

1. The compound MSG is commonly used in cooking as a flavor enhancer.
- (a) (5 marks). From elemental analysis, it is found that MSG contains the following mass distribution: carbon (35.00%), hydrogen (4.69%), nitrogen (8.16%), oxygen (38.57%), sodium (13.52%). Find the empirical formula of MSG.
[Molar mass information (g/mol): carbon 12.01, hydrogen 1.01, nitrogen 14.01, oxygen 16.00, sodium 23.00]
- (b) (5 marks) By mass spectrometry, we find that MSG has a molar mass of 187.127 g/mol. Deduce the molecular formula of MSG. Explain why the result of mass spectrometry is somewhat different from what you expected from your molecular formula.
- (c) (5 marks) By infrared spectroscopy, we can show that MSG contains carboxylate and amine groups. Write down three different structural formulae possible for MSG.
- (d) (5 marks) Describe two experimental methods to determine the correct structural formula for MSG.

2.

- (a) (5 marks) For an aqueous solution containing 3.59 mM of SO_2 , what is the concentration of SO_2 in ppm? [Molar mass of sulfur is 32.065 g/mol]
- (b) (5 marks) Explain the physical origin of the octet rule using the concepts in quantum mechanics. [You just need to consider the outermost shell of Ne as an example].
- (c) (5 marks) Explain the following trend of electron affinity for halogens:
F, -327.8 kJ/mol; Cl, -348.7 kJ/mol;
Br, -324.5 kJ/mol; I, -295.2 kJ/mol
- (d) (5 marks) Draw the molecular orbital (MO) diagram of O_2 . Do you think the bond length of O_2^- is longer, shorter, or identical to O_2 ? Explain your answer.

3.

The equilibrium constants of pure water at different temperatures are given on the right.

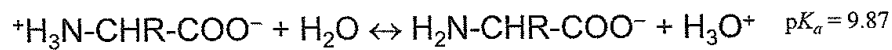
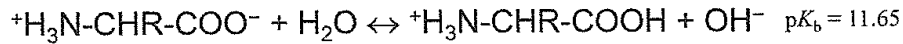
T (°C)	K_w ($\text{mol}^2 \text{dm}^{-6}$)
0	0.11×10^{-14}
10	0.29×10^{-14}
20	0.68×10^{-14}
25	1.0×10^{-14}
30	1.5×10^{-14}
40	2.9×10^{-14}
50	5.5×10^{-14}
100	5.1×10^{-13}

- (a) (5 marks) Determine the neutral pH for water at 100 °C. Explain whether a pH value of 6.5 at 100 °C is acidic or alkaline.

見背面

(b) (10 marks) Calculate the pH of a 0.050 M aqueous solution of alanine.

Hints: the structural formula of alanine in water is $^+H_3N-CH(R)-COO^-$, where R = CH_3 .



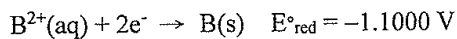
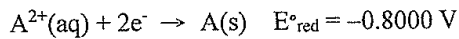
(c) (5 marks) Explain whether the pK_a of alanine is smaller or larger in blood than in pure water.

4.

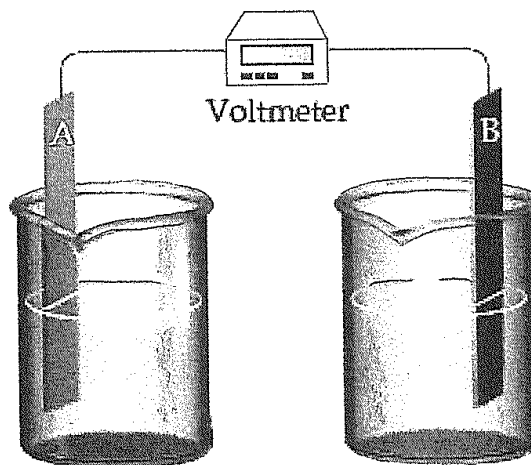
(a) (5 marks) The major inorganic species in shark teeth is known as fluorapatite (FAP) with the formula of $Ca_5(PO_4)_3F$. If some of the "PO₄" ions are substituted by carbonate ions, will the amount of Ca^{2+} ions per FAP unit increase, decrease, or remain the same? Explain why.

(b) (5 marks) Consider the substituted FAP compound with a formula of $Ca_y(PO_4)_{3-x}(CO_3)_xF$. Experimentally it is found that the ratio of $Ca/P = 1.70$. Determine x and y .

5. Assume that you want to construct a voltaic cell that uses the following half-reactions:



You begin with the incomplete cell pictured here in which the electrodes are immersed in pure water.

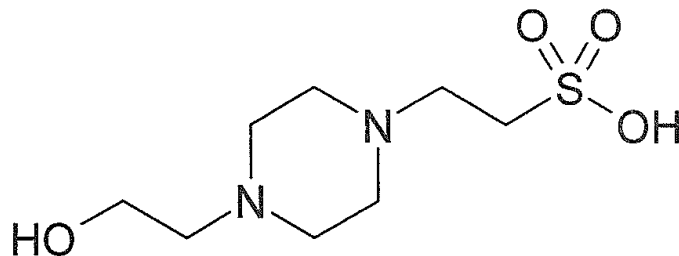


接次頁

- (a) (3 marks) What additions must you make to the cell for it to generate a standard emf?
- (b) (1 mark) Which electrode functions as the cathode?
- (c) (6 marks) Calculate the standard emf, calculate ΔG° at 298.0 K, and calculate the equilibrium constant K_{eq} at 298 K for this reaction.

6.

HEPES is widely used as a buffer in biology and it has the following formula.



- (a) (10 marks) HEPES is known to form zwitterionic ions at neutral pH. Write down the zwitterionic form of HEPES and provide two chemical reasons to justify your answer.
- (b) (5 marks) HEPES has $pK_{a1} = 3.0$ and $pK_{a2} = 7.5$. Write down the chemical reaction relevant to the buffering capacity of HEPES.
- (c) (5 marks) HEPES is commercially available as a sodium salt. After solubilizing some sodium HEPES in water, should you add acid or base to prepare a buffer at 7.40?

試題隨卷繳回