I.　單選題30題，每題3分，共90分

1. The Claus reactions, shown below, are used to generate elemental sulfur from hydrogen sulfide.

   $2H_2S + 3O_2 \rightarrow 2SO_2 + 2H_2O$　　atomic mass: O(15.9994), S(32.08)

   $SO_2 + 2H_2S \rightarrow 3S + 2H_2O$

   How much sulfur (in grams) is produced from 15.0 grams of O_2?

   a) 67.6 g　b) 10.0 g　c) 15.0 g　d) 30.1 g　e) none of these

2. A solution contains the ions Ag^+, Pb^{2+}, and Ni^{2+}. Dilute solutions of NaCl, Na_2SO_4, and Na_2S are available to separate the positive ions from each other. In order to effect separation, the solutions should be added in which order?

   a) Na_2SO_4, NaCl, Na_2S　b) Na_2SO_4, Na_2S, NaCl　c) Na_2S, NaCl, Na_2SO_4

   d) NaCl, Na_2S, Na_2SO_4　e) NaCl, Na_2SO_4, Na_2S

3. A mixture contained no fluorine compound except methyl fluoroacetate, FCH_2COOCH_3 (molar mass = 92.07 g/mol). When chemically treated, all the fluorine was converted to CaF_2 (molar mass = 78.08 g/mol). The mass of CaF_2 obtained was 35.3 g. Find the mass of methyl fluoroacetate in the original mixture.

   a) 59.9 g　b) 83.2 g　c) 29.9 g　d) 41.6 g　e) 20.8 g

4. Combustion of coal releases sulfur dioxide into the atmosphere. The following process converts this gas into sulfuric acid, a component of acid rain.

   $2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$

   $SO_3(g) + H_2O(l) \rightarrow H_2SO_4(aq)$

   If each tonne of coal produces 6.00×10^3 L of sulfur dioxide (measured at STP), what mass of sulfuric acid can result from combustion of each tonne of coal? (1 tonne = 1000 kg)

   a) 1.31×10^1 kg H_2SO_4　b) 1.32×10^4 kg H_2SO_4　c) 2.63×10^7 kg H_2SO_4

   d) 2.63×10^1 kg H_2SO_4　e) 5.25×10^1 kg H_2SO_4

5. Boyle's law states that:

   a) Equal amounts of gases occupy the same volume at constant temperature and pressure.

   b) The volume of a fixed amount of gas is inversely proportional to its pressure at constant temperature.

   c) The volume of a fixed amount of gas is directly proportional to its temperature in Kelvin at constant pressure.

   d) The total pressure of a mixture of gases is the simple sum of the partial pressure of all of the gaseous compounds.

   e) The rates of effusion of gases are inversely proportional to the square roots of their molar masses.

6. Given the heats of the following reactions:

		ΔH^o(kJ)
I.	$P_4(s) + 6Cl_2(g) \rightarrow 4PCl_3(g)$	–1225.6
II.	$P_4(s) + 5O_2(g) \rightarrow P_4O_{10}(s)$	–2967.3
III.	$PCl_3(g) + Cl_2(g) \rightarrow PCl_5(g)$	–84.2
IV.	$PCl_3(g) + \frac{1}{2} O_2(g) \rightarrow Cl_3PO(g)$	–285.7

Calculate the value of ΔH° for the reaction below:

$$P_4O_{10}(s) + 6PCl_5(g) \rightarrow 10Cl_3PO(g)$$

a) –110.5 kJ　b) –610.1 kJ　c) –2682.2 kJ　d) –7555.0 kJ

e) None of these is within 5% of the correct answer.

7. Which of the following statements best describes the Heisenberg uncertainty principle?

a) The exact position of an electron is always uncertain.

b) The velocity of a particle can only be estimated.

c) It is impossible to accurately know both the exact location and momentum of a particle.

d) The location and momentum of a macroscopic object are not known with certainty.

e) The location and momentum of a particle can be determined accurately, but not the identity of the particle.

8. Given the following information:

$Li(s) \rightarrow Li(g)$	enthalpy of sublimation of $Li(s)$ = 166 kJ/mol
$HCl(g) \rightarrow H(g) + Cl(g)$	bond energy of HCl = 427 kJ/mol
$Li(g) \rightarrow Li^+(g) + e^-$	ionization energy of $Li(g)$ = 520. kJ/mol
$Cl(g) + e^- \rightarrow Cl^-(g)$	electron affinity of $Cl(g)$ = –349 kJ/mol
$Li^+(g) + Cl^-(g) \rightarrow LiCl(s)$	lattice energy of $LiCl(s)$ = –829 kJ/mol
$H_2(g) \rightarrow 2H(g)$	bond energy of H_2 = 432 kJ/mol

Calculate the change in enthalpy for:

$$2Li(s) + 2HCl(g) \rightarrow H_2(g) + 2LiCl(s)$$

a) 302 kJ　b) –562 kJ　c) –497 kJ　d) –904 kJ　e) none of these

9. The molecular structure of $SOCl_2$ is nearly

a) pyramidal　b) bent　c) octahedral　d) trigonal planar　e) none of these

10. For how many of the following does the bond order decrease if you add one electron to the neutral molecule?

B_2, C_2, P_2, F_2

a) 0　b) 1　c) 2　d) 3　e) 4

11. When one mole of benzene is vaporized at a constant pressure of 1.00 atm and at its boiling point of 353.0 K, 30.23 kJ of energy (heat) is absorbed and the volume change is +28.90 L. What is ΔH for this process? (1 L·atm = 101.3 J)

a) 27.30 kJ b) 33.16 kJ c) 1.33 kJ d) 30.23 kJ e) 59.13 kJ

12. A salt, MY, crystallizes in a body-centered cubic structure with a Y^- anion at each cube corner and an M^+ cation at the cube center. Assuming that the Y^- anions touch each other and the M^+ cation at the center, and the radius of Y^- is 1.50×10^2 pm, the radius of M^+ is: $(\sqrt{2} = 1.414,\ \sqrt{3} = 1.732)$

a) 62.0 pm b) 110. Pm c) 124 pm d) 220. pm e) none of these

13. A benzene-toluene solution is allowed to come to equilibrium with its vapor. The vapor is then condensed and found to contain 50.0 mole percent of each component. Calculate the composition (mole percent) of the original solution. The vapor pressures of pure benzene and toluene at this temperature are: 750. torr and 300. torr, respectively.

a) 50.2% benzene b) 28.6% benzene c) 71.0% benzene d) 40.0% benzene e) none of these

14. What is reverse osmosis?

a) the application, to a concentrated solution, of a pressure that is greater than the osmotic pressure, such that solvent flows from the concentrated solution to the dilute solution

b) the application, to a dilute solution, of a pressure that is greater than the osmotic pressure, such that solvent flows from the concentrated solution to the dilute solution

c) the application, to a concentrated solution, of a pressure that is greater than the osmotic pressure, such that solute flows from the concentrated solution to the dilute solution

d) the application, to a dilute solution, of a pressure that is greater than the osmotic pressure, such that solute flows from the concentrated solution to the dilute solution

e) the application, to a concentrated solution, of a pressure that is greater than the osmotic pressure, such that solvent flows from the dilute solution to the concentrated solution

15. For a reaction: aA → Products, $[A]_0 = 4.4\ M$, and the first two half-lives are 56 and 28 minutes, respectively. Calculate k (without units). $(\ln 2 = 0.693)$

a) 7.9×10^{-2} b) 4.1×10^{-3} c) 3.9×10^{-2} d) 8.1×10^{-3} e) none of these

16. The reaction: $A \rightarrow B + C$

is second order in A. When $[A]_0 = 0.100\ M$, the reaction is 20.0% complete in 28.9 minutes. Calculate the value of the rate constant (in L/min·mol).

a) 8.65×10^{-2} b) 6.92×10^{-4} c) 1.95 d) 1.38 e) none of these

17. Of what use is it to find a rate law for a reaction?
    a) We can use the rate law to directly determine coefficients in the balanced equation.
    b) From the rate law we can evaluate potential reaction mechanisms.
    c) The rate law gives us a good indication of the thermodynamic stability of the products.
    d) The rate law can lead us to determine the equilibrium constant for the reaction.
    e) None of these.

18. At 500.0 K, one mole of gaseous ONCl is placed in a one-liter container. At equilibrium it is 4.5% dissociated according to the equation shown here: $2ONCl \rightleftharpoons 2NO + Cl_2$. Determine the equilibrium constant.
    a) 5.0×10^{-5}　b) 1.1×10^{-3}　c) 4.7×10^{-2}　d) 9.6×10^{-1}　e) 2.0×10^{4}

19. The reaction:
    $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$
    has $K_p = 45.9$ at 763 K. A particular equilibrium mixture at that temperature contains gaseous HI at a partial pressure of 4.00 atm and hydrogen gas at a partial pressure of 0.229 atm. What is the partial pressure of I_2?
    a) 0.229 atm　b) 0.381 atm　c) 1.52 atm　d) 10.9 atm　e) 69.9 atm

20. What is the equilibrium concentration of HPO_4^{2-} in a 0.115 *M* solution of $H_3PO_4(aq)$? ($K_{a1} = 7.5 \times 10^{-3}$, $K_{a2} = 6.2 \times 10^{-8}$, $K_{a3} = 4.8 \times 10^{-13}$)
    a) $8.4 \times 10^{-5}\ M$　b) $2.6 \times 10^{-2}\ M$　c) $4.8 \times 10^{-13}\ M$　d) $6.2 \times 10^{-8}\ M$　e) $2.3 \times 10^{-7}\ M$

21. Which of the following is true about the pH of a solution of sulfuric acid?
    a) If the solution is dilute the pH can not be calculated.
    b) If the solution is dilute the pH is completely controlled by the first dissociation.
    c) If the solution is dilute the pH is completely controlled by the second dissociation.
    d) If the solution is concentrated the pH is partially controlled by the second dissociation.
    e) If the solution is dilute the pH is partially controlled by the second dissociation.

22. Consider the following indicators and their pH ranges:

Methyl orange	3.2-4.4
Methyl red	4.8-6.0
Bromothymol blue	6.0-7.6
Phenolphthalein	8.2-10.0
Alizarin yellow	10.1-12.0

Assume an indicator works best when the equivalence point of a titration comes in the middle of the indicator range. For which of the following titrations would methyl red be the best indicator?

a) 0.100 *M* HNO_3 + 0.100 *M* KOH
b) 0.100 *M* aniline ($K_b = 3.8 \times 10^{-10}$) + 0.100 *M* HCl
c) 0.100 *M* NH_3 ($K_b = 1.8 \times 10^{-5}$) + 0.100 *M* HCl
d) 0.100 *M* HF ($K_a = 7.2 \times 10^{-4}$) + 0.100 *M* NaOH
e) 0.100 *M* acetic acid ($K_a = 1.8 \times 10^{-5}$) + 0.100 *M* NaOH

23. The K_f for the complex ion $Ag(NH_3)_2^+$ is 1.7×10^7. The K_{sp} for AgCl is 1.6×10^{-10}. Calculate the molar solubility of AgCl in 1.0 *M* NH_3.

a) 5.2×10^{-2}　b) 4.7×10^{-2}　c) 2.9×10^{-3}　d) 1.3×10^{-5}　e) 1.7×10^{-10}

24. What is the best way to ensure complete precipitation of SnS from a saturated H_2S solution?

a) Add more H_2S.　b) Add a strong acid.　c) Add a weak acid.
d) Add a strong base.　e) Add a weak base.

25. As $O_2(l)$ is cooled at 1 atm, it freezes at 54.5 K to form Solid I. At a lower temperature, Solid I rearranges to Solid II, which has a different crystal structure. Thermal measurements show that ΔH for the I → II phase transition is -743.06 J/mol, and ΔS for the same transition is -17.0 J/K mol. At what temperature are Solids I and II in equilibrium?

a) 13.6 K　b) 43.7 K　c) 19.8 K　d) 98.2 K
e) They can never be in equilibrium because they are both solids.

26. The following question refers to the following system:

$$3Ag(s) + NO_3^-(aq) + 4H^+(aq) \rightarrow 3Ag^+(aq) + NO(g) + 2H_2O(l)$$

Anode reaction: $Ag \rightarrow Ag^+(aq) + 1e^-$　　$\mathcal{E}° = -0.7990$ V

Cathode reaction: $NO_3^-(aq) + 4H^+(aq) + 3e^- \rightarrow NO(g) + 2H_2O(l)$　　$\mathcal{E}° = 0.9640$ V

Determine the equilibrium constant at 25°C.　　$\left(\mathcal{E} = \mathcal{E}° - \frac{0.0591}{n}\log Q\right)$

a) 6.193×10^2　b) 3.107×10^{89}　c) 4.211×10^{-9}　d) 2.375×10^8　e) 3.126

27. Choose the correct molecular structure for $SeBr_4$.

a) trigonal bipyramidal b) trigonal planar c) tetrahedral d) octahedral e) none of these

28. For the process $Co(NH_3)_5Cl^{2+} + Cl^- \rightarrow Co(NH_3)_4Cl_2^+ + NH_3$ what would be the ratio of *cis* to *trans* isomer in the product?

a) 1 : 1 b) 1 : 2 c) 1 : 4 d) 4 : 1 e) 2 : 1

29. Which has the greatest number of unpaired electrons?

a) The square planar complex $Ni(CN)_4^{2-}$.
b) The tetrahedral complex $FeCl_4^-$.
c) Neither of the above have any unpaired electrons.
d) Both (A and B) have the same number (non-zero) of unpaired electrons.
e) More information is needed.

30. When heat is added to proteins, the hydrogen bonding in the secondary structure breaks apart. What are the algebraic signs of ΔH and ΔS for the denaturation process?

a) Both ΔH and ΔS are positive.
b) Both ΔH and ΔS are negative.
c) ΔH is positive and ΔS is negative.
d) ΔH is negative and ΔS is positive.
e) ΔH is positive and ΔS is 0.

II. 問答題2題，每題5分，共10分

1) Balance the following equation by half-reaction method.
$CrI_3(s) + Cl_2(g) \rightarrow CrO_4^{2-}(aq) + IO_4^-(aq) + Cl^-(aq)$ in basic solution

2) Arsenic acid (H_3AsO_4) is a triprotic acid with $K_{a1} = 5.00 \times 10^{-3}$ ($pK_{a1} = 2.30$), $K_{a2} = 8.00 \times 10^{-8}$ ($pK_{a2} = 7.10$) and $K_{a3} = 6.00 \times 10^{-10}$ ($pK_{a3} = 9.22$). Calculate the pH of a 0.20 *M* NaH_2AsO_4 solution.