類組：化學類　科目：綜合化學（1001）　　※選擇題請在答案卡內作答，非選擇題請在答案卷內作答

（元素原子量如下：**H =1, D=2, C=12, N=14, O=16, F=19, Na=23, S = 32, Cl=35.5, P= 31, K = 39, Ca = 40, Mn = 55, Fe = 55.85, Br=80, Rb=85.5, I = 127），　Faraday constant=96500 Cmol^{-1}, Gas constant R= 8.314 J K^{-1} mol^{-1} ; 5.189 × 10^{19} eV K^{-1} mol^{-1} or 0.082 L atm K^{-1} mol^{-1}, Plank Constant h= 6.626×10^{-34} J·s**

（一）. 選擇題，每題兩分　（20 題，共四十分）.

1. The oxidation state of S in sulfurous acid is A.　The oxidation state of Cl in chlorous acid is B.　What is A+B ?

A	+7	B	+8	C	+9	D	+10	E	+11

2. Balance the following reaction (M and N are elements): **a M^{4+} + b N^{2+} ➔ c M^{2+} + d N^{7+}**　　What is a+b+c+d?

A	10	B	11	C	12	D	13	E	14

3. A 1.0 M HF solution is added some NaF, how does the percent dissociation of HF become?

| A	larger	B	smaller	C	unchanged	D	could not be determined

4. The product is colorless in the dimerization of yellow X gas at 25 °C.　If it was found that as the reaction temperature increases, the color of the mixture is getting darker. Is this dimerization reaction an endothermic or exothermic reaction?

A	not related	B	endothermic	C	exothermic	D	could not be determined

5. A solution contains 0.10 M HA (if K_a = 4.0 x 10^{-5}) and 0.10 M NaA. Calculate the pH of this solution.

A	5.4	B	5.0	C	4.0	D	4.4	E	4.6

6. For the gas reaction of N(CH$_3$)$_3$ with HBr, reaction figure shown below, if no air is present in the reaction tube, what will be the ratio (*r*) of N(CH$_3$)$_3$/HBr gas traveling distances to the point where white ring of HN(CH$_3$)$_3$Br forms.
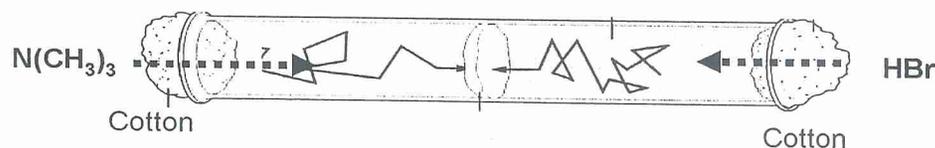

A	1.0-1.15	B	1.15-1.20	C	1.20-1.25	D	1.25-1.30	E	>1.30

7. Pure rubidium (Mw=85.5) crystallizes in a body-centered cubic lattice; the edge length of the unit cell is 562 pm. What is the density of rubidium in grams per cubic centimeter?

A	$2 \times 85.5 \times 6.02 \times (5.62)^3 \times 10^{-1}$ g/cm^3	B	$\dfrac{5 \times 85.5 \times 10}{6.02 \times (5.62)^3}$ g/cm^3	C	$\dfrac{4 \times 6.02}{10 \times (5.62)^3}$ g/cm^3
D	$\dfrac{2 \times 85.5 \times 10}{6.02 \times (5.62)^3}$ g/cm^3	E	$\dfrac{4 \times 85.5 \times 10}{6.02 \times (5.62)^3}$ g/cm^3		

8. Shown below is a phase diagram for compound X. You wish to purify a sample of X that was collected at P = 1.0 atm and T = 100 K by sublimation. In order to sublime the sample, you should
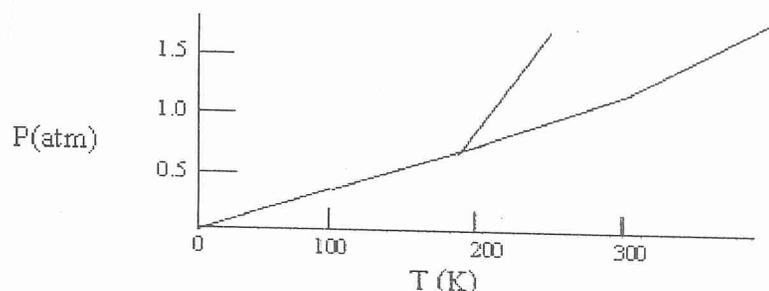
注意：背面有試題

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A	increase T to 300 K, keeping P = 1.0 atm.	B	abandon the attempt to sublime X.
C	lower P to 0.5 atm and then increase T to 200 K.	D	increase P to 1.5 atm and then increase T to 300 K.
E	increase T to 300 K and then lower P to 0.5 atm.		

9. Liquid A has a vapor pressure x. Liquid B has a vapor pressure y, and $x > y$.

   What is the mole fraction of A in the liquid mixture of A + B, if the vapor above the solution is 50% A?

A	$y/(2x + 2y)$	B	$y/(x + y)$	C	$x/(2x + 2y)$
D	$x/(x + y)$	E	none of these		

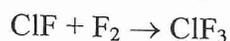10. Calculate the total number of unpaired electrons in the following two complex ions:

    $[Zn(H_2O)_6]^{2+}$, $[NiCN_4]^{2-}$ (square planar), $[Co(NH_3)_6]^{3+}$ (strong field).

A	0	B	1	C	2	D	3	E	4

11. At 25°C, the following heats of reaction are known:

	ΔH (kJ/mol)
$2ClF + O_2 \rightarrow Cl_2O + F_2O$	167.4
$2ClF_3 + 2O_2 \rightarrow Cl_2O + 3F_2O$	341.4
$2F_2 + O_2 \rightarrow 2F_2O$	−43.4

   At the same temperature, calculate ΔH (kJ/mol) for the following reaction:

   $ClF + F_2 \rightarrow ClF_3$

A	−217.5	B	−108.7	C	+217.5	D	−130.2	E	none of these

12. In an isothermal process, the pressure on 1 mol of an ideal monatomic gas suddenly changes from 4.00 atm to 100.0 atm at 25°C.

   Calculate ΔV.

A	−5.87 L	B	6.11 L	C	−6.11 L	D	5.87 L	E	none of these

13. In a certain reversible expansion, a system at 300. K absorbs exactly 6.00×10^2 J of heat.　In the irreversible recompression to the original state of the system, twice as much work is done on the system as is performed on the surroundings in the expansion.　What is the entropy (J/K) change of the system in the recompression step?

A	0.00	B	2.00	C	−4.00	D	-2.00	E	4.00

14. The reaction $2H_2O(g) \rightarrow 2H_2(g) + O_2(g)$ has a positive value of $\Delta G°$. Which of the following statements must be true?

A	The reaction is slow.
B	The reaction will not occur. That is, when $H_2O(g)$ is introduced into a flask, no O_2 or H_2 will form even over a long period of time.
C	The equilibrium lies far to the right.
D	The reaction is exothermic.
E	None of these is true.

15. In which of the following changes is the work done by the system the largest at 25°C?

A	an isothermal reversible expansion of an ideal gas from 1 L to 10 L
B	an isothermal expansion of an ideal gas from 1 L to 10 L against an opposing pressure of 5 atm
C	an isothermal free expansion of an ideal gas from 1 L to 10 L
D	an isothermal expansion of an ideal gas from 1 L to 10 L against an opposing pressure of 1 atm
E	The work is the same for all these processes.

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16. The energy expressions for the electrons in the He^+ ion and the hydrogen atom are $E_n(H) = -a/n^2$　and　$E_n(He^+) = -4a/n^2$

Which of the following statements is(are) correct?

I	For the transitions $n_1 \rightarrow n_2$, the frequency is larger for H than for He^+.
II	The first ionization energy of the H atom is smaller than the second ionization energy of the He atom.
III	The 1s orbital in He^+ is larger (in the sense that the probability density is shifted outward) than the 1s orbital in H.

A	I only
B	II only
C	III only
D	I and II only
E	I, II, and III

17. Which combination of quantum numbers is *not* allowed?) (Combinations are listed as follows: n, l, $m_{(l)}$, $m_{(s)}$.)

A	6	5	−5	½
B	6	−5	−1	1/2
C	8	2	2	½
D	9	8	−4	½
E	All are allowed.			

18. Solid KF has a lattice energy of −804 kJ/mol and a heat of solution (in water) of −15 kJ/mol. RbF has a lattice energy of −768 kJ/mol and a heat of solution (in water) of −24 kJ/mol. Which salt interacts more strongly with water?

A	They form equally strong attractions with water, because they both have negative heats of mixing.
B	KF, because it has a more exothermic lattice energy
C	RbF, because it has a more negative heat of hydration
D	KF, because it has a more negative heat of hydration
E	RbF, because it has a less exothermic lattice energy

19. Arrange the following compounds by their acidity.

(ex. strongest acid > ? > ? > weakest acid).

I. cyclohexanol　　　II. phenol　　　III. benzenethiol　　　IV. 2,2,2-trichloroethanol

A	IV > II > III > I
B	IV > III > II > I
C	II > III > IV > I
D	III > II > IV > I
E	None of above arrangement is true.

20. What reagents will you use to convert compound X to Y?

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A	$NaBH_4$, then H^+
B	$LiAlH_4$, then H^+
C	H_2/Pd/C
D	H_2/Raney Ni.
E	All of above treatments.

(二). 計算與問答題，每題四分　(15 題，共六十分).

1. At 25°C and 1 atm, 300 g NaN_3 was inflated, calculate the volume of the N_2 gas released from the inflation.

2. If H_3A is a triprotic acid with $k_{a1}=1 \times 10^{-4}$, $k_{a2}=1 \times 10^{-8}$, $k_{a3}=1 \times 10^{-13}$. (A) Calculate the equilibrium concentrations of HA^{2-} in 1.0 M H_3A solution.

(B) (Continue from above question). Calculate the pH of a 1.0 M solution of NaH_2A.

3. The formation reaction of gaseous hydrogen fluoride from hydrogen and fluorine has an equilibrium constant of K= 64 at a certain temperature. Three components (3.000 mol each) were added to a 1.500-L flask. Calculate the equilibrium concentration of **HF** at this temperature.

4. A first-order reaction is 35% completed in 600 second.
   How long will it take (in second) for the reaction to go to 98% completion?

5. The reaction between bromate ions and bromide ions in acidic aqueous solution is given by the following equation:
   $BrO_3^-(aq) + 5Br^-(aq) + 6H^+(aq) \longrightarrow 3Br_2(l) + 3H_2O(l)$　　　　Rate = $k[BrO_3^-]^x [Br^-]^y [H^+]^z$.
   Using the following four experiment results to determine (a) the orders for all three reactants. (b) Calculate the rate constant.

Exp	BrO_3^- (M)	Br^- (M)	H^+ (M)	Measured Rate
1	0.2	0.4	0.2	1.6×10^{-4}
2	0.4	0.2	0.4	6.4×10^{-4}
3	0.4	0.4	0.2	3.2×10^{-4}
4	0.2	0.4	0.4	6.4×10^{-4}

6. The reaction: $2 N_2O_5 (g) \longrightarrow 4NO_2(g) + O_2(g)$ was studied at two temperatures and the following values of rate constant **k** were obtained. Calculate the value of E_a (in kJ) for this reaction.

Temp (°C)	30	40
k (s^{-1})	3.65×10^{-4}	1.35×10^{-3}

7. In using the gaseous diffusion method for the Uranium(U^{235})-enrichment, calculate the number of diffusion steps required to enrich **0.700%** $^{235}UF_6$ to **6.00%** $^{235}UF_6$, if the initial $^{235}UF_6 : {}^{238}UF_6 = $ **0.7 : 99.3** (**Briefly show your calculation**)

8. Name the following compounds (or complexes) in English. (1 pt each, no partial credit will be given)
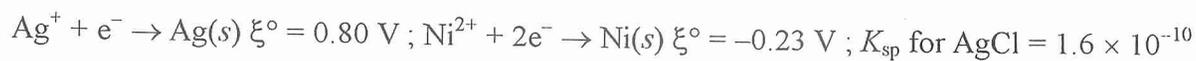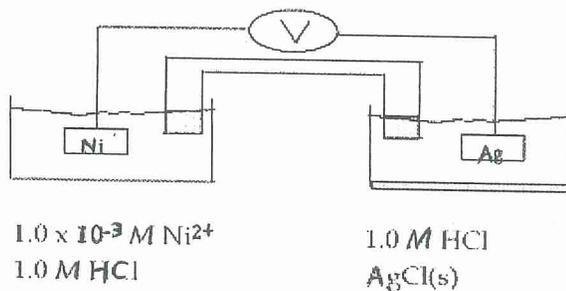   A. $Pt(C_2H_3O_2)_2$　　　B. MoH_2　　　C.　　$Mn(NH_2CH_2CH_2NH_2)_3^{2+}$　　　D.　　$Co(NH_3)_5NO_2^{2+}$
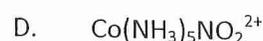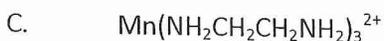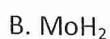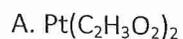
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9. Calculate ξ (cell potential) at 25°C for this cell, given the following data:

1.0×10^{-3} M Ni^{2+}
1.0 M HCl

1.0 M HCl
AgCl(s)

$Ag^+ + e^- \rightarrow Ag(s)\ \xi° = 0.80$ V ; $Ni^{2+} + 2e^- \rightarrow Ni(s)\ \xi° = -0.23$ V ; K_{sp} for AgCl $= 1.6 \times 10^{-10}$

10. ΔH_{vap} for water is 40.7 kJ/mol.　Calculate the boiling point of water at 0.500 atm.

11. A 5.00-g sample of a compound is dissolved in enough water to form 100.0 mL of solution. This solution has an osmotic pressure of 25 torr at 25°C. If it is assumed that each molecule of the solute dissociates into two particles (in this solvent), what is the molar mass of this solute?

12. Calculate $\Delta G°$ for $H_2O(g) + \frac{1}{2} O_2(g) \rightleftharpoons H_2O_2(g)$ at 600. K, using the following data:

$H_2(g) + O_2(g) \rightleftharpoons H_2O_2$　　　　$K_p = 2.3 \times 10^6$ at 600. K
$2H_2(g) + O_2(g) \rightleftharpoons 2H_2O(g)$　　$K_p = 1.8 \times 10^{37}$ at 600. K

13. 5.00 mol of a monatomic ideal gas at 25.0 C, pressure of 10.0 atm. Suppose the external pressure is lowered to 1.00 atm in a reversible adiabatic process.　Calculate the work for the process.

14. The N_2O molecule is linear and polar. Write
   a) the Lewis structures of N_2O (including resonance form),
   b) the formal charge and the hybridization of the central atom

15. Use Molecular Orbital to explain the following observations
   a) B_2 and O_2 are paramagnetic, but C_2, N_2 and F_2 are diamagnetic
   b) NO^+ is more stable than NO^- (anion)