(I) 單一選擇題 (每題 3 分)

1. Which statement is FALSE?
   a) The change in internal energy ΔE for a process is equal to the amount of heat q_v absorbed at constant volume.
   b) The change in enthalpy ΔH for a process is equal to the amount of heat q_p absorbed at constant pressure.
   c) A bomb calorimeter measures ΔH directly.
   d) If q_p for a process is negative, the process is exothermic.
   e) The freezing of water is an example of an exothermic reaction.

2. Which form of electromagnetic radiation has the longest wavelength?
   a) gamma rays
   b) microwaves
   c) radiowaves
   d) infrared radiation
   e) x-rays

3. How many electrons can be contained in all the orbitals with n = 3?
   a) 2　　b) 8　　c) 10　　d) 18　　e) 32

4. Which of the following sets of quantum numbers would NOT be possible for an electron in an atom?

	n	l	m	s
a)	1	0	0	1/2
b)	3	2	-1	-1/2
c)	4	4	1	1/2
d)	2	1	1	-1/2
e)	6	1	-1	1/2

5. Which molecule has a dipole moment?
   a) CH_4　　b) CCl_4　　c) CO_2　　d) SO_3　　e) none of these

6. What is the order of bond angle for the following molecules?
   a) $CH_4 > H_2O > NH_3 > CO_2$
   b) $CO_2 > CH_4 > NH_3 > H_2O$
   c) $CO_2 > NH_3 > H_2O > CH_4$
   d) $H_2O > CO_2 > CH_4 > NH_3$
   e) $NH_3 > H_2O > CO_2 > CH_4$

7. For the reaction A + B → products, the following data were obtained:

Initial rate (mol/L•s)	0.030	0.059	0.060	0.090	0.090
$[A]_o$ (mol/L)	0.10	0.20	0.20	0.30	0.30
$[B]_o$ (mol/L)	0.20	0.20	0.30	0.30	0.50

What is the experimental rate law?
   a)   Rate = k[A]
   b)   Rate = k[B]
   c)   Rate = k[A][B]
   d)   Rate = $k[A]^2[B]$
   e)   Rate = $k[A][B]^2$

8. The value of the equilibrium constant K depends on
   i)   the temperature of the system.
   ii) the nature of the reactants and products.
   iii) the concentration of the reactants.
   iv) the concentration of the products.
   a) i, ii   b) ii, iii   c)   iii, iv   d) i, iv   e) ii, iv

9.   For which gas do the molecules have the highest average velocity?
   a) He   b) Cl_2 c) CH_4 d) NH_3 e) all gases the same

10. The pH of a solution is raised from 3 to 5.   Which of the following statements is FALSE?
   a)   The pOH decreases from 11 to 9.
   b)   The $[H^+]$ decreases by a factor of 20.
   c)   The final $[OH^-]$ (at pH = 5) is 10^{-9} M.
   d)   The initial $[H^+]$ (at pH = 3) is 10^{-3} M.
   e)   The initial solution could be 0.001 M HNO_3.

11. Which of the following will NOT make a buffered solution?
   a)   100 mL of 0.1 M Na_2CO_3 and 50 mL of 0.1 M HCl
   b)   100 mL of 0.1 M $NaHCO_3$ and 25 mL of 0.2 M HCl
   c)   100 mL of 0.1 M Na_2CO_3 and 75 mL of 0.2 M HCl
   d)   50 mL of 0.2 M Na_2CO_3 and 5 mL of 1.0 M HCl
   e)   100 mL of 0.1 M Na_2CO_3 and 50 mL of 0.1 M NaOH

12. The following are produced by radioactive processes.   Which one has mass but no charge?
   a)   alpha particle   b)   beta particle   c)   gamma ray   d)   neutron   e)   positron

13. Which of the following is false?
    a) The absorbed does of radiation is the energy deposited in a sample when it is exposed to radiation.
    b) The SI unit of the absorbed does is gray (Gy) and $1Gy = 1 J \cdot Kg^{-1}$.
    c) Dose equivalent (Sv) = biological effectiveness (Q) x absorbed does (Gy)
    d) The biological effectiveness of β radiation is about 20 times of α radiation
    e) The activity of a sample is the number of nuclear disintegrations that occur per second.   1 Bq is equal to one nuclear disintegration per second

14. Which of the followings is not the state function?   (I) Internal energy, (II) Enthalpy, (III) Heat, (IV) Work, (V) Free energy, (VI) Volume
    a) I, II   b) III, IV   c) V, VI   d) I, III   e) IV, VI

15. How many unpaired electrons does $[Fe(CN)_6]^{3-}$ have? (the atomic number for Fe is 26)
    a) 0   b) 1   c) 3   d) 5

16. Which of the following intermolecular links can be made by hydrogen bonds:
    a) CH_3NH_2 to CH_3NH_2
    b) $CH_3\text{-}O\text{-}CH_3$ to $CH_3\text{-}O\text{-}CH_3$
    c) HBr to HBr
    d) PH_3 to PH_3

(II) 簡答題 (每題 2 分)

1. Please describe **Pauli exclusion principle**.

2. Please describe **Hund's rule**.

3. Please write down the electron configuration of N_2 molecule in ground state

4. Please describe **the second law of thermodynamics**

5. Please describe electron configuration for F atom.

6. Please draw the Lewis structure for I_3^-.

7. Please complete the following reaction:
    $CH_2=CH_2 + Br_2 \rightarrow$

8. Please complete the following reaction:
    $CH_3CO_2H + CH_3OH \rightarrow$

(III) 問答題 (請寫計算過程) (每小題 3 分)

If a 50.0 mL sample of 0.100M HCN (Ka = 6.2 x 10^{-10}) is titrated with 0.100 M NaOH, calculate the pH of the solution at the following points.

1. at the halfway equivalent point in the titration

2. at the equivalent point

3. Calculate the solubility of $CaCO_3$ (Ksp = 8.7x10^{-9}) in moles per liter.

4. Calculate the standard heat of formation of the compound ICl in kJ/mol

$Cl_{2(g)} \rightarrow 2Cl_{(g)}$ ΔH° = 242.3 kJ/mol

$I_{2(g)} \rightarrow 2I_{(g)}$ ΔH° = 151.0 kJ/mol

$ICl_{(g)} \rightarrow I_{(g)} + Cl_{(g)}$ ΔH° = 211.3 kJ/mol

$I_{2(s)} \rightarrow I_{2(g)}$ ΔH° = 62.8 kJ/mol

For the melting of ice, ΔH° = 6.03 x 10^3 J/mol and ΔS° = 22.1 J/mol • K

5. Predict ΔG° for the melting of ice at -10°C.

6. Is this process spontaneous? Please explain the reason.

7. The number of a certain radioactive nuclide present in a sample decays from 1.00 x 10^3 to 2.50 x 10^2 in 10 minutes. What is the half-life of this radioactive species?

Please calculate the pH values for the following solutions

8. Calculate the pH value for a 1.0 x 10^{-5} M solution of HCN. Ka = 6.2 x 10^{-10}.

9. Calculate the pH of a 1.0 x 10^{-3} M solution of NaF. For HF, Ka = 7.2x10^{-4}.

10. What amount in gram of Al(s) can be produced from Al_2O_3 if 5 mol e^- is supplied? The atomic mass of Al is 26.98

11. The reaction taking place in a cell is $Cd_{(s)} + 2 Ni(OH)_{3(s)} \rightarrow Cd(OH)_{2(s)} + 2 Ni(OH)_{2(s)}$ and the emf of the cell when fully charged is 1.25 V. What is the reaction free energy in kJ • mol^{-1}? The Faraday constant is 9.6485 x 10^4 C (mol $e^-)^{-1}$

12. The reaction of the Daniell cell is $Cu^{2+}_{(aq)} + Zn_{(s)} \rightarrow Zn^{2+}_{(aq)} + Cu_{(s)}$ E° = 1.10 V

Calculate the potential at 25°C of a Daniell cell in which the concentration of Zn^{2+} ion is 1.00 M and that of the Cu^{2+} ions is 0.0010M. R = 8.3145J • K^{-1} • mol^{-1} Faraday constant is 9.6485 x 10^4 C (mol $e^-)^{-1}$.