說明： 1. 請依序作答並標明題號。
2. R=8.314 J K^{-1}mol^{-1} ; h=6.626x10^{-34} J s ; k=1.38x10^{-23} J K^{-1} ; F=96485 C mol^{-1}
electron mass=9.11x10^{-28} g ; electron charge=1.602x10^{-19} C
atomic weight: K=39.12 g mol^{-1}, H=1.008 g mol^{-1}

1. (a) Draw the plot of P vs. V for the Carnot cycle.
   (b) Calculate w(work) and q(heat) for each step.   (10%)

2. Calculate the entropy of CO crystals at absolute zero.   (4%)

3. If we assume that air contains 80% N_2 and 20% O_2, calculate the proportion of
   N_2 and O_2 in water. (Henry's constant of N_2 and O_2 in water are 6.51x10^7 torr
   and 3.30x10^7 torr, respectively.)   (6%)

4. (a) Calculate the average speed <v> for hydrogen molecules at 300 K.
   (b) Calculate the partition function for a hydrogen atom at 300 K in a container of
       1 m^3 volume.   (10%)

5. A reaction follows the rate law -d[C]/dt = k[C]$^{3/2}$ (8%)
   (a) integrate the rate equation if initial concentration is [C]$_o$.
   (b) Calculate the half-life time.

6. Bismuth (Bi) undergoes β emission (99.96%) and α emission (0.04%). If the
   half-life is 19.7 min, please find k_α and k_β for α emission and β emission,
   respectively. (6%)

7. Potassium (K) crystallizes with a body-centered cubic lattice. The length of the
   side of the unit cell is 533.3 pm. Calculate   (12%)
   (a) the density of potassium crystals.
   (b) the distance between 200 planes.
   (c) the radius of potassium atom.

8. (a) What is the de Broglie wavelength of an electron that has been accelerated
       through a potential difference of 100 V?
   (b) Calculate the energy in joules (J) and in electron volts (eV) of photons of
       wavelength 400 nm.   (8%)

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9. Please write down the Hamiltonian operator and Schrödinger equation for the hydrogen molecule (H_2).　(8%)

10. Applying molecular theory to the ground states of N_2 and O_2,　(12%)
    (a) write the electron configurations of N_2 and O_2.
    (b) predict the magnetic properties.
    (c) predict which R_e (equilibrium distance) is larger and which D_e (dissociation energy) is larger.

11. (a) What is the zero-point energy in the diatomic molecules?　(8%)
    (b) How to determine the value of the zero-point energy by experiments?

12. (a) How does laser work? What is "Raman effect"?
    (b) Why laser much improves the spectroscopic measurements by Raman spectrometers?　(8%)