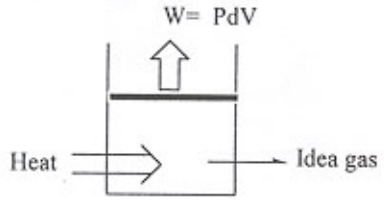
(可使用計算机)

[1] 請利用下圖模式簡要說明



(a) 熱力學第一定律 (First law of thermodynamics), (9)
(b) 恆溫及可逆反應所產生的功 (Isothermal and reversible work). (9)

[2] 請利用 Carnot Cycle 簡要說明
(a) 熱機效應 (The efficiency of a heat engine), (9)
(b) 熱力學第二定律 (Second law of thermodynamics). (9)

[3] 請仔細閱讀下列短文後回答所提問題

Scientists have always had trouble describing the nature of light. In many experiments light shows a definite wavelike character, but in many others light seems to behave as a stream of photons. The dispersion of white light into spectrum by a prism is an example of the first type of experiment, and the photoelectric effect is an example of the second. Because light appears wavelike in some instances and particle-like in others, this disparity is referred to as the *wave-particle duality of light*. In 1924, a young French scientist named Louis de Broglie reasoned that if light can display this wave-particle duality, then matter, which certainly appears particlelike, might also display wavelike properties under certain conditions. This proposal is rather strange at first, but it does suggest a nice symmetry in nature. Certainly if light can be particlelike at times, why should matter not be wavelike at times?

(a) 請舉例說明"*light appears wavelike in some instances and particle-like in others*"的現象. (8)
(b) 請寫下 de Broglie 有關 wave-particle duality of light 的公式, 並利用此公式計算一質量爲 $9.1\times10^{-31}Kg$, 速度爲 $3\times10^{3}m/\text{second}$ 的電子的 de Broglie 波長=? (8)
(c) 上題的波長是屬於可見光(visible),紫外光(ultraviolet) 或是紅外光(infrared) 的範圍? 請說明. (8)

[4] 請仔細閱讀下列短文後回答所提問題

The Schrodinger equation is our fundamental equation of quantum chemistry. The solution to the Schrodinger equation is called *wave function*. Solution to the time-independent Schrodinger equation is called *stationary-state wave function* because it is independent of time. Many problems of interest to chemists can be treated by using only stationary-state wave function. For example, a free particle of mass m that is restricted to lie along a one-dimensional interval of length a, which is called "*a particle in a box*".

(a) 上文中 wave function 如何表示?請舉例說明. (8)

(b) 何謂 stationary-state? 爲何許多有關化學的問題都可以 stationary-state wave function 來解決? (8)

(c) 請說明"free particle"在以下環境中運動時的邊界條件(boundary condition)爲何?

(c.1) A three-dimensional box, (4)

(c.2) A cyclic benzene ring. (4)

[5] 與 "Particle in a one dimensional box"相較, "free particle"的運動不會受到限制, 它可以在無位能的一維空間自由運動 ($V(x)=0$; $-\infty < x < +\infty$).

(a) 寫出 free-particle 的運動方程式, 即 Schrodinger equation, (8)

(b) 證明下列兩式爲其"Schrodinger equation"的解. (8)

$$\psi_1(x) = A_1 \exp\left[\frac{i(2mE)^{1/2}x}{\hbar}\right];\ \psi_2(x) = A_2 \exp\left[\frac{-i(2mE)^{1/2}x}{\hbar}\right],$$

本份試題可以使用電子計算機

(1) Define the following terms.
(a) biosensor (2%)
(b) ionic strength (2%)
(c) buffer solution (2%)
(d) monochromator (2%)
(e) solid-phase extraction (2%)
(f) partition chromatography (2%)

(2) Briefly describe the differences between the following terms.
(a) digestion and extraction (3%)
(b) precision and accuracy (3%)
(c) detection limit and sensitivity (3%)
(d) a working electrode and a counter electrode (3%)
(e) atomic absorption spectrometry and atomic emission spectrometry (3%)

(3) Describe the general classification of column chromatographic method. (5%)

(4) (a) What is capillary electrophoresis ? (5%)
(b) How capillary electrophoresis works ? (5%)

(5) Describe the preparation of 100 mL of 6.0 M HCl from a concentrated solution that has a specific gravity of 1.18 and is 37% (w/w) HCl (36.5 g/mol). (10%)

(6) Calculate the pH change that takes place when a 100-mL portion of (a) 0.0500 M NaOH and (b) 0.0500 M HCl is added to 400 ml of a buffer solution that is 0.200M in NH_3 and 0.300 M in NH_4Cl. (Ka for NH_4^+ is 5.70×10^{-10}; Kw is 1.00×10^{-14}) (10%)

(7) A solution contains 0.0100 M IO_3^-, 0.0100 M I^-, 1.00×10^{-4} M I_3^-, and pH 6.00 buffer. Consider the reactions

$$2\ IO_3^- + I^- + 12\ H^+ + 10e^- \rightleftharpoons I_3^- + 6H_2O \qquad E^0 = 1.210\ V$$

$$I_3^- + 2e^- \rightleftharpoons 3I^- \qquad E^0 = 0.535\ V$$

(a) Write a balanced net reaction that can occur in this solution. (2%)
(b) Calculate E^0 and K for the reaction. (2%)
(c) Calculate E for the conditions given above. (2%)
(d) At what pH would the concentrations of IO_3^-, I^-, and I_3^- listed above be in equilibrium. (2%)

(8) The purity of pharmaceutical preparation of sulfanilamide, $C_6H_4N_2O_2S$ (168.18 g/mol), can be determined by oxidizing the sulfur to SO_2 and bubbling the SO_2 through H_2O_2 to produce H_2SO_4. The acid is then titrated with a standard solution of NaOH to bromothymol blue end point, where both of sulfuric acid's acidic protons have been neutralized. Calculate the purity of the preparation, given that a 0.5136-g sample required 48.13 mL of 0.1251 M NaOH. (10%)

(9) Substances A and B have retention times of 16.40 and 17.63 min, respectively, on a 30.0 cm column. An unretained species passes through the column in 1.30 min. The peak widths (at base) for A and B are 1.11 and 1.21 min, respectively. Calculate
(a) the column resolution (2%)
(b) the average number of plates in the column (2%)
(c) the plate height (2%)
(d) the length of column required to achieve a resolution of 1.5 (2%)
(e) the time required to elute substance B on the longer column (2%)

(10) In the DPD colorimetric method for the free chlorine residual, which is reported as parts per million of Cl_2, the oxidizing power of free chlorine converts the colorless amine N,N-diethyl-p-phenylenediamine to a colored dye that absorbs strongly over the wavelength range of 440-580 nm. Analysis of a set of calibration standards gave the following results

ppmCl_2	absorbance
0	0.000
0.50	0.270
1.00	0.543
1.50	0.813
2.00	1.084

A sample from a public water supply is analyzed to determine the free chlorine residual, giving an absorbance of 0.113. What is the free chlorine residual for the sample in parts per million Cl_2? (10%)