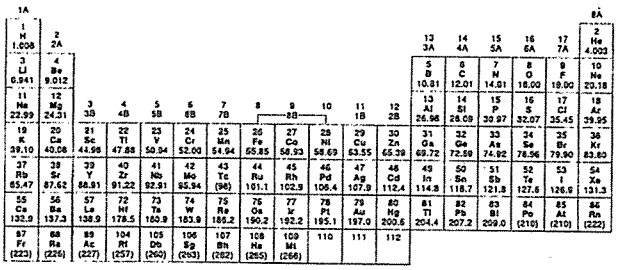

R=8.314 J/mol-K;
m_e=9.109 x 10^{-31} kg;
h=6.626x 10^{-31} J-s;
1 J=1 kg m^2 s^{-2}

本試卷共十題，每題十分。
請利用文字，圖表或公式，計算，解釋及描述下列問題。

1. In the particle in a box model, the energy level is quantized as $E_n = \frac{n^2h^2}{8mL^2}$

(1a). Calculate the energy required (in J) to promote an electron from n=1 to n=2 state in a box of 0.10 nm.

(1b). Nanoparticles can be approximated as electrons confined in a box. What would be your expectation on the maximum absorption wavelength changes with increasing radius of nanoparticles? Explain.

2. Experiments have shown that the homonuclear O_2 molecule is paramagnetic (i.e. have un-paired electrons).
(2a). To construct molecular orbitals in O_2, first put up atomic orbitals of two O atoms on the right- and left-hand side. In between the two atomic orbitals, draw the energy diagram of the O_2 molecular orbitals, and use lines to connect atomic and molecular orbitals to show which atomic orbitals are contributed to specific molecular orbitals. Then fill in electrons and use them to explain why O_2 is paramagnetic.
(2b). Arrange O_2^{2-}, O_2^-, O_2 three molecules in the order of increasing bond length (from small to large).

3. Maxwell-Boltzmann showed that gas molecules in equilibrium temperature have a speed distribution.
(3a). Draw three-dimensional Maxwell-Boltzmann speed distributions for N_2 gas at 100 K and 300 K.
(3b). Describe how to experimentally determine this speed distribution.

4. An ideal gas of 1 mole initially at 300 K is expanded reversibly and isothermally from 2.0 L to 4.0 L. Calculate ***q, w, ΔU, ΔS, ΔG.***

5. Draw a **Pressure** (y-axis)-**Temperature** (x-axis) phase diagram of water. Specify the phases, triple point and critical point. Compare and explain the slopes (amplitude and +/- sign) of co-existence lines.

6. If solid AgCl is placed into water, some will dissolve based on the following equilibrium:

$$AgCl_{(s)} \rightleftharpoons Ag^+_{(aq)} + Cl^-_{(aq)}$$

The equilibrium constant (also called K_{sp}) is **1.6 x 10^{-10}** at 25°C. Calculate ΔG^o_{rxn}.

7. Calculate the pH at the equivalent point when 25.0 mL of 0.10 M NH_3 is titrated by 0.10 M HCl solution. The Ka for $NH_4^+{}_{(aq)}$ is **5.6 x 10^{-10}**.

8. Calculate the equilibrium constant for the following reaction at 25°C:

$$Sn_{(s)} + 2Cu^{2+}_{(aq)} \rightleftharpoons Sn^{2+}_{(aq)} + 2Cu^+_{(aq)}$$

Given the standard reduction potentials at 25°C are:

$Sn^{2+}_{(aq)} + 2\,e^- \rightarrow Sn_{(s)}$, (-0.14V); $Cu^{2+}_{(aq)} + e^- \rightarrow Cu^+_{(aq)}$, (+0.15V)

9. Iodine atoms combine to form molecular iodine in the gas phase: $I_{(g)} + I_{(g)} \rightleftharpoons I_{2(g)}$

This reaction follows second-order kinetics with rate constant of **7.0 x 10^9 M^{-1} s^{-1}** at 23°C.
(9a). If the initial concentration of [I] was 0.086 M, calculate the [I] after 2.0 min.
(9b). Calculate the half-life of the reaction when the initial concentration of [I] is 0.60 M.

10. The absorption maximum for the octahedral complex ion $[Co(NH_3)_6]^{3+}$ occurs at 470 nm.
(10a). What is the d-orbital electron configuration of cobalt ion in this complex?
(10b). Draw the d- atomic orbitals, and use the crystal field theory to explain the energy splitting responsible for the observed color.
(10c). Calculate the crystal field splitting in this complex in kJ/mol.

試題隨卷繳回