＊請在答案卷上標明題號依序作答

- **Gas constant: R = 8.314 J/mol-K = 0.0821 L-atm/mol-K**
- **Atmic mass: H = 1.0, He = 4.0, C = 12.0, O = 16.0, N = 14.0, Cl = 35.5, Na = 23.0, P = 31.0**
- **C = 3.00 × 10^8 m/s; h = 6.63 × 10^{-34} J-s; F = 96500 C/mol**

I. 選擇題（90%, 每題 3 分，單選與多重選混合，每題答案可能 1 至多個，全部選對始得題分 3 分）

1. Which of the following conversion is correct?
   (A) -3°C = 270.15 K (B) 15 mg = 0.15 g (C) 28 torr = 28 mmHg (D) 33 nm = 3.3 × 10^{-9} m

2. A typical commercial-grade phosphoric acid is 85.0% H_3PO_4 by mass and density 1.70 g/mL. Calculate the molarity of the acid.
   (A) 8.67 M (B) 14.7 M (C) 17.3 M (D) 12.0 M

3. For the ion $^{32}_{16}S^{2-}$, which of the following statement is true?
   (A) the atomic number is 16.
   (B) the number of protons is 16.
   (C) the number of electrons is 16.
   (D) the number of neutrons is 16.

4. Solubility rules predict precipitate formation for mixing 0.1 M aqueous solutions of
   (A) NaCl and $Hg(NO_3)_2$ (B) HCl and $Ba(OH)_2$ (C) H_2SO_4 and $Ba(OH)_2$ (D) Na_2S and $Cu(NO_3)_2$

5. Which of the following concerning with CH_3CH_2OH is true?
   (A) It's a weak electrolyte.
   (B) The functional group of CH_3CH_2OH is hydroxyl group.
   (C) CH_3CH_2OH and CH_3OCH_3 are structural isomers.
   (D) The enthalpy of vaporization of CH_3CH_2OH is greater than CH_3OCH_3

6. The concentration of a hydrogen peroxide solution can be determined by titration. If 22.4 mL of a 0.0150 M $KMnO_4$ solution are required to oxidized 25.0 mL of a H_2O_2 solution. What is the concentration of the hydrogen peroxide solution? $2MnO_4^- + 5H_2O_2 + 6H^+ \rightarrow 5O_2 + 8H_2O + 2Mn^{2+}$
   (A) 0.00538 M (B) 0.0134 M (C) 0.0167 M (D) 0.0336 M

7. Which of the following statement about acid and base is correct?
   (A) HSO_4^- can act as a Brønsted-Lowry base.
   (B) H_2CO_3 is a polyprotic acid.
   (C) The acidity of 0.10 M solution: NaF = NaCl < HClO < $HClO_2$
   (D) In the reaction: $Cu^{2+}(aq) + 4Cl^-(aq) \rightleftharpoons [CuCl_4]^{2-}(aq)$, Cu^{2+} is the Lewis acid.

8. For 25.00 mL of HF(aq) with unknown concentration is titrated to the equivalence point with 19.80 mL of 0.01246 M $Ba(OH)_2$? What's the concentration of the unknown acid?
   (A) 0.009868 M (B) 0.01573 M (C) 0.01974 M (D) 0.03146 M

9. If one mole of H_2 and CH_4 gases are compared at 25°C and 1 atm, which of the following quantities will be equal to each other?
   (A) number of gas molecules (B) volume (C) root-mean-square speed (D) average kinetic energy.

10. How many orbitals have the quantum values of n = 3 and ℓ = 2?
    (A) 2 (B) 3 (C) 5 (D) 9

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11. Which of the following molecules would you expect to be polar?
(A) PCl_5 (B) H_2Se (C) XeF_2 (D) SF_4

12. Which of the following can form hydrogen bonds with water?
(A) HCOOH (B) $C_2H_5COC_2H_5$ (C) C_6H_6 (D) F^-

13. In order to prepare a buffer with pH 7.1, which of the following pair should you choose best?
(A) HCOOH/NaHCOO ($K_a = 1.8 \times 10^{-4}$)
(B) $CH_3COOH/NaCH_3COO$ ($K_a = 1.8 \times 10^{-5}$)
(C) $H_2CO_3/NaHCO_3$ ($K_a = 4.4 \times 10^{-7}$)
(D) NH_4Cl/NH_3 (K_b of $NH_3 = 1.8 \times 10^{-5}$)

14. A face-centered cubic cell contains 8 X atoms at the corners of the cell and 6Y atoms at the faces. What is the empirical formula of the solid?
(A) X_4Y_3 (B) X_3Y_4 (C) X_3Y (D) XY_3

15. Which of the following substance would you expect to be more soluble in benzene than in water?
(A) C_5H_{12} (B) CH_3OH (C) HBr (D) NaBr

16. A solution is 35.0% by mass carbon tetrachloride (CCl_4) in benzene (C_6H_6) at 20°C. The vapor pressure of pure benzene and pure carbon tetrachloride at this temperature is 74.61 mmHg and 91.32 mmHg, respectively. Calculate the vapor pressure of the solution at 20°C (assume ideal solution).
(A) 58.1 mmHg (B) 78.2 mmHg (C) 80.5 mmHg (D) 87.7 mmHg

17. Which of the following aqueous solutions has the highest boiling point (assume 100% dissociation for all soluble ionic compounds)?
(A) 0.20 *m* HNO_3 (B) 0.18 *m* NaCl (C) 0.15 *m* K_2CO_3 (D) 0.25 m HF(aq)

18. The reaction of nitric oxide with hydrogen at 1280°C is: $2NO(g) + 2H_2(g) \rightarrow N_2(g) + 2H_2O(g)$
From the following data collected at this temperature:

Experiment	[NO] (M)	$[H_2]$ (M)	Initial Rate (M/s)
1	5.0×10^{-3}	2.0×10^{-3}	1.3×10^{-5}
2	10.0×10^{-3}	2.0×10^{-3}	5.2×10^{-5}
3	10.0×10^{-3}	4.0×10^{-3}	10.4×10^{-5}

(A) The reaction is second order in H_2.
(B) The rate law of the reaction: rate = $k[NO]^2[H_2]^2$
(C) The value of the rate constant, k, is 2.6×10^2.
(D) When [NO] = 2.0×10^{-3} M and $[H_2] = 3.0 \times 10^{-3}$ M, the rate of the reaction is 9.4×10^{-9} M/s.

19. The conversion of cyclopropane to propene in the gas phase is a first-order reaction with a rate constant of 6.7×10^{-4} s^{-1} at 500°C.
(A) The integrated rate law of the reaction is $1/[A]_t = kt + 1/[A]_0$. (A: stands for cyclopropane)
(B) The half-life of the reaction is 1.0×10^3 s.
(C) If the initial concentration of cyclopropane is 0.25 *M*, after 8.8 min the concentration of cyclopropane is 0.18 M.
(D) It takes 33 min for the concentration of cyclopropane to decrease from 0.25 *M* to 0.15 *M*.

20. The rate constant of a first-order reaction is 3.46×10^{-2} s^{-1} at 25°C. What is the rate constant at 77°C if the activation energy for the reaction is 50.2 kJ/mol?
(A) 3.47×10^{-2} s (B) 1.07×10^{-2} s (C) 4.06×10^{-2} s (D) 0.702 s

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21. The following mechanism has been suggested for the reaction: $H_2O_2 + 2H^+ + 2I^- \rightarrow I_2 + 2H_2O$

Step 1	$H_2O_2 + I^- \rightarrow HOI + OH^-$	*Slow*
Step 2	$OH^- + H^+ \rightarrow H_2O$	*Fast*
Step 3	$HOI + H^+ + I^- \rightarrow I_2 + H_2O$	*Fast*

(A) The rate law deduced from the mechanism is: Rate = $k[H_2O_2][I^-]$.

(B) Step 3 is the rate determining step.

(C) OH^- is the intermediate included in this mechanism.

(D) H^+ is the catalyst for the reaction.

22. When the reaction $2H_2S(g) \rightleftharpoons 2H_2(g) + S_2(g)$ is carried out at 1065°C, $K_p = 0.012$. Starting with pure H_2S at 1065°, what must the initial pressure of H_2S be if the equilibrated mixture at this temperature is to contain 0.250 atm of $H_2(g)$?

(A) 1.06 atm (B) 1.86 atm (C) 0.94 atm (D) 0.90 atm

23. For the endothermic reaction in a closed container: $CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$, which of the following actions would favor shifting the equilibrium position to form more CO_2 gas?

(A) The temperature is raised.

(B) Some CaO is added to the system.

(C) Some $CaCO_3$ is added to the system.

(D) A catalyst is added to the reaction mixture.

24. A 5.5 L sample of a 0.25 M HNO_3 solution is mixed with 1.2 L of a 0.34 M HCl solution. What is the pH of the mixture?

(A) 0.27 (B) 0.57 (C) 1.07 (D) 0.50

25. What is the pH of a solution that is 0.10 M $NaCH_3COO(aq)$? For CH_3COOH, $K_a = 1.8 \times 10^{-5}$.

(A) 1.69 (B) 5.13 (C) 8.87 (D) 9.26

26. Given the following notation for an electrochemical cell and the standard reduction potential at 298 K:

$Ni(s) \mid NiCl_2(aq, 1\ M) \parallel AgNO_3(aq, 1\ M) \mid Ag(s)$

$Ag^+ + e^- \rightarrow Ag$	$E^\circ = 0.80$ V
$Ni^{2+} + 2e^- \rightarrow Ni$	$E^0 = -0.28$ V

(A) Under standard conditions and 298 K, $E^\circ_{cell} = 1.88$ V.

(B) Under standard conditions and 298 K, $\Delta G^\circ = -208$ kJ.

(C) Increase the concentration of $AgNO_3(aq)$ will increase the E_{cell}.

(D) At equilibrium and 298 K, E_{cell} is less than zero.

27. For the complex ion $[FeF_6]^{4-}$, F^- ion is a weak field ligand.

(A) The oxidation number of central metal is +6.

(B) The complex ion is paramagnetic.

(C) There are 2 unpaired electrons in each complex ion.

(D) This is a low-spin complex.

28. According to the molecular orbital theory, compare the properties of N_2^- and N_2:

(A) N_2 molecule is diamagnetic.

(B) The bond order: $N_2^- > N_2$.

(C) The bond length: $N_2^- > N_2$.

(D) The bond energy: $N_2^- > N_2$.

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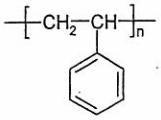
29. For the organic compounds, which of the following statement is true?

(A) Benzene molecule,  , will undergo addition reaction.



(B) $CH_3CH_2C_6H_5$ is the monomer of polystyrene polymer; structure shown as figure.
(C) $CH_3CH_2NH_2$ is a primary amine.
(D) Protein is a condensation polymer.

30. For the radioactive radiation, which of the following statement is true?
(A) $^{131}_{53}I$ is a radioactive isotope.
(B) γ-radiation shows the greatest penetrating power.
(C) The radioactive decay rate can be increased by raising the temperature.
(D) The nuclear reactions are first order reactions.

II. 計算問答題 (10%)

31. Consider the decomposition of barium carbonate: $BaCO_3(s) \rightarrow BaO(s) + CO_2(g)$.
(A) Use the data in the following table to calculate the values of ΔH°, ΔS°, and ΔG° at 298 K.
(B) Calculate the equilibrium constant, K, at 298 K.
(C) At what temperature will the reaction be spontaneous?

	$BaCO_3(s)$	$BaO(s)$	$CO_2(g)$
ΔH_f° (kJ/mol)	-1216	-554	-394
S° (J/mol.K)	112	70.4	214
ΔG_f° (kJ/mol)	-1138	-525	-394

Periodic table of the elements

1 1A												13 3A	14 4A	15 5A	16 6A	17 7A	18 8A
1 H 1.008	2 2A																2 He 4.003
3 Li 6.941	4 Be 9.012											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
11 Na 22.99	12 Mg 24.31	3 3B	4 4B	5 5B	6 6B	7 7B	8 8B	9 8B	10 8B	11 1B	12 2B	13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.88	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.39	31 Ga 69.72	32 Ge 72.59	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc (98)	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3
55 Cs 132.9	56 Ba 137.3	57 *La 138.9	72 Hf 178.5	73 Ta 180.9	74 W 183.8	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	89 †Ac (227)	104 Rf (261)	105 Db (262)	106 Sg (263)	107 Bh (262)	108 Hs (265)	109 Mt (268)	110 Ds (271)	111 Rg (280)	112 Uub		114 Uuq		116 Uuh		118 Uuo

*Lanthanide series	58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm (147)	62 Sm 150.4	63 Eu 152.0	64 Gd 157.3	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0	71 Lu 175.0
†Actinide series	90 Th 232.0	91 Pa 231.0	92 U 238.0	93 Np 237.0	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (260)