

國立清華大學命題紙

99 學年度 生醫工程與環境科學系 乙組(環境分子科學組) 碩士班入學考試

科目 普通化學 科目代碼 2401 共 6 頁第 1 頁 *請在【答案卷卡】內作答

(I) Multiple Choices. Please choose the one alternative that best answers the question. (50%, 2% of each)

- The element oxygen consists of three naturally occurring isotopes: ^{16}O , ^{17}O , and ^{18}O . The atomic mass of oxygen is 16.0 amu. What can be implied about the relative abundances of these isotopes?
(a) More than 50% of all O atoms are ^{17}O . (b) Almost all O atoms are ^{18}O .
(c) Almost all O atoms are ^{17}O . (d) The isotopes all have the same abundance.
(e) The abundances of ^{17}O and ^{18}O are very small.
- A 1.375 g sample of mannitol, a sugar found in seaweed, is burned completely in oxygen to give 1.993 g of carbon dioxide and 0.9519 g of water. The empirical formula of mannitol is
(a) CHO (b) CH_7O_3 (c) $\text{C}_3\text{H}_2\text{O}$ (d) $\text{C}_3\text{H}_7\text{O}_3$ (e) CH_2O
- How many molecules of N_2 gas can be present in a 2.5 L flask at 50°C and 650 mmHg?
(a) 2.1×10^{-23} molecules (b) 4.9×10^{22} molecules (c) 3.1×10^{23} molecules
(d) 3.6×10^{25} molecules (e) 0.081 molecules
- Chlorine gas can be prepared in the laboratory by the reaction of solid manganese dioxide with hydrochloric acid. (The other reaction products are aqueous manganese chloride and water.) How much MnO_2 should be added to excess HCl to obtain 275 mL of chlorine gas at 5.0°C and 650 mmHg?
(a) 1.18×10^{-4} g (b) 0.896 g (c) 1.22 g (d) 49.8 g (e) 8,440 g
- Based on the solubility rules, which of the following will occur when solutions of $\text{ZnSO}_4(\text{aq})$ and $\text{MgCl}_2(\text{aq})$ are mixed?
(a) ZnCl_2 will precipitate; Mg^{2+} and SO_4^{2-} will be spectator ions.
(b) ZnSO_4 will precipitate; Mg^{2+} and Cl^- will be spectator ions.
(c) MgSO_4 will precipitate; Zn^{2+} and Cl^- will be spectator ions.
(d) MgCl_2 will precipitate; Zn^{2+} and SO_4^{2-} will be spectator ions.
(e) No precipitate will form.
- Which of the following equations does *not* represent an oxidation-reduction reaction?
(a) $3\text{Al} + 6\text{HCl} \rightarrow 3\text{H}_2 + \text{AlCl}_3$ (b) $2\text{H}_2\text{O} \rightarrow 2\text{H}_2 + \text{O}_2$
(c) $2\text{NaCl} + \text{Pb}(\text{NO}_3)_2 \rightarrow \text{PbCl}_2 + 3\text{NaNO}_3$ (d) $2\text{NaI} + \text{Br}_2 \rightarrow 2\text{NaBr} + \text{I}_2$
(e) $\text{Cu}(\text{NO}_3)_2 + \text{Zn} \rightarrow \text{Zn}(\text{NO}_3)_2 + \text{Cu}$

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科目 普通化學 科目代碼 2401 共 6 頁第 2 頁 *請在【答案卷卡】內作答

7. In the following chemical reaction the *oxidizing agent* is
$$5S + 6KNO_3 + 2CaCO_3 \rightarrow 3K_2SO_4 + 2CaSO_4 + CO_2 + 3N_2$$

(a) S (b) N_2 (c) KNO_3 (d) $CaSO_4$ (e) $CaCO_3$
8. When 38.0 mL of 0.1250 M H_2SO_4 is added to 100.0 mL of a solution of PbI_2 , a precipitate of $PbSO_4$ forms. The $PbSO_4$ is then filtered from the solution, dried, and weighed. If the recovered $PbSO_4$ is found to have a mass of 0.0471 g, what was the concentration of iodide ions in the original solution?
(a) 3.10×10^{-4} M (b) 1.55×10^{-4} M (c) 6.20×10^{-3} M (d) 3.11×10^{-3} M (e) 1.55×10^{-3} M
9. The octane value of gasoline refers to its
(a) percentage C_8H_{18} by volume. (b) radiation dose. (c) alcohol level.
(d) ability to resist engine knocking. (e) percentage of unsaturated hydrocarbons.
10. Which one of the following statements about fission and fusion is *false*?
(a) Fission occurs among the heaviest isotopes, whereas fusion occurs more readily for light isotopes.
(b) For a fission reaction the mass defect (Δm) is negative, whereas for fusion Δm is positive.
(c) In order for fusion reactions to occur, temperatures must be in the millions of degrees.
(d) The fission of Pu-239 atoms produces a great number of isotopes of a large number of elements.
(e) Neutron-induced fission processes can occur at room temperature, rather than at millions of degrees.
11. 5.00 g of hydrogen gas and 50.0 g of oxygen gas are introduced into an otherwise empty 9.00 L steel cylinder, and the hydrogen is ignited by an electric spark. If the reaction product is gaseous water and the temperature of the cylinder is maintained at 35°C, what is the final gas pressure inside the cylinder?
(a) 7.86 atm (b) 18.3 atm (c) 2.58 atm (d) 6.96 atm (e) 0.92 atm
12. When photons with a wavelength of 310.0 nm strike a magnesium plate, the maximum velocity of the ejected electrons is 3.45×10^5 m/s. Calculate the binding energy of electrons to the magnesium surface.
(a) 386 kJ/mol (b) 419 kJ/mol (c) 32.7 kJ/mol (d) 321 kJ/mol (e) 353 kJ/mol
13. The Lewis structure for a chlorate ion, ClO_3^- , should show _____ single bond(s), _____ double bond(s), and _____ lone pair(s).
(a) 2, 1, 10 (b) 3, 0, 9 (c) 2, 1, 8 (d) 3, 0, 10 (e) 2, 1, 9

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科目 普通化學 科目代碼 2401 共 6 頁第 3 頁 *請在【答案卷卡】內作答

14. The azide ion, N_3^- , is very reactive although it is isoelectronic with the very stable CO_2 molecule. This reactivity is reasonable inasmuch as
- a Lewis structure cannot be written for the azide ion that has nitrogen formal charges of zero.
 - there is no valid Lewis structure possible for the azide ion.
 - there are resonance structures for azide ion but not for carbon dioxide.
 - nitrogen cannot form multiple bonds.
 - charged species always decompose in solution.
15. Silver metal crystallizes in a face-centered cubic lattice with L as the length of one edge of the unit cube. The center-to-center distance between nearest silver atoms is
- $L/2$
 - $2^{1/2}L$
 - $2L$
 - $L/2^{1/2}$
 - None of the above.
16. At $10^\circ C$ one volume of water dissolves 3.10 volumes of chlorine gas at 1.00 atm pressure. What is the Henry's Law constant in mol/L·atm?
- 3.8
 - 0.043
 - 36
 - 3.1
 - 0.13
17. Nitric oxide reacts with chlorine to form nitrosyl chloride, $NOCl$. Use the following data to determine the rate equation for the reaction.



Expt. #	[NO]	[Cl ₂]	Initial Rate
1	0.22	0.065	0.96 M/min
2	0.66	0.065	8.6 M/min
3	0.44	0.032	1.9 M/min

- rate = $k[NO]$
- rate = $k[NO][Cl_2]^{1/2}$
- rate = $k[NO][Cl_2]$
- rate = $k[NO]^2[Cl_2]$
- rate = $k[NO]^2[Cl_2]^2$

18. The isomerization of cyclopropane follows first order kinetics. The rate constant at 700 K is $6.20 \times 10^{-4} \text{ min}^{-1}$, and the half-life at 760 K is 29.0 min. Calculate the activation energy for this reaction.
- 5.07 kJ/mol
 - 27.0 kJ/mol
 - 50.7 kJ/mol
 - 160 kJ/mol
 - 270 kJ/mol

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科目 普通化學 科目代碼 2401 共 6 頁第 4 頁 *請在【答案卷卡】內作答

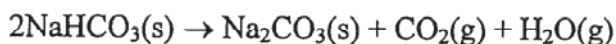
19. At a particular temperature the first-order gas-phase reaction $\text{N}_2\text{O}_5 \rightarrow 2\text{NO}_2 + (1/2)\text{O}_2$ has a half-life for the disappearance of dinitrogen pentoxide of 5130 s. Suppose 0.450 atm of N_2O_5 is introduced into an evacuated 2.00 L flask. What will be the total gas pressure inside the flask after 3.00 hours?

- (a) 0.969 atm (b) 0.105 atm (c) 0.795 atm (d) 1.14 atm (e) 0.864 atm

20. What is the pH of a solution prepared by mixing 50.0 mL of 0.300 M HCl with 450.0 mL of 0.400 M HIO_3 ? [$K_a(\text{HIO}_3) = 1.6 \times 10^{-1}$]

- (a) 1.52 (b) 0.80 (c) 0.72 (d) 0.89 (e) 0.66

21. Sodium carbonate can be made by heating sodium bicarbonate:



Given that $\Delta H^\circ = 128.9 \text{ kJ/mol}$ and $\Delta G^\circ = 33.1 \text{ kJ/mol}$ at 25°C , above what minimum temperature will the reaction become spontaneous under standard state conditions?

- (a) 0.4 K (b) 3.9 K (c) 321 K (d) 401 K (e) 525 K

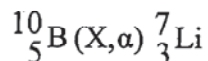
22. Under standard-state conditions, which of the following half-reactions occurs at the cathode during the electrolysis of aqueous nickel sulfate at 25°C ?

- (a) $2\text{H}_2\text{O} \rightarrow \text{O}_2 + 4\text{H}^+ + 4\text{e}^-$ (b) $\text{Ni}^{2+} + 2\text{e}^- \rightarrow \text{Ni}$ (c) $2\text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{H}_2 + 2\text{OH}^-$
 (d) $\text{Ni} \rightarrow \text{Ni}^{2+} + 2\text{e}^-$ (e) none of these

23. Which of the following complex ions would absorb light with the *longest* wavelength?

- (a) $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$ (b) $[\text{Co}(\text{NH}_3)_6]^{2+}$ (c) $[\text{CoF}_6]^{4-}$ (d) $[\text{Co}(\text{CN})_6]^{4-}$ (e) $[\text{Co}(\text{en})_6]^{2+}$

24. In the following reaction, identify X.



- (a) α (b) n (c) p (d) ${}^0_{+1}\text{e}$ (e) β

25. Which is the product of the reaction of one mole of HCl with one mole of 1-butyne?

- (a) 1-chloro-1-butene (b) 1-chloro-2-butene (c) 2-chloro-1-butene
 (d) ethyl chloride + acetylene (e) 1-chloro-butadiene

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(II) Complete this paragraph with the words and phrases that follow. (13%)

All acids have certain properties in common. When dissolved in water they produce a _____ taste, they turn _____ from blue to red, and they react with metals such as iron and _____ to liberate _____. Water solutions of bases, on the other hand, taste _____, turn litmus from _____ to _____, and produce a _____ sensation when rubbed between the fingers. As long as we are dealing with water solutions of these substances, we can use the _____ definition of an acid and a base, which states that an acid is any substance that releases _____, while a base is any substance that releases _____. The _____ definition eliminates the need for water in the definition by defining acid-base reactions in terms of a _____ from an acid to base, regardless of solvent.

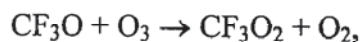
(III) Tritium is a radioisotope of hydrogen and has a half-life of 12.3 years. If you initially had 1.0×10^{-7} mole of tritium, please

- calculate the decay rate of the sample. (3%)
- how many moles of tritium would be left after 78 years? (3%)

(IV) For the reaction $3\text{H}_2(\text{g}) + \text{N}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g})$, $K_c = 9.0$ at 350°C .

- Calculate K_p . (2%)
- Calculate ΔG° at 350°C . (2%)
- What is ΔG at this temperature when 1.0 mol NH_3 , 5.0 mol N_2 , and 5.0 mol H_2 are mixed in a 2.5 L reactor? (2%)
- In what direction does the reaction proceed under the conditions in part c? (2%)

(V) An unusual atmospheric reaction leading to ozone destruction is



the analysis of which has yielded an Arrhenius frequency factor (A) and activation energy of $2.0 \times 10^{-12} \text{ cm}^3 \text{ molecule}^{-1} \text{ s}^{-1}$ and 11.6 kJ/mol, respectively. Calculate the rate constant for this reaction at an altitude of 35 km, where the temperature is -34°C . (6%)

(VI) The base ionization constant for NH_3 is 1.8×10^{-5} at 25°C .

- Determine the hydroxide ion concentration and the percentage ionization of a 0.150 M solution of ammonia at 25°C . (3%)
- Determine the pH of a solution prepared by adding 0.005 mol of proton to the solution in part (a)? (3%)

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- (VII) Potassium bromide, KBr, crystallizes like NaCl in a face-centered lattice. The ionic radii of K^+ and Br^- ions are 133 pm and 195 pm, respectively. Assuming that all Br^- ions are positioned in the face and corners of the unit cell, while the K^+ ions are positioned along the edge alternating between anions, calculate the length of a unit cell edge. (5%)
- (VIII) Explain how the number of protons and neutrons in a radioactive nucleus can be used to predict its probable mode of decay. Illustrate your answer with a schematic graph, properly labeled, showing stable nuclides (nuclei) in relation to number of protons and neutrons. (6%)