國立彰化師範大學 97 學年度博士班招生考試試題

系所：科學教育研究所　　組別：丙組　　科目：基礎化學

☆☆請在答案紙上作答☆☆　　

A. 單選題 (60%)

1. If the Thomson model of the atom had been correct, Rutherford would have observed
   (A) alpha particles going through the foil with little or no deflection.
   (B) alpha particles greatly deflected by the metal foil.
   (C) alpha particles bouncing off the foil.
   (D) positive particles formed in the foil.
   (E) None of the above observations is consistent with the Thomson model of the atom.
2. The average mass of a carbon atom is 12.011. Assuming you were able to pick up only one carbon unit, the chances that you would randomly get one with a mass of 12.011 is
   (A) 0%. (B) 0.011%. (C) about 12%. (D) 12.011%. (E) greater than 50%.
3. The limiting reactant in a reaction
   (A) has the lowest coefficient in a balanced equation.
   (B) is the reactant for which you have the fewest number of moles.
   (C) has the lowest ratio of moles available/coefficient in the balanced equation.
   (D) has the lowest ratio of coefficient in the balanced equation/moles available.
   (E) none of these.
4. A 0.307-g sample of an unknown triprotic acid is titrated to the third equivalence point using 35.2 mL of 0.106 M NaOH. Calculate the molar mass of the acid.
   (A) 247 g/mol (B) 171 g/mol (C) 165 g/mol (D) 151 g/mol (E) 82.7 g/mol
5. How many electrons in an atom can have the quantum numbers $n = 3$, $l = 2$?
   (A) 2 (B) 5 (C) 10 (D) 18 (E) 6
6. On a planet where the temperature is so high, the ground state of an electron in the hydrogen atom is $n = 4$. What is the ratio of IE on this planet compared to earth?
   (A) 1 : 4 (B) 4 : 1 (C) 1 : 16 (D) 16 : 1 (E) 1 : 1
7. Which one of the following statements is *false*?
   (A) The change in internal energy, ΔE, for a process is equal to the amount of heat absorbed at constant volume, q_v.
   (B) The change in enthalpy, ΔH, for a process is equal to the amount of heat absorbed at constant pressure, q_p.
   (C) A bomb calorimeter measures ΔH directly.
   (D) If q_p for a process is negative, the process is exothermic.
   (E) The freezing of water is an example of an exothermic reaction.

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8. Consider the following gas samples:

Sample A	**Sample B**
$S_2(g)$	$O_2(g)$
n = 1 mol	n = 2 mol
T = 800 K	T = 400 K
P = 0.20 atm	P = 0.40 atm

Which one of the following statements is *false*?

(A) The volume of sample A is twice the volume of sample B.

(B) The average kinetic energy of the molecules in sample A is twice the average kinetic energy of the molecules in sample B.

(C) The fraction of molecules in sample A having a kinetic energy greater than some high fixed value is larger than the fraction of molecules in sample B having kinetic energies greater than that same high fixed value.

(D) The mean square velocity of molecules in sample A is twice as large as the mean square velocity of molecules in sample B.

(E) Assuming identical intermolecular forces in the two samples, sample A should be more nearly ideal than sample B.

9. What type of structure does the $XeOF_2$ molecule have?

(A) pyramidal (B) tetrahedral (C) T-shaped (D) trigonal planar (E) octahedral

10. Which of the following molecules has a bond order of 1.5?

(A)O_2^+ (B) N_2 (C) O_2^- (D) C_2 (E) none of these

11. If a molecule demonstrates paramagnetism, then

I. the substance can have both paired and unpaired electrons.

II. the bond order is not a whole number.

III. it can be determined by drawing a Lewis structure.

IV. it must be an ion.

(A) I, II (B) I, II, IV (C) II, III (D) I only (E) all of the above are correct

12. Ammonia is prepared industrially by the reaction: $N_2(g) + 3H_2(g) \leftrightarrow 2NH_3(g)$. For this reaction, ΔH^o = -92.2 kJ and K (at 25°C) = 4.0×10^8. When the temperature of the reaction is increased to 500°C, which of the following is true?

(A) K for the reaction will be larger at 500°C than at 25°C.

(B) At equilibrium, more NH_3 is present at 500°C than at 25°C.

(C) Product formation (at equilibrium) is not favored as the temperature is raised.

(D) The reaction of N_2 with H_2 to form ammonia is endothermic.

(E) None of the above is true.

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13. As water is heated, its pH decreases. This means that
    (A) The water is no longer neutral.
    (B) The K_w value is decreasing.
    (C) The water has a lower [OH^-] than cooler water.
    (D) The dissociation of water is an endothermic process.
    (E) None of these.
14. Which of the following solutions will be the best buffer at a pH of 9.26? (K_a for $HC_2H_3O_2$ is 1.8×10^{-5}, K_b for NH_3 is 1.8×10^{-5}).
    (A) 0.10 *M* $HC_2H_3O_2$ and 0.10 *M* $NaC_2H_3O_2$
    (B) 5.0 *M* $HC_2H_3O_2$ and 5.0 *M* $NaC_2H_3O_2$
    (C) 0.10 *M* NH_3 and 0.10 *M* NH_4Cl
    (D) 5.0 *M* NH_3 and 5.0 *M* NH_4Cl
    (E) 5.0 *M* $HC_2H_3O_2$ and 5.0 *M* NH_3
15. Given the following K_{sp} values: $PbCrO_4$, 2.0×10^{-16}; $Pb(OH)_2$, 1.2×10^{-15}; $Zn(OH)_2$, 4.5×10^{-17}; MnS, 2.3×10^{-13}, which statement about solubility in mol/L in water is correct?
    (A) $PbCrO_4$, $Zn(OH)_2$ and $Pb(OH)_2$ have equal solubility in water.
    (B) $PbCrO_4$ has the lowest solubility in water.
    (C) The solubility of MnS in water will not be pH dependent.
    (D) MnS has the highest molar solubility in water.
    (E) A saturated $PbCrO_4$ solution will have a higher [Pb^{2+}] than a saturated $Pb(OH)_2$ solution.

B. 計算與簡答 (40%)

1. Predict which of the following substances are likely to be soluble in water. (6%)
    (a) aluminum nitrate　　(b) magnesium chloride
    (c) nickel(II) hydroxide　　(d) lead(II) sulfide
    (e) magnesium hydroxide　　(f) iron(III) phosphate

2. Balance each of the following equations. (4% each)
    (a) $NO_2^-(aq) + Al(s) \rightarrow NH_3(g) + AlO_2^-(aq)$　　(in basic solution)
    (b) $NaCl(aq) + H_2SO_4(aq) + MnO_2(s) \rightarrow Na_2SO_4(aq) + MnCl_2(aq) + Cl_2(g) + H_2O(l)$

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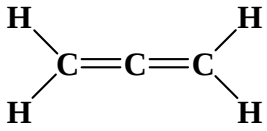
3. Rationalize the following lattice energy values: (5%)

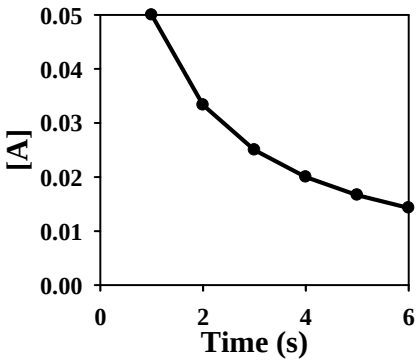
Compound	Lattice Energy (kJ/mol)
CaSe	-2862
Na_2Se	-2130
CaTe	-2721
Na_2Te	-2095

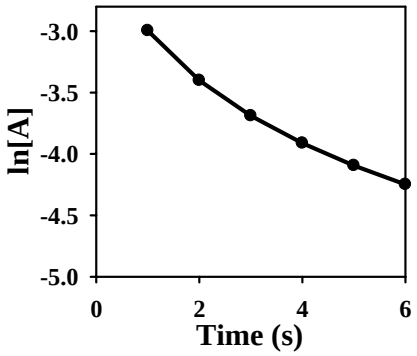
4. The allene molecule has the following Lewis structure:

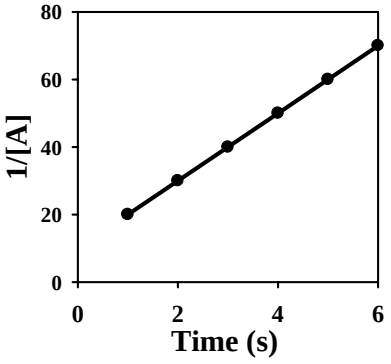


Are all hydrogen atoms in the same plane? Please explain your answer. **(5%)**

5. Experiment data for the reaction A → 2B + C have been plotted in the following three different ways (with concentration units in mol/L): **(8%)**







(a) What is the order of the reaction with respect to A and what is the initial concentration of A?

(b) What is the concentration of A after 9 s?

6. Place the species in each of the following groups in order of increasing acid strength. **(8%)**

(a) H_2O, H_2S, H_2Se (bond energies: H-O, 467 kJ/mol; H-S, 363 kJ/mol; H-Se, 276 kJ/mol)

(b) CH_3CO_2H, FCH_2CO_2H, F_2CHCO_2H, F_3CCO_2H

Give reasons for the orders you chose.