

※ 考生請注意：本試題不可使用計算機。請於答案卷(卡)作答，於本試題紙上作答者，不予計分。

Some useful constants

Gas constant $R = 8.314 \text{ J/mol}\cdot\text{K}$

Gravitational constant $G = 6.68 \times 10^{-11} \text{ N}\cdot\text{m}^2 / \text{kg}^2$

Mass of Sun $= 2.0 \times 10^{30} \text{ kg}$

Mass of Earth $= 6.0 \times 10^{24} \text{ kg}$

Radius of Earth $= 6.4 \times 10^6 \text{ m}$

Radius of Sun $= 7.0 \times 10^8 \text{ m}$

Electron mass $m_e = 9.1 \times 10^{-31} \text{ kg}$

Electron charge $e = 1.6 \times 10^{-19} \text{ C}$

Electric constant (permittivity) $\epsilon_0 = 8.85 \times 10^{-12} \text{ C}^2 / \text{N}\cdot\text{m}^2$

Magnetic constant (permeability) $\mu_0 = 4\pi \times 10^{-7} \text{ T}\cdot\text{m/A}$

Plank's constant $h = 6.63 \times 10^{-34} \text{ J}\cdot\text{s}$

$1 \text{ eV} = 1.6 \times 10^{-19} \text{ J}$

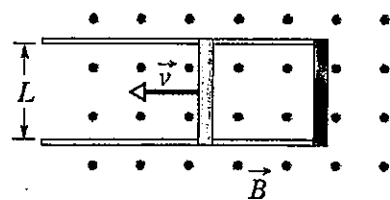
Boltzmann constant $k_b = 1.380 \times 10^{-23} \text{ J}\cdot\text{K}^{-1}$

第一部分：簡答題 (60 分)

共 12 題，每題 5 分，請於答案卷上標明題號並依序作答 (中英文作答均可，無需詳列計算過程)。

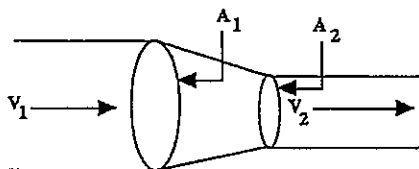
1. Following the science fiction, earth is a hollow shell, and there is a cavity in the center of the earth as the inner world. According to gravitation theory, what is the gravity field in that inner world?
2. The speed of a bullet as it travels down the barrel of a rifle toward the opening is given by $v = (-5.00 \times 10^7) t^2 + (3.00 \times 10^5) t$, where v is in meters per second and t is in seconds. The acceleration of the bullet just as it leaves the barrel is zero. What is the speed of the bullet as it leaves the barrel?
3. A disk rolls down a 30-degree slope without slipping. Given the inertial moment of a disk (mass M and radius R) $I = MR^2/2$, please find the frictional force for the disk during rolling down.

4. In the right figure, the conducting rod has length $L = 0.1 \text{ m}$ and is being pulled along horizontal frictionless conducting rails at a constant velocity with $v = 5 \text{ m/s}$. The rails are connected at one end with a metal strip. The rod has resistance of 0.4Ω and the

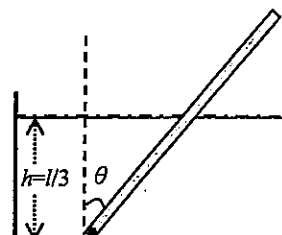


rails and connector have negligible resistance. A uniform magnetic field $B = 1.2 \text{ T}$ out of the page fills the region in which the rod moves. What is the power associated with the leftward external force needed to keep the rod moving at constant velocity?

5. Incompressible liquid flows along the pipe as shown in the following. What is the ratio of the speeds v_2/v_1 ?

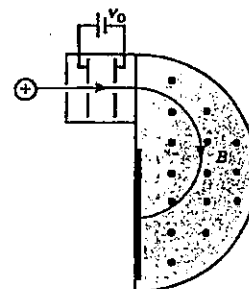


6. A wooden rod of uniform cross section and of length l is hinged at the bottom of a tank which is filled with water to a height $h = l/3$, as shown in right figure. If the density of wood is 0.45 g/cm^3 , find the angle θ from the vertical at which the rod is in equilibrium.

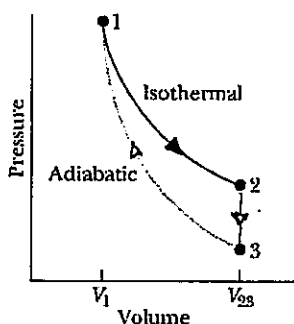


7. A Carnot refrigerator extracts 35 kJ as heat during each cycle, operating with a coefficient of performance of 4.60. What is the energy per cycle transferred as heat to the room?

8. In A. J. Dempster's mass spectrometer as shown in right figure, two isotopes with masses m_1 and m_2 are accelerated from rest by a potential difference V_0 . They then enter a uniform field B normal to the magnetic field lines. Assume both isotopes have the same charge q . What is the radius of the path in the magnetic field for the isotope with mass m_2 ?

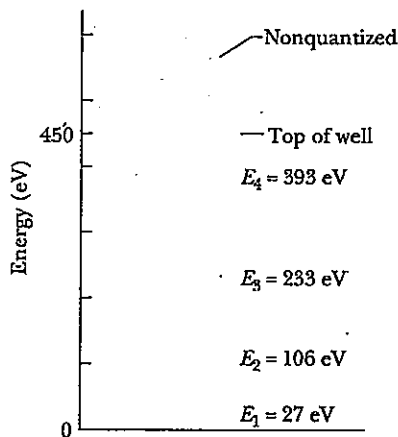


9. Three particles, each with positive charge Q , form an equilateral triangle, with each side of length d . What is the magnitude of the electric field produced by the particles at the midpoint of any side?
10. In the following figure $V_{23} = 3V_1$, and n moles of a diatomic ideal gas are taken through the cycle with the molecules rotating but not oscillating. What is the ratio of the temperatures T_1/T_3 ?



11. A source at rest emits light of wavelength 500 nm. When it is moving at $0.90c$ (c is light speed) away from an observer, please find the wavelength of light that observer detects.

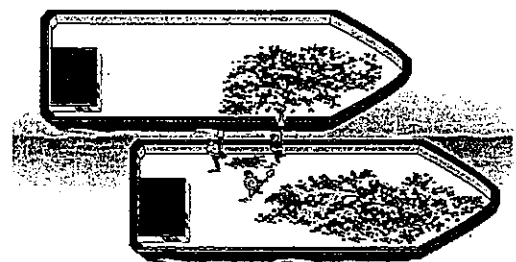
12. The figure below shows the energy levels for an electron in a finite potential energy well. If an electron in the $n = 2$ state absorbs a photon of wavelength 2.0 nm, what is the kinetic energy of the electron while it escapes the well?



第二部分：計算簡答題 (40 分)

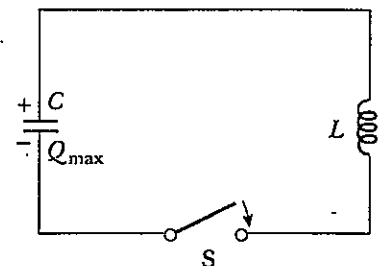
共 3 題，請於答案卷上標明題號依序作答，並詳列計算或答題過程 (中英文作答均可)。

1. In right figure, two long barges are moving in the same direction in still water, one with a speed of 12 km/h and the other with a speed of 22 km/h. While they are passing each other, coal is shoveled from the slower to the faster one at a rate of 1000 kg/min. How much additional force



must be provided by the driving engines of (a) the faster barge and (b) the slower barge if neither is to change speed? Assume that the shoveling is always perfectly sideways and that the frictional forces between the barges and the water do not depend on the mass of the barges. **(10 points)**

2. (a) Show a graphical and physical description of an LC circuit in one cycle oscillation. (Hint: Try to discuss the energies stored in the capacitor and inductor) **(5 points)**



- (b) Following above description, what are the time relations of charge

in the capacitor and current in the circuit? (Hint: Use the rule of energy conservation in one cycle

oscillation) **(5 points)**

(c) If the resistance of the wires in an LC circuit were not zero, would the oscillation persist? Please explain. **(5 points)**

3. (a) What assumptions did Plank make in dealing with the problem of blackbody radiation? Discuss the consequences of these assumptions. **(5 points)**

(b) In the photoelectric effect, explain why the stopping potential depends on the frequency of light but not on the intensity. **(5 points)**

(c) The Bohr's model of the hydrogen atom is based upon several assumptions. Discuss these assumptions and their significances; also describe them in math equations. **(5 points)**