國立中央大學103學年度碩士班考試入學試題卷

所別：物理學系碩士班 不分組(一般生)　科目：普通物理　共 2 頁 第 1 頁
物理學系碩士班 不分組(在職生)

本科考試禁用計算器

＊請在試卷答案卷（卡）內作答

本試題卷共有單選題 20 題，每題 5 分，答錯一題倒扣 1 分。

Some physical constants: $h = 6.63 \times 10^{-34}$joule-sec; $e = 1.60 \times 10^{-19}$coul; $m_e = 9.11 \times 10^{-31}$kg.

1. Which of the following has the dimension of time? (R: resistance; L: inductance; C: capacitance) (A) LC (B) LR (C) RC (D) R/L (E) None of the above.

2. The electron spin was first discovered in the Stern-Gerlach experiment. To let electrons of distinct spin angular momenta deflect into different trajectories, one has to apply (A) a uniform DC electric field (B) a uniform DC magnetic field (C) a non-uniform DC electric field (D) a non-uniform DC magnetic field (E) a uniform AC magnetic field.

3. Consider the Lennard-Jones potential energy $U(r) = 4\epsilon\left[(\sigma/r)^{12} - (\sigma/r)^6\right]$, where σ and ϵ are constants and r is the distance between two particles. At which distance r is the attractive force largest? (A) $r = \sigma$ (B) $r = 2^{1/6}\sigma$ (C) $r = 0$ (D) $r = (26/7)^{1/6}\sigma$ (E) $r = (26/7)^{1/6}\epsilon/\sigma$.

4. If we superimpose two sound waves with frequencies 400Hz and 402Hz, respectively, what is the resulting beat frequency? (A) 2Hz (B) 4Hz (C) 401Hz (D) 160800Hz (E) $401/(2\pi)$Hz.

5. A uniform string of linear mass density μ and length L hangs vertically under gravity. How long does it take a wave to propagate from the bottom to the top of the string? (A) $L/\sqrt{\mu g}$ (B) $L\sqrt{\mu/g}$ (C) $2\pi\sqrt{L/g}$ (D) $\sqrt{L/g}$ (E) $2\sqrt{L/g}$.

6. Consider a point particle of mass m lying at a distance d above some infinitely large sheet, whose mass per unit area is σ. What is the magnitude of gravitational attractive force between these two objects? (G is the gravitational constant.) (A) $4\pi Gm\sigma$ (B) $2\pi Gm\sigma$ (C) $Gm\sigma/2$ (D) $Gm\sigma/d^2$ (E) $Gm^2/(4d^2)$.

7. Consider an electron inside a square quantum well of depth 10eV, and the width of the well is 1nm. What is the ground-state energy? (The zero potential is designated at the bottom of the well. Hint: You can get an estimate from the infinite-well problem.) (A) 0.003eV (B) 0.03eV (C) 0.3eV (D) 3eV (E) 0eV.

8. A simple way to produce X-rays is to bombard some heavy metal target with high-speed electrons. If the shortest wavelength of the resulting X-rays is approximately 1Å, what is the bias voltage applied on the accelerating electrons? (A) 12.4mV (B) 12.4V (C) 12.4kV (D) 12.4MV (E) 12.4GV.

9. Consider the quantum state $l = 3, m_l = 3$. What is the angle (in radians) between the angular momentum and the $+z$ direction? (A) $\sin^{-1}\sqrt{3/4}$ (B) $\cos^{-1}\sqrt{3/4}$ (C) $\pi/6$ (D) $\pi/2$ (E) 0

10. An electric dipole consists of two opposite charges, each with mass m and charge $\pm q$ (respectively), and the two charges are separated by a distance d. Under a uniform external electric field $\mathbf{E}$, the electric dipole performs simple harmonic oscillation if the angle between the dipole and $\mathbf{E}$ is small. The period of this oscillation is (A) $2\pi\sqrt{2md/(qE)}$ (B) $2\pi\sqrt{qE/(2md)}$ (C) $2\pi\sqrt{2qE/(md)}$ (D) $2\pi\sqrt{md/(2qE)}$ (E) none of the above.

11. Continued from the last question, if initially the dipole is at rest and perpendicular to the external electric field, what is its angular speed (in terms of rotation instead of oscillation) when it becomes parallel to $\mathbf{E}$? (A) $2md/(qE)$ (B) $qE/(2md)$ (C) $2qE/(md)$ (D) $md/(2qE)$ (E) none of the above .

- [12-13] In Compton's scattering experiment, suppose a high-energy photon of wavelength λ moves in the $+x$ direction and collides with a particle at rest (with rest mass m). After the collision the scattered photon recoils (moves in the $-x$ direction) with a wavelength λ'.

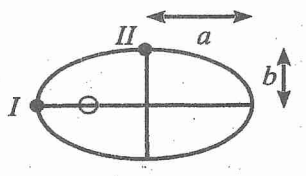
12. The wavelength of the scattered photon λ' is equal to (A) $\lambda - 2h/(mc)$ (B) $\lambda + 2h/(mc)$ (C) $\lambda/(1 + mc\lambda/h)$ (D) $\lambda/(1 - mc^2\lambda/h)$ (E) none of the above.

13. What is the momentum of the scattered particle? (A) $h(1/\lambda - 1/\lambda')$ (B) $h(1/\lambda + 1/\lambda')$ (C) $-hc(1/\lambda + 1/\lambda')$ (D) $hc(1/\lambda - 1/\lambda')$ (E) none of the above.

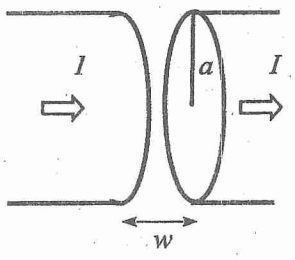
注意：背面有試題

14. A planet is rotating about the sun in an elliptic orbit. If its speed at the *perihelion* (point I) is v, what is its speed at point II? (A) $[(a-\sqrt{a^2-b^2})/b]v$ (B) $[(a+\sqrt{a^2-b^2})/b]v$ (C) $[(a-b)/b]v$ (D) $[(a+b)/b]v$ (E) $[(a-\sqrt{a^2-b^2})/(a+\sqrt{a^2-b^2})]v$

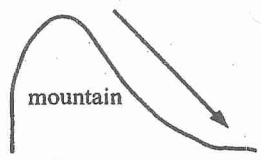
15. A fat wire of radius a carries a constant current I, which is uniformly distributed over its cross section. A narrow gap in the wire (of width $w \ll a$) forms a parallel-plate capacitor. Inside this gap, the magnetic field at a distance $s < a$ from the central axis is (A) $\mu_0 sI/(2\pi a^2)$ (B) $\mu_0 sI/a^2$ (C) $\mu_0 I/(2\pi s)$ (D) $\mu_0 I/(2\pi a)$ (E) none of the above.



Prob. 14



Prob. 15



Probs. 16-17

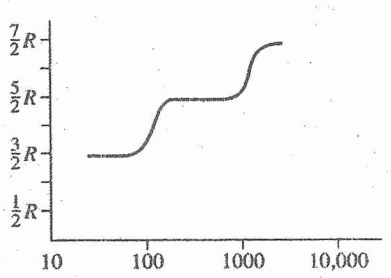
- [16-17] Strong winds carry air from high in the mountains down to the plains. The air (approximated as an ideal gas) descends very quickly such that it has no time to exchange heat with its surroundings

16. The process the air undergoes as it descends is approximately (A) isothermal (B) isobaric (C) adiabatic (D) constant-volume (E) free expansion.

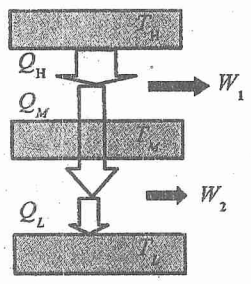
17. During this process, (A) the internal energy of the air considered decreases (B) the internal energy of the air increases (C) the air volume expands (D) the air pressure drops down (E) none of the above happens.

18. The constant-volume specific heat C_V (heat capacity per mole) for a diatomic ideal gas is shown in the following figure. Which of the following statements is correct? (A) Electronic excitations can be largely triggered at 2000K (B) Vibrational motion ceases at 50K (C) Vibrational excitations can be largely triggered at 300K (D) Rotational motion can be rarely found at 50K (E) All of the above statements are correct.

19. Consider two Carnot engines connected in series. The efficiency for the first engine is ϵ_1 while the efficiency for the second engine is ϵ_2. What is the overall efficiency of the combined system? (A) $\epsilon_1+\epsilon_2$ (B) $\epsilon_1\epsilon_2$ (C) $(\epsilon_1+\epsilon_2)/2$ (D) $\sqrt{\epsilon_1\epsilon_2}$ (E) $\epsilon_1+\epsilon_2-\epsilon_1\epsilon_2$



Prob. 18



Prob. 19

參考用

20. What is the bulk modulus (i.e., inverse compressibility) for a diatomic ideal gas measured from adiabatic compression/expansion? ($\gamma = 1.4$ for a diatomic ideal gas; P: pressure; ρ: density; T: temperature) (A) $\gamma T/P$ (B) $\gamma P/\rho$ (C) γP (D) P (E) none of the above.

注意：背面有試題