You may find the following equations and physical constants useful. However, it does not mean they are required in answering the questions.

$$[A] = [A]_0 - kat \qquad \ln[A] = \ln[A]_0 - akt$$

$$\frac{1}{[A]} = \frac{1}{[A]_0} + akt \qquad E_{cell} = E^0_{cell} - \frac{RT}{nF}\ln C$$

Gas constant R = 8.314 JK^{-1}mol^{-1} Faraday Constant = 96489 C

※注意：請於試卷上「選擇題作答區」依序作答。

Section A (80% 單選題 20 題，每題四分):

1. For the reaction, $2R + S \rightarrow 3M + N$, what is the correct definition of the reaction rate?

 A. $\frac{d[M]}{dt}$ B. $\frac{d[S]}{dt}$ C. $-\frac{1}{2}\frac{d[R]}{dt}$ D. $-\frac{1}{2}\frac{d[R]}{dt}$ $\frac{d[S]}{dt}$

2. What is the overall reaction order of the following rate law?

 $Rate = k[A][B]^{\frac{1}{2}}$

 A. 1½   B. 1   C. ½   D. -1½

3. If the half life of a reaction with respect to a reactant concentration is $\frac{0.693}{k}$, what is the reaction order of the reactant?

 A. First order   B. Second order   C. Third order   D. Zero order

4. Which of the following is the Zeroth law of thermodynamics?

 A. Energy can never be created or destroyed but it can be changed from one form to another.

 B. Two bodies in thermal contact are at thermal equilibrium with each other if the two bodies are at the same absolute temperature.

 C. Any process carried out in several steps, the overall ΔH is equal to the sum of the enthalpy changes (signed) for the individual steps.

 D. None of the above.

5. For any spontaneous chemical reactions in a beaker at constant temperature, which of the following condition must be satisfied?

 A. $\Delta S_{system} \geq 0$ B. $\Delta H - T\Delta S_{system} < 0$

 C. $\Delta G \geq 0$ D. $\Delta S_{universe} < 0$

6. For the titration of 0.1 M HClO$_4$ against 0.5 M NH$_3$ at 25 °C, what is the pH value at the equivalent point?

 A. pH = 7   B. pH < 7   C. pH > 7

7. Which one of the following reactants or product is a Lewis acid?
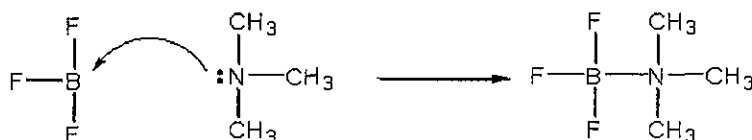
 A. BF$_3$ B. N(CH$_3$)$_3$ C. BF$_3$-N(CH$_3$)$_3$

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8. In an exothermic reaction, if we double the amount of reactants, which of the following statements is correct?
   A. The amount of heat evolved will be doubled
   B. The amount of heat absorbed will be the same
   C. The final temperature will be two times higher
   D. The amount of heat evolved will be the same

9. For a $[H^+]$ concentration of 0.01410 M, the pH value should read
   A. 1.85078
   B. 1.8508
   C. 1.851
   D. 1.85

10. Which of the following has the largest entropy at room temperature?
    A. One mole of He atoms
    B. One mole of CH_4 molecules
    C. One mole of CO_2 molecules
    D. 10 g of water

11. Which of the following reaction is NOT favored by the system entropy?
    A. $H_2 (g) + Br_2 (g) \rightarrow 2\ HBr (g)$
    B. $2H_2 (g) + O_2 (g) \rightarrow 2\ H_2O (g)$
    C. $H_2O (l) \rightarrow H_2O (g)$
    D. $HCl (aq) + H_2O (l) \rightarrow H_3O^+ (aq) + Cl^- (aq)$

12. What is the oxidation number of Mn in MnO_4^-?
    A. +5　　B. +7　　C. -5　　　　D. -7

13. What is the formal charge of P in the most stable Lewis structure of PO_4^{3-}?
    A. +1　　B. +2　　C. -1　　　　D. 0

14. Predict the shape of a chlorine trifluoride (ClF_3) molecule.
    A. Trigonal planar　B. Linear　　　C. T-shaped　　D. tetrahedral

15. What is the shape of the molecule ClF_4^-?
    A. Tetrahedral　　　B. Octahedral　　　C. Square planar　　　　D. Seesaw

16. Which of the following statement is CORRECT?
    A. Orbital means electron density
    B. For orbitals with the same l quantum number (same shape), the larger the orbital, the higher the energy
    C. Experimentally we can measure the shape of an orbital
    D. The 2s and 2p orbitals are degenerate for a carbon atom

17. Referring to the following wavefunction calculated for a particle in a one-dimensional box.
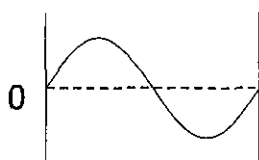
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The probability that a particle will appear in the middle of the box will be

A. 0.5　　　　B. 1.0　　　　C. 0.0　　　　D. 0.25

18. Given that a saturated NaCl solution has a concentration of 5.4 M, which of the following condition will cause NaCl to crystallize?

[NaCl (molar mass 58.44); $NaNO_3$ (molar mass 85.00)]

A. Addition of 1 M $NaNO_3$ solution to 5.4 M NaCl solution.

B. Addition of 10 g of NaCl crystals to 100 ml of 3 M NaCl solution

C. Addition of 6 M $NaNO_3$ solution to saturated NaCl solution

D. Addition of 1.0 g of $NaNO_3$ crystals to 10.0 ml of 4.4 M NaCl solution

19. Calculate the potential for the following cells at 25°C: Cr(s) / Cr^{3+}(0.040 M) // Cr^{3+}(2.0 M) / Cr(s)

A. 0.014 V　　　　B. 0.024 V　　　　C. 0.034 V　　　　D. 0.044 V

20. NO_2 gas will decompose at 573 K. The concentration of NO_2 is measured as a function of time:

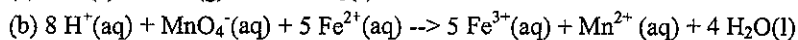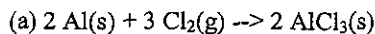| Time, sec	$[NO_2]$, M
0.0	0.01000
50.0	0.00787
100.0	0.00649
200	0.00481
300	0.00380

What is the reaction order with respect to NO_2?

A. Zero order　　　B. First order　　　C. Second order　　　D. Third order

※注意：請於試卷上「非選擇題作答區」依序作答，並應註明作答之大題及小題題號。

Section B (20%)

1. (10 marks) In each of the following chemical reactions, state which substance is oxidized and which is reduced. In addition, state how many electrons (*n*) are involved in the reaction. [Hints: you can write down the half-reaction to deduce *n*]

(a) 2 Al(s) + 3 Cl_2(g) --> 2 $AlCl_3$(s)

(b) 8 H^+(aq) + MnO_4^-(aq) + 5 Fe^{2+}(aq) --> 5 Fe^{3+}(aq) + Mn^{2+} (aq) + 4 H_2O(l)

2. (10 marks) Using standard reduction potentials, calculate the potential for the following cell at 298 K: Zn / Zn^{2+}(aq), 0.1 M // Cu^{2+}(aq), 1.0 M / Cu

Standard reduction potential at 298 K

Zn^{2+}/Zn = -0.76 V;　　　Cu^{2+}/Cu = 0.34 V
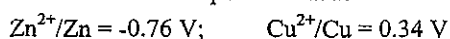
(a) Write down the half-reaction at the anode.

(b) Write down the half-reaction at the cathode.

(c) Using the Nernst equation, calculate the potential of the cell.

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