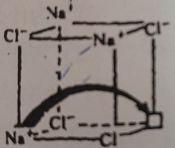
Solid

1. When doing researches on ionic crystal, we often investigate the electrostatic force of attraction or repulsion between the center ion and the ions that are at different distances around the center ion. Let the distance between the sodium ion in the sodium chloride crystal(NaCl) and the nearest chloride ion (the first layer ion) be **d**, and now take the sodium ion as the center, then:
2. Directly write the answer: The number of the second layer ion(Sodium ion closest to the central ion) is\_\_\_\_\_\_\_\_\_, and the distance between them and the center ion is\_\_\_\_\_\_\_\_\_\_(use **d** to represent)
3. We know that the radius of the Na+ is 116pm, and the radius of the Cl - is 167pm, and they are close to each other (ignore the gap) in the crystal. Find out the percentage of whole crystal space occupied by ions
4. Theoretically, the conductivity of high-temperature sodium chloride crystal（NaCl） is caused by the migration of sodium ions to another hole (taking one eighth of the cell in the right figure as an example). During the period, sodium ions have to pass through the smallest *triangular window* hole composed of three chloride ions (chloride ions do not contact each other). Please calculate the radius of the *triangular window.*



Chemical equilibrium

1. There exists an equilibrium A ⇌ B ⇌ C , the object product is substance B. If we increase the temperature, it is beneficial to increase the yield of product.E1,E2,E3 refer to the activation energy of A,B,C respectively. The phenomenon above indicates that the order of the activation energy is\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (connect with ‘<’) for example(E1<E2<E3)
2. There exists an equilibrium that . Given that the color of NO2 is Reddish brown, and the gas N2O4 has no color. Now, assume that there exists a system with NO2, N2O4, which reaches the equilibrium state.

Please choose the **true** statement(s): \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. The chemical equilibrium constant of the reaction decreases with the increase of temperature.
2. If we increase the pressure, the color of the gas will become deeper.
3. If we increase the amount of the NO2, the equilibrium will move to the direction of **reverse reaction**(to the **left**)
4. The positive reaction is an exothermic reaction.
5. The experiments have pointed out that, the density of anhydrous aluminum chloride measured in a standard thermodynamic pressure in different temperature is that:

|  |  |  |  |
| --- | --- | --- | --- |
| T/℃ | 200 | 600 | 800 |
| ρ/kg·L-1 | 6.8x10-3 | 2.65x10-3 | 1.51x10-3 |

1. Write the molecular formula of aluminum chloride at 200 ℃ and 800 ℃
2. What substances exist in the equilibrium state in 600℃?
3. Please calculate the partial pressure of the substances that exist in the equilibrium state in 600℃
4. Find out the Kc and Kp in 600℃

Quantum

1、Find the total degeneracy for (nx,ny,nz) = (8,1,2) 12.

Molecular Structure

1. What is the structure of the molecular ClO3F?
2. Given that N5+ is a non-linear ion, please write down all its Lewis resonance structure

[N≡N+-N--N+≡N]+ [N-=N+=N-N+≡N]+ [N≡N+-N=N+=N-]+

[N+=N-N--N=N+]+ [N+=N-N--N+≡N]+ [N≡N+-N--N=N+]+

Thermodynamics

1. Select the True statement\_\_\_\_\_\_\_\_\_
2. The process occurring in nature must be irreversible
3. **spontaneous process must be irreversible process**
4. The process of entropy increase must be spontaneous
5. Cp must be greater than Cv
6. Consider the following reaction:

The thermodynamic data of the two reactant is shown in the following chart(298K):

|  |  |  |
| --- | --- | --- |
|  | NO2 | N2O4 |
| ΔfHm°, KJ/mol | 33.2 | 11.1 |
| Sm°, J/(mol\*K) | 240.1 | 304.4 |
| Cp, J/(mol\*K) | 37.2 | 79.2 |
| ΔvapHm°, KJ/mol | 27.7 | 38.1 |

1. Calculate the ΔrHm°,ΔrSm°,ΔrGm°of the reaction in 298K
2. Calculate the K°of the reaction in 298K
3. Temporarily ignore the effect of temperature change on the entropy change and enthalpy change , please compare the value of K°under 308K and 298K using calculation, judge whether the **positive** reaction in the equilibrium is endothermic or exothermic.

4、Using calculation to compare the value of ΔrHm°in gas phase and liquid phase.

Acid and base, solution chemistry

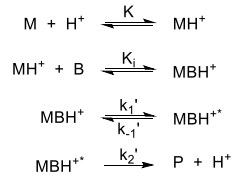
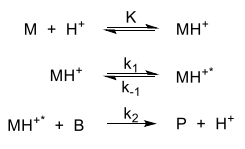
Kinetics

Water is a common solvent, and many reactions can take place in water. The reaction :

can be carried out in water.

The reaction shall be homogeneous acid-base catalytic reaction. In order to study the mechanism of the reaction, several experiments were carried out on the aqueous solution system containing M, B and P. Based on the obtained data, the researchers proposed two possible reaction mechanisms, as follows:

Mechanism 1: Mechanism 2:



In the above mechanism, MH+ \* and MBH+ \* are unstable active intermediates, and the elementary reaction without giving the rate constant in the above mechanism is rapid equilibrium,which does not affect the speed of the reaction.

When solving this problem, you can use **speed control step approximation, equilibrium approximation, steady-state approximation** and other methods to make reasonable approximation.

When solving this problem, C0 represents the initial concentration and C represents the concentration at time t. For example, C0, B is the initial concentration of B, and CB is the concentration of B at time t.

Under the condition of no acid catalysis, the experimental results show that the k'obs of the reaction is very small, which is almost negligible compared with acid catalysis.The kinetic experiment was carried out at 298K and 303k, and the obtained data were fitted as follows:

|  |  |  |
| --- | --- | --- |
| Trial | k’obs (L·mol-1·s-1) | T(K) |
| 1 | 5.42 × 10-9 | 298 |
| 2 | 1.62 × 10-8 | 303 |

1. It is known that the reaction M + B = P follows the Arrhenius theorem, please calculate the the activation energy of the reaction Ea when temperature range is 298K ~ 303K and there is no acid catalysis.
2. kinetic experiments show that when the concentration of B is large, dCP / dt(reaction speed) has nothing to do with CB. Based on this conclusion, judge which one of the two mechanisms might be the correct one for the reaction and explain the reason by calculation.
3. Under the condition of acid catalysis, when the concentration of B is large, the apparent rate constant of the reaction is k’obs = 2.79 × 10-4 mol · L-1 · s-1. If the initial concentration of B is 1.00 mol · L-1 and M is large excess, calculate the half-life period of the reaction to the reactant B.

Acid and base

1、Please compare the concentration of all the ions that are in an 1mol/L NaHCO3 solution and place them from the largest to the smallest and give your reason: