

答案一律寫在答案卷上，並標明題號，否則不予計分。

簡答題需做簡短說明，計算題需寫出計算過程。

一、Answer each of the following questions briefly (60%)

- Under the same conditions of temperature and pressure, one volume of chlorine gas reacts with three volumes of fluorine gas to yield two volumes of a product. What is the formula and geometry of the product?
- Decide whether the S in SF<sub>4</sub> obeys the octet rule. If it doesn't, indicate how the octet rule is broken.
- What is the oxidation number of (a) O in HFO molecule, (b) Fe in Fe<sub>3</sub>O<sub>4</sub>.
- What is the precipitate of the mixing solutions between AgNO<sub>3</sub>(aq) and [Co(NH<sub>3</sub>)<sub>3</sub>Br]Cl<sub>2</sub>?
- When aqueous potassium cyanide is added to a solution of copper (II) sulfate, a white precipitate, soluble in an excess of KCN, is formed. What is the formula of soluble species?

- What is the product of the reaction between dichromate ion and excess chromium metal?

The reduction potentials are:  $\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 6\text{e}^- \rightarrow 2\text{Cr}^{3+} + 7\text{H}_2\text{O}$   $E^\circ = 1.33 \text{ V}$

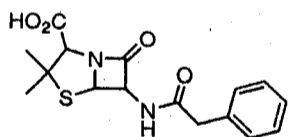
$\text{Cr}^{3+} + \text{e}^- \rightarrow \text{Cr}^{2+}$   $E^\circ = -0.41 \text{ V}$

$\text{Cr}^{2+} + 2\text{e}^- \rightarrow \text{Cr}$   $E^\circ = -0.91 \text{ V}$

- Predict whether a solution containing the salt K<sub>2</sub>HPO<sub>4</sub> will be acidic, neutral or basic.

For H<sub>3</sub>PO<sub>4</sub>,  $K_1 = 7.5 \times 10^{-3}$   $K_2 = 6.2 \times 10^{-8}$   $K_3 = 4.8 \times 10^{-13}$

- Penicillin G has the following structure. What is its molecular formula?



- In the uncatalyzed reaction:  $\text{N}_2\text{O}_4(\text{g}) \rightleftharpoons 2\text{NO}_2(\text{g})$ , the pressures of gases at equilibrium at 100°C are  $P_{\text{N}_2\text{O}_4} = 0.377 \text{ atm}$ , and  $P_{\text{NO}_2} = 1.56 \text{ atm}$ . What would happen to these pressures if a catalyst is added to the mixture?

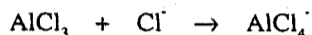
(背面仍有題目,請繼續作答)

10. What is the difference between (a) a  $2p_x$  and  $2p_y$  orbital, (b) a  $2p_x$  and  $3p_x$  orbital?
11. The spontaneous evaporation of water at  $25^\circ\text{C}$ , which factor, enthalpy or entropy, or both, is responsible for the spontaneity of this process?
12. The constituents of wine contain C, H and O. To confirm the age of a bottle of wine, which of the isotope would you choose in a radioactive dating study? Assume that the activities of the isotopes were known at the time the bottle was sealed.

The half-life of the isotopes are C-14: 5730 y; H-3: 12.5 y; O-15 124 s.

13. Consider the following reaction:  $\text{IO}_4^-(\text{aq}) + 2\text{I}^-(\text{aq}) + \text{H}_2\text{O} \rightarrow \text{I}_2(\text{s}) + \text{IO}_3^-(\text{aq}) + 2\text{OH}^-(\text{aq})$   
When  $\text{KIO}_4$  is added to a solution containing  $\text{I}^-$  labeled with radioactive I-128, all the radioactivity appears in  $\text{I}_2$  and none in  $\text{IO}_3^-$ . How can you deduce the  $\text{IO}_3^-$  come from,  $\text{I}^-$ ,  $\text{IO}_4^-$  or both?

14. Describe the change in hybridization (if any) of the Al atom in the following reaction:



15. Draw the Lewis structure of  $\text{CH}_3\text{NO}_2$  and determine the formal charge of N.

16. Which of the following species have tetrahedral geometry?

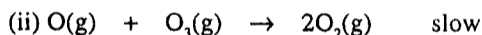
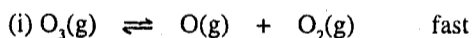


17. Which of the following types of compounds can form hydrogen-bonds with water molecule?

Alkyl halides, Carboxylic acids, Alkenes, Ethers, Ketones

18. Explain why a solution of HCl in benzene does not conduct electricity but in water it does.

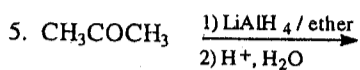
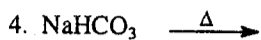
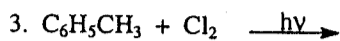
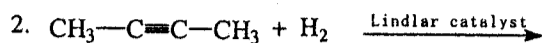
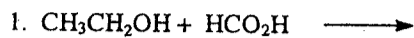
19. The mechanism of the decomposition of ozone as



Explain the fact that the rate of decomposition of ozone decreases with increasing  $\text{O}_2$  concentration.

20. Decide, on the basis of crystal field splitting patterns, whether each of the following compounds should be diamagnetic or paramagnetic. (a)  $\text{Co}(\text{CN})_6^{3-}$  (b)  $[\text{Co}(\text{NH}_3)_6]^{3+}$

二、Predict the major product of each of the following reactions. (10%)



三、Indicate which one of the two species in each of the following pairs is smaller. (10%)

1. Atomic radius: Be, Ba

2. Ionic character: NaH, SiH<sub>4</sub>

3. Electronegativity: Be, B

4. Melting point: NaF, MgO

5. Bond order: CN<sup>-</sup>, CN<sup>+</sup>

四、Calculation (20%)

1. Calculate the work done in kilojoules when 1.0 mole of water vaporizes at 1.0 atm and 100°C.

Assume that the volume of liquid water is negligible compared with that of steam at 100°C.

2. Calculate the molar solubility of Cd(OH)<sub>2</sub> (a) in pure water and (b) in a solution of pH = 8.00?

The K<sub>sp</sub> of Cd(OH)<sub>2</sub> is 1.2 × 10<sup>-14</sup>

3. Calculate the ΔG° for the reaction:  $\text{CaCO}_3(\text{s}) \rightarrow \text{CaO}(\text{s}) + \text{CO}_2(\text{g})$

Given	ΔH <sub>f</sub> <sup>o</sup> (kJ/mol)	S <sup>o</sup> (J/K·mol)
CaCO <sub>3</sub>	-1207	93
CaO	-636	40
CO <sub>2</sub>	-394	214

4. Calculate the lattice energy of lithium fluoride given the following data.

The heat of sublimation of Li(s) is 161 kJ/mol

The heat of formation of LiF(s) is -670 kJ/mol

The bond energy of F<sub>2</sub>(g) is 160 kJ/mol

Electron affinity of F(g) is -328 kJ/mol

Ionization energy of Li(g) is 520 kJ/mol