

Full Name:

Student ID #:

UNIVERSITY OF CANTERBURY

Mid Year Examination 2006

Prescription Number(s): CHEM 114

Paper Title: Introductory Chemistry

Time Allowed: TWO HOURS

Number of pages: 17

Before commencing work, read the instructions on this page.

1. This is both your examination paper and your answer book. You may use the blank page opposite for any additional working pertaining to that question.
2. Please ensure that your name and student ID# have been entered in the appropriate spaces above.
3. ANSWER ALL QUESTIONS.

Total marks = 110: you should allocate 1 minute per mark. Allow 10 minutes for reading time and checking time.

NOTE: There is a periodic table on p17.

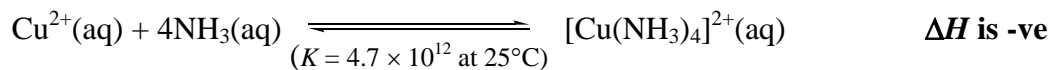
Please write your answers in the spaces provided

For examiners use only

1	2	3-4	5	6-11	Total
/15	/19	/18	/18	/40	/110

1. (15 marks)

- (a) In the equilibrium below, aqueous copper ions react with ammonia to produce a deep blue complex ion.



- (i) 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?
- (ii) 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?
- (iii) What does the magnitude of the equilibrium constant indicate about the stability of the complex relative to the reactants?

Question 1 continued on the following page

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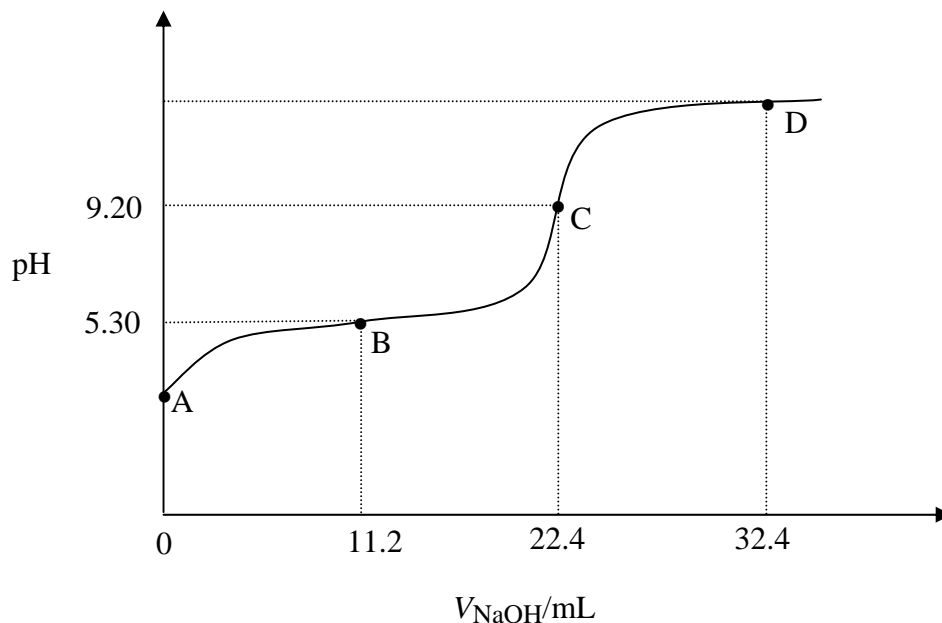
Question 1 continued

- (b) Hydrogen can be obtained from the reaction of methane with steam over a nickel catalyst. The equation for this reaction is:



- (i) Write an expression for the equilibrium constant, K , for this reaction.
- (ii) How would the **value** of K be affected by the addition of more methane at constant temperature?
- (iii) How will the **amount of hydrogen** present at equilibrium be affected if the total pressure of the system is increased, by decreasing the volume of the container, at constant temperature. Explain.

2. (19 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) What pieces of laboratory equipment would be used to measure out:

- (i) the volume of HA solution?
- (ii) the added volume of NaOH, V_{NaOH} ?

(b) **On the figure above**, clearly indicate and label the following:

- (i) the equivalence point;
- (ii) a buffer region.

Question 2 continued on the following page

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Question 2 continued

- (c) Using the results of the titration and the information provided, calculate the concentration of the acid, HA.
- (d) Using the given pH value for the solution at point B (5.30), calculate K_a (the acid ionisation constant) for HA.
- (e) What is the pH at point A?

Question 2 continued on the following page

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Question 2 continued

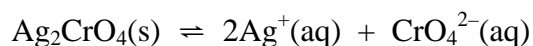
- (f) The endpoint of this titration could be detected using an indicator. Of the indicators listed below, which would be the most suitable? **Explain the reason for your choice.**

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

- (g) Explain the difference between a strong acid and a weak acid. Use equations to illustrate your answer.

3. (8 marks)

(a) Silver chromate dissolves sparingly in water as follows:



- (i) Give an expression for the solubility product, K_{sp} , in terms of the concentrations of the species involved.
- (ii) When silver chromate dissolves in water, what is the value of K_{sp} in terms of s , where s is the equilibrium value of $[\text{CrO}_4^{2-}]$?
- (iii) Given that $K_{\text{sp}} = 1.9 \times 10^{-12}$, calculate the concentration of silver ions in a saturated aqueous solution of silver chromate.
- (b) If a solution of silver nitrate ($7.00 \times 10^{-4} \text{ mol L}^{-1}$) were mixed with an equal volume of potassium chromate solution ($9.00 \times 10^{-3} \text{ mol L}^{-1}$), would you expect a precipitate to form? Explain your answer.

4. (10 marks)

- (a) Explain (using diagrams if necessary) why a block of ice in a beaker of water floats, whereas a block of frozen benzene in a beaker of liquid benzene sinks.

- (b) Acetone, $\text{H}_3\text{C}-\overset{\text{O}}{\parallel}{\text{C}}-\text{CH}_3$, is a common laboratory solvent. It is usually contaminated with water. Explain why acetone absorbs water so readily? In your answer, include a diagram to show the intermolecular force(s) involved.

- (c) Account for this fact: although ethanol ($\text{C}_2\text{H}_5\text{OH}$; bp 80°C) has a higher molar mass than H_2O (bp 100°C), the alcohol has a lower boiling point. Include a diagram in your explanation.

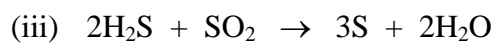
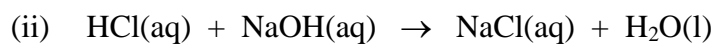
5. (18 marks)
- (a) When a piece of copper is placed in a colourless solution of silver nitrate, crystals form on the copper surface and a blue solution results. However, when a silver wire is placed in a blue solution of copper(II) nitrate no changes are observed.
- (i) What has been formed on the surface of the copper? Write an equation for this process.
- (ii) How is the colour change of the solution accounted for? Write an equation for this process.
- (iii) In what order would copper and silver appear in a metal activity series? Explain your answer.
- (b) What is a sacrificial metal? Give an example of the use of such a metal.

Question 5 continued on the following page

TURN OVER

Question 5 continued

- (c) For each (not necessarily balanced) equation below, state whether or not the reaction represents a redox process. Give your reasoning. In the case of the redox reactions, identify which element has been oxidised and which has been reduced. (Hint: You will need to use oxidation numbers).



Question 5 continued on the following page

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Question 5 continued

(d) The dioxovanadium ion (VO_2^+) reacts with zinc in acidic solution to form the VO^{2+} ion. In the process Zn^{2+} ions are formed.

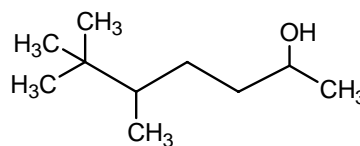
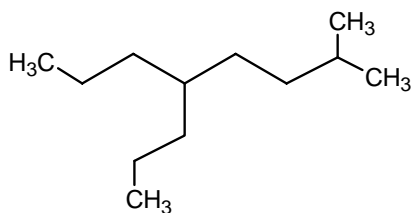
(i) Write the oxidation half equation for this process.

(ii) Write the reduction half equation for this process.

(iii) Write a balanced equation for the overall reaction.

6. (6 marks)

(a) Give systematic names for the following two structures.



(b) Draw a structure for *cis* 4-methyl-2-hexene.

7. (5 marks)

Predict the shape of the following molecules giving your reasons

(a) CH_3CHO

(b) CO_2

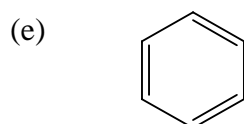
Question 7 continued on the following page

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Question 7 continued

(c) NH_3

(d) CH_4



8. (8 marks)

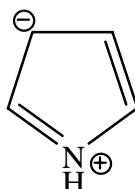
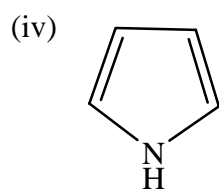
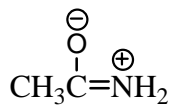
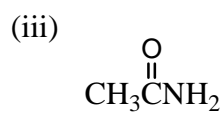
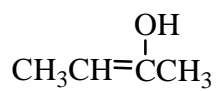
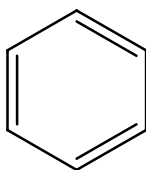
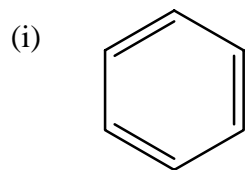
(a) Define the term “resonance”.

Question 8 continued on the following page

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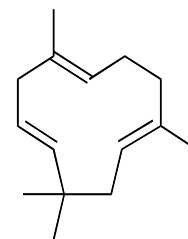
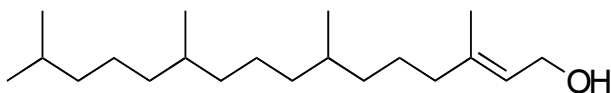
Question 8 continued

(b) Which of the following pairs are resonance structures? Give your reasons.



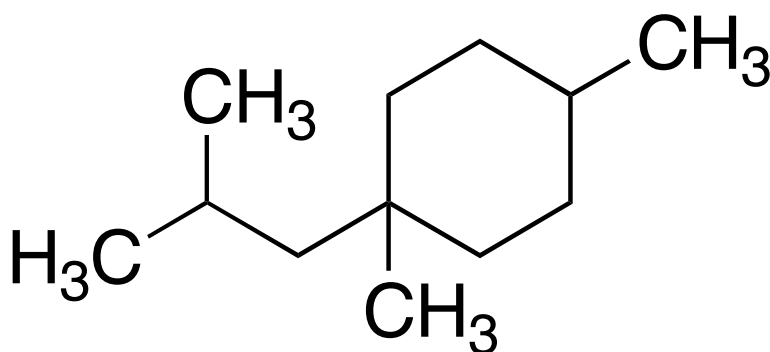
9. (6 marks)

Clearly identify the isoprene units in the two terpenes shown below. Identify, with arrows, the bonds that represent the head-to-tail linkages.



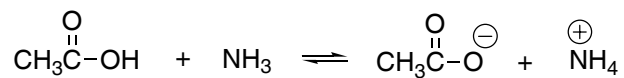
10. (5 marks)

Assign each carbon in the following structure as primary, secondary, tertiary, or quaternary giving your reasons.



11. (10 marks)

Answer the following questions using the reaction given below:



- (a) Explain the meaning of the symbol \rightleftharpoons ;
- (b) Identify, with reasons, all acids and bases in the reaction above;
- (c) Give a mechanism, using curly arrows, for the deprotonation of acetic acid (forward reaction);
- (d) Would you expect $\text{CF}_3\text{CO}_2\text{H}$ to be a stronger or weaker acid than acetic acid? Explain your answer.

END OF PAPER

Periodic Table

1 H 1.008																	2 He 4.00
3 Li 6.94	4 Be 9.01											5 B 10.8	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.0	10 Ne 20.2
11 Na 23.0	12 Mg 24.3											13 Al 27.0	14 Si 28.1	15 P 31.0	16 S 32.1	17 Cl 35.5	18 Ar 39.9
19 K 39.1	20 Ca 40.1	21 Sc 45.0	22 Ti 47.9	23 V 50.9	24 Cr 52.0	25 Mn 54.9	26 Fe 55.9	27 Co 58.9	28 Ni 58.7	29 Cu 63.5	30 Zn 65.4	31 Ga 69.7	32 Ge 72.6	33 As 74.9	34 Se 79.0	35 Br 79.9	36 Kr 83.8
37 Rb 85.5	38 Sr 87.6	39 Y 88.9	40 Zr 91.2	41 Nb 92.9	42 Mo 95.9	43 Tc (99)	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3
55 Cs 132.9	56 Ba 137.3	57-71 see below	72 Hf 178.5	73 Ta 181.0	74 W 183.9	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po (210)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	89-103 see below	104 Rf (257)	105 Db (260)	106 Sg (263)	107 Bh (262)	108 Hs (265)	109 Mt (266)	110	111	112						

57 La 138.9	58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm (147)	62 Sm 150.4	63 Eu 152.0	64 Gd 157.3	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0	71 Lu 175.0
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89 Ac (227)	90 Th 232.0	91 Pa (231)	92 U 238.1	93 Np (237)	94 Pu (242)	95 Am (243)	96 Cm (247)	97 Bk (245)	98 Cf (251)	99 Es (254)	100 Fm (253)	101 Md (256)	102 No (254)	103 Lr (257)
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