

※請將第 I 大題選擇題作答於試卷內之「選擇題作答區」。

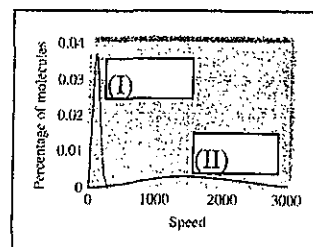
$$c = 3.00 \times 10^8 \text{ m/s}; h = 6.626 \times 10^{-34} \text{ J}\cdot\text{s}; R_H = 1.096776 \times 10^7 \text{ m}^{-1}; F = 96500 \text{ C/mol}$$

$$\text{Gas constant: } R = 8.314 \text{ J/mol}\cdot\text{K} = 0.0821 \text{ L}\cdot\text{atm/mol}\cdot\text{K}$$

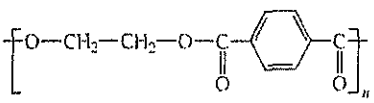
$$H = 1.01 \text{ g/mol}, C = 12.01 \text{ g/mol}, O = 16.00 \text{ g/mol}, N = 14.01 \text{ g/mol}, P = 30.97 \text{ g/mol}$$

I. 選擇題 (60%, 每題答案可能 1 至多個, 全部選對始得題分 3 分)

- Choose the one that has three significant figures in the answer:
 - $22.51 - 2.41$
 - 1.11×2.3
 - $861 \div 7$
 - $\frac{(767 - 21.6)0.2798}{0.1015 \times 298.15}$
- Choose the correct conversion in the followings:
 - $15 \text{ nm} = 1.5 \times 10^{-9} \text{ m}$
 - $75 \text{ mg} = 7.5 \times 10^{-2} \text{ g}$
 - $5 \mu\text{L} = 5 \times 10^{-6} \text{ L}$
 - $104^\circ\text{F} = 72^\circ\text{C}$
- For the ferrous ion, ${}_{26}^{53}\text{Fe}^{2+}$, it contains
 - 53 protons
 - 26 neutrons
 - 24 electrons
 - 51 nucleons.
- A typical commercial-grade phosphoric acid is 75% H_3PO_4 by mass and density 1.57 g/mL. Calculate the molarity (mol/L) of the acid.
 - 7.7 M
 - 12 M
 - 16 M
 - none of the above
- A student weighs out 0.5681 g of potassium hydrogen phthalate (KHP, molar mass = 204.0 g/mol) and titrates to the equivalence point with 21.54 mL of a stock NaOH solution. What is the concentration of the stock NaOH solution?
 - 0.01293 M
 - 0.1293 M
 - 0.06463 M
 - $6.463 \times 10^{-3} \text{ M}$
- According to the plots of relative molecular speed distribution of UF_6 (Mw: 352 g/mol) and H_2 (Mw: 2.01 g/mol) gas at 273 K,
 - The relative molecular speed distribution of UF_6 is plot (I).
 - The average kinetic energy of H_2 is greater than UF_6 .
 - The root mean square velocity of H_2 is greater than UF_6 .
 - The effusion rate of UF_6 is greater than H_2 .
- A 0.5865 g sample of lactic acid ($\text{C}_3\text{H}_6\text{O}_3$) is burned in a calorimeter whose heat capacity is 4.812 kJ/ $^\circ\text{C}$. The temperature increases from 23.10 $^\circ\text{C}$ to 24.95 $^\circ\text{C}$. Calculate the molar heat of combustion of lactic acid.
 - 8.902 kJ/mol
 - 15.18 kJ/mol
 - 1366 kJ/mol
 - none of the above
- The yellow light given off by a sodium vapor lamp used for public lighting has a wavelength of 589 nm. Calculate the energy of one photon of yellow light.
 - $3.91 \times 10^{-40} \text{ J}$
 - $3.91 \times 10^{-31} \text{ J}$
 - $3.37 \times 10^{-19} \text{ J}$
 - $3.37 \times 10^{-28} \text{ J}$
- Identify which of the following sets of four quantum numbers (n, l, m_l, m_s) can exist for an electron in an atom.
 - (3, 0, 0, +1/2)
 - (2, 2, 1, -1/2)
 - (2, 1, 2, +1/2)
 - (4, 2, -2, 0)



見背面

10. Which of the following ranking is correct?
 (a) ionic radius: $O^{2-} < F^- < Mg^{2+}$
 (b) first ionization energy: $Be < Mg < Ca$
 (c) acid strength: $CH_3CH_2COOH < CH_3COOH < ClCH_2COOH < FCH_2COOH$
 (d) freezing point: $0.10\text{ m } MgCl_2 < 0.10\text{ m } NaCl < 0.10\text{ m acetic acid} = 0.10\text{ m glucose}$
11. Which of the following molecule has tetrahedral geometry?
 (a) $SiCl_4$ (b) XeF_4 (c) NH_3 (d) SF_4
12. For the polymer with the following structure, which statement is true?

 (a) This is a condensation polymer. (b) This is a homopolymer. (c) This is a polyamide.
 (d) $HOCH_2CH_2OH$ is one of the monomer.
13. Which of the following molecule has geometric isomers?
 (a) $CH_3CH(NH_2)COOH$ (b) $CH_2=CClF$ (c) $[Cr(NH_3)_4Cl_2]^+$ (d) $[ZnCl_2(CN)_2]$ (tetrahedral)
14. A 0.400 g sample of a polypeptide dissolved in 1.00 L of an aqueous solution at $27^\circ C$ has an osmotic pressure of 3.74 torr. What is the molar mass of the polypeptide?
 (a) 180 g/mol (b) 2.00×10^2 g/mol (c) 2.00×10^3 g/mol (d) 2.03×10^5 g/mol
15. The vapor pressures of pure benzene (C_6H_6) and toluene ($C_6H_5CH_3$) at $20^\circ C$ are 75 mmHg and 22 mmHg, respectively. Consider a mixture containing 1.0 mol of benzene and 2.0 mol of toluene at $20^\circ C$, which statement is true?
 (a) The intermolecular force of benzene is greater than that of toluene.
 (b) The mole fraction of toluene in the solution is 0.50.
 (c) The total vapor pressure of the solution is 97 mmHg
 (d) The mole fraction of benzene in the vapor phase is 0.63.
16. One stage in the manufacture of sulfuric acid is the formation of sulfur trioxide by the reaction of SO_2 with O_2 in the presence of a vanadium(V) oxide catalyst.
 The chemical equation is $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$ $\Delta H = -198\text{ kJ/mol}$
 (a) Increase the pressure by adding neon gas at constant volume will favor the formation of $SO_3(g)$.
 (b) Compression the equilibrium mixture will favor the formation of $SO_3(g)$.
 (c) Raising the temperature will increase the equilibrium constant of the reaction.
 (d) In the presence of catalyst, the equilibrium constant of the reaction will be increased.
17. What is the ratio of HCO_3^- to H_2CO_3 ($[HCO_3^-]/[H_2CO_3]$) in blood of pH 7.4?
 For H_2CO_3 , $pK_{a1} = 6.37$, $pK_{a2} = 10.25$.
 (a) 0.093 (b) 1.0 (c) 5.4 (d) 11

18. Using the following information, calculate the lattice energy of AgF(s).
- | | |
|---------------------------------|-------------|
| enthalpy of formation of AgF(s) | -205 kJ/mol |
| enthalpy of formation of Ag(g) | +284 kJ/mol |
| ionization energy of Ag(g) | +731 kJ/mol |
| enthalpy of formation of F(g) | +79 kJ/mol |
| electron affinity of F(g) | +328 kJ/mol |
- (a) 971 kJ/mol (b) 1050 kJ/mol (c) 1217 kJ/mol (d) 1627 kJ/mol
19. The combustion of acetylene gas, $C_2H_2(g) + 5/2O_2(g) \rightarrow 2CO_2(g) + H_2O(l)$ is used in welding. For the reaction at standard states and 25°C, $\Delta H^\circ = -1299.5$ kJ, $\Delta G^\circ = -1235.1$ kJ, and $\Delta S^\circ = -215.5$ J/K, which statement is correct?
- (a) This is a spontaneous reaction.
 (b) This is an endothermic reaction.
 (c) The entropy of the system is decreased.
 (d) The maximum amount of useful work that can be accomplished under standard conditions by this system is -1299.5 kJ.
20. For the reaction at 25 °C, $2NO_2(g) \rightleftharpoons N_2O_4(g)$
 Calculate ΔG of the reaction if $P_{NO_2} = 0.29$ atm, $P_{N_2O_4} = 1.6$ atm.
 (a) -5.40 kJ (b) 1.90 kJ (c) 46.44 kJ (d) -1.17 kJ

Compounds	ΔH_f° (kJ/mol)	S° (J/mol-K)	ΔG_f° (kJ/mol)
$NO_2(g)$	33.84	240.5	51.84
$N_2O_4(g)$	9.66	304.3	98.28

II. 計算問答題 (40%)

- Consider the O_2^{2-} ion. (a) Draw the molecular orbitals energy-level diagrams of the ion. (b) Determine the bond orders. (c) Indicate the magnetic property (diamagnetic or paramagnetic) of the ion. (10%)
- Consider the complex ion $[CoF_6]^{3-}$. (a) Draw the crystal-field energy-level diagram and show the placement of d-electrons of the ion. (b) Is the ion diamagnetic or paramagnetic? (c) Is the ion a low-spin or high-spin complex? (F^- is a weak-field ligand.) (10%)
- For the galvanic cell $Cr(s) | Cr^{3+}(aq) || Cu^{2+}(aq) | Cu(s)$,
 - Write the anodic, cathodic, and the balanced net equation for the cell reaction.
 - Calculate the standard cell voltage at 298 K.
 - Calculate the standard free-energy change, ΔG° , of the reaction at 25°C.
 - What is the value of cell voltage when the reaction reaches equilibrium?
 $E^\circ(Cr^{3+}/Cr) = -0.74$ V, $E^\circ(Cu^{2+}/Cu) = +0.34$ V (10%)

4. The gas-phase decomposition of NO_2 , $\text{NO}_2(\text{g}) \rightarrow \text{NO}(\text{g}) + \text{O}_2(\text{g})$, is studied at 383°C , giving the following data and plots. In the figures [A] stands for $[\text{NO}_2]$.
- (a) Determine the order of the reaction.
- (b) What is the value of the rate constant?
- (c) How long will it take for the NO_2 to drop to 0.0020 M ? (10%)

Time (s)	$[\text{NO}_2] \text{ (M)}$	$1/[\text{NO}_2]$	$\ln([\text{NO}_2])$
0.0	0.100	10.0	-2.30
5.0	0.017	58.8	-4.07
10.0	0.0090	111.1	-4.71
15.0	0.0062	161.3	-5.08
20.0	0.0047	212.8	-5.36

