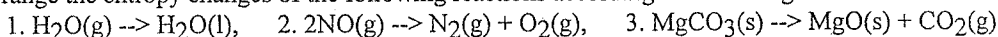第一部份 -- 選擇題 【以下二十題選擇題，各題皆只有一個答案是正確的，請將之選出，依題目次序
書寫於答案紙上。答對一題給四分，共 80 分。】

1) Arrange the entropy changes of the following reactions according to increasing ΔS^o values:
   1. $H_2O(g) \longrightarrow H_2O(l)$,　2. $2NO(g) \longrightarrow N_2(g) + O_2(g)$,　3. $MgCO_3(s) \longrightarrow MgO(s) + CO_2(g)$

   A. $\Delta S^o(1) < \Delta S^o(2) < \Delta S^o(3)$　　　B. $\Delta S^o(2) < \Delta S^o(3) < DS^o(1)$　　　C. $\Delta S^o(3) < \Delta S^o(2) < \Delta S^o(1)$
   D. $\Delta S^o(2) < \Delta S^o(1) < \Delta S^o(3)$　　　E. $\Delta S^o(1) < \Delta S^o(3) < \Delta S^o(2)$

2) For the reaction　$H_2(g) + S(s) \longrightarrow H_2S(g)$,　$\Delta H^o = -20.2$ kJ mol^{-1}　and　$\Delta S^o = +43.1$ J K^{-1}mol^{-1}　Which
   of the following statements is true ?
   A. The reaction is only spontaneous at low temperatures.
   B. The reaction is spontaneous at all temperatures.
   C. ΔG^o becomes less favorable as T is raised.
   D. The reaction is spontaneous only at high temperatures.
   E. The reaction is at equilibrium at 25°C under standard conditions.

3) Calculate K_p for the reaction　$SO_2(g) + NO_2(g) \longrightarrow SO_3(g) + NO(g)$　at 298 K.　Given the following
   free energies of formation (in kJ mol^{-1}):
   $\Delta G_f^o[SO_2(g)] = -300.4$,　$\Delta G_f^o[SO_3(g)] = -370.4$,　$\Delta G_f^o[NO(g)] = 86.7$,　$\Delta G_f^o[NO_2(g)] = 51.8$
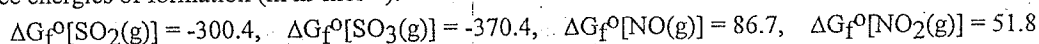
   A. 6.99×10^{-7}　　　B. 5.71×10^{-8}　　　C. 14.2　　　D. 475　　　E. 1.43×10^6

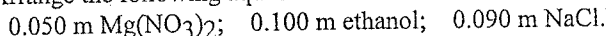4) According to Raoult's law, which statement would be true?
   A. the vapor pressure of a solvent over a solution decreases as its mole fraction increases.
   B. the solubility of a gas increases as the temperature decreases.
   C. the vapor pressure of a solvent over a solution is less than that of pure solvent.
   D. the greater the pressure of a gas over a solution the greater its solubility.
   E. ionic solutes dissociate in solution causing an enhancement of all colligative properties.

5) What is the boiling point of an aqueous solution of a nonelectrolyte that has an osmotic pressure of 10.50
   atm at 25 °C?　$K_b = 0.52$ °C/m.　Assume its density is the same as pure water.
   A. 0.22 °C　　　B. 0.429 °C　　　C. 100.43 °C　　　D. 99.78 °C　　　E. 100.22 °C

6) Arrange the following aqueous solutions in order of increasing boiling points:
   0.050 m $Mg(NO_3)_2$;　0.100 m ethanol;　0.090 m NaCl.
   A. $Mg(NO_3)_2 < NaCl < ethanol$　　　B. $ethanol < Mg(NO_3)_2 < NaCl$　　　C. $ethanol < NaCl < Mg(NO_3)_2$
   D. $NaCl < ethanol < Mg(NO_3)_2$　　　E. $Mg(NO_3)_2 < ethanol < NaCl$

7) Given a cell based on the spontaneous reaction:　$2AgCl(s) + Zn(s) \longrightarrow 2Ag(s) + 2Cl^- + Zn^{2+}$.　If the zinc
   ion concentration is kept constant at 1 M, and the chlorine ion concentration is decreased from 1 M to
   0.001 M, the expected change in cell voltage is:
   A. increase by 0.06 V　　　B. increase by 0.18 V　　　C. decrease by 0.06 V
   D. decrease by 0.18 V　　　E. increase by 0.35 V

8) Iron objects such as storage tanks and underground pipelines can be protected from corrosion by connecting
   them through a wire to a piece of:
   A. Pb　　　B. Ag　　　C. Sn　　　D. Mg　　　E. Cu

==

9) According to the band theory, which of the following provide an explanation for the high electrical conductivity of metals?
   1. a partly filled conduction band
   2. a valence band overlapping an empty conduction band
   3. a filled valence band
   4. a large gap between the valence band and the conduction band
   A. 1 and 2　　　　　B. 1 and 3　　　　　C. 3　　　　　D. 3 and 4　　　　　E. 4

10) Solid MgO has the same crystal structure as NaCl.　How many oxide ions surround each Mg^{+2} ion as nearest neighbors in MgO.
   A. 4　　　　　B. 6　　　　　C. 8　　　　　D. 12　　　　　E. none of these

11) 5 In a diffraction experiment, X-rays of wavelength 0.229 nm are reflected from a crystal of barium.　The first order reflection (n=1) is at an angle of 27.1°.　What is the distance (in pm) between layers of atoms in the crystal?
   A. 3.97 pm　　　　　B. 101 pm　　　　　C. 252 pm　　　　　D. 504 pm　　　　　E. 3970 pm

12) Which one of the following sets of quantum numbers is unacceptable?

	n	m	m_l	m_s		n	m	m_l	m_s		n	m	m_l	m_s
A.	4	3	-2	+1/2	B.	3	0	1	-1/2	C.	3	0	0	+1/2
D.	2	1	1	-1/2	E.	2	0	0	+1/2					

13) Which of the following species have delocalized molecular orbitals:
   NO_3^-,　NO_2^-,　O_3,　C_6H_6.
   A. none of them　　B. NO_3^-, C_6H_6　　C. NO_3^-, NO_2^-　　D. NO_2^-, O_3　　E. all of them

14) Which of the following has the smallest dissociation energy?
   A. O_2^+　　　　B. O_2^{2+}　　　　C. O_2　　　　D. O_2^{2-}　　　　E. O_2^-

15) Tetracyanoethylene has the following skeleton:

   Which of the following statements about tetracyanoethylene is/are true?
   1. The number of s bonds in the molecule is 9.
   2. The number of p bonds in the molecule is 5.
   3. Two of the carbon atoms are sp^2 hybridized.
   4. Eight atoms of the molecule are sp hybridized.
   A. 1 and 3　　　　　　　B. 2, 3, and 4　　　　　　　C. 2 and 4
   D. 1, 3, and 4　　　　　　E. all of these

16) The isomerization of cyclopropane follows first order kinetics.　The rate constant is 6.20×10^{-4} min^{-1} at 700 K, and the half-life at 760 K is 29.0 min.　Calculate the activation energy for this reaction.
   A. 5.07 kJ/mol　　B. 26.9 kJ/mol　　C. 50.7 kJ/mol　　D. 160 kJ/mol　　E. 269 kJ/mol

===

17) The following reaction in aqueous solution was found to be first order in $[OH^-]$, first order in $[C_2H_5Br]$, and inverse first order in Br^-: $C_2H_5Br + OH^- \rightarrow C_2H_5OH + Br^-$　　Rate $= k[C_2H_5Br][OH^-]/[Br^-]$

Which one of the following mechanisms is consistent with the observed reaction order?

A. $C_2H_5Br \rightleftharpoons C_2H_5^+ + Br^-$　(fast)
　$C_2H_5^+ + OH^- \rightarrow C_2H_5OH$　(slow)

B. $C_2H_5Br + H_2O \rightarrow C_2H_5OH + H^+ + Br^-$　(slow)
　$H^+ + OH^- \rightarrow H_2O$　(fast)

C. $C_2H_5Br \rightleftharpoons C_2H_5^+ + Br^-$　(slow)
　$C_2H_5^+ + OH^- \rightarrow C_2H_5OH$　(fast)

D. $C_2H_5Br \rightleftharpoons C_2H_5^+ + Br^-$　(slow)
　$OH^- + Br^- \rightarrow HOBr$　(fast)
　$HOBr + C_2H_5^+ \rightarrow C_2H_5OH + Br^-$　(fast)

E. none of these

18) The activation energy of a certain uncatalyzed reaction is 64 kJ/mol.　In the presence of a catalyst the E_a is 55 kJ/mol.　How many times faster is the catalyzed than the uncatalyzed reaction at 400°C?
A. 5.0 times　　B. 1.16 times　　C. 15 times　　D. 2.0 times　　E. 0.2 times

19) The ion $[Co(NH_3)_6]^{2+}$ is octahedral and high spin.　The complex is
A. Paramagnetic, with 1 unpaired electron.　　B. Paramagnetic, with 3 unpaired electron.
C. Paramagnetic, with 4 unpaired electron.　　D. Paramagnetic, with 5 unpaired electron.
E. diamagnetic.

20) The spectrochemical series is 　　$I^- < Br^- < Cl^- < F^- < OH^- < H_2O < NH_3 < en < NO_2^- < CN^-$
Which of the following complexes will absorb visible radiation of highest energy (shortest wavelength)?
A. $[Co(H_2O)_6]^{3+}$　　B. $[CoI_6]^{3+}$　　C. $[Co(OH)_6]^{3-}$　　D. $[Co(en)_3]^{3+}$　　E. $[Co(NH_3)_6]^{3+}$

第二部份 -- 問答與計算題 【 共 20 分。 】

1 (a) Calculate q, w, ΔE, ΔH for the reversible expansion of n mole of an ideal gas from V_1 to V_2 at constant temperature T.

　(b) Consider two bulbs with a stopcock between the two, the whole is in a bath at temperature T.　One has volume V_1 and contains n mole of an ideal gas.　The other contains a vacuum initially and has a volume such that the two bulbs together has volume V_2.　Calculate q, w, ΔE, ΔH for the gas when the stopcock connecting the two bulbs is open. 　　　　　　　　　　　　　　(12)

2 For the following compounds, predict the molecular molecular shapes.
　(a) XeF_4　　　　(b) BrF_5　　　　　　　　　　　　　　　　　　(8)