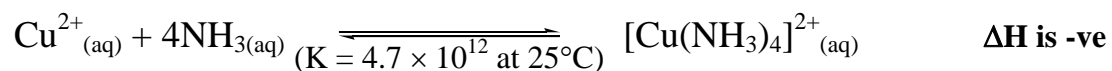


CHEM 121 TEST B

Question 1 (6 marks)

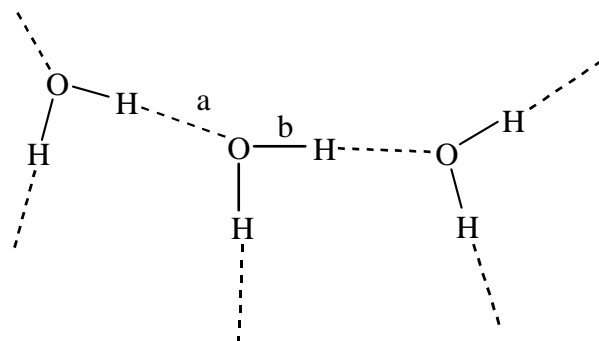
In the equilibrium below, pale blue aqueous copper ions react with colourless ammonia to produce a deep blue complex ion.



- (a) What would you expect to observe and what would be the effect on the value of K (if any) if the ammonia concentration was increased in the equilibrium system?
- (b) What would be the effect on the complex ion concentration if the temperature was increased and how (if at all) would the value of K be affected?
- (c) What does the magnitude of the equilibrium constant indicate about the stability of the complex relative to the reactants?

Question 2 (6 marks)

(a) The diagram shows some molecules in a sample of liquid water.

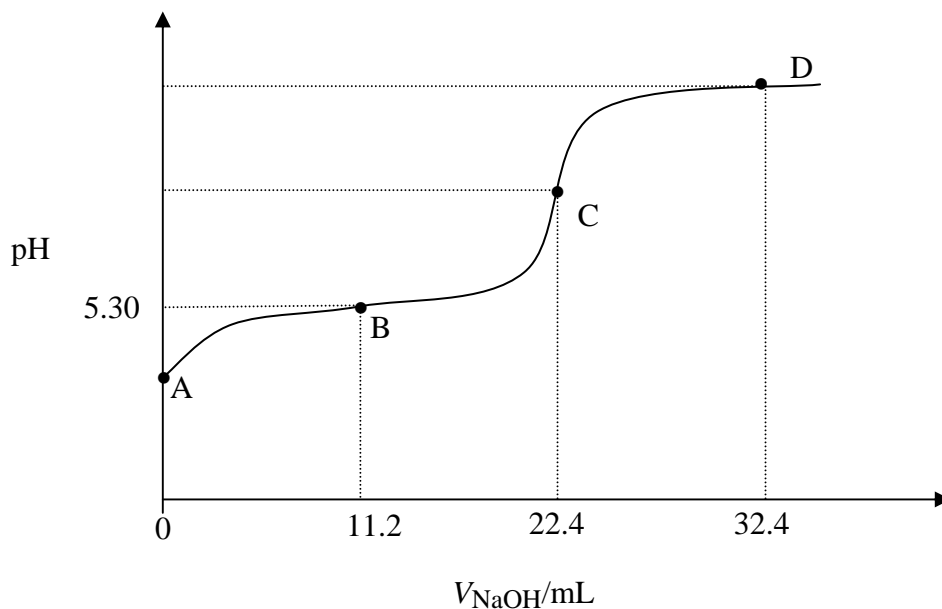


Choose the letter (a or b) that shows:

- (i) an intermolecular bond _____
- (ii) a hydrogen bond _____
- (iii) a covalent bond _____
- (iv) a bond which is broken during boiling _____

(b) Explain, using diagrams if necessary, why ice is less dense than water.

Question 3 (7 marks)



The figure above shows the titration curve obtained (using a pH meter) when a 20.0 mL sample of a solution of weak acid, HA, of unknown concentration, [HA] is titrated with standardised NaOH solution. The NaOH solution has a concentration of 0.110 mol L^{-1} and V_{NaOH} represents the volume in mL of NaOH which has been added. [Data: $K_w = 1.00 \times 10^{-14}$.]

- (a) **On the figure above**, clearly indicate and label the following:
- (i) the equivalence point
 - (ii) a buffer region
- (b) Using the results of the titration and the information provided calculate the concentration of the acid, HA.

(c) Using the given pH value for the solution at point B (5.30), calculate K_a (the acid ionisation constant) for HA.

(d) What is the pH at point A?

(e) The endpoint of this titration could be detected using an indicator. Of the indicators listed below, which would be the most suitable? **Explain the reason for your choice.**

Indicator	pK_a (indicator)
Lacmoid	5.3
Brilliant yellow	7.2
<i>o</i> -Cresolphthalein	9.0
2,4,6-Trinitrotoluene	12.3

Question 4 (15 marks)

- (a) For the combustion of methane (reaction (1)), use the provided thermodynamic data to calculate the ΔH° and ΔS° at 298 K. ($R = 8.314 \text{ J mol}^{-1} \text{ K}^{-1}$)



	$\Delta H^\circ_f / \text{kJ mol}^{-1}$	$\Delta S^\circ / \text{J K}^{-1} \text{ mol}^{-1}$
CH ₄ (g)	-74.9	186.2
CO ₂ (g)	-393.5	213.6
H ₂ O(l)	-285.8	69.9

- (b) From your answer in (a), calculate ΔG° for reaction (1). (If you were unable to obtain answers for (a),

use the **incorrect** values $\Delta H^\circ = -900 \text{ kJ mol}^{-1}$ and $\Delta S^\circ = -250 \text{ J mol}^{-1} \text{ K}^{-1}$)

(c) From your answer in (b), calculate K (the thermodynamic equilibrium constant) for reaction (1) at 298 K. (If you were unable to obtain an answer for (b), use the **incorrect** value $\Delta G^\circ = 100 \text{ kJ mol}^{-1}$)

(d) What do you understand a spontaneous reaction to be? From your calculations, explain whether reaction (1) is spontaneous as written or not.

(d) Calculate K

END OF PAPER