國立臺灣大學107學年度轉學生招生考試試題

題號： 20
科目：普通化學(A)

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1 H 1.00794																1 H 1.00794	2 He 4.002602
3 Li 6.941	4 Be 9.012182											5 B 10.811	6 C 12.0107	7 N 14.00674	8 O 15.9994	9 F 18.9984032	10 Ne 20.1797
11 Na 22.989770	12 Mg 24.3050											13 Al 26.981538	14 Si 28.0855	15 P 30.973761	16 S 32.066	17 Cl 35.4527	18 Ar 39.948
19 K 39.0983	20 Ca 40.078	21 Sc 44.955910	22 Ti 47.867	23 V 50.9415	24 Cr 51.9961	25 Mn 54.938049	26 Fe 55.845	27 Co 58.933200	28 Ni 58.6934	29 Cu 63.546	30 Zn 65.39	31 Ga 69.723	32 Ge 72.61	33 As 74.92160	34 Se 78.96	35 Br 79.904	36 Kr 83.80
37 Rb 85.4678	38 Sr 87.62	39 Y 88.90585	40 Zr 91.224	41 Nb 92.90638	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.90550	46 Pd 106.42	47 Ag 107.8682	48 Cd 112.411	49 In 114.818	50 Sn 118.710	51 Sb 121.760	52 Te 127.60	53 I 126.90447	54 Xe 131.29
55 Cs 132.90545	56 Ba 137.327	57 La 138.9055	72 Hf 178.49	73 Ta 180.9479	74 W 183.84	75 Re 186.207	76 Os 190.23	77 Ir 192.217	78 Pt 195.078	79 Au 196.96655	80 Hg 200.59	81 Tl 204.3833	82 Pb 207.2	83 Bi 208.98038	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 (266)	110 (269)	111 (272)	112 (277)		114 (289) (287)		116 (289)		118 (293)

本試題含單選題 25 題(75 分)，及三題敘述與計算題(25 分)，總分 100 分

(I). 單選題 (選出一個最適當的答案): 每題 3 分. (答案直接填入 "選擇題作答區" 內)

1. Considering proper number of significant figures, $23.000 \times 2.46 =$
   (A) 56.5800 (B) 56.580 (C) 56.58 (D) 56.6 (E) None of the above
2. A pH meter displays pH=9.1863 for an aqueous solution, and the resolution of the pH meter is ±0.01. What would be the most appropriate number to record the pH of the solution?
   (A) 9.2 (B) 9.19 (C) 9.186 (D) 9.1863 (E) None of the above
3. Which compound has the highest melting point?
   (A) NOCl (B) B_2H_6 (C) Ag_2SO_4 (D) NF_3 (E) CH_3OH
4. What is the chemical formula of sodium hypochlorite?
   (A) NaClO (B) $NaClO_2$ (C) $NaClO_3$ (D) $NaClO_4$ (E) None of the above
5. Hydrogen cyanide is a poisonous gas. The lethal dose is approximately 300 mg per kilogram of air when inhaled. What is the minimal amount of hydrogen cyanide that gives the lethal dose in a small room measuring 3.6x4.6x3.0 m? The density of air at 26 °C is 0.00118 g/cm^3.
   (A) 176 g (B) 17.6 g (C) 1.76 g (D) 0.176 g (E) 0.0176 g
6. Which of the following solution is the most acidic?
   (A) 0.1 *M* HI (B) 1.0 *M* HF (C) 0.1 *M* NH_4NO_3 (D) 1.0 *M* CH_3COOH (E) 1.0 *M* LiOH
7. A diatomic molecule has the valance electron configuration of $(\sigma_{2s})^2(\sigma^*_{2s})^2(\sigma_{2p})^2(\pi_{2p})^4(\pi^*_{2p})^4$. What is the bond order of this molecule?
   (A) 0 (B) 1 (C) 2 (D) 3 (E) 4
8. *meta*-dichlorobenzene can be chlorinated to form trichlorobenzene. How many trichlorobenzene isomers can be formed in this reaction?
   (A) 1 (B) 2 (C) 3 (D) 4 (E) None of the above
9. Acetonitrile (CH_3CN) is a polar organic solvent that dissolves many salts. The density of a 1.80 *M* LiBr solution in acetonitrile is 0.826 g/cm^3. What is the mole fraction of LiBr in this solution?
   (A) 0.497 (B) 0.994 (C) 0.0497 (D) 0.0994 (E) None of the above
10. What is the number of angular nodes in a hydrogen 3*d* orbital?
    (A) 0 (B) 1 (C) 2 (D) 3 (E) None of the above
11. A hydrogen 5*f* orbital has an angular momentum quantum number $l = ?$
    (A) 0 (B) 1 (C) 2 (D) 3 (E) None of the above
12. How many different F-S-F angles exist in the SF_4 molecular structure?
    (A) 1 (B) 2 (C) 3 (D) 4 (E) 5
13. The crystal field stabilization energy (CFSE) for the Ti^{2+} ion in an octahedral complex is
    (A) $-\frac{6}{5}\Delta_o$ (B) $-\frac{4}{5}\Delta_o$ (C) $-\frac{2}{5}\Delta_o$ (D) 0 (E) None of the above

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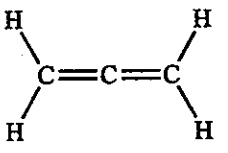
14. The van der Waals equation of gas state is $\left(P+a\frac{n^2}{V^2}\right)(V-nb)=nRT$. What is the coefficient b related to?
(A) Strength of intermolecular interactions (B) Density of gas (C) Temperature (D) Excluded volume of the molecule (E) None of the above
15. What is the number of vibrational modes in the acetone (C_3H_6O) molecule?
(A) 10 (B) 12 (C) 24 (D) 30 (E) None of the above
16. The order of the elementary reaction $CH_3Cl + I^- \rightarrow CH_3I + Cl^-$ is ?
(A) 0 (B) 1 (C) 2 (D) 3 (E) None of the above
17. Suppose a container is initially filled with 0.41 atm nitrogen, 0.59 atm oxygen, and 0.22 atm nitrogen oxide. Consider the gaseous equilibrium:
$N_2(g) + O_2(g) \rightleftharpoons 2\ NO(g)$
At 25°C, the equilibrium constant is 4.2×10^{-31}. What is the partial pressures of nitrogen after equilibrium is reached at 25°C? (R=0.082 $LatmK^{-1}mol^{-1}$).
(A) 0.52 atm (B) 0.70 atm (C) 0.86 atm (D) 3.9×10^{-16} atm (E) None of the above
18. An enzyme catalyzes the reaction $CO_2(g) + H_2O(l) \rightarrow HCO_3^-(aq) + H^+(aq)$. In a buffer solution, without the enzyme, the rate constant of the reaction is measured to be 0.039 s^{-1} at 25°C. In the presence of the enzyme at the same condition, the reaction proceeds with a rate constant of 1.0×10^6 s^{-1}. Assuming the collision factor is the same for both situations, which number below is closest to the value of the activation energy of the catalyzed reaction minus the activation energy of the uncatalyzed reaction at 25°C? (R=8.3 $Jmol^{-1}K^{-1}$)
(A) 21 kJ/mol (B) 42 kJ/mol (C) -7.4 kJ/mol (D) -21 kJ/mol (E) -42 kJ/mol
19. A student prepared a 0.10 *M* solution of formic acid and found its pH at 25°C to be 2.38. What is the K_a for formic acid at this temperature?
(A) 1.8×10^{-4} (B) 1.8×10^{-5} (C) 1.8×10^{-6} (D) 1.8×10^{-7} (E) None of the above
20. A student prepared a 0.50 *M* aqueous solution of CH_3NH_3Br and measured its pH. Which number should be the closest to the pH value?
(A) 1 (B) 4 (C) 7 (D) 10 (E) 14
21. A solution contains 1.0×10^{-2} *M* Ag^+, and 2.0×10^{-2} *M* Pb^{2+}. When Cl^- is added, both AgCl ($K_{sp}=1.8\times10^{-10}$) and $PbCl_2$ ($K_{sp}=1.7\times10^{-5}$) can precipitate. In the numbers listed below, what is the lowest concentration of Cl^- that could begin the precipitation?
(A) 3.0×10^{-2} *M* (B) 3.0×10^{-4} *M* (C) 3.0×10^{-6} *M* (D) 3.0×10^{-8} *M* (E) 3.0×10^{-10} *M*
22. Consider the following equation (**a** – **f** are coefficients):
a $Cr_2O_7^{2-}(aq)$ + **b** $H^+(aq)$ + **c** $I^-(aq) \rightarrow$ **d** $Cr^{3+}(aq)$ + **e** $I_2(s)$ + **f** $H_2O(l)$
If we set **a**=1 and balance the equation, what is the value of **e**+**f** in the balanced equation?
(A) 6 (B) 7 (C) 8 (D) 9 (E) 10
23. What is the oxidation number of the metal in $Ir(NH_3)_4Cl_2NO_3$?
(A) +1 (B) +2 (C) +3 (D) +4 (E) None of the above
24. Which complex below is the one with a *d-d* transition that absorbs photons with the highest energy?
(A) $[CrF_6]^{3-}$ (B) $[Cr(Cl)_6]^{3-}$ (C) $[Cr(CN)_6]^{3+}$ (D) $[Cr(NH_3)_6]^{3+}$ (E) $[Cr(H_2O)_6]^{3+}$
25. The chemical formula of dimethyl ether is?
(A) CHOCH (B) CH_3COOH (C) CH_3CH_2OH (D) CH_3OCH_3 (E) CH_3COCH_3

(I). 敘述與計算題 (共 25 分): **請於試卷上「非選擇題作答區」標明題號並依序作答。**

26. Allene is an interesting organic compound with the Lewis structure shown on the right. Answer the following questions.
(26A) (2%) Indicate the hybridization of each carbon atom in the allene structure.
(26B) (2%) Is the molecule planar? Draw the 3D structure formula for allene.
(26C) (2%) Does allene has a π-conjugated system? Explain your answer.



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27. Consider a hypothetical reaction with three elementary steps:

$$A+B \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} C \text{ (slow)}$$

$$C \underset{k_{-2}}{\overset{k_2}{\rightleftharpoons}} D \text{ (slowest)}$$

$$D \xrightarrow{k_3} E \text{ (fast)}$$

The rate constants: $k_1 > k_{-1}$, $k_2 < k_{-2}$. In equilibrium, the reaction almost completely forms compound D.

(27A) (5%) Sketch a reaction profile (potential energy as a function of reaction progress) that describes the mechanism. You must be qualitatively accurate on the relative energies.

(27B) (5%) Derive a rate law for the overall reaction in terms of [A] and [B] when excess B is present in the system. You must clearly state the approximations you made in the derivation.

28. A phase transition A→B has a ΔH of -38.4 kJ/mol, and the ΔS is -75.5 $JK^{-1}mol^{-1}$ at the standard condition. Assume those numbers are temperature independent. Answer the following questions:

(28A) (3%) Does the transition lead to a more ordered phase? Explain your answer.

(28B) (3%) Calculate the standard reaction Gibbs free energy for the reaction at 298K. Is the reaction spontaneous at 298K under standard conditions?

(28C) (3%) Estimate the temperature that this phase transition would occur under standard conditions.