類組：電機類　科目：近代物理(300F)　

參考用

※請在答案卡內作答

一. 單選題 (共 10 題, 每題 5 分. 每題有五個選項. 每答錯一題, 倒扣 1 分)

1. An inertial frame of reference S′ is moving with a constant speed of V in the positive direction of x with respect to the other inertial frame of reference S. Which expression holds between the time t_0 of the clock fixed at S′ and the time t of the clock measured at S? Here, we use $\beta = V/c,\ \gamma = 1/\sqrt{1-\beta^2}$ with c being the speed of light.

(A) $t = \beta t_0$

(B) $t = t_0/\beta$

(C) $t = \gamma t_0$

(D) $t = t_0/\gamma$

(E) $t = t_0$

2. A train (A) is running at a constant speed of 0.5c, and another train (B) is oppositely approaching to the train A at the speed of 0.4c. Suppose an observer is in the train A, what is the relative speed of the other train with respect to the observer? (c is the speed of light.)

(A) (1/12)c

(B) (9/10)c

(C) (1/8)c

(D) (3/4)c

(E) c

3. John sees two lightning flashes and determines that one happens 10 ns before the other. Which statement is true?

(A) Another inertial observer must find the order of events, the location of events, and the time difference to be the same.

(B) Another inertial observer must find the order of events to be the same but the location and the time difference may be different.

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(C) Another inertial observer must find the order of events and the locations to be the same but the time difference may be different.

(D) Another inertial observer might find the order of events, the locations and the time difference to be different.

(E) None of above is true.

4. A ψ particle with mass 1116 MeV/c^2 decays at rest to a proton with mass 938 MeV/c^2 and a pion with mass 140 MeV/c^2 . What can we say about the proton and pion momentum and energy?

(A) The proton and pion have the same magnitude momentum and energy.

(B) The proton and pion have the same energy but proton has more momentum.

(C) The proton and pion have the same momentum but the proton has more energy.

(D) The proton and pion have equal and opposite momenta and the proton has more energy.

(E) Need more information.

5. Consider the optical transition in a hydrogen atom, with the corresponding photon energy given by $h\nu = 3e^4m_e/(128\pi^2\varepsilon_0^2\hbar^2)$, where the various symbols are defined as in typical textbooks. Suppose we use Bohr's theory for the energy levels. Then the transition could occur between

(A) 1s and 2s states, (B) 1s and 2p states, (C) 2s and 3s states, (D) 2s and 3p states,(E) 3s and 4p states

6. Consider a massive relativistic particle with the following energy dispersion $E(k) = (\hbar^2v^2k^2 + \Delta^2)^{1/2}$. Which of the following statements is true, in regard to the phase and group velocities of the particle? ($\hbar = h/2\pi$. h = the Planck constant, v and Δ are parameters.)

(A) In the low energy limit where $\hbar vk \ll \Delta$, the group velocity is identical to the phase velocity.

(B) In the low energy limit where $\hbar vk \ll \Delta$, the phase velocity is twice as large as the group velocity.

(C) In the high energy limit where $\hbar vk \gg \Delta$, the group velocity is identical to the phase velocity.

(D) In the high energy limit where $\hbar vk \gg \Delta$, the group velocity is twice as large as the phase velocity.

(E) The group velocity can be greater than v.

7. In the Bohr model of hydrogen atom, what is the magnitude of the orbital magnetic moment of an electron in the 3rd energy level (i.e., the 2nd excited energy level)? (e: charge of an electron, $\hbar = h/2\pi$. h is the Planck constant, m_e: mass of an electron)

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(A) $e\hbar/3m_e$
(B) $e\hbar/2m_e$
(C) $3e\hbar/2m_e$
(D) $e\hbar/m_e$
(E) $2e\hbar/3m_e$

8. A particle in a cubic box with infinitely hard walls whose edges are L long. You can find the wave functions of the particle by Schrödinger's equation. Find the probability that the particle will be found in the volume defined by $0 \le x \le L/2$, $0 \le y \le L/2$, $0 \le z \le L/2$ when it is in the ground state. .
(A) 1/2
(B) 1/4
(C) 1/6
(D) 1/8
(E) 1/10

9. The ratio of the electron densities in the conduction bands of silicon (E_g = 1.14 eV) and germanium (E_g = 0.7 eV) at 400 K is close to (A) 0.44. (B) 2.27. (C) 70. (D) 588. (E) 345802.

10. In an infinite square well of length *a* there are 5×10^9 electrons per meter. If all the lowest energy levels are filled, the energy of the most energetic electron is (A) 0.59 eV. (B) 1.25 eV. (C) 2.35 eV. (D) 4.70 eV. (E) 9.4 eV.

二. 複選題 (共 10 題, 每題 5 分. 每題有五個選項. 每答錯一題, 倒扣 1 分)

11. Choose the correct statements below.
(A) What is stated in the principle of light velocity invariance is the speed of visible light.
(B) Since the upper limit of the speed of objects claimed by special relativity is the light speed, light has special meaning to special relativity.
(C) From the viewpoint of an object (for example, photon) running at the speed of light, the length in the direction becomes 0, so it is possible to instantaneously move.
(D) Massless objects can also move at a slower speed than the speed of light.

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(E) There is a case that special relativity theory can deal with acceleration movement

12. Choose the correct statements below.

(A) In the photoelectron effect, the maximum kinetic energy of photoelectrons from surface of metal depends on light intensity.

(B) Gamma Rays are a type of electromagnetic radiation.

(C) Assuming that an electron, a proton and an α-particle (nucleus of He atom) have the same kinetic energy, the particle that exhibits the shortest de Broglie wavelength is the electron.

(D) When the object is irradiated with X-rays, the wavelength of the scattered X-ray is shorter than the wavelength of the incident X-ray, which is caused by inelastic scattering of X-rays by electrons.

(E) The shape of the spectrum and the maximum intensity of a Blackbody only depend on temperature.

13. Sound waves, just like light waves, are quantized, and come in discrete amounts. It also satisfies the frequency-wavelength relation as light if we replace c by the speed of sound, typically $v \sim 343$ m/s. A speaker is putting out 1.00 W = 1.00 J/s of sound power at a frequency of 262 Hz. Which of the following statements are true?

(A) The wavelength of this sound is 1.145×10^{6} m.

(B) The wavelength of this sound is 1.309 m.

(C) The energy of one phonon (sound quanta) is 1.736×10^{-31} J.

(D) The momentum of one phonon (sound quanta) is 5.787×10^{-40} kg·m/s.

(E) The number of phonons coming out of this speaker per second is 5.76×10^{30} number/s.

14. A certain element, when all but one electron has been removed, emits light with a wavelength of 7.6 nm when an electron falls from n = 2 to n = 1. Which of the following statements are true? (Z = the atomic number of the element.)

(A) The energy of the photon is 163.2 eV.

(B) The Z value of this element is 5.

(C) The Z value of this element is 4.

(D) If this atom had an electron fall from n =9 to n = 8, the energy of the resulting emission photon would be 0.714 eV

(E) If this atom had an electron fall from n =9 to n = 8, the energy of the resulting emission photon would be 1.115 eV

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15. Which of the following statements are true, regarding the quantum-mechanical nature of electrons?

(A) The uncertainty principle is a manifestation of the wave-particle duality.

(B) The wave nature of electrons is suppressed in the high electron energy limit.

(C) Electrons behave like classical particles in sufficiently large sized electronic devices.

(D) The existence of band gaps in semiconductors is a manifestation of wave nature of electrons.

(E) Confinement of electrons tends to lower electron energy.

16. Consider electrons in a finite, square potential well in 1D. Which of the following statements are true?

(A) Electron probability distributions are always symmetric.

(B) Bound electron states do not exist if the potential well depth is sufficiently weak.

(C) The number of bound states would decrease if the electron mass could be decreased.

(D) The number of bound states would increase if the Planck constant could be increased.

(E) If the square potential is tilted to one side, the probability distribution of a bound state would be tilted to the same side.

17. Which of the following statements are true for the hydrogen atom? ($\mathbf{p}$ = momentum, $\mathbf{L}$ = angular momentum, E = energy)

(A) We can measure L_x and L_z of the electron simultaneously with arbitrary accuracy.

(B) We can measure L_x and $\mathbf{L}^2$ of the electron simultaneously with arbitrary accuracy.

(C) The kinetic energy of the electron contains two components: rotational and radial kinetic energies.

(D) We can measure total energy E and $\mathbf{L}^2$ of the electron simultaneously with arbitrary accuracy.

(E) We can measure p_x and L_z of the electron simultaneously with arbitrary accuracy.

18. Which of the following statements are true?

(A) In the case where the finite step height U of a potential step exceeds the total particle energy E, the wavefunction will penetrate into classically forbidden region so that there is net transmission of incident particle into the classically forbidden region.

(B) In a classically forbidden region, the wavefunction of a particle does not oscillate.

(C) Maxwell Boltzmann distribution is valid when the average distance between particles is large compared with the quantum uncertainty in particle position and particles are indistinguishable.

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(D) The wavefunctions of atomic electrons are unaffected by the application of a magnetic field, while the corresponding energies are affected.

(E) Spin is an intrinsic property of electrons and has nothing to do with coordinates.

19. Which of the following statements are correct?

(A) The maximum number of electrons that can lie in a shell specified by a principal quantum number n is $2n^2$.

(B) The Madelung constant for a one-dimensional array of ions of alternating sign with equal distance between successive ions is equal to 1.39.

(C) For silver, given that the number of conduction electrons per unit volume is $5.86\text{x}10^{28}$ m^{-3}, the Fermi energy is 5.517 eV.

(D) An LED is constructed from a PN junction based on a certain semiconducting material with energy gap of 1.55 eV. The wavelength of the emitted light is 800 nm.

(E) It may be assumed that the intrinsic electron concentration in silicon at room temperature is $1.6\text{x}10^{16}$ m^{-3}. Given that a piece of n-type silicon contains $8\text{x}10^{21}$ m^{-3} phosphorus impurity atoms, the hole concentrations at room temperature will be $3.2\text{x}10^{10}$ m^{-3}.

20. Which of the following statements are correct?

(A) In a semiconductor, the Fermi energy is in the energy gap E_g between the valance and conduction bands. Assuming $E - E_F = E_g/2$ and $E_g = 1.0$ eV and T = 25°C, the Fermi-Dirac distribution for conduction electrons reduces to the Maxwell-Boltzmann distribution.

(B) Maxwell–Boltzmann statistics is valid for hydrogen gas at standard temperature and pressure. It is also valid for conduction electrons in silver at 300 K.

(C) The measured ionization energy of He is $E_M = 24.60$ eV. Suppose that the interaction energy between the two electrons of a He atom is taken to be the difference between their common binding energy, assuming each moves independently in a Bohr orbit, and the measured ionization energy. The interaction energy would be approximately 29.72 eV.

(D) The energy difference between the two electron spin orientations when the electrons are in a magnetic field of 0.5 T is $5.79\text{x}10^{-5}$ eV.

(E) Magnetic flux density B = 2.14 T is required to observe the normal Zeeman effect if a spectrometer can resolve spectral lines separated by 0.5 Å at 5000 Å?