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※選擇題請在答案卡內作答，非選擇題請在答案卷內作答

一、選擇題(每題5%)

單選題:

1. A clock moves along the x axis at a speed of 0.60c and reads zero as it passes the origin. What time does it read as it passes the 180-m mark on this axis? c is the speed of light.
   (A) 0.50 μs
   (B) 0.60 μs
   (C) 0.70 μs
   (D) 0.80 μs
   (E) 0.90 μs

2. How much work must be done to increase the speed of an electron from rest to 0.50c? Note : the speed of light: 2.998×10^{8} m/s; mass of electron : 9.11×10^{-31} kg; elementary charge: 1.602×10^{-19} C.
   (A) 75.3 keV
   (B) 79.1 keV
   (C) 83.2 keV
   (D) 85.4 keV
   (E) 87.5 keV

複選題:

3. Which of the following statements are true?
   (A) It is possible for a photon to give up all its momentum to a free electron.
   (B) It is impossible for a photon to give up all its energy to a free electron.
   (C) The frequency associated with a photon increases as it moves toward the earth.
   (D) In Compton experiment, the greatest wavelength change possible corresponds to $\phi=180°$.
   (E) A bright light yields more photoelectrons than a dim one of different frequencies.

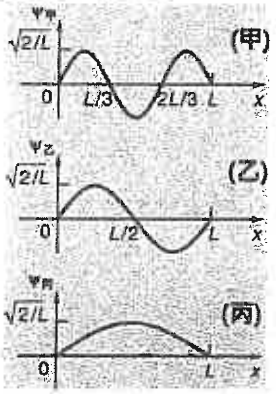
注意:背面有試題

※選擇題請在答案卡內作答，非選擇題請在答案卷內作答

4. Which of the following statements are true?
   (A) A blackbody or perfect absorber is also an ideal radiator.
   (B) The wavelength corresponding to the maximum intensity of the blackbody increases with its temperature.
   (C) The power per unit area emitted at the surface of the blackbody is proportional to the fourth power of its absolute temperature.
   (D) The energy density of the blackbody is proportional to the fourth power of its absolute temperature.
   (E) Rayleigh-Jeans Law well explain the experimental results of the blackbody radiation.

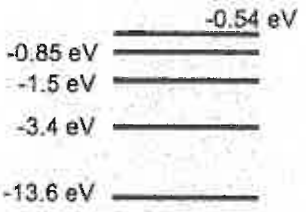
單選題:

5. Below are three wave functions for a particle in a box. Which has the highest energy?



   (A) (甲) and (乙) equal and highest.
   (B) (乙) and (丙) equal and highest.
   (C) (甲).
   (D) (乙).
   (E) (丙).

6. The energy levels of a hydrogen atom are given by $E = -13.6/n^2$ eV, as shown. Light with a continuous range of wavelengths from 450 nm to 700 nm is shined on the atom. All the light passes by the atom except particular energies that are absorbed by the atom, leaving black 'absorption lines' in the spectrum. How many absorption lines are seen?
   (A) 0
   (B) 1
   (C) 2
   (D) 3
   (E) 4



注意:背面有試題

複選題:

7. Which of the following statements are correct?

(A) A quantum particle in a box is in the lowest energy (ground) state. If the size of the box is increased, the wavelength and energy of the particle change as wavelength longer and energy smaller.

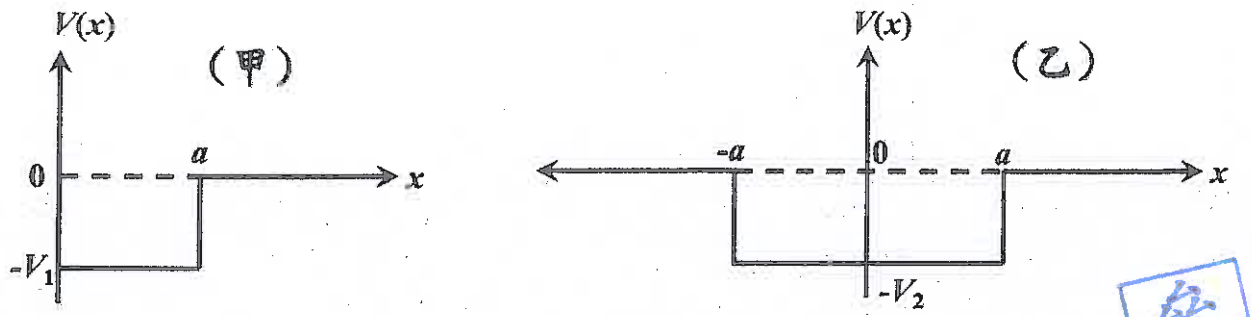
(B) An electron is confined to a box of length L. It is in an excited state. The momentum of the particle is uncertain because the particle is moving in two different directions.

(C) The Pauli exclusion principle says that no two fermions can be in the same quantum state.

(D) A pure semiconductor is an insulator, but becomes useful electrically when some of its atoms are replaced with different atoms.

(E) An energy band in a solid is an energy range densely packed with quantum states.

8. For a particle of mass m, consider the following two one-dimensional potential wells (甲) and (乙):



Which of the following statements are correct?

(A) As shown in the plot (甲), the well can support a bound state for an arbitrarily small depth V_1.

(B) As shown in the plot (乙), the well can support a bound state for an arbitrarily small depth V_2.

(C) For $V_1 = V_2$, the bound states of the potential of (甲) are also bound states of the potential of (乙).

(D) For $V_1 \neq V_2$, the bound states of the potential of (甲) are also bound states of the potential of (乙).

(E) For continuum states of a given energy, there is only one independent solution for the well of (甲), which is a stationary-wave solution at x = 0; there are two independent solutions corresponding to traveling waves in ±x directions for the well of (乙).

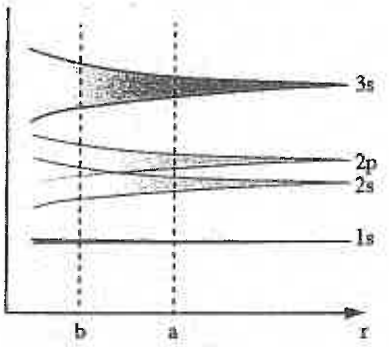
單選題:

9. An electron in hydrogen is excited to total energy = -1.51 eV (=-13.6/9 eV). How many different wave functions $\Phi_{n,l,m}$ in H have this same energy? (Ignore spin and fine structure etc.)
   (A) 1
   (B) 3
   (C) 6
   (D) 9
   (E) 10

10. How are atoms configured? Empty and filled energy levels.
   (A) Light atoms (like hydrogen and helium) have few filled levels and many empty ones, but heavy atoms (lead, uranium) are the opposite, with many filled levels and just a few empty ones.
   (B) There are the same number of possible levels for every atom and the number of electrons determines the fraction of these filled.
   (C) In most atoms there are more filled energy levels than empty ones.
   (D) In most atoms, there are more empty energy levels than filled ones.
   (E) In every atom, there are many more empty levels than filled ones.

複選題:

11. Consider a hypothetical element that forms a solid with bands as shown in Figure. Suppose the isolated atom has configuration and its equilibrium separation shown below. Please pick up the following solids, which are conductors.



   (A) $1s^2 2s^2$, its equilibrium separation is $r_0 = b$
   (B) $1s^2 2s^2 2p^1$, its equilibrium separation is $r_0 = a$
   (C) $1s^2 2s^2 2p^1$, its equilibrium separation is $r_0 = b$
   (D) $1s^2 2s^2 2p^6$, its equilibrium separation is $r_0 = a$
   (E) $1s^2 2s^2 2p^6$, its equilibrium separation is $r_0 = b$

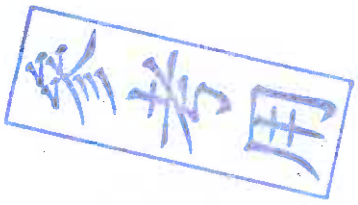
12. Why would behavior of Li be similar to Na?
   (A) because shape of outer most electron is similar.
   (B) because energy of outer most electron is similar.
   (C) because they have similar atom sizes.
   (D) because they have the same numbers of neutrons.
   (E) None of above

注意:背面有試題

單選題:

13. What assumption did Planck have to make to avoid the ultraviolet catastrophe?
    (A) The number of polarizations of light at high energy had to be modified
    (B) An upper limit had to be put on the frequencies of light that could occur
    (C) The energy in each mode had to come in multiples of a constant times the frequency
    (D) The energy in each mode had to come in multiples of a constant times the wavelength
    (E) Light had to be in circular orbits around atoms

14. How do we hope to detect gravity waves in the near future, or have they been detected in the past?
    (A) It is not conceivable that gravity waves will be directly detected in the near future
    (B) By measuring the bending of starlight around the Sun
    (C) By studying the change in the orbit of planets and/or satellites
    (D) By studying the rotation of sensitive gyroscopes in orbit around the Earth
    (E) By carefully measuring oscillations in the distance of two arms of a large interferometer



複選題:

15. A Borg Collective Cube ship is in the shape of a cube 3040 m on a side. The ship is then accelerated to a speed such that at least one of its dimensions is now 2000 m, as viewed by a stationary observer 1. Which of the following statements are true?
    (A) The other dimensions of the ship is also 2000m x 2000m.
    (B) The traveling speed of Borg Collective ship is 0.216 *c*.
    (C) The traveling speed of Borg Collective ship is 0.753 c.
    (D) The distance between α-Centauri C to the Earth is 4.2 light years. Therefore, the time requiring for travelling from α-Centauri C to the Earth is 19.4 years.
    (E) Same as (D), the clock time on the Borg ship it would take to go this distance is 3.67 year.

16. A Li^{++} ion has exactly one electron in it. This single electron is in the n = 3 state. Which of the following statements are true:
    (A) The binding energy of this electron is -13.6 eV.
    (B) The total angular momentum squared L^2 is measured. One of the possible outcomes can be $6\hbar^2$.
    (C) And the z-component of the angular momentum is measured. One of the possible outcomes can be $3\hbar$.
    (D) If the electron suddenly shifted to the n = 4 state, the energy be absorbed is 7.65 eV
    (E) Same as (D), the absorbed energy corresponds to a photon with a wavelength of 208 nm

二、 非選擇題

17. Describe the electron matter wave function and behaviors (draw two proper figures) in (a) Free space (5%) and (b) Single Crystal. (5%)

18. (10%) A Si semiconductor crystal sample has its length (L), width (W), and thickness (T) with unknown doping type and carrier's concentration. **Design an experiment to determine its type** (n-type? or p-type?) **and its carrier's concentration (n or p, choice one only).** (Hint: use Hall Effect, you can set any physical parameters to support your answer.)

注意：背面有試題