6.626 \times 10^{-34}$  J·s

Mass of an electron  $=9.110 \times 10^{-31}$  Kg

Speed of light  $=2.998 \times 10^8$  m/sec

Charge of an electron  $=1.602 \times 10^{-19}$  C

21. Maxwell proposed that

- (A) a changing magnetic field induces a current  
 (B) a static magnetic field induces a current  
 (C) a changing electric field has a magnetic field associated with it  
 (D) none of the above is correct.

22. A  $46$ -g golf ball has a velocity of  $30$  m/s and an electron ( $9.1 \times 10^{-31}$  kg) has a velocity of  $10^7$  m/s. What is the ratio of the de Broglie wavelength of the golf ball to the de Broglie wavelength of the electron?

- (A)  $5.9 \times 10^{-28}$                       (B)  $6.6 \times 10^{-24}$                       (C)  $1.4 \times 10^{-33}$                       (D)  $1.3 \times 10^{-30}$ .

23. The size of a nucleus can be estimated using the

- (A) Thomson                      (B) Geiger                      (C) Einstein                      (D) Rutherford model.

24. An electron is in a box  $0.2$  nm across, which is the order of magnitude of atomic dimensions. Find the  $2^{\text{nd}}$  excited permitted energy.

- (A) 28 eV                      (B) 46 eV                      (C) 38 eV                      (D) 52 eV

25. What is the ratio of many alpha particles are scattered by a foil through angles between  $60^\circ$  and  $90^\circ$  to the particles are scattered through angles of  $90^\circ$  or more.

- (A) 2                      (B) 3                      (C) 4                      (D) 5

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26. A rigid-walled box that extends for  $-L$  to  $L$  is divided into three sections by rigid interior walls at  $-x$  and  $x$ , where  $x < L$ . Each section contains one particle in its ground state. At what value of  $x$  is  $E(x)$  a minimum?

- (A)  $\frac{8\pi^2\hbar^2}{5mL^2}$    (B)  $\frac{17\pi^2\hbar^2}{3mL^2}$    (C)  $\frac{9\pi^2\hbar^2}{2mL^2}$    (D)  $\frac{27\pi^2\hbar^2}{8mL^2}$

27. A particle is in a cubic box with infinitely hard walls whose edges are  $2L$  long. The wave functions of the particle are given by  $\Psi = A \sin \frac{n_x\pi x}{L} \sin \frac{n_y\pi y}{L} \sin \frac{n_z\pi z}{L}$ ;  $n_x = 1, 2, 3, \dots$ ;  $n_y = 1, 2, 3, \dots$ ;  $n_z = 1, 2, 3, \dots$ ; Find the value of the normalization constant  $A$ .

- (A)  $\left(\frac{3}{2L}\right)^{3/2}$    (B)  $\left(\frac{1}{2L}\right)^{3/2}$    (C)  $\left(\frac{2}{3L}\right)^{3/2}$    (D)  $\left(\frac{1}{L}\right)^{3/2}$

28. Which of the following is "not" true?

- (A) In the **Stefan-Boltzmann** law the energy  $R$  radiated by an object per second per unit area is proportional to  $T^4$ .
- (B) In the **Wien's displacement** law. It quantitatively expresses the fact that the peak in the blackbody spectrum shift to progressively higher frequencies as the temperature is decrease.
- (C) The distribution function for photons is  $f(\nu) = \frac{1}{e^{h\nu/kT} - 1}$ .
- (D) Identical particles that are sufficiently far apart to be distinguishable, for instance, the molecules of a gas are controlled by **Maxwell-Boltzmann** distribution function.

29. With regard to the exchange of any pair of electron positions, the wave function for the electrons is:

- (A) symmetric   (B) asymmetric   (C) antisymmetric   (D) none of these

30. If the term symbol for an energy level is  ${}^4F_{5/2}$ , what is the total spin quantum number  $S$ ?

- (A)  $5/2$    (B)  $4$    (C)  $3$    (D)  $3/2$

(背面仍有題目,請繼續作答)

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## 二、非選擇題（請以原子筆在非選擇題答案卷上作答）

科目名稱：物理冶金（每題 5 分）

31. Explain why the dislocation lines can not end inside a crystal.

32. Please explain the cross-slip.

33. Assume that the potential energy between two simple, neutral molecules at separation  $r$  can be represented by the following relation

$$E(r) = -\frac{Aa_0^6}{r^6} + \frac{Ba_0^{12}}{r^{12}} \quad (a_0 : \text{the equilibrium separation})$$

By obtaining an expression for the force, determine the relationship between the constants A and B.

34. Suppose two orthogonal (mutually perpendicular) edge dislocations with perpendicular Burgers vectors intersect. Describe what happens to the dislocation lines, and discuss what influence this will have on their subsequent motion.

35. Twinning in FCC metals occurs on  $\{111\}$  planes and  $\langle 11\bar{2} \rangle$  directions. Please calculate the shear strain.

36. The stress intensity for the partial-through thickness flaw is  $K = \alpha\sigma\sqrt{\pi a}$ , where  $\alpha = \sqrt{\sec(\pi a / 2t)}$ ,  $a$  is the depth of penetration of the flaw through a wall thickness  $t$ . If a flaw in 2024-T3 aluminum alloy is 3 mm deep in a wall 9 mm thick, calculate how much stress this alloy can support. (The fracture toughness  $K_{IC}$  of 2024-T3 Al alloy is  $26 \text{ MPa m}^{1/2}$ .)