Full Name: .....

Student ID #: .....

UNIVERSITY OF CANTERBURY

Mid-Year Examinations 2005

Prescription Number(s):	CHEM 114
Paper Title:	Introductory Chemistry

Time Allowed: TWO HOURS

Number of pages: 14

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 p16.

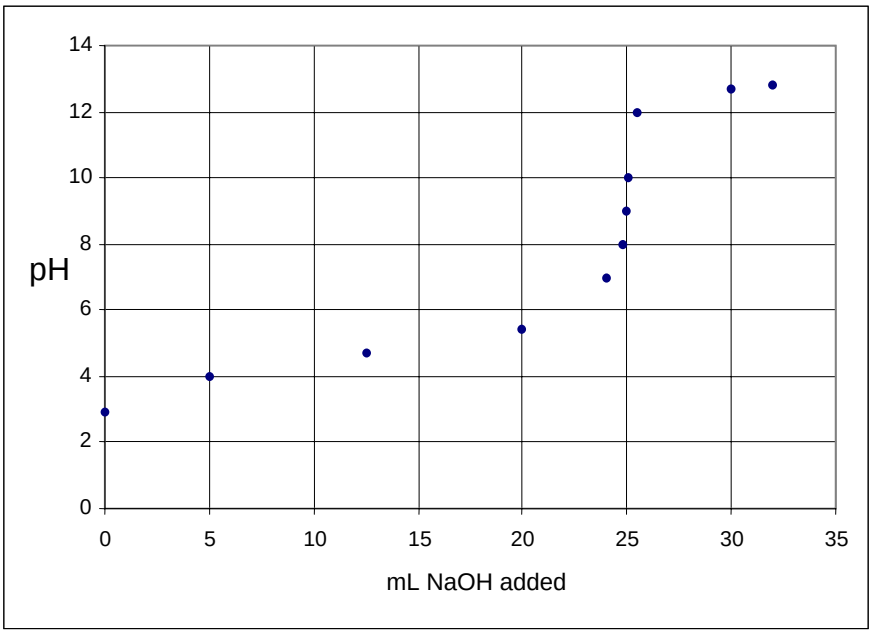
Please write your answers in the spaces provided

For examiners use only

1	2	3-5	6-7	8-12	Total
/16	/14	/24	/16	/40	/110

1. (16 marks)

Use this diagram to answer the following questions.



Variation of pH during titration of 25 mL of 0.1 mol L^{-1} $CH_3COOH(aq)$ with 0.1 mol L^{-1} NaOH(aq).

From the graph above:

(a) What is the pH of 0.1 mol L^{-1} ethanoic acid?

(b) Write an expression for the equilibrium constant of this acid in water.

(c) Use the information in (a) and the expression in (b) to calculate a value for the K_a of ethanoic acid.

(d) From the diagram, estimate the pH when the acid is half-neutralised.

(e) Use your answer to (d) to calculate a value for the K_a of ethanoic acid.

(f) Comment on the closeness of the two values of K_a you have calculated in (c) and (e).

(g) From the diagram, estimate the pH of the 0.05 mol L^{-1} sodium ethanoate solution formed at the end-point of the titration?

(h) Name a suitable indicator for this titration. Briefly explain your reasoning.

(i) What piece of laboratory equipment would you use to measure:

(i) the volume of the ethanoic acid solution?

(ii) the added volume of NaOH?

2. (14 marks)

(a) 10.0 mL of 0.001 mol L^{-1} $CaCl_2$ is mixed with 10.0 mL of 0.001 mol L^{-1} Na_2SO_4 solution. Will a precipitate of calcium sulfate form? $K_{sp}(CaSO_4) = 2 \times 10^{-5}$.

(b) Calculate the molar solubility (s in mol L^{-1}) of $BaSO_4$ in pure water. $K_{sp}(BaSO_4) = 1.1 \times 10^{-10}$.

(c) Calculate the solubility (s) of $Mg(OH)_2$ at pH 13. (Hint: first calculate the concentration of OH^- ions in the solution.) $K_{sp}(Mg(OH)_2) = 1 \times 10^{-11}$.

3. (10 marks)

NO from car engines is an important atmospheric pollutant.

The reaction $N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$ occurs under the following conditions:

temp (K)	reaction rate	K
300	very slow	4.5×10^{-31}
2100	rapid	3.4×10^{-3}

(a) Is this reaction endothermic or exothermic? Explain your reasoning.

(b) Assuming that the reaction reaches equilibrium in the cylinder of a car's engine, how would each of these changes affect the concentration of NO produced by an engine? Explain your reasoning in each case.

(i) Increasing the temperature.

(ii) Injecting extra air into the reaction mixture in the cylinder (at constant temperature).

(iii) Raising the compression in the cylinder (at constant temperature).

(iv) Increasing the concentration of petrol vapour, $C_8H_{18}(g)$ (at constant temperature).

4. (6 marks)

The pK_a of carbonic acid (H_2CO_3) is 6.38. Describe how you would make up 1 L of a carbonic acid/bicarbonate buffer whose pH is 6.70.

5. (8 marks)

The equilibrium constant, K_c, for the synthesis (as below) of ammonia from nitrogen and hydrogen (at 500ºC) is 6.0×10^{-2}.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

Predict the direction in which the reaction will proceed to reach equilibrium if the reaction components are mixed to give the following initial concentrations.

$[NH_3]_o = 1.0 \times 10^{-4}$ mol L^{-1}, $[N_2]_o = 5.0$ mol L^{-1}, $[H_2]_o = 1.0 \times 10^{-2}$ mol L^{-1}.

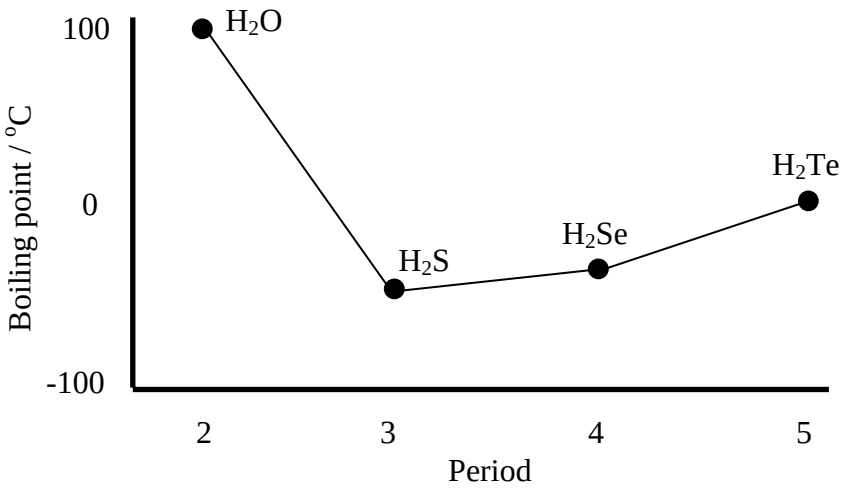
6. (10 marks)

Classify the following processes as (i) oxidation, (ii) reduction, or (iii) neither oxidation nor reduction. You will have to think in terms of oxidation numbers.

(a) $FeCl_2(s)$ being converted to $FeCl_3(s)$.
(b) The oxalate ion $(COO)_2^{2-}(aq)$ being converted to $CO_2(g)$.
(c) The chromate ion $CrO_4^{2-}(aq)$ being converted to the dichromate ion, $Cr_2O_7^{2-}(aq)$.
(d) The formation of metallic lead from lead dioxide.
(e) The conversion of the copper chloro complex $CuCl_4^{2-}(aq)$ to the copper chloro complex $CuCl_4^{3-}(aq)$.

7. (6 marks)

(a)



Explain why water has the highest boiling point of the compounds indicated in the diagram above?

(b) Explain why, on a very hot day, you would be happy to walk through a puddle of water in bare feet but not over a sheet of roofing iron.

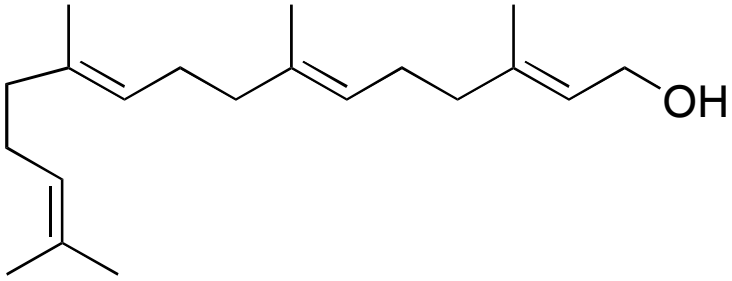
8. (8 marks)

Rank the following five acids in order of increasing acidity, giving detailed reasons for your choice.

CH_2FCO_2H CH_3OH CH_3CO_2H HCl CF_3CO_2H

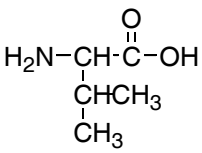
9. (4 marks)

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

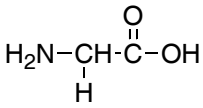


10. (8 marks)

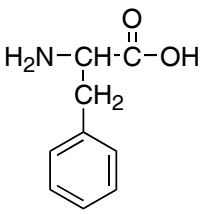
The structures of the amino acids valine, glycine, and phenylalanine are given below. Carefully draw the structures of the dipeptides glycine-phenylalanine and valine-glycine. Clearly indicate, with arrows, the peptide bond and any stereogenic centre(s) in each structure.



valine



glycine



phenylalanine

11. (4 marks)

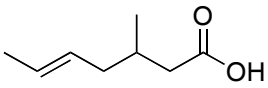
Briefly discuss, with examples, the role that chirality plays in nature.

12. (16 marks)

(a) Draw the structure of 4-methyl-2-pentanol. (2 marks)

(b) Indicate any stereogenic centre(s) in your structure in part (a). (2 marks)

(c) Name the following organic chemical. (3 marks)



(d) Draw the structure of the *cis* isomer of the molecule given in (c) and briefly explain your reasoning. (2 marks)

(e) Draw the structure of a constitutional isomer of the molecule given in (c) and briefly explain your reasoning. (3 marks)

(f) "Benzene (below) is unusually stable for an alkene and is not normally described as an alkene at all." Explain this statement. (4 marks)

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

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)